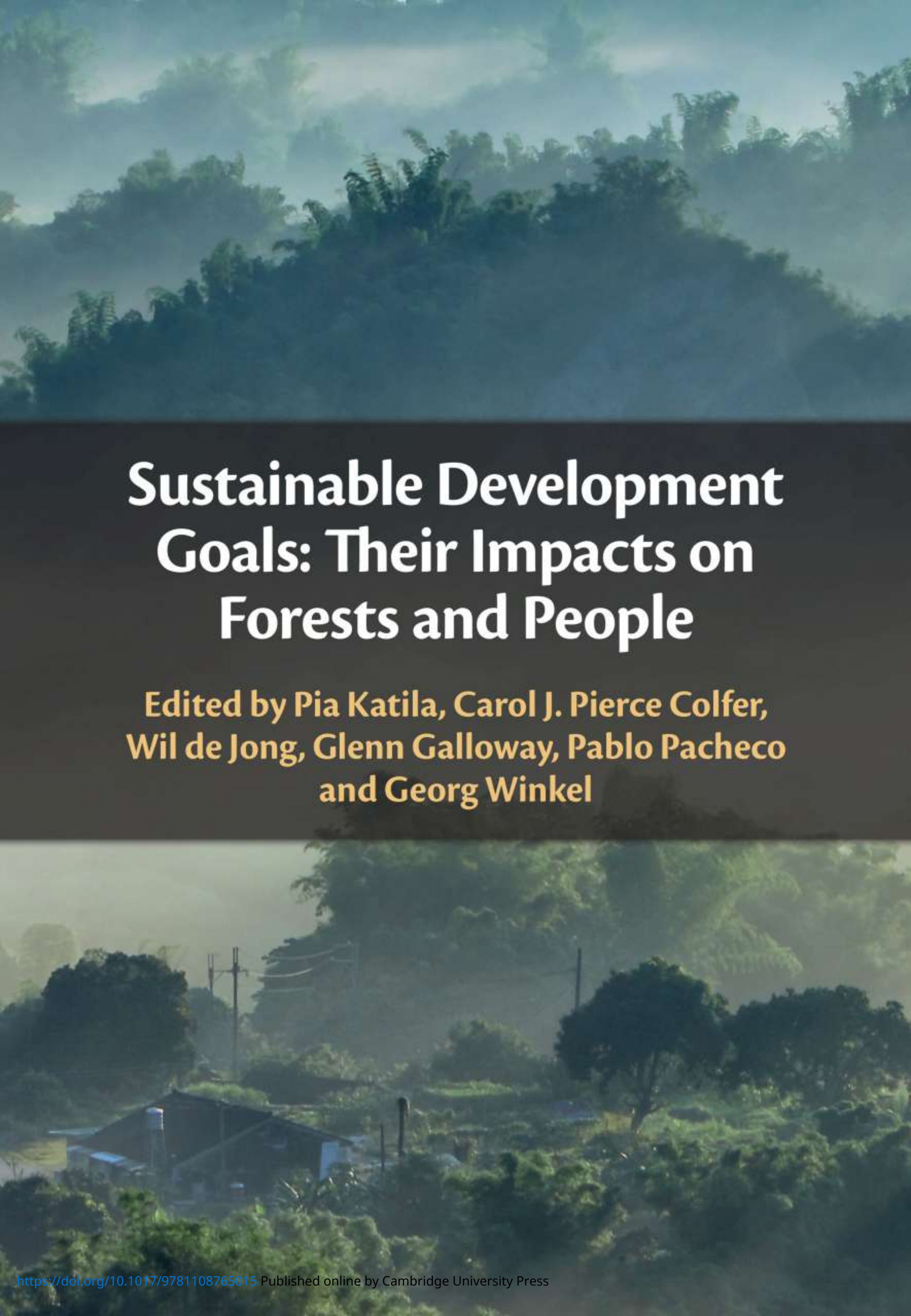

Sustainable Development Goals: Their Impacts on Forests and People

Edited by Pia Katila, Carol J. Pierce Colfer, Wil de Jong, Glenn Galloway, Pablo Pacheco and Georg Winkel

Sustainable Development Goals: Their Impacts on Forests and People

Forests provide vital ecosystem services crucial to human well-being and sustainable development, and have an important role to play in achieving the 17 Sustainable Development Goals (SDGs) of the United Nations 2030 Agenda. Little attention, however, has yet focused on how efforts to achieve the SDGs will impact forests and forest-related livelihoods, and how these impacts may, in turn, enhance or undermine the contributions of forests to climate and development. This book discusses the conditions that influence how SDGs are implemented and prioritised, and provides a systematic, multidisciplinary global assessment of interlinkages among the SDGs and their targets, increasing understanding of potential synergies and unavoidable trade-offs between goals. Ideal for academic researchers, students and decision-makers interested in sustainable development in the context of forests, this book will provide invaluable knowledge for efforts undertaken to reach the SDGs. This title is available as Open Access via Cambridge Core.

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Preface

The world's leaders agreed on the Sustainable Development Agenda, or Agenda 2030, in September 2015, and it officially came into force on 1 January 2016. The agenda is embodied in 17 Sustainable Development Goals (SDGs) and 169 associated targets to be achieved by 2030. Agenda 2030 applies to all countries and is now the major framework for guiding development policies and efforts across local to global scales. It calls for transformative changes to increase human well-being and prosperity while addressing environmental protection and climate change.

Human survival and well-being ultimately rest on the natural resources of the planet. Forests cover about a third of the world's land area and provide a wide range of ecosystem services that are crucial for human well-being and sustainable development worldwide. How forests and trees are included in Agenda 2030 and how the efforts undertaken by different sectors to advance towards the 17 SDGs will impact forests, forest ecosystem services, forest-related livelihoods and human well-being are thus important questions. Little attention, however, has yet focused on these issues, or on how the potential impacts, in turn, will support or undermine the contributions of forests to climate and sustainable development. Understanding the potential impacts of the SDGs on forests and forest-related livelihoods and development as well as the related trade-offs and synergies is crucial for efforts undertaken to reach these goals. It is especially important for reducing potential negative impacts and to leverage opportunities to create synergies that will ultimately determine whether comprehensive progress towards the SDGs will be accomplished.

Realisation of the lack of discussion on the potential and likely impacts of the SDGs on forests and forest-related livelihoods and the related synergies and trade-offs motivated the International Union of Forest Research Organizations (IUFRO) Special Project World Forests, Society and Environment (WFSE) to develop this book. It provides a systematic scientific assessment of potential and anticipated impacts of efforts to achieve the SDGs on forests, related socio-economic systems and forest-related development. It discusses the conditions that influence how SDGs are implemented and prioritised, and how these conditions and SDG implementation influence these impacts. Furthermore, it considers the important interconnections and linkages among the SDGs and the potential or anticipated trade-offs and synergies among the SDGs from the perspective of forests and related socio-economic systems, shedding light on how SDG implementation may transform existing forest-related development scenarios and affect the roles of forests in sustainable development in the future.

WFSE is a wide, open, independent network of experts and scientists coordinated by the Natural Resources Institute Finland (Luke). WFSE supports sustainable natural resource management, sustainable development and livelihoods, and related policy processes. It focuses on topics in the forest, society and environment interface that are recognised by the scientific community as important and having significant policy implications, but which appear not to be receiving adequate attention from the policy community. It addresses these topics in a holistic, interdisciplinary and collaborative manner, producing science-based, future-oriented, policy-relevant information.

The development of this book started by identifying and inviting a core group of lead authors to address the above-mentioned questions from the point of view of each of the SDGs. The lead authors were further tasked to form an international team of authors to collaborate in writing the SDG chapters.

In the course of the development of this book we organised two large workshops that brought together the lead authors of the SDG chapters and the editors of the book. The first workshop was organised in collaboration with the Food and Agriculture Organization of the United Nations (FAO) in Rome, Italy, in March 2018. The event brought together the lead authors and editors of the volume and colleagues from the FAO to discuss forest and SDGs interactions, especially the potential and likely impacts of the SDGs and their implementation on forests and related socio-economic systems.

The second workshop for developing this publication was organised in conjunction with the European Forest Institute's (EFI) Annual Conference and Scientific Seminar in Sardinia, Italy, in September 2018. This workshop concentrated on the main findings from the SDG chapters and the contextual conditions that influence how the SDGs are taken up and prioritised.

Furthermore, the editors of this book convened at the University of Florida, Gainesville, USA, in December 2018 to develop and discuss the findings and conclusions of the book.

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The development of this book was a collaborative effort involving 6 editors and 114 authors from universities and research and development organisations from different parts of the world (see ‘Contributors’ list for authors and their affiliations). Many of the authors contributed to this book on their own time, in addition to their primary duties and responsibilities. We sincerely thank all of them for the quality of their contributions, their commitment and the outstanding efforts that made this publication possible. Furthermore, we are grateful for the support of the authors’ host organisations for the in-kind contribution they provided by supporting the authors’ work.

The SDG chapters (Chapters 1–17) were reviewed by renowned scientists and experts. We are very grateful for their generous contributions to the development of this book. Their comments and guidance were crucial for improving the quality of this publication.

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Executive Summary

In 2015, 193 countries adopted Agenda 2030 for Sustainable Development and its 17 Sustainable Development Goals (SDGs). The SDGs build on the Millennium Development Goals (MDGs), but there are significant differences between them and the processes leading up to their adoption. The process leading up to the adoption of the SDGs involved considerably broader participation. The SDGs expanded the focus by integrating a wider development policy agenda addressing many aspects of economic, social and environmental sustainability. In addition, while the MDGs were mainly relevant for developing countries, the SDGs apply to all countries.

The 17 SDGs and 169 related targets form an overarching development framework meant to guide government and non-state actor efforts at different scales, from global to local, until 2030. The SDGs and their targets form a complex, integrated system with clear sectoral emphases, but also strong interlinkages among goals and targets. The agenda does not explicitly address these interlinkages, or the synergies and trade-offs among targets.

Forests provide ecosystem services that are crucial for human well-being and, as such, are critical for reaching the SDGs. Yet, forests are only explicitly mentioned in two SDGs. SDG 15 (Life on Land) focuses on the protection, restoration and sustainable use of terrestrial ecosystems and halting the loss of biodiversity. The other, SDG 6 (Clean Water and Sanitation), calls for the protection and restoration of forests in one of its targets: Target 6.6 aims at protecting and restoring water-related ecosystems, including forests. Due to the interrelated nature of the SDGs and targets, the implementation of the SDG agenda will inevitably influence forests and forest-related livelihoods and the possibilities to achieve the forest-specific targets. Understanding the potential impacts of SDGs on forests, forest-related livelihoods and forest-based options to generate progress towards achieving the SDGs, as well as related trade-offs and synergies, is crucial for efforts undertaken to reach these goals. It is especially important for reducing potential negative impacts and to leverage opportunities to create synergies, which will ultimately determine whether comprehensive progress towards the SDGs is accomplished.

No Poverty – SDG 1

SDG 1 seeks to ‘end poverty in all its forms everywhere’, specifically by ensuring that the poor are covered by social protection systems; by securing their rights to economic resources, access to basic services and property ownership; and by building their resilience to economic, social and environmental shocks. The relationship between poverty reduction and forests varies across regions, decades, forest transition stage and degree of market access. The empirical literature shows that more secure property rights – especially for community land – and social protection in the form of cash transfers can support forest conservation, given the right contexts and conditionalities. As demonstrated by programmes that reforest hillsides and re-establish mangroves to prevent natural disasters, policies designed to reduce vulnerability can promote ecosystem-based adaptation, including expansion of forest cover. This is consistent with the evidence that forests are both a mainstay of rural livelihoods and a buffer and source of natural insurance. However, if poverty alleviation and national development strategies continue to be based on infrastructure and agricultural development, they are likely to remain in conflict with the conservation and sustainable management of forests.

Zero Hunger – SDG 2

Pressure to increase food production augments with population growth. Agriculture dominates landscapes around the world, and more food is being produced than ever before. Yet a large part of the population is undernourished. Concomitantly, much of the agricultural expansion related to achieving global food security is at the expense of forest ecosystems, which are critical for biodiversity and the provision of ecosystem services. SDG 2 seeks to 'end hunger, achieve food security and nutrition and promote sustainable agriculture'. A 'business-as-usual' approach to food production will continue to cause mass deforestation. This would be detrimental for biodiversity, impacting forest-dwelling communities who depend on forests for the direct provision of food. With the loss of forests comes the loss of far-reaching ecosystem services, vital for many facets of food production relied on by the wider population. SDG 2 and five of its targets (2.1–2.5) are closely related to forests. Targets 2.1 and 2.2 strive to end malnutrition and make nutritious food accessible to all. Investing in small-scale farmers and encouraging operations that grow a diversity of crops (Targets 2.3 and 2.5) are necessary for making Targets 2.1 and 2.2 a reality. Target 2.4 calls for sustainable and resilient agricultural practices. These five targets underscore the reciprocity between forests and SDG 2. Forest biodiversity is integral for nutrition and the ability to grow and harvest diverse crops. In turn, investing in small-scale farming systems and sustainable farming techniques can help conserve forests and enhance the integration of trees into landscapes. If we are to achieve SDG 2 sustainably, we need a reimagined food system that does not polarise agricultural production and the conservation of forest resources. This calls for land management that promotes the maintenance of biodiversity and integrated land-use planning. This is especially evident when examining the relationship between SDG 2 and the other SDGs, the majority of which are concomitantly contingent on each other.

Health and Well-Being – SDG 3

The achievement of SDG 3 depends on many other SDGs, yet there are also potential conflicts and trade-offs. Forests are of crucial importance to global health and well-being. In contrast, short-term economic and human health gains from further forest conversion (e.g. deforestation for food production) will create direct and indirect health risks for humans, as well as for other biota. Controlling indiscriminate burning and clearing of forests can reduce significant harm to health and well-being via improved quality of water, soil and air (a transnational issue), by reducing exposure to some infectious diseases, through the preservation of traditional (and future) medicines and by supporting other forest resources and services, including climate regulation. Many infectious diseases are associated with forest disturbance and intrusions, and some may be prevented or modified through forest management. Universal access to sexual and reproductive healthcare services, including for family planning, is a critical SDG 3 target to decrease demographic pressures on forests at local, regional and global scales and to enhance human well-being. Greater exposure to green space, including urban forests, has been linked to many benefits for mental, social and physical health for the increasingly urban global population. More broadly, forests play important roles in enriching cultural and religious well-being.

Quality Education – SDG 4

Education has been characterised as ‘the golden thread’ that runs through all 17 SDGs. SDG 4 broadens the depth and breadth of education to people of all ages and expands its scope to a lifelong process spanning formal, non-formal and informal settings. It emphasises quality of educational access, particularly for girls and women and marginalised groups. Literature exploring pro-environment behaviour informs our consideration of how progress towards SDG 4 might impact forests, forest ecosystem services and forest-related livelihoods. The concept of pro-forest behaviour describes those elements of pro-environmental behaviour related to forests; encouraging and enabling pro-forest behaviour is the basis of building a positive relationship between SDG 4 and forests. Inclusive education that builds and reinforces positive attitudes towards forests, as well as relevant knowledge and competencies, and that helps individuals and communities feel or stay connected to forests, will

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foster and sustain pro-forest behaviours. This requires that education systems respect, nurture and enable Indigenous and traditional knowledge; promote forest-related environment and sustainability education; strengthen forest-related professional, technical and vocational education and capacity development; and capitalise on the power of both established and new media that will continue to evolve and emerge over time.

Gender Equality – SDG 5

Taking SDG 5 seriously in relation to forests brings to the forefront what is usually taken for granted in forest debates: people and their relationships, to one another and to forests. These relationships determine forest outcomes. Forest governance and everyday management are upheld by a superstructure of gendered forest relations (invisible to mainstream forestry) that often disadvantages women as a social group. Systemic and contextual factors such as health, gender-based violence and unpaid care work are crucial to the welfare of forest-dependent peoples and forests. So far, little progress has been made in implementing SDG 5 targets within forestry. Political will is needed to transform unequal relationships and to support demands for forest justice. There is a need to challenge privilege based on sex, class, ethnicity or caste and to destabilise inequitable micro- and macroeconomic structures such as commodification and to support democratic forest governance to work towards greater sustainability. It is also important to keep in mind that well-intentioned efforts, such as gender programmes, can have adverse effects if not cognisant of contextual power relations. The welfare and dignity that achieving SDG 5 would bring to forest peoples and livelihoods is essential to ensuring better managed and sustainable forests; however, the gender-neutral framing of some SDG goals undermines efforts towards achieving the outcomes called for in SDG 5.

Clean Water and Sanitation – SDG 6

Predicting the impact of SDG 6 on forests and people requires a balanced understanding of the relationship between forests and water. Notable aspects are that forest cover reduces annual runoff but correlates well with water quality, and that evapotranspiration from forests is important for downwind precipitation. Within this context a target-by-target review of SDG 6, informed by South American examples, suggests that SDG 6 is unlikely to exert a major influence on forest cover. Targets 6.1 and 6.2, concerning water and sanitation provision (likely to be the major focus of SDG 6), will have relatively little impact on forests except through a demand for hydrological

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ecosystem services and the use of wastewater in forestry. Within the four water resources targets (6.3–6.6) significant impacts may be limited to water efficiency considerations (Target 6.4) restricting plantations in water-stressed areas and Integrated Water Resources Management (Target 6.5) driving a more integrated view of catchments and their management. SDG 6 impacts will depend on the context of water–forest relationships (illustrated using the Hindu Kush Himalayas as an example), the extent to which SDG 6 is implemented and its alignment with forest policies. This alignment must be guided by a shared understanding of the complex relationships between water and forests and their impacts on both forest-dependent peoples and the communities downstream, and possibly downwind.

Affordable and Clean Energy – SDG 7

SDG 7 aims to ensure access to affordable, reliable, sustainable and modern energy for all. Forests contribute to SDG 7 through four pathways: sustainable use of traditional woodfuels, processed woodfuels, liquid biofuels and biopower. We hypothesise that the role of traditional woodfuels (e.g. firewood and charcoal) in household energy portfolios will decline in most low- and middle-income countries, but will not be completely replaced with modern fuels. In the transition to affordable clean fuels, processed woodfuels (e.g. pellets), liquid biofuels produced from forest feedstock and biopower will play an increasing role in energy service provision. How forest-based transitions to clean energy will fare relative to other renewable energy technologies including solar, wind and micro-hydro will depend on how renewable energy policy evolves, and on relative costs and storage capacity. Reaching SDG 7 through the promotion of large-scale hydro and agricultural commodity derived biofuels can threaten forests and forest-based livelihoods. In general, promoting transitions to sustainable forest-based clean energy supports the realisation of other SDGs, highlighting the potential for forests to play a significant role in discourse and action on the SDGs.

Decent Work and Economic Growth – SDG 8

Diverse combinations of predominant development paradigms (modernisation, economic growth, basic needs, sustainable development) that shape the agendas of governments, private sector, civil society and investors lead to differentiated prioritisation of SDG 8 targets, with mixed impacts on forests and forest-dependent livelihoods. At the country level, significant trade-offs are expected where growth policies and strategies focus on sectors competing with forestry for space and resources, such as agriculture, energy and mining.

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Combined, such policies and strategies lead to global trade-offs by exacerbating climate change. In these cases, decoupling economic growth from environmental degradation will be a major challenge. Synergies between SDG 8 and forests exist where sustainable development is explicitly sought in the forest sector, focusing on tree plantations, timber and non-timber forest products from natural forests, eco-tourism and environmental services. Enhanced enabling environments help minimise trade-offs and maximise synergies by reconciling government policies and private sustainability standards, formalising community stewardship of tropical forests, addressing informality in forest-product value-chains and providing incentives for youth to become involved in forest-based economic activities.

Industry, Innovation and Infrastructure – SDG 9

SDG 9 and its 8 targets and 12 indicators will have multiple impacts on forests, forest-based livelihoods and forest-based economies. Major trade-offs are anticipated between SDG 9 and SDG 15 (Life on Land), especially if economic expansion and increasing planetary impacts remain coupled. More specifically, the implementation of Target 9.1 and its corresponding indicators (road, infrastructure and transportation expansion) may lead to irreversible and widespread forest degradation and deforestation. As such, the short- and long-term environmental and social costs of this goal need to be better assessed, especially in light of the fact that other SDG 9 targets, e.g. small-scale industry expansion (Target 9.3) and access to information and communications technology (Target 9.C), may have diverse consequences for forests and livelihoods, depending on how they are applied. We call for reforms of SDG 9 to promote and support alternative socio-economic models that are not based on indefinite economic growth nor reliant on the ongoing expansion of infrastructure, but, rather, necessitate forests and terrestrial ecosystem services to be essential building blocks of a green and sustainable economy.

Reduced Inequalities – SDG 10

SDG 10 calls for reducing inequalities within and among countries. Considerable synergies and complementarities can be found between the SDG 10 targets and the goals of environmental justice, which comprise three interrelated dimensions: representational, recognition and distributive justice. However, the disjuncture between SDG 10 and environmental goals within the SDGs may undermine efforts to promote environmental justice. Trade is not included in SDG 10; this is an important gap as markets for forest products can drive forest resource extraction, exacerbating inequalities

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among actors within global production networks. If SDG 10 addresses structural inequalities, it is also likely to support distributive, representational and recognition justice for forest-dependent populations. However, the myopic translation of its aspirational targets into easily measurable indicators may dampen the potential effects of addressing SDG 10 in advancing environmental justice. Addressing migration-related targets and indicators is likely to elevate the importance of these issues in forestry policy and research, while also prompting a rethinking of some of the underlying assumptions informing existing research in forestry. Managing migration requires incorporating a better understanding of the net effects of migration on environmental justice and the multiple drivers that contribute to positive outcomes for forest-dependent populations.

Sustainable Cities and Communities – SDG 11

Cities have become critical drivers of global socio-economic, behavioural and environmental changes far beyond urbanised borders. Their transformative force has been recognised with the endorsement of SDG 11 to 'make cities and human settlements inclusive, safe, resilient and sustainable'. The capacity to address global urban challenges through the implementation of SDG 11 depends on how cities prioritise resources and urban planning strategies over the next decade. This prioritisation is context specific and depends on socio-economic development trajectories, spatio-temporal urbanisation patterns and strategic urban visions. The implementation of SDG 11 will have effects on forests and forest livelihoods near and far from urban centres. The strategic inclusion of urban and peri-urban forests in city agendas and planning may help manage potentially adverse effects, emphasising the role forests play in delivering ecosystem services to urban and rural people, and fostering productive rural–urban relationships. If SDG 11 implementation aims at fostering people–nature connections in cities, it can help to avoid the negative consequences the 'urbanisation of minds and attitudes' may have on forests and forest-based livelihoods. Currently, many cities prioritise SDG 11 targets focused on basic services such as housing, transport, waste management and sanitation. Less attention is given to SDG 11 targets encouraging inclusive access to urban forests, protecting cultural and natural heritage or improving urban–rural linkages. SDG 11 shows synergies with all the other SDGs, creating opportunities for human health and well-being, green justice, resilience and adaptive capacity in and around cities. These synergies, delivered through sound urban forestry approaches for example, could benefit not only urban dwellers, but also forest communities by reducing pressure on forest resources. The potential role of urban forests in achieving SDG 11 implementation may

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be enhanced through the New Urban Agenda and global networks that help create multi-scale bridges for collective stewardship involving a large range of government and other actors. The benefits that greener and more resilient cities may have on forests and forest-dependent livelihoods will largely depend on integrated governance and territorial planning.

Responsible Consumption and Production – SDG 12

The focus of SDG 12 – sustainable consumption and production (SCP) – has been part of the international policy discourse for more than four decades, but the uptake of SCP has not been smooth and has tended to be biased towards relatively weak measures. The inclusion of SCP in the SDG framework gives hope that it will receive stronger attention in international efforts for sustainable development. Although SDG 12 targets and indicators make no direct reference to forests or forest communities, achieving the targets will result in positive contributions towards forest conservation and will support forest-dependent livelihoods. SDG 12 targets can contribute to reducing trade-offs among other SDGs: in particular, Target 12.3 – aimed at reducing food waste and food losses – can limit trade-offs between SDG 2 (Zero hunger) and SDG 15 (Life on Land). SDG 12 can contribute to creating enabling conditions for advancing a more responsible and sustainable supply of timber and other forest commodities, also linked to more responsible demand. SDG 12 has its limitations, including the lack of absolute limits to consumption of forest products or products that place pressures on forests leading to deforestation and forest degradation. The main players for achieving SDG 12 targets with positive outcomes for forests will comprise national governments, large companies and consumers involved in global value chains. A thorough integrative SCP approach that addresses systemic issues is required to achieve sustainable forest management and land use associated with responsible consumption.

Climate Action – SDG 13

Climate change causes changes in forests, their ecological functions and ecosystem services. Many of these changes will negatively impact people, plants, animals and microorganisms that depend on forests. SDG 13 aims to reduce greenhouse gas emissions that cause climate change and to drive adaptation actions. Current commitments are insufficient to reach the Paris Agreement goals of restricting global warming to less than 2°C and increasing the resilience of vulnerable communities. Better forest and land management can contribute up to 20 per cent of the Paris goals while increasing community and ecosystem resilience, and can therefore help progress towards reaching the

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Paris Agreement goals. Strong synergies between SDG 13 and forests can drive investment in sustainable forest management, forest restoration and forest conservation. However, achieving these synergies is challenged by unsustainable forest exploitation and pressures to develop land for agriculture, urban areas and infrastructure. Maximising potential synergies between forests and SDG 13 requires long-term finance and local collaboration; currently, only 3 per cent of climate finance is dedicated to forest actions, and much less is used for local implementation. Improved forest management and conservation can be achieved through a more efficient use of finances, increased investment from public and private sectors and stronger commitment to local actions.

Life below Water – SDG 14

The targets of SDG 14 address the world's oceans, covering more than 70 per cent of the planet; they also address the coastal zones, where a range of coastal forests are located. In this chapter we investigate the potential negative consequences of SDG 14 on forest resources, using the example of coastal mangrove forests. SDG 14 is likely to have negative impacts on forest resources because it focuses primarily on fisheries, potentially excluding other coastal natural resources. Many SDG 14 targets are more appropriate for oceanic areas rather than the complex governance arrangements found in the coastal zone. This means that coastal forests such as mangroves may be neglected, inadvertently impacted or fall through the 'policy gap' between terrestrial and marine legislation or between different levels of governance. This has impacts on the human populations that rely on the ecosystem services provided by mangrove forests, and has implications for environmental justice. To minimise the impacts of SDG 14 on mangrove forests and associated coastal communities, we recommend that SDG 14 indicators should be broadened to encompass other coastal and oceanic natural resources, that decentralisation of coastal zone governance should continue to be encouraged and that management regimes should include coastal communities and enshrine principles of environmental justice.

Life on Land – SDG 15

SDG 15 requires the maintenance of life on land and endorses priorities already established through international conventions and agreements. The scale and complexity of tropical forest loss and biodiversity decline versus the limited resources for conservation and forestry poses many challenges. The main innovation of SDG 15 is that decision-makers will see this goal as one to integrate with other SDGs. The risk, however, is that short-term priorities and a 'business-as-usual' approach will undermine this. There will be trade-offs between SDG 15 and other SDGs resulting from competition for land, but there are also opportunities for synergies and opportunities that require recognition. Greater cross-sectoral integration, not just sectoral policy reform, is essential to advancing SDG 15. We encourage conservation and development professionals to engage with those responsible for all the Agenda 2030 targets to ensure that SDG 15 is a priority in all SDG-related processes.

Peace, Justice and Strong Institutions – SDG 16

SDG 16 addresses three broad thematic areas: (1) peace and the reduction of armed conflict; (2) the rule of law, accountability, transparency and access to justice; and (3) inclusiveness and participation. Research on peace and armed conflict reveals highly variable effects on forests and people. Conflict may prevent the conversion of forests to agriculture, or drive illicit crop production; it may foster migration into or out of forested areas. Peace may be accompanied by state-supported mining and expansion of commercial agriculture, and/or may improve enforcement of environmental laws. In general, laws in many countries favour the political elite, large-scale industry actors and international trade, and thus the focus of SDG 16 on the 'rule of law' risks reinforcing existing inequalities. The goals of SDG 16 may best be served by legal reforms that strengthen local rights to land and resources, and by greater involvement of non-state actors and institutions at multiple scales – from traditional governance systems to global-scale initiatives. While there has been much recent progress in promoting participatory forest management, this is often tightly controlled by the state, contributing to local administrative burdens without redistributing power and benefits. In sum, the impacts of SDG 16 on forests and people depend on how its interpretation and implementation shape power and resource distribution.

Partnerships for the Goals – SDG 17

Successful attainment of SDG 17 is essential for implementing the other 16 SDGs, all of which depend upon secure means of implementation and durable partnerships. Funding for forests from official development assistance and other sources has trended upwards since 2000, providing reason for cautious optimism. However, REDD+ finance is declining. Private sector investment remains important. The idea of impact investment, which aims to solve pressing environmental and social problems while providing a return for investors, could make a significant contribution to the SDGs. However, not all sustainable development finance promotes forest conservation. Increasing funding for agricultural production often incentivises the conversion of forests to agricultural land while resulting in deforestation. The policy of zero net deforestation is leading to the creation of partnerships to promote deforestation-free commodity supply chains for four forest-risk commodities (palm oil, soy, beef and timber). Some innovative partnerships have been created to promote sustainable development involving intergovernmental organisations, the private sector, research institutes, non-governmental organisations and grassroots organisations. However, such partnerships exist within a neoliberal global economic order in which there are net financial flows from the Global South to the Global North that negate financial flows for sustainable development.

Synergies, Trade-offs and Contextual Conditions

Findings across the SDGs indicate that the ones that can be linked to deforestation or forest degradation are primarily SDG 9 (Industry, Infrastructure and Innovation), SDGs 1 (No Poverty), SDG 2 (Zero Hunger), and SDG 7 (Affordable and Clean Energy). The largest threat to forests linked to SDG 9 is undoubtedly infrastructure expansion, which often encourages mega agro-industrial projects. The impact of SDGs 1 and 2 on forests is projected to occur through an expansion of agricultural production, which leads to deforestation and forest degradation. Land-use change driven by agricultural expansion is mostly linked to SDG 2. While SDG 1 is not directly focused on food production, it is likely to lead to similar impacts on forests because a high proportion of the global poor live in rural areas, and supporting their emergence from poverty can most readily be achieved by boosting income from agriculture or other natural resource-based activities. SDG 7 implementation may have negative and positive impacts on forest cover and forest condition. Its successful implementation will reduce consumption of woodfuels, offset by increases in the use of hydrocarbon-based fuels or other cleaner energy sources. Future energy trends include turning to improved woodfuels, such as wood pellets, and the use of liquid biomass fuels, such as palm oil-based biodiesel, whose production may happen at the expense of forests.

The undesirable impacts described above resulting from trade-offs implicit in the pursuit of different SDGs are counteracted by SDG 13 (Climate Action) and SDG 15 (Life on Land). The implementation of these two SDGs is primarily expected to have positive impacts on forests, while the impact on forest peoples is less clear.

The impacts of the SDGs on forests and people, as well as the positive and negative interactions among SDGs and how those will affect forests and

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people, are influenced by contextual conditions. These include a country's national development status and trajectory and the overall condition of forests. Many of these conditions are actually targeted by the SDG agenda. Like the SDGs, these conditions do not operate in isolation, but, rather, interact in complex ways. This results in a web of interactions of SDGs and contextual conditions leading to observed and projected impacts on forests and people.

In the analysis of the findings across the SDG chapters, two broad groups of SDGs emerge. One includes SDGs that primarily focus on institutional, governance and social conditions (1 No Poverty; 3 Good Health and Well-being; 4 Quality Education; 5 Gender Equality; 10 Reduced Inequalities; 12 Responsible Consumption and Production; 13 Climate Action; 16 Peace, Justice and Strong Institutions). These contribute to an enabling environment for inclusive forest management and conservation with associated livelihood benefits. A second group of SDGs concern land use directly and thus are expected to impact forests directly (2 Zero Hunger; 6 Clean Water and Sanitation; 7 Affordable and Clean Energy; 8 Decent Work and Economic Growth; 9 Industry, Innovation and Infrastructure; 14 Life below Water; 15 Life on Earth). Progress in the first group of SDGs results in synergistic interactions and positive outcomes for forests and peoples. Among the second group of SDGs, the potential for trade-offs is high, with important repercussions for forests and people. Understanding the potential for these trade-offs is essential in order to avoid implementation pathways that favour a small subset of these SDGs at the expense of the others.

Key Lessons

The key lessons that emerge from this volume, drawing on a reflection process among the editors and on deliberations among lead authors during a collaborative workshop, can be articulated as follows: (1) forests are often a foundation for sustainable development, and thus need to be fully considered in decision-making processes related to the SDGs; (2) the implementation of the SDGs will impact forests and people dependent on them in many ways, with the exact impact being contingent on the specific ecological, socio-economic and political context; (3) within the SDGs, partially conflicting visions for forests and people are implicit that correspond to distinct values and interests, making it necessary to consider trade-offs and set priorities when implementing them; (4) there are fundamental values and principles that should guide sustainable development related to forests and peoples regardless of context, such as respect for basic human rights, the importance of intergenerational equity, the recognition of temporal dimensions of forest ecosystem conservation, the need to detect and address trade-offs, and applying acknowledged tenets of good governance; (5) implementation of the SDGs and associated goals and targets will require continuous learning and adaptation of implementation strategies and approaches, but possibly also targets, taking into consideration observed outcomes. Creative and forward-looking human engagement at the forest-people interface is urgently needed to ensure that sustainable development benefits both forests and peoples.

Abbreviations

APEC	Asia Pacific Economic Cooperation
CATIE	Tropical Agricultural Research and Higher Education Centre
CBD	Convention on Biological Diversity
CDM	Clean Development Mechanism
CIAT	International Centre for Tropical Agriculture
CIFOR	Center for International Forestry Research
CITES	Convention on International Trade in Endangered Species
CPF	Collaborative Partnership on Forests
DFID	Department for International Development
EFI	European Forest Institute
EIA	Environmental Impact Assessment
EKC	Environmental Kuznets Curve
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FLEGT	Forest Law Enforcement, Governance and Trade
FLR	Forest Landscape Restoration
FPIC	Free, Prior and Informed Consent
FSC	Forest Stewardship Council
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
HLPF	High-Level Political Forum
ICT	Information and Communication Technology
IFPRI	International Food Policy Research Institute
IIED	International Institute for Environment and Development
ILO	International Labour Organization
IMF	International Monetary Fund
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
ITTO	International Tropical Timber Organization
IUCN	International Union for Conservation of Nature
IUFRO	International Union of Forest Research Organizations
LAC	Latin America and Caribbean
LDC	Least Developed Countries
LMIC	Low- and Middle-Income Country
LULUCF	Land Use, Land-Use Change and Forestry

MDG	Millennium Development Goal
MRV	Monitoring, Reporting and Verification
NDC	Nationally Determined Commitments
NGO	Non-Governmental Organization
NTFP	Non-Timber Forest Product
NYDF	New York Declaration on Forests
ODA	Official Development Assistance
ODI	Overseas Development Institute
OECD	Organisation for Economic Co-operation and Development
PEFC	Program for the Endorsement of Forest Certification
PES	Payment for Ecosystem Services
R&D	Research and Development
RECOFTC	The Centre for People and Forests
REDD+	Reducing Emissions from Deforestation and Forest Degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries
RRI	Rights and Resources Initiative
RSPO	Roundtable on Sustainable Palm Oil
SCP	Sustainable Consumption and Production
SDG	Sustainable Development Goal
SFM	Sustainable Forest Management
SIDS	Small Island Developing States
SME	Small- and Medium-Sized Enterprises
SMFE	Small and Medium Forest Enterprises
SPP	Sustainable Public Procurement
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNCLOS	United Nations Convention on the Law of the Sea
UNCTAD	United Nations Conference on Trade and Development
UN DESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
UNFF	United Nations Forum on Forests
UNISDR	Currently known as UNDRR, United Nations Office for Disaster Relief Reduction
UNSD	United Nations Statistics Division
UNU-WIDER	United Nations University World Institute for Development Economics Research

USD	US Dollar
VNR	Voluntary National Review
VPA	Voluntary Partnership Agreement
WBCSD	World Business Council for Sustainable Development
WHO	World Health Organization
WRI	World Resources Institute
WTO	World Trade Organization
WWF	World Wide Fund for Nature
ZND	Zero Net Deforestation

Introduction

Pia Katila, Carol J. Pierce Colfer, Wil de Jong, Glenn Galloway, Pablo Pacheco
and Georg Winkel

The Aim of This Book

In 2015, 193 countries adopted Agenda 2030 for Sustainable Development and its 17 Sustainable Development Goals (SDGs). Each goal is composed of a number of targets to be achieved by 2030. The goals and the 169 targets cover a wide range of social, economic and environmental issues addressing crucial global challenges, including ending hunger and poverty, protecting life below water and on land, advancing sustainable production and consumption, and guaranteeing well-being to all with reduced inequalities. Agenda 2030 forms an overarching framework that is expected to guide government and non-state actor efforts at different scales, from global to local, until 2030. The global indicator framework to follow and periodically review the progress towards the SDG targets was adapted in 2017 (UN 2017). The main responsibility to reach the SDG targets rests with national governments, but the agenda calls for cooperation and global partnerships that bring together governments, civil society, the private sector, the United Nations (UN) system and other social actors.

The SDGs (Table I.1) and their targets form a complex, integrated system with clear sectoral emphases but also strong interlinkages among goals and targets. The agenda does not explicitly address these interlinkages, nor the synergies and trade-offs among targets. In many instances, efforts to advance one target can directly or indirectly contribute to the advancement of other targets. In other instances, progressive measures for one target can hinder the achievement of others.

Natural resources are the fundamental basis for life and human well-being. Many of the efforts to achieve the SDGs and specific targets will have direct or indirect impacts on natural resources, the services they provide and the ways they are used, along with the distribution of their benefits. Forests cover about one-third of the world's land area and are crucial for fundamental ecological processes and human well-being – from climate regulation and

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Table I.1 Sustainable Development Goals

Goal 1. End poverty in all its forms everywhere
Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture
Goal 3. Ensure healthy lives and promote well-being for all at all ages
Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
Goal 5. Achieve gender equality and empower all women and girls
Goal 6. Ensure availability and sustainable management of water and sanitation for all
Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all
Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
Goal 10. Reduce inequality within and among countries
Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable
Goal 12. Ensure sustainable consumption and production patterns
Goal 13. Take urgent action to combat climate change and its impacts*
Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development
Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
Goal 17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development

* Acknowledging that the United Nations Framework Convention on Climate Change is the primary international, intergovernmental forum for negotiating the global response to climate change.

Source: UN 2015

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pollination services to provision of timber and non-timber forest products. They also provide habitat for a vast array of plants and animals. The future of the world's forests is thus critical for sustainable development at all scales, from global to local.

Yet, forests are explicitly mentioned in only two SDGs. SDG 15 (Life on Land) focuses on the protection, restoration and sustainable use of terrestrial ecosystems and halting the loss of biodiversity. SDG 6 (Clean Water and Sanitation) calls for the protection and restoration of forests in one of its targets: Target 6.6 aims at protecting and restoring water-related ecosystems, including forests. Due to the interrelated nature of the SDGs and targets, the implementation of the SDG agenda will inevitably affect forests and forest resources, thus impacting the possibilities to achieve these forest-specific targets. This will further affect the capacity and potential of forests to provide important ecosystem services (e.g. climate regulation, soil protection and formation, biodiversity protection, water regulation and supply, and an environment for recreation) and consequently to contribute to achieving the SDGs and supporting human well-being and sustainable development in the future.

This book presents a comprehensive interdisciplinary assessment of potential and anticipated impacts of efforts towards attaining the different SDGs on forests and forest-related livelihoods. It identifies possible synergies and trade-offs associated with efforts to achieve the SDGs and the goods and services provided by forests. The assessment places special attention on interactions among the goals and their impacts on forests, forest use and forest-related livelihoods and economies, as well as how the goals and their interactions affect policies and governance relevant to forests. We expect that this book will thus contribute to the formulation of more integrated and coherent policies for reaching the SDGs and targets – policies that would leverage beneficial synergies and minimise the inherent trade-offs among the targets. By analysing the interactions among the SDGs through a forest lens, this book provides an analysis of the SDG framework from the point of view of this crucial natural resource base on which human well-being depends.

The book addresses the following questions:

1. What are the possible and anticipated impacts of efforts to achieve the 17 SDGs and related targets on forests and forest-related livelihoods? What are the contextual conditions that determine how SDGs are implemented and prioritised, and how do these conditions and related SDG implementation pathways influence impacts on forests and related livelihoods?

2. What are the important interconnections and interlinkages among the SDGs and related trade-offs and opportunities for beneficial synergies vis-à-vis

forests, forest ecosystem services and forest-related livelihoods in different contexts? How may the implementation of the SDGs transform existing rural well-being scenarios and forest-dependent economies?

Here, we introduce the SDGs and the processes that led to their adoption. We also summarise the importance of forests for human well-being and the crucial role and contributions of forests towards reaching the SDGs.

The Road to SDGs

The challenge of maintaining environmental sustainability in the context of economic growth and material well-being entered global discussions in the UN Conference on the Human Environment in Stockholm in 1972. Several years later, the report of the Brundtland Commission, *Our Common Future*, placed the concept of sustainable development into the global environmental and development agenda. It defined *sustainable development* as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (UN 1987).

Since that time, sustainable development has been the overarching theme and guiding principle of global development. It was the main concept for the UN Conference on Environment and Development held in Rio de Janeiro in 1992: the summit adopted Agenda 21 – a programme of action for sustainable development worldwide. Building on the declaration from the Stockholm conference, it presented the first international plan of action for global sustainable development into the twenty-first century (UN 1994).

The 2002 World Summit on Sustainable Development in Johannesburg, South Africa, reaffirmed this commitment and included a reference to the three pillars of sustainable development by assuming 'a collective responsibility to advance and strengthen the interdependent and mutually reinforcing pillars of sustainable development – economic development, social development and environmental protection – at the local, national, regional and global levels' (UN 2002: 1).

In 2000, the UN Millennium Summit adopted the Millennium Declaration with eight time-bound targets, the Millennium Development Goals (MDGs), with a deadline of 2015. It committed all countries to reduce extreme poverty and set a road map towards the implementation of the MDGs, which focused on eradicating extreme poverty and hunger; achieving universal primary education; promoting gender equality and empowering women; reducing child mortality; improving maternal health; combatting HIV/AIDS, malaria and other diseases; ensuring environmental sustainability; and developing a global partnership for development (UN 2000).

The MDGs became widely accepted goals, but were mostly relevant for developing countries. While remarkable progress has been made towards these goals, especially in eradicating poverty and improving access to primary education, progress has been uneven within and across countries (UN 2012). The MDG framework's format – based on a limited number of concrete end goals and numerical targets – has been acknowledged as one of its main strengths (UN 2012). However, this approach has also been criticised for addressing complex development challenges with only eight concrete goals and reducing the development agenda to meeting basic material needs. The resulting narrow focus on selected indicators has accordingly been criticised for ignoring issues that are not captured with specific, quantifiable indicators, thus potentially leading to shifting priorities when implementing the MDGs (Fukuda-Parr 2017).

While the SDGs build on the MDGs, there are significant differences between them and the processes leading to their adoption. The process leading to the acceptance of the MDGs was criticised for being top-down, led by technocrats with limited consultations with other sources of knowledge and expertise. The process leading to the adoption of the SDGs was based on considerably broader participation. The SDGs were negotiated mainly through the Open Working Group of the UN General Assembly, whose work paralleled the work of the High-Level Panel on the Post-2015 Development Agenda set up by the UN Secretary General. The process included an extensive global consultation and negotiation involving the interests of specific social groups such as women, Indigenous peoples, farmers and non-governmental organisations (Dodds et al. 2017, Fukuda-Parr 2016, Stevens and Kanie 2016).

The SDGs broadened the focus from that of the MDGs towards a wider development policy agenda addressing many aspects of economic, social and environmental sustainability. While the MDGs were mainly relevant for developing countries, the SDGs apply to all countries. They also address issues that were not included in the MDGs and ones that the MDGs were criticised for only partially including, such as inequality, gender, political and human rights, economic development and climate change.

Agenda 2030 is a universal plan of action that aims at guiding development efforts and national development policies until 2030. It recognises that the SDGs are 'integrated and indivisible and balance the three dimensions of sustainable development: the economic, social and environmental' (UN 2015: 1). Universal development and ending poverty in the spirit of 'no one will be left behind' are the central principles of Agenda 2030. 'Eradicating poverty in all its forms and dimensions, including extreme poverty' is considered the 'greatest global challenge and an indispensable requirement for sustainable development' (UN 2015: 1).

SDGs as a Complex, Integrated System

While the SDGs are stated to form a complex, integrated system of goals and interrelated targets that cut across traditional administrative sectors, many of the goals have an overall sectoral focus. Furthermore, the references to sectors other than the ones specifically addressed in a specific goal are not systematically considered (Boas et al. 2016). There is great variation in the nature and scope of the SDGs, and the related targets have different functions. Some targets are ends in themselves, while others are means towards reaching other targets by supporting the development of an enabling environment or providing resources that support the achievement of other targets (Elder et al. 2016, Holden et al. 2017). The relationship among the more intermediate targets can be synergistic, and a lack of progress in one may often hinder progress within another. In other instances, however, efforts towards achieving a specific target can undermine progress towards another one (Elder et al. 2016). While synergies among the targets can increase the effectiveness of implementation, incompatible targets lead to trade-offs. In addition, the interactions among the SDGs are non-linear. Deficient performance in one crucial goal or target can potentially undermine progress in the overall agenda. Similarly, the implementation of one target at the expense of a non-compatible one can reinforce the trade-offs.

The interlinkages and interactions among the SDGs and related targets are receiving increasing attention. Le Blanc (2015) conducted a network analysis of the links among SDGs and targets (except those related to implementation) based on their wording. The results show that the SDGs are unequally connected. Some goals are connected through multiple targets, while others have weak connections to other goals. Sustainable consumption and production (SDG 12), reducing inequality (SDG 10), eliminating poverty (SDG 1) and promoting economic growth and employment (SDG 8) are directly or indirectly linked to at least ten other goals. Life on land (SDG 15) is linked to six other goals. The results of the network analysis were compared to previous studies that had used a nexus approach to analyse the interconnections among climate, land, energy and water targets. This showed that most of the relevant interactions identified in nexus studies are not explicitly captured in the wording of the SDGs and targets.

SDG interactions have also been analysed through classifying and clustering the goals and their interactions. Waage et al. (2015) have proposed a framework whereby the SDGs are grouped into three domains and represented by three nested circles: well-being (comprising SDGs 1, 3, 4, 5, 10, 16) in the inner circle, infrastructure (comprising SDGs 2, 6, 7, 8, 9, 11, 12) in the middle circle and environment (comprising SDGs 13, 14, 15) in the outer circle. The potential interactions among SDGs are closely related to their position in the framework. The authors argue that there is potential for synergies among the goals in the inner level as they focus on different aspects of human well-being. Similarly, the outer-level environmental goals are interrelated and potentially synergistic. The infrastructure goals in the middle contribute to the achievement of the well-being goals, but compete for limited environmental resources such as land for agriculture, forestry or energy. The trade-offs between the inner- and outer-level goals need to be addressed within the infrastructure goals, which requires effective governance of these goals (Waage et al. 2015).

Different approaches have been proposed to address the interlinkages among the goals and targets. In this connection the nexus approach has gained renewed attention. For instance, the UN Prototype Global Sustainable Development Report (UN 2014: 21) advocates for the climate–land–energy–water–development nexus as a 'pragmatic approach to integrated assessment for selected clusters of strongly interlinked issues'. In general, the nexus approach aims at increasing policy coherence across sectors. The water–energy–food nexus has received special attention as a research agenda and development paradigm (Biggs et al. 2015, Bizikova et al. 2013, FAO 2014, Hoff 2011, Leck et al. 2015, Weitz et al. 2016). The downside of the nexus approach is that it specifically focuses on the interactions among a chosen, limited number of SDGs and targets, and thus fails to acknowledge possible important linkages to other SDGs that could be crucial for the specific SDGs under study.

As an attempt to develop a more comprehensive approach, Nilsson et al. (2016) present a framework consisting of a typology of interactions, where the interactions and relationships among SDG targets are assigned scores ranging from +3 (indivisible), +2 (reinforcing), +1 (enabling) and 0 (neutral) to –1 (constraining), –2 (counteracting) and –3 (cancelling). This framework is suggested as an approach to systematically assess the target-level interactions. It recognises that the scoring is context specific and is affected by timescale, governance arrangements, technology and geography.

As these analyses demonstrate, the SDGs and related targets form a complex, interconnected set of different kinds of goals. However, these interconnections are neither systematically recognised nor addressed in the SDG agenda: 'A tendency to ignore interlinkages among sectors and across national borders has meant that success in one area or location has all too often come at the expense of increasing problems elsewhere' (UN 2014: 21). Understanding the interactions among the targets is thus fundamental for making comprehensive progress towards the targets and ensuring that progress towards a specific target is not impeding the achievement of other targets (Griggs et al. 2017).

Forests and SDGs

Human welfare is ultimately based on global natural resources and biodiversity; the sustainable use of these resources within environmental limits is the foundation for sustainable development (Holden et al. 2017). Forests cover about one-third of global land area, totalling nearly 4000 million ha (FAO 2016a). However, ecological, social and economic conditions vary greatly in different parts of the world, among countries and even within countries, leading to great variations in forest–human interactions, the importance and potential contributions of forests for achieving the SDGs, and the potential and likely impacts of policies and measures for progressing towards the SDGs.

Brief Overview of the World's Forests

The global forest area is made up of 3695 million ha of natural forest and 291 million ha of planted forest.[1] Natural forest area continues to decline and planted forest area to increase. From 2010 to 2015, the natural forest area worldwide decreased by 6.5 million ha per year, while the reported planted area increased by 3.3 million ha per year. Most planted forests are located in Asia, with 129 million ha, followed by Europe, with 83 million ha (FAO 2016a).

Most of the world's forests are located in tropical countries (44 per cent), followed by temperate (26 per cent), boreal (22 per cent) and subtropical countries (8 per cent). Forest loss has also been concentrated in tropical countries, particularly in South America and Africa: from 2010 to 2015, tropical forest area declined by 5.5 million ha per year. In general, forest area has declined in Central America, South America, South and Southeast Asia and in Africa, while increasing in Europe, North America, the Caribbean, East Asia and Western-Central Asia (Keenan et al. 2015).

The pressures on forests are related to population growth through the increasing demand for forest-based products and services and through increasing competition for the use of land currently forested. The world's population has increased concurrently with global forest loss, leading to declining per capita forest area. While on average it declined from 0.8 ha to 0.6 ha per capita from 1990 to 2015, during this period the forest area per capita in the tropics nearly halved and declined by more than 35 per cent in the subtropics (FAO 2016a, Keenan et al. 2015).

[1] FAO (2012) definition of forest: Land spanning more than 0.5 hectares with trees higher than 5 metres and a canopy cover of more than 10 per cent, or trees able to reach these thresholds in situ.

Forest ownership and management rights are an essential part of forest governance; they are important in shaping the ways forests are used and managed and for the distribution of related costs and benefits. Most of the world's forests (76 per cent) are publicly owned, and about 20 per cent are privately owned; for the rest, information is not available (FAO 2016a). Public ownership is highest in Western and Central Africa (99 per cent), Western and Central Asia (98 per cent) and South and Southeast Asia (90 per cent).

The share of privately owned forests is highest in East Asia and Oceania (42 per cent) and North America (33 per cent) (FAO 2016a). The category of privately owned forests includes forests legally held by individuals, communities and firms. Individual, smallholder and family forest ownership is dominant in many European countries; it is increasing in countries with formerly centrally planned economies due to privatisation and restitution policies (Forest Europe 2015). Forest tenure reforms in China and Vietnam have led to forestland being allocated, leased or contracted to individuals and families, increasing the forest area under some degree of private management (Hou et al. 2017, Yasmi et al. 2017). In the United States, 58 per cent of forests are under private ownership, including private corporate ownership, which covers 19 per cent of forests.

According to the Rights and Resources Initiative data from 58 countries, covering 92 per cent of global forest area, private individuals and firms own 11 per cent and Indigenous and local communities 12 per cent of the total forest area in the analysed countries (RRI 2018). The areas owned by Indigenous and local communities totalled 447 million ha in 2017. Furthermore, Indigenous and local communities hold legally designated rights to 80.5 million ha of the publicly owned forests, meaning that 'national law recognises Indigenous Peoples' and local communities' rights to access and withdrawal, as well as to participate in the management of forests or to exclude outsiders' (RRI 2018: 8). Taken together, most forest area either legally owned by or designated for Indigenous and local communities is located in Latin America, followed by Asia and then Africa (RRI 2018).

Governments maintain legal and administrative authority over publicly owned forest areas; a large part of this is used and managed by Indigenous and local communities on the basis of customary, community-based tenure systems without formal government recognition. This, combined with the fact that large areas of government-administered forests have been granted to companies and investors under concession and license agreements without acknowledging the existing customary rights, has led to conflicts and disputes over forestland (RRI 2018). This situation has had serious negative livelihood implications for peoples residing in and around forests.

Forests' Contributions to SDGs

Forests provide ecosystem services that are crucial for human welfare. The contributions of forests to achieving the SDGs were explored before the SDGs were formally adopted and have since been further analysed and discussed (Brack 2014, FAO 2016b, 2018; Grazer and Keeton 2017, Sunderland et al. 2013, Vira et al. 2015). Forests can be directly or indirectly linked to each of the SDGs. Forests provide plant- and animal-based products that are important as foods and medicines, contributing directly to ending hunger (SDG 2) and ensuring health and well-being (SDG 3). Forestry employment can contribute to providing decent work (SDG 8) and forest-based incomes can contribute to ending poverty (SDG 1), and these incomes can be used to buy food, which further contributes to food security (SDG 2). Forests also provide clean water and influence hydrological cycles and downstream water supply, contributing to water and sanitation (SDG 6). Forest biomass can contribute to reducing global dependence on fossil fuels for energy (SDG 7), and forests can contribute to responsible consumption and production (SDG 12) by providing renewable materials to substitute non-renewable ones. Forests can also support industrial development and innovation (SDG 9). Some forest communities are among the most equitable globally, relating to gender (SDG 5) and equality (SDG 10), while participatory forest management approaches contribute to inclusive societies and building inclusive institutions (SDG 16). Forests are crucial for carbon storage and for regulating climate (SDG 13). Forests also provide supporting services, such as nutrient cycling and crop pollination, that are fundamental for sustainable agricultural production. Furthermore, mangroves (SDG 14) provide coastal protection benefits, strengthening coastal community resilience to climate-related hazards. Forest-related cultural ecosystem services include recreational, spiritual, religious and other non-material benefits. These benefits are important for rural and urban populations and contribute to learning and physical and mental well-being (SDG 4 and SDG 3) and more resilient and sustainable cities (SDG 11). Furthermore, most of the world's terrestrial biodiversity is found in forests (SDG 15).

Forest ecosystem services contribute to human welfare at different scales. At a global scale, all people benefit from the climate change mitigation and crop pollination services of forests. A large share of the global population also benefits from forest-based products such as wooden furniture or timber for housing. In addition, it is estimated that 350 million rural inhabitants are highly dependent on forests for food security, livelihoods and energy, while an estimated 60 million Indigenous peoples are totally dependent on forests for their subsistence (World Bank 2008).

Impacts of SDGs on Forests and Livelihoods

As already noted, despite the profound importance of forests for human well-being and their important role in reaching the SDGs, forests are only mentioned in two: in single targets under SDGs 6 (Clean Water and Sanitation) and 15 (Life on Land). Due to the interrelated nature of the SDGs and targets previously discussed, the implementation of the SDG agenda will inevitably influence the possibilities to achieve these forest-specific targets. In addition, SDG implementation will likely affect the capacity and potential of forests to provide the important ecosystem services described and consequently sustain forests' contributions to achieving the SDGs.

The implementation of the SDGs is principally in the hands of national governments: 'Targets are defined as aspirational and global, with each Government setting its own national targets guided by the global level of ambition but taking into account national circumstances. Each Government will also decide how these aspirational and global targets should be incorporated into national planning processes, policies and strategies' (UN 2015: 13). From the viewpoint of international law, the SDGs are considered as norms at the 'softest end of the soft law–hard law continuum' (Persson et al. 2016: 60). SDG 17 focuses specifically on the means of implementation, concentrating on finance, technology, capacity-building, trade and systemic issues, including policy and institutional coherence, multistakeholder partnerships and data, monitoring and accountability. In addition, specific targets under each SDG relate to the implementation of the given SDG. Yet many targets are rather vague, aspirational-outcome targets that do not specify the ways or conduct by which they should be achieved: different pathways can be taken (Persson et al. 2016). Moreover, the implementation targets do not address the interdependencies and interlinkages among the goals and targets (Stafford-Smith et al. 2017). Beyond the key role national governments play in Agenda 2030, it is important to recognise the emerging importance of regional and local governments, communities and private-sector entities in SDG implementation.

The implementation of the SDGs varies according to economic prosperity, political stability, social cohesion and national circumstances, such as geographic features, natural resource base, level of technological development, and policy, institutional and social frameworks. National circumstances and development priorities will influence how the SDGs are prioritised and how they are included in national policies and strategies. In this connection, the extent and condition of forest resources and the role of forests in industrial development and for livelihoods, as well as social and cultural perspectives and voices pertaining to forest use and conservation, are important factors in shaping the policies and strategies that relate to forests and the relative importance given to forests in relation to other land uses.

Understanding the potential impacts of SDGs on forests, forest-related livelihoods and forest-based options to generate progress towards achieving the SDGs, as well as the related trade-offs and synergies, is crucial to the efforts undertaken to reach these goals. It is especially important for reducing potential negative impacts and to leverage opportunities to create synergies that will ultimately determine whether comprehensive progress towards the SDGs will be accomplished.

Little attention, however, has yet focused on possible and likely impacts that efforts undertaken by different sectors to advance towards the 17 SDGs will have on forests, forest ecosystem services, forest-related livelihoods and human well-being, or on how these impacts, in turn, will contribute to or undermine the contributions of forests in achieving the SDGs. Efforts to achieve the SDGs may result in an emphasis on forest management and production or on forest protection, or a combination of both. Where the emphasis lies will affect the ecosystem services provided by forests and the associated benefits accruing to different segments of society. In this light, efforts to achieve some of the SDGs will likely drive additional land-use change and deforestation. Developments in sectors such as agriculture, transport, mining and energy may have crucial implications for forest-related development. Policies and actions to improve governance and build effective institutions for natural resource management may affect the conditions shaping forest resource use, benefit-sharing and sustainable production, while also affecting gender concerns and wider issues of social equity and equality.

Impacts of SDG implementation can vary according to geographical scale. National policies favouring more gender-equitable land tenure, for instance, can wind up being ignored at the local level. Progress on a particular SDG in one location can lead to harmful impacts in other locations. For example, a study on seven developing countries that have experienced forest transition – a shift from net deforestation to net increase in forest cover – found that in most cases reforestation was accompanied with deforestation in other countries through trade in timber and agricultural products (Meyfroidt et al. 2010).

The impacts can also vary according to the time horizon. Intensifying the use of forest products (e.g. collection of non-timber forest products) can support livelihoods and increase incomes in the short term, but in the long term may lead to depletion of the resource base and reduced availability of these products, resulting in declining incomes.

Assessing the impacts of the SDGs and related policies on forests and people is not a trivial undertaking. It requires a thorough look into the SDGs and the inherent trade-offs and synergies among them, the contextual factors that shape how the SDGs are prioritised and implemented, and the consequent impacts on forests and people.

Chapters 1 to 17 focus on the potential impacts of the implementation of the SDGs on forests and forest-related livelihoods and economies, taking into account the considerations discussed. Each chapter is dedicated to the analysis of one of the 17 SDGs. The analyses focus especially on people who live in or near forests and who depend on forests for their material, social, cultural and emotional well-being. In the following chapters these impacts are generally referred to as impacts on 'forests and people'. Based on existing evidence, these chapters identify the most important contextual conditions that guide or determine how a specific SDG is prioritised or pursued and discuss the possible impacts of its implementation on forests and the goods and services forests provide in different contexts. They also consider the linkages among the SDGs, identifying important opportunities for synergies and drawing attention to possible or unavoidable trade-offs.

Chapter 18 synthesises the findings from Chapters 1 to 17. Chapter 19 concludes with broad conclusions on a few key lessons learnt, with a view to providing guidance for the future co-evolution of people and forests in a changing world.

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Chapter 1 SDG 1: No Poverty – Impacts of Social Protection, Tenure Security and Building Resilience on Forests

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Key Points

- The relationship between poverty reduction and forests varies across regions, decades, stage in the forest transition and degree of market access.
- Achieving the specific targets of SDG 1, such as social protection and secure land tenure, can have positive effects on forests, especially if benefits are conditional on forest conservation.
- The overall effect on forests of pursuing SDG 1 depends on which poverty reduction policies are pursued; for instance, allocating forest land to poor farmers has very different implications for land use than targeting payments for ecosystem services to poor farmers.
- Exposure and vulnerability to environmental shocks in coastal areas and near steep slopes can be mitigated by forests – if the poor retain access to forest products and ecosystem services.

1.1 Introduction

SDG 1 seeks to 'end poverty in all its forms everywhere'. Poverty is increasingly recognised as a multidimensional concept. For example, the UN Multidimensional Poverty Index (used in the UN Human Development Reports) considers multiple deprivations that people might experience in the domains of health, education and standard of living (UNDP 2018). The World Bank's (2001) 'attacking poverty' framework is another widely used multidimensional approach to poverty (see Lawlor et al. 2013 for an application to forests). Building on the work of Sen (1999), this framework focuses on how opportunities, security and empowerment interact to promote human well-being. While quantifying all of these dimensions remains a challenge, the World Bank (2018) reports multidimensional indices of poverty that encompass multiple SDGs through measures of educational achievement (SDG 4),

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access to drinking water and sanitation (SDG 6) and access to electricity (SDG 7), as well as considering whether income is sufficient to satisfy basic needs (SDG 1). Thus, the SDGs taken together embody the multidimensional approach to human development and poverty reduction.

Target 1.1 of SDG 1 focuses squarely on consumption poverty by calling for eradication of extreme poverty as defined by a monetary threshold (Table 1.1). However, SDG 1 also engages with other dimensions of poverty, recognising ‘poverty in all its dimensions according to national definitions’ (Target 1.2). Targets 1.3–1.5 specify how to reduce poverty: by ensuring that the poor are covered by social protection systems; by securing the rights of the poor to economic resources, access to basic services and property ownership; and by building their resilience to economic, social and environmental shocks.

In this chapter, we focus on the three targets under SDG 1 that specify strategies for reducing poverty, allowing us to draw on the existing evidence base about how those strategies affect forests. Specifically, we examine the potential consequences for forests of (1) implementing social protection systems that cover the poor and vulnerable (Target 1.3), (2) increasing the land tenure

Table 1.1 SDG 1 Targets

1.1	Eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day
1.2	Reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions
1.3	Implement nationally appropriate social protection systems and measures for all, including floors, and achieve substantial coverage of the poor and the vulnerable
1.4	Ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance
1.5	Build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters
1.A	Ensure significant mobilization of resources from a variety of sources, including through enhanced development cooperation
1.B	Create sound policy frameworks at the national, regional and international levels, based on pro-poor and gender-sensitive development strategies

Source: Adapted from https://sustainabledevelopment.un.org/sdg1 security of the poor (Target 1.4) and (3) reducing the vulnerability of the poor and building their resilience to shocks (Target 1.5). Recognising that more than 75 per cent of the global poor live in rural areas (World Bank 2016) and that poverty and forest cover are coincident in many parts of the world (Sunderlin et al. 2008), our analysis of these three targets focuses on the rural poor and their relationships with forests.[1] These relationships are moderated by market access – e.g. through its effect on land rents and therefore incentives for deforestation (Angelsen 2010, Pfaff et al. 2007) – as well as through its effects on employment opportunities, credit availability and insurance against environmental shocks.

We set the stage for our analysis of these relationships by examining the correlation between forests and extreme poverty (defined by a global income/consumption standard) at the cross-country level (as relevant to Target 1.1) and the role of forests in national poverty reduction strategies (as relevant to Target 1.2). We conclude the chapter by relating our analysis to the means of implementation for SDG 1, suggesting that the implications for forests depend on whether national policymakers recognise the role of forests in rural livelihoods.

1.2 Relationship between Forests and Poverty

The relationship between poverty and forests is the subject of a large body of literature. Household-level studies have demonstrated how forests support rural livelihoods – as a source of subsistence, a safety net and a potential pathway out of poverty (Cheng et al. 2017) – through ecosystem products (Angelsen et al. 2014, Shackleton et al. 2011) and services (Daw et al. 2011). In the other direction, poverty or income level is often included as a potential driver of deforestation in models at both the micro- and macro-scale (Atmadja and Sills 2015, Busch and Ferretti-Gallon 2017). Atmadja and Sills (2015) conclude that evidence on the relationship is mixed, with studies of Latin America more likely to find an environmental Kuznet's curve (Choumert et al. 2013) or win–lose relationship (i.e. correlated poverty reduction and deforestation). The environmental Kuznet's curve is one possible explanation for the 'forest transition', or the widely observed empirical regularity that forest cover declines until a turning point or transition, after which gains in forest cover due to natural regeneration and plantations overtake losses due to deforestation (Angelsen and Rudel 2013). The mechanisms underlying this common path vary across regions and reflect the mutual effects forests and economic development have on each other (Rudel et al. 2005). The effect on

[1] Due to greater purchasing power, a poor urban family may have a greater impact on forests than a rural family living in extreme poverty. However, given that the goal is to eradicate poverty, we choose to focus on the more numerous rural poor.

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forests of external aid to reduce poverty is likely to vary depending on the stage of the forest transition, possibly accelerating forest loss in early stages and encouraging the transition to forest recovery in later stages.

To provide empirical context we plot national poverty rates against forest cover across three decades and four regions. While acknowledging that trends and patterns in poverty vary depending on the dimensions considered and the thresholds applied (World Bank 2018), we consider the percentage of the population living in extreme poverty, as measured by the USD 1.90 per day threshold established by the World Bank in 2015 and consistent with SDG Target 1.1.[2] As shown in Figure 1.1, in East Asia and Latin America an

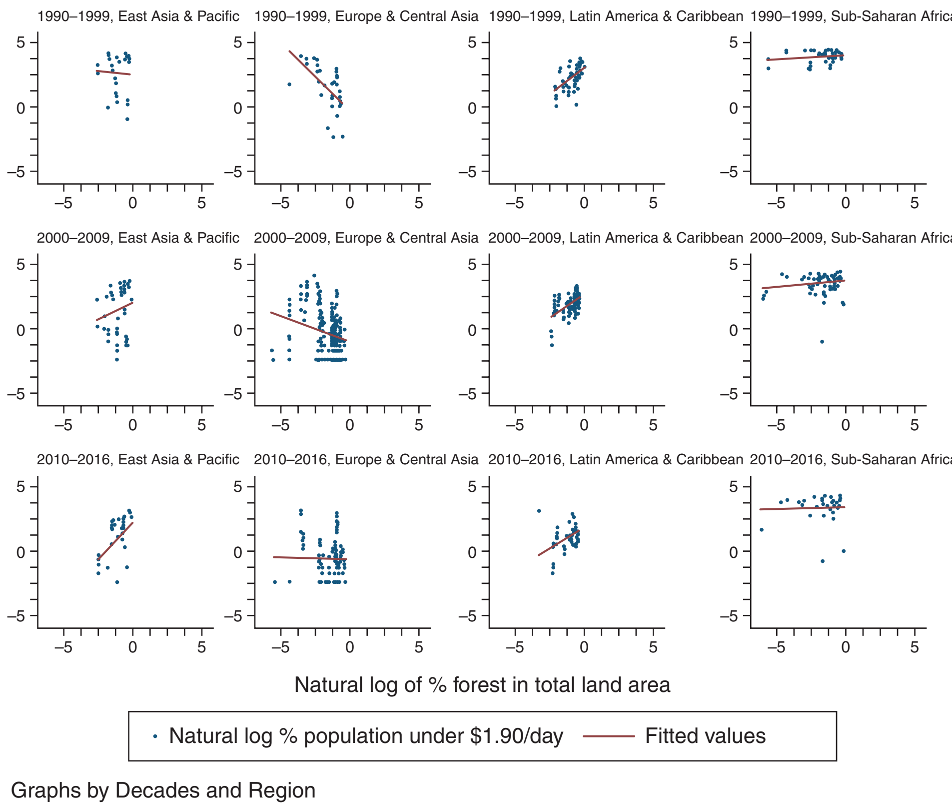

Figure 1.1 Relationship between forest cover and poverty, by decades and regions. Data source: World Bank.[3]

[2] See Ferreira et al. (2015) for an explanation of why, despite using different numbers, the SDG USD 1.25 per day and World Bank USD 1.90 per day poverty thresholds are consistent.

[3] Total land size by country: https://data.worldbank.org/indicator/AG.LND.TOTL.K2 Total population by country and year: https://data.worldbank.org/indicator/SP.POP.TOTL Poverty headcount earning less than USD 1.90/day (percentage of total population) by country and year (not all years are available for each country): https://data.worldbank.org/indicator/SI.POV.DDAY Forest area (sq km): https://data.worldbank.org/indicator/AG.LND.FRST.K2

inverse relationship between poverty and forests emerges over time: by the most recent decade, lower poverty rates are clearly associated with higher forest cover. In Europe and Central Asia, higher poverty rates are associated with a higher percentage of forest cover in earlier decades, with no apparent relationship in the most recent decade. In Africa, there is no relationship evident in any decade. While these plots only show correlations, they suggest that the effects on forests of pursuing SDG 1 are likely to vary across regions and time, and that there may not be any systematic relationship in the region with the highest levels of extreme poverty (sub-Saharan Africa). It could be that there are nonlinearities (e.g. kinks, reversed relationships) across the income continuum that are poorly characterised by this simple analysis. For example, those living far above the USD 1.90 per day threshold may have a very different relationship with forests than those living far below it.

To provide policy context we consider the role of forests in Poverty Reduction Strategy Papers (PRSPs). The International Monetary Fund (IMF) considers these policy documents to preserve national ownership of poverty reduction strategies and provide flexibility reflecting the particular circumstances of countries supported through their Poverty Reduction and Growth Trust (IMF 2018). PRSPs reveal whether national governments consider forests and poverty reduction to be 'friends' (i.e. synergistic relationship), 'foes' (i.e. competitive relationship) or completely independent of one another (i.e. no relationship). Pursuit of SDG 1 is likely to lead to better outcomes for forests in countries where conservation and sustainable management of forests are considered synergistic with poverty reduction. Of the 12 low-income or low-middle-income countries with the highest forest cover per capita, 9 have PRSPs. Table 1.2 summarises these, noting both specific references to forests and the overall stance towards forests, revealing policy priorities and political realities.

The PRSPs reflect different national positions on the role of forest conservation and sustainable management in poverty reduction, which we categorise as: (1) no role – forest protection is a responsibility unrelated to poverty reduction; (2) implicit – environmental protection (including forest protection) is a cross-cutting theme but few explicit actions related to forests are included; (3) supporting – forest protection and sustainable management is expected to contribute to poverty reduction, e.g. through ecosystem services; and (4) major – better governance of forests could be a key source of economic growth and thus critical for poverty reduction. Many PRSPs suggest that forests play an implicit or supporting role in poverty reduction. In contrast, the PRSPs consistently identify transportation infrastructure and agricultural development as important means of poverty reduction, both of which are tied to deforestation. This reflects conflicting policy priorities in some countries, while in other countries (especially those with relatively abundant forests and

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Table 1.2 Forests in the PRSPs in countries with high forest cover

Country, Year of publication[a]	Forest (ha) per capita	Reference to forests	Likely impact on forest	Role of forest	Poverty indicator used
Republic of Bolivia (2001)	5.3	Increase rural employment through better roads, irrigation and electrification infrastructures, and access to land for agriculture and settlement; increase export competitiveness of agricultural products; increase non-agricultural income, such as rural tourism; actions to reduce levels of risk and vulnerability to water scarcity and natural disasters include reforestation and environmental conservation through integrated, sustainable natural resource management.	Negative	Implicit – Not a major economic sector; mainly to ensure rural resilience	Income to purchase a basket of goods and services
Rep. of Congo (2012)	5.0	Improve forestry and wood industry through specialised schools and industrialisation, improved forest management, and improved utilisation of non-wood forest products; forest conservation through participatory approaches and strategies such as REDD+, PES and forest certification.	Positive	Major – Forestry a source of national wealth (5.6% of GDP, 10% of foreign trade, 16 000 jobs)	Multidimensional (employment, access to services, quality of governance, income)

Mongolia (2003)	4.6	Forests need to be protected and expanded, mainly to provide ecosystem services to support other sectors; notably, livestock forests are acknowledged for their potential to generate jobs for the poor, e.g. through tree planting and forest utilisation.	No impact	Implicit – Mainly to support livestock, avoid desertification and provide informal jobs	Income
Royal Government of Bhutan (2004)	3.6	The 2020 target includes maintaining 60% of Bhutan's land area under forest coverage in perpetuity (from 72% forest cover in 2004), increase access to roads, increase income and employment; 'preserving and promoting cultural heritage and environment conservation' is one of the plan's 5 main objectives.	Negative	Supporting – Strong baseline environmental policies and environmental conservation is 1 of 5 pillars of long-term economic development	Household expenditure
Republic of Zambia (2006)	3.3	The overall strategy of broad-based wealth and job creation through economic infrastructure and human development focuses on rural development and agriculture (irrigation, food security, roads, livestock, microfinance); forests are a part of the natural resources sectoral plan as the main provider of household energy, with untapped potential for generating income from wood industries and tourism.	Negative	Implicit – Forests contribute 3.7% of GDP via charcoal and firewood production	Income level; forest loss/ degradation an indicator and result of poverty

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Table 1.2 (cont.)

Country, Year of publication[a]	Forest (ha) per capita	Reference to forests	Likely impact on forest	Role of forest	Poverty indicator used
Lao PDR (2006)	2.8	Effective poverty reduction is achieved through increased agricultural productivity and better access to markets via better roads.; sustainable and participatory forest management mentioned as a subcomponent in 1 of 5 strategies for reducing rural poverty; poverty reduction can reduce environmental degradation, and economic growth can encourage environmental conservation if accompanied by education and training and development of scientific and technological capacities.	Negative	No role – Co-location: most poverty found in remote highlands, where forests are located	Includes lack of agricultural land
Dem. Rep. of Congo (2006)	2.2	As 1 of 6 sectors with growth potential, forestry is targeted with actions to improve forest management and institutions; 1 pillar of poverty reduction is improved governance, notably in forestry and mining sectors.	Positive	Major – Better governance needed to tap into this income	Peace, access to public services and productive capital, governance and meeting basic needs

Rep. of Guinea-Bissau (2011)	1.3	Environmental management and protection is a subcomponent of promoting inclusive, sustainable economic development, which is the last of 6 core areas in poverty reduction; the focus is on building capacity to address natural disasters including forest degradation; strategy for targeting the very poor focuses on revitalising agriculture, notably cashew and rice production.	Negative	Supporting – Small part of 1 of 4 core areas for poverty reduction related to sustainable economic development	Monetary and non-monetary (housing, sanitation, safe drinking water, consumer durables)
United Rep. of Tanzania (2010)	1.0	Alleviate income poverty by focusing on identified growth areas in agriculture, tourism, manufacturing and mining, and cross-sectoral drivers (e.g. roads, energy, water); forestry and forest products are one of 7 agricultural sub-sectors targeted for growth by 2015, as part of reducing income poverty; forest is a factor of production that needs to be used more efficiently for productivity gains and value addition.	Negative	Supporting – via tourism, rural job creation	Income, well-being, and good governance

[a] Not included due to lack of PRSP: Solomon Islands, Vanuatu and Zimbabwe

relatively low income) it reflects the view that forest resources are a means of economic development (Maini 2003). In sum, while the PRSPs suggest a wide range of approaches to forest policy, their almost universal call to alleviate rural poverty through agricultural and infrastructural development is likely to result in forest loss.

1.3 Social Protection

Target 1.3 calls for implementing nationally appropriate social protection systems and measures for all, including floors, and achieving substantial coverage of the poor and the vulnerable. Tirivayi et al. (2017) point out that forest-dependent peoples are typically poor and vulnerable, and therefore in particular need of social protection. Social protection systems, including programmes such as unemployment insurance and pensions for the elderly, are designed to help people cope with shocks and meet their basic needs. Over the past 20 years, cash transfer programmes have become a prominent component of social protection systems throughout the developing world (Handa et al. 2017, Hulme et al. 2012).

In addition to protecting recipients' human capital, cash transfer programmes can also affect households' economic production. The intent of most cash transfer programmes is to break the intergenerational transmission of poverty to children and build their human capital by increasing their consumption of food, health services and education (Baird et al. 2014, Bastagli et al. 2016, Manley et al. 2013). But cash transfers can also affect the economic production of households, especially family farmers who are otherwise cash constrained. These changes in households' production could impact forest resources both positively and negatively. For example, infusions of cash could increase pressure on forests if they enable households to expand their agricultural operations. Or, transfers could decrease pressure on local ecosystems if they enable migration to cities or the establishment of non-farm businesses.

There are multiple other pathways through which cash transfers could affect forests. A regular cash flow could make households less vulnerable to income shocks and thus less likely to rely on forests as 'natural insurance' (Pattanayak and Sills 2001) through harvesting and selling forest products. Cash transfers can enable increased consumption, with significant effects on deforestation locally or through markets for products that drive deforestation, such as beef, milk, soy and palm oil. Tracking the associated supply responses across space and time is challenging, making it difficult to quantify the full causal impacts of social protection systems on forests.

Many studies examine the effects of cash transfers on agricultural productivity. They typically find that in addition to building children's human capital, cash transfers help households increase their agricultural output (Tirivayi et al. 2016). This empirical regularity is likely associated with the other consistent finding that transfers increase purchases of agricultural inputs, such as chemical fertiliser. This could mean transfers are promoting agricultural intensification (increases in agricultural output without corresponding increases in hectares farmed), although increases in the area farmed (i.e. extensive agriculture) are also possible. Among these studies, there are a few that directly consider impacts on land use, including forests.

Our search of the literature uncovered ten studies of how cash transfers to the rural poor affect natural resources, including one study of remittances rather than government transfers (López-Feldman and Chávez 2017). Table 1.3 summarises the nine studies that estimate impacts on land use (the tenth study – Gilliland et al. 2018 – focuses on fisheries). All of the study sites are in the early stage of the forest transition, i.e. forest loss is ongoing. The recipients of the cash transfers generally have limited market access. Two of the studies (Alix-Garcia et al. 2013, Ferraro and Simorangkir 2018) combine household survey data with geospatial data to identify impacts on forests; the remaining seven report impacts on land used for farming. Two of the studies (Lawlor 2015, López-Feldman and Chávez 2017,) also examine impacts on forest product harvesting. Finally, two of the studies (Alix-Garcia et al. 2013, Lawlor 2015) explore how variations in market access affect transfers' impacts on natural resources. Overall, this literature finds that both conditional and unconditional cash transfer programmes have significant impacts on consumption and production in the short run (e.g. after only two years of payments).

Specifically, there is evidence that cash transfers might be encouraging land intensification in Lesotho (Daidone et al. 2014) and among farmers with larger landholdings in Mexico (Gertler et al. 2012, Todd et al. 2010). Transfers are promoting agricultural expansion among smallholders and those receiving agricultural subsidies in Mexico (Todd et al. 2010), Malawi (Asfaw et al. 2016b) and Zambia (Lawlor 2015). Cash is enabling the previously landless to farm in Mexico (Gertler et al. 2012, Todd et al. 2010) and increasing the number of farmers in Ethiopia (Asfaw et al. 2016a) and in Zambia among households living more than 10 km from markets (Lawlor 2015). In Ethiopia, transfers are reducing the likelihood of leaving land fallow (Asfaw et al. 2016a). The only evidence that cash transfers can decrease the likelihood of participating in agriculture comes from the López-Feldman and Chávez (2017) study of remittances in Mexico. However, their sample

Table 1.3 Studies evaluating the effect of cash transfers on land use

Authors (year)	Country, programme	Type of income support*	Study design	Impacts of cash transfers on …	
				Land use	Non-farm business and wage labour
Todd et al. (2010)	Mexico, *Oportunidades*	CCT for extremely poor households with children	Treatment-comparison with randomised data and matching weights	– Increases likelihood of farming land among previously landless – Increases per capita area farmed by smallholders; no change for large landholders – Increases in area farmed, largest for those receiving agricultural subsidies	Not reported
Gertler et al. (2012)	Mexico, *Oportunidades*	CCT for extremely poor households with children	Randomised treatment – control	– Increases likelihood of farming land among previously landless – No impact on land area used among landed farmers	– Increases likelihood of owning non-farm business
Alix-Garcia et al. (2013)	Mexico, *Oportunidades*	CCT for extremely poor households with children	Instrumental variable	– Increases deforestation due to increased consumption of beef and milk – Impacts appear larger in isolated communities	Not reported
Daidone et al. (2014)	Lesotho, Child Grant Program	UCT for poor households with children	Randomised treatment – control	– No impact on the probability of growing crops or area farmed	– Reduces non-farm businesses for labour-constrained households – Reduces participation in wage labour

Asfaw et al. (2016a)	Ethiopia, Tigray Social Cash Transfer Pilot Programme	UCT for extremely poor, labour-constrained households	Matched treatment – comparison	– Increases probability of growing crops – Decreases likelihood of leaving land fallow	– Reduces non-farm businesses for female-headed households – Reduces participation in wage labour
Asfaw et al. (2016b)	Malawi, Social Cash Transfer Program	UCT for extremely poor, labour-constrained households	Randomised treatment – control	– Increases area farmed – Increases adoption of sustainable farming practices	– Reduces non-farm businesses for labour-constrained and female-headed households – Reduces charcoal/ firewood businesses and increases petty trade enterprises – Increases number of days adult males spend earning wage income
López-Feldman and Chávez (2017)	Mexico	Remittances	Instrumental variable	– Decreases likelihood of participating in agriculture or natural resource extraction as well as reliance on environmental income	– Increases likelihood of earning wage income

Table 1.3 (cont.)

Authors (year)	Country, programme	Type of income support*	Study design	Impacts of cash transfers on …	
				Land use	Non-farm business and wage labour
Ferraro and Simorangkir (2018)	Indonesia, Program Keluarga Harapan	CCT for extremely poor households with children	Matched treatment-comparison	– Reduces village forest loss	Not reported
Lawlor (2015)	Zambia, Child Grant Programme	UCT for households with a child under age 5	Randomised treatment – control	– No impacts on fuelwood or bushmeat Close to markets (< 10 km) – increases use of charcoal – no impact on decision to farm – increases area farmed Far from markets (> 10 km) – no impact on charcoal use – increases likelihood of farming – increases area farmed	– Increases likelihood of owning non-farm business

*CCT: Conditional Cash Transfer

UCT: Unconditional Cash Transfer

excludes the country's smallest villages, with perhaps the most limited market access. Across the studies there is no evidence that cash transfers promote afforestation/reforestation.

In addition to agricultural impacts, two studies estimate impacts on households' natural resource use. In Mexico, remittances decreased harvesting of natural resources (firewood, timber and wild fruits, plants and meat) as well as reliance on environmental income (López-Feldman and Chávez 2017), supporting the hypothesis that transfers can replace natural insurance. However, in Zambia, cash transfers had no impact on consumption of bushmeat or fuelwood, and for households living within 10 km of markets, transfers increased the likelihood of using charcoal by 10 percentage points (Lawlor 2015). This is especially notable because charcoal is the principal driver of forest loss in Zambia (Day et al. 2014) and many other African countries, highlighting the importance of coupling poverty reduction programmes with clean energy initiatives (see Chapter 7).

Some of the studies reviewed also estimate impacts on livelihood strategies beyond farming and natural resource use. For example, in Mexico transfers increased the number of households owning small businesses by 67 per cent (Gertler et al. 2012), and remittances increased the likelihood of earning wage income by 14 percentage points (López-Feldman and Chávez 2017). In Zambia, transfers promoted diversification into non-farm businesses, with much larger impacts on those living close to markets (increased likelihood by 23 percentage points) than those living far from markets (increased likelihood by 11 percentage points) (Lawlor 2015). The magnitude of these impacts on non-farm businesses is quite large, especially considering these impacts are estimated after only two years of cash transfers. Taken together, these results provide evidence that cash transfers can help households diversify livelihood strategies, and may decrease pressure on forests over the long run by decreasing reliance on agriculture for income.

The two studies that harness geospatial data to identify the impacts of cash transfers on forests are most relevant to the question of how reducing poverty will impact forests because they capture not only how beneficiary households respond, but also spillovers to other households. Cash transfers could have significant multiplier effects, raising non-beneficiaries' consumption and production while avoiding inflation (Handa et al. 2017, 2018). This could have implications for land use, for instance, if beneficiaries' increased demand for food is met by increased food production by their neighbours or neighbouring communities. However, the two studies provide contradictory results. Alix-Garcia et al. (2013) find that transfers increased deforestation in Mexico, whereas Ferraro and Simorangkir (2018) find that cash transfers decreased deforestation in Indonesia. Both studies examine impacts after five years of payments. In Mexico, cash transfers increased deforestation rates by 15–33 per cent. The authors investigate how impacts vary according to market access and observe the largest impacts in isolated communities, which they conclude is because better market access diffuses the supply response across other communities. In Indonesia, on the other hand, transfers reduced village forest loss by 20 per cent (3.63 ha). The authors find some heterogeneity of impacts across forest governance institutions, with the largest reductions in forest loss in community forests, followed by concessions and protected areas. This raises the question of whether the cash transfers influence collective action, as well as household livelihood strategies. Further research is needed to understand the causal mechanisms.

Taken together, what can we say about the potential impact on forests of expanding the coverage of social protection systems? Clearly, the impacts of cash transfers vary by region due to differences in access to markets for land, labour, inputs and outputs, as well as differences in forest clearance costs and land tenure. The Indonesia study is the only one that finds clear positive impacts on forests. The remaining studies suggest that in the short run, rural households invest part of the transfers in their farms and that this results in the expansion of farmed area. Furthermore, households increase their food consumption, which elicits a supply response that increases pressure on forests. In the long run, some households living close to markets may be able to shift out of agriculture to non-farm businesses or wage labour, decreasing pressure on forests (cf. Sierra and Russman 2006). This could be encouraged by making cash transfers conditional on forest conservation, as in payments for ecosystem services (PES) (Alix-Garcia and Wolff 2014, Rodríguez et al. 2011). PES are often presented as a means to reduce both rural poverty and ecosystem degradation, although the targeting rules that maximise poverty reduction are likely to differ from the rules that maximise conservation benefits (James and Sills 2018). Both experience and field experiments have demonstrated the importance of local institutions in moderating the effects of PES, including effects on poverty (Sills and Jones 2018). The moderating effect of community tenure in the Indonesia case (Ferraro and Simorangkir 2018) suggests this may also be true of cash transfers.

1.4 Land Tenure

Target 1.4 calls for ensuring equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services. Access depends fundamentally on transportation infrastructure (SDG 9) and basic services including housing (SDG 11), water (SDG

6) and energy (SDG 7), all of which can generate demand for ecosystem products and/or services, with implications for forests. In this section we focus on ownership and control over land, in particular on the security of private and communal land tenure.

Land tenure encompasses the institutions and policies that determine how land and its resources are accessed, who can hold and use these resources, for how long and under what conditions (Robinson et al. 2014). Tenure regimes can be characterised both by *who* holds rights (an individual, a community, a private entity, the state or, in the case of open access, no one) and by the *security* of those rights (defined by degree of protection against eviction and ability to exclude others). Elbow (2014) notes that tenure security can be achieved through public recognition of customary or Indigenous rights, certificates that secure the rights to use or manage resources, or titling of community-managed land or individual property rights. This is reflected in Indicator 1.4.2, which measures both the fraction of the population with legally recognised documentation of land tenure and the fraction of the population who perceive their rights to land as secure. Land tenure security is the perception that rights will be upheld by society (Sjaastad and Bromley 2000) or the certainty 'that a person's rights to land will be recognised by others and protected in cases of specific challenges' (Land Portal 2018). Securing land tenure has long been recognised as a tool for reducing poverty and enhancing economic development since it can both encourage investment and facilitate access to credit.

The security of land tenure affects forests through several channels. First, the need to secure tenure by demonstrating investment in the land may encourage deforestation in some contexts (Alston et al. 2000) and tree planting in others (Barbier and Tesfaw 2013). In many contexts, insecure tenure creates disincentives to invest in reforestation or forest management since land users have no assurance of reaping future benefits (Chazdon et al. 2016). Additionally, when forest users perceive their rights to the resource as time-limited or insecure, they are incentivised to harvest as much of the resource as fast as possible. Numerous studies have found that insecure land tenure promotes faster timber harvesting (Dorner and Thiesenhusen 1992, Puppim de Oliveira 2008, White and Martin 2002). Where the agents of deforestation are external to the customary occupants of the land, tenure insecurity for those occupants means that they do not have clear rights or incentives to defend forests from the external agents. Finally, access to technical assistance and direct conditional incentives to conserve forest (such as REDD+) may require secure tenure (Larson et al. 2013). On the other hand, increasing land tenure security can increase deforestation if it encourages investment in profitable agricultural activities that replace forest, such as plantation crops, or sale of land to agents that plan to clear the forest (Liscow 2013). In sum, the literature reports cases of tenure security both reducing and increasing deforestation, with differences related to livelihood strategies, socio-cultural institutions, tenure type, level of inequality (in communal tenure systems) and numerous other factors.

In a recent systematic review, Robinson et al. (2014) identify 36 publications that report 118 relationships between specific forms and security of tenure and (sub)tropical deforestation. All major regions of the tropics are represented in their sample. They categorise studies based on whether tenure security has a causal relationship with positive forest outcomes (defined as slowing deforestation or maintaining/regenerating forests) or negative forest outcomes (defined as accelerating deforestation). They find that communal (but not private or customary/traditional) tenure increases the likelihood of positive forest outcomes. Tenure security is consistently associated with positive forest outcomes across all types of tenure. This contrasts with the findings of a meta-analysis of spatially explicit econometric studies of deforestation by Busch and Ferretti-Gallon (2017). Based on 27 studies that estimate the effect of tenure security (defined as land ownership, legal title or duration of occupancy), they conclude that there is no systematic relationship between tenure security and deforestation.

To update the findings of Robinson et al. (2014) and Busch and Ferretti-Gallon (2017), we searched for recent studies (published in 2014 or later) of how tenure security affects forests, focusing on private and communal tenure. Like Robinson et al. (2014), we only include studies that give some indication of the degree to which tenure rights are secure. Following Robinson et al. (2014), we define forest outcomes as either positive or negative and only include studies that give some indication of the degree to which tenure rights are secure. The results of seven recent studies are summarised in Table 1.4. All of these studies estimate the effects of circumstances or interventions that increase tenure security.

L'Roe et al. (2016) find that formalising individual land claims in the eastern Brazilian Amazon by mapping and recording them in a state-run registry decreases deforestation on medium-sized properties (100–300 ha). Registration of land claims, however, has no impact on deforestation of larger properties. Holland et al. (2017) find the titling of private lands around a reserve only reduces deforestation when accompanied by 'forest friendly' restrictions.

In Uganda, Call et al. (2017) find that households are more likely to engage in tree-planting if they have secure tenure, are educated and live in isolated communities. In China, Lin et al. (2018) find that these types of investments are more likely when households can obtain logging permits but are not affected by tenure security.

Table 1.4 Effects of securing tenure on forests across tenure type: 2014–2017 studies

	Common-Property Regime			Individual Property		
	Positive Outcome for Forests	Negative Outcome for Forests	No Impact	Positive Outcome for Forests	Negative Outcome for Forests	No Impact
Brazil			BenYishay et al. (2017)	L'Roe et al. (2016)		
China						Lin et al. (2018)
Ecuador			Buntaine et al. (2015)	Holland et al. (2017)*		
Peru	Blackman et al. (2017)					
Uganda				Call et al. (2017)		

* Holland et al. (2017) find a positive effect on forests only when tenure security is bundled with restrictions on forest clearing and subdivision of properties.

Both Buntaine et al. (2015) and BenYishay et al. (2017) find that formalising Indigenous communities' land rights in Ecuador and Brazil, respectively, has no impact on rates of forest loss. In contrast, Blackman et al. (2017) find that titling Indigenous communities' land in Peru dramatically reduced deforestation in just three years. In order to obtain titles, the Peruvian communities had to submit sustainable management plans, which Robinson et al. (2017) argue may be necessary for tenure security to have a positive effect on forests. Blackman and Veit (2018) also find that allocation of tenure rights and management by Indigenous communities reduces deforestation in Bolivia, Brazil and Colombia (but not Ecuador).

In sum, the effect of increasing land tenure security (the perception that rights to land are recognised and will be upheld) on forests is context dependent. The existing evidence base suggests that increasing tenure security rarely leads to forest loss. However, the long-term effects are relatively understudied and hence unknown. As with direct cash transfers, there are suggestions that increasing tenure security is most likely to favour forests when accompanied by incentives or conditions that explicitly require forest conservation and sustainable management (Holland et al. 2017, Robinson et al. 2017).

1.5 Ecosystem-Based Adaptation to Climate Change

Target 1.5 is 'to build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters'. Forests have long been recognised as a safety net or form of natural insurance, providing both cash income and subsistence goods to poor rural households living on the forest margin, thus reducing their vulnerability and increasing their adaptive capacity and livelihood resilience (Agrawal et al. 2013, Byron and Arnold 1999, Pattanayak and Sills 2001). Poor and vulnerable populations tend to concentrate in remote and environmentally fragile areas (Sunderlin et al. 2008, Watmough et al. 2016), and they rely disproportionately on natural resources and ecosystem services to support their livelihoods, for both subsistence and income generation (Barbier 2010, Barrett 2005). This implies they are both more exposed (more often affected) and more vulnerable (lose more when affected relative to their income or wealth) to environmental shocks (Hallegatte et al. 2016). It also implies the effects of environmental shocks are likely to be channelled through ecosystems and moderated by the health of those ecosystems. Thus, managing for improved ecosystem health may be an effective way to reduce the exposure and vulnerability of poor populations to shocks and disasters.

There is increasing scientific and policy consensus that natural ecosystems can contribute to climate change adaptation by reducing exposure to shocks (Doswald et al. 2014, Munang et al. 2013). The role of forests in mitigating climate change itself through REDD+ is discussed in Chapter 13. Forests are often credited with reducing the sensitivity of ecosystems to extreme rainfall events, thus buffering communities from floods (Chapter 6), and mangrove forests can reduce damage from storm surges in coastal areas (Das and Vincent 2009, Chapter 14). Thus, measures to reduce exposure and vulnerability could include reforestation of slopes to prevent landslides and restoration of mangrove shelterbelts to protect coastal settlements against storms (Pramova et al. 2012). These are examples of ecosystem-based adaptation, or the conservation or restoration of natural ecosystems to reduce the vulnerability of people facing climate change threats (Vignola et al. 2009). This may be accomplished through public works programmes that jointly provide social protection and expanded forest cover (Tirivayi 2017). Ecosystem-based adaptation has been adopted in some National Adaptation Programmes of Action, as reflected in calls for afforestation and reforestation in Burkina Faso and Mali (to forestall desertification), Bangladesh (to stabilise the coast) and Haiti (to protect watersheds) (Locatelli et al. 2008). Thus, efforts to meet Target 1.5 could result in an expansion of forest area.

1.5.1 Sloping Land Conservation Program

The Sloping Land Conservation Program (SLCP) in China is another example of a national forest policy implemented to reduce exposure and vulnerability to environmental shocks. The SLCP is one of several programmes that China launched in response to a perceived 'national land-system sustainability emergency' in the late 1990s (Bryan et al. 2018). With rapid economic growth since the 1980s, China has experienced deforestation and land degradation (Liu and Diamond 2005). Deforestation and over-logging have exacerbated soil erosion, which is believed to threaten the safety of more than 100 million Chinese living in downstream sections of rivers in the eastern coastal region (Liu and Wu 2010). In particular, the massive floods of 1998, which resulted in more than 4000 deaths and serious economic damages, were blamed on soil erosion due to logging and deforestation in the Yangtze and Yellow River basins (Gutiérrez Rodríguez et al. 2016, Jin et al. 2017).

This perception that deforestation was to blame for the flooding led directly to the National Forest Protection Program, which banned logging, and the SLCP, which initially subsidised farmers to convert cropland to forest or grassland in the basins that had suffered flooding. In 2002, the Chinese government expanded the SLCP to cover most of the country (Liu et al. 2008). Under this programme, farmers with land prone to soil erosion and desertification are encouraged to convert agricultural fields to forest or grassland with subsidies from the government (Liu and Wu 2010). The subsidies, which many authors describe as PES, have been in the form of grain or cash. In their systematic review of the literature on the programme, Gutiérrez Rodríguez et al. (2016) find that most studies confirm the expected positive impact of the programme on forest cover and tree planting. Chen et al. (2015) concur that forest cover has increased, but note that some studies have raised questions about how much of the increase should be attributed to the SLCP and about the effects on ecosystem services.

In summary, forests have been recognised as potentially reducing both exposure and vulnerability to environmental shocks, including the extreme weather events that are expected to increase in frequency and severity with climate change. Particularly for the poorest and most vulnerable communities, investing in ecosystem services may be more effective, efficient and sustainable than infrastructure or technological options for adaptation (Locatelli et al. 2008). Thus, Target 1.5 provides an incentive to invest in forest protection and reforestation, especially in coastal zones, on steep slopes, in areas at risk of desertification and in critical watersheds. While these investments may be more likely to happen after a disaster (e.g. SLCP implementation in the wake of catastrophic floods), there are increasing calls to proactively implement ecosystem-based adaptation, including through afforestation and reforestation.

1.6 Conclusion and Means of Implementation

As with most SDGs, the suggested means of implementation for SDG 1 are mobilisation of resources and investment. For SDG 1, these are indicated by the proportion of government spending and international aid (grants and non-debt-creating inflows) allocated to three priorities: (1) poverty reduction; (2) education, health and social protection; and (3) sectors that disproportionately benefit women, the poor and vulnerable groups. While international aid to a country is not strictly a zero-sum game, clearly all governments operate under budget constraints. In this context, increasing the proportions of government spending and international aid on the priorities identified for SDG 1 could reduce the proportions of spending and aid allocated to forests (also a prominent concern for biodiversity; see Roe et al. 2013, Sanderson and Redford 2003). This could exacerbate the underfunding of the forest sector (Agrawal et al. 2013). Furthermore, as illustrated by the PRSPs, most governments prioritise infrastructure and agricultural development to alleviate rural poverty, with likely negative impacts on forests.

These trade-offs can be avoided if forests are understood to be fundamental to poverty reduction and hence included either as a means of poverty reduction (e.g. as part of ecosystem-based adaptation) or as a condition of poverty-reduction policies (e.g. social protection or titling policies that require commitments to forest conservation). Given the concentration of poverty in Africa, this is particularly important for the future of forests on that continent. There is some evidence that donors and governments are increasingly recognising the potential synergies between forest conservation and poverty reduction (Leisher et al. 2013). For example, Ethiopia's climate-resilient green economy strategy includes forest protection and restoration as one of the four pillars of economic development (FDRE 2011). Bilateral donors have invested resources in understanding forest–poverty relationships – for example, through the Ecosystem Services for Poverty Alleviation programme (Schreckenberg et al. 2018). This programme was funded by the UK's Department for International Development, along with the Economic and Social Research Council and Natural Environment Research Council. Likewise, CIFORs [4] Poverty and Environment Network attracted funding from international donors for rigorous research that carefully quantified the contribution of forest products to local livelihoods (Wunder et al. 2014).

While the importance of ecosystem goods and services to the rural poor has been established by this line of research, there is much less evidence on the types of interventions that can successfully achieve both forest conservation and poverty reduction (cf. Adams et al. 2004). For example, reviews of integrated conservation and development projects have generally concluded that most fail to achieve their goals (Naughton-Treves et al. 2005), and even that those goals are fundamentally contradictory (Miller et al. 2011). Likewise, the literature on PES has been cautious about its potential to simultaneously achieve forest conservation and poverty reduction, in part because these two goals may require different spatial targeting (Alix-Garcia et al. 2013, 2015; James and Sills 2018). Systematic reviews of the literature have found no evidence that PES harms recipients, but little evidence of benefits (Sills and Jones 2018).

Forest conservation is often pursued through reallocation of property rights to forests, either to government agencies to manage as protected areas or to communities to manage under sustainability requirements enforced by the government. Intuition suggests that restricting access to forest in protected areas should have a negative effect on local incomes, while decentralisation of forest management should increase incomes. However, recent research using rigorous quasi-experimental methods has found that protected areas can help alleviate poverty, with tourism as the likely mechanism (den Braber et al. 2018, Ferraro and Hanauer 2014, Pullin et al. 2013, Robalino and Villalobos-Fiatt 2015, Sims 2010). In a systematic review of impact evaluations of decentralisation, Samii et al. (2014) find three studies that report a positive effect on participants' household income (from forests or in total), suggesting a fairly thin evidence base. Further research into how impacts are moderated by institutions and other contextual factors is needed to understand the potential to achieve SDG 1 through forest initiatives (Sills and Jones 2018). Research that differentiates impacts on women, the poor and vulnerable groups may identify windows of opportunity or challenges. For example, Duchelle et al. (2018) report that REDD+ initiatives that limit deforestation have generally not negatively impacted local incomes. In sites where there have been negative impacts, they are concentrated among the highest-income households, resulting in greater equality of income. In the same sample, Larson et al. (2018) find negative impacts of REDD+ on women except

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in sites where there were explicit strategies to address their priorities (also see Chapter 5). Thus, opportunities for win–wins may be fairly narrowly defined and require detailed analysis and tailored policies.

In sum, the specific targets for SDG 1 include social protection, secure land tenure and reducing exposure and vulnerability to environmental shocks. The empirical literature shows that cash transfers as well as more secure property rights – especially for community land – can be conducive to forest conservation, given the right context and conditionalities. As demonstrated by programmes to reforest hillsides and protect mangroves, initiatives to reduce vulnerability to environmental shocks can adopt an ecosystem-based adaptation approach, thereby promoting an expansion of forest cover. This approach is consistent with the scientific evidence that forests are both a mainstay of rural livelihoods and a source of natural insurance. However, there is relatively little evidence that this scientific knowledge is shaping poverty reduction and national development strategies. To the extent that those strategies are based on infrastructure and agricultural development, they are likely to remain in conflict with forest conservation and sustainable management.

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Chapter 2 SDG 2: Zero Hunger – Challenging the Hegemony of Monoculture Agriculture for Forests and People

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Key Points

- A 'business-as-usual' approach to food production will continue to cause mass deforestation. This is detrimental for biodiversity, consequently impacting forest-dwelling communities who depend on forests for the direct provision of food. With the loss of forests comes the loss of far-reaching ecosystem services, vital for many facets of food production relied on by the wider population.
- SDG 2 and five of its targets (Targets 2.1–2.5) are closely related to forests. These five targets underscore the reciprocity between forests and SDG 2. Forest biodiversity is integral for nutrition and the ability to grow and harvest diverse crops. In turn, investing in small-scale farming systems and sustainable farming techniques can help conserve forests.
- If we are to achieve SDG 2 sustainably, we need a reimagined food system that does not polarise agricultural production and the conservation of forest resources. This calls for land management that promotes the maintenance of biodiversity and integrated land-use planning. This is especially evident when examining the relationship between SDG 2 and the other SDGs, most of which are concomitantly contingent on each other.

2.1 Introduction and Context

For the majority of human history, we sustained ourselves by foraging edible plants and hunting animals encountered in grasslands, forests and other wild habitats. Indeed, much of our evolutionary development is based on a complex system of hunting and gathering, which provided a varied and nutritious diet (Gordon et al. 2017). All that changed around 10 000 years ago when agriculture simultaneously emerged in various parts of the world, creating a food system that is very much dominant today (Harari 2014).

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Agriculture dominates the global landscape. More than 40 per cent of the global land area is under some sort of cultivation, and we produce more food than ever before in human history (Ellis et al. 2010, Springmann et al. 2018). Much of this expansion has come at the expense of our forests. Agricultural expansion is also pushing other environmental boundaries. Over half of the world's freshwater is appropriated to nourish our crops, soil erosion now exceeds soil formation, chemical herbicides and pesticides result in extensive and pervasive pollution, and agriculture now accounts for around one-third of greenhouse gas emissions (Springmann et al. 2018). While this expansion has had great environmental costs, it has not necessarily resulted in better dietary and nutritional outcomes (Bahadur et al. 2018).

Our global food system is characterised by a heavy reliance on a narrow range of crops and livestock (Khoury et al. 2014). Diets across the globe have shifted from being largely plant-based with complex carbohydrates and low in fats to diets high in fats and oils, meats and refined carbohydrates (HLPE Report 2017a). As a result, almost 2 billion of our global population are over-nourished, and around the same number remain under-nourished (HLPE Report 2017a). With the latter issue, the proportion of the world's population that goes to bed hungry has actually increased in recent years (FAO et al. 2017), while almost one-third of all food produced is wasted, either post-harvest or post-purchase (FAO 2011). There are repeated calls for food production to increase by between 50 per cent and 100 per cent in order to feed an ever-growing human population – a call now echoed throughout the academic and development literature (Tomlinson 2013). In short, our global food system has failed to achieve universal food security (Vandermeer et al. 2018).

With food security and nutrition currently prominent in terms of global development priorities, we need to fully comprehend the deficiencies in our food system and the impact it has on the wider environment, including forests and other ecosystems (HLPE Report 2017b). The current global food system leaves millions of people food insecure while contributing to over-production and generating significant environmental degradation (HLPE Report 2017a). Often, however, food security is measured solely in terms of food energy (i.e. calorie production), losing sight of the fact that, by definition, food security includes secure access to the foods needed for a nutritionally balanced diet (Bahadur et al. 2018, HLPE Report 2017a, Ickowitz et al. 2019). This focus on energy production has contributed to a dichotomisation in which food production, sustainable forest management and conservation are portrayed as mutually exclusive (Brussard et al. 2010). The clear separation of biodiversity conservation and agricultural production has been an impediment in achieving optimised outcomes for either (Gordon et al. 2017). A serious reform of the current food system is clearly needed.

The question central to this chapter is: *Can we feed and nourish the growing human population without further damaging our wider environment, especially forests, in the process?* Throughout the chapter we explore this question by examining SDG 2 (Zero Hunger) in relation to forests. First, we focus on the SDG 2 targets that are impacted by or will directly impact forests. This is followed by a discussion on the relationship between SDG 2 and the other SDGs in regard to forests.

2.2 Zero Hunger and Forests

SDG 2 seeks to 'End hunger, achieve food security and nutrition and promote sustainable agriculture' (United Nations 2015). The goal aims to end hunger and all forms of malnutrition by 2030. It also commits to 'universal access to safe, nutritious and sufficient food at all times of the year' (Table 2.1). The narrative further describes how achieving SDG 2 will require sustainable food production systems and resilient agricultural practices, equitable access to land for farmers and communities, technology and markets, and international cooperation on investments in infrastructure and technology to boost agricultural productivity. Targets 2.1–2.5 (Table 2.1) are closely entwined with forests and forest-related livelihoods. Unless agriculture and forestry are designed to coexist, the possible impacts of achieving SDG 2 on forests include increasing resource use to raise production, thereby creating more pollution (e.g. phosphorus, nitrates, fossil fuels) and higher rates of deforestation (Springmann et al. 2018).

Reflecting on this chapter's guiding question – *Can we feed and nourish the growing human population without further damaging our wider environment, especially forests, in the process?* – we begin to see how Targets 2.1–2.5 address this. Targets 2.1 and 2.2 can be viewed as the desired outcomes of SDG 2: to end all hunger and ensure that everyone, especially vulnerable populations, has access to nutritious food. Target 2.4 draws our attention to the need to achieve Targets 2.1 and 2.2 in a way that will sustain rather than degrade forest ecosystems. Finally, if managed correctly, Targets 2.3 and 2.5 are key to achieving SDG 2 while maintaining the ecological integrity of forests.

2.2.1 Forests and Targets 2.1 and 2.2

Agriculture expansion is the largest cause of deforestation, responsible for approximately 80 per cent of forest loss worldwide (HLPE Report 2017b, Kissinger et al. 2012). Recent research has found that more than one-quarter of permanent forest transformation is driven by commodity expansion, notably that of cattle, soy and oil palm (Curtis et al. 2018). This has devastating

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Table 2.1 SDG 2 targets and indicators

Target	Indicator(s)
2.1 End hunger and ensure access by all people to safe, nutritious and sufficient food, especially vulnerable populations	2.1.1 Prevalence of undernourishment 2.1.2 Prevalence of moderate or severe food insecurity
2.2 End all forms of malnutrition	2.2.1 Prevalence of stunting among children under 5 years of age 2.2.2 Prevalence of malnutrition among children under 5 years of age
2.3 Double the agricultural productivity and incomes of small-scale food producers	2.3.1 Volume of production per labour unit 2.3.2 Average income of small-scale food producers
2.4 Ensure sustainable food production systems and implement resilient agricultural practices	2.4.1 Proportion of agricultural area under productive and sustainable agriculture
2.5 Maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species	2.5.1 Number of plant and animal genetic resources for food and agriculture secured 2.5.2 Proportion of local breeds classified as being at risk, not at risk or at unknown level of risk of extinction
2.A Increase investment in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks	2.A.1 The agriculture orientation index for government expenditures 2.A.2 Total official flows to the agriculture sector
2.B Correct and prevent trade restrictions and distortions in world agricultural markets	2.B.1 Agricultural export subsidies
2.C Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information	2.C.1 Indicator of food price anomalies

Source: IAEG-SDGs 2016

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consequences for both forests and people. Forests contain 80 per cent of terrestrial biomass and provide habitat for more than half of the world's known terrestrial plant and animal species (Aerts and Honnay 2011, Shvidenko et al. 2005). Forests contribute directly and indirectly to food security and nutrition in numerous ways and for various groups of people (Broegaard et al. 2017, Powell et al. 2015). All those who rely to some extent on forests and trees for their livelihood can be considered forest-dependent (HLPE Report 2017b). Byron and Arnold (1997) further this definition by making a crucial distinction between those who rely on forest use and have no alternative and those who use forest products or engage in economic activities involving forests, but do so as a matter of choice.

Communities located in remote areas in and around forests are heavily dependent on forest resources for their livelihoods, especially food (Powell et al. 2015). The types of food from forests and the ways it is harvested have cultural and traditional significance to Indigenous groups (Kuhnlein et al. 2009). These groups often live as hunter-gatherers or shifting cultivators on a subsistence basis (Padoch and Sunderland 2014). Shifting cultivation, also known as swidden agriculture, involves the intermittent clearing and burning of small patches of forest for subsistence food crop production, followed by longer periods of fallow in which the forest regenerates and restores the productivity of the land (Cramb et al. 2009). Swidden agriculture is practised in many countries in the tropical regions of Africa, Asia and Latin America (Mertz et al. 2009). In places with an abundance of land and low human population, shifting cultivation can be managed sustainably to preserve biodiversity and soil fertility while contributing to food security, and can have a long-term, often beneficial, influence on the floristics and ecology of the forests concerned (Maezumi et al. 2018). However, this is less likely to be as sustainable in places with denser populations (Peng et al. 2014, Vira et al. 2015).

People who live in proximity to forests are also somewhat dependent on forests for food security and nutrition. These people are usually involved in agricultural practices either within or outside of the forest, and use forest products partly for their own subsistence and partly for income generation (HLPE Report 2017b). For those more involved in agriculture, dietary supplements from forests are of critical importance to diet diversification for a more nutritious diet (Broegaard et al. 2017). Take bushmeat for example. Bushmeat is derived from wild terrestrial animals and is a significant source of protein extracted from the forest (Nasi et al. 2011). In tropical areas where livestock production is limited and domesticated meats are unaffordable, bushmeat is an important source of micronutrients and protein (Fa et al. 2015). Relatedly, forests act as an economic and environmental safety net, helping households and communities recover from shocks (Wunder et al. 2014). After a poor harvest or drought, food from forests often provides dietary substitutes during periods of scarcity. In times of food insecurity, maternal food deprivation can cause childhood malnutrition and ill health, effects that can linger long into adulthood, ultimately affecting life-long productivity and health (Agarwal 2018). The role of safety net that forests play is important for the most vulnerable groups and relates directly to Targets 2.1 and 2.2.

In addition to the direct provision of food, forest plants are used as feed for livestock, another source of meat and income generation (Baudron et al. 2017). Furthermore, forests contribute to food security and nutrition through the provision of energy. In places where people have no alternative energy sources, wood gathered from the forest is used as the main fuel for cooking. One-third of the global population relies on woodfuel for cooking (HLPE Report 2017b). The ability to cook food expands food options and is important for food safety and water purification (Jin et al. 2017).

The contributions of forests to Targets 2.2 and 2.3 reach far beyond communities living in and near forests. When discussing forest-dependent people, it is difficult to truly understand what this encompasses. Attempts to quantify the number of forest-dependent people worldwide have been made primarily using information on food and income generated from forests. However, these methods do not consider that most agricultural activities depend on ecosystem services provided by forests, which would drastically increase the number of forest-dependent people (HLPE Report 2017b). Forests deliver ecosystem services such as water regulation, soil protection, nutrient circulation, pest control, pollination and carbon-cycle regulation, all of which support food production at the farm, landscape and global scales and mitigate the impacts of climate change (Cumming et al. 2014).

Nevertheless, forests possess inherent trade-offs. They can harbour species that contribute to human wildlife conflict via crop or livestock damage, and pests or diseases that can transfer to crops, livestock and people. For example, in the United Kingdom badgers have been known to spread bovine tuberculosis to dairy cattle (HLPE Report 2017b). However, evidence shows that the benefits of forests to agriculture far outweigh the costs (Reed et al. 2017a). Moreover, the trade-offs mentioned here would still be a challenge, perhaps intensified by fragmentation and deforestation from agriculture. Loss of habitat leaves wildlife populations in search of food and water, resulting in livestock predation and competition for water and grazing land (HLPE Report 2017b).

To summarise, forests are vital to nutritious food production through the direct provision of diverse and nutritious food, energy for cooking and ecosystem services (Powell et al. 2015, Reed et al. 2017a). These contributions are particularly important for the nutrition and food security of vulnerable populations (Targets 2.1 and 2.2); they also impact the food security of the global population (HLPE Report 2017b). As such, the importance of conserving the ecological integrity of forests is undeniable (FAO 2019). However, the current dominant food system results from precisely the contrary: namely, a denial of this importance. This emphasises the need to bear in mind forest conservation to achieve Target 2.4's aim to 'ensure sustainable food production systems and implement resilient agricultural practices' (see Table 2.1).

2.2.2 Forests and Targets 2.3, 2.4 and 2.5

This section explores how the current food system polarises food production and forest conservation, when in fact they should and can be harmonised. We pay special attention to the role of maintaining genetic diversity (Target 2.5) and investing in small-scale food producers (Target 2.3) in sustainable food systems (Target 2.4) to reduce hunger and malnutrition (Targets 2.1 and 2.2), ultimately needed to achieve SDG 2. Throughout this discussion we draw attention to the impacts of achieving these targets on forests and people.

A POLARISING FOOD SYSTEM

Agricultural expansion, production and trade, particularly in the past 100 years, have been the greatest drivers of land conversion and habitat loss, as well as the major direct cause of deforestation (Gibbs et al. 2010). More efficient and productive agriculture has now reached increasingly into marginal lands and is a major land use worldwide (Springmann et al. 2018). With this has come trade and transport, meaning agriculture is now connected to markets and finance across the globe (Swain et al. 2018). The globalisation of agribusiness has resulted in a shift from traditional wholesale markets towards vertically coordinated supply chains that favour large-scale monocrop production (FAO 2015).

Whether rapid agricultural expansion causes deforestation or takes place on previously cleared land has been missing from the conversation on agriculture for some time. A study by Gibbs et al. (2010) reveals that the total net increase in agricultural area was more than 100 million ha across tropical regions during the 1980s and 1990s. More than 55 per cent of this new land came from intact forests and 28 per cent came from disturbed forests (forests previously affected by shifting cultivation, woodfuel collection and other forms of gradual degradation). This confirms that during those decades forests were the primary source for new agricultural land, and expansion has not come from previously cleared or degraded land (Gibbs et al. 2010). This trend persists: forest-rich tropical countries with lower production costs and fewer environmental regulations are being used to meet the continuously growing demand for agricultural land. Much of this land is used as pasture for livestock and to grow livestock feed and commodity crops such as sugarcane, soybeans and oil palm (Curtis et al. 2018).

Nutrition transitions are occurring in tandem with deforestation and environmental change. Rural communities whose land is converted to monoculture agricultural production, such as oil palm, lose not only their forests but in many cases their formerly diverse diets sourced from multi-functional landscapes (Ickowitz et al. 2016). This can equate to cultural losses, such as the loss of foods with symbolic meanings or food required for certain traditions (Cockx et al. 2018). Clearing land with no regard for conserving biodiversity has not only diminished the dietary variety of people living in or near forests, but also that of the wider population too.

Historically, the achievement of food security has focused primarily on calorie intake rather than nutrition (Ickowitz et al. 2019). There exists today a triple burden: malnutrition, consisting of deficiencies in dietary energy intake (hunger), estimated to affect more than 800 million people worldwide in 2017; nutrient deficiencies – such as a lack of iron, iodine or vitamin A – which affect some 2 billion people (2017); and the rapidly growing number of people who are overweight, estimated by the World Health Organization at 1.9 billion adults in 2016 (39 per cent of the world's adult population), of which 650 million (13 per cent) were classified as obese (HLPE Report 2017a). This is expected to intensify. As countries urbanise and incomes rise, diets tend to become high in sugar, fats, refined carbohydrates, meat and dairy (WRI 2018). Although small portions of meat and dairy can provide important micronutrients, half of the global population consume 50 per cent more protein than needed (WRI 2018). Ruminant meat (cattle, sheep, goats) consumption is expected to grow 88 per cent by 2050. Ruminant livestock uses two-thirds of global agricultural land (WRI 2018), and approximately two-thirds of all soybeans, maize and barley and one-third of all grains are used as feed for livestock (Willett et al. 2019).

The EAT–Lancet Commission describes a universal healthy reference diet that links healthy foods with improved human health and environmental sustainability. The diet consists of vegetables, fruits, whole grains, legumes, nuts, unsaturated oils and low amounts of seafood and poultry. The diet recommends low to no consumption of unhealthy foods such as red meat, processed meats, added sugar, starchy vegetables and refined grains (Willett et al. 2019). Transitioning to a diet similar to the healthy reference diet requires a reduction in global consumption of unhealthy foods by more than 50 per cent (Willett et al. 2019).

Adding to the mounting concerns of the current food system is food waste. It is estimated that a third of all food grown is wasted, either post-harvest or post-purchase (FAO 2011). Food loss occurs along the entire food chain and has negative economic, social and environmental consequences (Aschemann-Witzel et al. 2015, FAO 2011). Food waste at the beginning of the food chain is prevalent in low-income countries. These losses are largely due to technical limitations in harvesting and a lack of storage and cooling facilities, as well as packaging and marketing systems (FAO 2011). Food waste in medium- and high-income countries shows an opposite trend, with most food wasted at the consumer level. This can be attributed to poor purchase planning and best-before dates, quality standards and aesthetic expectations, enabled by consumers who can afford to waste food (Aschemann-Witzel et al. 2015, FAO 2011). When food is wasted, the resources used in its production and transportation are also squandered (Aschemann-Witzel et al. 2015).

From this discussion, it is clear the production and consumption trends driven by the current food system are problematic for both people and forests. The focus on maximising the production of select commodity crops has resulted in mass deforestation for monocrop agriculture. The logic behind our current approach to agriculture has become disconnected from what agriculture is so dependent on: nature (Gordon et al. 2017) and its biodiversity (Sunderland 2011). This is made worse by the fact that the system has failed to achieve global food security and nutrition. Rather, the current system relies on a narrow range of crops, and diets have shifted to become less diverse and nutritious, negatively impacting the health of people and forests.

The complex polarisation of the approaches needed to feed current and future populations while conserving forests and the wider environment is a fundamental development issue. It has led to the protectionist paradigm of separating nature from agriculture rather than the two operating in synergy (Harari 2014). The achievement of SDG 2 is contingent on recoupling nature and agriculture. Diverse and nutritious diets are synonymous with biodiversity. Moving forward, current production and consumption trends need to change. As much as this is for the benefit of people, it presents a challenge to our current habits. Achieving SDG 2 necessitates a behavioural change in what food we consume, as well as how we manage and produce food. The following sections explore how maintaining genetic diversity (Target 2.5) and investing in smallholder farmers (Target 2.3) will help address these needed changes for a food system that is resilient (Target 2.4) and nutritious (Targets 2.1 and 2.2).

TARGET 2.5: GENETIC DIVERSITY IN CROPS

Achieving SDG 2 can improve nutrition and positively impact the health of people and forests. This requires changing a defining characteristic of our current food system: the increased reliance on only a very few species, leading to

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the increased homogenisation of diets (Khoury et al. 2014). Since agriculture began some 12 000 years ago, approximately 7 000 plant species and several thousand animal species have been used for human nutrition (Burlingame et al. 2012). Today, although certain traditional and Indigenous communities continue to use a multitude of species in their diets, the general global trend has been towards diet simplification, with consequent negative impacts on human food security, nutrition and health (FAO 2019, Powell et al. 2015). It is estimated that three-quarters of the varietal genetic diversity of agricultural crops has been lost over the last century (Khoury et al. 2016). Just 12 crops and 14 animal species now provide most of the world's food (Burlingame et al. 2012, Khoury et al. 2014).

As the biodiversity used in food and agriculture declines, the food supply becomes less sustainable and more vulnerable (FAO 2019). The narrowing of the genetic basis of our food systems means there is less resilience to the consequences of climate change such as droughts, floods, fires and incidences of pest outbreaks (Deutsch et al. 2018, Schipanski et al. 2016). Less genetic diversity means fewer opportunities for the growth and innovation needed to provide food security and boost agricultural production at a time of soaring food prices and competition with production for biofuels. For example, Tigchelaar et al. (2018) estimate that the predicted 4°C temperature increase worldwide will lead to losses of up to 87 per cent in global maize production. In addition, the nutritional value of some crops could change (Smith and Myers 2018). With increased carbon dioxide in the atmosphere it is postulated that while plant growth may indeed increase, the nutritional quality of staple crops such as potatoes, barley, wheat and rice may fall due to an increase in carbohydrate production and a reduction in protein levels (Ebi and Ziska 2018). This would have a major nutritional impact on the billions of people who rely on these staples.

Not only does relying on a few, select crops leave the food system vulnerable to climatic changes, it lacks the diversity proven to have a plethora of nutritional benefits (HLPE Report 2017a). Biological diversity includes countless plants that feed and heal people, many crop varieties and aquatic species with specific nutritional characteristics, livestock species adapted to harsh environments, insects that pollinate fields and micro-organisms that regenerate agricultural soils. As discussed in Section 2.1, forests contain most of the world's terrestrial biodiversity and provide ecosystem services vital for the survival of other ecosystems (Springmann et al. 2018). An investment in conserving forest biodiversity is an investment in future food security that is diverse, nutritious and resilient (FAO 2019).

To summarise, achieving SDG 2, specifically genetic diversity (Target 2.5), requires the conservation of biodiversity. As forests are home to most of the

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world's terrestrial biodiversity, this means forest conservation should be at the forefront of our considerations. Further, genetic diversity in our food supply benefits people in several ways. First, genetic diversity enhances dietary nutrition and health. Second, it is integral for climate change adaptation and mitigation. This helps build resilience (Target 2.4) and lessen vulnerability to shocks, thereby benefitting the socio-economic well-being of producers and those who are supported by them. Finally, genetic diversity and maintaining biodiversity, especially that of forests, helps sustain the numerous ecosystem services on which people rely. Clearing forests to grow a minimal assortment of crops is no longer an option. Forests can and should be integrated into agriculture rather than being viewed as being 'in the way' of production. The next section discusses the importance of investing in smallholder farms and enhancing biodiversity in agriculture.

TARGET 2.3: INVESTING IN SMALLHOLDER FOOD PRODUCERS

The pervasive image of modern agriculture is of a vast swath of swaying cereals tended by industrial-scale machinery. This is certainly the case in much of the temperate world. However, in the tropics most of the food produced originates in complex multi-functional landscapes, characterised by small farms producing a wide variety of products (Ricciardi et al. 2018). This diversification is critical for livelihood strategies (don't put all your eggs in one basket) as it provides resilience against both economic and environmental shocks – the latter increasingly driven by climate-induced droughts, floods and other events. Smallholder systems are estimated to produce between 30 per cent (Ricciardi et al. 2018) and 70–80 per cent (FAO 2014) of the world's food. Even with this wide range, it still represents a significant proportion of global food production.

Unlike in temperate regions, the majority of smallholder farmers in tropical regions do not benefit from national or regional subsidies (Chirwa and Dorward 2013). Post-harvest losses are considerable in these systems, yet little to no government support is available for most farmers. They stand to lose their markets due to cheap, subsidised products being dumped on their own production range (FAO 2015, McMichael 2005). In short, smallholder farmers are a resilient and productive group that contributes to global food security in often unseen ways; they deserve more support and the opportunity to compete in fair and equitable market systems. Development support should complement existing knowledge and practices within local systems.

Unfortunately, a growing worldwide trend in the demography of farmers works against such long-term support. Many farmers support their children's education, who, in turn, tend to shun farming as an occupation. As a result, farmers are growing older and less able to manage the land. There is a general trend for small farms to consolidate into larger production units both in temperate and tropical production systems, which is problematic because large-scale commercial agriculture is the driver of approximately 40 per cent of deforestation in tropical and subtropical regions (FAO 2016).

Target 2.3 seeks to change this by doubling the agricultural productivity and income of small-scale food producers, particularly women, Indigenous peoples, family farmers, pastoralists and fishers. Smallholders would benefit from mechanisms that provide access to essential services, such as credit, electricity and transport needed to participate in agribusiness. This could be made more accessible through instruments such as group savings and loan associations, chattel mortgages and leasing (FAO 2017). Furthermore, farmers, especially youth, would benefit from opportunities to develop technical skills and entrepreneurial training. Helping smallholders build the technical capacity and access to the resources necessary to remain competitive in the food system would improve the socio-economic well-being of many.

Investing in smallholder producers is very much related to forests, as many smallholder farmers operate near forests. As discussed in Section 2.1, farmers in rural areas rely on the forest as a safety net for a bad harvest. Additionally, it is good to be near forests for the resources they provide, such as plants used to feed livestock, wood for fences and other structures, improved soil nutrients and much more. Giving smallholder farmers everywhere access to support is important for the aforementioned reasons; however, smallholder farmers near forests present a unique opportunity to conserve forest ecosystems through integrated land uses such as agroforestry (Godfray et al. 2010).

Agroforestry, as defined by Lundgren and Raintree (1982), is 'the name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economical interactions between the different components' (HLPE Report 2017b: 34). There are three classes of agroforestry systems: agrisilvicultural systems, combining agricultural crops and trees or shrubs; silvopastoral systems, combining trees and pasture for grazing livestock; and agrosilvopastoral systems, combining crops, pastures and trees (Nair 1993, Vira et al. 2015).

Trees on farms can generate an array of benefits for communities and the environment. Trees provide shade for shade-tolerant crops, which increases yields. Cocoa grown under tree shade can produce yields for 60–100 years, compared to 20 years or less without shade (Obiri et al. 2007, 2011; Ruf and Schroth 2004). Another example is the presence of fruit trees in agroforestry systems. They have been shown to help fill seasonal gaps in fruit supply (Jamnadass et al. 2011, Vinceti et al. 2013) and attract wild animals

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for hunting (Sylvester and Segura 2016). Essentially, agroforestry helps maintain biodiversity, genetic diversity and the associated benefits of forests – i.e. improved soil fertility resulting in increased crop yields, fodder for livestock, woodfuel for cooking, ecosystem services necessary for food production, etc. In some cases, agroforestry can be an appealing alternative to conservation agriculture. Conservation agriculture relies on reduced tillage of soils and preserving crop residues to prevent soil erosion. However, some farmers rely on crop residues to feed livestock (WRI 2018). Agroforestry allows this practice to continue and improves soil quality.

It is important to note that land rights are key to investing in land and pursuing long-term investment activities, such as planting trees. In much of the world, rural and forest dwellers lack registered or formalised rights to land. Recent work has drawn attention to the importance of recognising customary rights and shared rights to land and forests, as well as a need to reduce the bureaucracy and legal obstacles of granting community rights (WRI 2018).

Certification schemes and market-based mechanisms are one way of supporting agriculture that integrates forest conservation. These schemes encourage integrative alternatives to the polarising approach that has dominated thus far. Market-based mechanisms and certifications engage multiple stakeholders, including farmers, government, communities and private companies, incentivising sustainable management and production. There are numerous examples, including the REDD+ programme, that offer results-based payments for actions reducing forest carbon emissions, such as sustainable agriculture practices (REDD 2016).

Certifications allow an independent assessment of a defined set of management standards that promote and measure sustainable forest management (CEPI 2006, HLPE Report 2017b). Some certification schemes (e.g. The Forest Stewardship Council (FSC), and the Programme for the Endorsement of Forest Certification (PEFC)) are focused on sustainable forest management in general, while others are focused specifically on food production and forests (e.g. the Round Table on Sustainable Palm Oil (RSPO), and the Round Table on Sustainable Soy (RTRS)) (HLPE Report 2017b). These schemes are proving to be successful. Take RSPO, for example: nearly 2.5 million ha of palm oil is RSPO certified, which represents 21 per cent of global production (HLPE Report 2017b). However, forest certification is primarily focused on boreal and temperate forests, while only 6 per cent of the total certified area is in the tropics (MacDicken et al. 2015), leaving ample room for improvement.

In addition, high-income countries tend to protect their own natural resources and import from lower-income countries to sustain consumption (Mills Busa 2013). With this in mind, consumption strategies such as certification schemes can be as important a buffer to forests as protected areas (HLPE

Report 2017b). In the same vein, it is worth noting that although protected areas are undeniably important, they can be managed in a way that is restrictive to local people and the resources needed for their diets, again reinforcing the importance of systems that sustainably integrate multiple uses.

2.2.3 Integrated Landscape Management

Taking what we have learned from Targets 2.1 to 2.5, a common theme emerges: the need for management that recognises the multiple uses of landscapes and the ways they impact each other (Kremen and Merenlender 2018). As this chapter has shown through the discussion of forests and agriculture, landscapes are a mosaic of natural and human-modified ecosystems that cannot be neatly separated from one another (Reed et al. 2017b). Our failing food system and degraded forests are a testament to the need for a new approach to food production (Ickowitz et al. 2019). The landscape approach answers this call for change, as it seeks to 'provide tools and concepts for allocating and managing land to achieve social, economic, and environmental objectives in areas where agriculture, mining, and other productive land uses compete with environmental and biodiversity goals' (Sayer et al. 2013: 8349).

SDG 2 targets span sectoral and geographic boundaries and involve multiple stakeholders along the entire supply chain, including consumers, producers, policymakers and many other actors. Operationalising integrated landscape management for forests and agriculture necessitates building partnerships among states, rural communities and industry. This requires new legislation, policies and novel forms of forest governance, such as co-management or community managed forests (HLPE Report 2017b). In particular, agricultural policy should be linked to health, education and trade policies that simultaneously promote human and planetary health (Willett 2019). This can help facilitate changes in behaviour and production.

Furthermore, a landscape approach calls for enhancing stakeholder capacity and coordination. It is pertinent that stakeholders are included in decision-making processes related to land management. Stakeholder involvement is increasingly recognised as a means to manage competing interests and as a way to be explicit about potential trade-offs. More than half of the national forest policies and programmes revised since 2007 in 42 countries now include measures to enhance the involvement of traditional forest users in decision-making processes (FAO 2014, HLPE Report 2017b).

GENDER CONSIDERATIONS

Social processes are key in decisions about forest-dependent livelihoods and forest-resource management, as well as governance processes and the distribution of benefits, with strongly differentiated gender roles and impacts (HLPE Report 2017b). These differences need to be considered while managing integrated landscapes. Women tend to grow a greater diversity of products, experiment more with folk varieties and landraces (and thus agrobiodiversity) and are often reliant on broader aspects of biodiversity for herbal medicine – linking both health and nutrition (Sunderland et al. 2011). Women are primarily responsible for food preparation and allocation and, as such, are usually the 'guardians' of household food security (WFP 2002). Yet women's access and control over land and resources is generally inferior to that of men in the same household or community (Agarwal 2018). Where women do have access to land, they tend to use it for food production, and income generated from such land is more likely to be utilised for the well-being of the household, whether for nutritional, health or other benefits (Wan et al. 2011).

Women and men tend to have differing tasks and responsibilities in the production and provision of food, including wild foods (Sunderland et al. 2014). Many women face gender-specific constraints that cut their productivity and limit their income-earning potential. There are gender gaps in access to land, credit, technology, employment and markets. Even though they are often primary resource users, women usually participate much less than men in formal land management and policy decisions (Leisher et al. 2016). Cultural, socio-economic and institutional factors contribute to gender inequality. These range from the societal perceptions of women's roles and the time women have to spend on domestic responsibilities and childcare to disparities in literacy, education, physical abilities, technical skills and access to training and extension services.

Target 2.3 specifically identifies women as a group of smallholder farmers that need support in order to achieve SDG 2. This is especially timely with the 'feminisation' of agriculture due to male out-migration and moves towards off-farm sources of income (Doss 2014, FAO 2017).

Many female farmers lack access to credit and extension services despite evidence suggesting that investment aimed at women leads to the increase of both farm and non-farm incomes at the household level. Although development policymakers and agencies increasingly recognise the crucial contributions of female farmers to food security, contemporary agricultural policies and research do not often directly address the needs of female farmers, focusing instead on traditionally male-dominated cropping practices. Such 'gender blindness' in the context of sustainable agricultural development is a risk to future food security given the major contributions of women to agriculture in the Global South. This underscores the importance of gender considerations in integrated landscape management planning processes. Moreover, a better understanding of what forest resources women are using for food and agriculture is useful for knowing what forest resources are of value to local communities and how to sustain them.

2.3 Synergies and Trade-offs with Other SDGs

Nutrition is an indispensable cog without which the SDG machine cannot function smoothly (Global Nutrition Report 2017). Poor nutrition has varied causes, many of which are intimately connected to work being undertaken to accomplish other SDGs. There is huge potential for making connections among the SDGs, but there is also the potential for incoherence. These trade-offs and synergies will have varied impacts on forests. The Global Nutrition Report (2017) finds that improving nutrition can have a powerful multiplier effect across the SDGs. Indeed, it indicates that it will be a challenge to achieve any of the SDGs without addressing nutrition. The report identifies five key fields where SDG 2 interacts at a broader scale with the other SDGs. In this section we use these five fields as a backdrop to discuss the trade-offs and synergies between SDG 2 and other SDGs, and how these impact forests.

1. Sustainable food production (relevant SDGs: 13, 14, 15) is key to nutrition outcomes. Agricultural yields will decrease as temperatures increase by more than 4°C. Increased carbon dioxide will result in decreased protein, iron, zinc and other micronutrients in major crops consumed by much of the world (Ebi and Ziska 2018, Tigchelaar et al. 2018). Unsustainable fishing (SDG 14 Life below Water) threatens 17 per cent of the world's protein and a source of essential micronutrients (Golden et al. 2016). Policies and investments to maintain and increase the diversity of agricultural landscapes are needed to ensure small and medium-sized farms can continue to produce the 53–81 per cent of key micronutrients they do now (Herrero et al. 2017). As this chapter has explored, diversifying crops using sustainable agriculture practices and supporting small-scale farmers can enhance terrestrial biodiversity (SDG 15 Life on Land) and enable a food system that is more resilient in the face of climate change (SDG 13 Climate Action). While mechanisms for achieving SDG 15, such as protected areas, can benefit forest conservation, they can also restrict forest use and negatively impact the diets of forest-dependent communities. Sustainable food production approaches such as agroforestry and integrated landscape management show potential for harmonising the objectives of SDG 2 and SDG 15 (Timko et al. 2018).

2. Strong systems of infrastructure (relevant SDGs: 6, 7, 8, 9, 11, 12) play key roles in providing safe, nutritious and healthy diets (SDG 2), clean water and sanitation (SDG 6) and more resilient communities overall (SDG 11). Contamination of food from unclean water and poor sanitation is associated with 50 per cent of under-nutrition; it leads to diarrhoea and can cause death, especially among young children. Improved infrastructure (SDG 9) can help deliver resources and services to underserved areas. Improved infrastructure such as cooling systems and storage facilities can reduce food waste. Furthermore, affordable and clean energy (SDG 7) can reduce the reliance on wood from forests for cooking fuel.

The impacts of improved infrastructure on forests and SDG 2 are twofold. First, infrastructure such as roads can help smallholder farmers access previously inaccessible markets and create decent work opportunities (SDG 8). This has the potential to encourage younger generations to continue participating in agriculture and incentivise farmers to continue farming diverse crops at a small scale, which would help reduce the formation of large-scale conglomerates that put pressure on forests. Second, improved access to remote areas may be beneficial for markets and delivering services, but building roads and other infrastructure can cause environmental harm, such as deforestation. In addition, improved access to these areas makes it easier for bigger industries to move in. This is where sustainable consumption (SDG 12) is important. Market-based mechanisms and certifications, like the examples discussed in Section 2.2.2, can help regulate the impacts of new infrastructure and industry on forests.

3. Health systems (relevant SDG: 3) have an important role in promoting infant and young child feeding, supplementation, therapeutic feeding, nutrition counselling to manage overweight and underweight concerns, and screening for diet-related noncommunicable diseases in patients. Yet our analysis shows that health systems are not delivering where they should: for example, only 5 per cent of children aged 0–59 months who need zinc treatment are receiving it. As discussed in Section 2.1, forests play a substantial role in the health and well-being of people (SDG 3). Forests provide nutritious food such as bushmeat, fruits and nuts, as well as providing wood for cooking meals. However, it should be noted that food can be a health risk, as in the case of bushmeat being linked to Ebola outbreaks. Overall, nutrition from forests improves health, helping keep people out of hospitals. The importance of eating nutritious food to maintain good health is accentuated in remote areas where access to healthcare is variable.

4. Equity and inclusion (relevant SDGs: 1, 4, 5, 8, 10, 16) matter for nutrition outcomes: ignoring equity in the distribution of wealth, education

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and gender will make it impossible to end malnutrition in all its forms. Approximately 767 million people live in extreme poverty, and 46 per cent of all stunting falls in this group (Global Nutrition Report 2017). This group is often neglected or excluded. Reflecting on the discussion in Section 2.2.2 about lack of support for smallholder farmers and women, the relationship between SDG 2 and SDG 4 (Quality Education) shows potential to reduce inequalities (SDG 10) among men and women (SDG 5 Gender Equality) and smallholder farmers and big industry. Workshops on conservation agriculture and other knowledge-sharing opportunities would be of great benefit to farmers and forest peoples. Education relates to decent work opportunities because skill building opens up new work opportunities and stimulates economic growth (SDG 8) and reduces poverty (SDG 1). The impacts on forests depend on the type of work and how growth is managed.

Another key intersection regarding equity and inclusion is the relationship between SDG 16 (Peace, Justice, and Strong Institutions), SDG 10 (Reduced Inequality) and SDG 2. SDG 16 aims to end corruption and exploitation and develop effective, accountable and transparent institutions at all levels. Transparency and regulation is very important for industries clearing or extracting forest resources. This is heightened by the fact that there are communities that do not have recognised rights over their land. In some cases, this has resulted in the loss of land to private companies. This can lead to deforestation by the company or by communities who have lost their farmland and moved to other forested areas. SDG 16 could improve tenuous land rights, securing land and resources vital to nutritious diets, as well as regulate industry to prevent the exploitation of forests.

5. Peace and stability (relevant SDG: 16) are vital to ending malnutrition. The proportion of under-nourished people living in countries in conflict and protracted crisis is almost three times higher than in other developing countries. Long-term instability can exacerbate food insecurity in many ways. In the worst-case scenario, conflict can lead to famine. When conflict or emergencies occur, nutrition must be included in disaster risk reduction and post-conflict rebuilding. On the other hand, forests act as a safety net during periods of crises and conflicts, as they provide food substitutes during times of insecurity. Additionally, peace and stability support law and order, which fosters an environment conducive to sustainable forest management. Whether managed at the national level or the community level, sustainable management conserves biodiversity, which is necessary for food security and nutrition.

2.4 Conclusion

Under our current food system, forests are treated either as a space for agricultural expansion or a threatened resource needing protection from such expansion (HLPE Report 2017b). Breaking down this siloed thinking to realise that agriculture and forests are inextricably linked is an important step in achieving SDG 2. As this chapter highlights, our current food system is failing people and forests. Although we are producing more food than ever before, our population is characterised by both under- and over-malnutrition. Forests – exceptional sources of biodiversity and ecosystem services necessary for food and agriculture – are being destroyed for a limited selection of crops and livestock. A lack of diversity reduces nutrition and leaves our food system vulnerable to the vicissitudes of a changing climate.

SDG 2, specifically Targets 2.1–2.5, brings optimism to the future of forests and people. These targets emphasise biodiversity, sustainability and integration – all key ingredients of a resilient food system. Achieving SDG 2 should be based on the integration of food production and forests within the context of land management; this will both require and result in positive changes. For instance, major change will be required in both national and global governance systems and processes. The SDGs are an emerging opportunity in this regard, as they are all dependent on each other. Some SDGs have seamless synergies, such as SDG 2 and SDG 3, while others are bound to face trade-offs. We have reached a point where collaboration across sectors is needed more than ever. Forests can play an enormous role in facilitating this collaboration.

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Chapter 3 SDG 3: Good Health and Well-Being – Framing Targets to Maximise Co-Benefits for Forests and People

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Key Points

- The achievement of SDG 3 depends on many other SDGs; some SDGs are logically inconsistent, especially in the attempt to increase conventionally defined GDP while preserving natural capital.
- Any short-term gains for human health from further forest conversion (e.g. food production) creates short- and long-term, direct and indirect health risks for humans, as well as for other biota.
- Failure to ensure universal access to sexual and reproductive healthcare services (including family planning) will increase pressure on forests at local, regional and global scales.
- The burning and clearing of forests cause significant harm to health via impaired quality of water, soil and air; increased exposure to infectious diseases and impacts climate regulation.
- Many infectious diseases are associated with forest disturbances and intrusions; some important infectious diseases have emerged from forests (notably HIV/AIDS).
- Greater exposure to green space, including forests, provides mental and physical health benefits for the growing global urban population.

3.1 Introduction

The third SDG is very ambitious. It includes the words 'health' and 'well-being', which both have lofty, multiple and contested meanings and aspirations. Echoing the almost-forgotten World Health Organization (WHO) slogan proclaimed at the Alma Ata conference in 1978 of 'health for all by the year 2000', SDG 3 proclaims the aspiration 'well-being for all' by 2030. However, this is a pledge for the world to promote this aspiration rather than

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achieve it – a task probably considered unwisely ambitious, even by the SDG framers.

In 1948, the newly formed WHO defined human health as 'a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity' (WHO 2019b). Then revolutionary, this definition challenged the disease-focused medical model of health that was (and is still) the common perception of not only lay people, but also many health workers. It challenged convention by recognising the importance of the social and mental dimensions of health.

In recent decades, the WHO definition has been increasingly criticised, mainly for its use of the word 'complete'. Today, in a world with so many people with chronic illnesses and disabilities, complete health is unattainable for hundreds of millions, perhaps billions. Indeed, some argue that the pursuit of complete health is counterproductive because it promotes the re-medicalisation of the concept of health, allowing profit-seeking corporations such as pharmaceutical companies, the medical screening industry and often health workers themselves to seek opportunity and personal gain through new drugs, blurring the distinction between normal variation (including ageing) and pathology (Huber et al. 2011).

Unlike in 1948, many people today live reasonably fulfilling lives in their older years, while in the mid-twentieth century infectious diseases crippled and shortened the lives of many and were seen as the major global health problem. For young people with conditions such as undernutrition, hookworm or malaria, the potential of cure and a period of 'complete' health (lasting at least some decades following treatment) seemed a realistic aspiration for health workers in a milieu encouraged by the WHO in 1948. Today, suggesting that most 70-year-olds with diabetes or arthritis can become completely healthy is unrealistic. Nevertheless, 'rectangularising the curve' – maintaining good, though rarely (if ever) complete, health well into old age – remains an important goal. The pathways to this goal of excellent, albeit imperfect, lifelong health are increasingly understood in theory but remain out of reach for billions, as so many of the determinants of health remain fragile, damaged, endangered, unattainable and structural. Few are within the ability of individuals or communities to change.

A lesser known criticism of the WHO health definition is its lack of environmental or ecological dimension, including its relationship with forests. In 1990, the pioneer of primary health care, Maurice King, suggested that the WHO insert 'sustainable' as the second word in its health definition (King 1990). Like all other suggested amendments, this has been resisted so far. However, there is increasing understanding, including within the WHO, that there are crucial environmental underpinnings of health and that many of these determinants lie far beyond the expertise of clinicians – that is, of doctors and other health workers who encounter and treat the sick.

The Declaration of the Alma Ata conference identifies two of eight essential components of primary health care as environmental: (1) adequate nutrition, and (2) safe water and basic sanitation. The 1986 Ottawa Charter, a landmark in health promotion, pays even more attention to environmental issues. It declares that the fundamental conditions and resources for health are 'peace, shelter, education, food, income, a stable ecosystem, sustainable resources, social justice and equity' (WHO 1986). These (and others) have become known as the social (and environmental) determinants of health and are considered to determine the inequity of health outcomes among populations. Many of these conditions and resources are related to other SDGs, illustrating a difficulty not only for this chapter but also for the others. Virtually all 17 SDGs are related to health and well-being in some way, as well as to each other. One risk of the SDG approach is inadvertently reinforcing barriers among disciplines and lobby groups. On the other hand, progress with many SDGs is likely to have synergistic benefits: the WHO describes the SDGs as a blueprint for systematically addressing the social determinants of health (Government of South Australia and WHO 2017).

Although this chapter focuses on forests, health and well-being through the lens of specific SDG 3 targets (for the complete list, see Table 3.1), we stress that the public goods (the 'ends') of health and well-being have many non-environmental determinants, including caste, class, corporate, cultural, economic, educational, epigenetic, ethnic, gender, genetic, nutritional, political, social and spiritual aspects. These are listed alphabetically to stress that they are all important; prioritising any one is subjective. We acknowledge that some analysts will argue that some categories (e.g. social) may embrace subsets (e.g. political). No framework of analysis will satisfy everyone. An analogy from biology is of survival. Humans need air, water and food, but death from suffocation is fastest: this does not mean air is more important than food, considered over a longer period. While humans may survive with only air, water and food – perhaps in a windowless cell – they will certainly not thrive with those inputs alone. Other aspects, such as social connections, are also vital to foster even an imperfect state of physical, mental and social well-being. Some of these relate to forests and their services.

Well-being is also a contested, context-dependent term. The WHO defines it as part of health, whereas the Millennium Ecosystem Assessment conceptual framework considers health as one of five components of well-being, along with material sufficiency, security, good human relations, and freedom and choice (Butler et al. 2003).

This chapter discusses the impacts of achieving SDG 3 targets on forests, forest people and humans more broadly, including background on important connections between some specific SDG 3 targets and forests and their services. We argue that failure to make significant progress with Target 3.7, concerning sexual and reproductive healthcare services, will have significant adverse effects not only on forests, but on all other SDGs.

In Table 3.1 we highlight in bold those SDG 3 targets with forest connections discussed in detail in this chapter. The others are still relevant to forest-dependent populations and are referred to within the sections.

Table 3.1 SDG 3 targets, highlighting those particularly pertinent to forests and forest populations (targets in bold have forest connections discussed in detail in chapter)

Target	Description
3.1	By 2030, reduce the global maternal mortality ratio to less than 70 per 100 000 live births
3.2	By 2030, end preventable deaths of newborn and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1000 live births and under-5 mortality to at least as low as 25 per 1000 live births
3.3	**By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases**
3.4	**By 2030, reduce by one-third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being**
3.5	Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol
3.6	By 2020, halve the number of global deaths and injuries from road traffic accidents
3.7	**By 2030, ensure universal access to sexual and reproductive health-care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes**
3.8	**Achieve universal health coverage, including financial risk protection, access to quality essential healthcare services and access to safe, effective, quality and affordable essential medicines and vaccines for all**

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Table 3.1 (cont.)

Target	Description
3.9	**By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination**
3.A	Strengthen the implementation of the WHO Framework Convention on Tobacco Control in all countries, as appropriate
3.B	Support the research and development of vaccines and medicines for the communicable and non-communicable diseases that primarily affect developing countries, provide access to affordable essential medicines and vaccines, in accordance with the Doha Declaration on the TRIPS Agreement and Public Health
3.C	Substantially increase health financing and the recruitment, development, training and retention of the health workforce in developing countries, especially in least developed countries and small island developing States
3.D	Strengthen the capacity of all countries, developing countries, for early warning, risk reduction and management of national and global health risks

Source: https://sustainabledevelopment.un.org/sdg3

3.1.1 Health and Forests

We conceptualise the links between forests and population health at three scales (Figure 3.1) (World Bank 2008). We also stress that the relationship is bidirectional: forest effects on health are not all positive, and people's improved well-being can have good and bad impacts on forests.

However, forests do have important benefits for health for all people. Most proximally, about 350 million people live very close to or within dense forests and are substantially dependent on them. Of these, about 60 million (mostly Indigenous) are wholly dependent on forest ecosystem services for food, water, fuel, medicine, culture and livelihood. At a second scale is a larger population, though of uncertain size, that lives away from the forest, may never even visit one and yet depends on and, in some cases, consciously consumes services such as drinking water, firewood or bushmeat. Across these two scales are at least 13.5 million people employed formally in forestry (Garland 2018).

Most of the global population is at the third scale; many are exposed on a frequent basis to the urban forest and may visit other forests on holiday. Most

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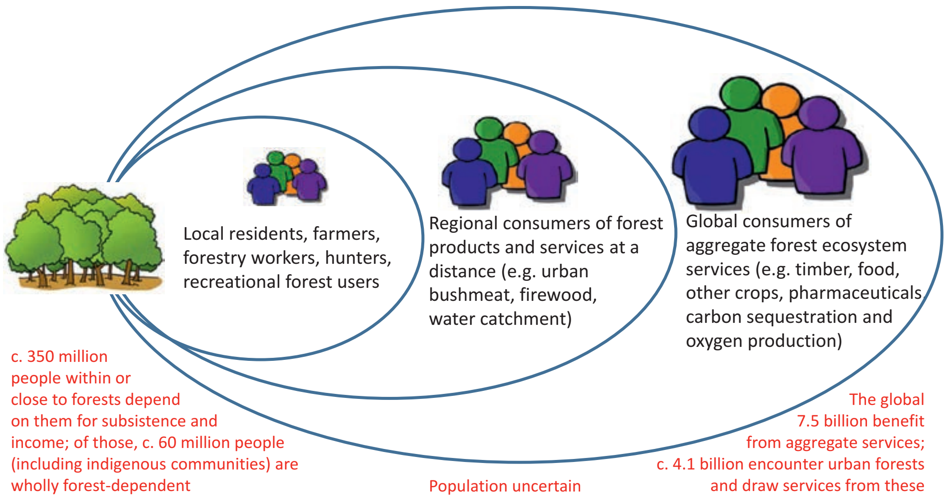

Figure 3.1 Multi-scale impacts of forests on the health and well-being of populations.

consume, often indirectly, forest products such as timber, food and pharmaceutical discoveries from around the world. This entire population benefits, whether they know it or not, from other services, especially the carbon-regulating and oxygen-providing functions of forests. A small but significant fraction of people in the second and third category consciously seek contact with forests (near and far), as well as with other aspects of nature. There is increasing appreciation that this group may experience direct health benefits.

3.2 Sustainability, Limits, Population and the 'Free Market'

The ecological impacts of achieving SDG 3 (and its specific targets), as with the other human-focused SDGs, need to be framed within the debates about ecological sustainability, population and market processes. These factors affect the pursuit of health and well-being for all and the fate of the world's forests. Importantly, decades of often-fluctuating concern about the impact of humans on natural resources have included warnings that exceeding the limits of natural resources is both possible and catastrophic for human well-being. As early as the 1970s, *The Limits to Growth* (Meadows et al. 1972) identified major aspects of future crisis brought on by accelerating industrialisation and population growth, leading to depletion of non-renewable resources and many forms of environmental decline. More recently, the planetary boundaries framework aims to establish the limits beyond which human activities fatally undermine the ecological integrity on which human life ultimately depends (Steffen et al. 2015). Forests are at the heart of three dangerous ecological trends. Biodiversity loss and biogeochemical disruption have already breached limits, while land-system change and climate disruption are approaching the danger zone.

The exploitation of natural resources is driven by economic (and population) growth and this highlights a fundamental concern: currently, achieving SDG 3 and most other human-centric SDGs requires ongoing economic growth. Healthcare and the well-being of the growing global (and local) populations of consumers is costly, and this has impacts on the environment and sometimes directly on forests. Forest transformation can provide local employment, generating cash and opportunities for financially poor and often vulnerable populations. It can also greatly increase food production. These opportunities can then be used to engage more broadly with the wider economy and to facilitate better education and healthcare. Earth system and population health concerns become lost in such discussions. Furthermore, existing market forces do little to protect nature or promote the broader social determinants of health.

Solutions to these problems require transformative thinking and alternative economic models. Impressive improvements in nutrition and health in the early twenty-first century have been achieved in Ghana, Vietnam and Brazil, where government programmes provided benefits such as cash for mothers, support for smallholders and land grants (Lappé et al. 2013). Such programmes, which may ease the pressure on forests, are in opposition to current (neoliberal) economic principles. Alternative economic models that decouple economic growth from environmental degradation (Target 8.4) are required to safeguard health. This chapter discusses some integrated approaches to poverty, population, health and environmental management that seek optimal outcomes for both forests and people (see Box 3.2).

3.3 Forests, People and SDG 3 Targets

3.3.1 Ending Epidemics and Controlling Communicable Diseases

Target 3.3 specifically calls for ending epidemics of HIV/AIDS, malaria and tuberculosis (three major 'communicable' or 'infectious' diseases that are the focus of sustained global control efforts) and of a collection of diseases grouped because of neglect. A high population burden of communicable diseases is generally linked to poverty and underdevelopment. Poverty is deepened by ill health, the costs of seeking treatment and lost livelihood. The control of communicable diseases has increased globally with good health literacy (particularly regarding sanitation, food safety and minimising interpersonal, vector and zoonotic transmission of infections), vaccination

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programmes, surveillance and response. In poor countries and regions, the capacity and effectiveness of health systems to provide these services (Target 3.8) is often limited – particularly for remote communities, including those in forested regions.

Many important communicable diseases have little or no association with forest ecology (such as influenza, tuberculosis, viral hepatitis and sexually transmitted infections other than HIV), although they may affect forest-associated populations. However, seeking to fulfil Target 3.3 has implications for forest management with regards to malaria and some other forest-origin or associated diseases.

Malaria affects 219 million people, with almost half a million deaths (in 2017), 90 per cent in sub-Saharan Africa (WHO 2018a). The global campaign focuses on eradicating the malarial parasite with the use of insecticide-impregnated bed nets, domestic spraying, diagnosis and treatment (Bauhoff and Busch 2018). However, the density and activity of vector mosquito populations can be affected by deforestation, particularly in Asia and Latin America. Rutted ground and roads resulting from forest clearance, forest edges and cleared patches provide free-standing water, optimum temperature and protection from desiccation for mosquito development – often transiently – and may favour vectors over non-vectors (Guerra et al. 2006). This knowledge can be used locally to reduce malaria through forest management, but is more commonly used to identify risk. Forest workers may be susceptible to local infection or exposed to new species of malaria as they penetrate new forests, as demonstrated in the emergence of monkey malaria (*Plasmodium knowlsei*) as a new human disease (Barber et al. 2017). Infected forest workers may also introduce malarial parasites to disease-free forests. In frontier settlements, children (highly susceptible), if not adults, will perpetuate and amplify malarial infection. Disease fronts can establish: 99 per cent of Brazil's malaria now occurs in the Amazon basin (Chaves et al. 2018).

The so-called Neglected Tropical Diseases with either significant prevalence in forest-based populations or with a link to forest transformation, positive or negative, are listed in Table 3.2. Many of these conditions afflict Indigenous and other forest-dwelling populations and are strongly associated with poverty, low health literacy and poor or underfunded health services (Target 3.8). Relatively simple medication, if available and affordable, can have a dramatic effect on many of these diseases. Forest management may also play a part in the prevention of some of these disease conditions.

HIV/AIDS is among a new group of infectious diseases, recognised since the 1970s, that have wildlife and environmental origins. For HIV/AIDS, its forest association is historic (Sharp and Hahn 2011). It is now a human-specific

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Table 3.2 Neglected tropical diseases and forests

Neglected tropical disease	Deforestation effect					Comment
	Direct	In direct	Worsened	Improved	Mixed	
Schisto-somiasis		Y	Y			Results from post-forest land-use change, particularly involving water/irrigation; affects many tropical regions, but not South Asia
Soil transmitted helminths	Y	P	Y			Forest-to-crops conversion can change soil biodiversity; decreased soil-pathogen competition promotes threadworm/hookworm, especially with increased soil moisture following flooding; increased site-contamination for resettled (previously mobile) forest groups associated with poor sanitation, bare feet, open defecation
Buruli ulcer		Y	Y			Geographically associated with upper catchment areas; also wetlands recently converted to farming
Chagas disease	Y		Y		Y	Associated with forest workers/poor housing; deforestation favours synanthropic triatominae (e.g. *T cruzi*) and wild mammal hosts, amplified in palm oil plantations
Leishmaniasis (Kala Azar)	Y		Y		Y	Associated in Latin America with forest clearing/residential expansion and synanthropic vector/host combinations; some vector sand fly and host wildlife species persist in modified/plantation forest; associated in Sudan with forest/peri-forest exposure

Onchocerciasis (river blindness)		Y	Y		Y	Reduced disease associated with deforestation and loss of shade, but difficult to separate impact of wide scale use of DDT (1970s); in West Africa deforestation appears to have expanded the range of vector
Echinococcosis		Y	Y		Y	Land-use change in South China favours different hosts in endemic area – transient increases following deforestation, resurgence following reforestation; increases in Europe/North America due to urbanisation of foxes/landscape transformation
Snakebite	Y		Y			Risks to forest workers; some snakes have colonized suburban and urban areas, exploiting new synanthropic resources (like rodents)
Yaws		Y				Endemic in some remote forested locations; compounded by lack of healthcare access (e.g. Congo Pygmies); also serve as infection reservoir for gorillas
Lymphatic filariasis	Y	**Y** **P**				Risk to Malaysian forest workers from sub-periodic *B. malayi* vectors and wildlife reservoirs (e.g. leaf monkeys)
Sleeping sickness	Y			Y		Scrub clearing originally used to reduce tsetse fly infestation (West Africa); significant disease risk appears in SSA wet tropical forests; most cases in DR Congo
Rabies	Y	P				Deforestation impacts on host (vampire) bats increases overlap with humans (likewise for bat hosts of lyssavirus in Australia). Most human transmission via peridomestic dogs

Table 3.2 (cont.)

Neglected tropical disease	Deforestation effect					Comment
	Direct	In direct	Worsened	Improved	Mixed	
Dengue, Chikungunya **(arboviruses)**	Y	Y	Y			Associated historically with forest clearing/sylvatic cycle/peri-domestic vector; deforestation drives new risk of sylvatic strains of Dengue although urbanisation provides better vector habitat (*Ae. aegypti* most closely associated with human habitation and indoors, also *Ae. albopictus*)
Leprosy		Y/P				Wildlife reservoirs (e.g. armadillos) may be impacted in the Americas
Deep mycoses	Y	P				Risk to forest and agricultural workers from agricultural plants (e.g. tea, rubber) and forestry; highest numbers in Madagascar and Brazil
Scabies		P	Y			Wildlife reservoirs including forest spp. play minor role
Trachoma	Y	P	Y			Desertification – as sequelae to deforestation, associated with dry dusty conditions, lack of water for adequate face washing)

(P = association with poverty, poor sanitation and access to healthcare; Y = yes; SSA = sub-Saharan Africa) virus of global significance: currently, 36.9 million people have HIV/AIDS, two-thirds of whom live in Africa (WHO 2019a).

Forest dwellers and workers are among those who continue to be impacted: it easily spreads with extractive industries, associated with ad hoc development (with transient single males or prostitution). For those afflicted it increases demands for traditional medicines, food and income (Lopez 2008). Access to adequately funded and resourced health services with appropriate education and anti-viral medication is critical to supporting at risk and infected individuals (Targets 3.8, 3.C).

Other forest-origin diseases include Ebola, Zika, Nipah and SARS corona virus. These have also caused significant outbreaks in recent decades. Increasing human density in biodiverse areas has been associated with the emergence of these diseases (Jones et al. 2008). Contact (often indirect) between wildlife (particularly bats, rats and primates) and humans through consumption, dispersal of hosts following habitat loss, amplification following loss of predators or competitors, and exposure through deforestation, road construction and wildlife farming provide opportunities for cross-species virus transmission. Relatively few diseases have gone on to be capable of sustained human-to-human transmission. Many others episodically spill over from their wildlife and environmental sources and are local health risks. For example, 39 of 187 arboviruses (transmitted by mosquitoes) identified in the Amazon basin during road construction can cause disease in humans (Vasconcelos et al. 2001).

Importantly, forest-origin diseases are not limited to the tropics, developing countries or even to deforestation. For example, Lyme disease is a significant risk to recreational forest users and residents in the USA and has expanded its range as a result of reforestation of previously cleared areas and altered host-pathogen dynamics. While bringing many benefits, the novel ecology of human-modified environments, including restored forests, plantations and urban parks, creates opportunity for new species combinations and disease emergence (McFarlane et al. 2012).

Predicting and preventing the next pandemic (i.e. multi-country epidemic) has been a focus of research and investment with consequences for forests, forest dwellers and the global population, as efforts are best employed to stop the spread, and possibly the emergence, at the source. Initiatives such as the US Agency for International Development Emerging Pandemic Threats programme have deployed scientists to remote forests to catalogue wildlife pathogens. Such programmes assist Target 3D to strengthen the capacity, particularly in developing countries, for early warning, risk reduction and management of national and global health risks. In regions where the burden of traditional infectious diseases remains significant, foreign investment in identifying pathogens that may cause future pandemics (capable of reaching developed nations) has the potential to create tensions, as well as fear. This may be sensitively and usefully navigated on a community or country basis. However, the experience of the 2013–16 Ebola pandemic in West Africa illustrates the complexity of stopping outbreaks of even identified diseases.

Ebola virus was identified in 1976 in Zaire and Sudan, with episodic outbreaks in Central Africa, associated with climatic and environmental factors, multispecies wildlife mortality and bushmeat consumption (Real et al. 2017). The virus recently spread to West Africa, potentially as habitat change and food availability impacted the ecology of the speculative bat hosts. Across West Africa in recent decades, agriculture, palm oil and other plantations have accelerated forest transformation, impacting fruit bat ecology (Wallace et al. 2014). The virus transmission that began the West African outbreak is believed to have occurred when a child played in a tree where bats roosted. However, it was the subsequent movement of infected people and the poor capacity of local health systems to perform surveillance, identification, containment or treatment of infected people that enabled the virus to spread extensively, resulting in 28 616 suspected cases and 11 310 deaths.

Disease regulation as a proposed ecosystem service of intact or pristine forests (Millennium Ecosystem Assessment 2005) is not broadly applicable. There is no doubt that ecological change can alter infectious diseases epidemiology, but there is no simple inverse relationship (Tucker Lima et al. 2017). Indeed, new zoonotic diseases from wildlife may ultimately cease emerging as a result of ongoing forest destruction and biodiversity loss. Sophisticated epidemiological understandings have provided targeted approaches to lowering risk, but these rarely promote forest conservation. For example, the 1998 outbreak of Nipah virus in Malaysia and Singapore, traced to contact between fruit bats (facing habitat loss and/or escaping haze from forest fires) and intensively farmed pigs, has not reoccurred, due in part to removing bat-attracting mango trees from pig pens (Pulliam et al. 2012). The example of Ebola illustrates the vast spatial and temporal scales over which the clearing, burning and replacement of forests may have altered the migratory patterns, population sizes and distributions of wildlife hosts. Although the capacity to address such scales is not currently available, ecosystem-based approaches to disease prevention that maximise co-benefits for people and nature are evolving (McFarlane et al. 2018).

WATERBORNE DISEASES

Waterborne diseases refer to a diverse group of pathogens including protozoa (such as giardia and cryptosporidia) and bacteria (such as typhoid, cholera and dysentery). Forests have a role to play in reducing illness and deaths from waterborne diseases and pollution through the protection of water catchments, reducing the impact of flooding, and in local climate regulation. Both the excess of water (e.g. flooding and faecal contamination) and its shortage (e.g. droughts and limited water for proper sanitation) can increase the risk of waterborne diseases, making climate change a concern for this group of diseases. The WHO estimates that waterborne diarrhoeal diseases were responsible for 2 million deaths in 2017, with most occurring in children under 5 (WHO 2018b) (see Target 3.2).

Natural (upper) catchments have reduced exposure to pollutants and waterborne pathogens associated with human and livestock activity. Additionally, forested watersheds generally offer higher-quality water than alternative land uses and do so at a lower cost than equivalent technology. For example, in 1997 New York City conserved the Catskill Mountains (the city's main water source) rather than install a new water filtration plant costing USD 4–6 billion, with USD 250 million a year in operating costs (Chichlinisky and Heal 1998).

The biophysical properties of forests also contribute to water quality. In Fiji, catchments cleared of their forest cover, or where riparian vegetation has been lost, show elevated incidence of waterborne infectious diseases such as typhoid and leptospirosis (Jenkins et al. 2016). Forested catchments also improve water discharge and protect against downstream flooding, although this is influenced by specific properties of the forest and catchment and the extremity of flooding (Chandler et al. 2018).

3.3.2 Reducing Non-Communicable Diseases and Promoting Mental Health

NON-COMMUNICABLE DISEASES

Target 3.4 calls for calls for a one-third reduction in premature mortality from non-communicable diseases (NCDs). NCDs are responsible for almost three-quarters of all deaths globally, the majority of which occur in low- and middle-income countries. Six NCDs are included in the top 10 global causes of mortality (WH0 2018c): cardiovascular diseases, stroke, chronic obstructive pulmonary disease, Alzheimer's disease, respiratory cancers and Type 2 diabetes. Unhealthy diets, physical inactivity, exposure to tobacco smoke and the harmful use of alcohol are considered the most important NCD risk factors.

The global increase in overweight and obesity and its many associated health conditions, including cardiovascular diseases, diabetes and cancer, is in part connected to excess food consumption and reduced physical exercise. Unhealthy diets, particularly with high fatty and red-meat intake, as well as nutrient-poor, energy-dense diets, are increasingly common among poor populations in low-income settings with limited health literacy. Genetic factors make some populations especially vulnerable to diabetes. Frequently, depression, social exclusion, vulnerability and a sense of being exploited contribute to these unhealthy behaviours. The importance of forest protection for exercise and mental health are discussed below. First, we draw attention to the impact of two components of unhealthy diets on the destruction of forests.

There is a strong link between high red-meat consumption (especially beef) and the risk of death from heart disease, other NCDs and several forms of cancer (Kmietowicz 2017). Worldwide, meat production has tripled over the last four decades, increasing 20 per cent in the last decade alone. Demand for red meat, historically popular in Western countries, is growing in developing economies, in part because of its perceived status. Beef production is a major driver of deforestation, woody encroachment of savannahs and desertification. Production of livestock feed crops and pastures are the major cause of deforestation of Amazonian forests (Armenteras et al. 2017). Extensive grazing drives deforestation elsewhere, including Australia's tropical savannas, the world's largest intact savanna ecosystem. Increased cattle numbers contribute to rising quantities of the potent greenhouse gas methane as well as nitrous oxide – important issues for SDG 13 (Climate Action). Excessive beef production is deeply problematic in an era striving for sustainable development, and it has profoundly adverse health consequences (Potter 2017). Awareness of these harms has not driven per capita reduction of meat production or consumption in traditional (developed) producing countries.

Another leading cause of tropical deforestation with adverse impacts on diet is the production of palm oil. Palm oil is an affordable source of cooking oil and is valuable as a replacement for polyunsaturated oils, which have the potential to form harmful trans-fatty acids. A modest ingestion of palm oil appears to be safe; however, as a widely used ingredient of calorie-dense processed foods, it can be injurious. Indonesia and Malaysia produce 86 per cent of the world's palm oil, significantly contributing to their economies (WWF 2018). Production and continued expansion in these countries comes at a very high cost to native forests (and Indigenous peoples), along with significant harms to health.

In contrast, conserving forests as a source of nutrient rich foods is important for associated Indigenous people and subsistence farmers (Ickowitz et al. 2016). Micronutrient deficiencies affect two billion people worldwide, predisposing them to disease and poor cognitive development. For forest-associated groups, there can be a cost-effective synergy of healthy people, food harvesting and stewarded forests. This should be valued against the destruction of forests for unhealthy global diets, hunger reduction (SDG 2) and the production of greenhouse gasses (SDG 13).

MENTAL HEALTH

The WHO reports that 14 per cent of the global burden of disease is attributed to mental health disorders, with 75 per cent of affected people from low-income countries (WHO 2018c). The role of forest loss in these figures is not known. However, the stimulation and stresses of urban life – more than half of the global population live in urban areas – has generated interest in the consequences of nature deprivation, a situation forewarned in the 1950s by René Dubos, one of the founders of ecological public health at the planetary scale. There are also impacts for Indigenous and other non-urban forest people. For many, the landscapes of personal and community significance have disappeared, often rapidly and recently. Solastalgia – the psychic or existential stress caused by environmental change (Albrecht et al. 2007) – can be profound and amplified by disempowerment, marginalisation, the loss of religious or cultural sites and identity.

Most of the research and practice concerning natural environments and mental (and physical) health is undertaken in urban and developed settings. That increased exposure to high-quality green and blue space (tree-lined streets, parks, gardens and water views) is beneficial to physical and mental health is intuitively attractive to all who value nature. However, as with the disease regulation theory, the idea that exposure to green space is automatically beneficial to health is simplistic. Many of the world's poorest and least healthy populations, including Indigenous and other populations living in or around forests, are exposed to considerably more green space than the average urban inhabitant, yet have poor physical health. While absence of nature contact may be harmful, abundant exposure does not fully offset other risk factors for ill health.

For most of the global population now classed as urban dwellers, there is evidence of positive effects of visiting or even having green space in one's neighbourhood, not just for the wealthier in leafy suburbs. Gains may be greatest for groups otherwise deprived of access (Taylor et al. 2015). There is growing evidence that biological diversity is responsible for some of the reported positive effect (Aerts et al. 2018). Biological mechanisms account for some of the reported health benefits. For example, in addition to the physiological contributions to cardiovascular health from increased exercise, cleaner air and less noise (Donovan et al. 2015), there is growing evidence that the human microbiome may be enhanced by exposure to biodiverse environments, including forests (Prescott et al. 2016). Immune function and other objective biomarkers for health, such as cortisol levels and blood pressure, may also be improved (Rook 2013). Some studies have found that even brief interactions with nature can produce marked increases in cognitive function (Berman et al. 2008).

The distribution of green space across cities is now considered a source of health inequity, recognised broadly, for example, by the European Environment Agency and as a specific target within SDG 11 (Sustainable Cities and Communities). Box 3.1 discusses this in more detail.

Box 3.1 Urban Forests and Health

The term 'urban forest' has been in use since the 1970s and includes all trees within a metropolitan boundary. There is growing recognition of urban forests' importance to health and, more recently, also its ecological value.

Health benefits include reduced flows and nutrients in storm water, pollution control, shade and urban heat island reduction, by 4–5°C in some settings (Livesley et al. 2016) – of growing importance under climate change. Trees reduce air pollution due to cars, industry and coal burning. All tree species capture PM10 (particulate matter up to 10 microns in diameter), but some are much more efficient than others (Manes et al. 2016, Yang et al. 2005). Trees can store and remove carbon and, depending on type and form, reduce particulate matter by 7–24 per cent. The urban forest also provides opportunity for residents to have some contact with nature and to garner its benefits, such as reducing developmental issues in children and behavioural issues in young adults, improving mental health more generally, and as a backdrop for exercise (see Target 3.4). Improved recovery time in patients with natural views or direct exposure to nature has led to the purposeful planting of trees around hospitals and medical centres (CSH 2018). Interestingly, exposure to virtual forests (and nature) is reported to have significant impact on cognitive function in people with dementia (Moyle et al. 2017).

However, some trees (such as poplars) emit volatile organic compounds that interact with car exhausts and increase the concentration of ground-level ozone, particularly during heatwaves (Willis and Petrokofsky 2017). Trees provide habitat for urban animals, including birds, squirrels, possums, monkeys and bats, providing many valuable benefits, though some carry infectious diseases, e.g. West Nile virus, Lyme disease, Hendra virus (McFarlane et al. 2012). Another drawback is hay fever, which can be debilitating, from allergenic plants, including trees with high pollen counts. Increased risks of fires in towns and cities due to climate change can be aggravated by urban forests.

Nevertheless, urban forest design, sometimes referred to as green infrastructure, is potentially a significant factor – and is increasingly recognised – in human health and ecosystem service protection and conservation (Kowarik and von der Lippe 2018).

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Outside cities, there is further evidence of positive effects (Maller et al. 2006). In South Korea – a highly industrialised, urbanised nation with a high rate of suicide – the therapeutic exposure to national parks is now being vigorously promoted. In Japan, the term *shinrin-yoku* refers to the practice of 'forest bathing' for well-being, with growing evidence that this is beneficial. The positive benefits of spending time in wilderness to deal with death, including one's own, have been investigated in Canada. New Zealand has pioneered 'green prescriptions' that recommend physical activity, a concept that has grown to include the added benefits of exercising in nature. The Healthy Parks Healthy People (HPHP) movement, particularly active in Australia and the USA, promotes the benefits of park use to increase social well-being and reduce NCDs. HPHP has also pioneered some significant cross-sectoral relationships between government health and environment sectors.

In summary, there is persuasive evidence of benefits to mental and physical health from increased exposure to forests, at least for those for whom it is not a daily event. These benefits are likely greatest for those living in urban areas and whose basic health needs (nutrition, housing and an income allowing dignity and physical security) are largely met (Tomita et al. 2017).

MENTAL AND PHYSICAL WELL-BEING BEYOND THE URBAN FOREST

The suffering, especially mental, when Indigenous and other peoples lose their forests has been relentless for centuries and continues today, although poorly documented and almost universally overlooked by the colonising groups. An authentic commitment to reduce mental health suffering resulting from the forest-conversion actions of others requires protecting forests and the rights of their traditional custodians (e.g. West Papuans and the Congo Pygmies; Ohenjo et al. 2006). Prohibition of forest use, including for culturally important products such as bushmeat or medicine, regardless of the abundance of non-traditional alternatives, may cause psychological unrest and affect well-being (e.g. various Congo basin forest peoples; Dounias and Ichikawa 2017).

Protecting the eudemonic well-being of many groups and populations not resident in forests is still deeply grounded in forest protection. Collective well-being is reflected, for example, in respect for sacred sites or ancestors and the opportunity to pass on biodiverse natural resources and customary tenure rights to future generations, in turn protecting well-being, identity and kinship (Fritz-Vietta 2016). An estimated 5–8 per cent of global forests are considered to be sacred. Protecting these forests has profound consequences for people as well as conservation. For example, monk-led community conservation of 18 000 ha of rare lowland evergreen forest in Northern Cambodia, motivated by reverence for the example and teaching of Buddha, has been

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focal in post-Khmer Rouge community recovery (ARC 2010). In summary, forest conservation promotes mental well-being in diverse ways.

FORESTRY ACCIDENTS

Statistics on forestry accidents are difficult to obtain and are sparsely reported outside developed nations. Available reliable data suggest that forestry-related work is extremely hazardous. Occupational health and safety for many who work in forestry is poorly regulated, particularly for those who work informally. Tree felling is the deadliest occupation in forestry; in developing countries, chainsaws may be involved in nearly half of all forestry accidents. Other reported issues include chemical exposure (e.g. pesticides), hearing loss, heat- and cold-related diseases, repetitive stress syndromes and musculoskeletal trauma (Garland 2018). Sedentary machine operators have increased risk of diabetes and obesity. Addressing SDG 3 targets would benefit these groups and those exposed to hazardous chemicals. Halving road traffic accidents globally (Target 3.6) would also benefit forestry workers.

3.3.3 Reproductive Health and Family Planning

Target 3.7 calls for universal access to sexual and reproductive healthcare services, including family planning, information and education, and the integration of reproductive health into national strategies and programmes. Although this target encompasses a range of important issues, its most relevant aspect to forests (and the other SDGs) is to promote access to contraception and thus to slow population growth (Starbird et al. 2016).

There is abundant evidence that rapid population growth hinders economic development, intensifies resource insecurities and environmental damage, and fuels conflicts (Bongaarts 2016, Butler and Higgs 2018, Husain et al. 2016, Population Institute 2015). No country has been able to advance from least-developed status while fertility remains above four children per woman, unless (and only for as long as) it has vast oil or other natural-resource income. Generally, economic development has only taken off after fertility falls well below three children, being highest in countries with below-replacement fertility (O'Sullivan 2017). Successful voluntary family planning programmes preceded the economic growth of the East Asian tiger economies.

Forest-dependent people, including Indigenous minority groups, tend to have higher fertility than their national averages and are disadvantaged in access to family planning. This impacts family finances, resource security and the health and well-being of women and children, as well as demands on forests. Smaller families and wider child spacing mean more investment per child. Universal access to family planning would help close the development gap between forest dwellers and urbanised communities.

Even in developed countries, more than 40 per cent of pregnancies are unintended. Access to contraception and the outcomes of unwanted pregnancies are problematic for many (Foster et al. 2018), and each birth draws more heavily on Earth's natural resources (Wynes and Nicholas 2017).

Population growth is a major driver of forest loss. The Food and Agriculture Organisation of the UN (FAO 2016) reports a strong correlation across regions between forest loss and increase in rural population. Traditional swidden agriculture relies on long forest fallows, but as fallow periods shorten under population pressure, forest remnants shrink and become degraded before being permanently cleared. Commodity-driven deforestation is reported as the largest category of forest loss (Curtis et al. 2018) but small-holder plots are also cleared for 'commodity agriculture', often enabled by nearby large-scale commercial plantations or new roads through forests. In Africa, subsistence agriculture is the dominant cause of forest conversion (Curtis et al. 2018). Burgeoning population and affluence in emerging economies increases commodity demand; this is also driven by affluent populations globally.

The IPCC-led[1] modelling of future climate change scenarios found that limiting warming to 2°C is only feasible with population growth much lower than current UN projections. A major stumbling block is agricultural demand, making further deforestation unavoidable (Riahi et al. 2017). The World Resources Institute estimates that achieving replacement-level fertility (about 2.1 children per woman) by 2050 could save an area of forest the size of Germany, seeing this as 'a multi-win solution to humanitarian, economic and environmental challenges, and an important item on the menu for a sustainable food future' (Searchinger et al. 2013: 2).

How much population-growth reduction may be achieved by the SDGs is complex and uncertain. Since the 1980s, the 'demographic-economic' rationale for slowing population growth, once a central pillar of the development agenda that influenced many norms, has been diluted, largely replaced by reproductive health services, emphasising only the 'reproductive health and rights' rationale for family planning, undertaken in many developing countries by poorly funded health ministries and some NGOs (Bongaarts 2016). The reproductive health and rights framing is today missing two vital ingredients: political will, stemming from the conviction that high population growth threatens economic development, and a focus on motivating people to want smaller families and to use contraception. Together, these elements can reduce the fatalistic acceptance of large families and gain support for family planning even in patriarchal societies.

[1] Intergovernmental Panel on Climate Change.

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There are tentative signs of rekindled interest in the demographic rationale. Integrated development projects, under the 'population, health and environment' (PHE) model (Oglethorpe et al. 2008), are gaining recognition for achieving behavioural changes more rapidly than single-sector interventions, e.g. in environmental management, health and sanitation practices and diversified livelihoods, as well as those embracing smaller families and women's access to education and employment (see Box 3.2).

Box 3.2 Conservation, Community Health, Family Planning and Livelihoods

Conservation initiatives have recognised the importance of supporting the health and livelihoods of local populations in high-conservation-value areas for some time (Ancrenaz et al. 2007). This is strongly supported within organisations such as the International Union for Conservation of Nature (IUCN), the UN Development Programme (UNDP) and the Word Wide Fund for Nature (WWF), and it takes many forms.

In North Kayong, Kalimantan, Indonesia, the Alam Sehat Lestari (ASRI) clinic provides villagers with the most extensive healthcare services in the area and incentives to stop them from logging in the adjacent Gunung Palung National Park, such as 70 per cent discounts on medical fees. The clinic represents an alternative to health services provided by forestry companies. Patients who cannot afford medical fees, and so might otherwise resort to illegal logging, can choose to pay with various non-cash options, including native seedlings or labour. ASRI replants forests and trains ex-loggers to farm and run alternative businesses through a chainsaw buy-back scheme. Since inception, the number of logging households has decreased by 89 per cent, primary forest loss has stabilised and infant mortality has declined from 3.4 to 1.1 deaths per 100 households. This model is now being replicated elsewhere on the island of Borneo (Webb et al. 2018).

The Bwindi Impenetrable National Park in Uganda is home to about half of the world's remaining mountain gorillas. Conservation Through Public Health (CTPH) was initially established to address the transmission of diseases between gorillas, livestock and human populations. As it quickly became apparent that diversified livelihood assistance was needed to reduce park incursions, the project added livestock and microfinance programmes. It soon added family planning, realising that many parents were having more children than they wanted, while population growth countered conservation efforts. The project demonstrated strong synergies in cross-sectoral work, as the trust built through one area made communities more receptive to information in other sectors. Health and livelihood activities built support for conservation goals; ecological

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Box 3.2 (cont.)

understanding generated enthusiasm for family planning. Contraception use increased twelvefold, to more than 60 per cent of women. Gorilla numbers have subsequently increased (Wilson Center 2013).

The model adopted by CTPH is the PHE approach (Oglethorpe et al. 2008). PHE projects recognise that tackling population growth is crucial for the long-term sustainability of environment and development interventions. By engaging with communities on their own priorities and enabling them to draw linkages between their livelihoods, resource base, family size and ability to educate and provide for children, they are motivated and empowered to overcome cultural barriers to change. PHE projects have particularly built male support for family planning and female participation in natural resource management. Since the early 2000s, PHE projects have gained increasing recognition. Many established projects, such as Ethiopia's Ethio Wetlands and Natural Resources Association and Papua New Guinea's Tree Kangaroo Conservation Programme, have adopted PHE approaches to enhance their impact. CTPH is a role model for several other PHE projects and a successful advocate for PHE to be recognised and scaled up through government agencies.

3.3.4 Universal Health Coverage and Affordable Essential Medicines

Target 3.8 strives to achieve universal health coverage, including financial risk protection, access to quality essential healthcare services and access to safe, effective, good-quality and affordable essential medicines and vaccines. Seeking this goal has potential beneficial effects for forests and people. Universal health coverage would benefit forest dwellers and forests since few options exist in remote forest locations to access modern healthcare or pay for it – other than through illegal timber felling, hunting bushmeat or illegal pet or medicinal plant trade. Many conservation groups recognise this relationship (Box 3.2). Additionally, through enhanced protection of genetic resources, as proposed by the Nagoya Protocol (Convention on Biological Diversity), the vast traditionally used and potential medical resources provided by forests may receive better protection.

PROTECTING THE NATURAL PHARMACOPOEIA

Traditional knowledge derived from a close relationship to nature is extremely important for pharmacological resources locally and globally (Fabricant and Farnsworth 2001). Many drugs are derived from compounds found in plants, often identified via their traditional use (Chivian and Bernstein 2008).

Conservative estimates of flowering plant species worldwide is 250 000; there is likely an abundance of drugs yet to be discovered.

Preserving and maintaining biodiversity and associated traditional knowledge is extremely important for the cultural well-being of local communities. The WHO estimates that up to 80 per cent of developing country populations rely, in part, on traditional medicine for their primary healthcare needs (WHO 2015). In many settings, traditional health systems are culturally preferred, and often based on complex social and spiritual relationships and directly dependent on natural resources. However, traditional knowledge and associated pharmacological knowledge is vanishing very quickly (Reyes-García et al. 2013). So too are many therapeutic plant and fungal species, although intensive efforts are being made to identify species with potential therapeutic value.

Fulfilling Target 3.8 is likely to protect forest ecosystem services in two ways. The first benefit is the protection of unidentified 'natural pharmacopeia': ethically exploring, cataloguing and protecting traditional knowledge about natural pharmaceutical properties can help identify useful remedies. In parallel, protecting as many species as possible, particularly in their traditional settings (as stated in the 2010 Nagoya Protocol, also linked to SDG 15, Life on Land), can ensure this knowledge can be tested and applied if found beneficial. This can be summarised as protecting the unidentified 'natural pharmacopeia'.

The second benefit will flow from a more thorough investigation of the possible 'false pharmacopeia', referring particularly to animal parts, but also some plants and fungi, that have zero, marginal or even adverse health benefits, yet are harvested from the wild (especially for consumption by large urban markets) and have significant harmful ecological effects despite their cultural importance. Numerous wildlife species, some inhabiting forests, have been pursued to (near) extinction for their alleged pharmaceutical benefits, including charismatic mammals such as the rhinoceros, snow leopard and tiger, as well as the humble pangolin (Byard 2016). Evidence of therapeutic benefits for many traditional remedies involving animal parts is extremely limited.

3.3.5 Improving the Quality of Air, Water and Soil

Target 3.9 calls for a *substantial* reduction in the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination. There is broad recognition of the health burden of air pollution, particularly from fossil fuels and petrochemicals, as well as its disproportionate impact on the poor (Landrigan et al. 2018). This, and to a lesser extent water and soil pollution control, has several direct implications for forests. Exposure to hazardous chemicals, particularly pesticides, is a recognised risk for forestry workers (Garland 2018).

AIR POLLUTION

Air pollution is chiefly from the combustion either of fossil fuels such as coal and petroleum or of biomass. The latter include forest fires, a burn following clearing of forests, and/or the burning of organic-rich forest soils (peats). The frequency of peat fires appears to be increasing due to climate change (Seidl et al. 2017), via intensifying drought, heat, stronger winds and increased dry lightning storms. Other forms of biomass combustion relate to burning as an agricultural practice, as a form of land management and as a household fuel.

HOUSEHOLD-ASSOCIATED AIR POLLUTION

Biomass, including dung, crop residues and wood, provide the main cooking fuel for at least 2.8 billion people (Bruce et al. 2015). Much of this is combusted inside dwellings with poor ventilation, contributing to high rates of respiratory and other diseases. Increasingly referred to as household-associated air pollution (Goldemberg et al. 2018), smoke-induced diseases are responsible for the premature death of 4.3 million people annually, with women and young children most affected (Bruce et al. 2015). An estimated 500 000 children under 5 die each year of preventable and treatable respiratory conditions, worsened by household air pollution, undernutrition and inadequate health care (Langbein 2017). Considerable effort over decades has been directed to developing low-cost, safer cooking stoves, but with variable success (Goldemberg et al. 2018). Furthermore, gathering fuelwood can have significant environmental impact, in some areas driving desertification (Masera et al. 2015).

Any successful attempt to attain SDG 3.9 needs to promote the replacement of forest products with forms of energy less damaging to health and the environment. This may be possible through large-scale electrification using wind and solar power (or with hydroelectricity, as in the case of Ecuador); yet, in most settings the cost of clean electrical power (e.g. solar, wind or hydro), though increasingly plausible for lighting, is still too high to make this a likely prospect for populations living away from centralised, reliable energy supplies. Gas is being increasingly used, especially in Brazil and India; though far better for health, it still results in significant carbon emissions and is unaffordable for most (Goldemberg et al. 2018). The flooding of forests and farmland to produce hydroelectricity has been a source of controversy in many areas, particularly when benefits are realised at a distance from the land lost.

RESPIRATORY DISEASE ASSOCIATED WITH FORESTRY

Specific hazards associated with wood processing and manufacturing industries (e.g. inhaled sawdust, pulp and mould) can lead to a range of bacterial, fungal and airborne endotoxin infections, generating respiratory disorders such as wood workers' lung and hypersensitivity pneumonitis (Adhikari et al. 2015, Sforza and Marinou 2017). These conditions can affect not only workers but also people living in the vicinity of these industries.

FOREST FIRES AND TRANSNATIONAL AIR POLLUTION

In some parts of the world, especially Southeast Asia, the Amazon and sub-Saharan Africa, the deliberate, seasonal burning of forests, mainly to promote agriculture and plantations, creates a substantial health hazard (Johnston et al. 2012). For example, forest burning during the dry season in Kalimantan and Sumatra (Indonesia) contributes regularly to dangerous levels of air pollution. In 2015, as climatic conditions resulted in drought and greatly intensified fire activity in the region, persistent, hazardous levels of smoke pollution (haze) resulted in an estimated 100 000 deaths across Indonesia, Malaysia and Singapore – more than double those from previous reported events in 1997 and 2006 (Koplitz et al. 2016). Such hazardous conditions can cause schools and many workplaces to close, grounding of air traffic and residents being encouraged to stay indoors. Not all residents can gain respite indoors or have means to evacuate. In 2002, several ASEAN[2] nations passed a Transboundary Haze Pollution Act that financially penalises companies for smoke-haze activities beyond the borders of individual countries. Since 2017, sustainability certification of forest industries in Indonesia has significantly reduced deforestation and associated fires (Carlson et al. 2017). Similar concerns over the quartet of forest fires, particulate matter pollution, respiratory disease and carbon emissions exist in the Amazon basin.

FORESTS, WATER AND SOIL

All measures that protect agricultural productivity and ensure food and water safety have significant benefits for health. Forests enhance soil biodiversity and organic matter recycling; limit desiccation, erosion and dryland salinity; and promote pest control by providing shelter for pest-predators. The capacity of forests to reduce soil contamination from pollutants may be significant, yet it remains under-researched. Phytoremediation of contaminated

[2] Association of South East Asian Nations

land (including heavy metals and radioactive material) does utilise some tree species, as well as grassland and forbs. Large, uncontrolled forest fires can result in water pollution that reduces the quality of water emerging from forests.

CLIMATE CHANGE, FORESTS AND HEALTH

Climate change primarily results from the accumulation of heat-trapping gases in the atmosphere. It can thus be conceptualised as a form of air pollution, worsened not only by the transfer of carbon in fossil fuels but also from biomass (including in the soil) and, increasingly, from tundra and peat to the atmosphere (and ocean). Its health effects are protean, but still largely in the future. Heat stress for outdoor labourers, already significant where conditions and underlying health are poor, will amplify in impact, affecting many people in and near forests engaged in such labour. Further impacts, including direct trauma, are anticipated from heatwaves from other forms of extreme events, including rising sea levels, storm surges, droughts, flooding, fires and high winds.

Addressing Target 3.4 by reducing forest destruction, including fires, would have the co-benefit of reducing carbon emissions (not only of overlying vegetation but in some cases underlying peat), which can be of global significance during El Niño years (Page et al. 2002). Emissions from peat oxidation resulting from water-table lowering add to the carbon burden. In Southeast Asia, forest and swamp conversion for plantations and other agriculture means that a major carbon sink is now a carbon source (Miettinen et al. 2017). Reducing emissions from deforestation and forest degradation, and reducing health impacts of climate change, are already important elements of UN climate policy. Additionally, the potential for coastal mangrove forests to provide protection from coastal storm surges is now contributing to their conservation (Feller et al. 2017), and the ability of the urban forest to reduce a city's temperature is increasing recognition of the value of trees (Box 3.1). Action to avoid tipping globally important forest areas into other, post-clearance ecological states additionally protects future carbon sequestration (Miettinen et al. 2017).

Other impacts on health through climate change are manifold: global food price increases, local crop failures (to which subsistence populations are particularly vulnerable), reduced labour productivity and alterations in the epidemiology of vector-borne and other infectious diseases. In the long run, perhaps most importantly, the highly indirect, politically mediated 'tertiary' effects from famine, economic disruption, population displacement and conflict will prove most harmful (Butler 2014).

3.4 Summary and Recommendations

Table 3.3 summarises the impacts of implementing SDG 3 targets on forests and forest-dwelling people. Benefits to forest people assume targets will be pursued through a social justice lens (poor-preferencing) or at least neutrality, so that, at the minimum, forest people are not disadvantaged by development.

In theory, most SDG 3 targets can be improved in ways that protect forests, as discussed in this chapter. In reality, the pathways are predicated on increased economic growth (and possibly population) and that is likely to cause harm to forests, rather than be beneficial or neutral. Finally, we conceptualised the links between forests and population health at three scales (Figure 3.1) and summarise the findings of this chapter in this way.

Table 3.3 Summary of impacts of implementing SDG 3 targets on forests and forest people: benefits (green), context-dependent harms or benefits (yellow)

SDG 3 targets		Impacts	
		On forests	On people
1	Reduced maternal mortality		
2	Reduced neonatal and under-5 mortality		
3	Communicable disease control		
4	Reduction of non-communicable diseases and mental health problems		
5	Prevent substance abuse		
6	Road traffic accidents		
7	Reproductive health		
8	Universal health coverage		
9	Pollution and hazardous chemical control		
A	Tobacco control		
B	Improved vaccines and medicine access		
C	Health financing and recruitment		
D	Early risk warning		

HOW ATTAINING SDG 3 COULD AFFECT FORESTS AND POPULATIONS DEPENDENT ON FORESTS

- Improving health and well-being of Indigenous and other forest-adjacent communities can positively impact forests where these groups play a crucial role in forest stewardship, including sustainable management of natural resources.
- Economic development of forested areas that ignores harm to Indigenous and local people and the ecosystem services on which they rely will almost inevitably decrease their health and well-being.
- Access to family planning, health education, investment in clean water and sanitation, alternatives to wood biomassfuel and control of large forest fires have co-benefits to people and forests (Targets 3.7, 3.8, 3.9, 3.C and other SDGs).
- Achieving universal health coverage has an important role to play in making healthcare affordable and reducing pressure on forests from (catastrophic) health expenditure (Target 3.8). Health workers should be aware of potential negative consequences of development (such as disempowerment and its mental health consequences; sedentary lifestyles; nutrient-poor and unhealthy food; tobacco, alcohol and other substances; commercial sex trade) (Targets 3.3, 3.4, 3.5, 3.7, 3.8, 3.C).
- Traditional medical systems should be integrated into contemporary healthcare to ensure the most culturally appropriate treatment for Indigenous peoples. Medical and other healthcare personnel should collaborate with traditional healers to provide more efficient services and gain better understanding of traditional practices necessary for appropriate healthcare. Preservation of cultural and ecological knowledge is also valued by pharmacological research (Target 3.8).
- Research and surveillance for emerging diseases and health risks at the forest interface is best coupled with support to address existing disease burdens, reducing risks and improving health literacy and capacity (Targets 3.3, 3.D).

HOW ATTAINING SDG 3 COULD AFFECT FORESTS AND THOSE WHOSE COMMERCIAL LIVELIHOODS ARE DEPENDENT ON FORESTS

- Reduction of hazardous chemicals and air, water and soil pollution and contamination will improve the health of forestry workers and adjacent communities (Target 3.9).
- The work-related health problems of Indigenous and traditional people and other people engaged in unorganised sectors (e.g. leaf plate-making,

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handicraft) are largely unreported and not specifically identified within SDG 3. Work-related injuries and even mortality resulting from forestry is important but also largely unreported.

- Control of vast forest and peat fires and the resulting haze and transnational air pollution and associated loss of life is relevant to local as well as distant populations; efforts to strengthen the capacity to reduce and manage global health risks include such fire control (Target 3.D).
- Infectious diseases emerging from disturbed forests or from the hunting or dispersal of vectors and wildlife hosts may be a particular risk to forestry workers (e.g. malaria) or plantation farmers (e.g. Chagas disease). Surveillance and management of forests to limit infectious disease risks requires further research, but includes positive and negative outcomes for forests and forest people (Targets 3.3, 3.D).
- The target to reduce non-communicable diseases, where linked to dietary commodities associated with health risks such as red meat or palm oil, may challenge extensive forest clearing for their production (Target 3.4).

HOW ATTAINING SDG 3 COULD AFFECT FORESTS AND REGIONALLY DEPENDENT POPULATIONS

- Recognition that natural forest catchments are cost-effective in addressing water pollution and quality should encourage their protection and re-establishment (Target 3.9).
- Urban demand for bushmeat, bush medicines and some timbers is driving unsustainable pressure on forests. Alternatives need to be identified and promoted.

HOW ATTAINING SDG 3 COULD AFFECT FOREST AND GLOBAL AND URBAN POPULATION

- Climate change is not singled out as a global health risk in SDG 3; however, we note not only that this exists, but also that reducing forest destruction has the co-benefit of maintaining carbon sequestration and local climate regulation. International cooperation is required to address this risk (Target 3.9).
- As with all scales described here, universal access to family planning has an important role in reducing human pressure on forests (and natural resources). This is relevant not only for populations in forested areas, but also for those at any distance where consumption drives demand for forest products (Target 3.7).
- Cultural and spiritual ecosystem services of forests contribute to the well-being of many people who may rarely (if ever) visit them. Recreational

forest users may gain additional mental, physical and immunological benefits from forests. This is an area that warrants further research (Target 3.4).

- The urban forest is increasingly valued and developed for the mental, social and physical well-being it can provide urban dwellers. Linking improvements in health with urban-forest use and proximity could contribute to forest maintenance and expansion more generally (Target 3.4).

3.5 Conclusions

This chapter has reviewed many ways in which genuine attempts to attain the targets associated with SDG 3 can protect forests, forest ecosystem services and the people who rely on them. It has discussed the close relationship between many aspects of health and forests, not only for Indigenous and other peoples directly dependent on forest benefits but, less directly, for the global population. Forests play an important part in maintaining earth systems, and their erosion has potentially negative and catastrophic consequences for the health and well-being of the global human population, particularly those already vulnerable. Adjustments to our definitions of health, protection of its social and ecological determinants and recognition of planetary limits will contribute to global health and, in so doing, will safeguard forests.

This chapter has identified the cognitive dissonance evident in the SDGs that seek to expand economic growth (as conventionally defined) yet protect natural capital, including forests. The chapter has also discussed how a failure to improve reproductive health, especially by inadequate provision of family planning services and other influences on fertility, threatens forests and forest populations and will also threaten the achievement of many other SDGs. A way forward may be to foster the understanding, among those with more political and economic power, that their health and well-being will be promoted by more biosensitive activities, such as a diet less reliant on animal products, less wasteful consumption and more contact with nature. These principles also apply for many people in the global aspirational class, and give homage to those Indigenous and traditional groups that still live by these values.

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Chapter 4 SDG 4: Quality Education and Forests – 'The Golden Thread'

Peter Kanowski*, Dollie Yao* and Stephen Wyatt

Key Points

- Education is argued to be at the heart of sustainable development. SDG 4 aims to broaden and deepen education to people of all ages and expand its scope to a lifelong process spanning formal, non-formal and informal settings. SDG 4 emphasises quality of educational access, particularly for girls, women and marginalised groups.
- Education plays a foundational role in developing the knowledge, competencies and attitudes that foster pro-environment behaviour, yet this relationship is not simple or direct. Individual and community attitudes to the environment, their competencies in managing it and their sense of connectedness to nature are key factors in fostering pro-environmental behaviour.
- Pro-forest behaviours are those intended to benefit forests, or the components of forest ecosystems, in some way. There are many manifestations of and pathways to these behaviours.
- Encouraging and enabling pro-forest behaviours, in all their forms and contexts, is the basis of positive linkages between SDG 4 and forests.
- The formal, non-formal and informal elements of education systems have complementary and synergistic roles in facilitating pro-forest behaviours and outcomes.
- In these contexts, progress towards SDG 4 will benefit forests if education:

  1. Informs, encourages and enables pro-forest behaviour;
  2. Respects, nurtures and enables Indigenous and traditional knowledge;
  3. Promotes forest-related environment and sustainability education in each of formal, non-formal and informal settings;

* Lead authors.

4. Strengthens forest-related professional, technical and vocational education and training, and capacity development;
5. Capitalises on the power of both established and new media.

4.1 Introduction

This chapter explores the relationships between *SDG 4 Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all*[1] and forests – specifically forest ecosystem services, forest-related livelihoods and human well-being. The 2030 Agenda for Sustainable Development understands education to be 'at the heart' of sustainable development (UNESCO et al. 2016: 24) and as 'the golden thread that runs through all 17 [SDGs]' (Thomson 2017). This is in part because SDG 4 conceives of education in very broad terms, encompassing formal, non-formal and informal elements over a person's lifetime (UNESCO 2016). The Incheon Declaration (UNESCO et al. 2016: 27), which articulates the rationale for SDG 4, argues that:

> Evidence of education's unmatched power to improve lives, particularly for girls and women, continues to accumulate. Education has a key role in eradicating poverty: it helps people obtain decent work, raises their incomes and generates productivity gains that fuel economic development. Education is the most powerful means of achieving gender equality, of enabling girls and women to fully participate socially and politically, and of empowering them economically.

The ambition articulated by SDG 4 builds on both the Millennium Development Goals and the *UN Decade of Education for Sustainable Development 2005–2014* (UNDESD)[2] (UNESCO 2016). The UNDESD drew from precursor initiatives and experiences in both environmental and sustainability education (Thomas 2017, UNESCO 2016 Table 1.2, Wals and Benavot 2017), including initiatives addressing forest-related topics such as biodiversity conservation, climate change and the green economy.

However, little of the research exploring the relationships between education and sustainable development focuses explicitly on forests; rather, as in the SDGs, forests are present as part of wider cultural, social and terrestrial landscapes (Buckler and Creech 2014; Introduction (this volume)). Nevertheless, inferences can be drawn for forests because many of the challenges to and

[1] Commonly abbreviated to 'Quality education'.

[2] Education for Sustainable Development (ESD) is also characterised as Education for Sustainability (EfS); see Buckler and Creech (2014).

opportunities for sustainable development are manifest in and for forests (UNEP 2011), and because experience in environmental and forest-related education informs education for sustainable development, and vice-versa (Gilless 2015, NEEF 2015).

We first overview education as conceived under SDG 4 (Section 4.2) and discuss how key contexts frame the relationships between SDG 4 and forests (Section 4.3). We then explore how progress towards SDG 4 targets might have impacts on forests and interact with other SDGs (Section 4.4), and ways to develop elements of SDG 4 to the benefit of forests (Section 4.5). Drawing on pro-environment behaviour concepts, we propose *pro-forest* behaviour as foundational to SDG 4 progress benefitting forests. Finally, we briefly note synergies between SDG 4 and other SDGs (Section 4.6) and offer concluding observations (Section 4.7).

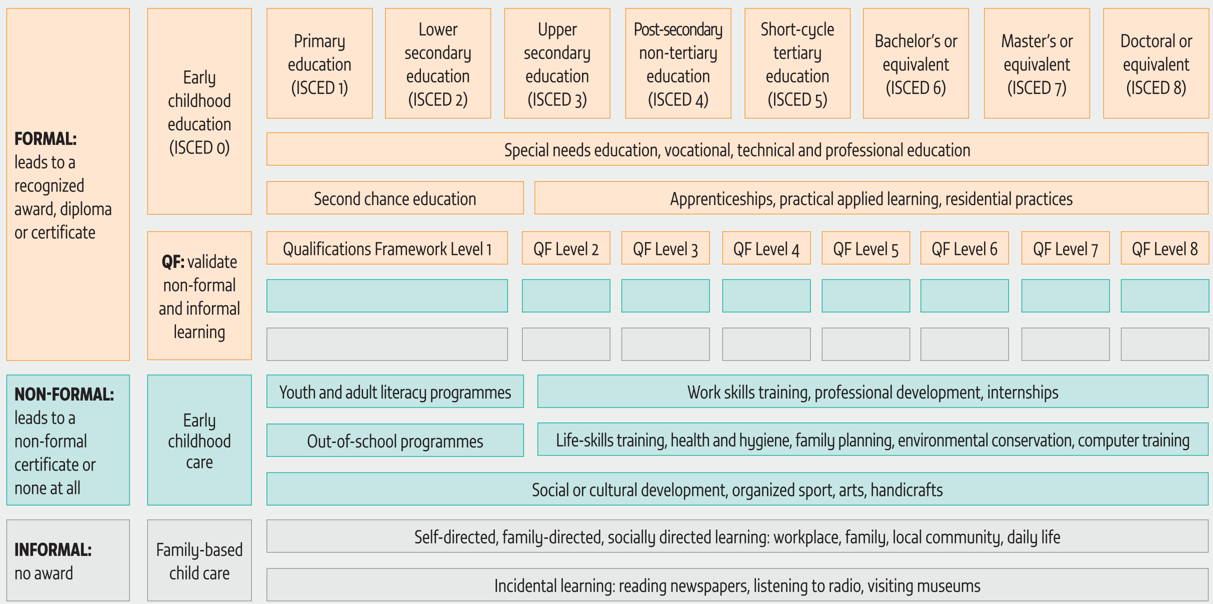
4.2 SDG 4: Quality Education

SDG 4 is avowedly 'comprehensive, holistic, aspirational, ambitious and universal' (UNESCO et al. 2016: 24). It focuses on broadening and deepening education, to reach people of all backgrounds and all ages with effective and relevant learning (UNESCO et al. 2016); it expands the scope of education beyond the traditional focus of the formal schooling environment and years, to a lifelong process in a wide range of formal, informal and non-formal settings.

SDG 4 characterises *formal education* as education delivered in an organised system, occurring in institutions and leading to a recognised award. *Non-formal education* occurs in planned learning settings outside of formal systems, such as professional and capacity development. *Informal education*, which includes Indigenous knowledge, happens outside of organised programmes. It includes learnings from everyday activities and is increasingly facilitated by new technologies (UNESCO 2016, Figure 4.1).

The breadth of SDG 4 (Table 4.1) is reflected in its targets. Each is supported by specific indicators; the UN reports annual evaluations of progress towards targets (UN SDG Knowledge Platform 2019).

Figure 4.2 presents a stylised representation of SDG 4 targets: how they are situated and interact along axes represents the type of education and the stage of life. Some targets, such as those directed at gender equality and inclusivity, apply across the full spectrum of educational settings and stages; others, such as access to early education, are specific to stages. While only Target 4.7 ('Sustainable Development and Global Citizenship') of SDG 4 explicitly addresses sustainability, it is argued that progress towards other SDG 4 targets also underpins progress towards sustainability, and towards other SDGs (UNESCO 2016, Wals and Benavot 2017). This assertion is necessarily qualified, as 'education *can* make a critically important contribution to progress towards the SDGs, but this is by no means inevitable' (Sterling 2016: 211).



Source: GEM Report team.

Figure 4.1 General form, structure and elements of lifelong education, as conceived by the post-2015 development agenda. Source: UNESCO 2016: Figure 0.1. CC BY-SA 3.0 IGO [5077].

Table 4.1 SDG 4 targets

	SDG 4 Targets
4.1	By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes
4.2	By 2030, ensure that all girls and boys have access to quality early childhood development, care and pre-primary education so that they are ready for primary education
4.3	By 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university
4.4	By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship
4.5	By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, Indigenous peoples and children in vulnerable situations
4.6	By 2030, ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy
4.7	By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and nonviolence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development
4.A	Build and upgrade education facilities that are child, disability and gender sensitive and provide safe, non-violent, inclusive and effective learning environments for all
4.B	By 2020, substantially expand globally the number of scholarships available to developing countries, in particular least developed countries, small island developing States and African countries, for enrolment in higher education, including vocational training and information and communications technology, technical, engineering and scientific programmes, in developed countries and other developing countries
4.C	By 2030, substantially increase the supply of qualified teachers, including through international cooperation for teacher training in developing countries, especially least developed countries and small island developing states

Source: UN SDG Knowledge Platform 2019

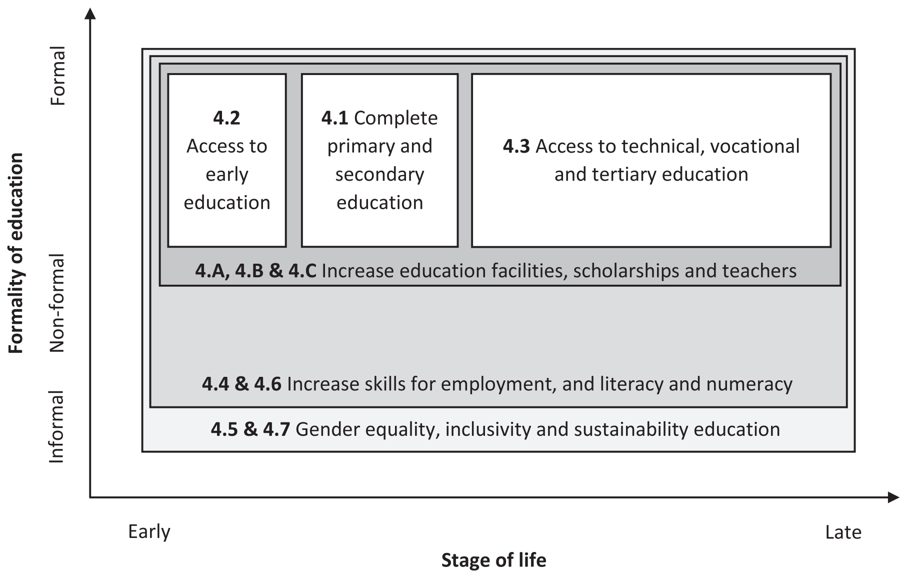


Figure 4.2 Stylised representation of the coverage of SDG 4 targets (numbered), in relation to formality of education and stage of life. (Source: Inspired by UNESCO 2016, Figure 0.1).

As we discuss further, this caveat applies to the impacts of SDG 4 on forests as much as it does to the SDGs more generally.

4.3 Contextual Conditions

We identify four sets of contexts for the adoption of SDG 4 and its impacts on forests: the quality and reach of education (Section 4.3.1); Environment and Sustainability Education (Section 4.3.2); the relationship between education and behavioural change (Section 4.3.3); and the nature of relationships between people, forests and pro-forest behaviour (Section 4.3.4).

4.3.1 The Education System

The characteristics of national education systems – often comprising sub-national, both public and private components – provide a foundational context for SDG 4, particularly levels of access at different stages and quality at all stages. The education system encompasses all formal, non-formal and informal elements of education, and their 'life-wide contexts (family, school, community, workplace and so on)' (UNESCO et al. 2016: 30). It therefore includes the various forms of adult learning and education (UNESCO et al. 2016) and capacity building (Bloomfield et al. 2018) related to forests.

A central focus of SDG 4 is to improve access to education, particularly for school-aged children. Despite substantial progress over the past 50 years

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(World Bank 2018), some 263 million children worldwide aged 6–17 do not attend school (UIS 2016). Currently, only 2 of 8 world regions have achieved the goal of universal lower-secondary education, and 3 are projected to not even achieve universal primary education by 2030 (UNESCO 2016). There are significant gender dimensions to access: worldwide, girls are twice as likely as boys to not start school, and rates of completing primary school are as low as 25 per cent for girls in the poorest families in low-income countries (World Bank 2018).

Educational quality is an issue of universal concern. The quality of a country's education system is often associated with the difference between richer and lower- and middle-income countries (Wals and Benavot 2017), although there is significant variation within these categories (UNESCO 2017, Figure 20.1). Richer countries are characterised as having well-developed and relatively well-funded formal education systems, with high rates of participation and effective learning through to post-secondary level; the situation in lower- and middle-income countries is typically the converse (WEF 2016a).

Consequently, the situation in many poorer countries' school systems has been described as a learning crisis, characterised by inadequate educational systems and schools (World Bank 2018). Unless these are addressed (for proposed actions WEF 2016a, World Bank 2018), neither the ambitions of SDG 4 in those countries nor the potential positive impacts on forests we discuss herein are likely to be realised.

4.3.2 Environment and Sustainability Education

The second context is that of environment and sustainability education (ESE; Sterling et al. 2017).[3] ESE was founded on promoting environmental literacy, which extends beyond simply knowledge of the environment to adoption and promotion of pro-environment behaviours (Leicht et al. 2018); it does so particularly by fostering relevant competencies and a sense of connectedness to the environment through experiential learning (NEEF 2015). ESE programmes specifically focused on forests have been developed to complement school curricula in many countries (e.g. Australia: Forest Education Foundation 2018; Scotland: OWL Scotland 2018; the USA: Project Learning Tree 2018), often beginning at the pre-school level, e.g. European forest kindergartens (Gregory 2017).

The UNDESD extended the environmental literacy concept to sustainability more broadly, seeking – in the SDG context – to integrate education

[3] ESE includes 'Education for Sustainable Development' (ESD) and 'Education for Sustainability' (EfS) (UNESCO 2016).

into sustainable development, and vice-versa (Leicht et al. 2018), and enable transformative societal change (UNESCO 2014). There was global progress in developing and implementing education for sustainable development (ESD) during the UNDESD (Buckler and Creech 2014), but there is significant variation in SDG 4 indicators among otherwise comparable countries (UNESCO 2017).

4.3.3 Education and Pro-Environment Behavioural Change

Quality education plays a fundamental role in achieving sustainability globally by fostering pro-environment behaviour (UNESCO 2016) – i.e. 'behaviour that is undertaken with the intention to [positively] change the environment' (Stern 2000: 408). For example, holistic pedagogical practices that complement immersive environment experiences with pre-experience preparation and post-experience follow-up are more likely to foster pro-environment attitudes than less holistic approaches (Stern et al. 2014). The pathways through which education exerts influence are not simple, linear or direct. Behaviour is determined by a suite of complex and interconnected elements that vary contextually; it is easy to oversimplify these elements and overestimate their causality (Heimlich 2010, Steg and Vlek 2009). With these caveats, we summarise the most influential elements in terms of Kollmuss and Agyeman's (2002) categorisation of demographic, external and internal factors in Figure 4.3, and discuss them below.

Education and gender are the most influential demographic factors (Kollmuss and Agyeman 2002). Increasing the duration, intensity or quality of education increases pro-environment behaviour (Zsóka et al. 2013). In many (but not all) contexts (Villamor et al. 2014), women are more likely

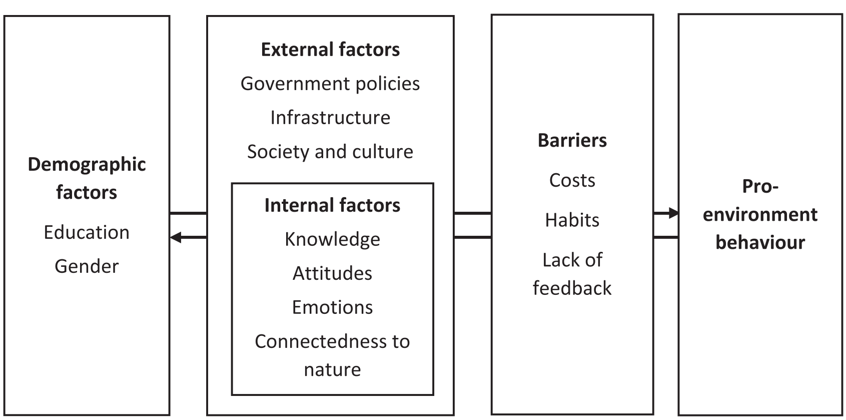

Figure 4.3 Simplified model of factors shaping pro-environment behaviour. Source: Adapted from Kollmuss and Agyeman 2002, Figure 7.

than men to empathise with environmental causes and behave accordingly (Hunter et al. 2004).

External factors including infrastructure, policies and social and cultural factors form the context in which behavioural decisions are made. Infrastructure (e.g. the accessibility of recycling bins) enables or hinders pro-environment behaviour (Freed 2018). Government policies (e.g. taxes) can successfully deter certain behaviours, such as plastic bag usage (Convery et al. 2007). Social and cultural norms are particularly powerful because they set standards, e.g. in relation to energy and water-conserving behaviour (Reese et al. 2013).

Internal factors comprise various psychological factors, notably knowledge, attitudes, emotions and habits (Kollmuss and Agyeman 2002). These are often the target of education-based interventions (Stern et al. 2014). Knowledge, including of behavioural options to achieve environmental outcomes (Frick et al. 2004), is foundational but not solely influential. Positive attitudes and emotions towards the environment are relatively strong determinants of pro-environment behaviour (Roczen et al. 2014), particularly a sense of *connectedness to nature* (Otto and Pensini 2017).

Pro-environment behaviour is inhibited by various barriers, conceptualised by Diekmann and Preisendörfer (2003) in terms of cost. Low-cost behaviours (i.e. relatively easy or inexpensive, such as using a recycling bin) are more likely to be performed than high-cost behaviours, such as using public transport instead of a car (Boyes and Stanisstreet 2012). Many behaviours are habits – learned routines performed without conscious intention – and are challenging to change (Steg and Vlek 2009). Moreover, pro-environment behaviours can wane without positive feedback, such as a sense of satisfaction or social approval (Kollmuss and Agyeman 2002).

Furthermore, the benefits pro-environment behaviours convey can be overshadowed by the overall impact of higher-consumption lifestyles. Behaviours are therefore unlikely to be transformative in isolation. For example, environmentally conscious people who recycle can have a similar overall ecological footprint to their less environmentally conscious counterparts who do not (Csutora 2012).

In summary, education is an important foundation for pro-environment behaviour, but such behaviour depends on a suite of complex, interconnected and contextual factors. Fostering behavioural change requires strategies developed thoughtfully in this light.

4.3.4 Relationships between People, Forests and Pro-Forest Behaviours

The fourth context is the diverse relationships between people and forests. Broadly, we characterise these at individual, household and community levels; we distinguish those dependent directly or indirectly on forests

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for livelihoods (e.g. forest-dwelling people or forestry sector employment, respectively) from those with less-dependent relationships (e.g. most urban residents). There are also socially and culturally constructed relationships, which differ, for example, between Indigenous and non-Indigenous peoples and their environments (Tengö et al. 2017); over time and between actors in a particular country (Dargavel 1995, Hull 2011); or between societies in forest-rich compared to forest-poor countries (Sands 2013).

These different relationships are recognised in various ways: for example, through major groups in international intergovernmental processes (e.g. the UN Forum on Forests); as stakeholder groups in international or national multi-stakeholder platforms (e.g. The Forest Dialogue and Brazilian Diálogo Florestal, respectively); or in relevant principles and criteria under mechanisms promoting sustainable forest management (SFM), such as forest certification systems (e.g. FSC and PEFC[4]) or SFM processes (e.g. the Montreal Process).

Attitudes and behaviours towards forests are shaped and mediated by a range of internal and external factors. We suggest it is helpful to focus on pro-forest behaviours, which we define by adapting Stern's (2000) definition of pro-environment behaviours as those that are intended to benefit forests, or the components of forest ecosystems, in some way. We recognise that there are many pathways to and manifestations of pro-forest behaviour (Beery and Wolf-Watz 2014).

We suggest that pro-forest behaviours are evident and can be fostered across the full spectrum of people–forest relationships for natural and planted forests in urban and rural landscapes. They may manifest in forest protection and conservation activities undertaken by individuals and groups, ranging from Indigenous peoples to environmental and forestry agencies and corporations; in SFM implementation by Indigenous and local communities, private landowners and public forest managers; in various forms of forest and landscape restoration; and in product choices made by consumers. We argue that education has a key (albeit complex) role in fostering pro-forest behaviours.

4.4 Possible Impacts of Progress towards SDG 4 on Forests

SDG 4 is anticipated to have a range of societal benefits, as discussed in Section 4.1. Progress towards SDG 4 may affect forests in various ways, which we categorise (from general to specific) under the following overlapping outcomes:

[4] Forest Stewardship Council (FSC), The Programme for the Endorsement of Forest Certification (PEFC).

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1. improved education, in the broad sense intended by SDG 4, for individuals, communities and societies (Targets 4.1, 2, 3 and 6);

2. greater equality and inclusiveness, for women and vulnerable people, including Indigenous peoples (Target 4.5);

3. greater knowledge about and skills for sustainable development (Target 4.7);

4. employment associated with forests and the forest-based economy (Target 4.4);

5. post-secondary education relevant to the environment and sustainability, and professional, technical and vocational education and training specifically relevant to forests (Target 4.3).

4.4.1 Improved Education

Progress towards SDG 4, at levels from the most foundational and general (e.g. improved literacy and numeracy) to the more specific and targeted (e.g. increased numbers of qualified teachers), is expected to lead to benefits at a range of scales, from those of the individual and family to those of community and society (Table 4.2). Multinational surveys of representative

Table 4.2 Generalised examples of benefits of education

	Individual/family	Community/society
Monetary	Higher probability of employment Greater productivity Higher earnings Reduced poverty	Higher productivity More rapid economic growth Poverty reduction Long-run development
Non-monetary	Better health Improved education and health of children/family Greater resilience and adaptability More engaged citizenship Better choices Greater life satisfaction	Increased social mobility Better-functioning institutions/service delivery Higher levels of civic engagement Greater social cohesion Reduced negative externalities

Source: Adapted from World Bank 2018, Table 1.1.

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national adult populations since 1993 demonstrate both that the aggregate level of environmental concern increases with national wealth (as measured by GDP), and that people with higher levels of formal education are more likely to express concern for the environment, regardless of personal wealth, political preference or individual characteristics (Franzen and Vogl 2013). While there are obvious caveats to these results – they are limited to middle- and high-income countries (Franzen and Vogl 2013) and are unlikely to adequately sample the views of groups for whom forests have particular significance, such as Indigenous peoples – they nevertheless suggest a strong role for education in raising environmental awareness. However, to adapt Sterling's (2016) caution: while education can contribute to pro-forest behaviour, this not guaranteed.

As discussed in Sections 4.3.3 and 4.3.4, such awareness and concerns may foster pro-forest actions – e.g. landowners supporting biodiversity conservation (Drescher et al. 2017) or individual awareness, mitigation and adaptation regarding climate change (Wamsler et al. 2012). More educated individuals are more likely to follow up environmental concerns with activism to advance a pro-environment political agenda (Clery and Rhead 2013). However, specific outcomes for forests from educational improvements envisaged by SDG 4 depend on complex interactions, across and within levels of social organisation and individual and group values, worldviews, norms and behaviours (Drescher et al. 2017).

4.4.2 Greater Equality and Inclusiveness

Improving equality of access to and inclusivity in education has significant benefits for disadvantaged groups, and potentially for forests.

ADDRESSING GENDER DISPARITY

Gender disparity is manifest in most societies, but is most marked in terms of educational access and participation in low-income countries and regions, where the out-of-school population is disproportionately high (UIS 2017). Correspondingly, the general consequences for forests of addressing this disparity differ between lower-income and higher-income societies.

LOWER-INCOME SOCIETIES

Improving participation by women and girls in education is central to the goal of improving their lives, the lives of the families and communities of which they are members, and educational outcomes generally:

> Better educated women tend to be healthier, participate more in the formal labor market, earn higher incomes, have fewer children, marry at a later age, and enable better health care and education

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> for their children, should they choose to become mothers. All these factors combined can help lift households, communities, and nations out of poverty. (World Bank 2017)

Women with fewer children have more time to engage in productive work or education, which reduces their preferred family size and helps normalise educational attainment for women (Colfer et al. 2008). While population growth, particularly in poorer countries, usually increases direct pressures on forests, this pressure can be mediated by greater human development (Jha and Bawa 2006), to which education is a fundamental contributing factor (UNDP 2018).

In general, 'increases in women's incomes have greater impacts on food, health and education expenditure and therefore on overall household well-being than increases in men's incomes' (FAO 2013: 9). As an additional year of schooling can increase a woman's earnings by 10–20 per cent (UN Women 2012), women's education offers a more direct pathway to improving household well-being, and also diminishes – at least in principle – the need for household members, typically men (Sunderland 2014), to access forests for commercial products at unsustainable rates.

Improved literacy, education and practical skills related to income generation or employment increase women's social status and self-confidence, thereby increasing the effectiveness of their participation in forest management through organisations such as community forest user groups (Agarwal 2010, Coleman and Mwangi 2013, FAO 2013). Women's participation in decision-making can reduce gender-based conflict because it leads to more equitable access to forests (Coleman and Mwangi 2013). Furthermore, women's participation can lead to greater forest conservation and restoration through a range of direct and indirect pathways (Agarwal 2009).

The importance of empowering women in relation to forest and tree management is amplified by the *feminisation* of rural communities and economies globally, as men migrate for or in search of employment elsewhere (Alston et al. 2018, Mukhamedova and Wegerich 2018, Tamang et al. 2014).

HIGHER-INCOME SOCIETIES

Gender disparity also remains significant in most rich countries. As the World Economic Forum (WEF 2016b: 1) notes, 'Female talent remains one of the most underutilised resources, so in addition to the moral case for gender equality, which has mostly been won, there is a business case'. In nearly 100 countries, women make up most university enrolments, but overarching cultural and societal factors result in skews against women in Science, Technology, Engineering and Medicine (STEM) fields, where women comprise only 32 per cent of graduates (WEF 2016b). This impacts on forest-related professions, as well as others.

In forest-sector contexts specifically, gender gaps persist (Brown et al. 2010, Eriksen et al. 2016, Hansen et al. 2016). However, as Lawrence et al. (2017: 113–14) note:

> Female leadership potential has been recently emphasised as a source of untapped potential in forest industry. … Higher diversity is also associated with better sector image, retention of much required talent pool, innovation and better reflection of customer and stakeholder needs, all of which are significant sources of market and financial benefits over the longer run.

Consequently, addressing the educational, employment and societal constraints that limit women's participation in the forest-sector workforce can be expected to deliver a range of positive outcomes: for individuals and organisations, for innovation and workforce capacity in forest management and forest-based value chains, and for the rural and regional economies on which these value chains are typically embedded.

ADDRESSING INDIGENOUS RIGHTS, INTERESTS AND DISADVANTAGES

The importance of access to appropriate education for Indigenous peoples is now well-established internationally (e.g. UNCED Forest Principles 5a and 12d, UN 1992), but implementation remains challenging. Article 14 of the UN Declaration on the Rights of Indigenous Peoples (UNDRIP 2007) asserts that Indigenous people have a right to control education systems so they are culturally appropriate and in their own language. The relevance of Indigenous knowledge (IK)[5] is increasingly recognised in contemporary forest management (Parrotta and Trosper 2012) for the benefits it delivers to both Indigenous and wider communities, and for SFM (Ens et al. 2012, Lyver et al. 2017).

IK is typically rooted in distinct ontologies, incorporating cultural values and norms:

> Knowledge is not secular. It is a process derived from creation, and as such, it has a sacred purpose. It is inherent in and connected to all of nature, to its creatures, and to human existence … Traditions, ceremonies, and daily observations are all integral parts of the learning process. They are spirit-connecting processes that enable the gifts, visions, and spirits to emerge in each person. (Battiste 2002: 14–15)

Consequently, IK is inherently place- and context-specific; it is often privileged, with restrictions on knowledge sharing and learning (e.g. to elders,

[5] Also referred to as traditional forest-related knowledge, TFRK, and other terms.

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men or women), typically intended to ensure that those who hold knowledge appreciate how this knowledge may and should be used. While the foundations and perspectives of IK and modern Western science differ (Fenstad et al. 2002), it is important to appreciate the complementary relationship between various tenets of traditional knowledge and those of ecological sciences, and the value of learning from both realms (Parrotta and Trosper 2012). Education systems for both Indigenous and non-Indigenous peoples can capitalise on this complementarity and its synergies, while respecting differences.

The importance of culture and values, and of oral and experiential teaching and learning, can mean that IK education is seen principally in terms of informal and non-formal approaches, in a family or a community setting. However, Indigenous education also occurs in other modes, including the most formal and advanced (Allen and Krogman 2013, Dockry et al. 2016, Hoagland et al. 2017), and practice-based co-learning through co-management (Ens et al. 2012). Many such examples demonstrate how awareness, understanding and respect for IK can be integrated into both formal and non-formal education about forests; and how forest-related IK can contribute to enhancing forest management.

More broadly, recognition of the validity and utility of IK and of Indigenous education systems can empower Indigenous communities seeking an enhanced role in forest management, or the recognition of their traditional rights, e.g. in post-colonial societies such as Canada, Australia and New Zealand (Wyatt et al. 2010). Thus, an important outcome of advancing SDG 4 ambitions in terms that are respectful and inclusive of IK can be the greater empowerment of Indigenous peoples in relation to their rights and interests in forests (Bulkan 2017).

4.4.3 Greater Knowledge and Skills

ESD begins from the premise that ‘certain knowledge and skills promote sustainability more than others’ and aims to create empowered and responsible global citizens (UNESCO 2016: 11). Education generally, and that for sustainability specifically (EfS), support sustainable development in two ways: through knowledge and skills that foster values and behavioural change; and through building ‘greater agency to address complex sustainability challenges’ (UNESCO 2016: 11). The former is most relevant in addressing issues about which there is a high level of agreement, and the latter where there is uncertainty and contingency (UNESCO 2016). Forest-related examples of such issues might be, respectively, the significance of biodiversity loss and the best means to address trade-offs between conservation and development.

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In the EfS context specifically, Wals and Benavot (2017) characterise these approaches as instrumental and emancipatory, respectively. Instrumental education communicates the knowledge and skills that foster sustainable behaviours; emancipatory education operates on a deeper, value-based level to foster independent, reflective, responsible behaviours (Wals and Benavot 2017). They suggest three general ways education supports sustainable development: recognising and drawing on diverse viewpoints, including IK; emphasising learning across disciplinary and societal boundaries; and helping learners acquire new life skills and competencies, and interpret and apply them in more holistic and systemic understandings of complex realities (Wals and Benavot 2017).

Enhancing environmental and sustainability literacy fosters commitment and action, enables the identification of environmental issues and the capability to respond and provides the agency required to tackle wicked problems and facilitate transformative change (UNESCO 2016). Developing such literacy is the premise of established environmental education programmes (NEEF 2015), including those focused specifically on forests, which provide platforms for greater pro-forest thinking and decision-making at all levels of social organisation, from individual to international.

4.4.4 Employment and the Forest-Based Economy

Forest management, production systems and value chains are an important source of employment, particularly for forest-dependent and other rural communities, employing some 54 million people formally and informally worldwide (World Bank 2016). In a world in which the importance and value of the green economy (UNEP 2011) and bioeconomy (Lawrence et al. 2017) are growing, forest-related employment should expand far beyond traditional roles associated with management of forests and harvesting and processing of wood and non-wood products. A much wider knowledge and skill base will be required for the sustainable management of forests and trees, including those on farms and in cities, for the full range of ecosystem goods and services, and for the continuing development and success of innovative and sustainable forest industries, on both small and large scales (Macqueen et al. 2018, Panwar et al. 2016, Sanchez Badini et al. 2018).

While there remain some forest-related roles that require little formal education, including those for which high levels of informal Indigenous and local knowledge are particularly valuable, the knowledge and skill requirements for forest-sector employment continue to evolve (Brandth and Haugen 2000, Lawrence et al. 2017): away from simply labour-based and towards more knowledge-based skills requiring post-secondary education, including advanced mechanical and information technology skills, entrepreneurship and business skills (e.g. ecotourism) and high-level communication, organisation and people management skills (Lawrence et al. 2017). As noted in Section 4.4.2, many of these skills are associated with women, reiterating the importance of gender equality in access to relevant education and training.

The evolution of forest-related employment needs to be supported and facilitated by equitable and affordable access to relevant education and training, particularly in formal and non-formal contexts. Consistent with the breadth of SDG 4, such education and training needs to be broadly conceived and accessible, to reach diverse groups:

- Members of Indigenous communities acquiring higher levels of technical, specialist and business knowledge to complement their traditional knowledge, to better participate in green economy roles, such as those created by ecosystem services markets or ecotourism (Altman and Kerins 2012, Ens et al. 2012, Russell-Smith et al. 2013, UNEP 2011);
- Members of rural communities acquiring higher levels of technical, specialist and business knowledge, to allow them to better participate in or capitalise on forestry sector employment in various ways (Hiedanpää and Salo 2017, Mayett-Moreno et al. 2017, Sanchez Badini et al. 2018);
- Public, private and community organisations relying on technically and vocationally skilled staff to respond to the diversification of the forest-based economy, which is creating the need for new knowledge and skill sets in a wider array of organisations (UNEP 2011);
- Tertiary students in a wide range of forest-sector-related programmes, whose participation reflects a growing interest in enhanced degree programmes and leads to a stronger and more diverse professional workforce (Gilless 2015).

4.4.5 Professional, Technical and Vocational Education and Training

The evolution of scientific professional and technical forestry education has been described elsewhere (Innes and Ward 2010, Kanowski 2001). Notwithstanding its strengths in developing cadres of well-educated and trained professional and technical foresters, the limitations of this model are apparent – e.g. in terms of its privileging of particular interests (Ojha et al. 2009), or its focus on only some elements of forested landscapes and on only some of the diverse skills required to manage them in dynamic social and landscape contexts (Gilless 2015, Hull 2011).

Consequently, both professional and technical education and training relevant to forests have changed significantly in the late twentieth and early twenty-first centuries (AP-FECM 2018, Rekola et al. 2017, Temu and Kiwia 2008). University forestry curricula have been broadened, strengthening the social sciences, humanities and interdisciplinarity; programmes have become more inclusive, and more networked and internationalised; and student communities have become more diverse (Gilless 2015). Topic areas that were once marginal, such as agroforestry or community forestry, are now mainstream, and the focus of specific institutions and programmes as well as elements of broader curricula (RECOFTC 2018, Yayé et al. 2015). International collaboration seeks to strengthen forest-related education networks, student mobility and curricula (Kanowski 2015, Rekola et al. 2017, Temu and Kiwia 2008, Yayé et al. 2015), as forestry education continues to evolve and adapt to ensure its relevance. However, challenges remain in aligning curricula and skills sought by employers, particularly in terms of the balance and relevance of generic and technical skills (Ramcilovic-Suominen et al. 2016).

These challenges are paralleled at the technical and vocational levels, which are historically underdeveloped in many lower-income countries and for the natural resource sectors (Robinson-Pant 2016, UNEP 2017), and which must contend with perceptions, particularly among youth, that rural-based occupations and work are those of last resort (Robinson-Pant 2016). However, as Robinson-Pant (2016) and Lawrence et al. (2017) note for the agriculture and forestry sectors, respectively, there are significant opportunities to improve household livelihoods, rural communities' resilience, and environmental outcomes from more effective technical and vocational education that is also more inclusive of women, who now comprise a much greater proportion of farmers and rural workers. While green knowledge and skills are foundational in technical and vocational education and training (TVET) for rural work (INRULED 2012), they should also be embedded in TVET more widely (UNESCO-UNEVOC 2017).

Such challenges also extend into the arena of non-formal education, in its many forms relevant to forests. The continuing decline of traditional public extension services in many countries (Mogues et al. 2015) has fostered new approaches, including those capitalising on the rapid development and reach of information and communication technologies (Sagor et al. 2014), and more community-based approaches (Catacutan et al. 2015, Reid 2017). These activities are increasingly seen in the context of broader knowledge and innovation systems (Lubell et al. 2014), based on capacity development for co-production of useable knowledge (Clark et al. 2016), in which boundary workers may play critical roles. Forest-related examples illustrative of the diversity of actors and approaches include the UK Sylva Foundation's *myForest* and Forest Schools initiatives (Sylva Foundation 2018), which facilitate forest information and knowledge exchange for landowners and schools, respectively; structured multi-stakeholder dialogue processes, such as Brazil's Forest

Dialogue (Diálogo Florestal 2018); and the research partnerships and outputs of international public good research centres such as the World Agroforestry Centre (World Agroforestry Centre 2018) and international forest-related initiatives such as forest and landscape restoration (Chazdon et al. 2017).

4.5 Advancing the Ambitions of SDG 4 Relevant to Forests

While the ambitions of SDG 4 are global, transcending countries and sectors, many forest-related actors have particular interest in fostering synergies between SDG 4 and forests. We propose five priorities that forest-related actors might seek to advance in this context.

4.5.1 Encouraging and Enabling Pro-Forest Behaviour

It is evident that pro-forest behaviour at various levels of social organisation, from the individual to the international, derives from a complex combination of factors that are both internal and external to the individual and the community. Education that builds and reinforces understanding and knowledge of forests and competencies in forest management, and that helps individuals and communities to feel or stay connected to forests, has a foundational role in fostering or sustaining pro-forest attitudes and behaviours. The formal, non-formal and informal elements of education systems have

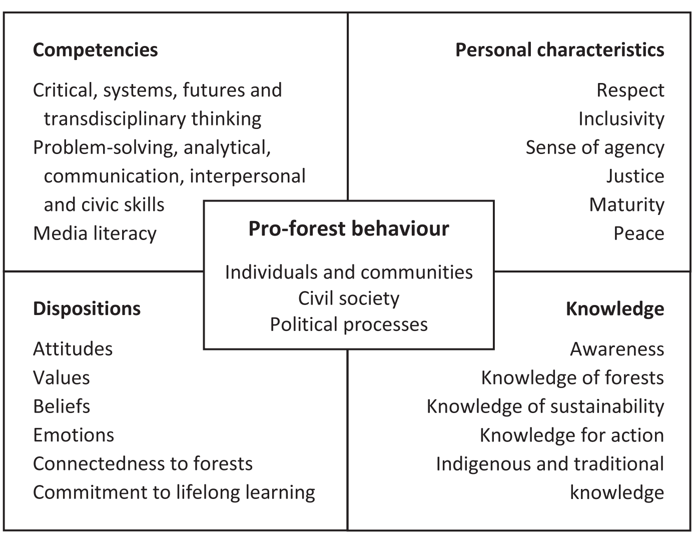

Figure 4.4 Outcomes of forest-related education contributing to pro-forest behaviour.
Source: Adapted from Ardoin et al. 2017, Lozano et al. 2017 and University of Florida 2017.

complementary and synergistic roles in facilitating these outcomes. Figure 4.4 draws from generic models of learning outcomes from environmental education (Ardoin et al. 2017), the ESD literature (Lozano et al. 2017) and sustainable development curricula (University of Florida 2017) to present a stylised model of educational outcomes that contribute to pro-forest behaviour.

A central goal of education about forests should be to provide opportunities and enable experiences that help individuals develop a sense of connectedness to forests, or that sustain and enrich connectedness that already exists. Strategies to achieve this need to be diverse, to reflect the diversity of ways in which people learn and the diversity of their backgrounds and circumstances (Collins and Bilge 2016), and will obviously differ between, for example, Indigenous communities in which individuals have intimate cultural and material connections to their forests, rural communities in which connectedness to the forested environment is part of daily life, and urban communities for whom the most common experience of forests is of urban and peri-urban settings. They will differ in their form and elements between higher-income and lower-income countries. At their core, these strategies share the common purpose of fostering a personal sense of connectedness to forests, as the basis for fostering pro-forest attitudes and behaviour.

It is evident that these behaviours are most likely to be expressed when external actors and factors enable and support pro-forest actions. Such enabling and support measures are embedded or implicit in concepts such as a landscape approach (Sayer et al. 2013), forest and landscape restoration (Chazdon et al. 2017), locally controlled forestry (Elson 2012) or biophilic cities (Beatley and Newman 2013). These principles need to be translated into policies, processes and outcomes that recognise and respect different forms of knowledge and enable partnerships for its use: e.g. between state management agencies, researchers and Indigenous and local communities (Fisher et al. 2017); between investors and traditional forest owners (Elson 2012); or between local authorities and communities in urban environments (Mattijsssen et al. 2017).

Encouraging and enabling pro-forest behaviour, in whatever context and form, is the basis of connecting SDG 4 and forests. It underpins each of the following areas of activity.

4.5.2 Respecting, Nurturing and Enabling Indigenous and Traditional Knowledge

The standing and value of Indigenous and other forms of traditional knowledge for forests and their management are now well-recognised, as are both the epistemological differences and potential complementarities with modern scientific knowledge (Mistry et al. 2016). Forest management that draws on both Indigenous and scientific knowledge can explore a wider range of options than that limited to either paradigm (Mistry et al. 2016, Parrotta et al. 2009), and can be an important element of empowering Indigenous communities (Altman and Kerins 2012, Bulkan 2017, Tengö et al. 2017).

Capitalising on Indigenous and other forms of traditional knowledge to the benefit of Indigenous and local communities, and of society more widely, faces a range of challenges. These include the privileging of scientific knowledge in environmental governance and management, the restrictions on access to some elements of IK to specific knowledge holders, the loss of Indigenous and traditional knowledge due to loss of agency and to a range of societal forces, and challenges of integrating elements of traditional and scientific knowledge in contemporary policy and management contexts (Mistry et al. 2016, Tengö et al. 2017). Nevertheless, a diverse range of examples (Bulkan 2017, Parrotta and Trosper 2012) and policy development at international and national levels (Tengö et al. 2017) illustrate how these challenges can be addressed.

The common theme that underlies these examples is one of respect by other parties for Indigenous and traditional knowledge, and of a range of measures to nurture this knowledge and enable its use. Fundamentally, governments and other actors have to create the space in knowledge systems and in policy and decision processes for IK (Hill et al. 2012, Tengö et al. 2017); and, where Indigenous people have lost agency and standing, as in many settler societies, foster and support the engagement of Indigenous peoples in those processes. Non-governmental and community-based organisations and forestry businesses can play significant enabling roles in these diverse contexts (Chhetri et al. 2013, Nikolakis and Nelson 2015, Waller and Reo 2018).

Commitment by non-Indigenous actors to respecting, nurturing and enabling Indigenous and traditional knowledge benefits both Indigenous and non-Indigenous communities and the relations between them, and should lead to more adapted and sustainable forest management.

4.5.3 Promoting Forest-Related ESE in Formal, Non-Formal and Informal Settings

FORMAL

Forest-related ESE is already well-established in many formal education systems, at pre-school, primary and secondary levels. While the UNDESD fostered progress for ESE curriculum integration globally, including the institutionalisation of ESE in many countries, teacher capacity and curriculum implementation remain limited in others (UNESCO 2014). For example, in some countries, ESE has been de-emphasised due to a focus on content and skills relevant to economic growth, and greater emphasis on standardised curricula and testing (McBeath et al. 2016, Witoszek 2018).

Immersive and experiential forest-related ESE is especially effective in fostering pro-forest behaviour and delivers a range of wider learning and behavioural benefits (Project Learning Tree 2018), and so complements and extends classroom-based learning. Therefore, programmes that connect children to forests from the outset of their formal education (we have noted a small number of the many examples in preceding sections), and those that engage tertiary students similarly in a variety of settings (Hill et al. 2008, van Wynsberghe and Moore 2015), are most likely to enable pro-forest behaviours. ESE principles are reinforced and demonstrated by whole-of-institution approaches that embed sustainability into the facilities and operations of the learning environment (UNESCO-UNEVOC 2017) – a goal to which many institutions are already committed (University Alliance for Sustainability 2018).

NON-FORMAL

Non-formal forest-related ESE is an essential complement to formal approaches in fostering pro-forest behaviour. For example, businesses are seeking training and professional development through a range of actors to improve their sustainability performance (UNESCO 2014). Non-formal modes of education can be more effective than formal modes in reaching marginalised groups, such as women forest owners who have little agency in a traditionally male domain (Redmore and Tynon 2011). Experiential co-learning approaches (e.g. farmer field schools) can be effective in many contexts, particularly for those who are resource-poor, such as smallholder farmers and tree growers, and can facilitate both scaling up and fostering local adaptation (FAO 2017). In contrast, eco-tourists – a resource-rich group – are demonstrably willing to pay for non-formal ESE (Walter 2009). In urban environments, community engagement programmes offer non-formal ESE that foster and support pro-forest behaviour: e.g. Chicago's long-established Treekeepers (Dwyer and Schroeder 1994) or Singapore's Community in Bloom and Community in Nature (Er 2018). Non-formal education can also be an effective and targeted way to reach groups on the margins of society; e.g. ESE delivered through the USA's Sustainability in Prisons Project reduced recidivism (LeRoy et al. 2012).

INFORMAL

Informal education is widely encompassing and ubiquitous, and therefore also important for forest-related ESE, as the following examples illustrate. Informal learning frequently occurs in social settings when knowledge is transferred through social networks; for example, children learn pro-environment behaviour directly and indirectly from their parents (Ando et al. 2015), and, conversely, environment-related learning from school can reach parents through their children (Eilam and Trop 2012). Children also learn from role models, especially adults, whose behaviour instils environmental literacy and responsibility and helps develop relevant character and leadership traits (Stern et al. 2018).

NGOs and community groups are active informal educators and can promote pro-forest knowledge and behaviours through awareness campaigns, such as those directed at reducing deforestation or responsible consumption, or engagement programmes such as those for community-based forest restoration (Boyer-Rechlin 2010). Online communities can be effective means of improving people's scientific literacy and increasing pro-environment behaviour (Robelia et al. 2011). Researchers and knowledge institutions can engage, educate and learn from the public through citizen–science projects (Bonney et al. 2014).

In urban environments, parks and green spaces are important sites for learning about trees, particularly for children, whose play and interaction with nature not only develops appreciation for the environment but also improves their cognitive abilities and physical growth (Clements 2004). However, they can be equally important for adults, especially those with low levels of environmental knowledge. Similarly, community-based activities, such as community gardens or environment groups, are an important vehicle for informal knowledge and skills development and exchange (Krasny and Tidball 2009). The increasing body of evidence of positive relationships between people's physical and mental health and various forms of experience of trees and forests (Dzhambov et al. 2018), and of feelings of well-being associated with exposure to wood in buildings compared to harder materials (Strobel et al. 2017), also offer potentially powerful means of informal learning about the value of forests and forest products, as the basis for pro-forest behaviours.

MUTUALLY REINFORCING FORMAL, NON-FORMAL AND INFORMAL EDUCATION ABOUT FORESTS

There is strong circumstantial evidence that learning about and experiencing forests – in informal, non-formal and formal settings – forms the foundations of pro-forest behaviour. This suggests that, from a forest perspective, SDG 4 implementation should focus on promoting forest-related content and opportunities to experience trees, forests and forest products. New technologies can assist this in a variety of ways, complementing established structures and modes. For example, social media can support self-regulated, on-demand learning through personal learning environments (PLEs); these are personalised learner-driven platforms to aggregate, create and share knowledge using digital tools, and so help to bridge formal and informal learning (Dabbagh and Kitsantas 2012). The highly autonomous nature of PLEs synergises well with other forms of learning, such as lifelong and workplace learning, and so this approach is widely applicable (Attwell 2007) as well as increasingly available.

4.5.4 Strengthening Professional, Technical and Vocational Education and Training

Tertiary forestry education has evolved (see Section 4.4.5), and frequently in the context of significant changes to national higher education systems (Kanowski 2015). In conjunction with shifts in student preferences and employment opportunities that parallel the emergence of a wider landscape approach (Sayer et al. 2013) to forests and forestry, these changes challenge tertiary educators and institutions to deliver both a broader curriculum and specific elements that address the need for increasing specialist knowledge across the natural and social sciences and their intersection, and in relevant generic knowledge and skills such as those in business and communication.

These challenges suggest a range of responses, which themselves demand new or more effective partnerships within and between tertiary education institutions and other actors, notably employers and professional associations. These partnerships should support:

- New modes of teaching and learning, including online learning using a variety of platforms and mechanisms, ranging from mass participation Massive Open Online Courses (MOOCs) to personalised micro-credentials (Carey and Stefaniak 2018, Carrera and Ramírez-Hernández 2018);
- More interdisciplinary and integrated curricula and programmes, providing students with a more diverse and individually relevant portfolio of knowledge and skills, which in turn allows them the wider suite of employment opportunities and career pathways necessary in contemporary and future employment markets (WEF 2016c);
- Shifting the locus of professional forestry education to Masters-level programmes (Innes 2015), and strengthening learning and knowledge partnerships with industry at all stages of professional and technical education (Sagor et al. 2014, Yayé et al. 2015);
- Further internationalising programmes by enabling international participation of students in a variety of ways (e.g. exchanges, joint degrees or degree elements, placements), explicitly internationalising curricula, and supporting complementary activities such as students' active participation in international processes (Yunita et al. 2017);

- Through all of these means, broadening access to and inclusivity of programmes, and enhancing the diversity of those studying forest and forestry-related courses and programmes. These goals are being actively pursued by many institutions and networks (e.g. AP-FECM 2018, Gilless 2015, Rekola et al. 2017).

These challenges are perhaps more marked in many countries for TVET than professional education, because TVET systems for rural sectors are often less well-developed. Strengthening 'skills related to the quality of life, productivity skills and skills related to organization, attitudes and values', and 'providing business and entrepreneurial skills training to improve understanding of market opportunities and improve managerial expertise', should underpin future TVET, in recognition that rural people deriving their livelihoods from farms and forests are also likely to want or need to derive income from other, non-farm or forest activities (Robinson-Pant 2016: 19–20).

4.5.5 Capitalising on the Power of the Media

Both old (print, radio and television) and new (online, social) media are near-ubiquitous and influential forces in disseminating environmental information and messaging, reflecting and changing attitudes and norms, encouraging or discouraging pro-environment behaviour, and enhancing or subverting educational experiences. Digital disruption is changing the ways in which people access information, and is challenging established models of reporting and programming (Newman et al. 2017). Media literacy is arguably now more important than ever, in an era of post-truth news and of social media that can facilitate the propagation of misinformation (Williams et al. 2015).

Despite the media transition, traditional means of communication continue to be important. Television is still the primary news source in many countries (Newman et al. 2017) and remains influential in shaping viewers' understanding of environmental issues (Hofman and Hughes 2018, Huang 2016). For example, nature documentaries supported by post-viewing material have been demonstrated to instigate long-term behavioural change (Hofman and Hughes 2018).

The power of social media has been harnessed by many actors – government, business, NGOs and community groups – to promote their perspectives on pro-forest behaviour. One of the strengths of social media is its interactivity, which enables the strategic building of communities and relationships through two-way communication and networking (Lovejoy and Saxton 2012). These online communities can create engaging informal learning environments, especially when users continue to generate and post content (Mason and Rennie 2007). However, both old and new media can work against pro-forest efforts. Journalists may compromise the accuracy of scientific information to increase entertainment value, thereby misrepresenting a story (Frank 2014). Environmental issues can also be framed through narrow perspectives, reinforcing perspectives that prioritise economic growth, or disseminating misconceptions such as that deforestation is confined to the Global South (Lewis 2000). Media can disseminate information unsupported by science, as is evident in reporting of climate scepticism (Painter 2011). In this context, Boykoff and Boykoff (2007) note the role of journalistic norms such as *personalisation* (to focus on human-interest perspectives) and *balance* (to present both sides of a story).

Media literacy is therefore an increasingly essential component of education to foster pro-forest behaviour. It enables people to critically analyse the accuracy and credibility of media content, to identify intents, and to effectively access and create media (Koltay 2011). Education can also help bridge knowledge inequality gaps and empower people to learn through media, as educated people are more likely to use media for personal information gain (Wei and Hindman 2011). In summary, both old and new media can facilitate or constrain the ambitions of SDG 4 in relation to forests.

4.6 Synergies

Education is at the heart of sustainable development, underpinning progress towards all other SDGs through various direct and indirect pathways. Core competencies, such as literacy and numeracy, are the basis for fostering individual agency to participate in society in terms more likely to realise their potential. It is this human potential that other SDGs variously seek to nurture or capitalise on. Education catalyses virtuous circles: those who receive early education are more likely to continue learning formally and non-formally (OECD 2014); educated parents are more likely to invest in their children's education (Pufall et al. 2016); education provides the platform for knowledge generation and capacity building to support SDG implementation; and education, in conjunction with experience of forests, fosters pro-forest behaviours across the domains of other SDGs. However, as Rieckmann et al. (2017: 7) warn, 'not all kinds of education support sustainable development. Education that promotes economic growth alone may well also lead to an increase in unsustainable consumption patterns'. This caution emphasises the rationale and need for education to be embedded in an environmental and sustainability context, as discussed in Section 4.3.2.

In these terms, education is pivotal to improving well-being and livelihoods, particularly through securing income from decent employment (SDG 8, Hanushek and Wößmann 2007), enabling the alleviation of poverty (SDG

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1) and hunger (SDG 2), and access to clean water (SDG 6) and clean energy (SDG 7). Education, especially maternal education, improves child health and reduces family sizes (SDG 3, Colfer et al. 2008). Education empowers women (SDG 5) and marginalised groups (SDG 10) to participate fully in society by instilling values of inclusion and challenging the socio-cultural norms that contribute to inequality. Education is also core to climate action (SDG 13) as it fosters concern and capacity for action, particularly for those vulnerable to climate-related disasters (Wamsler et al. 2012).

Economic development (SDG 8) is strongly linked to education quality (Hanushek and Wößmann 2007) and, similarly, underpins multiple facets of development, including sustainable built environments (SDG 11) where knowledge institutions can cluster and collaborate. Universities and other knowledge sector actors are key to generating and applying knowledge to drive sustainable development, generally through partnerships (SDG 17, Charles 2011) and inclusion and diffusion mechanisms such as international scholarships to build capacity at a global scale (SDG 17). However, as cities grow, education inequalities may widen without adequate education infrastructure (SDG 9), particularly in poorer and peri-urban areas (UNESCO 2016).

As discussed in Sections 4.4 and 4.5, targeted education can foster pro-forest behaviour more directly, through research and training to build capacity for SFM (SDGs 14, 15); education campaigns to encourage responsible consumer choices and production that minimise consumption and waste (SDG 12) and conserve energy (SDG 7); corporate education to discourage unsustainable business models (SDG 12); farmer education to discourage deforestation (SDGs 14, 15; Sills and Caviglia-Harris 2015); technical training to enable forest-conserving technologies and their applications (SDG 9); and civic education that empowers people to participate in public policy processes and challenge elite interests (SDG 16) or support planning decisions that better protect forests (SDG 9).

4.7 Conclusions

There is a persuasive case that progress towards SDG 4 is a foundation for progress towards the other SDGs. However, it is also the case that progress towards SDG 4 will not necessarily benefit forests, or the livelihoods of those who depend on forests, unless the *inclusive and equitable quality education and lifelong learning for all* envisaged by SDG 4 fosters pro-forest behaviour by individuals, communities and societies. Pro-forest behaviour is supported by education – formal, informal and non-formal – that shapes pro-forest attitudes and builds and enriches relevant competencies and a sense of connectedness between people and forests. As in other arenas of forest knowledge and management, non-Indigenous people and those not dependent on forests have much to learn in this realm from Indigenous peoples and other holders of traditional and local forest knowledge; there are both synergies and power in partnerships between these and scientific forms of knowledge. There is compelling evidence that engagement with nature from an early age fosters connectedness between people and forests across diverse societies, in both rural and urban contexts, providing the basis for the formation of pro-forest attitudes and behaviours. These can be further amplified, with relevant capacities and skills developed, by subsequent formal, non-formal and informal education.

There are many examples globally of approaches to developing knowledge about forests, and of fostering pro-forest attitudes and behaviours. These can be part of formal curricula from pre-school to tertiary levels, of non-formal education such as capacity development, and of informal learning among families, peers and communities. Educational systems that recognise the significance of each of these modes, and the ways in which they reinforce each other over an individual's lifetime and within their societal contexts, will be most effective in encouraging pro-forest behaviour. However, access to education and the quality of education remain major constraints for many of the world's poorer people, for girls and women in many societies, and for marginalised groups such as Indigenous and forest-dependent peoples. Addressing such disadvantage, as SDG 4 seeks to do, has the potential to realise significant benefits for forests as well as for these people, many of whom depend directly or closely on forests. Correspondingly, fostering a greater sense of connectedness to forests among those in the world who are advantaged – typically those in richer countries, and in cities – can be expected to benefit forests; such connectedness also benefits the well-being of people whose day-to-day lives are more physically distant from forests. There are both great opportunities and considerable challenges for all involved in formal, non-formal and informal education, if the ambitions of SDG 4 are to be realised in ways that benefit forests and our many forms of dependency on them.

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Chapter 5 SDG 5: Gender Equality – A Precondition for Sustainable Forestry

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Key Points

- Forestry cannot be thought of in isolation from its relations with other sectors and other parts of people's lives – for both the health of the forests and the well-being of forest peoples.
- Forest governance and everyday management are upheld by a superstructure of gendered forest relations – invisible to mainstream forestry – that often disadvantages women as a social group.
- Well-intentioned gender programmes can backfire, causing adverse effects on forests and forest peoples, if the efforts are not cognisant of context and power relations.
- Constant awareness of differences among various social groups – men, women, different classes, ethnicities – and how their interests intersect differently in various forest contexts is needed for everyone's energy, creativity and motivation to contribute to sustainable forest management.
- Research suggests that greater democratic governance of forests leads to better environmental outcomes.
- The gender-neutral framing of some SDG goals undermines efforts towards achieving the outcomes called for in SDG 5.

5.1 Introduction

SDG 5's ambition to 'achieve gender equality and empower all women and girls' is extremely important in forestry contexts. It brings attention to aspects that make forest livelihoods possible but often get subsumed in conventional forestry definitions, associating forests only with timber, woody biomass or biodiversity conservation. Taking SDG 5 seriously in relation to forests brings to the forefront what is usually taken for granted or backgrounded in forest

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debates: people, and their relationships to one another and to the forests, which determine forest outcomes.

We first analyse the context for SDG 5 in relation to forests; second, we consider how taking SDG 5 seriously might impact forests and people's livelihoods. So far, little progress has been made in implementing these targets within the forestry sector. Our analysis is built around SDG 5's nine targets (Table 5.1). Though defined separately in Goal 5, the issues the targets raise are inextricably linked to one another in the everyday lives of women and men. Bringing change to one would affect other aspects. We demonstrate the need to understand large systemic connections from a broad perspective. To do so, we turn to compelling feminist research on gender and forest livelihoods. We also go beyond forestry research to cutting-edge gender research on themes and targets where research in relation to forest contexts is scarce. We then theorise on insights from this research to what we know about forest contexts.

Taken together, the subsections titled 'Implications' in this chapter build a framework for analysis and raise serious questions in relation to interventions

Table 5.1 SDG 5 targets

5.1 End all forms of discrimination against all women and girls everywhere
5.2 Eliminate all forms of violence against all women and girls in the public and private spheres
5.3 Eliminate all harmful practices, such as child, early and forced marriage and female genital mutilation
5.4 Recognize and value unpaid care and domestic work
5.5 Ensure women's full and effective participation and equal opportunities for leadership at all levels in political, economic and public life
5.6 Ensure universal access to sexual and reproductive health and reproductive rights
5.A Undertake reforms to give women equal rights to economic resources, and access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws
5.B Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women
5.C Adopt and strengthen sound policies and enforceable legislation for the promotion of gender equality and the empowerment of all women and girls

Source: Adapted from https://sustainabledevelopment.un.org/SDG5 in forestry if equality and sustainability are to guide forest action. The analysis, while focused on forest contexts, is also relevant for other sectors (e.g. agriculture), as is evident from the research we draw on and the ways these issues are intertwined in people's everyday lives.

Gender, as it is discussed here, is not synonymous with women – a common mainstream assumption. Rather, gender, as a category of analysis, studies relationships of power based on sex/sexuality and the ways in which relationships may be organised. We therefore analyse not only how this organisation in different contexts may discriminate against certain social groups based on their sex, but also how men's and women's positions in society are always cross-cut by intersecting dimensions of power such as class, caste, age, ethnicity and sexual orientation.[1] Much of the research on forestry and gender comes from the Global South, but research on this topic is gaining ground in the Global North. There are differences in these contexts, but also striking parallels and connections, as we show in the following sections.

We begin with Target 5.1: the elimination of discrimination against women and girls. This section establishes the context of gender and forest relations and the potential for SDG 5 targets to be achieved in forest contexts. Extensive research on forestry shows that what is taken by mainstream forestry to be 'work' often ignores women's work in forests. We reflect on the implications of this research in relation to forestry and the anticipated impact that achieving the target might have for forests and forest livelihoods.

5.2 Elimination of Discrimination: What Does It Look Like in Forestry Today? – Target 5.1

Women are central to the work done in and around forests, yet forests have long been a male public domain. Most recently, FAO's *The State of the World's Forests* (2018) report, building on global data, states that women's forest-related work often surpasses that of men. Research from both the Global South and North shows how what has been considered work or valuable in forests has commonly involved activities associated with men: activities related to the commodification of forest products whose trade is often male-dominated. This is especially problematic as, in many places (if not most), men and women have different divisions of labour and differences in their ability to act and make decisions regarding forests and forest resources. Not actively addressing discrimination in this sector is not only

[1] Most human rights law continues to deploy 'gender' as a synonym for 'women'. This failure to truly grapple with gendered systems of power means that these policy instruments are unable to effectively tackle gendered inequalities.

a setback for an equitable society, but also a huge obstacle for sustainable forest management.

Although research since the 1970s has highlighted gendered differences, gender-neutral approaches have coloured forestry policies and programmes, both in the Global North and South. The view of institutions as gender-neutral and meant for all is an important factor in discrimination against women. These institutions tend to take the interests of certain men (of a particular class, age, ethnicity and race or caste) as the norm – as is evident in past forestry programmes in the Global South, such as social forestry, joint forest management or community forestry in the 1970s–90s (Agarwal 2010). This is equally true of the Global North (Reed 2008) and in relation to women from Indigenous communities (Mills 2006). Current programmes such as REDD+ and large land-investment schemes seem only to be repeating past errors. A study of 23 early-stage REDD+ projects found that none listed women as a stakeholder group, although five initiatives listed fair benefits to women as an equity goal. A follow-up study three years later found that women's well-being in REDD+ sites had fared worse than the villages' as a whole, and that being in a REDD+ site was significantly associated with a drop in women's well-being when compared to a control group over the same period (Larson et al. 2018). Similarly, studies in Indonesia (Li 2015) bring to light negative economic consequences shouldered by women and their larger communities when forest-based roles are ignored during negotiation processes with investors proposing large-scale land acquisitions. Women in particular were absent from informational meetings and had little or no knowledge of what would happen to their lands.

The insecurity of women's forest rights under national law continues to be an obstacle. A recent global assessment of the legally recognised rights of Indigenous and rural women to community forests in 30 low- and middle-income countries (RRI 2017) concludes that none of the assessed countries adequately recognise women's rights. Rights to inheritance, community membership, community-level governance (voting and leadership) and community-level dispute resolution are wanting, despite constitutional commitments to protect women's rights.

Research also shows that the personal, spiritual, emotional and non-economic aspects in women's and men's everyday lives cannot be separated from decision-making about forests. In both the Global North (Arora-Jonsson 2013) and South (Agarwal and Saxena 2018), women have often chosen to forego economic benefits in favour of other forest outcomes they see as benefitting their communities, families and themselves (see Box 5.1). These elements central to the lives of forest-dependent peoples are often disregarded in academic and political discourses that prioritise the economic value of forests.

Box 5.1 Beyond Economic Benefits

India's Forest Rights Act (FRA) of 2006 recognises the 'rights of ownership, access to collect, use, and dispose of minor forest produce' of forest-dwelling communities.[2] Tendu (*Diospyros melanoxylon*) leaves, an important minor forest product in Central India, are collected primarily by tribal women and constitute a crucial source of cash. As tendu is a nationalised minor forest product (MFP), the forest department had a monopoly on its trade. This changed with the enactment of the FRA, which empowers forest-dwelling communities to sell such MFPs to traders of their choice.

In 2017, when a private trader offered a better rate for tendu leaves than the forest department, tribal women from six Odisha villages contracted a deal with the trader. The forest department strongly opposed the deal and insisted that the leaves could only be sold to the department. Tendu leaves are a significant source of revenue for the state government (estimated at more than USD 70 million).

The choice available to these women was to sell the leaves to the forest department and earn whatever the department had to offer, or not to sell the leaves at all. Time was a crucial factor in the women's decision, as tendu leaf quality deteriorates quickly without proper storage, which was unavailable to the villages. The women agreed unanimously to trade on their own terms and forego the potential revenue from tendu if the forest department did not come around. The women wanted the department to respect their rights under the FRA. In a major victory for the women, the forest department acknowledged – albeit after six months of sustained protests – that communities have the right to engage in the private trade of nationalised MFPs.

Source: Agarwal and Saxena 2018.

Violence by men (and sometimes by female relatives), lack of access to birth control or decisions regarding childbearing, domestic work and lack of access to information or education prevent many women from participating, owning or managing forests and resources in and beyond the household (Colfer 2011). As a woman from a forest in Odisha remarked, 'What is the point of protecting the forests when we cannot protect ourselves?' (Arora-Jonsson 2013: 204). In forest livelihoods, as elsewhere, the feminist slogan remains clearly relevant: the personal is political. Matters around bodily integrity, domestic partnerships and household-level power dynamics are deeply intertwined with what takes place in the public sphere of management, conservation and business.

[2] https://forestrights.nic.in/pdf/FRAAct.pdf

Studies shows that women are consistently at a disadvantage in relation to institutional support in extension, information, technical support and other services (Lambrou and Nelson 2010). In Sweden, a governmental inquiry demonstrated that male-dominated forestry networks and greater links to economic resources for men than women have contributed to the slow progress of gender equality within the forestry sector (DS 2004: 39). A technical study of formalisation procedures on forest tenure across four countries – Indonesia, Uganda, Peru and Nepal – shows that most government officials managing these processes in each country were men. Only 18 per cent of the officials were women, and only 17 per cent of officials believed that strengthening the rights of special groups such as women and Indigenous peoples was a formalisation objective (Herawati et al. 2017).

The lack of female extension agents and officers is especially troubling in light of research showing that women often prefer female extension agents in order to discuss their interests regarding agriculture. A study in Tanzania shows that men too prefer female extension agents as they feel women are more inclined to listen to them than the male extension agents (Due et al. 1997). Another such example (from Arora-Jonsson 2013) is an assessment report of community forestry groups in Odisha by male authors with little direct contact with the village women that reported the women as being oppressed and lacking agency in forest contexts. In contrast, ethnographic research by a woman at the same time and in the same place presents a different picture, pointing to the many ways in which women's groups were taking action both for themselves and for the forests, showing ways in which they could be supported for forest health and themselves. Research in Senegal (Moore et al. 2001) shows that contact with women officers was a strong predictor of the level of women's knowledge about natural resource management (NRM) and adoption of management practices, also contributing to the level of men's knowledge. Mechanisms established specifically to have contact with women, such as employing women agents, are important for women.

These examples have implications for forestry since it is clear that the lack of networks, good extension and sensitivity to the experiences of different groups is likely to hamper forest production and health. They highlight the need for officers and researchers who might have better access to women. More importantly, research stresses that the main difference lies not in the sex of extension workers or forest officers, but in their ability and training to listen to the contextual needs of different groups and the importance of making an effort to reach out to them (Due et al. 1997, Jafrey and Sulaiman 2013, Quisumbinq and Pandolfelli 2010).

5.2.1 Implications

This research shows overwhelmingly that forestry cannot be considered in isolation. As the previously given quote by the Odisha woman highlights, forestry cannot only be about trees but needs to link to other parts of people's lives. Questions of safety in the forests and the home, the spiritual and cultural significance that forests represent for many Indigenous and local communities worldwide, and the ability of women and other vulnerable groups to participate in forest-related decision-making are equally important for forestry agencies to consider.

Past lessons are being ignored. Discrimination against women often results from the institutional make-up of official bureaucracies and other outsiders and discriminatory legislation as much as it derives from customs within communities. The role of forestry officials on the ground, as well as other natural resource officials, is extremely important. The ratio of men to women working in forestry is significant: it is important that forest departments hire more women. Yet this is rarely the case. It is even more important that forest officers are trained to listen to concerns of different groups and to concerns that may differ from mainstream forestry as usually defined.

As the SDGs are implemented we need to confront the gendered nature of institutions, particularly in local areas, but also across the scale to the national and international levels responsible for the policymaking and projects that also shape conditions on the ground. Policymaking needs to be sensitive to these nuances when promulgating reforms intended to be gender-inclusive.

5.3 Women's Rights over Their Own Bodies – Targets 5.2, 5.3 and 5.6

Forests are particularly linked to violence or the equally debilitating fear of violence. In studies from the Global South, women speak of their fear of violence at the hands of contractors engaged in forest investments (Arora-Jonsson 2013), often associated with big multinational companies and other forest outsiders (Zamora and Monterroso 2017). Forests are seeing increased violence against environmental defenders in ongoing conflicts over territory and resources, and sometimes violence perpetrated by government authorities in their zeal for conservation (RRI 2018). In 2016, at least 200 forest defenders were murdered (almost 10 per cent more than in 2015) in different conflicts over land and resources; 40 per cent of the victims were Indigenous (Global Witness 2017). Female land and human rights defenders are murdered less often, but are more often subject to sexual violence and are less likely to be able to denounce these abuses. Nevertheless, there are emblematic cases such as that of Bertha Caceres in Honduras, assassinated in 2016.[3] Caceres was an Indigenous Lenca woman and a Goldman Environmental Prize recipient in 2015,[4] and was killed for her opposition to a hydroelectric dam. Women and transgender forest defenders are especially vulnerable to sexual assault by fellow activists due to remoteness to the outside world (Mallory 2006).

Insidious everyday violence takes place within the walls of the home, including in forested areas. Studies show that poverty and alcohol abuse as well as climate-induced socio-economic changes in Kenya (Scheffran et al. 2014), or drought- and income-related stress in Australia (Whittenbury 2013) have led to an increase in violence against women. While these factors may provoke some men into violence against women in forested areas, incontrovertible evidence demonstrates that men's violence against women is widespread everywhere (for a review of 34 countries in North America and Europe, see Alhabib 2010). In India, lower-caste working women are subjected to routine violence and sexual abuse by the upper castes (Jayal 2003, Kumari 2017). In Sweden, considered to be one of the most progressive countries in terms of gender equality indices, Lundgren et al. (2001) found that nearly every second woman, at some point since her 15th birthday, has experienced violence at the hands of a man, regardless of ethnicity or social class. In Aotearoa, New Zealand, more than one-third of women (35.4 per cent) reported physical and/or intimate partner violence in her lifetime (Simon-Kumar et al. 2017). Research from South Africa shows the increasingly negative effects of violence on the mental health of victims (Lagdon et al. 2014). Data for 87 countries from 2005 to 2016 shows that 19 per cent of girls and women aged 15–49 experienced physical and/or sexual violence from an intimate partner in the previous year (HLPF 2017: 1).

Strategies to counter violence against women have had varying success. It is clear that male violence against women, and some men, is enabled by constructions of masculinity and the desire for control that go far beyond catalytic factors such as alcohol consumption. Scholars argue, however, that in some cases reducing alcohol consumption (Jewkes 2002) and access to arms – as, for example, in Sudan and Kenya (Budlender and Alma 2011, Scheffran et al. 2014) – can contribute to curtailing the frequency of violence. Education is important: women who are highly educated have an edge, although the relation between empowerment and the risk of violence is non-linear and education does not always mitigate the risk of violence (Jewkes 2002, Mabsout and van Staveren 2010).

3 www.theguardian.com/world/2017/feb/28/berta-caceres-honduras-military-intelligence-us-trained-special-forces www.greenpeace.org/international/en/news/Blogs/makingwaves/revealed-investigation-uncovers-the-plot-to-m/blog/60633/

4 www.goldmanprize.org/recipient/berta-caceres

Kusuma and Babu (2017) argue for the need to coordinate efforts among a range of relevant areas and groups: health, education, police, judiciary and community groups. This is especially relevant for forest contexts, which are often remote and far from such services. A review study of 142 documents on violence against women, mainly in high-income settings, indicates that education, youth projects and interventions in school-based dating violence can be successful in counteracting intimate partner and sexual violence among adolescents (Lundgren and Amin 2015). Research from Turkey shows that the involvement of medical professionals such as nurses and midwives has a key role in counselling women, including about the legal rights that protect them from the risk of violence (Özcan et al. 2016). Access to reproductive health services, including family planning, has helped reduce poverty, contributed to improved nutrition and educational outcomes, and saved mothers' lives, benefitting not only women but society more generally. Supporting girls' and women's education and the prevention of HIV infections by providing contraceptives has been shown to reduce the number of births, and that in turn mitigates deforestation effects as less land is taken over for agriculture (Starbird et al. 2016).

Context-based factors as well as resources and household assets can protect women from violence, as shown in 30 sub-Saharan African countries (Cools and Kotsadam 2017), in Nicaragua (Grabe 2010) and in different parts of India (Bhattacharya et al. 2011, Panda and Agarwal 2005). Ownership of resources also correlates with health. For example, propertied women in South Africa are better able to protect themselves from HIV/AIDS infections (Swaminathan et al. 2008). Income equality or men's economic subordination, not only in relation to women, is seen as a threat to a certain hegemonic masculinity. In such cases violence may be used to resolve a crisis of male identity (Jewkes 2002, Lwambo 2013). Behrman et al. (2014) in South Asia and sub-Saharan Africa and Mabsout and van Staveren (2010) in Ethiopia note a perception among some that increasing women's access to resources can increase violence against them. However, no linear relation between the two has been noted in practice.

Violence should be dealt with not only as a women's issue, but also as a gendered and systemic one. Researchers link increasing violence (warfare, domestic abuse) and criminality in sub-Saharan Africa with changing sex roles that no longer allow men to perform an idealised form of masculinity and act as breadwinners (Barker and Ricardo 2005, Lwambo 2013; also noted in Nicaragua, Evans et al. 2017). The Responsible Men's Club in Vietnam (Hoang et al. 2013) was one attempt to work with men that yielded important insights about men's relationships to their wives and also how these relationships were interconnected across scale, extending far beyond the household.

Many link violence to the weakness of the state (Dolan 2002, Schroeder 1999) and its inability to address caste and class violence, as in India (Jayal 2003, Kumari 2017). Violence against women must be tackled in a variety of ways and across various scales. Forest actors are vital to this in forest areas.

5.3.1 Implications

In contexts where forest issues are being debated, there is a need to work actively against gender-based violence and the lack of access to sexual and reproductive health. Legal rights are important, as is the work of state authorities, including forest authorities. At the same time, violence is not only an individual action but is tied to a larger question of gender and power, and contextual factors are extremely important.

A weak state can lead to greater gender-based violence. Efforts to counter violence have often resorted to the criminalisation of perpetrators, disregarding larger structural contexts and minimising success in reducing violence. The increasing focus on criminalisation that has emerged in both international law and the international-security domain risks obfuscating and downsizing the collective and public dimension of state responsibilities to reduce violence. Indeed, criminalisation strategies allow states to circumvent their duty to address the social, political and economic structural dimensions at the root of this severe form of violation of women's human rights (Pividori and Degani 2018).

Parental support and peer networks (Chandra-Mouli et al. 2015, Faxon et al. 2015), along with safe spaces for women, are important in giving women agency and safety from violence (Eduards 2002). Again, forest authorities have an important role to play: for example, in providing training within forest departments, helping to provide safe spaces for women and spaces for their participation in decision-making on their own terms. The need for greater attention to these issues in the forest context is pressing since the official realm of forestry the world over is male-dominated. By not actively taking up questions that concern SDG 5 in other arenas because they appear unrelated to their forestry work, forest actors help to ensure that issues surrounding violence against women remain barriers to an equal, democratic and sustainable forestry.

5.4 Recognition of Unpaid Work through Social Policy and Public Provisions – Target 5.4

Women are often overburdened with care work in the home and perform much of the unpaid domestic labour everywhere. Research in Nicaragua shows that women identified their domestic work, and men's failure to share it, as a main reason why they did not participate in community decision-making regarding forests (Mairena et al. 2012). Unpaid care work adversely affects both women and men, though it lowers women's income more (Qi and Dong 2016, on China). Even in a context of increasingly egalitarian policies such as in Canada, the gendered care gap is widening, with women taking on the bulk of this work (Proulx 2016). Time-use studies have led to a recognition of women's unpaid work in both the Global North and South. As research shows, however, recognition is insufficient. We need to rethink the androcentric socio-economic institutions and narratives that lead to such disparities. As a case from Malta indicates, pressure to conform to gender norms, combined with poor government policies (no paid parental leave, higher male salaries), coincides with an overall resistance among spouses to reallocate responsibilities (Camilleri-Cassar 2017).

This is particularly so in the forest sector. Most of women's forest-based labour is unpaid, and forest products that women are responsible for are often less economically valuable. Research in Scandinavia (Kaldal 2000) shows that women's forest work not associated with timber tends not to be regarded as work. Even where women do not do forest-based labour themselves, their tremendous care duties make forest-based labour possible for other family members. Especially in lower-income countries, a whole regime of unacknowledged care work upholds the forest sector. Exacerbating this hidden work is migration, especially in the Global South. Islam and Shamsuddoha (2017) show that in Bangladesh women left behind are burdened with additional work, including securing food for the family while the men are away. In cases where men migrate and are not able to or do not send money home, women must generate income to sustain their families. This is not always culturally acceptable, raising concerns for trafficking and exploitation. This is confounded by development-induced displacement and resettlement where women usually receive fewer benefits than men (Lin 2008). Michocha (2015) argues women act as shock absorbers when families are displaced, taking responsibility for sourcing food, cooking and child care.

In some countries, social provisions such as help with childcare or child allowances have been central to women entering the labour force and achieving economic independence. These provisions have counteracted women's weak social positions vis-á-vis public decision-making and enabled them to enter public arenas. Yet, the forestry sector remains an aberration. In Sweden some argue that the increasing number of women forest owners is likely to presage a change in forest management (Nordlund and Westin 2011). So far, practice has yet to bear this out. The forest sector continues to be dominated by a narrow group of actors – mostly men – despite increasing numbers of women forest owners (Holmgren and Arora-Jonsson 2015).

In cases where inequitable norms that privilege men remain intact, social provisions may be inadequate. Regardless of incentives, the participation of men in care work is lower than that of women in both the Global North and South. In Sweden, despite generous paternity benefits, fewer men than women take childcare leave (Duvander et al. 2010), due in part to higher wages for men. In Korea (Peng 2011) women are encouraged to enter the labour market, but their jobs are more often in non-regular and service sectors, impeding the attainment of gender equality. Yoon (2014) shows that in Korea the state tends to omit the role of family-provided care services, overestimating its own role and suggesting that much more in-depth understanding of the contributions to care, both qualitative and quantitative, is needed. Furthermore, policies that focus on flexible work hours – intended as an alternative to the male model of 'working hours'– disregard the gendered pay gap and social norms (Lewis and Plomien 2009) and can reproduce rather than reduce gender inequalities (Figart and Mutari 2000). Neither do they reduce the job deficit (Estévez-Abe and Hobson 2015). The increasing commodification of care work is gendered female worldwide, and tends to be low-paid.

Scholars argue that state provision of 'merit goods' – goods and services deemed valuable for every citizen, such as child allowance, unemployment insurance, schooling and healthcare – accompanied by targeted cash payments are much more likely to increase productivity and reduce inequalities (Bergmann 2004). They call for valuing care work on a par with other activities (Baker 2008). Research from Chile and Mexico shows that childcare services can enhance gender equality if the state commits to such goals, gives sufficient financial resources and develops effective regulations (Staab and Gerhard 2011). Moreover, findings from Argentina, Bolivia, Brazil and Chile indicate that non-contributory pension funds can be a key measure to reduce gender gaps in benefits at old age (Arza 2017). Drawing on findings from a multi-country cash-transfer programme in sub-Saharan Africa, Asfaw (2016) concludes that promoting cash programmes can positively affect livelihoods as well as agricultural productivity, provided there is coordination with other sectoral development programmes and attention to local contexts.

5.4.1 Implications

The research cited herein is thus important to consider in the forestry context as much as in other walks of life. Meeting Target 5.4 in the forestry world requires recognising that women's care work, often invisible, underpins the recognised and overtly valued commercial work, widely considered as men's work.

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Informal employment characterises the lives of most working women, especially in the Global South: see Ghosh (2015) for India and Lopez-Ruiz et al. (2017) for Central America. Women's need to control their participation in local non-timber forest products (NTFPs) and other forest-related markets needs to be addressed (Section 5.6 discusses women's participation in markets). Merit goods such as those described here have been shown to be beneficial not only for men and women, but also for agricultural productivity (Asfaw 2016). Similar outcomes could be expected within forestry if merit goods provide resources and time for men and women.

The thrust of this research indicates the need for a systemic and contextual understanding, including addressing paid and unpaid forest-related labour in one frame. This entails acknowledging care work in the home and the subsistence work that men or women carry out in the forest. The need for interconnected policies and programmes is urgent (Peng 2011). As the examples demonstrate, the role of authorities and other official actors is vital in these efforts.

5.5 Women's Right to Decision-Making – Target 5.5

In contrast to the themes discussed earlier, there is considerable research on the participation of marginalised social groups, including women, in forest decision-making. Few women participate in forestry decision-making forums in the Global North and South (Agarwal 2010, Reed 2008). The RRI study (2017) across 30 countries in Asia, Africa and Latin America found that women's right to participate in community-level forest governance processes was the most inadequately protected community-level right analysed in the study.

The devolution of forest decision-making has been an important global trend in recent decades. In settings related to rural development and forestry in both the Global North and South, decision-making power is often captured by male elites. Studies from South Asia report intense conflict in local groups managing high-value forests. Older and elite men become more active in forest-user groups managing high-value forests, making women's effective participation harder to achieve (Adhikari and Di Falco 2008, Lama et al. 2017). Similarly, studies in Nicaragua (Evans et al. 2017) and Colombia (Sandoval-Ferro 2013) show that women in some Indigenous communities, with equal rights on paper to manage the forest, forego their own interests. They are pressured to accept decisions guided by male interests and men's groups, defined as having more benefit to the wider community.

A similar pattern of elite capture can be seen in Europe in a forest management context (Arora-Jonsson 2013), as well as in EU programmes that stipulate the participation of local groups in development. In a process of

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devolution of local governance activities in the UK, for example, Tickell and Peck (1996) observed that male power was naturalised as the legitimate conduit for effective local governance. The political process in unelected bodies privileged pre-existing male networks, while their modus operandi marginalised and excluded women and their interests.

In such cases, quotas for women have been useful, though sometimes quotas have also resulted in token rather than substantive and comprehensive participation among women (RRI 2017). According to studies in rural Andhra Pradesh, India (Afridi et al. 2017), women village council heads in reserved seats were initially seen to be less effective at administration and tackling corruption, though in several districts they caught up after one year. The findings suggest that learning speeds among female Executive Committee members may depend on their starting point (e.g. level of education, intra-group dynamics and reciprocal support among the women members) as well as the complexity of their administrative tasks and responsibilities. Programmes to make women's representation more effective from the start require a better and more detailed understanding of hurdles to this effectiveness and its variation with individual, resource and community characteristics (Afridi et al. 2017). Importantly, this entails working actively to reduce disparities with men in access to technology and information (Mwangi et al. 2011).

Research across South Asia indicates that women's groups tend to be more rigorous in forest conservation (Agarwal 2010). It remains unclear whether this leads to better conditions for them.

Gender balance in forest-user groups in East Africa and Latin America was shown to be associated with more participation and enhanced forest sustainability (Mwangi et al. 2011). From her research in Northern India, Minocha (2015) concludes that a perception among women interviewed was that more active participation by women in council meetings and similar decision-making bodies would result in more resistance to big infrastructure projects that adversely affect livelihoods or cause displacement.

Adding a few women to committees will not ensure that all women's interests are addressed or that governance necessarily becomes more effective. Real positive change requires a willingness to accommodate the interests and issues taken up by marginalised groups and openness to changing decision-making forums and structures (Arora-Jonsson 2013). In forestry forums, women often raise issues not considered central to forests or forestry, such as violence, lack of decision-making power and inattention to other community issues they consider related to forests. Such issues that touch upon spaces other than forests, such as the home or village, while not directly related to timber and forest products, impinge on people's relations to the forests and to each other. They play an important part in what actually happens in forests. This is the 'space-off'[5] of forestry, i.e. the invisible relations and spaces often disregarded in decision-making on forests (frequently focused on certain economic interests) that are nonetheless vital in supporting forestry and the well-being of forest peoples (Arora-Jonsson 2013).

Separate spaces or networks supported from outside mainstream decision-making forums have been important for women to press their demands in forest contexts, suggesting a need for new thinking about forest governance. These demands have been expressed when women have organised across loyalties such as ethnicity, indigeneity, class or caste (Arora-Jonsson 2013). In such cases, support (not necessarily monetary) from the outside (NGOs, government agencies) has been important for women's groups to make claims and be heard (Arora-Jonsson 2013, Schroeder 1999, Sundar 1998). Similarly, support for collectives may also need to be combined with individualised support, as shown by microfinance interventions such as an HIV-prevention measure for transgender and cisgender[6] women using drugs (Lall et al. 2017). It is clear that no one solution fits all contexts. Women's groups are not the solution in all contexts. Even in the same place, different strategies might be needed at different times, including both individual and collective approaches.[7]

5.5.1 Implications

Better, more equitable management is required. The empirical research makes clear that decision-making would represent a wider diversity of interests related to forests if marginalised people were included. Research also suggests that greater democratic management leads to better environmental outcomes.

To achieve equitable management, individualised support is important, but so is a wider systemic approach. Hurdles to women's actual participation exist even when there are quotas or legally recognised governance rights. Contextual factors need to be addressed in each case to ensure the realisation

[5] Arora-Jonsson borrows the term from de Lauretis, who explains 'space-off' as the 'spaces in the margins of hegemonic discourses, social spaces carved in the interstices of institutions and in the chinks and cracks of the power-knowledge apparati. It is there that the terms of a different construction of gender can be posed … in the micropolitical practices of daily life and daily resistances that afford both agency and sources of power' (1989: 25).

[6] Cis women identify with the gender they are assigned at birth, unlike transgender women, who do not.

[7] For example, in Odisha, some women's microcredit groups were groups in name only. Others carried out microcredit activities, but were controlled by a few men from village committees. Still others were able to use the space provided to make demands and bring about change (Arora-Jonsson, 2013).

of women's governance rights. A willingness to address systemic obstacles and undertake structural change is required, rather than merely adding women and other marginalised groups to existing structures. Practically, this would entail recognising the 'space off' of forestry in mainstream discussions and a disposition to consider dynamic and flexible organisational forms. If we are serious about involving women as a group in decision-making on forests, we need to allow possibilities for women to take part in decision-making in various ways – in concert with each other, from within their own spaces and also as individuals from within formal institutions (Arora-Jonsson 2013).

5.6 Rights to Economic Resources and Control over Land and Resources – Target 5.A

This section discusses women's rights to resources including: (1) rights, access and control over land, and (2) policies and projects on income generation designed to give women increased economic resources.

5.6.1 Tenure Rights

Strong legislation and accessible mechanisms to implement women's forest rights are essential, but the enabling conditions needed for such achievements must be understood within local contexts. Depending on context, law can work as perceived authority preventing violence and enabling women's rights in ways that village leadership may be unable to do. Rao (2007) advocates hybridity in the pursuit of gender equality, wherein socially validated rights are addressed alongside formal instances of law. Rankin (2003) calls for recognition of the limits to undertaking change within the boundaries of households or villages, cautioning against strengthening place-based institutions such as the local civil society built on hierarchical premises. Specific components of secure tenure[8] must be considered carefully before and during actions designed to secure women's tenure rights and legal entitlements.

The question of collective as opposed to individual rights is extremely pertinent in the forest context since a substantial percentage of forest-dependent communities, especially in the Global South, rely on community-based tenure systems (formal and/or informal) in order to control and access land. Under many such collective tenure systems, the community rather than any individual community member is understood as 'owning' land. This can make the situation for women more complex to understand and to guarantee

[8] Tenure refers to the bundle of legal entitlements that comprise a landholder's ability to control, use, access and benefit from land and natural resources.

rights due to various layers of governance, especially in customary systems. In several instances in South Asia, women's customary rights of access were undermined by the creation of forest management committees that created new rules of access disregarding women's previous customary access (Agarwal 1995). Interestingly, a recent study across the 80 community-based legal frameworks analysed within 30 low- and middle-income countries found that the frameworks that provided the strongest legal protection for communities as a whole also provided the most robust protection for women community members (RRI 2017).

Projects with little understanding of the context often create new inequalities. For instance, Chung (2017) examined a large-scale land deal for industrial sugar-cane production in the coastal region of Tanzania. The forms for land valuation and compensation claims distributed by the government only included the names of male household heads (unless the households were headed by females) 'It was assumed that husbands and fathers were the de facto owners of the land and that they were the ones that would collect compensation payments on behalf of their families' (Chung 2017: 115). Even though wives of landowners saw this as common practice, nearly all women interviewed speculated that their husbands would use the money and/or run away with it to pay bride-wealth for younger women, leaving them and their children destitute. Women of the Barabaig tribe (among whom polygyny is actively encouraged) noted that some men took on more wives or mistresses, using the prospect of cash compensation as credit.

5.6.2 Income Generation

The ubiquitous adoption of income-generation programmes and policies advocating the opening of markets for women (connections with SDG 9 – Industry, Innovation and Infrastructure) are also relevant for women's rights to resources. In forestry contexts, these have included the establishment of markets for NTFPs, making handicrafts, being involved in forest work, etc. These initiatives are meant as a key to empowerment, improved family income and nutrition, and children's education.

Access to markets is important for women, but the benefits depend on the kind of control they have over their own involvement and its implications for forest sustainability. For example, in Burkina Faso's plans for REDD+ programmes, engaging the women-dominated shea trade is an important strategy. Related decisions were made, however, without consulting the women or women's groups involved (Westholm and Arora-Jonsson 2015). An example from Odisha, India, shows how women may work to circumvent such disempowerment: women from the lower castes in some areas opted not to sell their bamboo goods in the new local markets especially for NTFPs because men made all the decisions on pricing and location. Instead, they chose to sell in kind only to other women in order to have control over their trade (Arora-Jonsson 2013). This was an attempt to address their own needs and to avoid situations where dependency on markets led to further poverty for their communities. In Burkina Faso, the linking up to international markets has led to increased pressure to provide shea nuts and consequent environmental degradation (Elias and Arora-Jonsson 2017). These instances provide important insights to consider when addressing SDG 5 and SDG 1 (No Poverty). They also challenge targets proposed by SDG 9 (Industry, Innovation and Infrastructure).

Many income-generation programmes meant ostensibly to empower women have in fact become projects where women are expected to raise incomes for domestic use and take part in projects that serve other development and market agendas (Chant 2016). Indigenous women's income-generating activities with respect to large-scale oil palm projects in Indonesia provided women with sorely needed income. In some communities this income was accompanied by a more equal distribution of household work among partners. In others, women's workload simply increased in ways that were fundamentally unsustainable since domestic tasks did not decrease. Furthermore, working conditions for women were part-time, insecure and lower paid (Li 2015).

Indeed, a significant body of research suggests that women's agency and well-being cannot be secured through an increase in income alone. A study of intra-household decision-making in 3000+ households in Ethiopia (Mabsout and van Staveren 2010) found that increases in women's incomes do not necessarily result in increased decision-making power within households. Instead, many women compensated for having taken on some of men's ideal responsibilities by more assiduously performing women's traditional roles, including submission. The research on microcredit enterprises, extremely popular in the last two decades, reports similar findings. There are no automatic benefits since the programmes insufficiently explore the dynamics of women's social networks (Maclean 2010) and ignore the role of men and of gender power dynamics (Chant 2014).

5.6.3 Implications

Tenure rights: Given the cross-cutting nature of women's tenure rights, legal reforms that strengthen these rights must extend beyond the realm of forestry as traditionally conceived. They must address women's underlying needs with respect to family law, access to justice and a broad array of obstacles to women's economic agency (i.e. their capacity for choice and action) that render them vulnerable to both economic and physical forms of violence. Women and men need support to be able to negotiate changing norms within the community.

Work is needed to devise constructive approaches to bolstering women's forest rights and titling, which can have negative effects without sufficient attention to particular contexts. This is especially so for women's livelihoods in cases where women are dependent on commonly held and managed resources. Strong norms that 'good women do not inherit land' (Rao 2008) put pressure on women not to claim a share in their inheritance even if there are no brothers. Mainstream neoliberal policies that advocate individual ownership can backfire for women, who may be exploited and divested of their titles (Ramdas 2009, Ahlers and Zwarteveen 2009).

How government agencies act in such contexts is of vital importance. Institutions directly involved in the formalisation processes granting forest and land rights often prioritise men. More creativity is needed to develop titling processes that positively affect women's lives in different social and cultural contexts.

Income generation: Income generation and involvement in projects can be counterproductive and can become a 'feminisation of responsibility' (Chant 2016). But they can also have surprising outcomes, not necessarily related to the income they generate but to the space they provide for women to take up their particular concerns (Arora-Jonsson 2013). In such cases, outside support for women is important. For example, in a Dominican Republic project, support from NGOs enabling women to control their money gave them an edge in negotiating HIV protective behaviour vis-à-vis their partners (Ashburn et al. 2008) – linked also to SDG 3 (Good Health and Well-Being). Likewise, in Bangladesh participation in microcredit-based productive activity (SDG 1 – No Poverty) protected women from poor communities against marital violence (Hadi 2005), and in South Africa women participating in women's HIV support groups received both practical and emotional support (Dageid and Duckert 2008). In such cases, the role of outsider help, such as from NGOs or officials, is vital.

Strategic and practical interests: These debates touch on the question of women's strategic and practical interests in relation to forests and how those are intertwined. Feminists have long been critical of development interventions such as income-generation programmes that might fulfil individual women's practical interests but fail to deliver on larger structural changes and their strategic interests. It is believed that strategic interests are those derived from an analysis of women's subordination and the formulation of strategic objectives to overcome it. Practical gender interests, on the other hand, arise from the concrete conditions of women's lives and are usually a response to an immediate perceived need. They do not generally entail a strategic goal such as women's emancipation or gender equality (Molyneux 1985).

Arora-Jonsson (2013) draws on her studies of women's grassroots activism in forest contexts to argue that though useful to understand some aspects of discrimination, this division of women's lives into practical and strategic interests can be counterproductive. The articulation of practical needs and claim-making in relation to forestry have in themselves challenged structural disadvantage. On the other hand, strategic considerations such as tenure or a conscious involvement of women in organisations for forest governance could well become a tool to rubber stamp existing inequalities.

These studies suggest that there is no clear division between the two. Depending on the process and the context, income-generation activities or short-term practical help for individual women in forestry contexts *can* lead to larger changes, as can structural change initiatives. What is clear is the need for supporting structures in the home and in public that enable women and other marginalised or vulnerable groups to participate in maintaining forests sustainably and to voice their particular interests.

5.7 Enhance the Use of Enabling Technology for Women's Empowerment – Target 5.B

Information and communication technologies (ICTs) are enabling the participation of women in social, political and economic processes at greater rates than in the past (Alves and Steiner 2017). However, structural and socio-cultural factors, including poverty, illiteracy and gender norms and practices, may limit women's access to ICTs and other technologies, with resulting impacts on women's empowerment and agricultural productivity (Mogues et al. 2009, O'Brien et al. 2016). Agricultural extension work and access to technology packages focus more on men, tending to view women as less important to development initiatives (Mogues et al. 2009). O'Brien et al. (2016) show that involving men and women as couples in technology-related training events can improve women's access to new and emerging agricultural information.

Gender biases in technology access and dissemination and disparities in information access have consequences even when women are part of the decision-making process (Mwangi et al. 2011). A study on female ICT intermediaries in rural China and India found that although access to ICTs could improve women's status in the short term, such gains were reversed in the absence of broader changes in society. The choices they made while using ICTs always took place in the context of 'societal expectations (and their own) [which] continued to be structured by patriarchal values' (Oreglia and Srinivasan 2016: 506).

Socio-cultural values and gender norms are, however, not static or unchallenged. Masika and Bailur (2015) argue that ICTs should be understood not as automatic sources of women's empowerment, but as a site of contestation where women carefully calibrate gender relations in complex ways. Clearly, more attention should be paid to women's socio-cultural contexts and the bargains they make. In comparison to men, they are less likely to have wide informal networks they can tap into to fulfil their needs.

5.7.1 Implications

The research on ICTs and gender draws attention to the significance of power structures and societal norms in shaping women's access to technologies and their impacts on gender relations. This has implications for facilitating women's agency and empowerment. Given this, addressing structural factors that shape forestry management is more critical than focusing exclusively on individual constraints.

Additionally, technologies should be targeted in ways that facilitate women's technology adoption. This could be accomplished, for example, by ensuring that extension visits to user groups be undertaken by both men and women, or by raising awareness and providing requisite skills among male agents of the sustainability benefits of proactively engaging women resource users (Mwangi et al. 2011). Authors suggest that (1) technologies should be designed to take into account women's time constraints, and (2) extension should be accompanied by training in the skills necessary for ensuring and sustaining technology adoption (Mwangi et al. 2011). More structured and formal access for women and other marginalised groups is also necessary. ICT can play an important role in that process.

5.8 Policies and Legislation for Gender Equality and Empowerment – Target 5.C

Not all gender-sensitive policies are necessarily implemented. Indeed, practice often strays far from the progressive language of policymaking. Passing gender-sensitive laws and policies is nevertheless a key component of gender equality. The manner in which gender-sensitive laws are crafted, implemented and legislated have significant consequences on their enforceability.

Emphasis on women or gender in policies often implies an increase in responsibility. Ecofeminist arguments about women's closeness to nature were mobilised by bureaucrats to enrol women in conservation and soil improvement programmes, primarily increasing women's workload without much desirable change in their everyday lives (Leach 2007). In other cases, assumptions about women's vulnerability to climate change have led to policymaking that has increased their responsibilities rather than addressing their disadvantages (Arora-Jonsson 2011). Holmes and Jones (2013) observe that policies often reproduce unequal gender norms. Social policy has made positive inroads, but it needs to move beyond reproducing harmful stereotypes that define women only as mothers and men as oppressors.

Critics have argued that gender mainstreaming policies have served merely to bureaucratise gender and that adding women to existing programmes merely underwrites their previous invisibility by reducing them to a check mark on required forms. This has absolved agencies from doing anything substantive about gender discrimination. Some have in fact argued for doing away with the idea of gender mainstreaming altogether (see Arora-Jonsson, 2014, for an overview of this debate).

5.8.1 Implications

An individual-based approach can disregard systemic gender-based discrimination. For example, Sweden's forest-sector policy on gender equality encourages women to take an active part in the forest sector and focuses on their role as economic agents benefitting the sector. While these overtures to individual women are important, the approach ignores the systemic reasons for women's absence from the sector (Holmgren and Arora-Jonsson 2015).

On the other hand, a gender-neutral approach or the absence of policies on gender can make it difficult for officials and others wanting to create space for change. For example, while Swedish environmental policy has promoted gender equality as an important cornerstone of its work in development aid, there has been little attention to gender in domestic environmental policies. This lack of policy support within the country has made it more difficult for forestry and environmental officials to challenge discrimination related to gender and power relations. On the other hand, its policies on gender in development aid have forced NGOs and others to pay attention to gender-based discrimination, which has sometimes helped women to organise themselves (see Case Study 16.4 in Chapter 16).

The discourse on gender has made space for intersectional approaches within international organisations in a way that was previously much more difficult (Arora-Jonsson and Sijapati 2018). This indicates that there is a need for policies on gender, but they must allow for hybridity (Rao 2007) and flexibility (Arora-Jonsson 2013) and enable a careful analysis of gender and power

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relations in each context. Blanket statements about the poverty or vulnerability of all women or women's closeness to the environment often become counterproductive to the interests of women.

5.9 Conclusions

One of the major conclusions from the literature overview is the importance of understanding the contextual and systemic nature of inequalities if we want to act for greater justice and sustainable forestry. There are no automatic gains in gender equality from greater development, expansion of markets for women, inclusion in forestry forums or poverty alleviation programmes. They might bring economic benefits to some, but for others they can exacerbate adverse conditions. As is clear from the instances cited in the chapter, concern for the dignity and welfare of forest-based peoples requires contextual responses that go beyond these measures. They need institutional support and structural change from 'business as usual'. As is clear from the research discussed here, forest governance and everyday management are upheld by a superstructure of gendered forest relations (invisible to mainstream forestry) that often disadvantages women as a social group. Paying close attention to this 'space-off' of forestry is vital if we are to reach towards sustainable and equitable forest relations promoted by the SDGs.

Forests are a key site where the goal of sustainable development and its linkages with gender equality play out. Yet, there are significant challenges and barriers to the implementation of SDG 5 across the North and South. While the contexts in these places differ greatly, similar features recur in forestry contexts across the world.

Decision-making on forests at all levels is dominated by groups of men from certain castes, class or age groups. Women often have less access to the information needed for decision-making. Men are also overwhelmingly the targets for forestry interventions – reflective of current tenure systems wherein more men than women own forest land. However, beyond ownership, perception biases as well as gender norms and values tend to position forestry as a male domain. Poverty and the lack of supportive infrastructure in countries in the Global South do correlate with discrimination, but it is also clear that welfare and development do not automatically lead to greater gender equality, and inequitable relations of power in forestry stretch across the Global North and South (Arora-Jonsson 2013). This is true in universities and international organisations where the legacy of purely technical approaches to forestry education is still entrenched. Thinking through how SDG 5 targets may be applied in various forestry contexts provides a space for new ideas to emerge and to challenge convention at a time when new directions are sorely needed.

Taking SDG 5 seriously implies a fundamental change in approaches to forests and the environment – one that incorporates systemic and contextual factors as well as people's relations outside of forestry. This change entails learning from the past. New forest-related initiatives have yet to take up these gender lessons (e.g. REDD+).

Progress will entail taking into account connections between the Global North and South. Forestry as a profession and field of work has interconnected features in its organisation and the ideologies that drive it. The responses to challenges within it must also recognise these interconnections. For example, violence in the forests in the Global South often results from struggles with multinational companies based in the Global North, which derive their influence from their work and trade there. Concepts that travel between the North and South have different implications in different places. For instance, women in (Indigenous) communities in some areas of the Global South risk backlash when using the term 'gender'. It has been associated with taking power away from men and with Northern or external ideologies that threaten custom (Geetha 2002). In other cases women have taken up the English term 'women's rights' (even if they do not speak English) to forward their claims as a group. The likelihood of success with this strategy has been enhanced with support from NGOs and others that have also engaged men's help. In contrast, questions of gender in forest contexts in the Global North have been ignored by practitioners, with the argument that gender equality has already been reached (Arora-Jonsson 2013). Taking account of SDG 5 in different contexts requires different strategies, as well as paying attention to the various connections between contexts and scales.

Closer attention to SDG 5 highlights the invisible labour and relations so crucial to good forest management, and helps to develop democratic and sustainable strategies so key to forest relations and of benefit to forest people (with close connections to most other SDGs – especially SDGs 1–4, 6, 7, 10, 13–16). Such attention could promote voice and a focus on dignity and rights. It could demand compliance on the part of institutions that perpetrate injustice, sometimes unconsciously, by carrying on with business as usual (in relation to SDGs 8, 9, 17) – such as the current focus on business within forestry and agriculture and the assumption of gender neutrality, as in the Indonesian palm oil case (Section 5.6), in the ways education is gendered in content and the student body, the provision of information and so on.

Forest management can improve with the involvement of heterogeneous groups, and especially women (Agarwal 2010, Mwangi et al. 2011). Increasing women's access to funds and social provisions such as childcare allowances benefits their families and larger communities (e.g. Bergmann 2008, Butler et al. 2012). It provides some recompense for their 'invisible work' in forests that remains otherwise unacknowledged. Valuing such care work as well as women's work in the forests on a par with other conventional forest activities is likely to increase productivity and reduce inequalities (Baker 2008). As women's household-level bargaining power increases, rates of HIV and undernutrition and violence decrease (Ashburn et al. 2008, Mabsout and van Staveren 2010), and additional energy, creativity and motivation to sustain forests could be brought to bear.[9] These aspects are enhanced by more secure forest rights (RRI 2017).

The gender-neutral framing of the other SDG goals could undermine efforts towards rights called for in SDG 5. This requires serious attention to the norms that form the basis of many of the other SDGs. For example, SDG 8's focus on economic growth could lead to serious disadvantages for marginalised groups. The call for decent work for women, without acknowledging the underlying discrimination within the current system, could merely exacerbate gender inequalities. The focus on trade and women's involvement in markets called for in SDGs 8 and 9 can undermine both the environment (Elias and Arora-Jonsson 2017) and gender equality (Li 2015).

From the point of view of SDG 5, political will is needed to transform unequal relationships, challenge privilege based on sex, class, ethnicity or caste, and destabilise inequitable micro- and macroeconomic structures (based on notions of private property, commodification etc.). Forest agencies and other actors need to interact seriously with other governmental agencies, NGOs and others that provide services and pay attention to community concerns beyond the forests. Greater democratic governance of forests leads to better forest management, but the institutional forms need to be flexible and responsive to the context. Companies need to be more accountable, and forest-sector education needs to expand to include the social and the cultural. The International Union of Forest Research Organizations (IUFRO) has an important role to play in this context – in questioning business as usual in what IUFRO does, and also in undertaking gender research and analysis of forestry policies and programmes to better understand gender dynamics in forestry. The welfare and dignity that achieving SDG 5 would bring to forest peoples and livelihoods is essential to ensuring better managed and sustainable forests.

[9] The Center for International Forestry Research's Adaptive Collaborative Management programme, which worked closely with rural forest women in 11 countries in the early 2000s, saw these benefits accrue (see www.cifor.org/acm/ and Colfer 2005).

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Chapter 6 SDG 6: Clean Water and Sanitation – Forest-Related Targets and Their Impacts on Forests and People

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Key Points

- SDG 6 seems unlikely to exert a major influence on forest cover and indeed is unlikely to be pursued with forests in the forefront of consideration.
- Full implementation of Targets 6.1 and 6.2 could positively impact forest people, yet this is not an implementation priority.
- SDG 6 may focus attention on the role of forests (as providers of hydrological ecosystems services) in protecting clean drinking water resources; the exact role of forests here requires careful consideration.
- Particular attention should be given to reforestation strategies to improve water availability in areas with soil degradation and reduced infiltration. Target 6.4 may restrict the spread of new plantations in semi-arid areas and Target 6.5 may drive a more integrated view of catchments and their management.
- It is necessary to consider forest–water interactions at the catchment, regional and continental scales; actions with a beneficial impact at one scale may have an adverse impact at another.

6.1 Introduction

SDG 6 is designed to 'ensure the availability and sustainable management of water and sanitation for all' (UN 2018). It defines clean, accessible water as an essential part of the world we want to live in, one that should be universally and easily accessible across the globe. As we shall see in this chapter, the anthropocentric orientation of the SDG title is later modulated by a more integrative view of some of the specific targets. However, it already shows the potential for conflict in the competition for water under conditions of scarcity. While not a central consideration in the development of SDG 6, there

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are intrinsic links between forests and water. Trees, as living organisms, need water to exist and thrive; as critical landscape components, they strongly influence water availability at local and continental scales. The exact nature of this influence is still a point of scientific debate, although in recent decades we have witnessed the slow emergence of a more nuanced picture of forest–water relationships. Understanding the potential impacts of SDG 6 on forests and people requires a balanced appraisal of these relationships.

The chapter first briefly summarises the current understanding of forest–water interactions in order to identify the critical SDG 6 targets for forestry. An in-depth discussion of target impacts on forest cover focuses on two areas: South America and South Asia. These two areas have diverse conditions where forests play an important role in upstream/downstream and inter-catchment interactions, where achieving SDG 6 will require active interventions. The final section takes a wider perspective to discuss the key considerations for improving SDG 6 and forestry interactions at the global scale.

6.2 Forest and Water Interactions

The traditional understanding of how forests and water interact is influenced by long-standing beliefs regarding the role of forests in the water cycle, which are not always supported by science (Calder 2005). The current scientific understanding is much more nuanced and needs to be stated clearly in order to understand the links with the new requirements on water management emerging from SDG 6, enabling us to distinguish between positive synergies and potential misconceptions. Important initial considerations for this discussion are the big regional differences worldwide in forest cover, climate zones and land-use changes. The following summary considers both the traditional catchment-scale water balance and recent interest in the recycling of evaporated moisture at much larger, inter-catchment scales.

1. At the catchment scale, decades of research with paired catchments and process studies have shown that, relative to shorter vegetation, forest cover *reduces* catchment run-off at the annual scale because trees have higher rainfall interception rates and higher transpiration rates during dry periods (Andréassian 2004, Bosch and Hewlett 1982, Zhang et al. 2017). Dry season flows are particularly likely to be reduced in forest catchments as tree roots can extract soil water from greater depths than shorter vegetation. Reductions in annual run-off for the most extreme change from 100 per cent grass cover to 100 per cent forest cover can be substantial, ranging from 15 per cent to at least 50 per cent (Fahey and Payne 2017, Marc and Robinson 2007). Run-off reduction has been found at catchment scales as large as thousands of square kilometres (Iroumé and Palacios 2013, Silveira and Alonso 2009, Zhang et al. 2017).

2. Run-off reduction is greatest for young, growing forests. The reduction may be smaller for old mature forests with low leaf-area indices. Different tree species take up water at different rates (Huber et al. 2010).

3. In certain cases, by increasing soil infiltration and thus groundwater recharge, forests may allow a temporally more even redistribution of run-off, thus increasing dry season flows (but still with reduced annual flow) (Calder 2005). Most evidence, however, points to a reduction in dry season flows following afforestation, although the pattern in areas with seriously degraded soils is less clear (Bruijnzeel 2004) and the overall effect is likely to vary with tree density (Ilstedt et al. 2016).

4. The special case of cloud forests, which intercept fog and cloud droplets, may possibly increase annual yields in the very specific (typically mountain) locations in which they occur (Bruijnzeel 2001, 2011). However, the fog formation may itself depend in part on recycling of evaporated moisture from upwind forests.

5. At very large (subcontinental) scales, recycling of forest evapotranspiration potentially increases the downwind rainfall (Ellison et al. 2017, Sheil 2018, van der Ent et al. 2010) and thus run-off (after any interception losses in the recipient catchment).

6. The impact of forest cover on flood peaks, as opposed to run-off, is more controversial, both because the effect on extreme flows is uncertain and because the means of quantifying the impact is disputed (see discussion in Alila and Green 2014).

7. Because of the greater evapotranspiration and consequently lower (on average) soil moisture content in forested catchments, the generally higher infiltration capacity of forest soils and the greater carbon sequestration (which aids water storage), forests can absorb more of the rain and so reduce flood peaks for given low to moderate rainfall events. This effect does not occur if the soil is already saturated, for example from a previous rain event or from soil water accumulated over a wet season (Bathurst et al. 2011).

8. Forests may not be effective in reducing flood peaks produced by extreme (but rare) rainfall events as the above absorption effect is overwhelmed by the amount of rain (Bathurst et al. 2011).

9. Forests can reduce the *frequency* with which a given flood peak occurs for all (not just low to moderate) flood sizes (Kuraś et al. 2012).

10. Forest cover often (but not always) reduces sediment yield compared with other land covers, especially those involving soil disturbance. The annual specific sediment yield in a logged catchment may exceed that in an undisturbed forested catchment by up to one order of magnitude under conditions of best management practice or two orders of magnitude in cases of severe ground disturbance or extreme events coinciding with the logged condition (Bathurst and Iroumé 2014). However, in areas of high natural sediment yields or during certain extreme events such as tropical hurricanes, the vegetation cover may have relatively little impact on overall sediment yield (Calder 2005).

11. By excluding other management approaches (e.g. fertiliser application) and limiting soil erosion, forests usually imply less-polluted water. Deposition of most atmospheric pollutants are generally higher to forests and, in regions of high (industrial) pollution, this has historically caused acidification of catchments and run-off, especially with coniferous forest cover (Calder 2005). However, this threat is reducing in the advanced economies as industrial emissions are controlled and energy production moves away from coal and other fossil fuels. In certain areas (e.g. the southwest of Western Australia), the rise in the water table following the removal of forest cover has resulted in a redistribution of soluble salts, causing severe soil salinisation and loss of crop-growing capacity (Peck and Hatton 2003). Lowering of the water table following afforestation of grasslands has also been associated with soil salinisation (e.g. in Brazil and Hungary) (Jobbágy and Jackson 2004, Tóth et al. 2013).

12. Forest–water interactions have traditionally been studied at the river catchment scale, emphasising the impact of forest cover or its absence on downstream water users and communities. The increasing interest in the recycling of forest evapotranspiration at the subcontinental scale, though, highlights the impacts that may be felt downwind over large distances and across catchment and national boundaries (Ellison et al. 2017). Additionally, forestry activities (including forest loss) often take place on a patchwork basis, rather than uniformly across an entire catchment, especially at the larger catchment scale. Moreover, the phenomenon of deforestation and its impacts on landscape and water availability are evident at scales larger than the catchment. It is therefore necessary to consider forest–water interactions at the catchment, landscape and subcontinental scales; actions with a beneficial impact at one scale may have an adverse impact at another.

6.3. Relevance of SDG 6 to Forests and Forest People

SDG 6 is one of the new goals that emerged in 2015. Indeed, water was a notable omission from the SDG predecessors, the Millennium Development Goals (MDGs). In spite of its importance for achieving many of the MDG targets (WWAP 2009), it was hidden within MDG 7 Ensure Environmental Sustainability under the dual Target 7.C: 'To halve the proportion of the universal population without sustainable access to clean and safe drinking water and basic sanitation by 2015'. This has important implications for SDG 6's policy context. While most of SDG 6 is new, the goal starts with an inherited focus on the water, sanitation and hygiene (WASH) agenda, which has developed a strong momentum after nearly two decades of MDG work. The drinking-water target was considered a big success as it was met five years before the deadline, but the sanitation target was never achieved. Although the proportion of the global rural population without access to improved sanitation has declined by nearly a quarter, half of people living in rural areas, including forested areas, do not have access to these facilities (UN 2015). Given this failure and the momentum behind the WASH agenda, it seems likely that a large proportion of the resources allocated to SDG 6 will be focused on sanitation. The reality is that the impact of MDG Target 7.C on the forestry sector and related policies was minimal; the same may be expected of the WASH impact. Two exceptions are an increasing interest in (1) the role of forests – as providers of hydrological ecosystem services – in protecting clean drinking water resources (Brauman et al. 2007), and (2) the use of wastewater in forestry (FAO 2018a). In Section 6.5.2 we discuss interest in nature-based solutions, forests' role therein and the wider role of forests in precipitation recycling.

Pointers towards an increased interaction between global water goals and forestry appear in the final MDG Report (UN 2015). It devotes attention to the 663 million people still using unimproved drinking water sources, mainly in sub-Saharan Africa but also in South Asia, and the shocking 2.4 billion still using unimproved sanitation. It highlights how 30 per cent of the planet's land area is covered by forests that not only support 1.6 billion people but also help 'provide additional benefits … such as clean air and water' (UN 2015: 52) and support river catchments yielding three-quarters of the globally available freshwater. It implicitly assumes that changes in deforestation, afforestation and reforestation rates affect water resources. There are big regional differences in the way these interactions take place. South America and Africa have experienced the larger net losses of forest area, while large-scale afforestation programmes in China have offset continued rates of net loss in Southern and Southeastern Asia, all with corresponding impacts, positive or negative, on water balances. The exact nature of these processes is very important because one of the other key identified global environmental drivers is water scarcity, which affects more than 40 per cent of the global population – a figure that is projected to rise. Although the main problems are in the dry areas of Northern Africa and Western Asia, scarcity affects every continent. Major sectors that compete for water are agriculture (for irrigation, livestock and aquaculture), industries and municipalities. Agriculture, mainly through irrigation, takes nearly 70 per cent of freshwater withdrawals. Forests are not mentioned in the section about scarcity of the MDG 7 report, but their role in determining total water quantity and quality in catchments is critical.

After intense water-sector lobbying and proven interest from the public and governments in the consultations after Rio+20 (UNESCO-IHP 2014), SDG 6 has gone much further than the MDGs, with a set of completely new targets covering the whole gamut of integrated water resources management, as the water sector wanted (Table 6.1). This substantially increases the potential impact of SDG 6 on forests and forestry, as four of the new targets (6.3–6.6) are focused on water resources and not just on WASH. The drinking water and sanitation targets (6.1 and 6.2) are maintained and indeed enhanced with an ambitious 'for all' specification, which substantially increases their difficulty and cost. The means of implementation targets (6.A and 6.B) are neutral for the forest sector, although Target 6.B could have implications for hydrological ecosystems services involving forests. The UN SDG 6 synthesis report (UN 2018) reinforces the message that water management is critical. Water scarcity, flooding and quality are identified as the key determinants in social and economic development, and water efficiency is identified as the main factor to balance growing competing demands. The new SDG 6 targets incorporate all these aspects and, consequently, define the areas where SDG 6 implementation potentially impacts upon forests significantly.

Progress towards achieving each SDG 6 target is quantified by at least one indicator (UN Water 2018a). Section 6.4 assesses target impacts on forests through the actions that will be needed to ensure a positive direction for the respective indicator(s). Indicators 6.3.1–6.6.1 are the main focus of the analysis. Indicators 6.1.1 and 6.2.1 are the proportion of the population using, respectively, safely managed drinking water and sanitation services.

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Table 6.1 SDG 6 targets and monitoring indicators for Targets 6.3–6.6
6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all
6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations
6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally *Indicators: 6.3.1 Proportion of wastewater safely treated* *6.3.2 Proportion of bodies of water with good ambient water quality*
6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity *Indicators: 6.4.1 Change in water-use efficiency over time* *6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources*
6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate *Indicators: 6.5.1 Degree of integrated water resources management implementation (0–100)* *6.5.2 Proportion of transboundary basin area with an operational arrangement for water cooperation*
6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes *Indicator: 6.6.1 Change in the extent of water-related ecosystems over time*
6.A By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies
6.B Support and strengthen the participation of local communities in improving water and sanitation management
Source: https://sustainabledevelopment.un.org/sdg6 (orange = WASH targets; yellow = targets and indicators with potential forest impacts; white background = means of implementation targets)

6.4 SDG 6 and Forests: Key Links

This section examines the potential impacts of SDG 6 on forests (summarised in Table 6.2).

Table 6.2 Potential impacts of SDG 6 indicators on forests

Indicator	Response for favourable indicator score
6.1.1 Proportion of population using safely managed drinking water services	Maintain forest cover to ensure good water quality in water supply catchments. Establish forested riparian buffer strips to maintain stream water quality.
6.2.1 Proportion of population using safely managed sanitation services, including a hand-washing facility with soap and water	No direct link but target generally favourable for forest people.
6.3.1 Proportion of wastewater safely treated	Encourage agroforestry schemes using treated wastewater. Maintain forest cover for treating wastewater (e.g. in schemes for induced precipitation recycling).
6.3.2 Proportion of bodies of water with good ambient water quality	Maintain or increase forest cover to enhance water quality. Change plantation tree species to enhance water quality and quantity.
6.4.1 Change in water-use efficiency over time	Require increased water efficiency from forests as forestry is combined with (relatively inefficient) agriculture in allocating available water between economic activities. Change plantation tree species, density and location to improve water-use efficiency.
6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources	Restrict establishment and continuation of plantation forest in water-limited areas (e.g. semi-arid regions) to maximise water availability. Maintain forest cover in upwind areas to safeguard downwind water resources dependent on recycled evapotranspiration.

Table 6.2 (cont.)

Indicator	Response for favourable indicator score
6.5.1 Degree of integrated water resources management implementation (0–100)	Integrate forest management with water resources management. Change plantation tree species, plantation characteristics and riparian buffer strips to optimise water availability and quality.
6.5.2 Proportion of transboundary basin area with an operational arrangement for water cooperation	Integrated consideration of forest management, including downstream impacts (within catchment) and downwind impacts (between catchments).
6.6.1 Change in the extent of water-related ecosystems over time	Reforest agricultural land, replace exotic tree plantations with native forests and implement other scenarios to maintain water availability and quality, with potential impacts on forest people.

6.4.1 Access to Safe and Affordable Drinking Water and Adequate and Equitable Sanitation and Hygiene – Targets 6.1 and 6.2

As noted in Section 6.3, Target 6.1 is somewhat neutral regarding the forest sector. Forests do not, of themselves, provide safe drinking water or sanitation services. Nevertheless, to the extent that stream waters in forested catchments tend to be of higher quality than in agricultural or urban environments, the treatment costs to bring them to a safe potable level may be lower, with a beneficial effect on affordability. It is common to find catchments maintained with a forest cover to form a source of clean water for a nearby city (e.g. Valdivia, Chile, receives water from a 12.7 km^2 catchment hosting evergreen native forest). Also, direct extraction of drinking water from streams without treatment is also generally safer in forested catchments than elsewhere (e.g. important for Indigenous populations of tropical forests). The performance of Indicator 6.1.1 (Proportion of population using safely managed drinking water services) could therefore be enhanced by a greater forest cover in water supply catchments. In some regions, forest cover is increasing through natural regeneration following abandonment of agricultural land. In other cases it may be worth deliberately afforesting catchments to provide purer water for water treatment plants, as the cost of treating lower-quality water in the absence of forest cover can be high (hundreds of thousands to millions of US dollars per year for individual cities; Ashagre et al. 2018). That cost would have to be compared with the costs of afforestation (including the potential removal of people from the land and the loss of agriculture). Reduction in run-off, and thus water availability, resulting from the afforestation would also have to be considered (e.g. Target 6.4). A more feasible and cheaper option may be the introduction of forested buffer strips along riparian zones, to reduce or interrupt nutrient fluxes to streams in agricultural catchments and sediment fluxes from both agricultural catchments and forested catchments undergoing logging. In the absence of other pressures, Indicator 6.1.1 is likely to favour maintaining existing forest covers. Given the multiple pressures on land resources, however, it would not be surprising if the forests' (high) worth to drinking-water quality was simply ignored, leaving the successful achievement of Target 6.1 increasingly dependent on artificial water treatment. The target would then be irrelevant to forests. Target 6.2, with its emphasis on sanitation and hygiene *for all*, should have a positive impact on forest people – that is, those who live in forests and whose lives and livelihoods depend directly on the forest environment and forest resources. Difficulties of accessibility, though, are likely to mean that forest people in remote areas will be among the last to benefit from this target (although perhaps being among those least in need of it).

6.4.2 Improving Water Quality – Target 6.3

Indicator 6.3.1 (Proportion of wastewater safely treated) is not closely linked to forests. However, to the extent that there is an interest in using treated wastewater for forestry, this indicator may drive an increase in, for example, agroforestry schemes. Forests have themselves been proposed as treatment areas for wastewater as part of wider schemes for induced precipitation recycling (Layton and Ellison 2016). Indicator 6.3.2 (Proportion of bodies of water with good ambient water quality) is more relevant in view of the potential for land use to affect water quality in rivers, reservoirs, estuaries and downstream wetlands. For example, in streams in native forests in Chile, nitrate (NO_3-N) and ammonium concentrations are very low and nitrogen (N) export is very low (0.2–3.5 kg N ha^{-1} yr^{-1}) (Perakis and Hedin 2001, 2002). The conversion of native forests to other land uses may therefore be expected to lead to increased NO_3-N and total N export. Conversion of native forest to pasture in southern Chile is associated with increased N fluxes and increased dominance of NO_3-N (exports up to 11 kg ha^{-1} yr^{-1}), although some of this increase may be attributable to pasture fertilisation (Oyarzún and Huber 2003). Conversely, afforestation may change soil pH and alter nutrient cycles (Hong et al. 2018). Nevertheless, because fertiliser use in plantation forestry – in terms of total use – involves a lower application frequency and smaller land areas compared with agricultural systems (May et al. 2009), the conversion of crop or pastureland to plantations (or even reverting to natural forest) is expected to improve water quality.

In most cases, logging of planted forests may produce elevated sediment export, mainly because of mechanised site preparation, road building and clear-cutting operations in steep terrain, rather than exposure of soil to rainfall (Bathurst and Iroumé 2014). Research in forest plantations in central Chile found that forest roads produce more sediment than hill slopes; after clear-cutting, the relative contributions increased from 16 per cent to 25 per cent for hill slopes and from 37 per cent to 45 per cent from forest roads (Schuller et al. 2013). Sediment delivery to streams increases if logging operations take place in rainy periods (with adverse impacts on drinking water and aquatic habitats), but the application of contemporary best management practices, which include guidelines for logging during dry periods, can limit logging-related sedimentation (Bathurst and Iroumé 2014). Although forest certification has enhanced the adoption of best management practices in Chile, forestry operations are still associated with increased sediment transport and decreases in water quality relative to unmanaged forests.

Because of forests' generally positive impact on water quality, Indicator 6.3.2 favours maintaining forest cover and increasing cover in protected or degraded catchments. Specifically, achieving good indicator scores for plantation forests will require careful consideration of tree species and the development and implementation of best management practices.

6.4.3 Water Efficiency and Improved Availability – Target 6.4

Indicator 6.4.1 (Change in water-use efficiency over time) tracks the value added (in US dollars) per volume of water withdrawn (cubic metres), by a given economic activity over time (UN Water 2018a). The UN International Standard Industrial Classification of All Economic Activities, Revision 4 code combines forestry with agriculture and fishing. This means that forestry as an economic activity will be considered jointly with agriculture when comparing water use with other sectors. It is already acknowledged that irrigation, as the largest consumer of water by volume, should be one of the big targets for water efficiency (HLPW 2018). There will therefore be increased attention to the efficient use of water in the forestry sector, which may eventually constrain the establishment and continued presence of plantation forests in the water-stressed areas highlighted by Indicator 6.4.2 (Level of water stress: freshwater withdrawal as a proportion of available freshwater resources). This indicator is demand-driven and measures the ratio between withdrawals and the difference between total renewable water resources and the environmental flows (Vanham et al. 2018). Strictly, it considers only blue water: the liquid water in rivers, lakes, wetlands and aquifers. However, the amount of blue water is determined by the upstream flows of green water – rainwater held in the unsaturated zone of the soil and available to plants – which is determined by terrestrial ecosystem functions or natural land use (e.g. forests or natural grasslands) and by consumptive water use in rain-fed agriculture and forest plantations. Therefore, analyses of water-stressed environments may lead to closer examinations of the consumptive use of water by forests.

In terms of biomass production per litre of water, trees are considered efficient users of water. Nevertheless, Soto-Schönherr and Iroumé (2014) found in Chile that water-use efficiency (i.e. kilograms of biomass produced per unit of water consumed) differs only a little between forests and grasslands: forests produce 0.1–4 kg of biomass per cubic metre of water, while grasslands produce 0.5–1.3 kg. However, because trees use more water than shorter vegetation, there is a central inconsistency (at least at the catchment scale) between the aims of maintaining forest cover (desirable for many reasons, including lower soil erosion and higher water quality) and of increasing water availability (which implies reducing forest cover). This is less concerning in high-rainfall areas (where there is enough water for all activities) but could be critical in semi-arid areas. This means that forestry as an economic activity will be compared directly with agriculture and other activities when deciding on use of limited water resources. Replacing forest by agriculture could increase annual run-off (and food supply), but at the expense of the forest ecosystem and timber supply. For example, replacement of natural vegetation with agricultural cover in a 175 360 km^2 catchment in South America produced a significant increase in annual mean discharge and high-flow season discharges because of reduced infiltration and evapotranspiration rates (Costa et al. 2003). Conversion of forest cover may ultimately lead to destruction of the land resource itself (Contreras et al. 2013). Thinning of forests considered unnaturally overgrown as a result of fire-suppression programmes has been proposed to increase water supply, e.g. in North America (Poulos 2018), but this may ignore the many other changes produced by forest management (Jones et al. 2009, NRC 2008). For example, forests play important roles in regulating the world's temperatures and freshwater flows, storing carbon and providing a broad range of important but less recognised benefits (Ellison et al. 2017). At the subcontinental scale, replacement of forests by shorter vegetation could imply less rainfall in downwind regions (Creed and van Noordwijk 2018) and possibly therefore less run-off, although the magnitude of this effect remains to be quantified.

Overall, forest plantations with fast-growing species use more water than native forests, although many of the comparisons are limited to old-growth native forests versus young plantations (Soto-Schönherr and Iroumé 2016). Results from southern Chile, for a wide range of latitudes and forest compositions and ages, showed that annual interception accounts for approximately 21 per cent of incoming precipitation in the mean, albeit with some margin of variation (Soto-Schönherr and Iroumé 2016). Within the range of variation, broad-leaved forests (including native broad-leaved and eucalyptus forests) generally exhibit higher interception losses than conifers. Indicative of the level of uncertainty, Huber et al. (2010) found that interception is lower, and water use is higher, in eucalyptus compared with pine plantations in southern Chile. Because of the relatively limited difference in canopy interception loss between native forests and forest plantations (Huber and Iroumé 2001, Soto-Schönherr and Iroumé 2016), the observed differences in water yield between the two must be explained, at least in part, by different transpiration losses.

Despite the above, forest plantations may not use more water than native forests at all stages of the forest rotation. As expected, water use is highest (and yield lowest) in the late stages of plantation growth, especially in short-rotation plantations with a high tree density, but water yield (especially summer water yield) increases just after clear-cutting, in the early phases of replanting (Iroumé et al. 2005, 2006). Again, variations between plantation species may exist (e.g. pine versus eucalyptus). Thus, water consumption by forests could be moderated by a small amount through careful choice of tree species (with an eye towards suitability to future climates), maintaining a mix of old and new growth (i.e. avoiding large-scale plantation of new growth), regulating tree density and choosing plantation location carefully, possibly implying longer growth periods or reduced timber yield. Nevertheless, such moderation is likely to be small compared with the effect of forest removal. Overall, the demands of Target 6.4 are likely to be inimical towards forest cover in many parts of the world.

6.4.4 Integrated Water Resources Management – Target 6.5

Integrated water resources management (IWRM) is defined as ‘a process which promotes the coordinated development and management of water, land and related resources in order to maximise economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems’ (Global Water Partnership 2017). It acknowledges the interconnected nature of hydrological resources and the interdependence of different water uses. Within the wider requirements of the definition, IWRM implementation implies the integrated management of water supply, water quality, flood management, navigation, hydroelectric power generation and other water provisions and services within a river basin. Within this balancing act, forest cover reduces water supply relative to other vegetation covers (at the annual scale) but has the potential to improve water quality. From points 8 to 10 in Section 6.2 it can be concluded that forest cover could probably be reduced without necessarily increasing damaging flood magnitudes, but flood frequencies might increase, as would soil erosion. These points refer to the catchment scale. At the subcontinental scale, forest evapotranspiration is not lost from the system but may be recycled as precipitation downwind. Water resources management needs to be integrated with forest management, an end likely encouraged by Indicator 6.5.1 (Degree of integrated water resources management implementation). Such integration is most required in regions where there are multiple and conflicting demands for water, where water supplies are restricted and forests account for significant water use (e.g. semi-arid regions) and where soil erosion is a significant problem (e.g. semi-arid regions, degraded lands and areas of unregulated agricultural expansion). The exact impact of Indicator 6.5.1 on forest cover will vary from basin to basin depending on economic, social, political and other circumstances. It seems more likely, though, that IWRM is implemented as a function of whatever level of forest cover happens to exist, and therefore reacts to rather than drives forest cover change.

In South America conversion of forest to agriculture is the major reason for changes in water availability to rivers and streams (Jones et al. 2017). The concept of virtual water (Yang and Zehnder 2007) assesses water-use efficiency based on water used to grow products traded globally. From 1986 to 2007, South America increased its annual use of water from 42 km^3 to 178 km^3 and became the continent using the greatest amount of water in food products traded globally, with significant increases in soy exports to China – which in turn has contributed to deforestation in Amazonia (Dalin et al. 2012).

In the Federal District of Brazil, river basins with substantial expansion of agriculture since the end of the 1970s show a dramatic decrease of base flow discharge by 40–70 per cent – presumably the effect of irrigation extractions more than compensating for the increase in run-off otherwise expected from reduced forest evapotranspiration. Additionally, the run-off ratio is significantly positively related to the cover of natural vegetation (Lorz et al. 2012). In south-central Chile, the run-off ratios in four large catchments were positively related to the area of native forest and negatively related to the area of eucalyptus and pine plantations (Lara et al. 2009).

Careful choice of tree species and plantation characteristics could moderate water consumption by forests. Reducing the area of forest plantations can potentially increase water availability at the catchment scale, as might replacing exotic fast-growing trees with native forest species, although it has yet to be proven that this would allow adequate timber yields to be produced with less water use. Native forest riparian buffers may increase water yield and improve water quality in forest plantations of eucalyptus in south-central Chile (Little et al. 2015) and along rivers in degraded native forest in south-east Brazil (de Souza et al. 2013). Forest thinning (Poulos 2018) should be approached with caution: thinned plantations may initially increase water yield (Forrester et al. 2012), but subsequent forest growth might take up the additional water, depending on the timing and degree of thinning (Perry and Jones 2017).

At the international level, Indicator 6.5.2 (Proportion of transboundary basin area with an operational arrangement for water cooperation) may drive a more integrated consideration of the forest environment, especially where a downstream or downwind state feels adversely affected by the forestry activities of an upstream or upwind state. At the subcontinental scales typical of many politically sensitive transboundary basins, the downstream impacts of upstream forestry activities may not always be significant. For example, there is no clear evidence for the so-called Himalayan environmental degradation theory, which proposes that loss of forest cover caused by a rapidly growing population in the Himalayan headwaters of the Ganges and Brahmaputra Rivers increases soil erosion and flood run-off, thereby generating increased flooding and siltation in the delta regions of Bangladesh (Hofer 1993). Downwind impacts at subcontinental scales are increasingly thought to be important but have yet to be proven conclusively (Creed and van Noordwijk 2018). Large amounts of moisture from evapotranspiration may be recycled within Amazonia and transferred to other parts of South America. However, the extent to which forest conversion has affected this precipitation recycling so far is yet to be clearly quantified (Bagley et al. 2014, Khanna et al. 2017, Spera et al. 2016, Swann et al. 2015). The impact of Target 6.5 is most likely to be a more integrated consideration of forest management, especially with respect to water resources management, both within and among river basins.

6.4.5 Protecting and Restoring Water-Related Ecosystems – Target 6.6

Indicator 6.6.1 (Change in the extent of water-related ecosystems over time) will drive careful consideration of the relationship between forest cover and the health and sustainability of water-related ecosystems. Although the title of Target 6.6 includes forests along with mountains, wetlands, rivers, aquifers and lakes, Indicator 6.6.1 considers only mangroves. The absence of other types of forests severely limits this indicator's degree of protection.

Despite the restricted nature of the indicator, forest-related water ecosystems services form an important underlying concept linked to the essence of Target 6.6. They are indeed one of the most proffered links between SDG 6 and forests, but they are not always properly understood and are difficult to quantify. For instance, not all forested areas safeguard water quality: rapid and aggressive afforestation and reforestation with exotic species reduces water availability, affecting its quality, especially in dry seasons (Filoso et al. 2017). Achieving good indicator scores requires maintenance of water flows – and of good water quality – to wetlands. This could imply reforesting agricultural areas, replacing plantations of exotic tree species and monocultures with a wider range of native trees (which may be slower growing), removing existing plantations or avoiding new plantations (e.g. in peatlands, páramo soils or semi-arid regions) and other scenarios. Such land management could have adverse consequences for livelihoods based on the existing agricultural and plantation activity (and for the production of the associated crops) but might open new employment prospects in forestry activities. Also, there is a high potential for payments for ecosystem services if those services are clearly proven. In the Hindu Kush Himalaya region, research is attempting to show the tangible value of water-related ecosystem services; for example, purification of the downstream water supply via upstream forests is an important ecosystem function that payments for ecosystem services schemes have attempted to quantify and that can contribute to achieving Target 6.3 by natural means (Ashagre et al. 2018). However, there is still a gap in our understanding of how individual attributes (such as changes in land-use patterns) impact ecosystem service flows, including water (Polasky et al. 2011, Nelson et al. 2013, Su and Fu 2013). In particular, it is difficult to correlate change in a land unit with change in the volume of ecosystem services that this unit provides (Bhatta et al. 2017).

Despite these uncertainties, payments are already being made to promote ecosystem services. Recently, the Chilean government, acting according to the UN Framework Convention on Climate Change (UNFCCC), gave a commitment to afforest (mainly with native tree species) 100 000 ha of degraded soils as a contribution to reducing greenhouse gases (CONAF 2016). To this is added some 470 000 ha that were burnt during the 2016–2017 (southern) summer season. Of this, the government will finance the afforestation of 100 000 ha on lands belonging to small- and medium-size owners, while the remaining burnt lands owned by larger forest companies are already being afforested. The aims of these afforestations are mainly to restore and improve the ecosystem services of the degraded areas, except for the afforestation of lands owned by larger private forest companies whose purpose remains timber production. Not all those forested areas would safeguard water quantity;

potentially, there could be resistance to forestry plantations in water-stressed regions, as highlighted by Indicator 6.4.2.

In conclusion, SDG 6 seems unlikely to exert a major influence on forest cover, and indeed is unlikely to be pursued with forests at the forefront of consideration (Table 6.2). Possible exceptions are that Target 6.4 may restrict the spread of new plantations in semi-arid areas and Target 6.5 may drive a more integrated view of catchments and their management. Plantations may be developed with more careful consideration of tree species and plantation characteristics. It seems much more likely, however, that native forest cover in much of the world will continue to decline in the face of pressures greater than SDG 6: (1) to convert forest for food production, driven by population growth and increasing aspirations for living standards worldwide; and (2) to exploit timber and other forest resources, driven first by those seeking a profit but ultimately responding to individual demand globally, with little consideration for the resulting impacts. The decline is exacerbated by the inability or unwillingness of governments in many countries to control such developments, and possibly by climate change reducing or shifting the areas of the world suitable for sustaining the current forests (Guardian 2019, WWF 2019). The extent of monoculture plantations, on the other hand, could increase or decrease: demand for plantation products (e.g. palm oil and timber) is likely to increase, but water efficiency considerations may curtail the spread of plantations in water-stressed areas.

6.5 Future Policy Considerations

6.5.1 Contextual Factors for SDG 6: The Hindu Kush Himalayas

Trying to understand the real impacts that SDG 6 may have on forests and forest people requires a careful evaluation of the context of water–forest interactions, in particular physical and social settings and the interactions with other SDGs. While context is always affected by local conditions, some situations do recur. The Hindu Kush Himalayas case illustrates some of the contextual factors that must be considered in implementing SDG 6 and highlights the upstream/downstream relationships, inherent where forested mountain areas feed major river systems, which can be found on all continents.

The Hindu Kush Himalayas harbour major river systems providing services, particularly in the form of recharge, to a mountain population of 240 million and a downstream population of 1.9 billion. Indirectly, 3 billion people are dependent on numerous ecosystem services, including climate and hydrological services provided at regional and global scales, and harvested commodities traded at multiple economic scales (Kotru et al. 2015). The

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observed overall increase in forest cover in India does not mean that forest degradation is controlled. An alarming rate of deforestation in parts of the Himalayas, primarily for agricultural land and fuel supply, threatens the sustained flow of forest ecosystem services. As is generally the case in South Asia, multiple sectors and actors influence forests and forest management; it is not only through forest management that the forest–water relationship can be improved for sustained water yield.

Multiple water-related objectives across a portfolio of SDGs present new challenges for policymakers and managers of forests and landscapes with partial tree cover. Hence, SDG 6 cannot be seen in isolation from other key challenges in the Himalayas, such as SDGs 1 (No Poverty), 2 (Zero Hunger) and 5 (Gender Equality). Thus, investments (e.g. in mass tourism) made upstream for addressing other SDGs are not necessarily environmentally friendly or complemented by good governance, making it potentially more difficult to achieve the SDG 6 targets (6.1, 6.3, 6.4 and 6.6). On the other hand, the policies, practices and investments necessary to achieve SDG 6 may not be coordinated with those for other SDGs, so positive outcomes for people are not ensured (Singh and Kotru 2018). The transboundary nature of hydrological resources – overlaying local, regional and national boundaries – make the challenges to safe water access more complex. New institutional responses are needed to tackle multiple water-related objectives across the full portfolio of SDGs, taking a multiple benefits approach (Creed and van Noordwijk 2018). A distinction may be made between a first group of SDGs (SDGs 1, 2, 6, 7) implying an increased demand for clean, reliably flowing water, and a second group of SDGs (5, 10, 12, 16) that stresses a change in power-sharing that allows multi-stakeholder involvement, thus increasing the need for transparency and equity in decision-making.

Several socio-economic and governance realities challenge forest regimes in fulfilling their socio-ecological role (as envisaged under SDG 6) in the Hindu Kush Himalayas (Kotru et al. 2017):

- poverty and inequity are still prevalent in South Asia, a water-deficit area;
- institutional capacities and existing policies are inadequate to meet the future challenge of forest management for sustained water yields;
- research on the forest–water relationship is essentially very limited, with no long-term monitoring data or studies available;
- there are very limited cross-sector policy interfaces (e.g. water policy and forest policy interface) that focus on a forest or landscape approach aimed at sustaining water services;
- sustainable forest management is seriously disadvantaged by a lack of proactive management, itself arising from policy deficits;

- data deficits and a lack of harmonised methodologies and data sharing mean that the planning and application of conservation and development strategies contributing to SDG 6 have only a limited foundation on firm data.

Future progress towards achieving Targets 6.3–6.6 in the Hindu Kush Himalayas will require improved upstream–downstream integration, improved transboundary cooperation and greater coordination and simultaneous progress in the implementation of different SDGs: for example, SDGs 1, 2 and 5 (already mentioned) and SDGs 13 (Climate Action), 15 (Life on Land) and 17 (Partnerships for the Goals). Adoption of a landscape approach would allow stakeholder priority interventions to be matched with public and private investments but, equally, there is a need for an improved understanding of the role of forests in influencing ecosystems services at the larger landscape scale. Greater efforts are required to make the communities struggling on the frontline of sustainable forest management more climate resilient.

6.5.2 Implementation of SDG 6

The final impact of SDG 6 on forests and forest people will be determined by the extent of its implementation. There are four important considerations here: finances, institutions, data and other SDGs. First, implementation costs are increasing: the estimated cost of achieving the WASH targets is USD 1.7 trillion (Hutton and Varughese 2016). While there are no reliable estimates of the whole cost of achieving SDG 6, it is clear that the required threefold increase for Targets 6.1 and 6.2 alone indicates a huge increase in water targets expenditure. As aid is decreasing, it is not at all clear where this money will come from. The UN calls for more technology transfer and new financing mechanisms, with some based on the recognition of the economic value of water and freshwater ecosystems (UN 2018). Forests may eventually benefit from the growing interest in nature-based solutions, which use or mimic natural processes to enhance water availability and water quality and to reduce risks associated with water-related disasters and climate change. The UN High Level Panel on Water specifically mentions that natural capital solutions, including the 'water-retaining abilities of forest', can be used at a fraction of the cost of engineering solutions (HLPW 2018). It labels forests as 'natural infrastructure' required to assure future supplies of water, calling for a better alignment of incentives to recognise the value of these services. It is of the utmost importance that natural capital solutions recognise the nuanced role of forests currently accepted as best practice and take into account local conditions. They should be particularly considered in the context of deforestation and forest degradation while recognising the need to understand water quantity effects at catchment, regional and continental scales. It is important to acknowledge that not all water-poor locations have forests to use as improvement tools.

Second, the success of SDG 6 depends on the existence of national and global institutions able and willing to implement the goal. While the WASH sector has spent nearly 20 years trying to achieve global targets, the level of institutional readiness for the new water resources targets is frequently low or non-existent at the country level. Even with the apparently successful MDG 7.C drinking water target, 53 countries were seriously off-target and 19 could not produce data. Good water governance depends on strong formal and informal institutions and the accompanying human resources. There is an acute lack of capacity across most developing countries, particularly in sub-Saharan Africa and South and Southeast Asia (UN 2018). With low institutional capacity, we can expect a slow articulation of the new targets within SDG 6 and, subsequently, low impact on the forest sector. However, since the creation of UN Water in 2003 as a focal point for coordinating efforts of UN entities and international organisations working on water and sanitation issues, the alignment of global water initiatives has increased (UN Water 2018b). Eventually this will lead to actions on the ground. The existence of SDG 6 in itself is a clear proof of the strength of these efforts. The HLPW (High Level Panel on Water 2018) has identified a number of initiatives especially relevant for states trying to implement SDG 6: the World Water Data Initiative; the OECD Water Governance Initiative; the Delta Coalition; High-level Experts and Leaders Panel on Water and Disasters, including an Alliance of Alliances on disaster risk-reduction researches; the initiative on Financing Water Infrastructure convened by the OECD; and the Water Innovation Engine. Whether these will accelerate SDG 6 implementation is yet to be seen, but they may support natural infrastructure projects with a role for forests.

The third consideration is the challenge of having enough good-quality data for monitoring SDG 6. It took a serious global effort from 1990 onwards to develop the WHO/UNICEF Joint Monitoring Programme, now the custodian of global WASH data for Targets 6.1 and 6.2. The situation is more complicated with the other targets as many countries lack the financial, institutional and human resources to acquire and analyse the required data. Fewer than half of UN member states have comparable data available on progress towards meeting the SDG 6 targets (UN 2018). This is important because countries will focus on being able to report to the Integrated Monitoring Initiative (UN Water 2018a). Accordingly, the factors monitored for each target are likely to become the focus of public policy. It is therefore important to understand how forests relate to this monitoring programme.

The final consideration is the dynamic interdependence between SDG 6 and the other SDGs (UN Water 2018c). The majority of these interlinkages are positive and mutually reinforcing. Since the MDG programme, the WASH targets have been identified as critical to: reducing poverty (SDG 1), malnutrition (SDG 2) and diseases (SDG 3); supporting education (SDG 4); and addressing gender (SDG 5) and other inequalities (SDG 10). Moreover, SDG 6 highlights how water of sufficient quality and quantity is required for food production (Target 2.4) and sustainable consumption and production (SDG 12). However, there are some targets – such as doubled agricultural productivity (Target 2.3), energy for all (Target 7.1) and sustained economic growth (Target 8.1) – that potentially could impact negatively on water resources and water ecosystems and, as such, on forests and forest people. IWRM (Target 6.5) is the appropriate framework to balance all these competing needs, for water and forests.

6.5.3 Integration of SDG 6 and Forests

The discussion of the contextual challenges in South Asia clearly shows both the difficulty and the necessity of aligning SDG 6 and forest policies. For this alignment to succeed in an IWRM framework, we need to follow a landscape approach at all levels. As larger forms of vegetation, trees use great amounts of water to produce biomass and for the process of evapotranspiration, more so than many other vegetation types, including crops and grasses. However, when considering Target 6.4 on increasing water-use efficiency and ensuring sustainable withdrawals and supply of freshwater and how it may impact forests and forest management, several issues need to be considered.

Firstly, most forests or tree-based landscapes are naturally occurring, rainfed systems. Globally, only 7 per cent of forests are planted forests, predominantly found in temperate zones (FAO 2015). Moreover, most of these planted forests are native species: only 20 per cent of planted forests – 1.4 per cent of forests globally – are exotic, and these are located mainly in the southern hemisphere (FAO 2015). It is assumed that natural forests will not be removed for the purposes of achieving Target 6.4 as they provide a wealth of other goods and services, including water-related ecosystem services. Consequently, discussion of water-use efficiency will be limited to planted forests, despite their representing only a small proportion of global forests.

Trees are highly resilient and adaptive organisms that optimise their water use. In other words, they drastically reduce their water consumption in periods of drought and use what they can when water is available (Chaves et al. 2002). This means that during periods without rain trees can use water stored in the soil; they generally have higher annual rates of water use than shallow-rooted, annual cropping and pasture systems. In high-rainfall areas (> 1500 mm per annum), planted forests can use up to 200 mm more water than pastures, but only if the water use is not energy limited. In low rainfall areas (< 600 mm per annum), forest plantations use an amount of water similar to annual crops and pastures. In intermediate rainfall areas, planted forests potentially use more water than annual crops and pastures. If this is in conflict with other demands for water, policies are required to regulate allocation of water to plantations among other uses. Policy instruments to regulate plantation water can be direct (e.g. a moratorium on land concessions) or indirect (e.g. a market for allocable water). For example, South Africa, Australia and India have implemented policies to regulate or limit plantation establishment (Brown et al. 2005, Dye and Versfeld 2007, Farley et al. 2005, van Dijk and Keenan 2007, Whitehead and Beadle 2004).

Even if trees are able to optimise their water use, it is important to note that management can be improved in order to further optimise water-use efficiency – including tailoring species selection, as well as thinning and harvesting techniques – to the environmental conditions such as slope, soil type and condition. More importantly, as planted forests are managed at the stand scale and water is managed at a catchment or basin scale, it is critical when planning to look at planted forests, and even tree-based systems more broadly, at the landscape level, taking into consideration the mosaic of land uses and their effects on water. This requires a cross-sectoral approach to land and water planning and management.

Integrated planning and management may require reframing our approach, taking into account integrated solutions such as agroforestry and the use of recycled wastewater in planted forests. Studies show that agroforestry increases water-use efficiency (Bai et al. 2016, Droppelmann et al. 2000). The recycling of treated wastewater for planted forests can reduce competition for water use (particularly in semi-arid and arid areas where water is scarce), reduce the costs associated with water treatment and reduce downstream contamination (FAO 2018a). Planted forests irrigated with treated wastewater in turn improve soil water-storage capacity, reduce soil degradation and erosion, combat desertification in arid areas and provide essential goods that support livelihoods, such as timber, pulpwood and fuelwood (FAO 2018a). According to FAO's Aquastat database (FAO 2018b), only 52 per cent of the municipal wastewater produced globally is recycled, so there is ample opportunity to explore such options. Egypt, Jordan, Mexico and Spain, among others, are exploring the use of treated wastewater for agroforestry and planted forests. In Jacksonville, North Carolina, USA, upstream forests are being irrigated with treated wastewater, with the forests acting as the final stage of the filtering process and returning water back into the catchment for use downstream (Tew 2016).

Much can be gained from a deeper integration of SDG 6 and forest policies. However, this integration must be guided by a shared understanding of the

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complex relationships between water and forests and their impacts on both forest people and the communities downstream, and possibly downwind.

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Chapter 7 SDG 7: Affordable and Clean Energy – How Access to Affordable and Clean Energy Affects Forests and Forest-Based Livelihoods

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Key Points

- The role of traditional woodfuels in energy service provision will decline, though energy stacking that includes traditional woodfuels is likely to persist low- and middle-income countries.
- The role of processed woodfuels, forest-derived liquid biofuels, and biopower in achieving SDG 7 will depend on relative costs and innovation in storage capacity of renewables including solar, wind and micro-hydro.
- Transitions to modern fuels (including electricity generated with large-scale hydropower and heavy reliance on agriculture-derived liquid biofuels) threatens forests and forest-based livelihoods.
- Energy transitions involving decreased reliance on traditional woodfuels and increased use of forest-derived modern fuels (e.g. pellets, biofuel) are generally synergistic with achieving other SDGs.

7.1 Introduction

Throughout the world, forests play a significant role in the supply of energy services. The role of forests in ensuring access to affordable, reliable and sustainable energy for all – the overarching objective for SDG 7 – varies widely. In the developing world, an estimated 3–4 billion people rely on solid fuels, primarily traditional woodfuels (e.g. firewood and charcoal) harvested from natural forests and woodlots, for cooking and heating (WHO 2016). For people in low- and middle-income countries where traditional woodfuels dominate the energy portfolio, reliance on biomass for household energy will decline overall in the coming decades, though the absolute number of traditional woodfuel users in sub-Saharan Africa and South and Southeast Asia will grow (Bonjour et al. 2013). To date, evidence suggests that traditional woodfuel harvesting affects deforestation and forest degradation in only a few hotspot

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locations (Bailis et al. 2015). However, rapid urbanisation in Africa and South and Southeast Asia, signalling a potential shift from firewood to charcoal for cooking and heating, raises concerns about the associated impacts on forests in the absence of introduction of clean fuels.

Many middle- and high-income countries are diversifying their domestic energy portfolios. Processed woodfuels and liquid biofuels are an increasingly important component alongside wind, solar, hydro and geothermal energy sources to increase the share of renewable energy in the global energy mix (Ellabban et al. 2014). The majority of liquid biofuels are produced from agricultural crops and residues that have negative impacts on forests when they are cleared to establish plantations. Sustainable uses of bioenergy are important pathways to ensure diversified renewable energy service provision and can broaden livelihood strategies in a wide range of settings. However, in the USA and Europe, renewable energy portfolios for electricity and heat increasingly demand industrially produced pellets, raising concerns about sustainability and high costs of transportation when pellets are not locally produced (Hanssen et al. 2017, Searchinger et al. 2018). New and more efficient technologies for producing electricity from biopower have increased attention and interest in South-eastern Europe, Japan and elsewhere (UNESCAP 2017). Notably, strategies to meet SDG 7 indicators that involve large-scale hydro projects, which frequently inundate forests, lead to deforestation and loss of livelihoods.

This chapter provides an analysis of the implications of achieving SDG 7 (Table 7.1) for forests and for people whose livelihoods depend on forests.

Table 7.1 SDG 7 targets for 2030

7.1 Ensure universal access to affordable, reliable and modern energy services
7.2 Increase substantially the share of renewable energy in the global energy mix
7.3 Double the global rate of improvement in energy efficiency
7.4 Enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology
7.5 Expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, particularly least developed countries, small island developing states and land-locked developing countries, in accordance with their respective programmes of support
Source: Adapted from United Nations 2015

To frame our analysis, we identify four forest energy pathways: (1) sustainable use of traditional woodfuels, (2) processed woodfuels, (3) liquid biofuels and (4) biopower and cogeneration.[1] We discuss their potential to address SDG 7 as well as their hypothesised effects on forest and forest-based livelihoods in the near to medium term.[2] We highlight that in the context of energy service provision at the household level, the major role of forest-based energy is for cooking (developing countries) and heating (globally), and that liquid biofuels primarily support transitions in the transportation and industrial sectors. Cogeneration of electricity or biomass gasification using forest products are the main pathways towards addressing electricity access using wood-based fuels. This study fills an important gap, given that most recent peer-reviewed articles about SDG 7 explicitly focus on energy for lighting and do not address energy for heating and cooking despite the fact that these are the main uses of forest-based energy (Baptista and Plananska 2017, Mentis et al. 2017, Yang and Yang 2017).

We first review theories related to energy transitions and consider the role that forest-based energy plays in both the energy ladder and energy stacking transitions. We then describe the four forest energy pathways we have identified and their implications for supporting both sustainable forest management and forest-based livelihoods. We connect each pathway to its potential contribution to the energy ladder and stacking transitions and the realisation of SDG 7. We also discuss energy transitions that have a large potential impact on forests and forest-reliant peoples, such as large-scale hydro development, but that do not include forest-derived fuels. We provide several case studies that highlight different ways in which forest products influence SDG 7 and how, in turn, progress towards SDG 7 targets impacts forests and people. The cases examined include a small-scale woodfuel (e.g. pellets) and improved cookstove enterprise in Rwanda, global experience with *Jatropha curcas*, and heating and electricity biopower from forest products in Southeastern Europe. We discuss palm-derived liquid biofuels as an example of how an energy transition to modern fuels contributes to deforestation and loss of forest-based livelihoods. The cases intentionally highlight the diverse range of impacts forests have on energy provision and the potential ways that meeting SDG 7 could affect forests – for better and for worse. Finally, we consider

[1] For this analysis, we consider biomass from forests and woodlands, and their contributions to energy production. Forests are land spanning more than 0.5 hectares with trees higher than 5 metres and a canopy cover of more than 10 per cent, or trees able to reach these thresholds in situ. Woodlands include trees able to meet the forest definition and land with a combined cover of shrubs, bushes and trees above 10 per cent. It does not include land that is predominantly under agricultural or urban land use (FRA 2015).

[2] We do not discuss in any depth non-forest-based energy pathways, which include fossil fuels and renewables other than bioenergy (i.e. solar, wind, geothermal, nuclear).

how the realisation of SDG 7 through forest-based energy pathways will influence other SDGs.

7.2 Energy Ladder and Energy Stacking Theories and SDG 7

Two competing theories posit a relationship between increases in income and energy consumption. The energy ladder theory (Leach and Mearns 1988) differentiates energy use into traditional (animal dung, crop residues and woodfuels), transitional (kerosene and coal) and modern (liquefied petroleum gas [LPG], electricity and other renewables). Under the energy ladder theory, household energy choice moves from traditional to transitional to modern fuels as incomes increase. Traditional fuels are more polluting and less efficient but cheaper, while modern fuels are more energy efficient and cleaner, but more expensive. Energy ladder transitions are linear and assume that as transitional and modern fuels are adopted traditional fuels are no longer used. A competing theory suggests that households will instead stack fuels and technologies as incomes increase. Energy stacking involves the use of multiple fuels by the same household, taking advantage of the benefits each fuel provides (Gupta and Köhlin 2006, Masera et al. 2000, Masera and Navia 1997, Nansaior et al. 2011). Under the energy stacking theory, modern fuel users continue to use traditional and/or transitional fuels irrespective of income level, and assume a gradually partial or full transition to modern fuels, including stacking of multiple fuels and technologies in diverse ways.

An important caveat of both the energy ladder and energy stacking hypotheses is that they place emphasis on household income as the major driver of energy transitions. Indeed, in several studies income is the most important factor in determining fuel choices (Arnold et al. 2006, Cooke et al. 2008, Foster et al. 2000, Heltberg 2005, Hiemstra-van der Horst and Hovorka 2008). We note that few studies have explored supply-side factors affecting fuel choice (Jagger and Shively 2014, Lewis and Pattanayak 2012, Rehfuess et al. 2010). Global estimates (GEA 2012, UN DESA 2015) predict the absolute number of people dependent on biomass fuels will increase through 2030, suggesting that policy-makers should be attentive to factors that influence the supply, demand, spatial distribution and governance dimensions of biomass fuels, including traditional woodfuels. Several studies have noted the lack of information available about fuelwood harvesting practices, geography and dynamics, specifically with respect to woody biomass availability within different land uses (Foley 2005, Hiemstra-van der Horst and Havorka 2009, Smeets and Faaij 2007). Insights into the combined spatial and behavioural dynamics of woodfuel supply and demand support a broader understanding of the role of forest products in sustainable energy transitions (Masera et al. 2006, Rehfuess et al. 2010).

7.3 Forest-Based Energy Pathways

Forest products play a range of different roles in energy service provision and sustainable energy transitions depending on a variety of contextual factors. We identify four energy service pathways for forest products: (1) traditional woodfuels, (2) processed woodfuels, (3) liquid biofuels and (4) biopower and cogeneration (Table 7.2). For each pathway we discuss: (1) sustainability or extent to which they contribute to renewable energy targets, (2) socio-economic dimensions of the pathway and (3) how the pathway connects to theories of energy ladders/stacking. We also briefly touch on the regional setting where the pathway is most common, actors engaged in the pathway, the scale of operation and governance. We acknowledge the challenge of differentiating forest-based energy from the broader category of bioenergy. The term 'bioenergy' refers to energy derived from any organic matter available on a renewable basis, including forest and mill residues, agricultural crops (including field and processing residues), wood and wood waste, animal dung, fast-growing trees and herbaceous crops, etc. In practice, it is quite difficult to disaggregate the relative contribution of forests to bioenergy in most contexts due to how data are reported and depending on the definition of forest. In energy terms, the most common use of biomass after traditional cooking/heating is for industrial heat and space heating (REN21 2018). The biomass feedstocks for electricity cogeneration are predominantly forest residues (including black liquor), bagasse and other agricultural residues.

7.4 Traditional Woodfuels

7.4.1 Context

Traditional woodfuels, which include both firewood and charcoal, represent more than half of the global wood harvest and nearly 8 per cent of the primary global energy supply (FAOSTAT 2015, REN21 2018). Roughly 2.8 billion people worldwide (Bonjour et al. 2013), including the world's poorest and most marginalised, burn traditional woodfuels to satisfy their basic energy needs, with cooking and heating being the major services provided. Globally, the absolute number of traditional woodfuel users will increase at least through to 2030 (Riahi et al. 2012). The traditional woodfuel sector is typically comprised of large numbers of small to medium-scale actors. Many traditional woodfuel consumers collect or produce their own woodfuels for subsistence consumption, though there is a rapidly growing trade in charcoal, particularly in sub-Saharan Africa and the Middle East. Traditional woodfuel markets often lack regulatory frameworks or operate in environments where rules related to the production, transport and sale of woodfuels are not enforced.

Table 7.2 Forest-based energy pathways

	Traditional woodfuels	Processed woodfuels	Liquid biofuels	Biopower and cogeneration
Products	Fuelwood and charcoal	Pellets, torrefied biomass; Other compressed wood products	Transportation biofuels; biodiesel	Pellets and other biomass converted to electricity; Co-firing with coal or fossil fuels
Regional focus	Low- and middle-income countries in the Global South	North America and Europe; China; Small-scale examples throughout the Global South	Central America; tropical areas of Africa and Asia; Europe	Europe; Japan; South Korea
Actors	Large number of small-scale producers and consumers	Small number of producers at various scales; Small- and medium-scale consumers	Medium- and large-scale producers; Small- and medium-scale consumers	Industrial and government sectors
Scale	Local with some regional trade	Local, regional or global	Regional or global	Regional or global
Governance	Unregulated; Informal sector	Regulated; Formal sector	Regulated; Formal sector	Regulated; Formal sector
Sustainability	Conditionally renewable but sometimes associated with forest degradation	Pressure to manage forest resources sustainably; Feedstock a supply issue in some settings	Pressure to manage forest resources sustainably; GHG, energy, water, land intensive	Pressure to manage forest resources sustainably; GHG, energy, water, land intensive
Livelihoods/ services/final energy use	Cooking and heating	Cooking and heating	Transportation sector; Electricity; Industrial development	Electricity; Heating, Cooking, Industrial development
Energy ladder or energy stacking	Stacking	Stacking	Ladder and stacking	Stacking

7.4.2 Sustainability

Woodfuel demand is frequently associated with deforestation and forest degradation (de Montalembert and Clement 1983, Eckholm 1975, Eckholm et al. 1984). Concerns about the impacts of firewood and charcoal consumption on forests have motivated interventions to reduce woodfuel consumption several decades. Often implemented by development agencies or other outside actors, interventions have tried to enhance fuel supply through tree nurseries and community woodlots, production of briquettes and promoting fuel-saving cook stoves. Despite decades of attempts, few interventions have achieved widespread success.

Researchers have quantified traditional woodfuel sustainability in different locations (Drigo et al. 2015, Ghilardi et al. 2016). One pantropical assessment estimated that roughly 30 per cent of the global wood harvest is unsustainable, leading to localised degradation, with hotspots concentrated in South Asia and East Africa (Bailis et al. 2015). The loss of terrestrial carbon resulting from woodfuel-consumption-driven land-cover change is equivalent to 1–2 per cent of global CO_2 emissions, and roughly 20 per cent of global land-use change emissions. There is now consensus that, in the absence of other drivers of land-cover change, woodfuel demand rarely results in long-term deforestation. However, under many circumstances it can cause forest degradation.[3] We understand that geographically specific biophysical and socio-economic factors play a critical role in woodfuel sustainability (Hosonuma et al. 2012 Hansfort and Mertz 2011, Mayaux et al. 2013, Singh et al. 2010, Smith et al. 2014b). Biophysical factors include land cover, species distribution, climatic conditions and topography, among others. Socio-economic factors include population distribution, growth and urbanisation rates, wood energy demand and other drivers of land-cover change. Policies affecting land use, forest management and energy preferences are also important to protecting forests and people in areas with populations dependent on traditional woodfuels.

A noteworthy exception of the impact of traditional woodfuel consumption on forest sustainability is the impact of woodfuel demand in humanitarian settings. Sudden influxes of people, and their need for cooking energy in particular, can place pressure on forest resources, as observed in large refugee camps in Kenya, Sudan, Somalia, Nigeria, Myanmar, Bangladesh and

[3] For this discussion, it is important to distinguish between deforestation, defined as direct human-induced conversion of forested land to non-forested land, and forest degradation, defined as long-term reduction of the overall potential supply of benefits from the forest, which includes carbon, wood, biodiversity and other goods and services.

elsewhere (Caniato et al. 2017, Thulstrup et al. 2018). Many of these camps are located in already fragile ecological settings.

7.4.3 Livelihoods

Woodfuels play an important role in the livelihoods of billions of people in the Global South. In a study of forest reliance among rural populations in 25 countries throughout the Global South, Angelsen et al. (2014) estimate that traditional woodfuels account for 35 per cent of forest income (subsistence plus cash). Despite the important role that woodfuels play in income generation and diversification, woodfuel reliance has negative consequences for human health (Bruce et al. 2000, Smith et al. 2014a). Household air pollution (HAP) related to burning solid fuels (including firewood and charcoal) was responsible for 2.6 million deaths in 2016 (Health Effects Institute 2018). Exposure to HAP related to burning biomass as fuel is the thirteenth-largest risk factor overall, and the second-largest environmental risk factor (in low and middle-income countries) for global burden of disease after ambient air pollution (Forouzanfar et al. 2015). Other health effects associated with firewood collection include risk of physical assault (O'Brien 2006), musculoskeletal injuries from carrying fuelwood bundles and insect and snake bites (Haile 1991). In addition to health burdens, reliance on traditional woodfuels has implications for allocation of productive time, particularly for women and children. Where forest resources are scarce, people dedicate more time to wood collection and frequently involve children in the activity. When young girls spend more time collecting wood, they spend less time in school and do not progress to higher levels of education (Oluwafemi et al. 2012).

7.4.4 Link to Energy Transition Theories and SDG 7

Traditional woodfuels have a limited role to play in the way that SDG 7 is articulated. Firewood and charcoal are at the lowest rung on the energy ladder. Munro et al. (2017), in a study in Sierra Leone, express concern for both the lack of attention to energy poverty in SDG 7 discussions and for the flawed dismissal of the role of sustainably sourced traditional woodfuels in supporting the realisation of SDG 7. They cite an overemphasis on 'modern energy', much of which is out of reach for lower-income groups, advocating for an approach that allows for the promotion of multiple energy sources, including traditional woodfuels. This view supports energy stacking as the theory of change required to move towards achieving SDG 7. However, ensuring modern and affordable access to clean energy will likely involve significant reductions in traditional woodfuels.

7.5 Processed Woodfuels and Liquid Biofuels

7.5.1 Context

We distinguish between two main types of forest-based bioenergy: processed woodfuels (densified or torrefied solid fuels), and production of liquid biofuels from forest and woodland products (e.g. *Jatropha curcas*). Processed woodfuels are widely used for home heating in Northern Europe and China; in a small but growing number of countries in the Global South they are used in tandem with micro-gasification cook stoves (Case Study 7.1). Liquid biofuels help society respond to the increased demand for renewable energy sources to meet EU climate policy and renewable energy targets and comply with international agreements on climate change. The transition to renewable fuels in countries addressing the SDG 7 framework may create demand for new forest-based fuel products (Case Study 7.2).

Case Study 7.1 Densified Pellets (Processed Wood Fuel) in Rwanda

Founded in 2012, *Inyenyeri*, a for-profit social benefit company in Rwanda, is a private sector firm marketing processed woodfuels (e.g. pellets, briquettes) and micro-gasification stoves. Other than *Supamoto*, a firm in Zambia, no other pellet/cook-stove promoter in sub-Saharan Africa operates at the same scale. The experience of *Inyenyeri* provides insights into the challenges related to pellet production, improved cook-stove selection and the structure of the marketing model for businesses providing household energy services (Jagger and Das 2018). Here we focus on their experience with producing pellets. The firm's business model requires supplying enough biomass pellets to support the current customer base. Obtaining sustainably sourced feedstock of adequate type and quantity and maintaining a functional production facility are the major issues *Inyenyeri* has dealt with during its pilot phase from 2012 to 2018. The firm has experimented with a range of feedstock supply options, including a trade-in mechanism whereby rural biomass collectors exchange feedstock for pellets, and sourcing sawdust and other feedstocks from larger-scale operations in relatively close proximity to the pelletising plant in north-western Rwanda. The logistics of storing, transporting and drying feedstock have provided additional complexity to the operation. *Inyenyeri* is currently in negotiations with the Government of Rwanda to source feedstock from pine plantations in order to maintain a consistent supply of high-quality material for pelletising. The capital investment required for building large pelletising factories and the challenges of maintenance and repair in central Africa have been obstacles to scaling-up pellet production. Relying on a single pelletiser

Case Study 7.1 (cont.)

is a problem in an environment where capacity for equipment maintenance is low. The efficacy of a decentralised versus centralised system of pellet production (i.e. a few large-scale factories versus several small- to medium-scale enterprises) should be considered.

Inyenyeri's experience over the past five years illustrates the complexity of building a market for a clean cooking solution involving processed woodfuels. The potential of pellet and fan micro-gasification cooking should continue to be explored, particularly in settings where widespread distribution of affordable LPG and electric cooking systems will be realised in the distant future. *Inyenyeri* represents an important test case for understanding how to achieve a clean cooking system using a renewable biomass source in sub-Saharan Africa.

Case Study 7.2 Jatropha Biofuel

Jatropha curcas is a shrub promoted in several low- and middle-income countries as a source of biofuel, with co-benefits of improving rural employment opportunities, diversifying income, securing biodiversity and regenerating degraded lands (Brittaine and Lutaladio 2010, Reubens et al. 2011, Valdés-Rodríguez et al. 2014, von Maltitz and Setzkorn 2012). It survives well in harsh climatic and soil conditions, making it attractive in areas where agricultural production is marginal. Several governments have provided financial incentives to promote *J. curcas* cultivation by smallholders and larger-scale plantations with the aim of fostering a market for biofuels (Jull et al. 2007, Pradhan and Ruysenaar 2014, Soto et al. 2015). Several *J. curcas* cultivation projects were initiated in Central America, where the plant is indigenous, and throughout tropical Africa and Asia in the early 2000s. Evidence of the impact of *J. curcas* cultivation for livelihoods and sustainability is mixed.

In a comparison of smallholder and plantation-based *J. curcas* production, van Eijck et al. (2013) found that smallholder production is associated with more secure land rights, GHG balance, improved biodiversity and effectiveness in the number of people reached. Smallholder projects tend to be more resilient, likely because of lower start-up and production costs (Kgathi et al. 2017). However, because government subsidies for *J. curcas* cultivation tend to go to households with more resources and better risk-coping strategies (Soto et al. 2015), the poorest households are often excluded from government programmes. Low-income households are most vulnerable to negative social effects of *J. curcas* cultivation and are most likely to abandon the

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Case Study 7.2 (cont.)

crop (Soto et al. 2018). Plantations, on the other hand, are associated with decreased food security, loss of land rights and decreased biodiversity (van Eijck et al. 2013). Plantation-based production creates more initial employment opportunities and higher incomes, but for a smaller number of people. The economic viability of plantations is limited in many settings because of high upfront costs, slow crop maturation and low yields, causing many projects to collapse before their yields can stabilise (Romijn et al. 2014, Gasparatos et al. 2015).

When cultivation involves clearing natural forest, impacts include deforestation, decreased biodiversity and threatened water sources (Creutzig et al. 2012, Fargione et al. 2008, Laurance et al. 2014, Wu et al. 2014). However, when *J. curcas* is planted on degraded lands, plantations have resulted in reduced soil erosion and renewed stimulation of biological activity, and thus improved soil quality, without competing with food production or depleting natural resources (Wani et al. 2012). Overall, small-scale *J. curcas* production on already degraded land not currently used for crop production has the best social and environmental impacts on forests and forest peoples (Skutsch et al. 2011).

A challenge for this study is the disaggregation of forest versus non-forest-based liquid biofuels. For example, while ethanol and biodiesel produced from agricultural residues are important in China, Brazil and Sweden, they are outside the scope of this study because they are not forest-based. Other liquid biofuels – for example, those derived from palm in Indonesia – play a major role in meeting liquid biofuel targets, but are considered a contributor to deforestation when primary forest is cleared to establish plantations (Case Study 7.3).

Renewable portfolio standards across countries and sectors influence the role of forest products in meeting renewable energy targets, with standards taking different shape depending on the sector, country and policy environment. To date, the EU Renewable Energy Directive (RED) may be the most impactful policy on forest-based bioenergy (Searchinger et al. 2018). RED is a binding target, though member states set their own (frequently non-binding or flexibly binding) domestic goals. Biofuels frequently play different roles in electricity and transportation sectors, ranging from wood pellets burned for electricity generation and household heating to liquid biofuels replacing fossil-fuel reserves in the transportation sector. For cooking, renewable energy

Case Study 7.3 Palm Biodiesel in Indonesia

The development of the biodiesel sector in Indonesia is driven by multiple factors, including (1) a national agenda to support energy security in response to heavy dependence on imported crude oil (Dermawan et al. 2012, Kharina 2016, Naylor and Higgins 2017), (2) expectations that developing the biodiesel sector contributes to efforts to mitigate climate change (da Silva Araujo 2014, McBride et. al. 2011, Sedjo 2011), (3) Indonesia's position as the world's largest producer of palm oil, and (4) a mechanism for mitigating risk associated with fluctuations in the global price of palm oil (Danny 2018, Nurfatriani et al. 2018). The National Energy Policy issued in 2014 mandates that new and renewable energy, including biodiesel, make up 24.5 per cent of the national energy mix by 2025 and 31 per cent by 2050. The main policy to develop the biodiesel sector has been the blending target of 30 per cent of biodiesel use by 2020. The blending target is applicable to the transportation, industrial and electricity sectors, with its main emphasis on the transport sector.

Estimating the impacts of palm oil production for biodiesel on deforestation in Indonesia is empirically challenging for several reasons (Obidzinski et al. 2012). First, the proportion of Indonesian palm oil that goes into biodiesel production is small. In 2017, 2.7 million tonnes – less than 10 per cent of total production – went into biodiesel (Wright and Rahmanulloh 2017). Second, palm oil is a product with multiple uses; biodiesel is only one of them. Large producers of palm oil derivatives can shift the palm oil from one purpose (e.g. food) to another (e.g. biodiesel) depending on economic conditions (Eynck et al. 2013).

Socio-economic analysis of the role of the palm oil sector with specific reference to biofuels is hindered by a lack of traceability of palm oil value chains. Biodiesel producers may receive palm oil from the company mills, from third-party corporate suppliers and from independent smallholders. Changes in biodiesel demand affects producers' allocation of palm oil; however, impacts on forests and smallholders depend more broadly on palm oil demand, which may or may not relate to demand for palm oil-derived biodiesel.

portfolios distinguish between sustainably produced pellet fuels that replace unsustainably produced charcoal and continued use of traditional biomass energy sources.

7.5.2 Sustainability

Bioenergy is controversial for its potential competition with crop production and because of potential links to deforestation (e.g. palm biodiesel, Case Study 7.3). A range of sustainability standards and monitoring frameworks have been developed since the USA and the EU each implemented bioenergy trade rules and regulations in 2007/2008 (Scarlat and Dallemand 2011). Bioenergy plays a particularly challenging role in renewable energy portfolios when sourced from forest products. Policies in place to prioritise waste, residues and specific crops help guide the monitoring and verification of liquid biofuel products, yet significant challenges remain to avoid unintended land-use changes resulting from renewable energy portfolio policies that incentivise bioenergy. Sustainability concerns include biodiversity impacts, landscape impacts, soil nutrients and protective functions, water impacts and GHG emissions. Renewable energy portfolio standards could increase forest product demand for bioenergy initiatives that produce electricity, transportation, heat and chemicals. Improved monitoring and verification of sources of processed woodfuels and liquid biofuels would provide a way to track the use of unsustainable forest products contributing to energy demand.

7.5.3 Livelihoods

Production of processed woodfuels and liquid biofuels is employment intensive, providing jobs at all stages in the value chain. REN21 (2010) estimates there were approximately 1.5 million direct jobs in 2010 for biomass production, operation, harvesting and transportation; biomass facility processing and upgrading; conversion plan construction, operation and maintenance; and distribution of final energy products. Due to the growing demand for bioenergy, the European Renewable Energy Council (EREC) and Greenpeace estimate the creation of 2.1 million new jobs in the sector by 2030 (EREC 2008). In many developed countries, regional policies support development of the bioenergy sector to enhance employment opportunities in rural economies (Halder et al. 2014). Similar potential for growth in the sector exists in low and middle-income countries; however, given the reliance of local populations on forests for a wide range of goods and services, energy and rural development policies should ensure that local populations are not harmed by development of the sector. Cultivation of some biofuel feedstocks is similar to other large-scale monoculture cropping schemes, having large impacts on the supply of goods and services provided by natural forests.

Buongiorno et al. (2011) modelled the aggregate effects of bioenergy on the forestry sector on both local and regional economies. The global forest products model (GFPM) projects the consequences of the global forest sector doubling the rate of growth of bioenergy demand relative to a base scenario, all else being equal. Doubling bioenergy demand leads to the convergence of the price of firewood and industrial roundwood, raising the projected price of industrial roundwood by nearly 30 per cent by 2030. The price of sawn wood and panels would be 15 per cent higher. The price of paper would be 3 per cent higher. Concurrently, the demand for all manufactured wood products would be lower in all countries, but production would rise in countries with competitive advantage. Global value added in wood-processing industries would be 1 per cent lower in 2030; forest stock would be 2 per cent lower for the world and 4 per cent lower for Asia. Estimated effects vary substantially by country. Overall, the analysis implies that development of the bioenergy sector will negatively affect forest product prices and forest sustainability in a number of countries.

7.5.4 Link to Energy Transition Theories and SDG 7

Processed woodfuels and liquid biofuels may play a major role in the realisation of SDG 7; however, pricing and market development for other renewables, along with the regulatory framework surrounding mandated portfolios and certification, will influence how their role evolves. In most low-income countries, there are few examples of processed woodfuels or forest-derived liquid biofuels utilised at a significant scale for cooking and heating, though the use of agriculture and forest-derived liquid biofuels in the transportation sector is common. Most likely, for residential and small-scale industrial use, processed woodfuels and liquid biofuels will be part of an energy stacking transition that also includes traditional woodfuels in low- and middle-income countries, and more diversified portfolios, including other renewables in higher-income countries. For the realisation of SDG 7, several challenges emerge. Modern woodfuels need companion heating and cooking technologies (e.g. improved stoves) to ensure that the energy is clean (i.e. achieving efficiency gains, emission reductions and associated health benefits). In many countries, the development of both processed woodfuels and forest-derived biofuels involves establishing entirely new supply chains or importing high volumes of biomass. The overall sustainability and economic feasibility of developing supply chains is complex.

7.6 Biopower Cogeneration for Electricity

7.6.1 Context

Biopower and combined heat and power systems (cogeneration) use biomass in the form of pellets or other wood products to generate electricity. In the USA, overall biomass electricity generation is increasing in total production but decreasing in share of the electricity mix, possibly due to the rapidly declining cost of natural gas and alternative renewable energy sources. Bioenergy is promoted for electricity generation as a way to decarbonise the electricity sector, reduce emissions and meet Intergovernmental Panel on Climate Change (IPCC) climate targets (Davis et al. 2018). In this context, many countries are exploring retrofitting coal plants to combust bioenergy for heat and power applications. In Brazil, biomass-derived charcoal could substitute for coal in the steel sector. To meet industry demands and phase out coal, millions of hectares of forest are necessary (Sonter et al. 2015). Despite infrastructure and pressure on forest resources, demand for biomass electricity continues to grow in Europe and Japan. Canada and the USA export a significant amount of wood pellets to supply UK and European markets. Dwivedi et al. (2014) estimate a 50–68 per cent decrease in GHG intensity for electricity from wood pellets used for electricity in the UK.

7.6.2 Sustainability

A major challenge for sustainable forest management and biopower production is to ensure the use of waste and residue biomass products before using virgin materials for electricity generation or district heating. Certification of sustainably sourced biomass for electricity generation is a challenge. The UK and the EU have introduced new requirements to sustainably source biomass for electricity, focusing on waste and residues rather than pure wood (European Commission 2016). Future targets that adhere to these priority measures can reduce pressure on forests. RED established non-binding criteria, including banning the use of biomass from land converted from high biodiversity forest areas and favouring national biofuel support schemes. Despite these reporting efforts, monitoring of the origin of biomass consumed in the EU remains a challenge to sustainably managing megawatt-scale biomass heat and power initiatives.

The IPCC Working Group Report includes biomass as a critical electricity generation technology along with carbon capture and storage (bioenergy carbon capture and storage or BECCS) in its models as one of the few ways to maintain two degrees of global warming without incurring significant costs to the electricity system. Future models of decarbonised electricity systems place the levelised cost of biomass electricity in a range similar to renewable electricity systems today – though it may require further integration for cost-effective, low-carbon biomass systems (Sanchez et al. 2015). The affordability and viability of such emissions reductions remain a point of debate and uncertainty, primarily due to the lack of alternative electricity supply options and the assumption that carbon sequestration remains cheaper than alternative generating sources, including solar and wind which do not have the same 'negative' emissions potential. Realising emission reduction strategies through BECCS technologies would require significant technological innovation and could impose higher costs than the IPCC estimates. This could significantly affect demand for bioenergy forest products and place pressure on forests in Africa and the Amazon region. Not all BECCS is produced and stored at the same location, which poses challenges to monitor and verify the emission reductions and avoid double counting.

Finally, an important consideration for the future of biopower in realising SDG 7 is the rapidly declining cost of solar, wind, geothermal and battery storage (Kittner et al. 2017). Renewable energy alternatives may affect demand for biopower in the future, but near-term generation indicates continued consumption of electricity from (mainly agriculture-sourced) biomass feedstocks in USA, China, Germany and Brazil. If expanded beyond agricultural capacity, there could be indirect effects on forests, such as the conversion of forestland to produce biopower crops or fast-growing wood pellet farms.

7.6.3 Livelihoods

Evidence of the livelihood impacts of the growth of biopower within the energy sector is limited. Government subsidies that support BECCS could induce conversion from natural forests to plantations to produce bioenergy, which may threaten forests or people with forest-based livelihoods. However, market stimulation of increased biopower energy demand may not have localised effects. For example, if bioenergy products for power generation in the EU are imported in pellet form from exporting nations such as the USA and Canada, employment generation may occur, but not in places where demand for biopower is realised.

7.6.4 Link to Energy Transition Theories and SDG 7

To the extent that biopower will replace other energy sources, particularly for district heating, it supports the stacking hypothesis. The RED set up legally binding mandates to target a certain percentage of energy consumption from renewable sources, and similar policies are in place in the UK. While electricity production using wood pellets will increase, it is unlikely to fully displace current modes of energy production.

Most notably, the RED has generated a large demand for wood pellets used in electricity generation and district heating for urban areas. The RED sets a binding target of 20 per cent final energy consumption from renewable sources by 2020, which includes biomass energy. All EU member states have created action plans, and a number of individual states with large heating demands and forest resources have turned to wood pellets as an energy technology to meet this target. Cogeneration of electricity and

Case Study 7.4 Biopower and Cogeneration in Southeast Europe

Most existing coal power plant infrastructure could transition at a relatively low cost to burning biomass pellets. Switching from coal to biomass pellets using existing infrastructure alleviates the financial burden of financing new infrastructure projects and has gained significant attention in the USA, Europe and China. Eastern European countries maintain large production and consumption shares of forest bioenergy for district heating and cogeneration. In particular, wood chips overtook natural gas in Lithuania as primary district heating fuels in 2017 (REN21 2017). Other countries in Southeast Europe – including Kosovo, Bosnia and Herzegovina, Serbia and Croatia – may continue this trend as they address rising air pollution and associated health burden concerns from burning lignite coal, and can switch fuels without significantly altering boiler technologies (Kittner et al. 2016). For emerging economies, biomass presents a dual challenge. The large area of forest cover in Kosovo provides a cost-effective alternative to lignite coal for household heating and electricity generation if managed domestically. However, sustainability issues remain, and a significant expansion of biomass reliance could increase demand for imported biomass, placing pressure on nations seeking extra revenue from wood product exports.

In Kosovo and the western Balkans, household heating remains a critical challenge to achieving SDG 7. It is expensive and difficult to provide affordable and reliable energy during the winter months, when temperatures can drop below freezing, and there is a high dependence on lignite coal for heating. The region has large areas of forest, allowing for the production and use of higher-quality woodfuels containing fewer toxic pollutants than lignite coal. However, lack of access to quality woodfuels has hindered availability for residents across the country. Switching from lignite towards cleaner bioenergy options could also reduce exposure to toxic trace metals, including chromium and arsenic (Kittner et al. 2018). Efforts to achieve the health benefits of burning cleaner heating fuels should pay special attention to the management and governance of land dedicated to growing fuel wood. Alternatively, if electric heat pumps are widely adopted, as they have been in other European nations, there could be better opportunities to use electricity for household heating and reduce the demand for woodfuels from forests. A significant expansion of the woodfuel market without domestic management could cause larger-scale woodchip operations and imports from as far away as the south-eastern United States, where fast-growing trees for wood pellets have surged in production over the past 10 years.

heat used for distribution throughout cities or buildings has emerged as a low-cost method to deliver critical renewable energy services to European households.

7.7 Large-Scale Energy Infrastructure Development and Impacts on Forests and Forest-Reliant People

Many emerging economies with low levels of electricity access view hydropower as a way to meet SDG 7 goals. There are an estimated 450 planned hydropower dams expected to generate dozens of gigawatts of electricity capacity across the Amazon, Democratic Republic of Congo and the Mekong River Basin (Myanmar, Laos and Vietnam) in the coming decade (Winemiller et al. 2016). If built to satisfy SDG 7 targets of clean and affordable energy without design precautions and consideration of environmental and social safeguards, these plants could drastically alter forest cover, biodiversity and local livelihoods. Widespread forest cover loss and concerns about displacing people from their homes are major concerns (Winemiller et al. 2016). For example, in Brazil, hydropower supplies more than two-thirds of electricity. Forest-dependent populations are displaced by dam construction, and new roads associated with dam development indirectly lead to agricultural expansion and increased forest cover losses (Barber et al. 2014, Zarfl et al. 2015). Plants are often justified as providing electricity to affected rural populations, even though they frequently fail to serve low-income or last-mile populations.

Hydropower often draws the attention of climate financiers that consider it a low-carbon electricity source. However, hydropower projects greater than 1 megawatt in size carry a substantial land footprint and require reservoirs spanning several hundred square kilometres, as is the case along the Amazon where reservoirs displace tropical forests to meet Brazil's demand for electricity (de Faria et al. 2015). Carbon emissions associated with these hydropower reservoirs include methane off-gassing, the carbon release from converted tropical forestland during dam construction and associated ecological changes in land use along the riparian zones (de Faria et al. 2015, Räsänen et al. 2018). In the Mekong, some hydropower reservoirs rival GHG emissions from fossil-fuel plants when considering the methane flux from reservoirs (Räsänen 2018).

Hydropower is also controversial due to uncertainty about whether plants can provide low-cost electricity access when alternative technologies are available (de Faria and Jaramillo 2017, Deshmukh et al. 2018). This includes options to use forest-based biomass for electrification or gasification and the adoption of solar or small hydropower-based mini-grids. At present, hydropower is appealing as basic solar home systems often fail to meet the demand required for rice milling or cooking that many populations without electricity access desire. Smaller, more ecologically friendly types of hydropower dams exist that can meet SDG 7 goals without destroying forests and displacing people. Mini hydropower projects with localised distribution are likely to have a far lower impact than large-scale efforts. Higher capacity mini-grids in Nepal, Myanmar and Laos provide new opportunities to utilise larger-scale solar photovoltaics or hydropower dams in complementary ways. A focus on the diversity of renewable energy options available, including those from solar, wind and biomass, can mitigate larger risks for land management, tropical forests and people who are seeking access to electricity.

7.8 SDG 7 and Its Relationship to Other SDGs

In order to understand the implications of fulfilling SDG 7 as it relates to other SDGs, we consider each of the four forest energy pathways reviewed and present the hypothesised impacts for both forests and forest-reliant peoples should SDG 7 be realised (see Table 7.3). Our assumption is that as progress towards SDG 7 increases, the role of traditional woodfuels will decline and the role of modern woodfuels and biofuels will increase.

7.9 Conclusion

This chapter reviews the role that forest-derived energy will play in the realisation of SDG 7, focusing on four pathways for forests to contribute to energy service provision: traditional woodfuels, modern woodfuels, liquid biofuels and biopower/cogeneration. Energy transitions in low- and middle-income countries will likely involve reductions in traditional woodfuel reliance for heating, cooking and small-scale industrial energy provision, whereas countries currently seeking to diversify renewable energy portfolios may see an increase in forest-based bioenergy as long as it remains competitive and cost-effective. The cost of other renewables will play a major role in determining how important forest-based energy sources are for electricity, heating, cooking and transportation. A recent and growing literature addresses various aspects of SDG 7 and the role of forests. Calzadilla and Mauger (2017) cite wind and solar as the most promising energy sources for developing countries while indicating concerns about the lack of attention to equity issues in case studies from Chile, India, Kenya and Mexico. In most settings, our expectation is a transition that involves the diversification of energy sources that households and businesses rely on rather than a complete transition away from current fuels and technologies. Baptista and Plananska (2017) cite problems of path dependence and inertia in the implementation of energy

Table 7.3 Trade-offs and synergies between fulfilling SDG 7 and other SDGs

SDG	Reduction in use of traditional woodfuels		Increase in processed woodfuels, liquid biofuels and biopower/cogeneration	
	Forests	People	Forests	People
1 No poverty	Reduced pressure on forests improves ecosystem services (+)	Reduced woodfuel reliance (+); Loss of employment (–)	Loss of ecosystems services (–)	Employment in renewables sector (+); Poor and last-mile populations left out of the transition (–)
2 Zero hunger	Reduced degradation allowing forest foods to flourish (+)	More efficient technologies requiring less fuel for cooking, more frequent/ diverse cooked meals (+)	Land degradation and loss of agricultural land from pressure to develop biofuels sector (–)	Potential decrease in food security in biofuel planation development areas (–)
3 Good health and well-being	Preservation of forests supporting human health and well-being (+)	Reduced exposure to household air pollution (+); Reduced risk of injury/ harm (+)	Loss of natural areas due to development of bioenergy (–)	Reductions in exposure to household air pollution (+)
4 Quality education		Reduced fuel collection and cooking time freeing people to go to school (+)		

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Table 7.3 (cont.)

SDG	Reduction in use of traditional woodfuels		Increase in processed woodfuels, liquid biofuels and biopower/cogeneration	
	Forests	People	Forests	People
5 Gender equality	Improved access for society to women's forest management capabilities (+)	Reduced fuel-collection time freeing women of drudgery; Improved cooking conditions increasing safety (+)		
6 Clean water and sanitation	Reduced impact on forest ensuring high-quality water (+)		Water tables affected by emphasis on fast-growing species (–)	Reduced cost and time to treat water by boiling (+)
8 Decent work and economic growth		Reduced harvest time for woodfuels decreasing dangerous activity (+); Loss of connection with forests and social aspects of woodfuel collection (–)		New sector development, employment generation (+)

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Table 7.3 (cont.)

SDG	Reduction in use of traditional woodfuels		Increase in processed woodfuels, liquid biofuels and biopower/cogeneration	
	Forests	People	Forests	People
9 Industry, innovation and infrastructure		Transition away from inefficient technologies (+)	New innovations in forest plantation use (+)	Emergence of biofuels sector as new in many countries – leading to diversified economies (+)
10 Reduced inequalities		Closing gap between those reliant on biomass and those with access to modern energy (+)	New opportunities for engagement in forest management (+)	
11 Sustainable cities and communities	Reduced pressure on urban trees and forests in rural areas supporting more sustainable environments (+)	Household adoption of modern fuels (+)		Commitment to renewable energy portfolios reduces household air pollution (+)
12 Responsible consumption and production	Reduces pressure on forests (+)			Increased use of more efficient technologies (+)

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Table 7.3 (cont.)

SDG	Reduction in use of traditional woodfuels		Increase in processed woodfuels, liquid biofuels and biopower/cogeneration	
	Forests	People	Forests	People
13 Climate action	Reduced GHG emissions from deforestation/ forest degradation and from improved combustion processes (+)	Mitigation of ambient and household air pollution exposure (+)		
14 Life below water	Reduced land degradation leading to less run-off and water pollution (+)		Increased pressure on water resources to irrigate bioenergy crops (–)	
15 Life on land	Greater biodiversity results from reducing woodfuel pressure on forest (+)	Securing ecosystem services for human well-being (+)	Increased role of biofuels in energy portfolios (+/–)	
16 Peace, justice and strong institutions	Reduced corruption in traditional woodfuel sector leading to decreased deforestation and forest degradation (+)	Reduced rent-seeking behaviour with respect to traditional woodfuels to improve livelihoods (+)	Increased focus on forest plantations as energy source reinforcing property rights (+)	Support for renewable energy targets and links to global climate institutions can enhance economies (+)
17 Partnerships for the goals				

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initiatives in sub-Saharan Africa, suggesting that transitions will be slow and likely support the use of multiple energy sources, making the energy stacking hypothesis most plausible. The case studies highlight the different trade-offs to consider when implementing SDG 7 targets and provide insights into the challenge of integrating forests into the transition to cleaner and more affordable energy systems.

Recognising the co-benefits associated with forest-based energy pathways generally supports the realisation of other SDGs. Partnerships with other SDGs that acknowledge the role of forests in energy service provision are particularly essential to improving livelihoods and conditions in forest regions (Gratzer and Keeton 2017). In contrast, if SDG 7 is realised through the promotion of large-scale energy infrastructure projects, including hydropower and land-intensive solar and wind farms, forest ecosystems and forest livelihoods could be at risk, compromising other SDG outcomes.

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Chapter 8 SDG 8: Decent Work and Economic Growth – Potential Impacts on Forests and Forest-Dependent Livelihoods

Dietmar Stoian*, Iliana Monterroso and Dean Current

Key Points

- Diverse combinations of predominant development paradigms lead to differentiated SDG 8 target prioritisations, with mixed impacts on forests and people.
- Significant trade-offs are expected for countries focused on the growth of agriculture, energy and mining: the decoupling of economic growth from forest-related environmental degradation will be a major challenge. Global trade-offs are anticipated on climate change.
- Synergy potentials exist where growth strategies and associated policies explicitly target the forest sector with a view on tree plantations, timber and non-timber forest products (NTFPs) from natural forests, ecotourism and payments for environmental services.
- Improvements in the enabling environment can help minimise trade-offs and maximise synergies by reconciling government policies and private sustainability standards, formalising community stewardship of tropical forests, addressing the informality prevalent in forest product value chains and providing specific incentives for youth to become involved in forest-based economic activities.
- Advancing decent work in the forest sector requires addressing gender, ethnicity and other social differentiation factors, as well as mobility aspects and labour safety.
- Alternative, more integrated measurements of economic growth and decent work are needed, accounting for broader environmental and social impacts.

* Lead author.

8.1 Introduction

8.1.1 Conceptual Foundations of Decent Work and Economic Growth

Since the early twentieth century, the core of prevalent socio-economic and political systems has been economic growth. This has fundamentally and irreversibly reshaped societies and the entire planet (Schmelzer 2017). In the aftermath of World War II, emerging theories and paradigms for developing non-industrialised countries in the Global South were largely based on the premise of economic growth (e.g. modernisation theory), if not overtly labelled as such (economic growth theory).

The concept of decent work, however, only appeared at the end of the twentieth century. Tensions between economic relationships and their social context arose in the late nineteenth century (Rodgers 2007), addressed by the emerging trade unions. Yet it was not until 1999 that the International Labour Organization (ILO) launched the concept of decent work. Its emergence reflected new development theories and paradigms that sought to overcome the limitations of the modernisation and economic growth theories and associated policies. Nurtured by Maslow's theory of human motivation, the 1970s laid the foundation for a development theory of human needs (Max-Neef et al. 1992). The resulting basic-needs paradigm reformed development programmes in the 1980s by integrating social indicators into the measurement of economic growth. Environmental indicators were added in the 1990s as the sustainable development paradigm emerged in response to global environmental degradation (Lélé 1991).

Policies and strategies based on diverse development theories and paradigms have varied effects on forests and forest-dependent livelihoods. This chapter introduces an analytical framework illustrating the evolution of such theories and paradigms, the contextual conditions shaped by them and the principal drivers determining the impact of SDG 8 implementation on forests and people dependent on them (Section 8.2). We then present key actors and stakeholders in the forest and other natural resource sectors and the latter's contributions to national economies. The subsequent assessment of anticipated impacts (Section 8.3) addresses forest-based economic growth and decent work in forest product value chains (FPVC) from livelihoods, enterprise and conservation perspectives. Synergies and trade-offs are then discussed, within SDG 8 implementation, and with other SDGs (Section 8.4). We conclude with an outlook on how overarching development paradigms lead to varying prioritisations of SDG 8 targets, and how decoupling economic growth from forest-related degradation will continue to be a challenge for countries seeking economic growth in natural resource sectors other than the forest sector (Section 8.5).

8.1.2 Indicators for Decent Work and Economic Growth

The SDG 8 targets and indicators reflect a firm grounding in economic growth paradigms and, to some extent, the paradigmatic evolution to a more integrated set of indicators, including social and environmental aspects (Table 8.1).

Table 8.1 SDG 8 targets and indicators

Targets	Indicators
8.1 Sustained per capita economic growth – min. 7 % GDP growth per annum in least developed countries	8.1.1 Annual growth rate of real GDP/capita
8.2 Higher levels of economic productivity	8.2.1 Annual growth rate of real GDP/employed person
8.3 Development-oriented policies for formalized micro-, small- and medium-sized enterprises	8.3.1 Proportion of informal employment in non-agriculture employment (by sex)
8.4 Global resource efficiency in consumption and production and decoupling economic growth from environmental degradation	8.4.1 Material footprint (per capita and GDP) 8.4.2 Domestic material consumption (per capita and GDP)
8.5 Full and productive employment, decent work for all women and men, and equal pay for work of equal value	8.5.1 Average hourly earnings of female and male employees (by occupation, age and persons with disabilities) 8.5.2 Unemployment rate (by sex, age and persons with disabilities)
8.6 By 2020, proportion of youth not in employment, education or training substantially reduced	8.6.1 Proportion of youth not in education, employment or training
8.7 Forced labour, modern slavery, human trafficking and worst forms of child labour eradicated (by 2025 child labour in all its forms)	8.7.1 Proportion and number of children engaged in child labour (by sex and age)
8.8 Labour rights protected and safe and secure working environments for all workers	8.8.1 Frequency rates of occupational injuries (by sex and migrant status) 8.8.2 National compliance of labour rights (freedom of association and collective bargaining, by sex and migrant status)

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Table 8.1 (cont.)

Targets	Indicators
8.9 Policies for sustainable tourism (job creation, promotion of local culture and products)	8.9.1 Tourism direct GDP (proportion of total GDP and growth rate) 8.9.2 Number of jobs in tourism industries (proportion of total jobs and growth rate, by sex)
8.10 Domestic financial institutions strengthened (enhanced access to banking, insurance and financial services)	8.10.1 Number of commercial bank branches and ATMs (per 100 000 adults) 8.10.2 Proportion of adults with an account at a bank or other financial institution or with a mobile-money-service provider
8.A Aid for Trade support for developing countries increased, in particular for least developed countries	8.A.1 Aid for Trade commitments and disbursements
8.B By 2020, a global strategy for youth employment and the Global Jobs Pact of ILO implemented	8.B.1 Total government spending in social protection and employment programmes (proportion of the national budgets and GDP)

Note: Targets are for 2030 unless stated otherwise.
Source: Adapted from UN (2019)

The SDG 8 targets and indicators align with the ILO (2018a) framework on the measurement of decent work, which is closely linked to four strategic pillars: (1) international labour standards and fundamental principles and rights at work, (2) employment creation, (3) social protection and (4) social dialogue and tripartism.

8.2 Framework for Analyses

8.2.1 Development Paradigms Driving Policies, Institutions and Markets

How 'less developed' countries can follow the pathway of 'developed' countries, or how they can be 'modernised', has been disputed by social scientists for more than a century. This debate has influenced development thinking

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and policymaking around the globe. In response to challenges and opportunities facing the developing world in the postcolonial era, the modernisation paradigm was developed in the 1950s. Advocates such as Rostow (1959) assumed a universal evolutionary path from traditional societies to the age of high mass consumption. The underlying assumption of relatively uniform, linear modernisation pathways was soon criticised. It was argued that the societal boundaries, political and economic institutions, and the social distribution of power underlying the absence of 'modern' societies had to be identified and solutions be developed accordingly (Tipps 1973).

Despite such criticism, the modernisation paradigm has strongly influenced development policies and strategies worldwide, with economic growth at its core and a simplistic equation: industrial transformation equals economic growth, which, in turn, allows poorer countries to catch up with industrialised countries. Eventually, economic growth would generate broader societal wealth through trickle-down effects (Thornton et al. 1978).

The modernisation and growth paradigms have had a strong imprint on tropical forests and, to some extent, temperate ones too. Starting in the 1950s, governments have increasingly treated forests as a natural capital reserve to be exploited for industrial transformation – initially through log sales, and progressively through value-added products. Processes of forest-based industrialisation occurred in several waves across forest-rich regions along the tropical belt: West Africa (1950s–70s), Southeast Asia (1960s–80s) and, more recently, the Congo and Amazon basins. However, the prevalent view of development as a purely economic phenomenon securing jobs and economic opportunities for the masses soon turned out to be a myth (Arndt 1983). When the waves started to ebb in the late 1970s it became evident that industrialisation based on natural resource processing is likely to perpetuate the pattern of dualism and inequality present in typical resource-rich countries, rather than leading to efficient growth, employment creation, greater equity and economic independence (Roemer 1979). The model of a 'dual economy' (Lewis 1954), which assumes that the agricultural sector (including forestry) generates the capital necessary for take-off towards industrialisation before becoming redundant, was shown to ignore the positive link between growth in industry and agricultural growth (Verner and Blunch 1999).

Over the past decades, new theories and models have emerged that provide a more nuanced picture of development processes: 'basic needs' (1970s), 'sustainable development' (early 1990s), 'sustainable livelihoods' and 'green growth' (both late 1990s). These are reflected in the Millennium Development Goals (2000), followed by the Sustainable Development Goals (2015). Lately, it has been suggested that alternative measures to GDP are needed, such as the Genuine Progress Indicator (GPI),[1] World Values Survey (WVS),[2] Happy Planet Index (HPI)[3] and Better Life Index[4] (Costanza et al. 2014).

Despite these conceptual advances, many factors that have long been driving economic policy in relation to natural resources are still at play. While protected areas in tropical countries have been expanded and forest ecosystem services figure more prominently on political agendas, development policies, institutions and markets continue to be largely driven by modernisation and economic growth paradigms. This prompts the question of what effects these paradigms have on the natural resource base of tropical countries and economic activities based on them – a question this chapter addresses with a view on forests and FPVC.

8.2.2 Analytical Framework

Our analytical framework for assessing the potential impacts of SDG 8 on forests and forest-dependent livelihoods has been derived from our own reflection, insight and conceptualisation. It accounts for the development theories and paradigms outlined in the previous section as well as contextual conditions that determine the impact of principal drivers:

- political–legal framework: principal policies geared towards forest, agriculture, energy, mining, tourism sectors;
- institutional support environment: technical and financial assistance by government agencies, non-governmental organisations (NGOs), the private sector;
- macroeconomic conditions: composition and evolution of GDP, formal and informal employment, standard of living;
- market forces: supply–demand patterns in the forest, agriculture, energy, mining, tourism sectors;
- status of the forest resource base: forest cover, degradation and deforestation; institutional arrangements for protecting forests;
- cultural contexts: importance of forests at societal, communal levels.

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[1] In addition to GDP measurement, the GPI considers the cost of the negative effects related to economic activity (e.g. resource depletion).

[2] Based on nationally representative surveys in almost 100 countries, the WVS provides cross-national time series on human beliefs and values.

[3] Drawing on existing metrics, the HPI accounts for well-being, life expectancy, inequality of outcomes and ecological footprint.

[4] OECD's Better Life Index measures 11 parameters (income, jobs, housing, health, access to services, environment, education, safety, civic engagement and governance, community and life satisfaction).

The analytical framework also accounts for interactions with policies and trends in relation to other natural resource sectors (agriculture, energy, mining) and associated services (tourism, provision of ecosystem services).

Within the forest sector, our assessment focuses on the following stakeholders:

- national and local governments
- international and local NGOs
- multinational and national companies
- corporate associations
- small and medium enterprises
- Indigenous and non-Indigenous groups dependent on forests

We assess the impact of SDG 8 on the forest sector with a view on the forest industry, forest-dependent people and the forest resource base (Figure 8.1).

8.2.3 Key Actors and Stakeholders

Our analytical framework distinguishes between key actors influencing the design and implementation of policies and strategies for achieving SDG 8 on the one hand, and forest-sector stakeholders affected by these policies

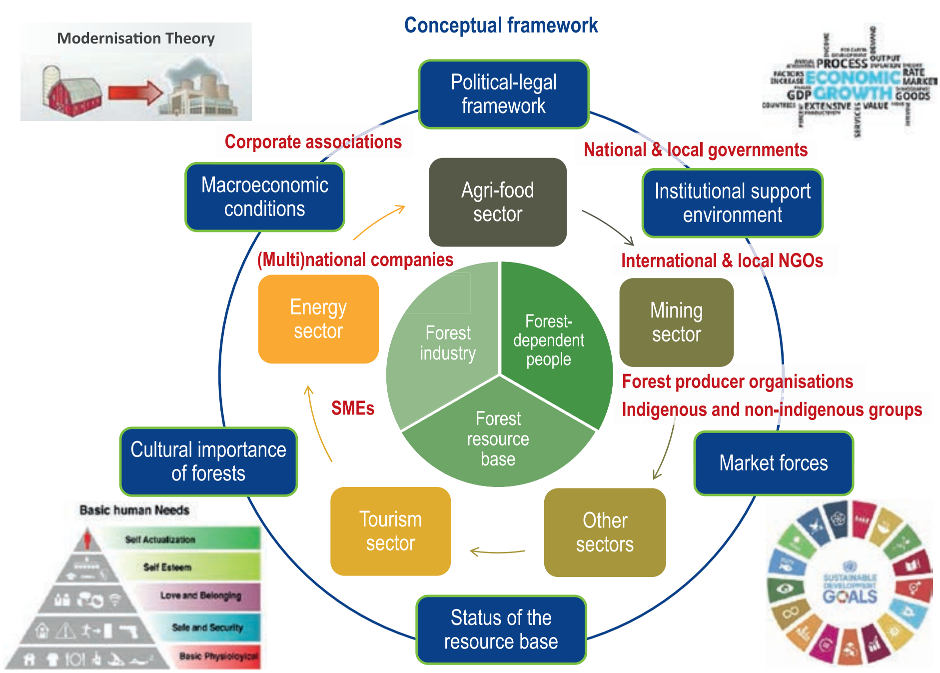

Figure 8.1 Analytical framework for assessing the impact of SDG 8 on forests and forest-dependent people.

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and strategies on the other. Key actors in the political arena are national and local governments, with their legislative, regulatory and executive powers varying according to governance structures and the degree of decentralisation. Principal stakeholders are forest users, including the forest industry and forest-dependent people. Further stakeholders are civil society organisations, ranging from local and international NGOs to corporate associations, and society as a whole. Depending on their role inside or outside of FPVC and their influence on political–legal and regulatory decisions, given groups may be both key actors and stakeholders. Their interactions are complex, as are the forest-tenure arrangements underlying interactions. In our assessment of statutory forest tenure (Table 8.2) and subsequent analyses, we focus on the top 10 countries with largest forest area (Top10-LFA) which account for 50 per cent of the global forest area and represent both industrialised (Australia, Canada, Russian Federation, United States) and emerging or developing economies (Brazil, China, DR Congo, India, Indonesia, Peru).

Table 8.2 reflects that, across the 58 countries studied, 72 per cent of the forest area in 2017 was publicly administered, while an increasing portion is owned by Indigenous peoples and local communities (13 per cent) or has been designated to them for their use (2.3 per cent). Forest tenure varies significantly across the Top10-LFA, ranging from countries where most of the forests are publicly owned and controlled (Russian Federation, DR Congo, India, Indonesia) to countries with incipient (Canada), moderate (Australia, Peru) or strong (Brazil, China) devolution of forest tenure and rights to local communities. In Australia, Brazil, Canada, India and the United States, significant portions of forests are owned by individuals and firms and, across the 58 countries studied, 12 per cent of the forest area was privately owned in 2017 (RRI 2018). On a global scale, the area of publicly owned forests for which management rights have been granted to private companies under concessionary or licensing agreements has increased from 6 per cent in 1990 to 14 per cent in 2010, as has the area of forests within protected areas which reached 16 per cent of global forest area in 2015 (FAO 2016). Not reflected in these figures are overlapping claims between publicly or privately owned forests and those under local customary rights.

NATIONAL AND LOCAL GOVERNMENTS

National and local governments play a central role in the future of forests as representatives of publicly owned forests and as policymakers and regulators. At the international level, coordinated government efforts contribute to meeting global (e.g. Bonn Challenge) and regional (e.g. 20 x 20 Initiative) goals. At the country level, the political–legal and regulatory frameworks reflect the role of forests in national development strategies, both as regards the forest sector and vis-à-vis other sectors. The principal management objective of the

Table 8.2 Statutory forest tenure (millions of ha) in the top 10 countries with largest forest area and the 58 countries included in the study of RRI (2018) which account for 50% and 86% of the global forest area, respectively, 2002 and 2017

	Government administered		Designated for indigenous peoples and local communities		Owned by indigenous peoples and local communities		Privately owned by individuals and firms	
	2002	2017	2002	2017	2002	2017	2002	2017
Australia	94.0	83.3	0.0	9.1	20.9	12.1	14.0	20.2
Brazil	341.0	238.4	10.7	40.4	75.3	118.1	94.3	99.9
Canada	319.3	318.3	0.2	0.3	6.6	6.8	21.7	21.6
China	76.1	75.2	–	–	103.1	124.3	–	–
DR Congo	157.3	152.4	–	0.2	–	–	–	–
India	56.0	59.3	–	–	–	1.1	9.4	9.8
Indonesia	97.7	85.4	0.3	0.8	–	0.01	1.5	4.9
Peru	58.8	54.4	1.6	5.0	10.5	12.8	5.3	0.1
Russian Federation	809.3	814.9	0.0	0.0	0.0	0.0	–	–
United States	129.2	130.0	–	–	7.3	7.5	166.6	172.6
World (58 countries)	**2 748**	**2 482**	**18.2**	**80.5**	**357.8**	**447.4**	**403.4**	**418.5**

Notes: Dashes (–) denote situations in which the tenure category is not legally possible under national law. For forest area, 'RRI largely relies on … data submitted by national governments to the FAO as input to the Global Forest Resources Assessment, which is published every five years. However, RRI may instead utilise alternate data concerning countries' total forest area where more recent or accurate information is available through other sources' (RRI 2018: 26).
Source: Own elaboration based on data for 58 countries by RRI (2018); share of global forest area based on comparison between 2017 data from RRI (2018) and 2015 data from FAO (2016)

world's forests in 2015 as defined by governments was the supply of forest products (31 per cent), protection of soil and water (31 per cent), multiple use (28 per cent) and conservation of biodiversity (13 per cent) (FAO 2016).[5] Important differences exist between countries with centralised governance and those with strong decentralisation (Larson and Soto 2008). Countries also differ regarding interactions between government agencies in charge of forests and those looking after other sectors, with implications for the role of forests in development strategies and the potential for private investments (Agrawal et al. 2013).

INTERNATIONAL AND LOCAL NGOS

NGOs often play an important role in technical assistance, capacity building and advocacy in support of liaisons between local communities, value chain stakeholders and governments. They have been instrumental in developing voluntary standards for sustainable forest management (SFM) and tree crop sectors (e.g. oil palm, cocoa). In countries where financial and human resources of government agencies have been downscaled due to structural adjustments, NGOs are critical for promoting development alternatives. In remote forest areas, they may be the only providers of technical and other services. Given their capacity to mobilise financial resources, international NGOs tap into funding streams that local NGOs find difficult to access. The latter, in turn, provide the expertise and local embeddedness needed for international NGOs to run impactful projects.

MULTINATIONAL AND NATIONAL COMPANIES

The corporate sector is another key actor, from multinational companies to those operating in national domains. Given the intrinsic nature of global FPVC, companies may make important contributions to SDG 8 in terms of employment generation, decent work, and sustainability of the natural resource base. Multinational companies are well placed to contribute to international agendas, such as the New York Forest Declaration where they represent 57 out of a total of 191 endorsing organisations (Climate Focus 2017). Private companies can also access emerging finance opportunities aligned with goals such as zero deforestation and programmes aimed at generating employment in the forest sector (FAO 2018). Transitioning towards SFM by private companies requires a combination of regulatory policies and financial instruments to restructure operations and spur technological innovation. Through public–private partnerships, multinational and national companies can shape the design and implementation of sustainability standards and practices along different nodes of FPVC.

[5] In some cases, multiple objectives have been set for forests – shares therefore do not add up to 100 per cent.

CORPORATE ASSOCIATIONS

Individual key actors and stakeholders may organise into corporate associations for better representation of their interests. In the natural resource sectors, such associations include the chambers of commerce, industry associations (wood, oil, gas, coal, tourism) and commodity associations (metals and minerals, crops, livestock). These associations may advance corporate social responsibility and, in the forest sector, may represent community forestry groups (e.g. Federation of Community Forestry Users, Nepal and Association of Forest Communities of Petén, Guatemala). Community-based associations can play important advocacy roles for SFM through community stewardship (Stoian et al. 2019). However, corporate associations may also promote agendas that effectively lead to deforestation – for example, through expansion of tree crop production (Benami et al. 2018) or hydroelectric dams (Fearnside 2016).

SMALL AND MEDIUM ENTERPRISES

Small and medium forest enterprises (SMFEs) often make up 80–90 per cent of the forest enterprises in tropical countries, and account for more than 50 per cent of forest-related jobs (Macqueen 2008). Their operations span timber, NTFP and ecotourism activities. Exact figures are scarce due to the high degree of informality in the SMFE sub-sector. Quantifying and addressing informal sectors in forestry can increase the availability of decent work among disenfranchised populations (FAO 2018). For SMFEs to develop into viable businesses, enabling environments are required that promote legal access to forest resources; incentives for sound forest management and value-adding; and the building of human, social, physical and financial capitals for sustainable production of timber and NTFPs (Donovan et al. 2006). Community forest enterprises (CFEs) are a subset of SMFEs with specific challenges: (1) legal entities that rarely address their realities and needs; (2) low levels of productivity and quality due to limited processing and management skills; (3) undercapitalisation; (4) long phases to reach maturity (often 20–40 years); and (5) limited participation of women in leadership positions and decision making (Stoian et al. 2009).

INDIGENOUS AND NON-INDIGENOUS GROUPS DEPENDENT ON FORESTS

The number of people relying on forests for some part of their livelihood and income is estimated at 1–1.6 billion, but reliable quantitative data for global estimates are not available (Agrawal et al. 2013). Many forest-dependent people are not organised or, if they are, are informally organised. In addition to legally constituted CFEs, there is a considerable number of unregistered forest producer organisations that can make important contributions to SFM and the generation of employment and income. This potential is yet to be fully exploited as local communities own or have been assigned use rights for more than 500 million ha of forests (Table 8.2), along with significant portions of forest they manage under customary rights that are not yet formally recognised. In many tropical countries, statutory and customary tenure regimes overlap, leaving local communities in a weak legal status (Wily 2011).

8.2.4 Natural Resource Sectors and Their Contributions to National Economies

SECTORS DEPENDENT ON NATURAL RESOURCES

The forest sector is but one of the natural resource sectors contributing to national economies and it often competes with these for land, investments and human resources. Such sectors include agriculture, energy (large-scale fossil fuel exploitation and hydro dams), minerals and metals, and ecotourism. When anticipating the impact of SDG 8 on the forest sector it is important to account for the contributions of these sectors to GDP, as governments may pursue growth policies focusing on natural resource sectors other than forestry given their weight in national economies.

Natural capital is the most or second-most important asset in low-income and lower-middle-income countries, constituting 47 and 27 per cent, respectively, of wealth in 2014 (Lange et al. 2018). It comprises both renewable (agricultural land, forests, protected areas) and non-renewable resources (fossil fuels and minerals/metals). Contributions of the non-renewables sectors to GDP generally outweigh those from the forest sector (Table 8.3), often coupled with significant environmental pressure (Schandl et al. 2016).

Table 8.3 shows that in the Top10-LFA, contributions of forest rents to GDP are low relative to those of other natural resource sectors – typically below 1 per cent.[6] Most of these countries rely on natural resources other than forests, with contributions to GDP of up to 11 per cent. Excluding DR Congo, forest rents contribute less than one-tenth of total natural resource rents in these countries. At the same time, household income in forest-rich regions often relies to a much higher extent on forest resources (Angelsen et al. 2014). Accounting for these additional contributions requires addressing informality in the forest sector and developing national-level statistics beyond GDP measurement. Indicators 8.1.1 and 8.2.1 alone will not capture the full value of forest-sector contributions to economic growth and productivity.

FOREST SECTOR

On a global scale, the formal forest sector is a relevant source of employment and gross value added, totalling 13.2 million employees and USD 606 billion, respectively, in 2011 (Table 8.4).

[6] The case of DR Congo is ambiguous, given the significant difference between World Bank and FAO data.

Table 8.3 Contributions of forest and other natural resource sectors to GDP in top 10 countries with largest forest area and the world in 2016, by forest area as per cent of land area

	Forest area (million ha)	% of land area	Rents (% of GDP)						Forest as % of total nat. res. rents
			Total natural resources	Oil	Gas	Coal	Mineral	Forest	
DR Congo	152.6	67	32.7	0.4	0	0	13.2	19.1 *	58
Brazil	493.6	59	3.1	1	0	0	1.4	0.7	23
Peru	74.0	58	7.7	0.5	0.2	0	6.7	0.2	3
Indonesia	91.0	53	2.5	0.6	0.2	0.5	0.7	0.5	20
Russian Federation	815.0	50	11.5	7	2.7	0.3	1	0.4	3
Canada	347.1	38	1.0	0.3	0	0.1	0.6	0.1	10
United States	310.1	34	0.3	0.1	0	0.1	0.1	0	0
India	70.7	24	1.9	0.4	0.1	0.8	0.4	0.3	16
China	208.3	22	1.1	0.3	0	0.3	0.4	0.1	9
Australia	124.8	16	5.5	0.2	0.2	0.5	4.5	0.1	2
World	**3999**	**27**	**1.9**	**1**	**0.2**	**0.1**	**0.4**	**0.2**	**11**

Notes: Natural resource rents are World Bank staff estimates based on sources and methods described in Lange et al. (2018). Forest rents are roundwood harvest times the product of regional prices and a regional rental rate.
*This figure is inconsistent with the 18.6% contributions to GDP reported by World Bank (2018a) for the combined agricultural, fishery and forest sectors in DR Congo for 2016; it is also in stark contrast to the 0.6% reported by FAO (2014) as contributions of the forest sector to GDP in DR Congo in 2011 – World Bank (2017) reports 18.5% for 2011.
Source: Own elaboration based on data for forest area in 2015 (FAO 2016) and World Development Indicators for contributions of natural resources to GDP in 2016 (World Bank 2017)

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Table 8.4 Contribution of the formal forest sector to employment and GDP in top 10 countries richest in forest area and the world, 2011

	Employment					Gross value added				
	Roundw. prod.	Wood proces.	Pulp and paper	Total for the forest sector		Roundw. prod.	Wood proces.	Pulp and paper	Total for the forest sector	
	('000)	('000)	('000)	('000)	% of total labour force	USD million	USD million	USD million	USD million	% of contr. to GDP
Australia	11	40	15	67	0.6	1 119	3 975	2 587	7 682	0.9
Brazil	133	434	205	772	0.7	7 036	5 802	9 676	22 513	1.1
Canada	47	112	75	234	1.2	5 759	6 679	7 351	19 789	1.2
China	1 021	1 304	1 516	3 841	0.5	32 386	41 120	53 013	126 519	1.6
DR Congo	15	1	–	16	0.1	29	56	–	85	0.6 *
India	246	246	215	707	0.1	28 097	352	2 509	30 958	1.7
Indonesia	103	211	131	445	0.4	5 904	1 805	6 860	1470	1.7
Peru	37	14	10	61	0.4	212	192	912	1,316	0.8
Russian Federation	228	261	111	600	0.8	2 767	5 108	5 200	13 075	0.8
United States	122	327	378	827	0.5	20 264	22 100	53 300	95 664	0.6
Total World	**3 456**	**5 439**	**4 339**	**13 233**	**0.4**	**169 488**	**170 131**	**266 334**	**605 953**	**0.9**

*see footnote to Table 8.3
Source: FAO (2014)

Table 8.4 illustrates that, across the Top10-LFA, 0.1–1.2 per cent of the total labour force are employed in the forest sector – about a quarter above the global average of 0.4 per cent. However, these figures refer to formal employment in the wood-based industry only. Including informal employment and NTFP-based activities would result in considerably higher figures. The number of employees in formal and informal forest enterprises (including family businesses) is estimated at 45 million (Shackleton et al. 2011). Similarly, forest-sector contributions to GDP would probably be at least twice the official figures when allowing for the informal or non-monetary economy (Lebedys and Yanshu 2014). According to the official data in Table 8.4, the combined contributions of roundwood production, wood processing, and pulp and paper production to GDP vary by 0.6–1.7 per cent across the ten countries – roughly one-fifth above the global average of 0.9 per cent. Forest-sector contributions are relatively highest in the developing Asia-Pacific region (1.5% of GDP), followed by sub-Saharan Africa (1.2% of GDP) (Lebedys and Yanshu 2014).

AGRICULTURAL SECTOR

The agricultural sector is the principle source of employment in many countries of the Global South, with widely varying contributions to GDP (Table 8.5).

Table 8.5 reflects that, despite its decreased importance relative to other sectors over the past decades, the agricultural sector is the principal source of employment in the countries with the largest forest area in the Global South, with important contributions to GDP. Reductions in agricultural employment were more pronounced in emerging economies (Brazil, China, Indonesia) than in less-developed countries (DR Congo, India, Peru), but the agricultural sector still employs 10–31 per cent of the total labour force in the former and 28–82 per cent in the latter. From 2000 to 2016, sector contributions to GDP in the Top10-LFA decreased from 11 to 8 per cent. Still, they are roughly double those at the global scale, which decreased from 5 to 4 per cent. In most of these countries, the decrease of GDP contributions was well below that of employment, pointing at increased efficiencies and higher value added in the agricultural sector vis-à-vis other sectors. DR Congo diverts from this trend as contributions to GDP reflect a marked decline despite the sector's fairly stable importance in terms of employment relative to other sectors. At the same time, Brazil's agricultural sector slightly increased GDP contributions, although employment as part of the total labour force decreased by about a half.

The combined contributions of agriculture, forestry and fishing to GDP (Table 8.5) can be compared with the specific forest-sector contributions (Table 8.4). With the caveat that datasets and reference years vary, it can be

Table 8.5 Employment in the agricultural sector between 2000 and 2017 and its contribution to GDP from 2000 to 2016 in the top 10 countries with largest forest area and the world

	Employment (% of total employment)				Contribution to GDP (%)			
	2000	2010	2017	Trend 2000–2017	2000	2010	2016	Trend 2000–2016
Australia	5	3	3	–47%	3	2	2	–22
Brazil	21	16	10	–52%	5	4	5	+3
Canada	3	2	2	–41%	n.d.	1	n.d.	n.d.
China	44	26	18	–60%	15	10	9	–42
DR Congo	85	80	82	–3%	32	21	19	–42
India	60	52	43	–28%	22	18	16	–25
Indonesia	45	39	31	–31%	16	14	13	–14
Peru	35	28	28	–20%	8	7	7	–13
Russian Federation	14	8	7	–54%	6	3	4	–27
United States	2	2	2	–9%	1	1	1	–12
Total World	**39**	**31**	**26**	**–32%**	**5**	**4**	**4**	**–29**

Notes: contribution of agricultural sector to GDP as value added of agriculture, forestry and fishing; n.d. = no data available
Source: Own elaboration based on World Development Indicators (World Bank 2018a, 2018b)

deducted that contributions of agriculture (and fishing) to GDP in the Top10-LFA are, on average, more than ten times those of the forest sector. At the same time, agricultural commodities such as soy, palm oil and beef are closely linked with deforestation. The associated loss of ecosystem services (e.g. in Brazil, Indonesia and Peru) points towards unsustainable development pathways (Carrasco et al. 2017a). On a global scale, agriculture contributes about one-quarter of greenhouse gas emissions, and decoupling these from agricultural production will remain a major challenge (Bennetzen et al. 2016).

TOURISM SECTOR

Tourism is another important source of employment, contributions to GDP and economic growth. In 2017, direct and total contributions of Tourism and Travel to global employment were 3.8 and 9.9 per cent; and to GDP, 3.2 and

10.4 per cent, respectively (WTTC 2018). The tourism sector significantly encourages economic growth, but it also degrades the quality of the environment (Danish and Wang 2019). This general picture needs to be modified with a view on nature-based tourism and, specifically, ecotourism. However, the exact delimitation and size of these sub-sectors are difficult to establish, and there is no universally accepted definition of ecotourism. In connection with the effects of SDG 8 on forests and Target 8.9 (policies to promote sustainable tourism), different types of ecotourism need to be considered. In the Global South, the focus should shift from modernist forms of ecotourism, aimed at mere economic development, to more locally controlled, participatory forms of community-based ecotourism (Regmi and Walter 2017).

In terms of environmental performance, there is evidence for both positive and negative impacts of ecotourism (Buckley 2018). A recent global systematic review of ecotourism impacts on forests in biodiversity hotspots found that ecotourism, as typically practised, leads to local deforestation due to increased demand for fuelwood, food and timber; but when accompanied by conservation mechanisms (e.g. protected area, ecosystem service payments, monitoring/enforcement), it can protect forests (Brandt and Buckley 2018). As ecotourism often implies visiting relatively remote areas, and significant numbers of ecotourists use long-haul air travel to reach to tropical destinations, its carbon footprint can be considerable (see Gale 2016).

MINING SECTOR

On a global scale, the mining of metals and minerals contributes to regional and national economies by generating budget and export revenues, employment and infrastructure development, while it is also responsible for causing a wide range of adverse environmental and social impacts (e.g. disruption of river flows, degradation of land and forest resources, impacts on livelihoods in local communities and disturbance of indigenous people's traditional lifestyles) (Yakovleva 2017). Compared with other industrial sectors, the mining industry faces some of the most difficult sustainability challenges (Azapagic 2004). Mining of minerals and metals is an important driver of deforestation in tropical countries, often far beyond operational lease boundaries and paired with contamination of soils and aquifers (Mwitwa et al. 2012). Different types of mining impacts can be distinguished (Megevand et al. 2013): the *direct* impact on forest cover may be fairly limited, but *indirect* impacts tied to larger infrastructure developments (e.g. power plants, dams, roads) can be considerable, as can be *induced* impacts associated with a large influx of workers (e.g. subsistence agriculture, logging, poaching) and widespread aquatic contamination through the use and discharge of toxic substances, as well as *cumulative* impacts related to artisanal mining, where many small individual mining sites add up to significant impacts.

ENERGY SECTOR

Given the diversity of the energy sector, a differentiated analysis is required with a view on SDG 8. Many countries rely heavily on fossil fuels and, to some extent, nuclear energy. At the same time, the renewable energy sector is growing around the globe, based on increasing use of hydropower, wind, solar energy, wood, residues from agriculture and forestry, biogas and various types of biofuels. Energy production is in direct competition with forests for land, and is potentially linked with environmental contamination, when involving open-pit coal mining, oil exploitation, the construction of hydro dams in forested river basins such as the Amazon, Congo and Mekong (Winemiller et al. 2016) and the production of certain biofuels. In the Brazilian Amazon, both hydro dams and mining threaten protected areas, boosted by a political–legal framework supportive of both sectors (Ferreira et al. 2014).

While economic growth and decent work will progressively be sought in the renewable energy sector, the constant push back of peak oil, gas and coal as new reserves become exploitable slows down progress in the energy transition. In 2015, only 17.5 per cent of global final energy consumption was produced through renewable energies, and only 55 per cent of this share was derived from modern forms of renewable energy, i.e. other than fuelwood and charcoal (UN 2018). The fossil fuel sector continues to be a major source of employment and economic growth, with a high environmental footprint (see O'Rourke and Connolly 2003). Similar trade-offs are reported for agricultural crops producing biofuels, such as sugarcane (Jusys 2017) and oil palm (Vijay et al. 2016).

Fossil fuel production and consumption are also the primary source of greenhouse gas emissions, with significant, mainly adverse effects on forests through climate change (Allen et al. 2010). The impacts of biofuel production and consumption on forests are more ambiguous. Biofuels produced from crops using conventional agricultural practices will likely not mitigate the impacts of climate change caused by the use of petroleum fuels, and will exacerbate stresses on water supply and quality as well as land use (Delucchi 2010).

8.3 Assessment of Anticipated Impacts

Before addressing the anticipated impacts of SDG 8 action on forests and forest-dependent people, it is insightful to look into progress towards SFM as recently reported with relation to SDG 15 (Life on Land). Although the forest area in the world continues to decline, the rate of loss has dropped by 25 per cent from 2000–5 to 2010–15, accompanied by a general trend towards protection of forest and terrestrial ecosystems (UN 2018). But the same report also stresses that escalating biodiversity loss requires urgent actions to protect and restore ecosystems and the biodiversity they support. While net forest area gains are reported for Central/Southern Asia and Eastern/South-Eastern Asia from 2005–10 to

2010–15, this does not necessarily imply that deforestation has halted altogether. The ongoing reduction in above-ground biomass stock in forests reported for these two regions points to continued loss or degradation of natural forests. In fact, part of the progress in net forest area change is due to the advance of plantations, which provide a very different level of ecosystem services compared to natural forests. Similarly, the largely positive trend in the proportion of forest area under legally established protected areas or long-term forest management plans does not ensure effective change on the ground unless accompanied by viable enforcement mechanisms and other enabling conditions.

8.3.1 Forest-Based Economic Growth

FAO (2018) holds that forests and FPVC are of critical importance for sustained economic growth, full and productive employment and decent work for all, especially in remote areas. While at the national level manufacturing, services and other natural resource sectors are principal sources of economic growth and employment, remote forest areas rely to a much higher extent on the forest sector (Angelsen et al. 2014). Yet, many tropical countries struggle to achieve sustainable work opportunities and economic growth based on their forest riches (Swamy et al. 2018). Only a few countries (e.g. Thailand and Malaysia) have successfully used their forest resources to trigger broad-based economic growth spilling over to other natural resource sectors, and from there to manufacturing and services. The nominal GDP contributions of the forest sector do not motivate policies to develop its untapped potential. At the same time, the absence of policies promoting forest-sector development underlies its widespread stagnation in tropical regions. Political disinterest can also be attributed to a general dearth of reliable data on overall contributions of forests to national economies, spanning formal and informal employment, and timber and NTFP value chains.

Fairly robust data are available for the formal forest sector, particularly as regards the wood-based industry. Global employment in the formal forest sector decreased by about 6 per cent over the past decade, from 14.0 million people in full-time equivalents in 2000 to 13.2 million in 2011 (Lebedys and Yanshu 2014). The decline was most pronounced in the forestry sub-sector[7] (21 per cent) and in the developed regions. Losses were partly offset by increased formal forestry employment in developing regions, where most of the estimated 41 million people in the informal forest-sector work (FAO 2014).

In the Global South, roundwood production is relatively more important than wood processing and the production of pulp and paper. Global

[7] FAO (2014) distinguishes three sub-sectors: forestry (roundwood production), wood processing, and pulp and paper.

value-adding across the three sub-sectors has only slightly increased (5 per cent), from USD 583 billion in 2000 (at 2011 prices and exchange rates) to USD 606 billion in 2011. The pulp and paper industry contributes most to the global gross value-added (44 per cent), followed by the wood industry and the forestry sub-sector (28 per cent each). Overall distribution of value-added across the sub-sectors remained stable in the 2000s, but the share of the pulp and paper industry has recently declined (FAO 2014).

Refined metrics are needed to fully document actual and potential contributions of the forest sector to economic growth and decent work, as are sub-national policies and strategies to promote forest-sector development in regions where there are few alternatives. These, in turn, need to promote formal employment opportunities, especially for young people, reduce labour market inequality (gender pay gap), promote safe and secure working environments, and improve access to financial services to ensure sustained and inclusive economic growth (UN 2018). Given the intrinsic differences between timber and NTFP value chains, gender-differentiated approaches are required that increase employment and income opportunities for women, particularly in NTFP value chains (see Sunderland et al. 2014).

The positive impact of SDG 8 on the forest sector may be supported by voluntary sustainability standards. Forest certification has had positive effects on indicators related to decent work, particularly regarding social security and forest worker safety (see Cashore et al. 2006). There is little evidence, however, that forest certification leads to significant economic growth in tropical countries (Romero et al. 2017). Similarly, the advance of 'zero deforestation' and similar eco-labels for agricultural commodities associated with deforestation (e.g. soy, palm oil, cocoa) have yet to show significant impacts on forest loss (van der Ven et al. 2018).

Looking forward, the potential of the forest sector to contribute to SDG 8 largely relates to developing markets and value chains for sustainable timber and NTFPs that stimulate economic growth, provide gender- and age-differentiated employment opportunities, and ensure forest conservation. In tropical and other forest regions, sustainable tourism has the potential for promoting both economic growth and decent work. Where robust mechanisms can be established, such endeavours may be complemented with payments for environmental services.

8.3.2 Decent Work along Forest Product Value Chains

ILO's guiding framework for international labour standards comprises 8 fundamental, 4 governance and 177 technical conventions. One of the fundamental conventions and 6 technical ones were crafted after ILO's proclamation of 'decent work' in 1999. The fundamental one relates to the Worst Forms of Child Labour Convention (1999), and the pertinent technical ones are Maternity Protection (2000), Safety and Health in Agriculture (2001) and Promotional Framework for Occupational Safety and Health (2006) (ILO 2018b). While the other fundamental conventions predate the proclamation of decent work, they are closely linked to the concept. Table 8.6 illustrates the status of these conventions for the Top10-LFA.

Table 8.6 shows that five of the Top10-LFA have ratified all eight of ILO's fundamental conventions: Canada, DR Congo, Indonesia, Peru and the Russian Federation. Two conventions crucial for SMFE development have yet to be ratified by several countries: Freedom of Association & Protection of the Right to Organise, and Right to Organise & Collective Bargaining. In addition, effective enforcement mechanisms need to be in place to ensure these rights, as shown in countries where conventions have been ratified but implementation is lacking (e.g. DR Congo).

Several ILO conventions have direct links with SDG 8 targets and indicators, particularly Targets 8.3 (SMEs), 8.5 (productive employment and decent work), 8.6 (youth employment), 8.7 (forced labour) and 8.8 (labour rights and safety). While most Top10-LFA have ratified the conventions pertinent to Target 8.5 (except China and the United States), they lag behind in the ratification of those relating to Targets 8.3 (rights to organise), 8.6 (night work of young persons) and 8.8 (night work of women, migrant workers). The latter is particularly problematic as women and migrant workers play prominent roles in the informal forest sector. This underlines the importance of enabling environments comprising the ratification of international conventions, their translation into national policies and the formalisation of all nodes of FPVC.

Decent work may also be offered in tree crop value chains by enterprises engaged in larger schemes that replace natural forests: for example, oil palm, rubber, timber and cocoa plantations. Employment effects are often significant but, in addition to environmental externalities, labour conditions may be precarious (e.g. labour safety in sawmills, exposure to agrochemicals). Labour conditions in the first nodes of forest product and tree crop value chains may become less attractive to the younger generation which, through increased availability of educational services in rural areas, are prompted to search out livelihood options other than forestry or agriculture. At the same time, better formal education fosters skills required for developing SMFE that provide local opportunities for educated youth. Along with better access to modern information and communication technologies (ICT), there will be increased opportunities for them as managers of such enterprises.

Table 8.6 Status of ILO's 8 fundamental conventions in top 10 countries with largest forest area (R=ratified, NR not ratified)

Convention	29	87	98	100	105	111	138	182
	Forced labour	Freedom of association & protection of the right to organise	Right to organise & collective bargaining	Equal remu-neration	Abolition of forced labour	Discrimi-nation	Minimum age	Worst forms of child labour
Australia	R	R	R	R	R	R	NR	R
Brazil	R	NR	R	R	R	R	R	R
Canada	R	R	R	R	R	R	R	R
China	NR	NR	NR	R	NR	R	R	R
DR Congo	R	R	R	R	R	R	R	R
India	R	NR	NR	R	R	R	R	R
Indonesia	R	R	R	R	R	R	R	R
Peru	R	R	R	R	R	R	R	R
Russian Federation	R	R	R	R	R	R	R	R
United States	NR	NR	NR	NR	R	NR	NR	R

Source: Own elaboration based on data from ILO (2017)

8.3.3 Forest-Dependent Livelihoods

Forest-dependent people vary widely, as do their relationships with forests (e.g. formal or customary rights), their livelihoods (e.g. forest and non-forest activities) and their demands on forests and the broader resource system (e.g. products and ecosystem services). Official accounts rarely capture the intrinsic nature of such relationships and tend to underestimate the monetary and non-monetary values of forests to these people and society. As forests continue to be degraded or converted to other land uses, forest-dependent people may be forced into other livelihood activities in their respective locations, move further into the forest or out-migrate altogether. At the same time, the rights of forest-dependent communities are progressively being recognised (RRI 2017), providing an institutional environment enabling them to determine livelihood shifts more autonomously rather than responding to externally driven pressures.

8.3.4 Gender, Intergenerational and Ethnic Equity

Empowerment of forest-dependent communities, including participation in decision making and strengthening of livelihoods, is closely linked to gender, age and ethnicity. Access to land and natural resources is a critical entry point for empowering women and marginalised groups as it defines social status and political power and structures relationships within and outside the household (Agarwal 1994). Official statistics on differentiated access to forest resources are scarce, as is information on women, youth and other vulnerable groups in relation to their participation as labour force in the forest sector. Given the often seasonal nature of forest-based activities, their participation tends to be intermittent, informal and underpaid (FAO 2018).

This lack of recognition influences policymaking. In many cases, women, indigenous peoples and other marginalised groups are not considered beneficiaries unless programmes target them explicitly (Larson et al. 2018). Despite important gender differentiation in the collection of forest products, with distinctive 'male' and 'female' roles (Sunderland et al. 2014), forests continue to be perceived as a 'male domain' and development interventions are often designed accordingly. Combined, these factors tend to perpetuate the position of women and other marginalised groups in the informal part of the forest sector, with the associated underestimation of their contributions to sector development. In countries such as Guatemala and Cameroon, where community rights to forests are formalised and where internal governance structures do not unduly favour male dominance or that of certain economic strata, women, youth and indigenous peoples can play important roles in the management of CFEs (see Belibi et al. 2015, Stoian et al. 2019).

8.3.5 Forest Conservation

Despite a 15 per cent reduction in the global rate of net forest loss from 1990 to 2015 (FAO 2016), forests and associated biodiversity continue to be threatened. While SDG 8 seeks to decouple economic growth from environmental degradation, there is also an opportunity to *couple economic growth with forest conservation and sustainable resource management*. For example, community-based forest management can link forest conservation with economic growth and livelihoods improvement through SMFE development and tourism (Macqueen et al. 2018). The relationship between forest concessions managed by private companies, forest conservation and local economic development is less clear (see FAO and EFI 2018). While inappropriate logging can lead to forest degradation, the primary drivers of deforestation lie outside the forest sector: commercial and subsistence/local agriculture, followed by infrastructure development, mining and urban sprawl (Hosonuma et al. 2012).

Forest conservation needs to be achieved from both outside, by checking extra-sectoral drivers of deforestation, and from within through SFM or preservation with limited human intervention. A comparative analysis of 40 protected areas and 33 community-managed forests showed that annual deforestation rates in the latter were lower and less variable than those in protected forests; forest conservation strategies should therefore encompass a regional differentiation of land use types, tenure rights, social and economic needs of local inhabitants, and local capacities (Porter-Bolland et al. 2012).

In regions where deforestation has been reduced or halted, opportunities exist for initiating landscape restoration. Diverse combinations of agroforestry systems and timber plantations can stimulate economic growth and recover ecosystem services, with the bottom line that forest, agroforestry and plantation forestry options generate income comparable to alternative land uses (Appanah 2016).

8.3.6 Anticipated Impacts within the Framework of SDG 8

Principal synergies between SDG 8 and forests can be expected for areas where national policies for economic growth and decent work explicitly target the forest sector, and where these are paired with adequate legislation for sustainable management and conservation of forests and effective enforcement mechanisms. Several tropical countries provide monetary incentives for carbon sequestration through reforestation (Baker et al. 2019), with payments typically varying between USD 800 and USD 1500 per ha. The establishment of timber plantations has important employment effects, as shown for Brazil, China and Indonesia (Tomberlin et al. 2001). Some countries also provide incentives for managing natural forests for timber and NTFPs (Agrawal et al.

2018), generating local employment and value added. Community-based forest management and processing of forest products by CFEs can be combined with ecotourism to generate additional employment and income, as documented for Petén, Guatemala (Stoian et al. 2019).

While such synergies have important employment effects at local and regional levels, their impact at national and global scales will continue to be modest in light of the limited contributions of the forest sector to GDP – 0.2 per cent worldwide and 0.7 per cent in lower-middle-income countries (World Bank 2017). Accounting for the informal sector could double forest-sector contributions to GDP (World Bank 2016), but contributions of other natural resource sectors will continue to outperform those of the forest sector in many tropical countries. This holds particularly for the agricultural and mining sectors and, depending on the energy mix in a given country, the energy sector. Most governments have long pursued growth strategies based on modernisation and economic growth theories. Without a major paradigm shift, national policies will continue to prioritise the natural resource sectors that contribute most to GDP.

Principle trade-offs within SDG 8 implementation, particularly as regards deforestation, relate to policies for competing natural resource sectors. But some trade-offs are also expected for areas of potential synergy. For example, a systematic review of the socio-economic impacts of large-scale tree plantations found ambiguous impacts: slightly positive for employment, mixed regarding livelihoods and negative for land and intertwined social factors (Malkamäki et al. 2018). Strong global evidence on long-term socio-economic impacts of large-scale tree plantations remains limited (Malkamäki et al. 2018). Similarly, the evidence base for inferring positive effects between ecotourism and forests is insufficient (Brandt and Buckley 2018). A recent review on development policies in relation to the SDGs found that many commonly applied development interventions do not explicitly consider natural resources, let alone forests, leading to suboptimal, unsustainable outcomes; even if interventions tackle both development and conservation goals, they often lack coordination and sufficient levels of natural capital to ensure long-term sustainability (Miteva 2019).

8.4 Synergies and Trade-Offs between SDG 8 and Other SDGs

With the aim to maximise synergies and minimise trade-offs with other SDGs, partnerships for working towards SDG 8 have emerged at global, regional and national levels. As of February 2019, the SDG Knowledge Platform lists 770 partnerships in relation to SDG 8 (UN 2019). The World Bank Group alone

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reports more than 570 active projects with a jobs angle, representing investments of close to USD 75 billion, reaching nearly 2 million new beneficiaries and leveraging additional investments through global partnerships (World Bank 2018c). The United Nations Conference on Trade and Development (UNCTAD) and its partners seek to mainstream the promotion of investment in SDG sectors and to build capacity for SDG-related projects (UNCTAD 2018).

For assessing potential synergies and trade-offs, we developed a matrix that juxtaposes SDG 8 with other SDGs. We first reviewed connecting targets and assessed interaction intensity (high, medium, low) and then, from the perspective of the forest resource base, forest-dependent people and the forest industry, we considered the nature of the interactions (synergies, neutral, trade-offs) in dependence on political-strategic priorities (Table 8.7).

Table 8.7 illustrates that, in relation to the forest sector, SDG 8 has strong interactions with SDGs 1, 2, 5, 7, 9, 10, 12, 13, 15, and 17. At the same time, interactions between SDG 8 and SDGs 3, 6, 11, 14 and 16 are less strong, and those with SDG 4 are important but relatively indirect. Our assessment is in line with the literature showing that forests are important to the success of many of the sectors and functions represented within the context of the SDGs. In an assessment depicting the SDGs as a network of linked targets, SDG 8 ranks third as regards the number of SDGs it is connected with (10), including strong links with SDGs 9 and 10 (3 linked targets each), followed by SDGs 12 and 14 (2 targets each) and SDGs 1, 2, 4, 13, 15 and 16 (1 target each) (Le Blanc 2015). Diversions from our assessment owe to our focus on the forest sector.

Synergies between SDG 8 and other SDGs regarding forest-dependent people, the forest industry and the forest resource base are likely in countries where policies and strategies explicitly focus on the forest sector and are accompanied by safeguards for SFM and forest conservation. Such synergies can be expected as regards poverty reduction (SDG 1), clean water (SDG 6), ‘modern’ renewable energies (SDG 7), forest industry development (SDG 9), reduced (gender) inequalities in FPVC (SDGs 5 and 10), safe and affordable housing based on materials derived from forests (SDG 11), responsible consumption of forest products (SDG 12), economic growth through forests managed and protected as carbon sinks (SDG 13) and sustainable forest products and ecotourism (SDG 15).

Trade-offs for forests are anticipated in countries where policies and strategies focus on other natural resource sectors, particularly agriculture, energy and mining. A principal challenge is the significant increase of global food production required to feed the world’s growing population (FAO 2018). Major trade-offs are anticipated between SDG 8 on the one hand, and SDGs 2, 13 and 15 on the other. Other trade-offs exist between the forest and mining

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Table 8.7 Intensity and nature of interactions between SDG 8 and other SDGs in relation to the forest sector and depending on political-strategic priorities

SDG 8 SDGs	Intensity of interactions High (dark grey) Medium (mid-grey) Low (light grey)	Nature of interactions depending on political-strategic priorities Synergies (yellow) Neutral (orange) Trade-offs (red)
SDG 1 – No Poverty		*Nature of interactions depends on sector focus of policies and strategies to foster employment and income for the poor:*
		Growth of the forest sector and ecotourism can generate additional employment and income for poor forest-dependent people.
		Growth of manufacturing and service sectors with low demand for natural resources may generate limited additional employment and income for poor forest-dependent people and be largely neutral to the forest resource base.
		Growth of other natural resource sectors may jeopardise livelihoods of poor forest-dependent people due to deforestation.
SDG 2 – Zero Hunger		*Nature of interactions depends on the type of agriculture promoted:*
		Sustainable intensification of agriculture and lower demand for animal-based food can contribute to zero deforestation over time, retaining options for forest-sector growth.
		Some forms of commercial and subsistence agriculture are primary drivers of deforestation, limiting forest-sector growth.

Table 8.7 (cont.)

SDG 8 SDGs	Intensity of interactions High (dark grey) Medium (mid-grey) Low (light grey)	Nature of interactions depending on political-strategic priorities Synergies (yellow) Neutral (orange) Trade-offs (red)
SDG 3 – Good Health and Well-being	High (dark grey)	*Nature of interactions depends on the sector focus of policies and strategies to foster economic growth and decent work:*
		Advancing decent work in the forest sector reduces occupational injuries; investments by CFEs in health facilities and services can improve the health of their members.
		Growth of manufacturing and service sectors with low demand for natural resources may be largely neutral to the health and well-being of forest-dependent people.
		Growth of other natural resource sectors may compromise health of forest-dependent people: malaria (hydro dams); contamination with heavy metals (mining) and agrochemicals (agriculture).
SDG 4 – Quality of Education	Low (light grey)	*Nature of interactions depends on the type, quality and location of educational facilities and services available to forest-dependent people:*
		Forest sector and ecotourism growth may curb outmigration from forest areas and spur reinvestment in education and expansion of educational services; these, in turn, can help upgrade capacities and skills for managing forests and SMFE.
		Upgrading general educational facilities and services is largely neutral to the forest resource base and, hence, does not affect forest-sector growth.
		Improved access to educational facilities may lead youth to search out livelihood options other than forest-based activities.

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SDG 5 – Gender Equality		*Nature of interactions depends on the sector focus of policies and strategies to foster economic growth and decent work:*
		Growth of forest-based ecotourism and NTFP value chains may foster gender equality; equal representation and participation in decision making of women and men in the management of forest enterprises may boost their economic and social performance.
		Growth of certain segments of the energy and agricultural sectors may be largely neutral to forest-dependent people and, hence, not affect gender equality among them.
		Growth of the mining sector and timber and fuelwood value chains may perpetuate gender inequalities.
SDG 6 – Clean Water and Sanitation		*Nature of interactions depends on watershed management regulations and the sector focus of policies and strategies to foster economic growth and decent work:*
		Forest sector growth based on SFM helps to maintain or restore forests as water-related ecosystems.
		Growth of forest-based sustainable ecotourism may be largely neutral in terms of water availability and quality and, hence, not affect forest-sector growth.
		Growth of the agricultural, mining and energy sectors and unsustainable tourism may induce deforestation and, thus, compromise water availability and quality; watershed management regulations may impose restrictions limiting forest-sector growth.

Table 8.7 (cont.)

SDG 8 SDGs	Intensity of interactions High (dark grey) Medium (mid-grey) Low (light grey)	Nature of interactions depending on political-strategic priorities Synergies (yellow) Neutral (orange) Trade-offs (red)
SDG 7 – Affordable and Clean Energy		*Nature of interactions depends on the type of energy promoted:*
		Growth of 'modern' renewable energies may reduce pressure on forests exploited for firewood and charcoal and, thus, provide opportunities for alternative forest-sector growth.
		Promotion of solar and wind energy may be largely neutral to forestry industry, forest-dependent livelihoods and the forest resource base in areas where firewood extraction is insignificant.
		Construction of large-scale hydro dams may increase deforestation and, thus, limit forest-sector growth.
SDG 9 – Industry, Innovation and Infrastructure		*Nature of interactions depends on the type of infrastructure promoted and the sector focus of policies and strategies to foster economic growth and decent work:*
		Promoting growth of the forest and ecotourism industries can create additional employment and income; road construction in forest areas can improve market access.
		Developing infrastructure for economic growth in urban areas may be largely neutral to the forest resource base and, hence, not affect forest-sector growth.
		Promoting growth of the agri-food, mining and energy industries and construction of roads and hydro dams may increase deforestation and, thus, limit forest-sector growth.

SDG 10 – Reduced Inequalities		*Nature of interactions depends on the sector focus of policies and strategies to foster economic inclusion:*
		There is high potential for economic inclusion in the forest sector where about 75% of employment is informal.
		Economic inclusion in the tourism sector may be largely neutral to the forest resource base and, hence, not affect forest-sector growth.
		Economic inclusion in the agricultural, mining and energy sectors may increase deforestation and, thus, limit forest-sector growth.
SDG 11 – Sustainable Cities and Communities		*Nature of interactions depends on the sectors affected by urban sustainability policies and strategies:*
		Increased demand for safe and affordable housing based on wood and other materials from the forest can spur forest-sector growth; demand for peri-urban forests as green public spaces can foster growth of ecotourism.
		Urban transport and settlement policies may be largely neutral to the forest resource base and, hence, not affect forest-sector growth.
		Urban water demand may impose restrictions on management of forest resources in nearby watersheds; demand for non-polluting energies may increase deforestation through expansion of hydro dams and, thus, limit forest-sector growth.

Table 8.7 (cont.)

SDG 8 SDGs	Intensity of interactions High (dark grey) Medium (mid-grey) Low (light grey)	Nature of interactions depending on political-strategic priorities Synergies (yellow) Neutral (orange) Trade-offs (red)
SDG 12 – Responsible Consumption and Production		*Nature of interactions depends on the sectors targeted by responsible consumption and production policies and strategies:*
		Promotion of building materials derived from wood and other forest resources, along with standards attesting their sustainability, provides incentives for forest sector and ecotourism growth based on SFM.
		Advance of sustainability standards attesting zero deforestation in agricultural commodity chains ensures neutrality to the forest resource base and, thus, does not affect forest-sector growth.
SDG 13 – Climate Action		*Nature of interactions depends on climate change regulations and the sector focus of policies and strategies to foster economic growth and decent work:*
		Forest-sector growth based on SFM helps to maintain or restore forests as carbon sinks and, thus, reduces greenhouse gas emissions; successful climate change mitigation measures support forest health and, thus, forest industry and forest-dependent people.
		Growth of the agricultural, mining, energy and tourism sectors may increase deforestation and/or greenhouse gas emissions; climate change regulations may impose restrictions limiting forest-sector growth.

SDG 14 – Life Below Water		*Nature of interactions depends on ocean management regulations and the sector focus of policies and strategies to foster economic growth and decent work:*
		Growth of inland aquaculture may be largely neutral to the forest resource base and, hence, not affect forest-sector growth.
		Forest-sector growth may be limited by: (1) expansion of fish and shrimp farming in coastal areas in response to regulations restricting fishing in open waters, leading to deforestation of mangroves and other coastal forest types; (2) regulations restricting the use of forest resources in coastal regions; (3) discharge of materials from areas deforested through agriculture and mining may affect growth of mangrove forests and associated forest-sector development.
SDG 15 – Life on land		*Nature of interactions depends on protected area regulations and the sector focus of policies and strategies to foster economic growth and decent work:*
		SFM sustains forest-sector growth; expansion and management of protected areas can foster growth of sustainable ecotourism.
		Growth of the agricultural, mining and energy sectors may increase deforestation and protected area regulations may restrict forest management and, thus, limit forest-sector growth.
SDG 16 – Peace, Justice and Strong Institutions		*Nature of interactions depends on the focus of policies and strategies to foster peace, justice and institutional strengthening:*
		Strong local institutions promote SFM and SMFE; reduction of illicit forest-related activities (illegal logging, wildlife trade, drug trafficking) linked with deforestation supports forest-sector growth.
		Non-forest-related regulations are essentially neutral to the forest resource base and, hence, do not affect forest-sector growth.

Table 8.7 (cont.)

SDG 8 SDGs	Intensity of interactions High (dark grey) Medium (mid-grey) Low (light grey)	Nature of interactions depending on political-strategic priorities Synergies (yellow) Neutral (orange) Trade-offs (red)
SDG 17 – Partnerships for the Goals		*Nature of interactions depends on the sector focus of policies and strategies to foster economic growth, decent work and partnerships:*
		Private, public and civil society partnerships can foster FPVC development; enhanced finance, technology, capacity development, trade and systemic support for the forest sector will spur its growth and decent work.
		Enhanced finance, technology, capacity development, trade and systemic support for the ecotourism sector may be largely neutral to the forest resource base and, hence, not affect forest-sector growth.
		Enhanced finance, technology, capacity development, trade and systemic support for the agricultural, mining and energy sectors may increase deforestation and, thus, limit forest-sector growth.

sectors. World demand for mineral resources has increased significantly since 2000 and continued growth in the technology, transportation and construction sectors will further fuel demand (Megevand et al. 2013). Untapped mineral resources are concentrated in the Amazon, Congo and Mekong basins. Growth of the mining sector implies important trade-offs between SDG 8 and SDGs 3, 5, 6, 12, 13, and 15 and, in view of armed conflicts around mineral resources in forested regions (Switzer 2001), with regard to SDG 16.

Countries rich in natural resources have long been known for strong links between resource extraction and environmental degradation. This ‘resource curse’ often leads to forest degradation, undermining Target 8.4, which seeks to decouple economic growth from environmental degradation (Swamy et al. 2018). In Ethiopia, for example, the government has embarked on a rapid economic growth trajectory emphasising agriculture and energy development, requiring vast tracts of land and competing with other ecosystems including forests (Weitz et al. 2014).

Progress towards all SDGs depends on multiple interactions among diverse stakeholder groups. Beyond potential synergies among SDGs, there is a need for identifying common interests among key stakeholders and developing mechanisms for coordinated, collaborative efforts. Cross-sector, multi-stakeholder dialogue is also needed to address conflicting interests and minimise trade-offs. Conflict resolution and stakeholder-informed prioritisation are required as there is considerable risk that SDG actions undermine one another and compromise the sustainable use of natural resources (Swamy et al. 2018).

8.5 Conclusions

As most governments in the Global South are pursuing ‘growth and trickle-down’ strategies to reduce poverty, while largely relying on natural capital, both renewable and non-renewable resources will be in high demand to achieve rapid economic growth (FAO 2010). As a result, significant trade-offs can be expected between achieving SDG 8 and SDGs focused on the conservation of natural resources, particularly SDGs 6, 13 and 15. At the country level, the effects of SDG 8 on forests will depend on the prioritisation of overarching development paradigms (modernisation, economic growth, basic needs, sustainable development) which, in turn, will lead to a differentiated prioritisation of SDG 8 targets by governments, the private sector, investors and civil society. Even in forest-rich countries such as Russia, Canada, Brazil, Indonesia and DR Congo, the contributions of the forest sector to GDP and overall economic growth are modest at best. Growth strategies are likely to continue to rely on natural resource sectors other than forestry (agriculture, energy, and mining), which, in many cases, directly compete with the forest sector for land, investments and human resources.

Efforts to factor forest ecosystem services into national accounts of natural capital are laudable and will play an increasing role in shaping the debate about the value of forests vis-à-vis that of alternative land uses. Still, for the foreseeable future such economic valuation of forests will hardly become a game-changer for halting deforestation and forest degradation at the global scale, given that competing sectors hold higher potential for generating economic growth, employment and, arguably, decent jobs. Decoupling economic growth from forest-related environmental degradation will continue to be a principal challenge in countries where such growth is sought by developing sub-sectors of agricultural (e.g. cereals, sugarcane, soy, beef) and tree crops (e.g. rubber, oil palm), the energy sector through expansion of hydro dams and the mining sector through granting licenses in extensive forest areas.

Conflicting growth policies and those neglecting environmental trade-offs reflect, to some extent, the architecture of the SDGs. It is argued that the global negotiation process for SDG formulation resulted from 'political' mapping rather than biophysical and socio-economic considerations; consequently, the political framework does not explicitly reflect the multiplicity of links that matter for policy purposes, and in practice the SDGs will be of limited use in providing guidance to address those various links (Le Blanc 2015). Furthermore, despite the notion of equivalence among SDGs, interventions and investments will be guided by societal goal prioritisation. Such a process, in turn, will reflect overarching development paradigms and, depending on the access to information and decision making among stakeholder groups, varying degrees of inclusiveness as regards prioritisation.

The nature of such processes will determine the extent to which the synergetic dimension of SDG 8 will figure more prominently. This would be reflected, for example, in significant numbers of poorer people involved in the establishment and management of timber plantations, the management of natural forests for timber and NTFPs, their processing into value-added products, and services related to ecotourism and the provision of environmental services. The impact of such endeavours can be expected to grow over time as the 'green' economy, public and private sustainability standards, and impact investments advance. Increasing the community stewardship of tropical forests will further contribute to synergies between forest conservation and livelihood development, with equitable benefit sharing between men, women and youth. Community-based approaches will allow for gender-differentiated opportunities in timber and NTFP value chains. Involvement of the youth and decent work in the forest sector can increase with better access to skills development programmes and modern ICT for running forest-based enterprises, ensuring long-term engagement and better positioning in FPVC.

However, in many countries and for many years to come, the societal prioritisation of SDGs will continue to follow established patterns: putting economic goals over environmental and social goals. For example, donor agencies such as the Department for International Development (DFID) are returning to an economic growth agenda. Such a strategy may achieve growth in partner countries but, without sufficient conceptual rigour, regulatory oversight or attention to the 'connective fabric' between growth and development, may yield to state–corporate interests and not achieve progressive, just development outcomes (Mawdsley 2015). In general, business-as-usual approaches to economic growth will perpetuate trade-offs with regard to the conservation of forests and the livelihoods dependent on them. However, the prioritisation of goals and actions that negatively affect forests may be unavoidable in given situations. In these cases, the overall SDG outcomes need to be acceptable from a broader societal development perspective ('justified deforestation') – for example, when the benefits from agricultural conversion outweigh the environmental costs (see Carrasco et al. 2017b). For this to happen, access to information and education needs to improve, societal debate needs to become more inclusive and paradigm shifts need to happen ('decent work and *decent* growth'). These shifts would reflect, and can be nurtured through, alternative approaches for measuring forest-sector impact – beyond GDP contributions, employment generation and the hectarage of forests set aside as protected areas. Such approaches allow for a more integrated measurement of economic growth, assessing its environmental impact by accounting for the conservation or depletion of overall natural capital stocks and its social impact by using metrics that account for gender, age and other factors of social differentiation. Results of integrated measuring can contribute to individual and institutional learning, foster innovative cross-sector partnerships and, based on these, more informed prioritisation of goals and better targeted interventions and investments by public and private sectors and civil society.

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Chapter 9 SDG 9: Industry, Innovation and Infrastructure – Anticipating the Potential Impacts on Forests and Forest-Based Livelihoods

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Key Points

- Target 9.1 and its corresponding indicators risk irreversible and widespread forest degradation and deforestation; the short- and long-term environmental and social costs of this goal need to be better assessed.
- The impacts of other indicators on forests (e.g. Target 9.3, Target 9.C) will largely depend on how they are implemented.
- Major trade-offs exist between SDG 9 and SDG 15 (Life on Land), especially if economic expansion and increasing planetary impacts remain coupled.
- Target 9.4 and its corresponding indicator should go beyond greenhouse gas emissions and intensity-based measures to ensure absolute reductions in ecological or material impact, as higher global material use will mean more pressure and competing demands on forests, likely impacting these ecosystems in negative ways.
- SDG 9 should be reformulated to promote and support alternative socio-economic models that are not based on indefinite economic growth or reliant on the ongoing expansion of infrastructure. In this light, the maintenance of ecosystem services and forests could be seen as essential building blocks of a green and sustainable economy.

9.1 Introduction

Sustainable Development Goal (SDG) 9 is centred on three main pillars: industry, infrastructure and innovation. With 8 targets and 12 indicators (broadly summarised in Table 9.1), SDG 9 will certainly have multiple impacts on forests, forest-based livelihoods and forest-based economies. This chapter explores some of the potential implications of this goal as currently proposed – within the context of forested landscapes – and examines possible interactions, synergies and trade-offs for implementation. In addition, it

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Table 9.1 Summary of targets and the main focus of the indicators for SDG 9

9.1. Infrastructure development (road and transportation expansion)
9.2. Industry and manufacturing (increase of manufacturing value added and employment)
9.3. Small-scale industry integration to markets and finance (proportion of small-scale enterprises in total value added and greater access to credit)
9.4. Clean and environmentally sound industry and resource efficiency (carbon intensity)
9.5. Research and development (R&D expenditure as fraction of GDP and number of researchers)
9.A. Financial, technological and technical support to LDCs and others (ODA and other financial flows to infrastructure)
9.B. Technology, research and innovation support to developing nations (proportion of medium- and high-tech industry value added)
9.C. Access to information and telecommunications in LDCs (proportion of population covered by a mobile network)
Source: https://sustainabledevelopment.un.org/sdg9

explores the potential implications of alternative socio-economic pathways for forests and forest-dependent peoples.

SDG 9 is seen as essential to achieving economic growth, making it inextricably linked to the aims of SDG 8 (Decent Work and Economic Growth). It acknowledges that industrialisation must be inclusive, environmentally sound and sustainable; that infrastructure must be resilient; and that technology must play a central role in achieving these aims through resource- and energy-efficiency and access to digital technologies.

As currently proposed, SDG 9 is embedded in an 'ecological modernisation' narrative, which places a greater emphasis on the role of science and technology in ensuring the compatibility between economic growth and environmental sustainability (Tracy et al. 2017). These assumptions can be viewed as contentious, especially as the human population – now exceeding 7.5 billion – grows at an annual rate of 1.1 per cent (UNEP 2016) and our global ecological footprint continues to increase, while global biocapacity is in decline (Wackernagel and Rees 1996). Moreover, the world is experiencing amplified income and wealth inequality: in 2015, the wealth of the richest 1 per cent surpassed that of the remaining 99 per cent (OXFAM 2016). These are important considerations when evaluating the potential impacts of SDG 9 on forests, forest-dependent peoples and forest-based economies, especially since four out of nine planetary boundaries are estimated to have been crossed: climate change, biosphere integrity (e.g. loss of biodiversity), land system change and alterations to biochemical flows (e.g. nitrogen and phosphorus cycles) (Steffen et al. 2015).

The UN (2017a) and the World Bank (2017) recognise some signs of global progress towards achieving SDG 9, including increases in manufacturing value added as a share of gross domestic product (GDP), growth in air transit, moderate gains in research and development investments, increases in development assistance for infrastructure projects (mainly transport and energy) and declines in CO_2 emissions per unit of manufacturing value added. Ninety-five per cent of the world's population lives within the range of a mobile-cellular signal and 50 per cent have access to the Internet, although only 11 per cent of the population in least-developed countries (LDCs) has access to the Internet. Also, basic infrastructure needs – sanitation, electrical power and water – remain unmet in many LDCs, especially in remote areas where many forests are found (Mead 2017). In this context, the UN (2017a) is calling for a renewed investment in infrastructure and a doubling of industry's share of GDP contributions in LDCs by 2030.

Some countries with significant forest cover have documented their progress towards SDG 9 in their Voluntary National Reviews (VNRs).[1] For instance, in Brazil's VNR, investment in energy is seen as central to development efforts, especially the generation of renewable energy. In Indonesia's VNR, infrastructure improvement and expansion, especially transportation (e.g. roads, railways, ports), is seen as central to reducing the remoteness of rural areas and to the nation's development plan. In India's VNR, it is reported that all forms of transportation (including non-motorised transport) are being rapidly expanded. India is also engaged in expanding manufacturing, promoting small and medium-sized enterprises (SMEs), improving rural access to energy, encouraging foreign direct investment (FDI) and expanding internet penetration. In China's executive summary, development – specifically in the form of innovative, low-carbon options – is seen as the main priority, with the major goals being to lift 50 million people out of poverty and double GDP and per capita income. For China, South to South cooperation is seen as fundamental, with investment in infrastructure playing an important role. Although these reports briefly mention environmental quality and protection, in most there is no mention of forests – neither of how these may contribute to the new economy, nor how they may be impacted or shielded from the impacts of industrialisation. Notably, in terms of environmental sustainability, Indonesia's VNR expresses a commitment to replace the linear economy with a circular one.

[1] Voluntary National Reviews can be accessed at https://sustainabledevelopment.un.org/vnrs/

While many nations are prioritising and promoting industrialisation and the expansion of infrastructure, manufacturing and trade, other contextual conditions occurring at the macro level influence the implementation and uptake of SDG 9 – most notably, factors related to the state of the economy, investment and governance. Between 1970 and 2010, the global economy tripled in size, from USD 15.4 trillion to USD 51.7 trillion (at 2005 constant prices), growing at an average annual rate of 3.1 per cent (UNEP 2016). This is due, in no small part, to a rise in economic openness globally, which has been shown to have a positive impact on economic growth (Costantini and Monni 2008). However, uniform liberalisation can also lead to deindustrialisation, impacting sectors in their early stages. The rate of industrialisation itself is dependent on a number of contextual factors related to competitive advantage. For instance, industrialisation is faster in countries with strong export performance and large domestic markets and in countries with undervalued exchange rates (Guadagno 2016). The expansion of industrial capacity – and the concomitant increases in output and employment – depend on levels of domestic and foreign direct investment (Agosin and Machado 2005, Szkorupová 2015).

The impacts of industrialisation on forests and the environment are complex. Greater income and affluence increase energy use and domestic material consumption (UNEP 2016), oftentimes affecting the environment in negative ways. For example, China's rapid industrialisation has led to rising energy use, particularly the use of coal, increasing the country's greenhouse gas (GHG) emissions. Industrialisation also tends to increase the use of minerals in relation to the use of biomass (UNEP 2016). Impacts on forests can be diverse. In some countries, increased economic development has led to increased forest areas as rural inhabitants emigrate to urban and semi-urban hubs to pursue non-farm jobs. While domestic impacts may be reduced in these cases, the global impact may grow if countries increase their imports of wood, food and other products.

Governance is an important factor in determining how SDG 9 plays out (Costantini and Monni 2008, Guadagno 2016). For instance, in contexts with weak governance (as in rural regions of many tropical nations), local people may be particularly affected by the expansion of large-scale infrastructure projects, especially in areas with unclear tenure regimes and weak property rights. Given the current power dynamics and corrupt practices in many countries, benefits from such projects may not be equitably distributed, possibly even leading to the fulfilment of a resource-curse hypothesis. Meanwhile, weak law enforcement may enable the spread of illegal activities and the unsustainable exploitation of forest resources.

Notably, all of these contextual factors come to bear when viewed through the lens of forests and forest-based livelihoods. Clearly, the implementation of SDG 9 in forest-dependent regions offers economic and employment opportunities. At the same time, the uptake of SDG 9 could lead to increasing pressures on the life-supporting systems – such as forest ecosystems and biodiversity – on which our societies and economies depend. This chapter aims to examine many of the complexities involved and address some of these nuanced synergies and trade-offs by exploring the potential impacts of implementing some of the targets and indicators proposed in SDG 9.

9.2 Potential Impacts of SDG 9 on Forests and Forest-Based Livelihoods

Enacting SDG 9 as currently proposed will have numerous and varied impacts on forest and forest-dependent peoples as a consequence of expanding infrastructure (Target 9.1), increasing manufacturing (Target 9.2), growing the SME sector (Target 9.3), developing cleaner and more efficient industries (Target 9.4) and increasing access to digital technology and telecommunications (Target 9.C). This section examines some of the potential outcomes, trade-offs and synergies of implementing these targets as currently proposed. Particular emphasis is given to Target 9.1, which may have impacts on forests that are not only considerable but potentially irreversible. The chapter also includes a brief discussion surrounding the possibilities of decarbonising air transit (Box 9.1). Table 9.2 broadly summarises the main conclusions of this analysis regarding the potential impacts of implementing some SDG 9 targets and indicators on forest ecosystems and forest-based livelihoods.

9.2.1 Expanding Infrastructure

IMPACTS OF ROAD EXPANSION

Indicator 9.1.1 focuses on increasing the proportion of rural people who live within 2 km of an all-season road. Roads have been shown to improve transportation (e.g. reduce costs, shorten travel times), facilitate access to markets and expand trade, encourage entrepreneurship and diversification of livelihoods, improve social integration and increase income and economic growth (Alamgir et al. 2017, Bucheli et al. 2017, Campbell et al. 2017). They have also been linked to better education and health, as they facilitate access to these services (Alamgir et al. 2017, Bucheli et al. 2017, Hettige 2006). For rural farmers, roads can link them to urban markets, enable access to agricultural inputs (e.g. fertilisers), raise crop prices and improve agricultural technology (Laurance and Burgues 2017). A recent study from Ghana found that improved roads led to more agricultural productivity while decreasing farm size (Acheampong et al. 2018).

The relationship between people and infrastructure is complex, as benefits and costs are often context-dependent, diverse and moderated by multiple factors.

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Table 9.2 Summary of analysis reflecting the potential impacts on forest ecosystems and forest-based livelihoods of implementing some SDG 9 targets and indicators

Target / Indicator	Potential Impact	
	Forest Ecosystems	Forest-Based Livelihoods
9.1. Infrastructure development (road and transportation expansion) [Section 9.2.1]	Largely negative.	Mixed, depending on the location and characteristics of specific group affected. Likely positive for forest industry.
9.2. Industry and manufacturing (increase of manufacturing value added and employment) [Section 9.2.2]	Mixed. Negative if overall environmental impact of economies increases (thus impacting forests directly or indirectly). Positive if greater value added is obtained from the same or lesser amount of resources.	Positive if greater value is added to forest products, possibly increasing forest-based employment in rural and urban areas.
9.3. Small-scale industry integration to markets and finance (proportion of small-scale enterprises in total value added and greater access to credit) [Section 9.2.3]	Mixed, depending on which types of SMEs are supported and their corresponding ecological footprints.	Positive, as greater employment and other social benefits could be generated through forest SMEs (including community-forest enterprises).
9.4. Clean and environmentally sound industry and resource efficiency (carbon intensity) [Section 9.2.4]	Mixed. Negative if environmental gains due to greater efficiency are offset by economic growth (i.e. rebound effect). Positive if absolute impact of industries and products is reduced.	N/A
9.C. Access to information and telecommunications in LDCs (proportion of population covered by a mobile network) [Section 9.2.5]	Mixed, depending on how mobile networks are employed.	Mixed, depending on how mobile networks are employed.

While roads can improve food access and diversity, they can also lead to lower nutrition as more processed foods become available (Bucheli et al. 2017). Roads do not de facto alleviate poverty, as effects are moderated by access to different modes of transport, which in turn could be moderated by income. Bryceson et al. (2008: 3) caution that, ‘applied uncritically to rural areas’, the assumption that roads automatically alleviate poverty ‘could easily slide into naivety about the power of road investment to catalyse development and a reductionism that casually assumes poverty reduction will necessarily follow’. Other studies show that impacts vary across socio-demographic groups (Bucheli et al. 2017).

In the context of forests, roads can be viewed as beneficial or detrimental, depending upon whether their impacts are viewed from a business, social or ecological perspective. Roads may also be viewed differently by different local groups – whether they are colonist populations, traditional communities with a long-term history in a place or Indigenous peoples. In the forest sector, poor infrastructure and road conditions are frequently cited as an important challenge facing small and medium forest enterprises (SMFEs), hindering the timely delivery of products and their competitive pricing (Macqueen 2008). Thus, infrastructure development is an important aspect of the enabling environment required for SMFEs to flourish (Macqueen 2008). Through improved access to markets, the expansion of all-season roads could ease the operations of many SMFEs in addition to facilitating agricultural activities. Moreover, large-scale forest operations could probably benefit from road expansion, facilitating access to new forest frontiers with valuable timber. Yet, this may increase the risk of future encroachment and deforestation in contexts of weak governance.

In terms of social impacts, roads can greatly affect rural incomes. Empirical evidence from Ethiopia shows that access to all-season roads reduced poverty by 6.9 per cent and increased consumption growth by 16.3 per cent (Dercon et al. 2009). In addition, some studies have also reported positive perceptions about roads and road expansion in rural communities, although rural dwellers recognise some of the downsides of road expansion (Clements 2013, Fyumagwa et al. 2013).

The deforestation and colonisation that often follow road building have irreversibly affected many forest-dependent Indigenous groups in the Amazon (Finer et al. 2008). Contact often translates into high mortality and other health implications, especially for people living in voluntary isolation (Finer et al. 2008, Napolitano and Ryan 2007), as roads facilitate the transmission of diseases (Alamgir et al. 2017). Road-building projects can increase social costs such as corruption and vulnerability to social exploitation, eroding traditional social structures (Alamgir et al. 2017, Hettige 2006). Other negative externalities include pollution, road hazards, threat to cultural sites and the perpetuation of car-centric development approaches (Bucheli et al. 2017).

Road expansion is associated with large ecological costs (Barber et al. 2014). A leading driver of habitat loss and ecosystem fragmentation and degradation (Ibisch et al. 2016), roads threaten much of the world's remaining wilderness. They are directly or indirectly linked to increased fire risk, proliferation of extractive – sometimes illegal – activities, over-exploitation of resources, increased wildlife mortality and biodiversity loss (Alamgir et al. 2017, Barber et al. 2014, Benítez-López et al. 2010, Ibisch et al. 2016, Laurance et al. 2014).

Roads frequently lead to agricultural expansion – the leading global driver of deforestation – as they are often built to promote agricultural production and food security (Laurance et al. 2014). The economic returns from agriculture motivates the clearing of forests (Busch and Ferretti-Gallon 2017). In Amazonia, 95 per cent of all deforestation occurs in close proximity to transportation networks: within 5.5 km of a road or 1 km of a river (Barber et al. 2014). Similar patterns have been found elsewhere (Alamgir et al. 2017).

The current expansion of road networks is unprecedented in human history (Campbell et al. 2017, Ibisch et al. 2016). Roads have already fragmented the Earth into more than 600 000 pieces of areas without roads, with only 7 per cent of these being larger than 100 km^2 (Ibisch et al. 2016). They have been described as highly contagious, in that they spread into secondary and tertiary roads. For every kilometre of legal road in the Amazon, there are about 3 km of illegal, unmapped ones (Barber et al. 2014), illustrating the lack the proper governance or the means to plan, monitor and control road networks in many countries (Ibisch et al. 2016). Their total length is expected to increase 60 per cent in the next 30 years (Alamgir et al. 2017), with 90 per cent of this expansion occurring in the Global South (in highly biodiverse tropical and subtropical regions, where a large share of forest-dependent communities live) (Laurance and Burgues 2017).

In response to these staggering numbers, some researchers are calling for a comprehensive global strategy for planned and strategic road expansion. They suggest constructing or improving roads in areas where these can generate higher social or human development returns (e.g. settled areas with higher agricultural potential, urban or peri-urban lands) and avoiding areas with high environmental values and lower agricultural potential (Campbell et al. 2017, Laurance 2018, Laurance et al. 2014). Other authors have made a call to leave remote areas roadless (or at least leave roads unpaved) and to strengthen governance (i.e. enforcement, monitoring) in areas that have long-established roads (Ibisch et al. 2016).

If faithfully implemented, Indicator 9.1.1 would continue fuelling the current road-building spree and risk irreversible and widespread forest degradation. As written, it ignores the environmental and social costs and trade-offs associated with road development. Target 9.1 should be rewritten to emphasise the need for roads to be well-planned and strategic (i.e. where to locate them to maximise benefits and minimise costs, as proposed by Laurance et al. 2014 and Campbell et al. 2017). Road-expansion costs need to be carefully assessed, especially since road-building proponents tend to overemphasise the benefits (Alamgir et al. 2017) and traditional environmental impact assessments (EIAs) tend to underestimate project costs and challenges (Laurance and Burgues 2017).

ANTICIPATED IMPACTS OF OTHER PROPOSED INFRASTRUCTURE PROJECTS

Multiple development projects are being planned, implemented or upgraded in Africa, Asia and Latin America, aimed at improving agricultural output and food security, mining exports and economic integration, among others. In South America, about 600 infrastructure projects are being planned, are underway or are already implemented in the energy, transportation (e.g. ports, railways) and telecommunication sectors, among others (COSIPLAN 2017). For example, oil projects now cover more than two-thirds of the Ecuadorian and Peruvian Amazon, many overlapping Indigenous territories and areas where people live in voluntary isolation (Finer et al. 2008, Napolitano and Ryan 2007). Indigenous groups in the region that oppose oil development on their lands have, in many cases, successfully ended projects (Finer et al. 2008).

Hydropower expansion is also underway across South America. Currently, there are plans to expand the number of hydro dams in the Andean foothills from 48 to 152 in the next 20 years, causing major disruptions in connectivity between 5 of the 6 major Andean tributaries and the Amazon River (Finer and Jenkins 2012, Gibson et al. 2017). In the Amazon basin, there are currently 191 dams, while another 246 are planned or are under construction (Gibson et al. 2017). The accumulated effects of current and proposed dams mean massive disturbances to the Amazon floodplain, South America's northeast coast and the regional climate (Latrubesse et al. 2017). Although the long-term impacts on biodiversity of mega-dams have been overlooked, Benchimol and Peres (2015) expose recent major local extinction threats to vertebrate species. Similarly, the impacts on forests should not be underestimated. Analysing the ecological impacts of current and potential dams, Finer and Jenkins (2012: 1) conclude that more than 80 per cent of the proposed projects in the Amazon 'would drive deforestation due to new roads, transmission lines or inundation'. In their review of green energy, Gibson et al. (2017: 928) conclude that 'the substantial greenhouse gas emissions and pronounced disruption of terrestrial and aquatic ecosystems from hydropower dams raise serious questions as to whether they should be considered "green energy" at all'.

Furthermore, China plans to expand infrastructure in Eurasia and around the Global South. It is currently investing about USD 100 billion annually for transport, energy and mining infrastructure in Africa (Alamgir et al. 2017, Laurance 2017), and its FDI increased tenfold between 2005 and 2015, largely for infrastructure development projects and resource extraction (Tracy et al. 2017). One of these major projects is the Belt and Road Initiative (BRI, also known as One Belt, One Road).

The BRI, announced in 2013, refers to the Silk Road Economic Belt and the 21st Century Maritime Silk Road, a significant development strategy intended to promote economic cooperation among countries along the proposed Belt and Road routes. The initiative aims to connect Asia, Europe and Africa along five routes, including international transport routes, core cities and key ports, and six international economic cooperation corridors. The BRI is open to all countries, as well as international and regional organisations; however, official maps and documents emphasise the importance of 71 countries in Asia, the Middle East, Eastern Africa and Eastern Europe (Figure 9.1). Unprecedented in scale (Tracy et al. 2017), the initiative has been identified as one of the 17 emerging issues that could affect global biodiversity, ecosystem services and conservation (Sutherland et al. 2018).

Most investments generated from the BRI have thus far been in infrastructure, energy and mining, ranging from a standard-gauge railway in Kenya to hydropower projects in Cambodia, and from the Prairie Road between China and Mongolia to lignite coal deposits in Pakistan. The BRI will increase investment and foster economic collaboration in the ancient Silk Road area; however, little attention has been paid to the ecological impacts generated from the massive construction of infrastructure and natural resources investments. Although China has been pursuing green investment opportunities (e.g. solar, hydropower), the country has not released any overarching guidelines for the sustainability requirements of BRI projects beyond individual institutions (Pike 2017). Moreover, the official document outlining the BRI's vision and actions (NDRC 2015) references environmental protection only in passing, with no mention of EIAs or strategic environmental assessments (SEAs) (Tracy et al. 2017: 74), which is particularly concerning since the 21st Century Maritime Silk Road passes through many South and Southeast Asian countries holding a high concentration of global biodiversity hotspots and forest-dependent communities. Likewise, many of the BRI's proposed routes cross protected areas (Sutherland et al. 2018) and will 'open for exploitation unique old-growth forests' (Tracy et al. 2017: 76).

While environmental protection has not yet been emphasised in the BRI (Sutherland et al. 2018), Chinese and foreign NGOs have committed to helping China develop guidelines under the umbrella of the China Green Leadership: Belt and Road Green Development project, which has resulted in the BRI Ecological Protection Cooperation Plan, issued in May 2017. In addition,

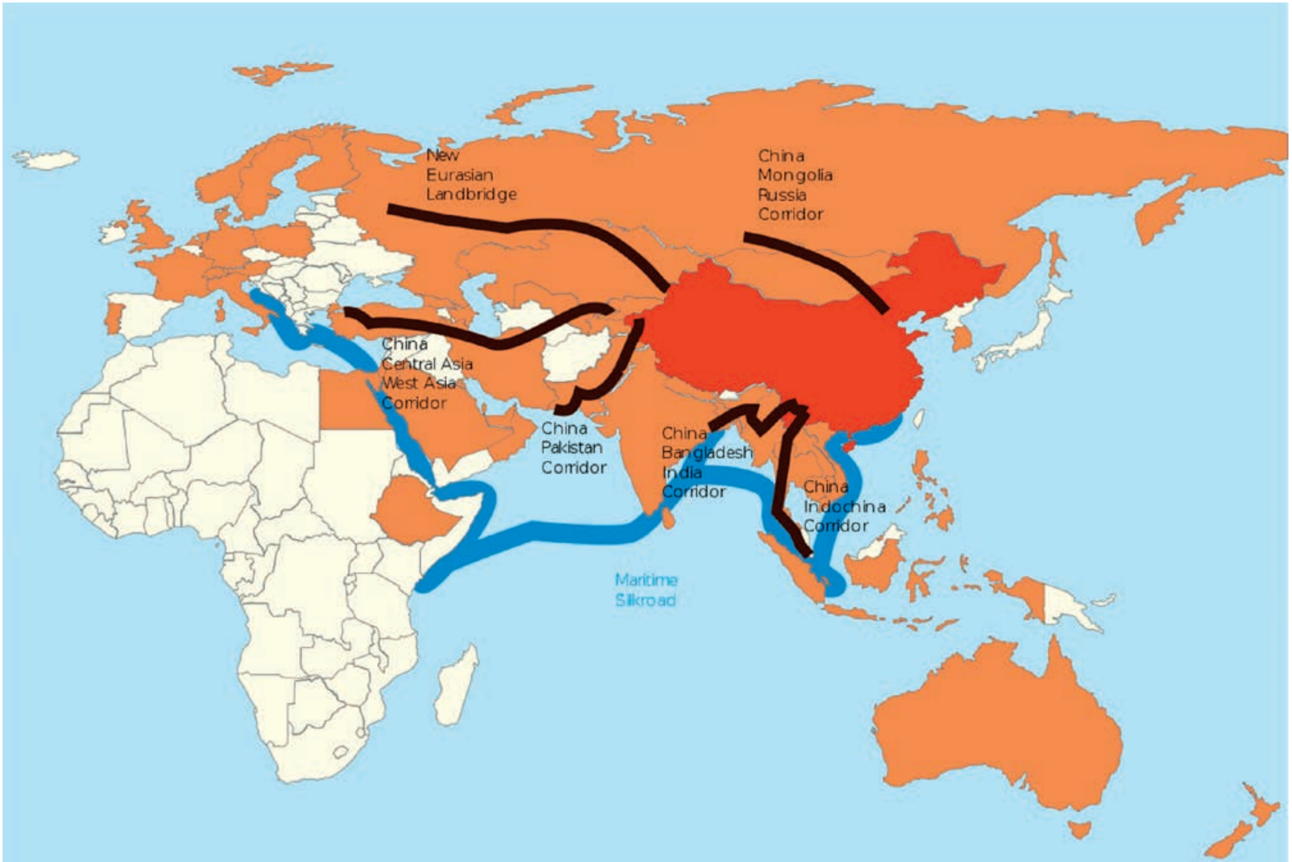

Figure 9.1 China's Belt and Road Initiative. Source: Creative Commons 'One Belt One Road' by Lommes, licensed under CC BY-SA 4.0.

President Xi has also called for creating a 'big data' service platform on environmental protection promising support for countries adapting to climate change (Normile 2017). For the new Silk Road to catalyse a new era of Chinese global resource stewardship and sustainable development depends largely on how China approaches the BRI – specifically, whether high-quality research and EIAs are conducted for each project and if this information is put to good use.

Over the past few decades, China has undertaken efforts towards the construction of an 'ecological civilisation', with encouraging examples such as the establishment of the Saihanba National Forest Park from a desertified area in the Mongolia Plateau. However, while China is seen to be greening some of its industries, there is concern that little consideration has been given to social safeguards and/or environmental assessments on transboundary and overseas development projects (Tracy et al. 2017). Moreover, China could be greening its industries by relocating production abroad, thereby exporting pollution and other environmental and social externalities. This echoes reservations about the potential of conservation projects to yield positive environmental impacts if nations merely relocate problems to others (Lambin and Meyfroidt 2011).

The BRI example is illustrative of the fact that key trade-offs exist between infrastructure expansion and the maintenance of biodiversity and ecosystem health. Infrastructure development has been identified as one of the main threats to biodiversity (Benítez-López et al. 2010). Although the benefits of the projects mentioned earlier are clear in terms of regional integration and economic cooperation, their negative and potentially irreversible short- and long-term impacts on ecosystems and the people that depend on them must be assessed. Laurance et al. (2015) analyse the potential impacts of 33 development corridors in Africa and conclude that many could have large and irreversible ecological costs, which will be greatest in biodiversity-rich equatorial forests and equatorial savanna woodlands. These corridors will intersect with around 400 protected areas and potentially damage an additional 1800. Although there is evidence from the Amazon rainforest that protected areas could mitigate the damaging impacts of infrastructure, they are no panacea because they still face strong development pressures (Barber et al. 2014).

Implementing Target 9.1 across the globe may compromise environmental and societal sustainability by contributing to ongoing processes that undermine the planet's life-supporting systems. An example of the complexity inherent in developing biofuels from food or forest stocks to advance Target 9.1 is given in Box 9.1. To ensure that the costs do not outweigh the benefits, more effective planning is necessary (Laurance and Burgues 2017). If infrastructure is to be sustainable and resilient, it must not harm the ecological services on which the economy and society depend.

Box 9.1 What Role Could the Forest Sector Play in Decarbonising Air Transit?

Indicator 9.1.2 focuses on passenger and freight volumes for different modes of transport. In 2017, the transportation sector accounted for 23 per cent of global energy-related GHG emissions (IEA 2017). To decarbonise, transport must either use green electricity or switch to biofuels. The expanded use of bioethanol and biodiesel will likely continue in nations where substantial production already exists, such as Brazil and the USA. Although there will be an ongoing food-versus-fuel debate as biofuels are increasingly used, groups such as the FAO and the International Energy Agency (IEA) have advocated for a food-and-fuels approach, with diversification of farmers' markets being one of several advantages to this approach (Michalopoulus 2017, Scott-Thomas 2015).

Ongoing research on using forest and agricultural residues to make advanced cellulosic-derived biofuels is likely to increase the volume of available biofuels over the mid- to long-term (IEA 2017). Biojet fuels for aviation illustrate the importance of the dynamics at play. In 2017, 4.1 billion passengers were carried by airlines (ATAG 2018). This is the fastest growing transportation sector globally and its GHG emissions are predicted to increase incrementally. Many airlines, aircraft manufacturers and industry associations have committed to voluntary, aspirational goals to collectively achieve carbon-neutral growth by 2020 and a 50 per cent reduction in GHG emissions by 2050 (relative to 2005 levels) (IRENA 2017). Such significant, longer-term emission reductions will only be achieved if airlines increasingly use renewable and sustainable aviation fuels (IRENA 2017). Unlike ground transportation, where there are alternatives such as electric-powered vehicles, aviation has no other ways to reduce its GHG emissions in the near term (IATA 2018).

Currently, the vast majority of global biojet fuels are derived from lipid feedstocks, such as vegetable oil, animal fats and used cooking oil (IATA 2015); these face a number of supply-side constraints. Advanced technologies using lignocellulosic biomass, such as forest or agricultural residues, have the potential to provide biojet fuel at the scale needed to meet long-term goals (IATA 2015). Theoretically, saw/pulp mill and forest residues could be supplied in a cost-effective and sustainable manner, piggybacking on the supply chains established by the wood-pellet companies and existing forest certification processes to provide a major source of the feedstock biomass to make drop-in biofuels/biojet fuels. To ensure sustainability, current forest certification mechanisms must be updated to incorporate the sustainable removal and use of residues (Larock 2017).

9.2.2 Promoting Industrialisation: Increasing Manufacturing Value Added and Related Employment

Target 9.2 promotes inclusive and sustainable industrialisation, with key indicators related to increasing manufacturing value added as a proportion of GDP and per capita (Indicator 9.2.1) and as a proportion of total employment (Indicator 9.2.2). The goal for LDCs is to double industry's share of GDP by 2030.

Manufacturing has a higher material intensity than the service industry (UNEP 2016). Between 1970 and 2010, global material use tripled, initially growing on average 2.7 per cent annually and accelerating to 3.7 per cent between 2000 and 2010. Per capita material use grew from 6.4 tonnes annually in 1970 to 7.9 tonnes in 2000 and to 10.1 tonnes in 2010. The increase in material intensity experienced in the 2000–2010 period is explained by a shift in manufacturing from more materially efficient economies (e.g. Europe, USA, Japan) towards less efficient ones (e.g. China, India, Brazil) (UNEP 2016). Greater overall material and energy use translates into greater environmental pressures (UNEP 2016), which likely means more pressures on natural forests and already stressed natural ecosystems.

Achieving Target 9.2 sustainably will require businesses, both large and small, to adopt efficient and environmentally benign process all along the value chain, from procuring raw materials to manufacturing goods to transporting finished products. The measures of success must extend well beyond our current preoccupation with measuring CO_2 emissions as a sole indicator of environmental impact (Gaussin et al. 2013). The uptake of a wide range of sustainability indicators for manufacturing, including how socio-economic benefits are distributed along global supply chains, will be essential in achieving this target.

Target 9.2 recognises that value-added manufacturing is one means of potentially achieving these goals. When applied to the context of forests and forest products, the term value added refers to a variety of solid wood products that extend beyond the traditional commodity products – logs, lumber, panel products and pulp and paper – typically manufactured by large, multinational corporations. These include engineered building products, finished building products, joinery, mouldings, millwork, cabinetry, furniture and other appearance products (Gaston and Pahkasalo 2017). The general premise underlying the promotion of value-added products within Target 9.2 is that more value can be derived and more jobs created per volume of wood harvested. Consequently, stakeholders – Indigenous peoples, governments, industry, organised labour, communities, environmental groups – embrace it as a sound conservation-based strategy and a viable alternative to commodity production (Grace et al. 2018, Kozak 2007).

Critics argue that value-added products represent a fairly inconsequential economic sector, perhaps a reflection of value-added producers generally being smaller in scale than lumber, panel and pulp and paper companies (Grace et al. 2018). The value of the global furniture sector alone is approximately USD 420 billion (wood furniture accounts for about one-third), and the growth trajectories for markets are more robust compared to upstream commodity goods (Gaston and Pahkasalo 2017). Interestingly, a sizeable share of value-added production occurs in urban settings and is sold to local markets (Gilani et al. 2018). This is an important result within the SDG 9 context. Increased urbanisation – especially in developing regions – may come with opportunities for small-scale value-added wood producers vis-à-vis increasingly accessible markets, decreasingly complex supply chains, less of a reliance on capital and the use of locally sourced materials.

Value-added products can also refer to the growing basket of bio-economy products, ranging from renewable energy to wood-based chemicals, which are derived from forest fibre and residues. The promise of the bio-economy presents an interesting opportunity for the future of forest producers (Roos and Stendahl 2016, Stern et al. 2018), especially since differentiation and innovation have clearly been shown to lead to higher levels of firm competitiveness within the forest sector (Hansen 2016, Korhonen et al. 2018). Several challenges surrounding this burgeoning sector remain, including questions of economics and long-term viability, requirements for robust policies that promote the substitution of fossil fuels with bio-based alternatives and increased collaboration needs across sectors to achieve success (Guerrero and Hansen 2018, Roos and Stendahl 2016).

9.2.3 Access of Small-Scale Industry to Finance and Market Integration

Target 9.3 focuses on increasing small enterprises' access to markets and financial services. Indicator 9.3.1 centres on increasing the proportion of small industry relative to total industry value, while Indicator 9.3.2 focuses on their access to credit or loans. SMEs are often labelled as the backbone of economies. Globally, they occur in large numbers and employ a significant share of the population, but this is especially the case in emerging economies (Creech et al. 2014). In these countries, most SMEs engage in the trade and manufacture of goods (Scott 2000).

The impacts of non-forestry-based SMEs on the environment and forests is an understudied topic (Nulkar 2014, Scott 2000); one of the few published studies finds mixed results (Scott 2000). In Zimbabwe's brick-making industry, small producers using wood-based fuels contributed to deforestation

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while large-scale producers using coal as an energy source contributed more CO_2 and SO_2 emissions per unit of output (i.e. number of bricks). Similarly, in Bangladesh's textile industry, small-scale dyers generated more water pollution per unit of output, although large-scale dyers generated greater overall pollution. The study shows that the environmental impacts of SMEs depend on the technologies employed, the types of impacts measured, the specific sector, and national regulations and enforcement capacities.

SMEs are widespread in the forest sector; estimates suggest that they provide about 50 per cent of employment and make up between 80 per cent and 90 per cent of forest-based businesses in the Global South (Macqueen 2008). It has been argued that SMFEs are beneficial to forest-dependent people because they generate local income and promote the sustainable use of forests. Although not always successful, community-based forest businesses have been shown to generate benefits for local communities, such as providing supplementary income, creating local employment, providing greater access to training and capacity-building, improving community infrastructure (e.g. schools, roads) and enhancing community-level governance and empowerment (Schreckenberg and Luttrell 2009, Tomaselli et al. 2014). Small-scale community forestry has had marginally better environmental outcomes in forest cover than other management options or open-access areas, although research is needed to establish more definitive conclusions (Burivalova et al. 2017).

One of the greatest challenges facing SMFEs relates to insufficient access to finance, due partly to high transaction costs and difficulties providing collateral (Kozak 2007, Spantigati and Springfors 2005). Thus, access to financial services, as proposed by Target 9.3, could prove beneficial for some SMFEs and forest-dependent people, especially if those funds are directed towards businesses dedicated to sustainable or regenerative activities creating positive societal externalities. Microfinance can fund more ecologically sensitive activities, such as renewable energy, organic agriculture and climate resilient projects (Allet and Hudon 2013), with green microfinance gaining increasing attention (Huybrechs et al. 2015). It is difficult to predict what impacts the broad promotion of SMFEs and microfinance may have on forests, as it will largely depend on the types of activities that are prioritised by governments and/or financial institutions and their respective ecological footprints. Notably, if microcredit is invested in agricultural expansion, it could have detrimental effects on forests.

9.2.4 Clean and Environmentally Sound Industry

Target 9.4 focuses on increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industry, with CO_2 emissions per unit of value added as the only indicator. Trends related to greening industries, businesses and the economy have gained traction in recent decades. At the company level, environmental corporate social responsibility (ECSR) has grown as a response to greater environmental awareness and increased expectations from the public (Chuang and Huang 2018). ECSR incorporates social, environmental and financial goals into the company's strategy and often involves practices covering a broad range of activities, including energy efficiency, recycling, certifications and greater stakeholder engagement (Chuang and Huang 2018). An increasing number of multinational firms are generating sustainability reports, although greater disclosure is not necessarily related to better environmental performance (Aragon-Correa et al. 2016).

Prominent, broad trends include notions of a circular economy, the bio-economy and the green economy (D'Amato et al. 2017). The circular economy refers to reducing the material inputs and waste outputs generated in product life cycles, while the bio-economy places more emphasis on the use of renewable biological resources as industrial inputs, with a central role for research and innovation (D'Amato et al. 2017). In comparison, the green economy is a broader, more global narrative that includes social equity as well as environmental sustainability goals and centres on 10 sectors (forestry being one of them) seen as key in the transition to sustainability (UNEP 2011). Despite the differences, they all have in common a trust in technological solutions as the means of change and a belief in the possibilities of green growth (D'Amato et al. 2017).

A central SDG 9 indicator of green industry is carbon intensity (i.e. CO_2 emissions per unit of value added). Many advances have occurred since the 1990s, with most countries reducing their carbon intensities. For instance, 0.47 kg of CO_2 were emitted per unit of GDP in 1990, while carbon intensity fell to 0.35 kg of CO_2 per unit in 2013 (at 2011 constant prices) (Ritchie and Roser 2018). Although carbon efficiency has improved greatly, critics caution that efficiency measures may not reduce emissions in absolute terms due to the rebound effect[2] (Korhonen et al. 2018). Although the global economy's carbon intensity has dropped, total emissions have not; they reached a plateau in 2014, increasing again in 2017. Hence, intensity-based indicators as proposed by SDG 9 may not be effective for tackling climate change or reducing environmental impact if the rebound effect is not taken into account. Efficiency gains should more than offset economic growth, and should ideally be accompanied by adequate policies to reduce consumption.

[2] The rebound effect occurs when increased efficiency lowers the cost of producing a good or service, which in turn increases consumption of this good or service, partially offsetting the beneficial effects of the new technology (Lambin and Meyfroidt 2011).

An underlying and fundamental assumption of SDGs 8 and 9 is that economic growth and environmental sustainability can be made compatible by decoupling environmental impacts from GDP growth. Economic decoupling refers to de-linking environmental degradation and resource consumption from economic growth.[3] The Environmental Kuznets Curve (EKC) is often used as evidence to show that as GDP rises in a country, pollution decreases. However, for indicators other than local air and water pollution (e.g. GHG emissions, biodiversity loss, soil degradation), the evidence for the EKC is not very strong (Raworth 2017). A recent meta-analysis concludes that 'early influential studies favoring EKCs are counterbalanced by recent estimates that do not corroborate the EKCs for deforestation' (Choumert et al. 2013: 26).

As for global material use, data shows that in the past century (1900s–2000), relative decoupling has occurred as material intensity decreased from 3.5 kg/USD in 1900 to 1.2 kg/USD in 2000.[4] However, since the 2000s, material intensity has increased, working 'against the hypothesis of decoupling' (UNEP 2016: 16). For example, while 1.2 kg of materials were needed per USD of GDP in the year 2000, by 2010 intensity had increased to 1.4 kg of materials per USD of GDP (UNEP 2016). Similarly, the World Bank (2017: 48) concludes that for the period 1990–2015, not only have very few countries achieved strong decoupling,[5] 'most countries show weak decoupling or intensified coupling'.[6] Current evidence for absolute decoupling is weak at best: 'there is little indication that any fundamental decoupling of raw economic growth from material use has occurred' (UNEP 2016: 89). Moreover, if the current trajectory of resource use continues (even stabilising resource use in high-income countries), global resource extraction will triple again by 2050 (Fischer-Kowalski and Steinberger 2017).

Material flows tend to increase with industrialisation (UNEP 2016), reflecting some of the ecological costs that achieving SDG 9 may bring to already stressed natural ecosystems. Higher global material use likely means more pressure and competing demands on forests and biodiversity due to extractive activities, such as mining and oil exploration, as well as a greater demand for agricultural products. Moreover, if GHG emissions are not curbed or reduced,

[3] Relative decoupling often relates to declining ecological impact per unit of GDP, while absolute decoupling refers to an absolute decline of ecological impact (Jackson 2011).

[4] Although material intensity decreased, absolute material flows increased 7.3-fold globally, while global GDP (in real terms) increased 19-fold.

[5] Indicators of environmental impact in the World Bank (2017) report include GHGs emissions, the unsustainable harvesting of forests and premature death due to environmental problems.

[6] Intensified coupling means that environmental impact increases even faster than economic growth.

the varied and multifaceted impacts on forests and forest-based communities will worsen (Kirilenko and Sedjo 2007, Nobre et al. 2016). Overall, due to the high global resource use, Fischer-Kowalski and Steinberger (2017: 386) suggest that 'decoupling well-being from biophysical resource use is more achievable than decoupling biophysical resource use from economic activity'. The challenge for high-income nations is even greater since they need to substantially reduce their use of material resources (Fischer-Kowalski and Steinberger 2017). The green industry needs to go beyond GHG emissions and resource efficiency to consider the absolute impact of industries and products within the global economy, possibly using more comprehensive indicators of sustainability, such as the ecological footprint (Wackernagel and Rees 1996) or the material footprint of consumption (UNEP 2016).

9.2.5 Expansion of Information and Communication Technologies

Target 9.C seeks to 'significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020' (UN 2017a). The intention here is to increase information availability, economic opportunity and connectivity to the global information society (UN 2017b). To measure progress against this goal, the proportion of a population covered by a mobile network is measured using data provided by the International Telecommunication Union (ITU 2017).

The core function of mobile networks is to transmit data. Data connectivity implies that textual or numerical information can be shared as well as visual information (like pictures or videos) or audio information (such as live voice calls or recordings). The impacts of this data-sharing on forest landscapes, biodiversity and communities can be both positive and negative. Data itself is neutral; how data is used determines impacts. For example, the rapid advancement of digital technologies in the forest sector is profoundly impacting forests and forest-dependent people, potentially improving livelihoods and empowering sustainable management. Mobile networks and information and communication technology (ICT) can work in conjunction to allow forest managers, forest-dependent communities and civil society to more effectively measure and report on forest health and activities in forested areas (Fry 2011). They can also be used to improve the livelihoods of communities by improving their access to information about markets, prices and other economic indicators that enable more equitable economic arrangements (Stienen 2007). Underserved forest-dependent peoples in low-income brackets can also use emerging financial technologies to join the formal economy and benefit from financial credit, easy and secure financial transactions and other banking services (Mbogo 2010).

On the other hand, the same technologies that allow for the monitoring and protection of forest landscapes could enable their exploitation and degradation. Higher quality maps and instant communication enable illegal logging operators and others operating outside forest governance regimes to better coordinate their activities, avoid monitoring and evade law enforcement measures. There are also material impacts from establishing and operating mobile networks. Physical infrastructure is required, typically towers with transmitting receivers at their peak, as well as connectivity to the electrical grid and transportation networks to conduct maintenance and upgrades. Mobile networks are also a significant and growing source of energy consumption globally (Fehske et al. 2011), meaning that further establishment and expansion of mobile networks will lead to increased carbon emissions and climate change adversely impacting forest health (Trumbore et al. 2015). The growth of mobile networks and the environmental impacts are well understood, and efforts are underway to ameliorate these impacts by designing more efficient networks that transmit more data using less energy per unit transmitted (Hilty et al. 2009, Wang et al. 2012).

Two of the most influential and quickly changing digital technologies that have clear applications in a forestry context are distributed web-connected devices (e.g. smart-phones) and remote sensing data. Distributed devices have become exponentially more powerful, interconnected and affordable, opening up opportunities for field data collection by trained professionals and the public alike. Mobile technologies can enable and empower Indigenous communities, citizens and other civil society actors interested in protecting forest landscapes to monitor illegal forest activities or map tenure rights (Swamy et al. 2018). In the Amazon rainforest in Brazil, local communities and civil society have collaborated with Google to develop tools that leverage machine learning technology on mobile devices to detect evidence of illegal logging by monitoring for the sounds emitted by chainsaws (White 2018).

Remote sensing data include passive reflectance data (i.e. imagery) collected from satellites, aircraft, drones or ground cameras as well as active data such as laser scanning (LiDAR) and radar, which can be collected from the sky or the ground. The temporal and spatial resolution of remotely sensed data have improved rapidly and, combined with the proliferation of cost-free imagery, have substantially increased the capacity for forest monitoring over the past decade, especially in less-industrialised countries (Romijn et al. 2015). Deforestation can now be monitored in near real time, and open cloud-based platforms can mitigate the storage and analysis challenges of the massive datasets required for such monitoring (Reiche et al. 2016). For example, in

2018 the FAO announced that it is collaborating with Google to provide free access to satellite data repositories and cloud computing for the 2020 Global Forest Resources Assessment at the national level. Open-source and cloud-based processing can improve the monitoring and management capacity of local governance organisations as well; anyone with a computer and an internet connection can undertake detailed and complex spatial analyses using remotely sensed data, provided they have the necessary competencies.

Given the complexity of mobile networks and ICT, it is no surprise that the pursuit of SDG 9.C is not uniformly positive or negative for forest landscapes, biodiversity or forest-dependent communities. Inequitable access to digital technology can increase the risk of forest degradation, conflict and over-exploitation of the resources upon which forest-dependent people rely (Fisher et al. 2018, Fox et al. 2008, Swamy et al. 2018). However, mobile data collection tools, open-source software and free or low-cost remote sensing data can lead to more equitable control and access to digital technologies. Moreover, recent developments in crowdsourcing – the creation of citizen-generated datasets – can not only increase the quantity of data collected (e.g. for remote sensing applications) at very low cost, but can also provide diverse stakeholder perspectives that may not be well-captured in traditional scientific field campaigns (Schepaschenko et al. 2015). In order to ensure successful uptake, these efforts must be coupled with decentralised training and capacity-building that is accessible to a diverse range of user groups (Fisher et al. 2018).

9.3 Synergies and Trade-offs Between SDG 9 and Other SDGS

Table 9.3 outlines the most prominent synergies and trade-offs, both current and potential, between SDG 9 (mainly Target 9.1, infrastructure expansion) and other SDGs. Some of the most salient synergies occur with SDG 8 (Decent Work and Economic Growth), as infrastructure (especially for transportation) tends to increase trade and thus consumption, which increases economic growth. Indicators 9.1.1 and 9.1.2 have a strong reinforcing effect with SDG 8. Similarly, Target 9.3 (promoting SMEs) could have a positive impact on SDG 8, especially regarding the creation of decent jobs. Another important synergy occurs with SDG 1 (No Poverty), as roads (indicator 9.1.1) tend to increase consumption and reduce income poverty. Likewise, SMEs could play an important role in reducing poverty and supporting the creation of sustainable cities and communities (SDG 11). Another clear synergy occurs between Indicator 9.4.1 (carbon intensity) and SDG 13 (Climate Action).

Table 9.3 Current and potential synergies and trade-offs between SDG 9 (mainly Target 9.1, infrastructure expansion) and other SDGs (based on a framework developed by Nilsson et al. 2016).

	Relationship	Interaction with Other SDGs	Explanation and Evidence
SYNERGIES	INDIVISIBLE	8 – Economic growth	Roads and infrastructure can expand trade, consumption and economic growth (Campbell et al. 2017).
	REINFORCING	1 – Poverty	Roads can increase income of rural populations, thus contributing to poverty-reduction efforts (Dercon et al. 2009).
	ENABLING	2 – Food security	Roads could improve the capacity to feed people as they have a positive relationship with agricultural production (Acheampong et al. 2018, Laurance 2016).
		3 – Good health/well-being	Roads could enable forest-dependent people to more easily access health services (Alamgir et al. 2017).
		4 – Quality education	More or better roads could mean easier access to quality education (Alamgir et al. 2017).
		5 – Gender equality	Access to education could increase with better roads, which could positively affect gender equity, as women might be able to gain better education, resulting in better capacity to defend/define their own rights.
		8 – Economic growth	If adequately supported, SMEs could generate decent jobs for forest-dependent communities and rural inhabitants.
		10 – Reduced inequalities	Inequality could be reduced by generating economic opportunities for rural inhabitants and forest-dependent communities.

TRADE-OFFS	CONSTRAINING	1 – Poverty	Roads could trigger conflict and uncontrolled 'frontier expansion and associated poverty' in areas inhabited by traditional people (Ibisch et al. 2016, supplementary material).
		2 – Food security	Roads could indirectly contribute to climate change (via forest degradation and deforestation), compromising food security over the long term. In remote regions, roads can lead to unsustainable exploitation of wildlife, making bush meat scarce for local residents. Roads may bring access to more food, but not necessarily more nutritious foods (Bucheli et al. 2017).
		3 – Good health/well-being	Ecosystem services that are central to people's health and well-being could be put at risk with roads (e.g. medicinal plants could become scarce with forest degradation/deforestation). Roads may constrain the achievement of Indicator 3.6.1 related to halving deaths in road accidents. Roads facilitate the incursions of human and animal pathogens and disease vectors (Alamgir et al. 2017) and could be at odds with some indicators of Target 3.3 (e.g. reducing HIV, malaria).
		5 – Gender equality	The ability to grow SMEs is important to women, but the benefits depend on the kind of control they can have over their own involvement and its implications for forest sustainability (e.g. are men making the decisions on pricing and location, thus disempowering women producers?).
		6 – Clean water and sanitation	Road expansion could impact water quality via soil erosion and sediments (Laurance and Burgues 2017).

Table 9.3 (cont.)

	Relationship	Interaction with Other SDGs	Explanation and Evidence
		10 – Reduced inequalities	Inequalities could increase for forest-dependent communities and other rural people if the resources upon which they depend are exploited, in the context of unclear tenure rights and disempowerment.
		14 – Life below water	Road building on flood lands or steep terrain could impact water quality and fish breeding sites, causing negative externalities on fisheries (Laurance and Burgues, 2017).
	COUNTERACTING	13 – Climate action	Roads are a ‘major proximate driver of habitat loss and fragmentation, wildfires, overhunting and other environmental degradation, often with irreversible impacts on ecosystems’ (Laurance et al. 2014: 229). Deforestation contributes a significant proportion of GHGs.
	CANCELLING	15 – Life on land	Roads penetrating into wilderness often have irreversible impacts on ecosystems and are a major proximate cause of fragmentation and habitat and biodiversity loss (Benítez-López et al. 2010, Laurance et al. 2014). Avoiding roads is one of ‘the most cost-effective of all conservation strategies’ (Alamgir et al. 2017: 1131).

As mentioned earlier, these interactions are highly contextual and are moderated by multiple factors. The interactions among goals can be complex and could play out in conflicting ways. For example, the impact of Target 9.1 on SDG 3 (Good Health and Well-Being) could be mixed. Roads are believed to facilitate 'incursions of human and animal pathogens and disease vectors' (Alamgir et al. 2017: 1135). At the same time, more roads could enable better access to health services for rural populations; however, more roads could simultaneously constrain progress on Indicator 3.6.1 (reducing road injuries) and Target 3.3 (on ending epidemics such as HIV and malaria). Similar potential conflicting pathways in the short and long term have been identified between Indicator 9.1.1 and SDG 2 (Zero Hunger), and even between Indicator 9.4.1 and SDG 13 if the rebound effect is not taken into account.

Important trade-offs include that road and transportation expansion could cancel out the achievements of SDG 15 (Life on Land), especially Indicator 15.1.1 (expanding forest area), Targets 15.2 (halting deforestation), 15.5 (reducing habitat degradation and loss of biodiversity), 15.7 (reducing poaching) and 15.8 (reducing the impact of invasive alien species). As discussed in Section 9.2.1, in the context of tropical and subtropical landscapes, roads are usually inconsistent with the conservation of remaining natural forests (Figure 9.2). With the potentially negative impacts of Target 9.1 on tropical forests (Swamy et al. 2018), keeping wilderness areas road-free is seen by some as the best strategy for their preservation (Barber et al. 2014, Laurance et al. 2014) because 'limiting forest access is the primary deterrent of land clearing' (Barber et al. 2014: 208). SDG 9 (Target 9.1) may also counteract SDG 13 as

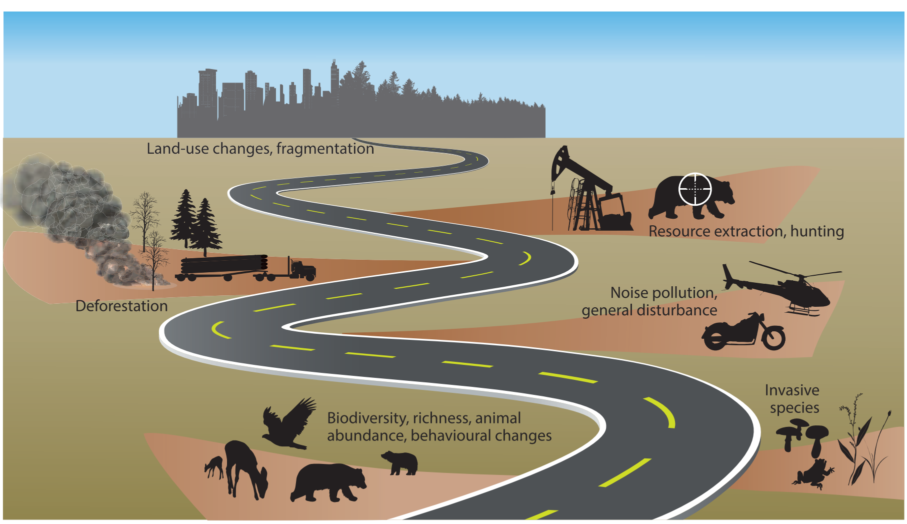

Figure 9.2 Impacts of roads on biodiversity. Adapted from: Ibisch et al. (2016) in supplementary material.

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tropical deforestation accounts for 25 per cent of GHGs emissions (more than all cars and trucks combined) (Barber et al. 2014). This will likely increase if the impacts of roads on reducing forest cover continues unabated.

9.4 An Alternative to Business as Usual: Exploring Different Socio-Economic Pathways

Given some of the serious and potentially irreversible impacts on forests from some SDG 9 targets and indicators, alternative socio-economic models and new development paradigms could be considered to mitigate some of these effects. Economic growth is increasingly recognised as a major driver of environmental impact, motivating the reassessment of growth's central role in our economies (Pacheco et al. 2018, Ripple et al. 2018). For instance, increased material wealth in industrialised countries is failing to deliver larger gains in well-being and life satisfaction (Jackson 2011); distinguishing and valuing qualitative aspects of well-being, quality of life and prosperity from the quantity of goods and services produced in the economy is imperative. This becomes increasingly relevant and urgent since we may be in a period of uneconomic growth, where the costs of economic expansion may well exceed the benefits (Daly 2013). A new paradigm is needed – one that delivers well-being and basic social standards while respecting the limits of our planet (Raworth 2017).

Various proposals are gaining traction in their attempts to redefine the primary goals of our economic systems and societies. Some of these include sustainable degrowth, the steady-state economy and other post-growth discourses (Raworth 2017, Schneider et al. 2010, Van den Bergh 2017); *buen vivir, sumak kawsay* or *suma qamaña*[7] (Ramirez 2012); the conservation economy (Ripple et al. 2018); and indicators such as the Genuine Progress Indicator, Gross National Happiness and the Happy Planet Index (De Graaf and Batker 2011, Kubiszewski et al. 2013).

Rethinking development and prosperity entails changing the way we measure progress towards forestry goals, which could put less emphasis on increasing production and GDP and greater focus on other indicators, such as decent employment, well-being, sustainability and other forms of wealth (e.g. cultural, social, spiritual, natural) (Tomaselli et al. 2017). Some community-forest operations have successfully incorporated goals and values into their *raison d'etre* that go beyond the profit motive, including the preservation of cultural practices, ecosystem restoration and political empowerment, among others (Hajjar et al. 2013, Trosper 2009). To this end, much could be learned from Indigenous

[7] Indigenous philosophies focused on the good living.

peoples around the world, who have long-held views as stewards of natural forests and opponents to forest conversion (Pokorny and De Jong 2015).

Forestry, as part of the conservation economy, could play an important role in encouraging lowered consumerism and reducing the global ecological footprint. As discussed in Section 9.2.4, more inclusive measures of sustainability are needed, beyond focusing solely on carbon emissions and reducing impacts per unit of value added.

> 'Forest-based businesses could contribute to the goal of one-planet living by refusing planned obsolescence as a built-in characteristic of products, instead prioritizing and guaranteeing the commercialization of long-lasting forest goods ... In addition, focusing on forest-based ecosystem services such as nature-based tourism and recreation, carbon sequestration, and watershed preservation, can, if done mindfully, enhance local economies while limiting material expansion' (Tomaselli et al. 2017: 146–7).

Locally controlled forestry could play an essential role in this transition (Tomaselli et al. 2017). Small- and medium-sized forest operations (including community-based businesses) tend to possess a stronger sense of place and deeper local ecological knowledge, especially if they have inhabited the same place for generations (Rockwell and Kainer 2015). By encouraging local economic activities, wealth could be distributed more locally and regionally (Pokorny and de Jong 2015), generating high-quality employment opportunities and improving rural livelihoods (Macqueen 2008).

Undoubtedly, natural forests will fare better in an economic and political system that more accurately recognises and internalises the value of nature and the innumerable direct and indirect services forests provide to society. Valuing nature should not necessarily be seen as a synonym for 'setting a price' or monetisation, but rather an attempt to better capture, protect and sustainably use the wealth afforded by nature. In this context, the maintenance of ecosystem services, forests and roadless areas could be seen as essential building blocks of a green and sustainable economy (based on strong sustainability concepts) that ensures well-being and healthy lives (see Chapter 3), rather than as stumbling blocks to development.

Capturing the costs or negative externalities of economic activities would also be central to a new economy. For instance, pricing fossil fuels (i.e. carbon pricing) closer to their true societal cost has been proposed as an important step for moving towards a conservation economy (Ripple et al. 2018). Curbing carbon and other GHG emissions will not only reduce the rate of climate change, but will also mitigate the negative impacts that climate change is having on the health of forest ecosystems – for example, the increased severity of forest fires in temperate and boreal forests (Hansen et al. 2013) and the increased risks of destabilising the Amazon rainforest if certain temperature thresholds are surpassed (Nobre et al. 2016). Having said that, if the growth economy and energy demands continue unabated, even green and renewable energy may have severe impacts on forest ecosystems and the people that directly depend on them (as discussed for hydropower in Section 9.2.1).

Other SDG 9 targets may also be well suited within an alternative socio-economic pathway. As mentioned in Section 9.2.5, information and communication technologies are not inherently positive or negative; their impacts depend on how they are employed and implemented. If our economic and political goals are to increase consumption and growth, then technology will most likely be used to achieve this. Indeed, technology has been incredibly effective at facilitating market access and spreading consumer culture worldwide. However, if our goals were to shift from material consumption towards sustainable well-being, then technology would likely play a central role facilitating this transition.

9.5 Conclusions

Our analysis shows that some SDG 9 targets will clearly impact forests in negative, and possibly irreversible, ways (especially Target 9.1), while for others it will depend on how they are employed (e.g. Target 9.C) or implemented (e.g. Target 9.3). SDG 9 does not seriously consider the overall environmental costs of industrialisation and how forests are thereby impacted, with the possible exception of accounting for a reduction of CO_2 emissions per unit of value added. Moreover, the premise of economic decoupling on which SDGs 8 (Recent Work and Economic Growth) and 9 are based is not strongly supported by current empirical evidence. This points to a potentially inherent contradiction between SDGs 8 and 9, on one hand, and SDG 15 (principal focus on the maintenance of forests and biodiversity) and possibly SDG 13 (Climate Action), on the other hand.

If SDG 9 were to seek and support alternative socio-economic models (possibly not based on indefinite economic growth or on ones that rely so heavily on the expansion of infrastructure), the maintenance of forests and ecosystem services would be seen as essential for a green and sustainable economy. Humanity is already exceeding the Earth's sustainable capacity (e.g. ecological footprint, loss of biodiversity, deforestation, climate change), so it is imperative to question what it would mean to continue expanding the consumer culture across the globe. If material consumption is to increase in LDCs and other less-industrialised nations, then should it not be reduced elsewhere to bring the human economy into a sustainable scale? While many nations currently do not satisfy the basic needs of their citizens and many could be seen to under-consume, many other countries over-consume the planet's limited resources and have even been called 'overdeveloped'. A great challenge lies in changing the current economic logic of these latter countries, where greater marginal consumption does not translate into significantly better quality of life. The SDGs do not seem to put any serious focus on this other side of the equation.

In this sense, SDG 9 does not seriously consider limits to the biophysical scale of the economy. This is a key question of sustainability (Daly and Farley 2011) and could be central to the long-term maintenance of natural forests and biodiversity. Moreover, issues of 'sufficiency' as a path to sustainability for industrialised economies are not really addressed by any of the SDGs (not even SDG 12, Responsible Consumption and Production).

Indicators are important because they influence and guide governmental policies, organisational norms and, ultimately, societal actions. 'Indicators arise from values (we measure what we care about), and they create values (we care about what we measure)' (Meadows 1998: 2). Although SDG 9 incorporates concepts such as *resilient, sustainable* and *equitable*, the indicators do not reflect any radical departure from 'business as usual' industrialisation, nor do they fundamentally challenge the economic *status quo*. This is problematic for the sustainability of forests, their biodiversity and the people who depend on them.

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