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,

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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/

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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

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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).

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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

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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

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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,

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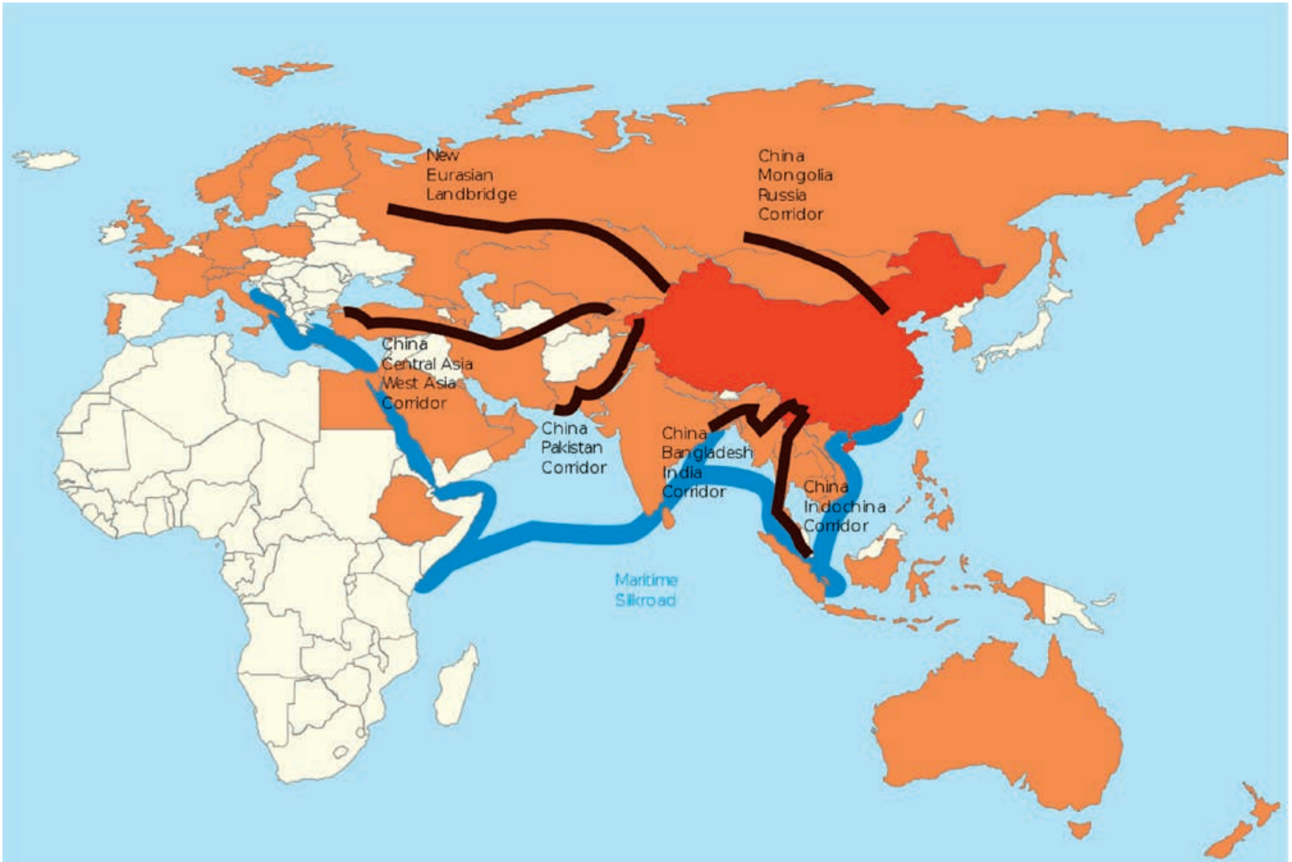

Figure 9.1 China's Belt and Road Initiative. Source: Creative Commons 'One Belt One Road' by Lommes, licensed under CC BY-SA 4.0.

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.

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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).

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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).

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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

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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).

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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.

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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

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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

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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).

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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.

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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).

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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

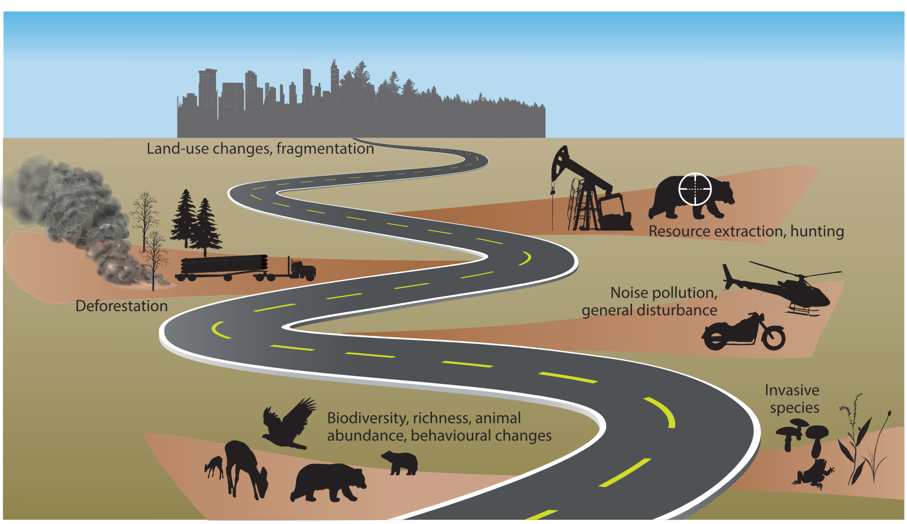

Figure 9.2 Impacts of roads on biodiversity. Adapted from: Ibisch et al. (2016) in supplementary material.

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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.

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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

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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,

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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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