IUFRO World Series Vol. 33

Forests, Trees and Landscapes for Food Security and Nutrition

A Global Assessment Report

Editors: Bhaskar Vira, Christoph Wildburger, Stephanie Mansourian

Funding support for this publication was provided by the Ministry of Foreign Affairs of Finland, the United States Forest Service, and the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management. The views expressed within this publication do not necessarily reflect official policy of the governments represented by these institutions.

Publisher:
International Union of Forest Research Organizations (IUFRO)

Recommended catalogue entry:
Bhaskar Vira, Christoph Wildburger & Stephanie Mansourian (eds.), 2015.
Forests, Trees and Landscapes for Food Security and Nutrition. A Global Assessment Report.
IUFRO World Series Volume 33. Vienna. 172 p.

ISBN 978-3-902762-40-5
ISSN 1016-3263

Published by:
International Union of Forest Research Organizations (IUFRO)

Available from:
IUFRO Headquarters
Secretariat
Marxergasse 2
1030 Vienna
Austria

Tel: +43-1-877-0151-0
E-mail: office@iufro.org
Website: www.iufro.org

Language editor: Stephanie Mansourian
Layout: Schrägstrich Kommunikationsdesign
Cover photographs: Terry Sunderland, Terry Sunderland, Miguel Pinedo-Vasquez
Rightmost photograph originally published as fig. 4.6. in Parrotta and Trosper (2012).
Reprinted with kind permission from Springer + Business Media B.V.
Printed in Austria by Eigner Druck, Tullner Straße 311, 3040 Neulengbach

Chapter 1
Forests, Trees and Landscapes for Food Security and Nutrition

Coordinating lead author: Bhaskar Vira
Lead authors: Bina Agarwal, Ramni Jamnadass, Daniela Kleinschmit, Stepha McMullin, Stephanie Mansourian, Henry Neufeldt, John A. Parrotta, Terry Sunderland and Christoph Wildburger

1.1 Problem Statement: Can Forests and Tree-based Systems Contribute to Food Security and Nutrition?

As population estimates for 2050 reach over 9 billion, issues of *food security*[1] and *nutrition* have been dominating academic and policy debates, especially in relation to the global development agenda beyond 2015. A total of 805 million people are undernourished worldwide, even though the trend appears to be slowly reversing (FAO et al., 2014) and *malnutrition* – defined as either under-5 stunting, anaemia among women of reproductive age or adult obesity – affects nearly every country on the planet (IFPRI, 2014). Despite impressive productivity increases, there is growing evidence that conventional agricultural strategies fall short of eliminating global hunger, result in unbalanced diets that lack nutritional diversity, enhance exposure of the most vulnerable groups to volatile food prices, and fail to recognise the long-term ecological consequences of intensified agricultural systems (FAO, 2013; FAO et al., 2013). In parallel, there is considerable evidence that suggests that *forests and tree-based systems* can play an important role in complementing agricultural production in providing better and more nutritionally-balanced diets (Vinceti et al., 2013); woodfuel for cooking; greater control over food consumption choices, particularly during lean seasons and periods of vulnerability (especially for marginalised groups); and deliver a broad set of *ecosystem services* which enhance and support crop production (FAO 2011a; Foli et al., 2014). Already, while precise figures are difficult to come by, it has been estimated that approximately 1.2-1.5 billion people (just under 20 percent of the global population) are forest dependent (Chao, 2012, cited by FAO, 2014a; Agrawal et al., 2013). These estimates include about 60 million indigenous people who are almost wholly dependent on *forests* (World Bank, 2002).

Despite these figures, much of these forests remain under government control (even if the trend suggests a slight increase in community control of forests; see Figure 1.1). Ultimately, who controls forests has important implications for the role of forests in food security and nutrition.

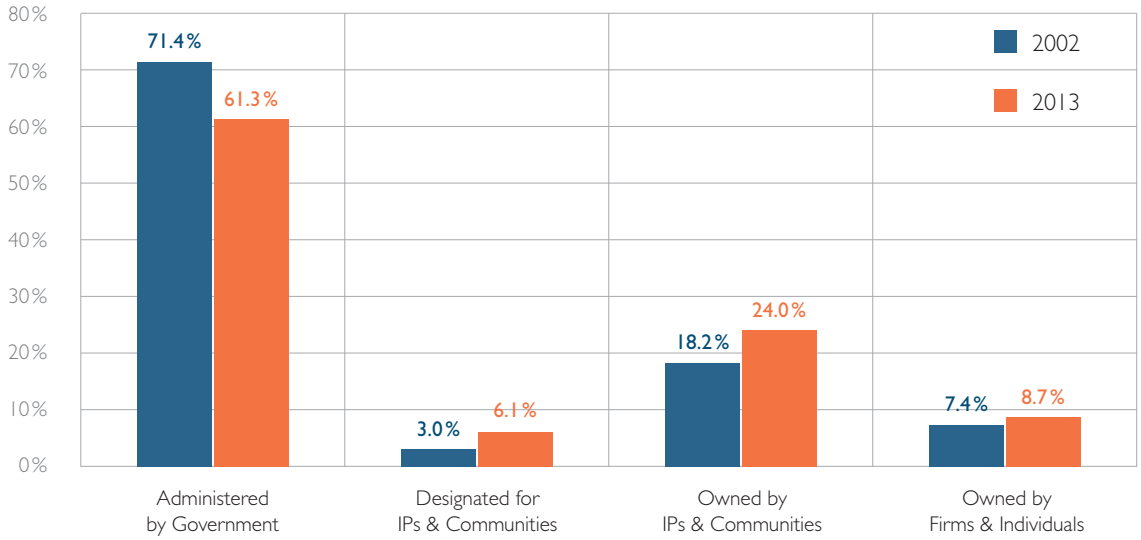
The loss and *degradation* of forests exacerbate the problem of *food insecurity* both directly and indirectly: directly, by affecting the availability of fruits and other forest- and tree-based food products, and indirectly by modifying ecological factors relevant for crop and livestock and thereby affecting the availability of food (van Noordwijk et al., 2014). As of 1990, an estimated nearly 2 billion ha of the world's land surface could be classified as degraded, the legacy of extended periods of mismanagement in some long-settled areas (Oldeman et al., 1991). Models of current global trends in land (soil) degradation indicate that between 1981 and 2003, approximately 24 percent of the global land area (in which 1.5 billion people live) could be classified as degrading (Bai et al., 2008). Evidence suggests that cropland and forests are disproportionately represented in these areas undergoing degradation, with consequent implications for net primary productivity, and associated impacts on populations that depend on these *landscapes* for food and nutrient provisioning.

While there is growing recognition that forests and tree-based systems complement farmland agriculture in providing food security and nutrition, responsibility for managing these diverse elements of the productive landscape is typically fragmented across different government departments and administrative jurisdictions in most countries. The complex, overlapping and interconnecting processes which link tree products and services to food security and nutrition are currently not adequately represented in forestry, agriculture, food or nutrition-related strategies at global and national levels, though their importance is often well known at more local scales by consumers, forest producers and farmers.

[1] All terms that are defined in the glossary (Appendix 1), appear for the first time in italics in a chapter.

Changes in statutory forest land tenure in low and middle income countries, 2002-2013, by percent

Figure 1.1



Source: RRI (2014)

While the evidence base for the role of forests and tree-based systems for food security and nutrition is growing (see for example, Johnston et al., 2013; Ickowitz et al., 2014) there remain many gaps in our understanding of this relationship and its potential contribution to reducing global hunger and malnutrition. There is a need to explore the forest-food nexus in much more detail, particularly in relation to the integrated management of multi-functional landscapes, and the multi-scalar and cross-sectoral *governance* approaches that are required for the equitable delivery of these benefits.

1.2 Prevailing Paradigms about Forests, Agriculture, Food Security and Nutrition

In 2012, at the UN Conference on Sustainable Development: Rio+20, the UN Secretary General proposed an ambitious goal to eliminate global hunger by 2025 – the so-called "Zero Hunger Challenge". Fulfilling this challenge requires not just providing universal and year-round access to food for the world's growing population, but doing so in a nutritionally-balanced way, while enhancing *livelihood* security for smallholders, reducing waste from consumption and production systems and also ensuring that these systems are sustainable. Evolving strategies to respond to this challenge primarily focus on achieving "*sustainable intensification*", by improving the productivity of agricultural systems, without causing ecological harm or compromising *biodiversity* and ecosystem services (FAO, 2011b; Garnett et al., 2013). Plant biologists, crop scientists and agronomists are working hard to find solutions both on-farm and in the laboratory, which may be able to achieve this desired increase in productivity without the sorts of ecological side-effects that were associated with the Green Revolution of the 1960s and 1970s (Struik and Kuyper, 2014).

There are reasons to be cautious about these production-centric approaches to the food security dilemma. As Amartya Sen demonstrated through his seminal work on famine, what keeps people hungry is not just the lack of food, but the lack of access to that food and control over its production (Sen, 1983). Enhancing global production of food through productivity increases will therefore not guarantee that those who are hungry will have the means to increase their intake of food. The resource poor, in particular, may not have the means by which to purchase the increased output of food that these new technologies promise, and may continue to rely on more locally-appropriate and accessible means of fulfilling their nutritional needs (Pinstrup-Andersen, 2009). What is needed is recognition of the ways in which people command access to food, how this varies by season, and how the interpersonal dynamics and biases (especially due to gender) of intra-household food allocation result in differential nutritional outcomes within families. Enhanced *food sovereignty* (encompassing food security, the right to food and healthy diets, as well as the right to control over one's own food system (Patel, 2009; Edelman et al., 2014)) can help ensure that local people have control over their own diets and are engaged in efforts to improve the nutritional quality of their diets.

Production is also constrained by the lack of equitable access to land, technology and capital, which typically remain unavailable to the large majority of smallholder farmers (there are an estimated over 500 million family farms worldwide) (FAO, 2014a; Pretty et al., 2011; Vanlauwe et al., 2014). In these contexts, food from forests and tree-based systems is likely to continue to form an essential part of household strategies to eliminate hunger and achieve nutritionally balanced diets. Unfortunately,

there is little current appreciation of the diverse ways in which these tree-based landscapes can supplement agricultural production systems in achieving global food security amongst the international and national decision-making communities. Many forms of *forest management* for food (whether strictly traditional or contemporary) including the creation of multi-storied agroforests, the planting of diverse forest gardens or, as discussed at greater length in this report, the management of *swidden*-fallows for food, have remained, with few exceptions, either invisible to researchers and planners or condemned by governments and conservationists. Even the many contributions that woodlands make to agricultural production outside of forests have been largely overlooked.

Paradigms for forest and tree management have also evolved considerably in the last fifty years, away from a state-controlled, production-centric approach to more collaborative systems which prioritise the needs of local people, and also value the roles of forests in providing critical ecosystem services, especially habitats for biodiversity (including *agrobiodiversity*), pollination, soil protection, water and climate regulation (Mace, 2014). Decentralised management systems now better reflect local demands, especially for woodfuel, fodder and small timber (Larson et al., 2010). More recently, new management regimes which take account of the key roles that forests and trees play in biodiversity conservation, the regulation of carbon fluxes, and the hydrological cycle have meant that these landscapes are being managed for a much more diverse (often non-local) set of purposes (Ribot et al., 2006). What has been relatively neglected, however, in these reconfigurations of forests and tree-based landscapes so far is an explicit recognition of the continued role that they play in food security and nutrition, especially in providing resilient and accessible production and consumption systems in general, and for some of the most vulnerable groups. For many of these groups, linking the health of forests and landscapes to food sovereignty also provides a potential mechanism and argument to enhance greater autonomy over local food and agricultural systems, as well as their wider landscapes and bio-cultural environments. In many ways, this is a missed opportunity for stakeholders and decision-makers, as a greater emphasis on these roles could allow forestry debates to engage more actively with wider concerns about poverty alleviation and sustainable human well-being, which are at the centre of global, national and local agendas.

1.3 Policy Context for this Report, Scope and Objectives

The contribution of forests to sustainable land use approaches which balance livelihood security and nutritional needs of people with other management goals is of high significance for the implementation of existing international commitments, including Agenda 21 and the three Rio Conventions (UNFCCC, CBD, UNCCD) adopted by the 1992 Earth Summit; the Global Objectives on Forests; the Millennium Development Goals; the UN Declaration on the Rights of Indigenous Peoples; as well as the ILO Indigenous and Tribal Peoples Convention (1989) No. 169. In the context of the discussions on the United Nations post-2015 development agenda, which seeks to establish a more integrated approach to poverty reduction in the framework of the Sustainable Development Goals, the contribution of forests to food security and nutrition, and the impact of food production on forests and landscapes are of particular relevance.

Against this backdrop, the Collaborative Partnership on Forests (CPF) tasked the Global Forest Expert Panel (GFEP) on Forests and Food Security to carry out a comprehensive global assessment of available scientific information on the relationship between forests and trees on the one hand, and food security and nutrition on the other, and to prepare a report to inform relevant international policy processes and the discussions on the post-2015 development agenda. The report is targeted particularly at decision-makers – policymakers, investors and donors – in order to provide a strong scientific basis for interventions and projects related to forests, *agroforestry* and landscapes aimed at addressing food security and nutrition.

The work of the GFEP on Forests and Food Security focuses on three key objectives:

- To clarify the different dimensions and the role that forests and tree-based systems play in food security and nutrition;
- To analyse the social, economic and environmental synergies and trade-offs between forests and food security and nutrition, and related management interventions; and
- To assess relevant frameworks and responses, as an input to research, international policy processes, and evolving development agendas in different regions of the world.

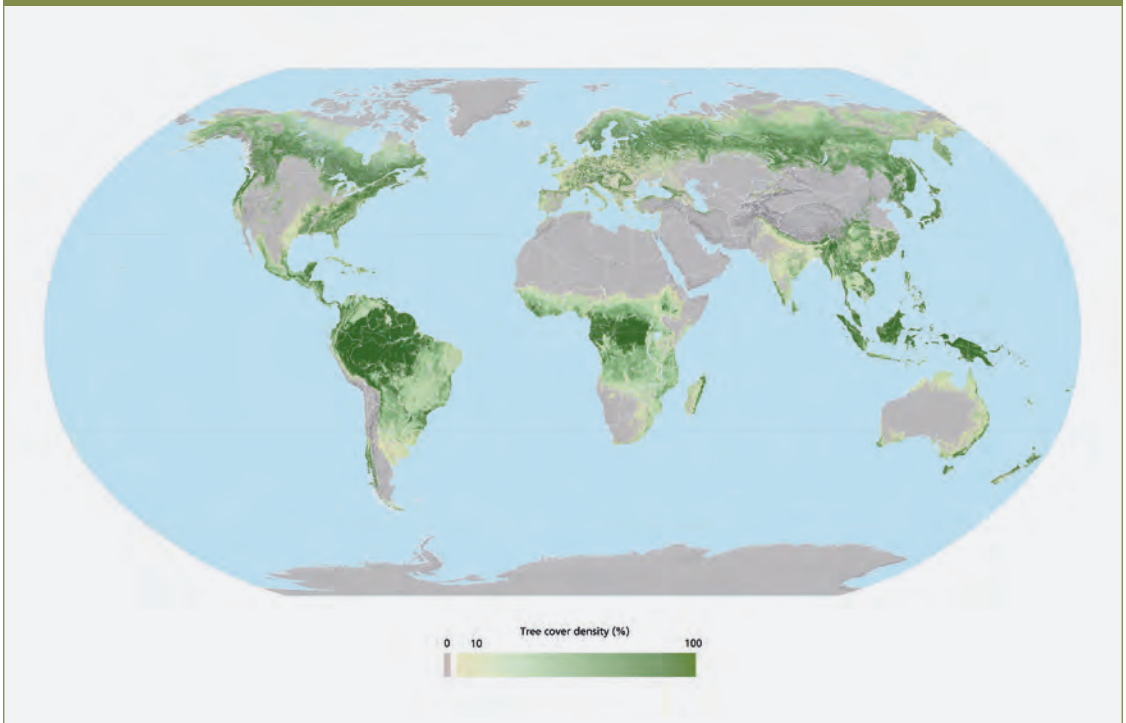
This report documents evidence of the relationships between forests and tree-based systems and food security and nutrition from different agro-ecological zones in all continents. However, a particular concern is those parts of the world that are characterised by deep-rooted hunger and malnutrition, where food security is a particular challenge, primarily in poorer nations and in the tropics (see Figure 1.2). Our discussion includes not only management of forests, woodlands, agroforests, and *tree crops* for direct food provisioning, but also the management of forested landscapes for the conditions they create that in turn affect all agricultural systems. The systems included in our analysis range from management of forests to optimise yields of wild foods and fodder, to *shifting cultivation*, through the broad spectrum of agroforestry practices, to single-species tree crop management (these systems are discussed in detail in Chapter 3 of this report). We consider the variability and applicability of these management systems within and across geographical regions, agro-ecological zones and biomes, highlighting the traditional and modern science and technology that underpin them.

Global maps of forest cover, hunger and undernourishment

Figure 1.2

FAO world´s forest map 2010

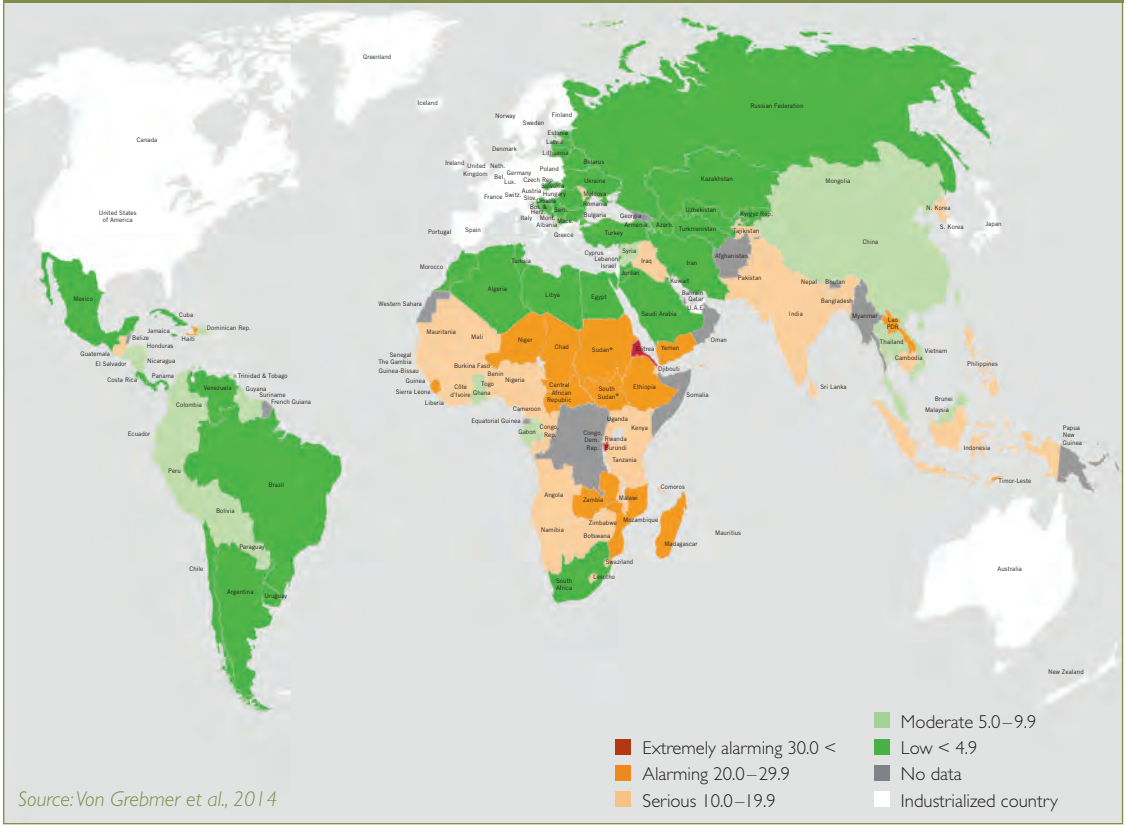
a



Source: FAO, 2010

Global Hunger Index 2014

b



Source: Von Grebmer et al., 2014

Although this report documents the role that forests and tree-based landscapes play in relation to food security and nutrition at a relatively aggregated level, it also highlights the important variations in these relationships. This includes regional variability, depending on agro-ecological conditions and their relative suitability for different forms of wild and cultivated harvests; seasonal variability, indicating the role that forest- and tree-based diets might play at particularly lean periods of the agricultural cycle; and socio-economic variability, which especially emphasises the roles that land and tree *tenure* and governance, human capital, financial capital, and gender play in mediating the ways in which people have access to, and consume, food from forests and tree-based landscapes.

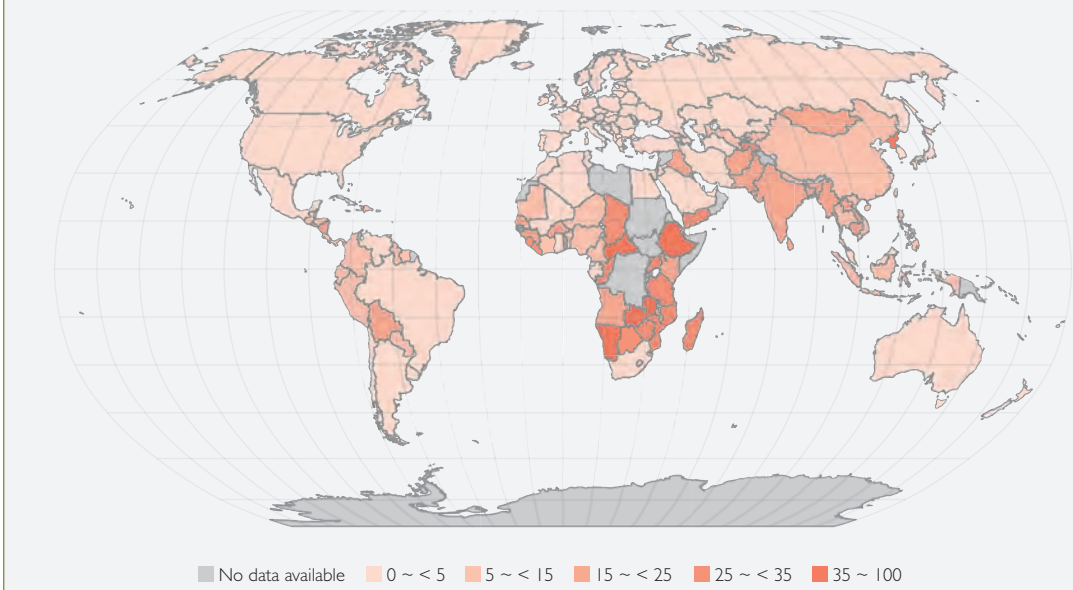
Throughout the report, there is specific attention to a number of important cross-cutting issues. Prominent amongst these is the role of gender specifically, and inequality more generally. Women and female children's roles in contributing to household *food systems* - both directly and indirectly - are substantial and often greater than men's, since they are the primary collectors of food, fodder and fuel from forests. In framing our discussion around the UN Secretary General's Zero Hunger Challenge, it is important to recognise the salience and importance of forest- and tree-based diets for these most vulnerable groups, even when the aggregate contribution to global food production from such landscapes might not be quite as significant. In addition, given the increasing feminisation of rural livelihoods and especially agriculture, as well as women's continued role in food provisioning for families, the report highlights the need to reach women as producers (by enhancing access to land, technologies, information etc.) and consumers who shape important behavioural choices in relation to food security and nutrition.

1.4 Structure of the Report

This report consists of six further chapters. Figure 1.3 provides a conceptual overview of the structure, and the broad linkages between the material presented in the different substantive chapters.

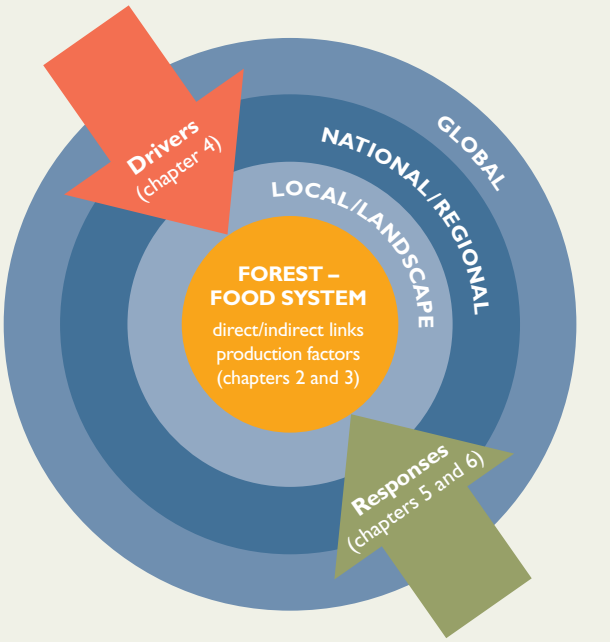
In Chapter 2, the available evidence on the direct and indirect roles that forests and tree-based landscapes play in providing food security and nutrition is presented, and critically assessed. Chapter 3 focuses on the forest-agriculture continuum, and the role of different landscape configurations in food production, the ways in which a mosaic of forest, agroforest and crop production systems combine and interact, and the importance of the social, cultural and economic contexts in which these systems exist, focusing on three factors that affect the socioeconomic organisation of forest and tree-based systems, namely: land and tree tenure and governance, human capital, and financial capital. Chapter 4 steps back from this landscape scale and examines the broader drivers – environmental, social, economic and political – that are impacting the forest-food security "nexus", and highlights the importance of these in framing available options for responding to hunger and malnutrition. Chapter 5 starts to discuss response options, at landscape scale, highlighting in particular the need for multifunctional landscapes

Prevalence of people undernourished (percent, 2012-14) C



Source: FAO, 2014b

Conceptual structure of the report Figure 1.3



to be governed for their ability to provide food security, natural resource conservation and sustainable livelihoods. In Chapter 6, these response options are examined in relation to the broader drivers of change, focusing in particular on the role of markets and incentives, different forms of governance and the public policy challenges associated with recognising and enhancing the role of forest-tree landscapes in food security and nutrition. Chapter 7 concludes with some key messages for a range of decision-makers in local and national governments, the intergovernmental community, as well as the business sector and civil society.

1.5 Forests and Tree-Based Landscapes for Food Security and Nutrition – a brief preview

1.5.1 Direct and indirect Contributions of Forests and Tree-based Systems to Food Security and Nutrition

As this report explores in some detail, forests and tree-based systems provide a steady supply of wild and cultivated fruit, vegetables, seeds, nuts, oils, roots, fungi, herbs and animal protein, which complement more conventional staple diets derived from agricultural production systems (and, in some cases, provide dependable staple sources for food security and nutrition). Evidence reviewed in the report (especially in Chapters 2 and 3) suggests that some 50 percent of the fruit consumed globally comes from trees (much of this collected by women and children) and recent studies show that access to forests and tree-based systems is associated with increased vitamin intake from fruit and vegetable consumption. What this growing evidence suggests is that, while forests are not a solution for global hunger in themselves, in many circumstances they play a vital supplementary role, especially during periods of unpredictability (such as long dry spells). In some regions, food from forests plays a central role in providing calorific staples (such as açai palm fruit in the Amazon; Brondizio, 2008). It is also increasingly recognised that food from forests provides micronutrients and contributes to *dietary diversity*, thereby supporting a shift away from calorific intake as the primary metric for food security, towards a broader understanding of nutritionally-balanced diets (FAO, 2013).

Forests provide not only food items, they are also critically important for providing fuel for cooking. In developing countries, 2.4 billion households still use conventional biofuels (firewood, charcoal, crop residues and cattle dung) for cooking and heating. This includes 90 percent of rural households in large parts of sub-Saharan Africa and 70–80 percent in China (Modi et al., 2005). The most important biofuel used as rural domestic fuel is firewood, and the numbers dependent on it and other traditional biofuels are expected to increase over time (IEA, 2004). Firewood shortages can have negative nutritional effects, since efforts to economise on firewood can induce shifts to less nutritious foods which need less fuel to cook, or cause poor families to eat raw or partially cooked food which could be toxic, or to eat leftovers which could rot if left unrefrigerated, or even to miss meals altogether (Agarwal, 1986).

Apart from these direct roles, forests support the diversification of livelihoods through income earning opportunities that contribute to household food security (see Figure 1.4). Their role in providing ecosystem services which underpin the agricultural production system – through soil formation, nutrient cycling and provision of green manure, water provisioning, pollination and microclimate regulation – further enhances synergies between the forest-tree landscape and the wider food production system (MA, 2005).

1.5.2 Drivers Affecting the Relationship between Forest-tree Landscapes and Food

Demographic change and mobility

In 2013, the world population totalled 7.2 billion and it is projected to exceed 9 billion by 2050, with most of the increase being in developing regions, especially Africa (Roberts, 2011). Consequently the demand for food, feed and fibre will increase, while per capita land availability will decline. A continued focus, therefore, on understanding and responding to the drivers of population growth is likely to remain an essential component of efforts towards ensuring food security in the twenty-first century. In addition to the increase in absolute numbers, however, changes in the structure and location of people –

with populations moving between rural and urban areas, as well as transnationally – are likely to have an important influence on the demand and supply of food. As Chapter 4 of this report discusses in some detail, the sheer scale of internal and international migration is unprecedented, and what is known about these numbers is likely to be a considerable underestimate due to undocumented movements. While international migration has become one of the defining features of globalisation, the world's population is also increasingly becoming urban, with more than half now living in urban areas (UN, 2014). Small cities and towns in Asia, Africa and Latin America that lie in or near tropical forest areas are likely to experience the greatest magnitude of urbanisation. Migration and urbanisation lead to profound changes in socio-economic systems, including the growing feminisation of rural landscapes in many of these regions. Urban migration is also resulting in major transformations in rural production-based economies, and associated loss of knowledge about forest foods and management. From a food security perspective, these trends have important implications for availability of, access to and relative dependence on forest products for food and income. However, research on the nexus between migration, urbanisation and forests remains very limited, let alone from a food security and nutrition perspective.

Shifts to market-driven economies

The last three decades have seen a considerable shift in public policy, encouraging the growth of markets and the private sector. The management of agrarian and forested landscapes for smallholders and their food needs is becoming less appealing to states in comparison to their desire to attract agro-industrial investors for large scale production systems, or for managing these landscapes in response to emergent global markets for carbon, biofuels and biodiversity (Fairhead et al., 2012). Pressures for the expansion of commodity exports are also adding to the degradation and loss of forest lands (Nevins and Peluso, 2008). As Chapter 4 points out, the resultant focus on enhancing production efficiency, specialisation and trade in agricultural commodities exposes vulnerable groups to the volatility of international commodity prices, and reduces their ability to access more localised food sources, over which they often have greater control. The food price spikes in 2008-09 demonstrated how the impacts of this volatility are felt, especially in those parts of the world that are least able to withstand such shocks, and contribute to undermining access to food for the poorest groups (Akter and Basher, 2014; Berazneva and Lee, 2013). As climate uncertainty adds to the potential volatility of global agricultural and commodity markets, developing more resilient production systems across the agricultural-forestry landscape is essential for ensuring food security and nutrition to the most vulnerable populations.

Consumer preferences and values

As discussed in Chapter 4, with increasing incomes, households' demand for food increases less than proportionally, and there is generally a dietary shift with decreasing importance of starchy staples (e.g. rice, wheat) and increased consumption of meat, fish, fruits and vegetables. Many forest foods are likely, in economic terms, to be seen as "inferior" goods (demand decreases with rising incomes and increases with declining incomes) and rising incomes would thus mean less forest food production, extraction and reliance. Delang (2006) notes, however, that forest food gathering is important in many rural communities with low economic growth, and likely to remain so, especially as per capita incomes rise relatively slowly in some parts of the world. Rising income and desire for meat consumption may also impact the demand for animal proteins, including bushmeat, with subsequent impacts on forests. Chapter 4 also suggests that forest food consumption is increasing in some high income countries, e.g. in northern Europe, apparently in response to perceptions that food should be locally grown, organic and aesthetic, indicating that we need to understand the dynamics of forest food consumption better.

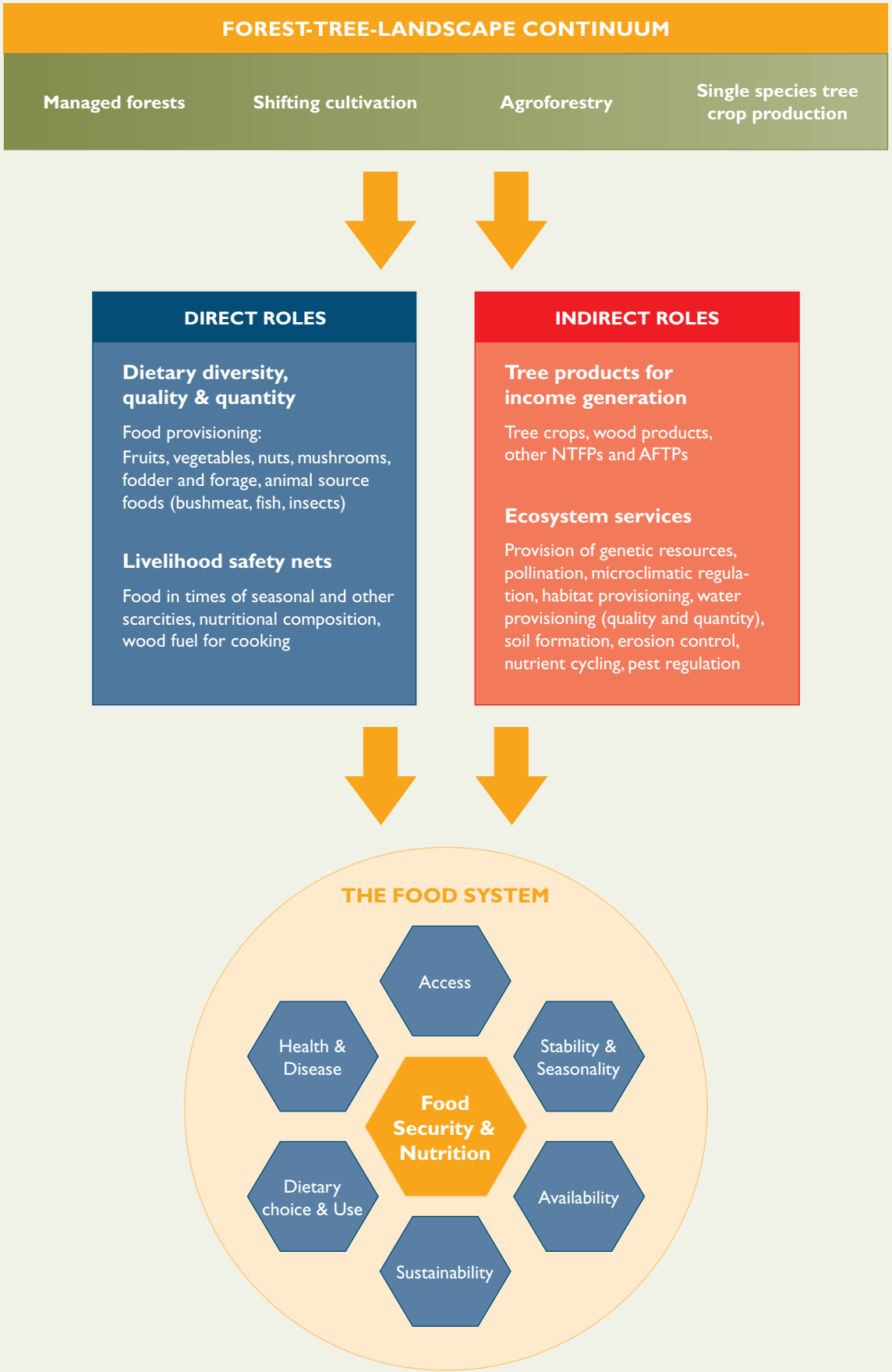
As Chapter 2 of this report discusses, household decision-making (mostly by women) regarding food use and practice is influenced by levels of knowledge on nutrition (FAO, 1997; Jamnadass et al., 2011). Translating the harvest and cultivation of tree foods and other forest foods into improved dietary intakes therefore involves making nutrition education and behavioural-change communication to women a high priority. But, as Chapter 2 emphasises, the education of men should also not be neglected, since they often have most control over household incomes, and need to be aware of the importance of diverse cropping systems and the spending of income on healthy foods.

Environmental transformation and degradation

The effect of human activities on *ecosystems* has been profound, particularly during the past century. Many critical thresholds of the earth's biophysical systems have already been crossed as a result of human activities (Rockström et al., 2009; Steffen et al., 2015). Though the consequences are complex, there is considerable evidence that ongoing and future *climate change* will have drastic impacts, especially in the poorest regions of the world. As Chapter 4 elaborates, people living directly off the production from the earth's ecosystems are particularly affected by these changes. Forests are affected by increasing temperatures, variable precipitation, *fragmentation*, *deforestation*, loss of biological diversity and spread of *invasive species*. These factors affect not only the extent of forest but also the structure and species composition within forests (and therefore, forest products) thus impacting on the availability of food and nutrition. Environmentally-induced changes affecting forest cover imply both direct and indirect consequences for food security and nutrition: direct consequences result from changes in the availability and quality of food and nutrition, while indirect consequences result from changes in income and livelihoods related to forest products.

The direct and indirect roles of forests and tree-based systems for food security and nutrition

Figure 1.4



1.5.3 Trade-offs, Conflicts and Synergies in Land Use, and Responses

Chapter 5 of this report discusses possible responses across the landscape, that attempt to reconcile competing demands for agriculture, forestry and other uses. There is no single configuration of land uses in any landscape that can provide all the different outcomes that people might find desirable. For example, the "best" landscape configuration for biodiversity conservation might include large areas of forest strictly protected from human use, but this might support the livelihood needs of a very small human population or even displace previously resident people (and the resultant conflict may undermine conservation impacts in the long run). In contrast, the "best" landscape for cereal production might contain very little forest at all. Other desirable outcomes, like malaria mitigation or food security may be best provided by more diverse landscapes. With increasing pressure on biodiversity and ecosystem services across many landscapes from the growing footprint of human activities, choices have to be made about what is desirable and how landscapes should be managed. There may be difficult decisions about the relative merits of enhancing short term outputs through intensification of increasingly overworked landscapes versus maintaining their long term ecological productivity. In a context where views on these options are often deeply entrenched and conflicts of interest are difficult to reconcile, consensus on what constitutes success may be difficult to achieve.

In a world characterised by increasing resource and land scarcity, these conflicts are likely to arise not just between the most desirable use of the agrarian-forest landscape, but also about how best to accommodate increased demands for land to allow for the expansion of urban settlements, industrial development and resource extraction. Dilemmas arise in relation to difficult choices about the most optimal configuration of land use in this mosaic, but also about who gets to decide when such choices need to be made, and whose interests are represented in the decision-making process. Trade-offs arise not just between alternative landuse options, but also amongst different resource users and stakeholders in a landscape, and their associated preferences. Political economy issues have often meant that a theoretically optimal landscape is unrealistic or unachievable on the ground.

Chapters 5 and 6 of this report emphasise the significant shifts in governance that are required to manage these trade-offs and difficult choices, and to promote pathways to more integrated multi-functional agricultural-forest landscapes for food security and nutrition. As Chapter 6 elaborates, many of these responses lie outside the land sectors altogether. The growing demand for food, fibres, energy and other products from the land often result in market pressures for exploitation that can lead to forest destruction if they are not managed through appropriate governance systems and institutions. Perverse incentives, such as subsidies that have been set up to address the demand for cheap food without considering environmental externalities, may aggravate these pressures. Issues of presence and representation require the adoption of more open, participatory and deliberative forms of multi-stakeholder governance, which enhance linkages between food security and forests. Power needs to be exercised in ways that are seen to be legitimate and accountable, and transformative change requires innovative multi-level linkages, and creative cross-sectoral partnerships. There is also a need for market and natural resource governance-related responses focusing on global processes that support sustainable supply, and innovative corporate and multi-actor initiatives that support inclusive value chains of forest and tree products. These need to be coupled with social and cultural response options to enhance food security where the focus is on cultural norms and values including gender, and social mobilisation such as advocacy.

1.6 Evidence and Knowledge Gaps

The diversity of the Earth's forest ecosystems and the human cultures associated with them has produced a vast array of food systems connected to forests and trees. These food systems are based on the traditional wisdom, knowledge, practices and technologies of societies. They are dynamic, developed and enriched through experimentation and adaptation to changing environmental conditions and societal needs, often over countless generations. Despite the huge potential of forest and tree foods to contribute to diets, knowledge on many forest foods, especially wild foods, is rapidly being lost due to social change and modernisation. Lack of knowledge in the community might be exacerbated by the effects of migration and movement, with considerable research demonstrating that information on forest-based foods is higher amongst long-term residents than migrants. Much of this knowledge is also associated with wisdom particularly held by the elderly and by women, with implications for its preservation and propagation within families and communities. Equally, many of these traditional forms of knowledge are non-formalised and have not been written down, which makes access to this information challenging. There are, of course, oral knowledge transmission traditions in many cultures (such as storytelling, folklore, music and informal learning within families) and there is a growing sensitivity in the research community to try and find ways of recording these non-formal forms of knowledge.

For the purposes of this report, however, this form of knowledge production and generation makes collation of evidence significantly more challenging. In reviewing the evidence, the authors have relied primarily on available literature, which has undergone processes of peer review and verification. Apart from work that is published in journals, they have used sources from a variety of organisations that have a repository of relevant information, and are reliable sources of data. Grey literature, where available, has been used and is indicated. What is largely missing are the voices

of the poor, which are typically under-represented in these more formalised sources of knowledge. Despite our best efforts, for many of the analyses undertaken in the assessment, there are considerable limitations on the availability of useful information from the literature and other relevant sources. Recognising these constraints, the assessment tries to point out where the current knowledge base is strong, where it is currently weak or lacking, and the degree of consistency in the literature (and among experts) regarding research findings (and other knowledge sources), all of which influence the degree of certainty regarding conclusions that may be drawn from the available evidence.

The message of this report is nuanced. As the detailed chapters demonstrate, there is variability in the ways in which forests and tree-based landscapes interface with human food and nutritional systems. In particular places, and for particular groups of people (and individuals), these landscapes provide goods, services and livelihood options that can be critical for avoiding the worst forms of hunger, malnutrition and destitution. As the discussion on the post-2015 Sustainable Development Goals becomes increasingly cognisant of the importance of nutrition-sensitive approaches to eliminating hunger, and to the wider role of natural ecosystems in supporting human well-being and development, these links between different forms of production across diverse landscapes will allow a much greater recognition of the role of forests and trees in global (and local) food security and nutrition.

References

Agarwal, B., 1986. *Cold Hearths and Barren Slopes*: *The Woodfuel Crisis in the Third World*. London: Zed Books.

Agrawal, A., Cashore, B., Hardin, R., Shepherd, G., Benson, C. and Miller, D., 2013. *Economic Contributions of Forests*. Background Paper to UNFF tenth Session, Istanbul, 8-19 April 2013.

Akter, S., and Basher, S.A., 2014. The impacts of food price and income shocks on household food security and economic well-being: Evidence from rural Bangladesh. *Global Environmental Change* 25: 150–162.

Bai, Z. G., Dent, D. L., Olsson, L. and Schaepman, M. E., 2008. Proxy global assessment of land degradation. *Soil Use and Management* 24(3): 223–234.

Berazneva, J. and Lee, D.R., 2013. Explaining the African food riots of 2007-2008: an empirical analysis. *Food Policy* 39: 28-39.

Brondizio, E.S., 2008. *Amazonian Caboclo and the Acai Palm*: *Forest Farmers in the Global Market*, New York: New York Botanical Gardens Press.

Delang, C.O., 2006. The role of wild food plants in poverty alleviation and biodiversity conservation in tropical countries. *Progress in Development Studies* 6 (4): 275-286.

Edelman, M., Weis, T., Bavsikar, A., Borras Jr, S. M., Holt-Gimenez, E., Kandiyoti, D. and Wolford, W., 2014. Introduction: Critical Perspectives on Food Sovereignty. *Journal of Peasant Studies*, 41(6): 911-931.

Fairhead, J., Leach, M. and Scoones, I., 2012. Green Grabbing: a new appropriation of nature? *Journal of Peasant Studies* 39(2): 237-261.

FAO, 1997. *Agriculture Food and Nutrition for Africa- a resource book for teachers of agriculture*. Food and Nutrition Division. Rome: FAO.

FAO, 2010. *Global Forest Resources Assessment.* Rome: FAO. http://www.fao.org/forestry/fra/80298/en/ [Accessed on 15 February 2015]

FAO, 2011a. *Forests for Improved Food Security and Nutrition report*. Rome: FAO. Available at: http://www.fao.org/docrep/014/i2011e/i2011e00.pdf [Accessed on 15 February 2015].

FAO, 2011b. *Save and grow: a policy makers guide to the sustainable intensification of crop production.* Rome: FAO. Available at: http://www.fao.org/docrep/014/i2215e/i2215e.pdf [Accessed on 15 February 2015].

FAO, 2013. *The State of Food and Agriculture*. *Better food systems for better nutrition*. Rome: FAO. Available at: http://www.fao.org/docrep/018/i3300e/i3300e00.htm [Accessed on 15 February 2015].

FAO, 2014a. *Towards Stronger Family Farms*. Rome: FAO. Available at: http://www.fao.org/3/a-i4171e.pdf [Accessed on 15 February 2015].

FAO, 2014b. *Food and Nutrition in Numbers.* Rome: FAO. http://www.fao.org/3/a-i4175e.pdf [Accessed on 15 February 2015]

FAO, IFAD and WFP, 2013. *The State of Food Insecurity in the World* 2013. *The multiple dimensions of food security*. Rome: FAO.

FAO, IFAD and WFP, 2014. *The State of Food Insecurity in the World* 2014. *Strengthening the enabling environment for food security and nutrition*. Rome: FAO.

Foli, S., Reed, J., Clendenning, J., Petrokofsky, G., Padoch, C. and Sunderland, T., 2014. Exploring the dynamics between forests, ecosystem services and food production: A systematic review protocol. *Environmental Evidence*. Available at: http://www.environmentalevidencejournal.org/content/3/1/15 [Accessed on 15 February 2015].

Garnett, T., Appleby, M., Balmford, A., Bateman, I., Benton, T., Bloomer, P. Burlingame, B., Dawkins, M., Dolan, L., Fraser, D., Herroro, M., Hoffman, I. Smith, P., Thornton, P., Toulmin, C., Vermeulen, S. and Godfray, C., 2013. Sustainable intensification in agriculture: Premises and policies. *Science* 341: 33-34.

Ickowitz, A., Powell, B., Salim, A. and Sunderland, T., 2014. Dietary Quality and Tree Cover in Africa. *Global Environmental Change* 24: 287–294. Available at: http://www.sciencedirect.com/science/article/pii/S0959378013002318 [Accessed on 15 February 2015].

IEA, 2004. Energy and Development. In: *World Energy Outlook*. Paris: International Energy Agency, OECD.

IFPRI, 2014. *Global Nutrition Report*. *Actions and Accountability to Accelerate the World's Progress on Nutrition*. Washington DC: IFPRI.

Jamnadass, R.H., Dawson, I.K., Franzel, S., Leakey, R.R.B., Mithöfer, D., Akinnifesi, F.K. and Tchoundjeu, Z., 2011. Improving livelihoods and nutrition in sub-Saharan Africa through the promotion of indigenous and exotic fruit production in smallholders' agroforestry systems: A review. *International Forestry Review* 13: 338–354.

Johnston, K.B., Jacob, A. and Brown, M.E., 2013. Forest cover associated with improved child health and nutrition: evidence from the Malawi Demographic and Health Survey and satellite data. *Global Health*: *Science and Practice* 1 (2): 237–248.

Larson, A.M., Barry, D., Dahal, G.R. and Colfer, C.P. (eds.), 2010. *Forests for People*: *community rights and forest tenure reform*. London: Earthscan.

MA (Millennium Ecosystem Assessment), 2005. *Ecosystems and human well-being*: *synthesis*. Washington DC: Island Press.

Mace, G., 2014. Whose Conservation? *Science* 345 (6204): 1558-1560.

Modi, V., McDade, S., Lallement, D. and Saghir, J., 2005. *Energy Services for the Millennium Development Goals*. Washington, DC: UNDP, World Bank, ESMAP.

Nevins, J. and Peluso, N. L., 2008. Introduction: commoditization in Southeast Asia. In: *Taking Southeast Asia to market*, edited by J. Nevins and N.L. Peluso. Ithaca: Cornell University Press, 1-24.

Oldeman, L.R., Hakkeling, R.T.A. and Sombroek, W.G. 1991. *World map of the status of human-induced soil degradation*, (2nd edn). Wageningen: ISRIC.

Patel, R., 2009. Grassroots Voices: food sovereignty. *Journal of Peasant Studies* 36(3): 663–706.

Pinstrup-Andersen, P., 2009. Food Security: definition and measurement. *Food Security* 1(1): 5-7.

Pretty, J., Toulmin, C. and Williams, S., 2011. Sustainable intensification in African agriculture. *International Journal of Agricultural Sustainability.* 9(1): 5–24.

Ribot, J. C., Agrawal, A. and Larson, A. M., 2006. Recentralizing while decentralizing: How national governments reappropriate forest resources. *World Development* 34(11): 1864-1886.

Roberts, L., 2011. 9 Billion? *Science* 333(6042): 540-543.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F.S.III, Lambin, E.F., Lenton, T.M., Scheffer, M., Folke, C., Schellnhuber, H.J., Nykvist, B., de Wit, C.A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P.K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R.W., Fabry, V.J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P. and Foley, J.A., 2009. A safe operating space for humanity. *Nature* 461: 472-475.

RRI, 2014. *What future for reform*? *Progress and slowdown in forest tenure reform since* 2002. Washington DC: Rights and Resource Initiative. Available at: http://www.rightsandresources.org/ [Accessed on 15 February 2015].

Sen, A., 1983. *Poverty and Famines*: *An Essay on Entitlement and Deprivation*. Oxford: Oxford University Press.

Steffen, W., Richardson, K., Rockström, J., Cornell, S.E., Fetzer, I., Bennett, E.M., Biggs, R., Carpenter, S.R., de Vries, W., de Wit, C.A., Folke, C., Gerten, D., Heinke, J., Mace, G.M., Persson, L.M., Ramanathan, V., Reyers, B. and Sörlin, S., 2015. Planetary boundaries: Guiding human development on a changing planet. *Science* Published online 15 January 2015.

Struik, P.C. and Kuyper, T.W. (eds.), 2014. Sustainable intensification to feed the world: concepts, technologies and trade-offs. *Current Opinion in Environmental Sustainability*. Special Issue (Volume 8).

UN, 2014. *World Urbanization Prospects*: *The* 2014 *Revision - Highlights*. New York: Department of Economic and Social Affairs, Population Division, United Nations.

Vanlauwe, B., Coyne, D., Gockowski, J., Hauser, S., Huising, J., Masso, C., Nziguheba, G. Schut, M. and Van Asten, P., 2014. Sustainable intensification and the African smallholder farmer. *Current Opinion in Environmental Sustainability* 8: 15-22.

Van Noordwijk, M., Bizard, V., Wangpakapattanawong, P., Tata, H.L., Villamor, G.B. and Leimona, B., 2014. Tree cover transitions and food security in Southeast Asia. *Global Food Security* 3 (3-4): 200-208.

Von Grebmer, K., Saltzman, A., Birol, E., Wiesmann, D., Prasai, N. Yin, S., Yohannes, Y., Menon, P., Thompson, J. and Sonntag, A., 2014. *2014 Gobal Hunger Index: The Challenge of Hidden Hunger.* Bonn, Washington, D.c., and Dublin: Welthungerhilfe, International Food Policy Research Institute, and Concern Worldwide. http://www.ifpri.org/publication/2014-global-hunger-index [Accessed on 15 February 2015]

Vinceti, B., Ickowitz, A., Powell, P., Kehlenbeck, K., Termote, C., Cogill, B. and Hunter, D., 2013. The contributions of forest foods to sustainable diets. *Unasylva* 64(241): 54-64.

World Bank, 2002. *A revised forest strategy for the World Bank Group*. Washington DC: World Bank.