Small-island agroforestry

Agroforestry is the provider of many basic needs on small islands.

Photo: World Agroforestry/Meine van Noordwijk

Suggested citation:

van Noordwijk M. 2019. Small-island agroforestry in an era of climate change and sustainable development goals. In: van Noordwijk M, ed. *Sustainable development through trees on farms: agroforestry in its fifth decade.* Bogor, Indonesia: World Agroforestry (ICRAF) Southeast Asia Regional Program. pp 229–243.

CHAPTER THIRTEEN

Small-island agroforestry in an era of climate change and sustainable development goals[a]

Meine van Noordwijk

Highlights

- Absence of a forest-agriculture divide has made small-islands fore-runners of agroforestry policies
- Specific forms of agroforestry match the ecological and social characteristics of small islands
- Ecologically, small islands share proximity to sea, limited freshwater reserves and low but globally unique ('endemic') biodiversity as characteristics
- Social characteristics are continued relevance of diversified subsistence support, limited economies of scale in participation in global markets and strong sense of identity

13.1 Introduction

Small islands exist in a wide range of absolute sizes, making counts of the total number of small islands that exist in the world uncertain. Indonesia, for example, is said to have more than 17 thousand islands, but although some of these are among the largest in the world (Borneo, Papua, Sumatra), it is not clear how many are classified as 'small'. A relevant distinction exists between those that are permanently inhabited and those that are not, but that criterion has borderline cases as well[b]. Being normally above sea level is a criterion for being an island, but an occasional flooding event (so that the island is not permanently above sea level) does not take it out of the island category. While there have been several initiatives

[a] With thanks to the organizers of and participants in the seminar "Agroforestry, small islands and climate change" at Pattimura University, Ambon (Indonesia) in November 2016 and to ICRAF colleagues who shared ideas, incl. Jonathan Cornelius, Jim Roshetko and Andre Ekadinata

[b] The definition of district and provincial borders hinges in some parts of Indonesia on the evidence whether or not specific islands where permanently inhabited at some point in the past; the discussion affects revenue sharing rules for resource extraction and can be hotly contested, similar to international issues in the S China sea that relate to settlement history

to represent the shared interests of small islands in global policy arena's, there is no universally agreed definition of what is small; among small island nations claims of leadership tend to be expressed by the largest among them, that may be least representative; the issues of small islands that are part of larger nations (such as Indonesia or the Philippines) differ partly from those that have nation status. Politically, small island nations, have achieved a clear voice in the climate change debate via the AOSIS association of small island states, some of which are expected to disappear with continued sea-level rise[1,2]. Some members of this grouping have 'mainland' or 'large island' parts as well (Figure 13.1). Indonesia as a country may have the largest number of 'small islands' of any country of the world, but does not belong to the AOSIS association. The concerns derived from a high vulnerability to sea level rise and climate change, however, apply to the small islands (inhabited or not) of small island states and archipelagic nations alike, as well as to the densely populated coastal zones of large islands and continents.

Figure 13.1 Small island states and other small islands of the world

Small islands share some properties with all coastal zones (proximity of the sea-land interface, vulnerability to climate change) and some with mountains (high-elevation islands of cool and wet climates, separated and surrounded by a sea of hotter lowlands) and the inhabited valleys ('inverse islands') between them (lower elevation peninsula's in a sea of non-vegetated rocks): remoteness, specific biodiversity values[c], lack of economies of scale. Yet, within a set of common characteristics, the history and cultural identity of the small islands in the Caribbean differs essentially from those in Southeast Asia and the Pacific, as their current population represents West Indian, African and European roots[3].

Agroforestry has a special character and possibly significance on small islands. In reflection on the special circumstances of small islands that can justify separate attention to the social-ecological systems that function on small islands, and that may imply a role for specific forms

[c] Volcanoes, some are both islands and mountains, have added an episodic destruction of local life followed by recolonization from outside to this "small island" dynamic, as described in the island biogeography literature

of agroforestry, seven points emerged, three ecological, three social and one integrated, forward looking one. These form the core of this chapter, after clarifying what the era of climate change and sustainable development goals entails.

13.2 An era of climate change and sustainable development goals

The world is in need of integrative concepts, as counterforce to the natural tendency of human institutions to fragment into self-contained silos. The wording for such integrative concepts may change faster than their core content, with sustainable development, green growth, planetary boundaries and low emission development as elements of current policy discourse (Figure 13.2). The acceptance in September 2015 of the UN 2030 agenda with 17 Sustainable Development Goals (SDG's) has provided new momentum to a debate that was initially shaped by the Brundtland report in 1987[4]. The 17 SDG's can be interpreted as belonging to two groups: 12 that relate to the land use nexus of income, food, water, energy, climate and biodiversity, and 5 that relate to the human dimensions of inequity, fairness, gender, education, conflicts and cooperation (Figure 13.3). On further analysis the 12 SDG's in the land use nexus may be represented by six aspects of land use that have clear interactions, opportunities for synergy and risks of conflicts and unavoidable tradeoffs (Figure 13.4). Agroforestry concepts can play a role in achieving these six SDG synergy opportunities[5]

Figure 13.2 The need for integrative approaches at the interface of basic needs, livelihoods, planetary boundaries, policy issues, landscapes and project cycles in theories of induced change

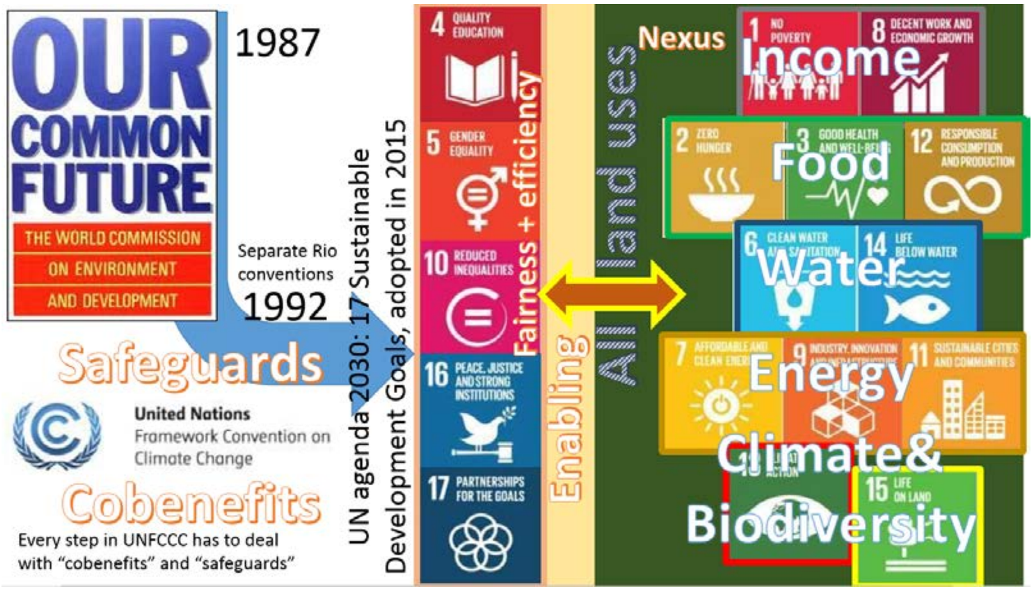

Figure 13.3 Pathway that led to the current set of 17 Sustainable Development Goals[6]

SDG's	Poverty, economic growth 1+8	Food, health, diets 2+3+12	Water, oceans 6+14	Energy, infrastructure, cities 7+9+11	Climate change, UNFCCC 13	Biodiversity and land health, CBD and UNCCD 15	4+5+10 + 16+ 17
1 + 8	Efficient transition to service-based economy in rural-urban continuum	Stronger value chains for food; income-based food security	Water footprint of traded commodities	Rural-urban continuum; renewable energy as growth engine; natural hazards contained	Low-emission development, ptotecting high-carbon stocks land cover	Biodiversity-friendly and non-degrading commodity production	Empowerment of underprivileged; fairness; transparency
2+3+12		Sustainable agriculture providing for healthy, affordable diets and adjusting demand	Blue water for irrigation; productive use of green water; wetlands, mangroves	(Peri) urban agriculture; waste reuse and reduction; integrated bio-energy	Climate-smart agriculture	Biodiversity-friendly agriculture; utilize both land sparing and land sharing opportunities	
6 + 14			Protect clean water sources, avoid pollution	Avoiding flood damage; grey water reuse; coastal zone health	Continental rainfall recycling; mangrove integrity	Water towers, springs, riparian zones, wetlands, mangroves	
7 + 9 + 11				Efficient use of renewable energy; no un-used waste	Climate smart cities with cool trees	Spatial planning of infrastructure & conservation	
13					Maximize high C stock land cover, CC buffering	Conserving, restoring high C-stock + high biodiv.habitat	
15						Min.20% fully protected; minimize loss elsewhere	

Distributional, gender-equity and non-area based goals interacting with all the above: 4+5+10+16+17
a) equitable land use planning, rules for access, guarding from environmental spillovers
b) education, access to dynamic, relevant knowledge; governance transparency; scrutiny of SDG progress

Figure 13.4 Interaction table between groups of Sustainable Development Goals (SDG's) and opportunities for integrated landscape solutions using agroforestry[4]

Box 13.1 Coconut: small island colonizer, multipurpose tree and agroforestry symbol

Across all tropical islands coconuts are a prominent part of the vegetation, and have become part of the 'visual brand'. With floating and sturdy fruits, it colonizes beaches easily. It provides protection (shelter), building materials, food, and income to island and coastal populations. Intercropping in coconut plantations, and their transformation to agroforestry, was linked to a shortage of other land and fluctuating copra prices in surveys in the Philippines[14].

Coconut palms can also be tapped as source of sugar – if there is sufficient fuelwood, but the woody petioles can also be used. Photos: World Agroforestry/Meine van Noordwijk

Seven characteristics of the social-ecological systems of small islands

For many of the Small Island Developing States (SIDS) of the Pacific Ocean, trees outside forests (TOF) and agroforestry constitute, perhaps, the single greatest foundation for the life and health[7]. Island soils, rivers, beaches, coastlines, people and the other plants and animals depend on it. The protection and planting of TOF and the protection and enrichment of traditional agroforestry systems and associated traditional knowledge can serve as a basis for addressing deforestation, forest degradation, 'agrodeforestation' and the loss of biodiversity (Box 13.1). In this analysis it may help to first identify which combination of environmental and social aspects define the 'small island' character (Fig. 13.5).

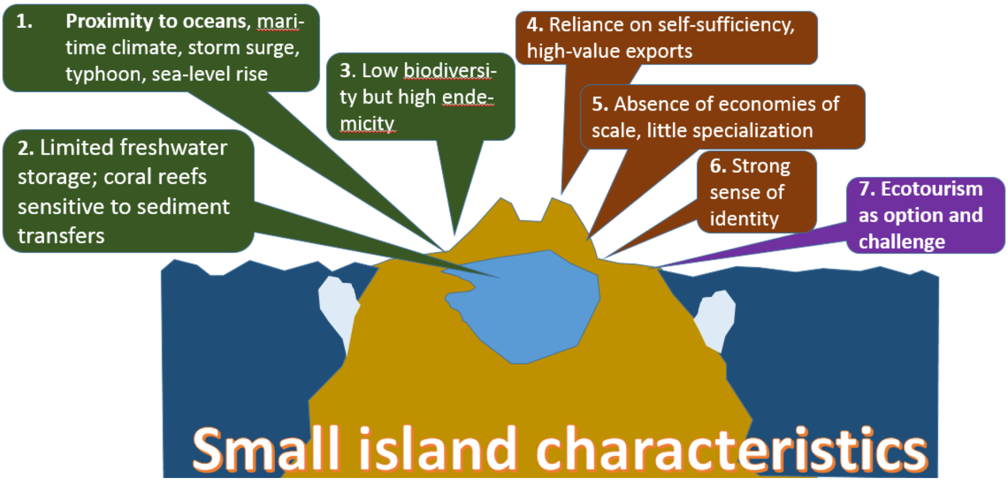

Figure 13.5 Seven specific aspects of social-ecological systems on small islands that provide context for agroforestry options

When considering small islands as social-ecological systems[8], we can distinguish a number of aspects of 'context' that are closely related to 'issues' within the globally agreed set of 'goals', and that shape the types of 'options' that have the best chance of 'induced change' in a desirable direction. As indicated in Figure 13.5, we found seven aspects (three ecological, three social, one integrated forward looking one) to be of particular relevance here.

Three **ecological** aspects imply high vulnerability to climate change and a specific place in the global biodiversity debate:

I. The coastal zone identity of small islands implies proximity to oceans, benefitting from the temperature and humidity buffering of large water masses in a maritime climate, but also involving exposure to the hurricanes and cyclones that are formed over heating surface water. They are also subject to the tsunami's that follow from sub-surface marine earthquakes, especially in the global ring of fire where tectonic plates clash. The maritime climate is subject to periodic shifts and long-term trends in global oceanic circulation and temperature differentiation (El Nino/La Nina, Indian Ocean Dipole and similar effects elsewhere). Human vulnerability to sea-level rise and episodic storm surges depends on access to higher elevation places to escape to. The contrast between day-night cycles in temperature between land and sea parts of the coastal zone may generate the air movement that brings rainfall to the islands, with specific roles for coastal forests, according to some authors[9].

II. Limited (fresh) groundwater storage, short (and thus 'flashy') rivers, saltwater intrusions in response to groundwater extraction and challenges to year-round water supply, especially where tourism increased the number of people and per capita water requirements. Coral islands[10] may be the group where limited freshwater supplies are most readily identified as constraint.

III. High endemicity (globally unique species) coupled to low species diversity (when compared per unit area), high extinction rates (dominating overall anthropogenic extinctions so far) and vulnerability to invasive species, while nearly all of global flora and fauna are by definition exotics. Most of the diversity of small islands is “between” rather than “within”. Islands can be considered to be ‘test tubes’ for flora and fauna — simple systems with multiple replicates that can be used to understand ecological community dynamics in more complex mainland systems[11,12].

Three **social** (economic) aspects, posing challenges to mainstream economic development trajectories, but also offering some protection to the common negative side-effects of such:

IV. Limitations on transport imply a greater reliance on self-sufficiency for human livelihoods, with multi-purpose trees (coconuts as prime example[13,14]), and integrated marine-terrestrial resource use of coastal zones. Participation in global markets mostly based on non-perishable, high-value-per-unit-volume commodities (spices, sandalwood, metal mines).

V. Absence of economies of scale in resource exploitation and plantation development, coupled to limited human resource specialization and cultural-religious resistance to immigrants.

VI. A human population that reflects multiple waves of immigration, with those established earlier claiming “indigenous” status relative to newcomers. Across the islands of Southeast Asia and the Pacific evolution of linguistic diversity mirrors biological speciation and extinctions (including those where the loss of canoe-grade timber closed down the escape routes)[d]. There tends to be strong attachment to place and sense of in-group identity[7].

A jointly shaped opportunity for social-ecological systems in sustainable development:

VII. Shifts from resource extraction and primary production to service sector jobs and livelihoods primarily linked to tourism provide opportunities for the “early movers” (Box 14.2), but tends to have a “shifting cultivation” character, constantly looking for the “pristine” frontiers, leaving strongly modified, degraded places in its wake.

[d] The “Easter island” theory that human settlement overused the vegetation and especially exhausted trees large enough to make canoes that allow people to move on to the next island

Box 13.2 Small islands, (eco)tourism and the multiple values of nature

The realization that 'small islands' have more economic potential in an 'eco-tourism' pathway than through agriculture has come at various points in history in different parts of the world.

> *"Sixty years ago nobody yet thought that 'wilderness' could be as valuable for our people as first-class wheat-lands. If our island keeps its current beauty, we'll soon see that the income from tourism more than compensates for any lost income from foregone reclamation for agriculture or afforestation. Not even counting the moral effect on our visitors, while the latter is the most important part."*
>
> *Jac-P Thijsse 1924, commenting on Texel*[i].

This quote pre-dates current debates on 'valuation' of Nature, asserting that the 'moral' benefits of (urban) tourists getting at least some experience of the birds, flowers and landscape beauty of 'wild' islands outweigh any gains from 'productive' land use, for the local as well as national economy. The quote also indicates a strong critique on the 'afforestation' programs that tried to replace moving sand-dunes ('desertification') by monoculture pine plantations. Scattered trees in the landscape and around the farms were certainly appreciated as part of the cultural history.

Jac-P Thijsse, a primary school teacher by training and an educator at heart, pioneered both environmental education and area-based nature conservation in the Netherlands, a century ago, influencing public policy discussions and attracting funding for 'Nature Monuments'.

i. Quoted in: Deen M. De Wadden: een geschiedenis. Thomas Rap, Amsterdam.

Agroforestry options in the light of the seven characteristics

Agroforestry[15], the presence and explicit use of trees in agriculture and as part of livelihoods strategies, is an important part of historical human adaptation to small-island conditions. A range of names describes specific forms of agroforestry in the eastern parts of Indonesia, including[16]: *Oma, Rau, Amarasi, Kamutu luri, Budidaya lorong, Sikka, Kebon, Ongen, Uma, Napu, Nggaro, Ngerau, Omang wike, Mamar, Okaluri, Pada Mbanda.* All of these can continue to share adaptive responses by:

1. Coastal zone management with mangroves and other coastal tree cover as protection from storm surges (climate or earthquake induced) as quantified for the 2004 Tsunami in Sri Lanka[17] and Indonesia[18], respectively, and for tropical cyclones in the Philippines[19]. Coral reefs in front of a coast may provide stronger protection from waves than any tree-based coastal vegetation, but coral reefs may disappear unless the sediment load of rivers is controlled – a service in which tree-based land use helps as part of a ridge-to-reef concept of land/seascape management.

2. The relevance of agroforestry and tree cover for protecting water resources on small islands is not essentially different from that on larger land masses and their

watershed management as a social-ecological priority, linking biophysical cause-effect relationships with local knowledge and socio-economic benefit streams[20,21,22].

3. Biological diversity of high vulnerability to invasive competitors, predators, pests and diseases calling for strict phytosanitary standards and *ex ante* studies preceding any planned introduction. Special *Tectona grandis* (teak) populations developed on Muna island (south of Sulawesi) with affinity to other Sulawesi provenances and likely human spread from mainland SE Asia in the past 1000 years[23]. A large-seeded Kenari (*Canarium indicum*) population was identified on Nissan island[24]. Banana's and plantain have followed human settlement across small islands[25]. Explicit attention to genetic diversity within species of a human-induced dispersal history can be rewarding, especially where it links to local knowledge[26,27,28].

4. Retain local production of perishable goods (vegetables, fruits) while potentially outsourcing major, storable staples; spice-agroforestry as historical focus on high value goods to join in global markets. The accounts of agroforestry in the eastern parts of Indonesia[29] and the Pacific[30] by make this point. The Dusun systems of the Maluku have a long history of combining spices with high-value per unit weight, with food crops for local use, including fruit trees and sago[31]. On the isolated Indian Ocean island of Soqotra (Republic of Yemen), an arid tropical climate and an annual period of isolation as winds weren't conducive for sailing boats, have moulded the local livelihoods and culture, with a prominent role for homegardens[32].

5. Lack of institutional segregation of 'forestry' and 'agriculture' due to their obvious and tight integration in the land- and seascapes, avoiding some of the challenges of continents and larger islands. While rainforests of the Solomon islands had often been described by Western scientists as untouched, pristine or virgin, they are actually sites of former settlement, with evidence of extensive forest clearance, and agriculture based on both swidden and intensified irrigation practices[33]. Where historically agriculture and forest were seen as part of an integrated land use pattern in many small islands, integration of such islands in unitary states has posed new challenges. Swidden cultivators and sago extractors living on the edge of lowland rainforest in central Seram, Maluku, have had to counter threats to their traditional agroforestry resource base posed by government-sponsored settlement and logging[34,35]. The traditional resource management rules known under the term 'Sasi' in Maluku are under pressure but can offer new meaning in the current re-appreciation of ecosystem services[36]. The main challenge in this respect is to reconcile local knowledge, the concepts on which public policy is based, and science-based quantification of environmental service functions rather than form and compliance with definitions[37].

6. Human diversity on small islands is associated with localized identity, and rich ethnobotanical and local ecological knowledge as basis for a wide range of location-specific agroforestry systems[38,39]. Clarke[40] commented on the irony that modern, aid-funded attempts to promote externally designed agroforestry in the Pacific, a region where agroforestry systems were developed thousands of years ago and where hundreds of species of trees are still used in a be wildering variety of ways.

Lazrus[2] discussed the perspective that island communities are not merely isolated, small, and impoverished but that they are often deeply globally connected in ways that reject such simple descriptions and will be essential for the world to accept just and equitable climate solutions[41].

7. Once the primary obstacles to transport are overcome, forms of (eco)tourism are a major opportunity to capitalize on the favourable climate, local identity, scenic beauty and social coherence of small islands. This pathway to development, however, can also be a challenge because of excessive demands on local resources, privatization of previously communal assets, increased social stratification, invasive exotics and global homogenization. The stories of how trees have been traditionally integrated with local culture and livelihoods can certainly be used to strengthen a marketable branding.

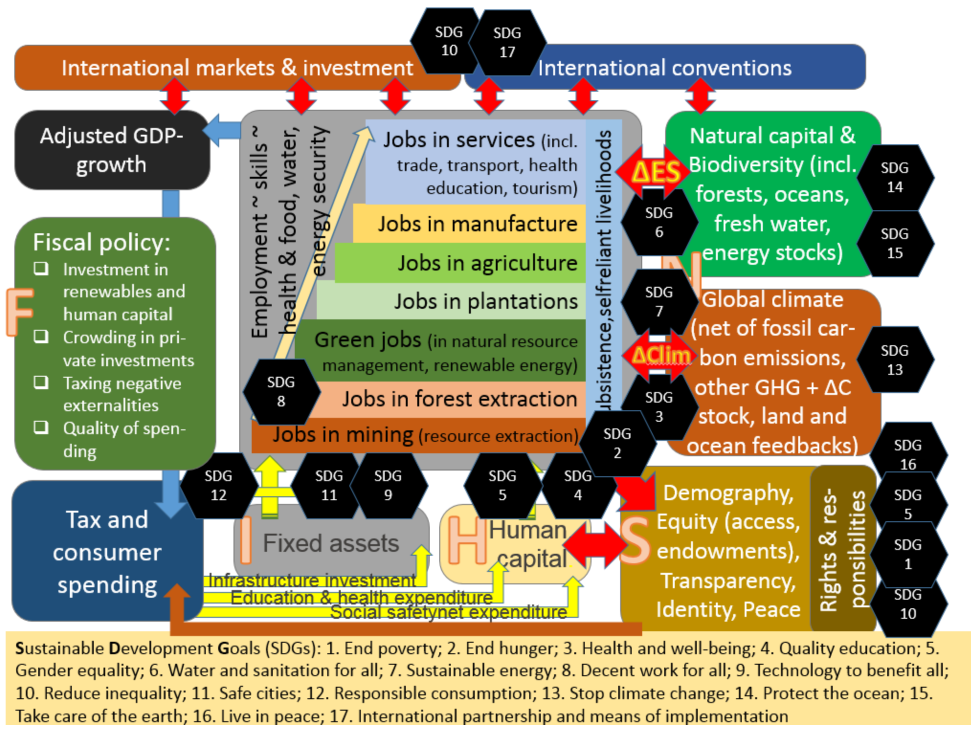

Figure 13.6 Outline of a dynamic model of the five capitals (N, H, S, F, I; natural, human, social, financial and infrastructural, respectively) in a national (or jurisdictional) economy[4]

13.5 Discussion

The sustainable development debate can be approached from many angles, but a focus on the sources of livelihoods, jobs and employment can be a powerful way to communicate with governments from local to national levels. In an outline of a dynamic model of a regional economy (Figure 13.6) four main types of jobs can be recognized, that are based on: A) resource extraction (incl. much forest management), B) primary production (incl. much of agroforestry attention so far), C) value-addition and manufacturing (that the 'value chain' and agroforestry-market line of research explore), and D) service-sector jobs. Where economic development can generally be understood as based on a progression from A to D as dominant segment of economic activity, small island extractive industries are restricted to high-value products (A), primary production is not easily shifting from meeting local to global market demands (B), while the economies of scale for stage C are limited. The logical step is to rapidly progress to D, before failed efforts in A, B or C have destroyed too much of the local ecosystem services as potential selling points for ecotourism.

The Ecosystem Services paradigm[42] is first of all a service-sector concept (see the language used), but one that interacts with the other three: trying to contain and control the extractive sectors, nudging the primary production sector into more ES friendly forms (incl. the certification debates[43]), controlling negative aspects of industries in stage C. New perspectives on the way small-island agroforestry can reinvent itself in an era of climate change and sustainable development goals can build on the positive dimensions of local identity and biodiversity in shaping eco-tourism as an advanced economic sector initiative.

References

[1] Pelling M, Uitto JI. 2001. Small island developing states: natural disaster vulnerability and global change. *Global Environmental Change Part B: Environmental Hazards* 3:49–62.

[2] Lazrus H. 2012. Sea change: island communities and climate change. *Annual Review of Anthropology* 41:285–30.

[3] Olwig KF. 2005. *Global culture, island identity*. London, UK: Routledge.

[4] van Noordwijk M, Duguma LA, Dewi S, Leimona B, Catacutan D, Lusiana B, Öborn I, Hairiah K, Minang PA. 2018. SDG synergy between agriculture and forestry in the food, energy, water and income nexus: reinventing agroforestry? *Curr Opin Environ Sustain* 34:33–42.

[5] van Noordwijk M, Mbow C, Minang PA. 2015. *Trees as nexus for Sustainable Development Goals (SDG's): agroforestry for integrated options*. Policy Brief 50 ASB Partnership for the Tropical Forest Margins, Nairobi.

[6] van Noordwijk M, Dewi S, Minang PA. 2016. *Minimizing the footprint of our food by reducing emissions from all land uses*. ASB Policy Brief 53. Nairobi, Kenya: ASB Partnership for the Tropical Forest Margins.

[7] Thaman RR. 2002. Trees outside forests as a foundation for sustainable development in the Small Island Developing States of the Pacific Ocean. *International Forestry Review* 4(4):268–276.

[8] Minang PA, van Noordwijk M, Freeman OE, Mbow C, de Leeuw J, Catacutan D, eds. 2015. *Climate-smart landscapes: multifunctionality in practice*. Nairobi, Kenya: World Agroforestry Centre (ICRAF).

[9] Van der Molen MK, Dolman AJ, Waterloo MJ, Bruijnzeel LA. 2006. Climate is affected more by maritime than by continental land use change: A multiple scale analysis. *Global and Planetary Change* 54(1): 128–149.

[10] Comte JC, Join JL, Banton O, Nicolini E. 2014. Modelling the response of fresh groundwater to climate and vegetation changes in coral islands. *Hydrogeology journal* 22(8):1905–1920.

[11] Gillespie RG, Claridge EM, Roderick GK. 2008. Biodiversity dynamics in isolated island communities: interaction between natural and human-mediated processes. *Mol. Ecol.* 17:45–57.

[12] Graham NR, Gruner DS, Lim JY, Gillespie RG. 2017. Island ecology and evolution: challenges in the Anthropocene. *Environmental Conservation* 44(4):323–335.

[13] Chan E, Elevitch CR. 2006. *Cocos nucifera* (coconut). *Species Profiles for Pacific Island Agroforestry* 2:1–27

[14] Bullecer R, Arellano Z, Stark M. 2003. Participatory assessment of the coconut-based agroforestry in San Isidro, Bohol, Philippines. Paper presented during the 2nd Agroforestry Congress in Pili, Camarines Sur, Philippines.

[15] van Noordwijk M, Lasco RD. 2016. *Agroforestry in Southeast Asia: bridging the forestry-agriculture divide for sustainable development*. Policy Brief no. 67. Agroforestry options for ASEAN series no. 1. Bogor,

Indonesia: World Agroforestry Centre (ICRAF) Southeast Asia Regional Program; Jakarta, Indonesia: ASEAN-Swiss Partnership on Social Forestry and Climate Change.

[16] Roshetko J, Mulawarman SW, Oka IN, 2002. *Wanatani di Nusa Tenggara*. Prosiding Loka Karya Wanatani Se-Nusa Tenggara 11-14 November 2001, Denpasar, Bali. Bogor, Indonesia: International Centre for Research in Agroforestry (ICRAF) Southeast Asia Regional Program and Winrock International.

[17] Mattsson E, Ostwald M, Nissanka SP, Holmer B, Palm M. 2009. Recovery and protection of coastal ecosystems after tsunami event and potential for participatory forestry CDM–Examples from Sri Lanka. *Ocean & Coastal Management* 52(1):1–9.

[18] Bayas JC, Marohn C, Dercon G, Dewi S, Piepho HP, Joshi L, van Noordwijk M, Cadisch G. 2011. Influence of coastal vegetation on the 2004 tsunami wave impact in west Aceh. *Proceedings of the National Academy of Sciences of the United States of America* 108: 18612 – 18617.

[19] Cinco TA, de Guzman RG, Ortiz AMD, Delfino RJP, Lasco RD, Hilario FD, Juanillo EL, Barba R, Ares ED. 2016. Observed trends and impacts of tropical cyclones in the Philippines. *International Journal of Climatology* 36(14):4638–4650.

[20] Rahayu, S, Widodo RH, van Noordwijk M, Suryadi I, Verbist B. 2013. Water monitoring in watersheds. Bogor, Indonesia: World Agroforestry Centre (ICRAF) SEA Regional Program.

[21] Leimona B, Lusiana B, van Noordwijk M, Mulyoutami E, Ekadinata A, Amaruzaman S. 2015. Boundary work: knowledge co-production for negotiating payment for watershed services in Indonesia. *Ecosystems Services* 15:45–62.

[22] van Noordwijk M, Kim YS, Leimona B, Hairiah K, Fisher LA. 2016. Metrics of water security, adaptive capacity and agroforestry in Indonesia. *Current Opinion on Environmental Sustainability* 21:1–8.

[23] Watanabe A, Widyatmoko A, Rimbawanto A, Shiraishi S. 2004. Discrimination of teak (*Tectona grandis*) plus trees using selected random amplified polymorphic DNA (RAPD) markers. *Journal of Tropical Forest Science* 16(1):17–`24.

[24] Leakey RRB, Nevenimo T, Moxon J, Pauku R, Tate H, Page T, Cornelius J. 2009. *Domestication and improvement of tropical crops for multi-functional farming systems.* Proceedings of 14th Australasian Plant Breeding Conference and 11th SABRAO Congress, 10-13 August 2009, Cairns, QLD, Australia.

[25] Ploetz RC, Kepler AK, Daniells J, Nelson SC. 2007. Banana and plantain—an overview with emphasis on Pacific island cultivars. *Species profiles for Pacific island agroforestry:* 21–32.

[26] Thaman RR. 1994. Pacific Island agroforestry: an endangered science. *Science of Pacific Island Peoples* 2:191–222.

[27] Thaman RR, Clarke W, Manner HI, Decker BG, Ali I. 2017. *Agroforestry in the Pacific Islands: Systems for sustainability*. Tokyo, Japan: United Nations University Press.

[28] Maxwell JJ, Howarth JD, Vandergoes MJ, Jacobsen GE, Barber IG. 2016. The timing and importance of arboriculture and agroforestry in a temperate East Polynesia Society, the Moriori, Rekohu (Chatham Island). *Quaternary Science Reviews* 149:306–325.

[29] Monk KA, De Fretes Y, Reksodiharjo-Lilley G. 2012. *Ecology of Nusa Tenggara and Malukku*. Singapore: Periplus.

[30] Elevitch CR, Wilkinson KM. 2000. *Agroforestry guides for Pacific islands*. Holualoa, Hawaii: Permanent Agriculture Resources (PAR).

[31] Matinahoru JM. 2014. *A Review on Dusun as an Indigenous Agroforestry System Practiced in Small Islands. New Horizon of Island Studies in the Asia-Pacific Region*. Occasional papers Kagoshima University No.54 (December 2014)

[32] Ceccolini L. 2002. The homegardens of Soqotra island, Yemen: an example of agroforestry approach to multiple land-use in an isolated location. *Agroforestry Systems* 56(2):107–115.

[33] Bayliss-Smith T, Hviding E, Whitmore T. 2003. Rainforest composition and histories of human disturbance in Solomon Islands. *AMBIO* 32*:*346–352.

[34] Ellen R. 1999. Forest knowledge, forest transformation: political contingency, historical ecology and the renegotiation of nature in Central Seram. *Transforming the Indonesian uplands*: 131–157.

[35] Ellen R. 2004. Processing *Metroxylon sagu* Rottboell (*Arecaceae*) as a technological complex: A Case study from South Central Seram, Indonesia. *Economic Botany* 58(4):601–625.

[36] Ellen R. 2006. Local knowledge and management of sago palm (*Metroxylon sagu* Rottboell) diversity in South Central Seram, Maluku, Eastern Indonesia. *Journal of Ethnobiology 26*(2):258–299.

[37] van Noordwijk M, Lusiana B, Leimona B, Dewi S, Wulandari D, eds. 2013. *Negotiation-support toolkit for learning landscapes*. Bogor, Indonesia: World Agroforestry Centre (ICRAF) Southeast Asia Regional Program.

[38] Lebot V, Siméoni P. 2015. Community food security: resilience and vulnerability in Vanuatu. *Human ecology* 43(6):827–842.

[39] Lauer M. 2017. Changing understandings of local knowledge in island environments. *Environmental Conservation* 44(4):336–347.

[40] Clarke WC. 2008. *Agroforestry in the pacific islands*. Dordrecht, the Netherlands: Springer.

[41] Harrison S, Karim MS, eds. 2016. *Promoting sustainable agriculture and agroforestry to replace unproductive land use in Fiji and Vanuatu*. Canberra, ACT: Australian Centre for International Agricultural Research.

[42] Namirembe S, Leimona B, van Noordwijk M, Minang P. 2018. Co-investment in ecosystem services: global lessons from payment and incentive schemes. In: Namirembe S, Leimona B, van Noordwijk M, Minang P, eds. *Co-investment in ecosystem services: global lessons from payment and incentive schemes*. Nairobi, Kenya: World Agroforestry Centre (ICRAF).

[43] Mithöfer D, van Noordwijk M, Leimona B, Cerutti PO. 2017. Certify and shift blame, or resolve issues? Environmentally and socially responsible global trade and production of timber and tree crops. *International Journal of Biodiversity Science, Ecosystem Services & Management* 13(1):72–85.