POLICY BRIEF

Agroforestry in rice-production landscapes in Southeast Asia

Prepared by the World Agroforestry Centre Southeast Asia Regional Program for the Food and Agriculture Organization of the United Nations in collaboration with the ASEAN Working Group on Social Forestry

World Agroforestry Centre Policy Brief No. 90

Rice-production landscape in Indonesia, with scattered trees in the paddies and diverse homegardens on the periphery

Photo: James M. Roshetko

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Mango trees in a rice field in Lao PDR. Photo: World Agroforestry Centre/Prasit Wangpakapattanawong

Rice (*Oryza sativa*) is the main staple food of Southeast Asia and rice-production landscapes are a major landcover that provide food security, income, employment and vital environmental services to the region. Southeast Asia is a key supplier of rice, producing one-third of the annual global yield. Rice-production landscapes are threatened by climate change. The integration of trees into rice-production landscapes strengthens the resilience of farmers and agroecosystems to climate change. Unfortunately, the advantages and potential of trees to mitigate climate change in rice-production landscapes are under-appreciated. This brief highlights seven messages for how these benefits can be better utilized through policy integration.

Rice-production landscapes are areas where multifunctional land uses are dominated by the cultivation of rice (*Oryza sativa*). Rice grows in a wide range of environments, from irrigated and rainfed lowlands to upland areas in both tropical and temperate climates. Rice-production landscapes are the biggest human-made wetlands and are predominantly managed by smallholder farmers. Worldwide there are over 160 million hectares of rice-production landscapes (Statista 2018). The rice-production systems in these landscapes are largely monocultures in nature where rice is the paramount or only crop. In most circumstances at the field level, little to no management is apportioned to non-rice crops. However, in other places in the landscapes, such as on slopes, road sides, in home gardens and on banks around the rice fields, vegetables and other food and feed crops are often grown and trees are planted.

Approximately half of the world's population — 3.5 billion people — have rice as their staple food. In Asia, many people consume rice two or three times a day, obtaining 30–70% of their dietary needs from the grain. Three-quarters of the global rice harvest is produced from 80 million hectares of irrigated lowland rice. About 45% of that area is found in Indonesia, Viet Nam, the Philippines and Thailand (Mutert and Fairhurst 2002). Thirty-one percent of the global rice yield is produced in Southeast Asia (Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Thailand, Timor-Leste and Viet Nam) on 48 million hectares (FAOSTAT 2016). Roughly 40% of the world's irrigation water — 30% of the world's developed fresh water resources — are used to irrigate rice.

Rice-production landscapes are an important land-use system, produce a principal global food staple, and provide valuable environmental services.

No.	Key messages	Policy implications
1	Rice, the main staple food of Southeast Asia, which covers more than 10% of land in the region, is threatened by climate change.	The major climatic threats to rice production are 1) rising sea-levels; 2) reduced and erratic river flows; 3) water scarcity; 4) salinity owing to higher sea levels and saltwater intrusion; 5) increased carbon dioxide and higher temperatures; 6) pests, diseases and weeds; and 7) prolonged droughts. The threats need to be fully recognized and measures taken to counter the detrimental effects.
2	Agroforestation (integration of trees) of rice landscapes strengthens farmers' resilience to climate change by diversifying farm production and income, reducing risks associated with market fluctuations and varying crop yields, and strengthens resilience against pests, diseases and other biophysical threats.	Policies and programs are required that support land-use planning that helps ameliorate climate risks and develops market opportunities and links for agroforestry products and services, value chains, agri-businesses, or micro- and small enterprises by individual farmers and farmers' groups.
3	While trees in rice landscapes strengthen farmers' resilience to climate change by mitigating threats, they may also present disadvantages, particularly, competition for light, nutrients and water and impediments to mechanization.	Awareness should be promoted of design and management practices that limit the disadvantages of trees in rice landscapes.

No.	Key messages	Policy implications
4	Good planning and design is essential for successful integration of trees in rice landscapes. Planning should incorporate communities and farmers' objectives, technical expertise, successful local examples of agroforestry, market opportunities, species' selection, germplasm availability, and access to climate information.	Effective principles to plan and design the integration of trees in rice landscapes should consider both biophysical and socioeconomic components; include all relevant stakeholders; embrace both scientific and local ecological knowledge; create new knowledge by testing innovations at various scales; and share experiences and lessons learned freely with a broad array of people.
5	Successful implementation and management of trees in rice landscapes depends on engaging leading farmers, testing species and management options under farmers' conditions, cultivating farmer–advisor relationships, establishing individual farmer's or group nurseries, and providing adequate technical knowledge and skills.	Farmers' group approaches are recommended for sharing experience and knowledge to facilitate the establishment and management of trees in rice landscapes. Groups should be formed by interested farmers, with farmers and advisors working closely together to define group objectives, establish nurseries, design and manage demonstration trials, strengthen value-chains, and evaluate innovations and learning across the rice landscape.
6	Access to technical, climate and market information and training opportunities leads to success, builds farmers' confidence and sustains momentum, making farmers and other local stakeholders more self-sufficient.	Rural advisory services can effectively link farmers and other stakeholders with sources of information and training opportunities by implementing training, learning visits, study tours, and developing farmers' field schools, demonstration trials and farmers' enterprises. Development of rural information centres for agriculture and climate change at village, sub-district or municipality levels enhances farmers' access to information and technical services.
7	The advantages and potential of integrating trees in rice landscapes in Southeast Asia are currently under-recognized and should be prioritized for further research and support to contribute to regional livelihoods' and conservation goals.	Links should be developed between agricultural and forestry institutions in both government and non-government sectors to implement contextual agroforestry research and share knowledge between countries and institutions, with emphasis on encouraging regional learning toward realizing the vision of the ASEAN Economic Community.

Findings[1]

1. Rice production is threatened by climate change

Rice is the world's most important food staple and a key product in the global economy. Rice-production landscapes are principal land-use systems, sources of employment and livelihoods, and providers of environmental services (Catacutan et al 2017). The commodity and production systems are threatened by climate change, land degradation, and over-exploitation of natural resources.

Rising sea levels inundate river deltas and coastal areas that are important rice-production landscapes, making crop production impossible in some areas. The salinity associated with higher sea levels and storm surges reduces rice production in affected areas; rice yields decrease with increased salinity. Reduced, erratic and extreme rainfall and river flows disrupt rice production owing to water scarcity and flooding. Data indicates rice yields may reduce 17–40% during droughts. Increases in carbon-dioxide levels promote biomass growth at expense of grain production; higher temperatures also reduce yields by as much as 10% for every rise of 1 °C in night-time temperatures. The stress of climate change heavily influences some pests and diseases. Rice brown spot and blast increase significantly during droughts. More weed infestation and rice–

[1] A key source of the findings in this brief was *Agroforestry in rice-production landscapes in Southeast Asia: a practical manual.* See References.

Figure 1. Left: Trees adjacent to rice paddies diversify farm production and act as a windbreak to protect the rice without blocking sunlight; Right: Borders of rice fields can be narrowed or widened depending on tree species. Photos: World Agroforestry Centre/James M. Roshetko (left); FAO/World Agroforestry Centre/Prasit Wangpakapattanawong (right)

weed competition are forecasted by climate-change models (Wangpakapattanwong et al 2017). These factors threaten the security of farmers' livelihoods and food supplies in Southeast Asia.

2. Trees strengthen local resilience to climate change

Agroforestation — the integration of trees (Roshetko et al 2007) — of rice-production landscapes strengthens farmers' resilience to climate change by diversifying farm production and income, reducing risks of market fluctuations and varying crop yields, and strengthening resilience against pests, diseases and other biophysical threats. Trees on farms optimize the use of available natural, human and financial resources. The products and incomes from trees provide safety nets for post-storm or post-disaster periods when rice crops are damaged or destroyed. Planting trees on boundaries and in patches where rice is less productive (for example, infertile soil, rocky outcrops) enhances farm productivity.

The many benefits of trees in rice-production landscapes include the production of food and medicines; fuelwood; large and small timbers, poles and stakes; fodder and green manure; and income from the sale of those products. The environmental services from trees are equally important, including soil conservation; fallow improvement; nitrogen fixation and nutrient cycling; windbreaks; shade and micro-site enhancement; and water regulation. Trees also contribute to bund or dyke consolidation, boundary demarcation, and accessible straw storage. They provide habitat for wildlife, including insects, which have an intrinsic value of their own but may also serve as predators of pests. Additionally, trees increase carbon storage as well as systems' adaptation to, and mitigation of, climate change. Rice agroforestry landscapes integrate fish (for example, tilapia and common carp) and/or ducks that provide an agroecosystem where the farm animals add nutrients to the rice while serving as predators (feeding on insects, molluscs and weeds) and tree shade cools their habitats and provides fodder and other sources of food, with each component generating additional farm income and improving the efficient use of resources.

3. Disadvantages of trees in rice-production landscapes

Despite the many benefits, care must be taken when integrating trees in rice-production landscapes owing to the disadvantages they also create. Some tree species may provide habitat for pests and diseases of rice (they may also provide habitat for the natural enemies of those pests and diseases). This may be minimized by planting multiple tree species. The presence of trees, and their root systems, reduces the efficiency of mechanization. While mechanization of rice production is limited in Southeast Asia, in areas where mechanization occurs or is planned, tree planting should be on boundaries and bunds or in areas where machinery does not pass.

The greatest potential negative effect of trees in rice-production landscapes is competition for light, nutrients and water. Heavy shade from trees reduces sunlight levels, which decreases plant growth, vigour and grain yields. Heavy shade may also increase humidity or other microclimatic conditions that favour pests and diseases. Tree also compete with rice for nutrients and water. This is particularly problematic in environments where nutrients and water are limited. The following principles can reduce trees' competition with rice: 1) Trees should be planted in lines perpendicular to the sun's path to minimize shade; 2) trees should be pruned to maximize sunlight and rainfall for the understory rice crop; 3) trees with thin canopies and those that fix nitrogen should be favoured to respectively reduce competition and provide nitrogen-rich green manure.

4. Good planning and design is essential

To maximize the synergies of trees in rice-production landscapes and minimize trees' negative effects, good planning and design is essential. To avoid unforeseen, adverse outcomes, planning should encompass the entire landscape, including its biophysical, socioeconomic and political components. It is particularly important to consider the interaction of rice production with other land uses. All relevant stakeholders should be involved: female and male farmers, different ethnic groups, government agencies, conservation and development organizations, and the private sector (traders and businesses). The concerns and priorities of all stakeholders should be considered. Similarly, both scientific and local ecological knowledge should be incorporated in planning and design. Additionally, planning should include analyses of value chains and market opportunities, germplasm availability for prioritized tree and annual crop species, and seasonal weather forecasts and long-term climate scenarios.

Besides an inclusive approach, planning should target the creation of new, locally-relevant knowledge by testing innovations at various scales. The characteristics of rural households and farms play significant roles in the adoption of agroforestry innovations to achieve production that is economically sustainable, and which supports agrobiodiversity (Sabastian et al 2017). Testing should include the development of nurseries to produce germplasm of trees and annual crops, farmers' demonstration trials to evaluate innovations, learning visits and workshops to exchange knowledge, and market activities (harvesting, processing, grading, group sales, enterprise establishment etc) to strengthen the integration of farmer-producers into commodity value-chains (Perdana et al 2012). The design of these various activities should be conducted collaboratively with farmers, advisors (researchers and development specialists) and others. The main principles of planting trees in rice landscapes include wider spacing, planting along boundaries, and selecting species that have limited disadvantages or positive attributes (thin crowns, fix nitrogen etc) (See point 3 above).

The experience and lessons learned from planning through to implementation of activities should be shared freely with a broad array of interested people, who should be encouraged to visit successful sites to see for themselves. Local farmers, rural advisors and others will also gain new knowledge when visitors share their experience.

5. Farmers' group approach facilitates learning

A farmers' group approach effectively and efficiently reaches large numbers of farmers. Through opportunities to learn and innovate with peers, farmers' groups empower members by providing the knowledge and skills needed to enhance and diversify the productivity and profitability of their farms. The approach facilitates the testing of species and management options under farmers' actual conditions through the activities outlined in point 4 above: nurseries, demonstration trials, learning visits, workshops and farm enterprises. The development of strong relationships between farmers and advisors further strengthens the farmers' group approach. Improved technical capacity and awareness of governmental regulations that are acquired through extension training and strengthened through participation in farmers' groups will enhance the rate of adoption of innovative agroforestry practices (Sabastian et al 2017).

The groups should be formed of interested, motivated farmers. Groups should be inclusive and representative of the community, including women, men, youth, ethnicities and economic classes, with specific effort made to include disadvantaged groups. In all communities, knowledge of agricultural and natural resource management differs by gender (Mulyoutami et al 2015), thus, it is essential to have both genders involved in groups. Depending on cultural norms, it may be necessary to organize sub-groups by gender. In mixed groups, the minimum participation level of either gender should be 33%. The venue and timing of group activities should be scheduled to meet the availability of all members. Group leaders and advisors should work closely to define group objectives and plan activities, with members providing input and approval of the objectives and activities.

Figure 2. Left: Rice-fish landscape in Viet Nam; Right: Farmers in Viet Nam discussing a design of agroforestry.
Photos: FAO/World Agroforestry Centre

6. Rural advisory services and farmer-to-farmer dissemination

As with other agroforestry activities (De Royer et al 2016, Do et al 2016, Roshetko et al 2017), rural advisory and extension services successfully support the integration of trees into rice-production landscapes. These services provide access to technical information through consultation, training, learning visits and study tours, and publications, thereby building group members' knowledge, confidence and leadership abilities. The process of working together makes groups and individual members more self-confident and sustains momentum.

As external services are not always (and sometimes rarely) available, farmer-to-farmer dissemination is a recommended approach that provides timely knowledge and advice (Martini et al 2017). Building the capacity of the members of farmers' groups who are excellent communicators is the key to success (Franzel et al 2015). These 'farmer-trainers' should have their capacity enhanced through a series of specialized farmers' field schools, helping them to develop farmers' demonstration trials and plan related activities, and through links to research agencies. Developing technical material — such as manuals and information sheets — with farmer-trainers encourages their self-learning after formal training. The best advisory material combines short descriptive texts with clear, 'how to' diagrams and should be tested with farmers before publication. Radio and other communication media, such as mobile phones, can increase the dissemination of agroforestry information but production expenses and limited network coverage in remote areas can restrict effectiveness (Paramita et al 2014). Participatory development of agro-climatic advisories before, during and after cropping seasons helps communities synthesise their knowledge, plan and reflect on appropriate action (Simelton et al in press). Rural resource centres enhance farmers' access to information and technical services (Degrande et al 2015).

7. The advantages of trees in rice-production landscapes are under-recognized

The integration of trees in rice-production landscapes diversifies farm production and incomes, reduces the risks associated with market fluctuations and varying crop yields, and strengthens resilience against pests, diseases and other biophysical threats; all of which strengthens farmers and agroecosystems' resilience to climate change. Additionally, trees in rice-production landscapes optimize the use of available natural, human and financial resources and expand the number of products and environmental services provided from the same area of land. The importance of integrating trees in rice-production landscapes will increase as human populations and the accompanying pressure on land continue to grow. Yet, the advantages and potential of trees in rice-production landscapes are currently overlooked.

Recognition of the importance of integrating trees in rice-production landscapes should be strengthened, emphasizing their potential to contribute to national and regional goals for livelihoods, conservation and resilience to climate change. Links should be developed between agriculture and forestry institutions, conservation and development organizations, the private sector, and governmental agencies from the local to national scales (Van Noordwijk and Lasco 2016). Emphasis should be on the design and implementation of contextual agroforestry research and sharing of knowledge and experience between institutions and countries for regional learning toward realizing the vision of the ASEAN Economic Community.

Recommendations

Toward achievement of the goals of the Vision and Strategic Plan for ASEAN Cooperation in Food, Agriculture and Forestry 2016–2025, the authors recommend that ASEAN Member States consider the following.

1. Recognize the threats posed by climate change to the production of rice in Southeast Asia and take measures to counter them.
2. Modify or create policies and regulations that support the integration of trees into rice-production landscapes and increase market opportunities for the commodities, services and farmers' enterprises produced in the landscapes by individual farmers and farmers' groups.
3. Raise awareness of the disadvantages of trees in rice-production landscapes and the practices to reduce them.
4. Promote inclusive planning and design for integrating trees into rice-production landscapes that incorporate the inputs and objectives of farmers and all other stakeholders, utilizing both scientific and local knowledge to create new knowledge and innovations of local relevance.
5. Support the use of a gender-equitable farmers' group approach to effectively strengthen and build the knowledge and skills of individuals and groups of farmers to diversify the productivity and profitability of their farms, including the development of farmers' enterprises and greater integration of farmer-producers into value chains.
6. Enhance rural advisory and extension services as key sources of information, knowledge and advice for individuals and groups of farmers, embracing the concept of farmer-to-farmer dissemination by motivated farmer-trainers.
7. Prioritize the recognition of the importance of integrating trees into rice-production landscapes, emphasizing trees' potential to contribute to national and regional goals for livelihoods, conservation, and resilience to climate change, and for regional learning towards realization of the vision of the ASEAN Economic Community.

Short list of selected trees species for rice-production landscapes

No.	Species	Common name	Location and main uses
1	*Artocarpus heterophyllus*	Jackfruit	Adjacent to rice fields. Windbreak, shade, fodder and fruit production
2	*Azadirachta indica*	Neem	Adjacent to rice fields. Windbreak, vegetables, medicine, pesticide and fodder (minor)
3	Bamboo (many species)	Bamboo	Adjacent to rice fields. Windbreak and building material
4	*Durio zibethinus*	Durian	Adjacent to rice fields. Windbreak, shade, fuelwood and fruit production
5	*Garcinia mangostana*	Mangosteen	Adjacent to rice fields. Windbreak, fruit production, and shade
6	*Gliricidia sepium*	Gliricidia	Adjacent to rice fields. Fodder, green manure, soil improvement, fuelwood
7	*Mangifera indica*	Mango	In or adjacent to rice fields. Fruit production and windbreak
8	*Moringa oleifera*	Moringa	Adjacent to rice fields. Food, fodder, medicine and cultural uses
9	*Nypa fruticans*	Nypa palm	In or adjacent to rice fields. Biofuel, roofing, alcohol, sap used as livestock feed
10	*Paraserianthes falcataria*	Albizia, falcataria	Adjacent to rice fields. Windbreak, shade, green manure and timber
11	*Psidium guajava*	Guava	In or adjacent to rice fields. Fruit and fuelwood production
12	*Sesbania grandiflora*	Grandiflora	On bunds. Green manure, soil improvement, fodder, poles and fuelwood

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Correct citation

Roshetko JM, Finlayson R, Öborn I, Sabastian G, Perdana A, Martini E, Mulyoutami E, Mercado Jr A, Jamieson C, Simelton E, Sinclair F, Wangpakapattanawong P, Ratnamhin A, Prameswari D, Ekawati D, Shono K. 2018. *Agroforestry in rice-production landscapes in Southeast Asia.* Policy Brief no. 90. Agroforestry options for ASEAN series no. 6. Bogor, Indonesia: World Agroforestry Centre (ICRAF) Southeast Asia Regional Program; Jakarta, Indonesia: ASEAN-Swiss Partnership on Social Forestry and Climate Change; Bangkok, Thailand: Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific.

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ASEAN Working Group on Social Forestry (AWG-SF) is government-initiated network that aims to strengthen social forestry in Southeast Asia through the sharing of information and knowledge. AWG-SF established by the Association of Southeast Asian Nations (ASEAN) Senior Officials on Forestry (ASOF) in August 2005, linking government forestry policy makers directly with the civil society organizations, research organizations, academia, private sector, and all of whom share a vision of promoting social forestry policy and practices in ASEAN.

The **ASEAN-Swiss Partnership on Social Forestry and Climate Change (ASFCC)** is a Partnership Programme of ASEAN that aims to contribute to the ASEAN Mandate and Policy Framework through support for the ASEAN Working Group on Social Forestry and the ASEAN Multi sectoral Framework on Climate Change towards Food Security.