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Sustainable soil management for enhanced productivity and climate benefits in ASEAN

Key Messages

- Healthy soils are vital to agricultural productivity as well as to biodiversity, air and water quality, and climate regulation. However, around the world, unsustainable land use and farming practices are leading to rapid erosion and soil degradation, imperilling food security.

- Soil degradation is a serious problem in Southeast Asia, driven to a great extent by agricultural intensification as well as deforestation. Most of the available cropland is on slopes that are highly prone to erosion and have acidic, often badly degraded soils. Across the region, many soils now have low levels of nutrients and do not hold water well; many are also polluted.

- Sustainable soil management (SSM) works to protect and restore soil health by minimising soil disturbance (e.g. by avoiding tillage), adding protective covers, enhancing organic matter, improving nutrient and water management, and preventing soil contamination.

- Along with preserving soils' long-term productivity, SSM can reduce farmers' spending on water, fertiliser and pesticides. SSM also enhances ecosystem services; increases soil carbon storage, helping to offset greenhouse gas emissions, and boosts resilience to climate change impacts such as extreme heat, droughts, heavy rains, floods, and saltwater intrusion due to sea-level rise.

- SSM encompasses a wide range of practices, many of which have been successfully applied in the ASEAN region. Conservation agriculture, for example, combines three key SSM strategies: minimal or no tillage, soil covers (e.g. mulch or cover crops) and crop rotations. Biochar, a soil amendment approach made by burning biomass at high heat, with limited oxygen, has shown promise in several Southeast Asian countries. Contour farming and terracing have a long history in the region's uplands. Organic agriculture is gradually expanding.

- SSM interventions need to be tailored to the local context and may require policy support, incentives and financial assistance, especially at the outset. Broader issues may need to be overcome, such as securing land tenure for low-income farmers. Equity and inclusion must be prioritised to ensure that women and other marginalised groups can fully benefit.

- National policies and ASEAN frameworks and guidance already support SSM. A key next step is to better integrate SSM with agriculture, land use and climate policies and strategies and ensure that agricultural extension programmes have the tools they need to promote and support SSM.

Biochar. Photo credit: Flickr/Simon Dooley

Healthy soils are dynamic ecosystems that convert decaying material and minerals into plant nutrients (Bot and Benites 2005). They are vital not only for agriculture, but also for biodiversity, human health, clean water and air, protection from floods and landslides, and climate regulation (Fierer et al. 2021; Turbé et al. 2010).

Maintaining soil health requires good management to preserve the soil's physical structure, chemistry, organic matter content, biology and water permeation, in accordance with the local conditions and soil type (Fierer et al. 2021). Key factors that affect soil health include planting and tilling methods, the inputs used (e.g. fertilisers, irrigation), the selection of crops, and whether those crops are rotated (Stewart et al. 2018).

Soil health can be assessed by measuring the soil texture, bulk density, pH and organic carbon concentrations. Soil is considered to be degraded when it has experienced changes in its physical structure, chemical makeup, and/or biological and ecological composition that reduce its ecosystem functions and services (Lal 2015). As a result of unsustainable soil management practices, about a third of the world's land is considered to be moderately to highly degraded (FAO 2015b). This has implications for crop productivity, for the resilience of agriculture to climate change, and greenhouse gas (GHG) emissions, as degraded soils store significantly less carbon.

In Southeast Asia, soil degradation is a serious problem, driven by deforestation, land conversion and harmful agricultural practices, many of which have been adopted as part of intensification (Legoupil et al. 2015). Most of the available cropland is on slopes that are highly prone to erosion and have acidic, often badly degraded soils, and pollution from agricultural inputs (e.g. excess fertiliser, pesticides) as well as from industrial and urban wastewater has caused further degradation. Many soils now have low levels of organic matter and nutrients and do not hold water well; salinisation is also a problem.

Governments have long discouraged traditional practices that they saw as harmful to the land, especially swidden agriculture, but more recent studies have questioned those assumptions – and actually shown that it is modern farming techniques that have rapidly degraded soils across Southeast Asia, especially in uplands (Dressler et al. 2017; Jepsen et al. 2019). Biodiversity and other ecosystem services have declined, and though overall incomes have risen, livelihoods are more insecure.

The harnessing of major rivers for economic development has also come at a cost. The impact of hydropower dams on sediment flows in the Lower Mekong River Basin has been widely discussed (see, e.g., Intralawan et al. 2019; Hecht et al. 2019; Yoshida et al. 2020), but irrigation systems have also affected soil quality. In the Red River Delta, for example, networks of canals, ditches, dykes, sluice gates, and compartmented fields supported a major increase in productivity, but also concentrated pollutants in the soil and water and reduced sediment flows that historically restored soil fertility (Morton 2020).

Recognising the importance of healthy, fertile soils for food security and agricultural livelihoods, ASEAN Member States have prioritised land and water resource management, aiming to stop and reverse land degradation, increase biodiversity, and ensure long-term sustainability (FAO 2015b). Sustainable soil management – abbreviated as SSM for the remainder of this brief – is central to those efforts.

What is sustainable soil management?

SSM encompasses a wide array of practices designed to make soils healthier. The best techniques to use depend on the context, but the 2015 World Soil Charter lays out the core vision:

Soil management is sustainable if the supporting, provisioning, regulating, and cultural services provided by soil are maintained or enhanced without significantly impairing either the soil functions that enable those services or biodiversity. The balance between the supporting and provisioning services for plant production and the regulating services the soil provides for water quality and availability and for atmospheric greenhouse gas composition is a particular concern (FAO 2015a, Principle 5).

In practice, SSM works by minimising soil erosion, adding organic matter, improving nutrient and water management, protecting the structure of the soil (e.g. by avoiding tillage, but also by avoiding soil compaction), protecting the soil from contamination (e.g. by fertilisers and pesticides), and preventing salinisation, acidification or alkanisation (FAO 2017).

The main motivation for most farmers to adopt SSM is that it will benefit crop production, but SSM is also valuable for both climate change mitigation and adaptation. It increases soil carbon storage, helping to offset greenhouse gas emissions, and can also reduce the need for chemical fertilisers, which produce emissions of their own (Hou 2021b; Amelung et al. 2020).

In addition, by improving water absorption, SSM can reduce irrigation needs and increase drought resilience. Better-draining and protected soils can also better withstand torrential rains and recover more quickly from floods. These are important benefits in a changing climate, as Southeast Asia is expected to experience more extreme and variable precipitation and, in some areas, worsening droughts (Hijioka et al. 2014). There are also SSM techniques to manage saltwater intrusion, a problem that is growing in Southeast Asia due to sea-level rise and land subsidence.

Finally, SSM can enhance rural households' resilience to climate change and other shocks by reducing their spending on inputs and protecting their most valuable asset: the land they cultivate. The poor are disproportionately vulnerable to climate change impacts on agriculture (Hallegatte et al. 2015). By boosting their incomes, SSM practices could thus enable farmers to better provide for household needs, build up savings and diversify their livelihoods. This means that SSM can help reduce socio-economic drivers of vulnerability as well, further enhancing its value as a climate-smart land use strategy (Lal and Stewart 2019).

The sections that follow delve deeper into SSM approaches, how they have been applied in ASEAN, and how its Member States, individually and collectively, are working to advance SSM. The brief ends with recommendations for policy-makers, development partners, practitioners and researchers.

Understanding soils and their degradation

The essence of sustainable soil management, as outlined in the World Soil Charter, is using soils in ways that maintain their essential functions and the many services they provide. Doing so requires understanding the complex makeup of soils and the roles they play.

Soils are made up of five main components: mineral matter, organic matter, water, air or gases, and live organisms (for an illustrated, very accessible explainer, see Needelman 2013). Soil mineral particles can vary significantly in size: from sand, which can be as large as 2 mm in diameter, to silt, ranging from 0.002 to 0.05 mm, to clay, with diameters smaller than 0.002 mm. Organic matter is made up of plants, animals and microbes at various stages of decomposition. The nutrients that plants can take from the soil come from organic matter and minerals. Those two components also determine the texture of the soil, its pH, and its water absorption and drainage.

Live organisms in the soil play key roles as well. A teaspoon of rich soil can contain a billion bacteria (Needelman 2013). Some fungi have symbiotic associations with plant roots, helping them absorb nutrients. Microorganisms and insects can also improve the texture of the soil and help aerate it.

Some soils on our planet are millions of years old, while others formed after more recent volcanic eruptions, glacial retreats or other events that changed the landscape (Needelman 2013). Soil is created as rocks and other minerals weather, sediments and organic matter accumulate, and chemical processes alter the particles. It is a very slow process – the median documented rate is 0.15 tonnes per hectare per year, far slower than soils are eroding under conventional agriculture (FAO 2015b). Because of this, soil is considered a non-renewable resource that is essentially being mined for agriculture.

Soils are essential to human survival: about 95% of the world's food is produced in soil. As noted in the introduction, however, soils do far more than sustain agriculture. They are major carbon reservoirs, holding more carbon than is contained in the atmosphere and terrestrial vegetation combined (FAO 2015b). They take up and release oxygen and other gases (Needelman 2013). They provide habitat. They recycle wastes, store them and make them available as nutrients. Soils also play a key role in the water cycle, absorbing runoff and precipitation, making it available to plants, and transferring it slowly to streams and groundwater. In the process, they also filter and remediate pollutants – though the amounts of pollutants that flow into soils today often exceed their remediation capacity.

Indeed, human activities are imperilling all the ecosystem services provided by soils. Erosion is a particularly severe threat (FAO 2015b). Though some erosion occurs naturally, agricultural practices such as ploughing, disc-tillage and vegetation burning can destroy organic matter, break up the soil structure and leave soils more vulnerable to erosion (Bot and Benites 2005). Erosion is likelier to occur if soils are left exposed, without protective mulch or vegetation. Exposed soils are also more prone to salinisation, which occurs when soluble salts are not washed down through the layers of soil, but instead build up, affecting plant growth (FAO 2017). Southeast Asia has an estimated 20 million ha of saline soils.

The loss of organic matter is another serious problem, as it reduces soil fertility. To compensate, farmers then need to add chemical or inorganic fertilisers, which increases their costs. If inputs are improperly managed, excess nutrients can flow into water bodies, causing eutrophication, potentially polluting drinking water, and releasing nitrous oxide into the atmosphere (FAO 2017). The use of heavy farm equipment, on the other hand, can compact the soil, which reduces its aeration, water drainage and infiltration and can hinder seed germination and root growth.

Protecting and restoring soils requires action across multiple sectors, but especially in agriculture, which also has the most to lose from continued soil degradation. Box 1 summarises SSM guidance from the Food and Agriculture Organization of the United Nations (FAO). The next section describes key SSM techniques and their development and climate benefits.

Interseeded cover crops on a maize field.
Photo credit: Flickr/Lynn Betts

Box 1.

FAO guidelines for healthy, sustainable soils

In 2017, the FAO published voluntary SSM guidelines, building on the principles of the revised World Soil Charter (FAO 2017). They are designed to help a wide range of stakeholders to understand the basic goals of SSM and ways to achieve them. Below is a summary of the key points:

1. Minimise soil erosion: Erosion by water and wind is the most significant threat to soils and the ecosystem services they provide. Reduced plant and residue cover, tillage and other activities that destabilise the soil can increase erosion. Mulching, cover crops, intercropping, reduced or no tillage, protective vegetation (including trees and shrubs for wind protection) and special techniques for cultivation on slopes and along water can reduce erosion.
2. Enhance soil organic matter content: Organic matter plays a central role in sustaining soil functions and fertility. Erosion, land conversion, tillage and fire can cause it to decline. Adding compost, manure or other carbon-rich wastes, adding cover crops, and practising organic agriculture can improve organic matter content.
3. Foster soil nutrient balance and cycles: Excessive use of inputs can result in surplus nutrients, such as nitrogen or phosphorus, leading to eutrophication, water pollution and increased greenhouse gas emissions. Careful management of chemical inputs and greater reliance on organic matter and cover crops can help ensure nutrient balance.
4. Prevent, minimise and mitigate soil salinisation and alkalinisation: The accumulation of water-soluble salts may occur when a soil has high evapotranspiration rates or experiences saltwater intrusion. Efficient, low-pressure irrigation with good drainage can help avoid these problems. There are also techniques to reclaim saline soils, or new uses may be found, such as growing salt-tolerant plants.
5. Prevent and minimise soil contamination: Soil contamination can come from a variety of sources, including fertilisers, the application of manure containing veterinary drug residuals, pesticides and herbicides, and contaminated water. Contamination can be reduced when the application of chemicals is minimised and other potential contamination sources are mitigated.
6. Prevent and minimise soil acidification: Acidic soil is caused by the removal of base cations and overuse of fertilisers and may limit the availability of some essential plant nutrients and damage roots, impair plant height, and decrease seed germination. This is a common problem in uplands in Southeast Asia. Soil amendments and better input management can help correct it.
7. Preserve and enhance soil biodiversity: Soils are among the planet's greatest reservoirs of biodiversity on earth, and soil organisms play key roles in ecosystems services. Reduced biodiversity can impact a soil's productivity, carbon content and nutrient cycling, and lead to erosion control and instability. Soil biodiversity can be protected and enhanced through plant cover, organic amendments, minimising soil disturbance (e.g. by avoiding tillage), limited pesticide use, intercropping and restoration of plant biodiversity.
8. Minimise soil sealing: Soil sealing happens when land is converted and covered by infrastructure and/or settlements. This is of particular concern when urban areas expand into fertile cropland. Policies are needed to protect soils with significant ecosystem services including high soil carbon stocks, high biological diversity or high agricultural suitability.
9. Prevent and mitigate soil compaction: Machinery and livestock may cause soil stress and reduce aeration, water drainage and biodiversity, and limit root growth and seed germination. Minimising vehicular traffic, adding organic matter to improve soil structure, and planting crops (including trees and shrubs) with strong roots can help address this problem.
10. Improve soil water management: Sustainably managed soils absorb water quickly, store it so it is available to plants, and drain efficiently when saturated. When these conditions are not met, crops can be waterlogged, or else receive too little water. Efficient irrigation systems, surface and sub-surface drainage systems, and soil cover are among the techniques used to address this.

Source: Synthesised from FAO (2017).

Techniques for soil enrichment and protection

SSM aims to reverse soil degradation trends and improve soil quality. In order to be effective, it must be implemented in conjunction with crop, nutrient, water, pest, and farm power management for truly sustainable results (Kassam et al. 2013). SSM can take many forms, including techniques that are widely applicable as well as context-specific measures.

Among the most prominent SSM methods is conservation agriculture, which has three pillars: minimal soil disturbance (by reducing or avoiding tillage), permanent soil organic cover and crop rotation (for an in-depth discussion, see Chapter 5 of Critchley and Radstake 2017).[1] Crop residues are left on the land, chopped up and incorporated into loosened soil. An herbicide may be used to kill weeds. Planting is done by pushing seeds into the prepared soil with a cultivator drill. If there is a long period between harvesting and the next planting, a cover crop may be used to further protect the soil. Different crops are rotated to diversify soil bacteria and fungi, help protect against diseases and recycle and rebalance nutrients in the soil.

There is strong evidence that conservation agriculture helps farmers adapt to climate change (Mizrabaev et al. 2019), by increasing water use efficiency, protecting the soil from drying out – an important benefit in arid areas and as temperatures rise – and improving soil drainage. It can also help increase soil carbon storage, aiding in climate change mitigation. The reduced need for fertiliser and for heavy farm equipment can further reduce emissions.

Several soil enrichment practices can be used, as part of conservation agriculture or on their own, to increase the organic content of soils and minimise the need for chemical fertilisers. These include crop rotations with nitrogen-fixing legumes, the use of animal manure (including by grazing livestock on cropland), green manures (uprooted or cut plant matter left to decompose on the field), household refuse (such as kitchen waste), composts and clean ash, among other options (FAO 2017). One option that is gaining prominence is biochar, discussed further in Box 2. Soil amendments can also be used to adjust soil pH – for instance, lime for acid soils and compost for alkaline soils.

[1] See also the FAO's resources on conservation agriculture: http://www.fao.org/conservation-agriculture/.

Box 2.

Biochar use in sustainable soil management

Biochar is a carbon-rich product made by heating biomass, such as wood, manure or leaves, in a closed container, at about 400–600°C, with limited oxygen (Joseph and Lehmann 2009; Hou 2021a). The use of biochar has emerged as an important SSM approach, used to improve soil productivity, carbon storage and water absorption capabilities.

Biochar is highly porous and has chemical properties that make it useful in adjusting soils' pH (Anawar et al. 2015). It has also been used successfully to remove harmful pollutants in mine wastes, enabling the soil to support the growth of new plant species. Plants grown in biochar-enriched soil may also be more resistant to disease. Biochar can enhance the growth of beneficial microbes (Muhammad et al. 2018), and it has been shown to significantly increase phosphorus availability (Glaser and Lehr 2019).

In Thailand, soil amendment using biochar has been found to improve the organic matter, nutrients and cation exchange[a] capacity of soil (Sriburi 2016). Elsewhere in the Mekong region, notably Cambodia and Laos, where fuelwood is a primary source of household energy, wastes from charcoal production could be used as biochar materials to improve soil productivity (Haruthaithanasan et al. 2016). In Indonesia, biochar use has improved rice yields (Lakitan et al. 2018) and enhanced wetlands (Susilawati et al. 2021).

From a climate mitigation perspective, biochar use is valuable both as a way to improve soil carbon storage (Bis et al. 2018), and as a way to generate "negative emissions" with lower impacts on land, water use and nutrients than other options (Smith 2016). This has led some to suggest building artificial biochar mines (Thengane and Bandyopadhyay 2020). In light of its many uses, some authors have argued that biochar use is key to achieving the Sustainable Development Goals (Kumar and Bhattacharya 2020).

[a] Cations are positively charged ions of different elements in the soil that are drawn to the negative charge of clay mineral and organic matter components of soil. Improving the cation exchange capacity of degraded soils is key to retaining nutrients and correcting soil pH. To learn more, see http://www.soilquality.org.au/factsheets/cation-exchange-capacity.

Organic farming can incorporate (or be part of) SSM strategies, especially when it comes to increasing soil carbon content, using organic amendments to enrich soils instead of chemical fertilisers, and fostering biodiversity (FAO 2017). However, organic farmers often till their land to control weeds and, as noted above, conservation agriculture often uses chemical herbicides (Donovan 2020).

Finally, there are SSM techniques designed to protect soils in specific landscape types that are common in ASEAN countries. About 64% of Southeast Asia's cropland is in uplands (Dierolf et al. 2001), meaning that a large share of cultivation occurs on hills and slopes, where erosion is a particularly large challenge. A full 75% of Vietnam's land area is sloped, for example, half of it at more than 20 degrees (Tran 2015). In Indonesia, 61% of the land is sloped, more than two-fifths of it at over 30 degrees (Agus 2015).

Along with keeping the soil covered – which is helpful everywhere – there are specialised SSM approaches to reduce erosion on slopes (FAO 2017). They include contour planting (that is, planting along the contours of a hill, instead of vertically up and down it), strip cropping (often combined with contour planting, using secondary crops to protect and enrich the soil), agroforestry, grassed waterways or vegetated buffer strips, and a technique that is long established in the region: terracing.

When planting near rivers or other bodies of water –another common phenomenon in Southeast Asia – buffer strips, wetlands and cover crops can be used to minimise the loss of soil particles, nutrients and contaminants, which can also contaminate the water (FAO 2017).

SSM in Southeast Asia

The ASEAN countries face multiple challenges that make sustainable soil management a top priority: from the heightened erosion risks created by farming on slopes, to the already fragile and low-fertility soils in the uplands, to saltwater intrusion linked to sea-level rise and land subsidence, to the intense pressures on scarce farmland in countries with fast-growing populations, to the special challenges involved in traditional rice farming (Legoupil et al. 2015; FAO 2015b; Critchley and Radstake 2017).

Some SSM approaches have a long history in Southeast Asia. Terracing in particular has been used for hundreds of years to prevent soil erosion and conserve water on slopes (Deng et al. 2021) as can be seen in Bali in Indonesia and Ifugao in the Philippines. Shifting cultivation, which has declined sharply in the region, in part because policy-makers blamed it for land degradation, is increasingly recognised as far less harmful to the land than what has replaced it: intensive, often highly erosive cultivation (Heinimann et al. 2017; Valentin et al. 2014). Organic agriculture was once the norm, of course, but now it is extremely limited. As of 2017, the ASEAN countries with the largest areas under organic cultivation were Indonesia, the Philippines and Thailand, with 208,042 ha, 200,065 ha and 91,266 ha, respectively (Willer and Lernoud 2019). When measured as a share of total cropland, the Philippines' 1.6% – distributed across some 166,000 small farms – was an outlier; in the other ASEAN countries, the share ranged from 0.01% in Malaysia to 0.5% in Vietnam.

Organic agriculture is advancing in the region however. In 2018, for example, Vietnam approved national organic standards, the Philippines revised its own standards, and Cambodia issued a roadmap to promote organic agriculture (Willer and Lernoud 2019). Indonesia has actively supported a "1000 Organic Villages" project, and Thailand launched a project aimed at converting a million rai (160,000 ha) to organic rice production within three years. Both Thailand and the Philippines have also hosted major regional events to promote organic agriculture.

Conservation agriculture in its modern form, using specialised equipment, is still relatively new and limited in Southeast Asia, but there are examples of its successful deployment. In Cambodia, for example, conservation agriculture is being used to enable sustainable intensification (Swisscontact 2020). A study with smallholders in two villages in Siem Reap found that conservation agriculture improved yields and reduced the need to weed fields by about one-third (Edralin et al. 2017). Engaging service providers who provide mechanised field operations for small farms could help expand conservation agriculture, but a study in Battambang in Cambodia found that while some could already purchase and profitably operate no-till planters, others would need policy support to do so (Vernet et al. 2020). With that support, offering no-till planters could potentially boost business.

One SSM intervention with particularly great development potential – and climate benefits – in Southeast Asia is to use rice straw to improve the soil instead of burning it, the most common practice now, which emits carbon dioxide, methane and nitrous oxide and creates large amounts of smoke (Rosmiza et al. 2017). Straw left in the field, however, can also release methane emissions, and removing it helps with pest control. Returning those residues into the soil, however, can help stabilise soil structure, reduce soil density, add nutrients, improve water retention and transmission, provide energy for microbial processes, increase cation exchange capacity and enhance productivity. This is why in Japan and Taiwan, for instance, a majority of the rice straw is returned to the fields.

A study in prime rice-growing areas of Malaysia's Kedah and Selangor provinces found that, in part thanks to government interventions, farmers were aware of some productive uses of rice straw, such as for compost and for animal feed (Rosmiza et al. 2017). Better information and extension services, however, could raise greater awareness of these benefits and motivate more farmers to make the switch.

Intercropping to reduce erosion is another strategy that has been widely tested in Southeast Asia. One study in Aceh province, Indonesia found that soil conservation techniques can significantly reduce erosion on sloped terrain, but different crops work best for cocoa, areca and oil palm plantations (Satriawan et al. 2015). Plots bounded by low ridges and planted with maize worked best on areca plantations, while groundnut cultivation best protected cocoa plantations, and a legume called *Mucuna bracteata* worked best on oil palm plantations. Intercropping also significantly reduced soil nutrient loss.

A study in the Philippine province of Isabela, meanwhile, found that using pigeon pea as a cover crop in-between plantings of maize, combined with no-till cultivation, reduced soil runoff and erosion, particularly during peak rainfall, helping to ensure sustainable production on sloping lands while improving crop yields (Contreras et al. 2014). It also kept the soil cooler.

Similarly, in Lampung, Indonesia, in a hilly, previously forested area where the planting of young coffee trees on hills was accelerating erosion, the use of cover crops underneath the trees was found to significantly reduce erosion. So did another approach tested, conversion to agroforestry plantations, in which case trees would help to stabilise the delicate soil. The analysis found the two treatments could reduce erosion by 90–97% (Yustika et al. 2019).

Another study, also in Lampung, showed how the planting of selected crops can help restore degraded soils. Two species that can be used as bioenergy crops (for cellulosic bioethanol), Erianthus and Napier grass, were successfully grown on the site of an abandoned mine, with both chemical and organic fertilisers, and were found to improve the quality of the soil and its carbon content (Sekiya et al. 2014).

Though many SSM solutions are still relatively new and small-scale, at least in the ASEAN context, successful projects across the region and beyond provide examples that could be widely emulated. For instance, Dr. William Dar, now Secretary of Agriculture in the Philippines, has pointed to the Bhoochetana ("Revival of the Soil") initiative in Karnataka, India, as a model (Dar 2017; ICRISAT 2018). In that project, farmers were given "soil health cards", based on scientific analysis of their soils, to identify problems they needed to address, along with sustainable solutions.

Dr. Dar has also promoted a three-pronged approach to agricultural intensification, with socio-economic measures to help farmers become "agripreneurs", including training to help them adopt key technologies; ecological strategies, including sustainable soil management and crop diversification; and the adoption of new crop varieties that are more pest- and disease-resistant and more climate-resilient (Dar 2017). One key change is to move away from monocultures and into multi-crop farms.

Ensuring inclusion in SSM interventions

SSM holds great promise for Southeast Asian smallholder farmers whose livelihoods are increasingly threatened by climate change – including low-income households with limited land and little cash to buy farm inputs. However, realising that promise requires careful implementation to ensure that vulnerable households can truly benefit, that no one is left behind, and that no unintended consequences occur.

A study of projects to promote biochar in developing countries, for example, found that too often, it was taken for granted that the technology would meet farmers' needs, while in reality, the suitability and uptake of new approaches often depends on their implications for farm labour, land tenure, gender roles and the broader dynamics of farming (Leach et al. 2010). A holistic understanding of the context and social structures in a given place is thus as crucial as technical appraisals in ensuring the success of SSM measures. This is especially true when farmers are asked to significantly depart from existing practices.

ASEAN Member States have highlighted gender and social inclusion as key components of adaptation measures (ASEAN 2015). These objectives require meaningful participation in decision-making, access to and control over resources, benefit-sharing, and balancing power relations. Social inclusion also requires the removal of institutional barriers and expanding opportunities for all groups in society. However, limited resources and strict budgets often make it difficult to reach smallholder farmers.

The impacts of land degradation are most felt in impoverished areas and fragile ecosystems, particularly by those whose livelihood and/or subsistence depends on the natural environment (Critchley and Radstake 2017). Yet low-income farmers may lack secure access to land, which has been found to generally lead to greater investments in soil fertility and other sustainable practices (Meinzen-Dick et al. 2019). Farmers who only have land for a short period may be incentivised to maximise yields in any way they can, even if they may compromise future soil fertility (Eder et al. 2021). Secure, formal land tenure is thus particularly important to enable long-term investments in soil health and the adoption of SSM practices.

Gender dynamics can also affect both the success of SSM implementation, and the distribution of its benefits. Gender-based constraints have been found to limit the uptake of SSM practice (FAO 2020a). Compared with men, women have less access to education and training, paid jobs, finance and land, and they are also under-represented in decision making (Agrilinks 2020). However, the extent to which empowering women can affect the success of interventions aimed at improving soil health is not well understood. Building knowledge of how gender dynamics affect SSM adoption is essential to ensure that women and men benefit equitably.

For instance, rural women often experience “time poverty” because their daily activities are time- and labour-intensive (Zhang et al. 2019). SSM approaches may further disadvantage them by increasing their workload. There is also evidence that conservation agriculture and other SSM techniques disproportionally benefit men, as they often target traditionally masculine labour practices (Giller et al. 2009).

The knowledge of Indigenous Peoples also needs to be recognised, as their traditional practices protected the land for centuries before governments deemed them to be environmentally harmful, as noted earlier. Swidden cultivation is a prime example. Derided as “slash-and-burn”, it has been blamed for deforestation and banned as a result, although its central tenet, rotating cultivation and fallowing of land, has actually been shown to help the land recover, thus maintaining soil fertility (Dressler et al. 2015).

Indeed, a major study of Indigenous land management practices in communities in Bangladesh, Cambodia, India, Indonesia, Lao PDR, Nepal and Thailand found that shifting cultivation had been a suitable, if not indispensable, approach in upland areas (Erni 2015). Case studies in India and Thailand, for instance, found that shifting cultivation for household food production provided a safety net for farmers, enabling them to engage in riskier cash crop production as well. The analysis concluded that with sufficient, legally recognised access to land, these practices can viably meet natural resource management and household food security needs today. Indigenous farmers would benefit from support to increase productivity and access markets, the study noted, but it is crucial that such supports be provided in a truly collaborative way, with prior consultation with shifting cultivators and informed participation.

SSM in ASEAN and international policies and guidelines

All ASEAN Member States are signatories to the United Nations Convention to Combat Desertification (UNCCD) and have committed to the Sustainable Development Goals (SDGs). SDG target 15.3 is to “combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world” (United Nations 2015).

To address these commitments, seven ASEAN Member States have committed to setting land degradation neutrality targets, and some have published reports outlining the challenges each country faces, with actions that will be taken in the next decade or two to address them. For instance, Indonesia found that as of 2013, it had 24.3 million ha of land that had been degraded by inappropriate land use and a lack of soil and water conservation measures, and identified soil and water conservation measures to tackle the problem and stem a decline in agricultural productivity (Republic of Indonesia 2015).

Thailand has highlighted land use conversion and inappropriate land management as leading causes of soil degradation (Kingdom of Thailand 2017). Its three targets aim to restore degraded forests; restore/rehabilitate degraded land, emphasising the use of sustainable agriculture; and reduce soil carbon loss and increase soil carbon sequestration. Cambodia, meanwhile, has identified deforestation, agricultural expansion, climate change, pests and diseases, unsustainable land management, and infrastructure development as key drivers of land degradation (Kingdom of Cambodia 2018). Cambodia estimates that it has 4.45 million ha of highly erodible land and has identified sustainable soil management and the promotion of animal waste management for soil improvement as ways to achieve its targets.

Ensuring the success of SSM in ASEAN countries will require broad collaboration at the regional and international levels, as well as engagement with civil society, local authorities, the business community and citizens. SSM is best addressed as part of a broader sustainable land management agenda.

International soil governance dates to 1981, when the first Soil World Charter was adopted by FAO member countries. The Charter recognised the rapid rise in demand for food worldwide and how soil degradation could constrain the growth of food production (FAO 1982). The Charter was updated in 2015 to reflect new research and evolving challenges (FAO 2015a).

In 2012, FAO initiated the Global Partnership on Soil (GPS) Forum as a knowledge- and experience-sharing mechanism. The forum aims to connect land users to policy-makers at the regional and global levels for effective soil governance to ensure the health and productivity of soils across the world and position soils in the global agenda. The GPS has five pillars of action: promotion of SSM, awarenessraising, research, information and data, and harmonisation (FAO 2020b). Most recently, the FAO Council endorsed the Voluntary Guidelines for Sustainable Soil Management to complement the World Soil Charter by further elaborating principles and practices for incorporation into policies and decision-making (FAO 2017).

The Asian Soil Partnership (ASP), meanwhile, was established in 2012 after a regional conference on soil information in Nanjing, China. Building on a list of shared priorities relating to soil knowledge, technology and training, participating countries, including all 10 ASEAN Member States, established the partnership to facilitate the exchange of knowledge and collaboration on shared challenges. That work is guided by the Asia Regional Implementation Plan, which outlines five pillars to promote sustainable soil management by encouraging investment, promoting targeted research, enhancing soil quality and harmonising methods for sustainable soil management (FAO and Global Soil Partnership 2016).

Within ASEAN, soil governance is addressed in the Vision and Strategic Plan for ASEAN Cooperation in Food, Agriculture and Forestry (2016–2025). Strategic Thrust 4, "Increase resilience to climate change, natural disasters and other shocks", includes an action programme to promote good agriculture practices to "minimize the negative effects on natural resources such as soil, forest and water and reduce the greenhouse gas emission" (AMAF 2015).

ASEAN's Guidelines on Soil Nutrient Management provide practical advice on how to sustainably manage soils, nutrients, waters and crops in the region and how to formulate appropriate policies to promote sustainable crop production and soil health (ASEAN Sectoral Working Group on Crops 2017). The implementation framework in the ASEAN Guidelines on Soil and Nutrient Management directly contributes to the Vision and Strategic Plan for ASEAN Cooperation in Food, Agriculture and Forestry (2016–2025), addressing sustainable technologies and resource management, trade and economic integration, and resilience to climate change (AMAF 2015), ultimately aiming to ensure food security in the region.

An agenda for action

Widespread adoption of sustainable soil management practices is crucial to the long-term viability of agriculture in ASEAN countries. Land degradation is already a serious problem, and without SSM, the combined effects of erosion, salinisation, loss of organic matter, and climate change could sharply reduce agricultural productivity across the region. It is time to step up efforts to promote SSM and support farmers and the service providers who work with them in adopting appropriate SSM measures.

Upland farming near Lake Sebu in the Philippines. Photo credit: ILO/Allan Barredo

Recommendations for policy-makers

- Prioritise SSM in land use and agriculture strategies, reflecting the critical importance of healthy soils for long-term food security, rural livelihoods, biodiversity and climate resilience. This includes addressing land degradation risks associated with land conversion and/or agricultural intensification, integration of SSM in agricultural extension programmes, and realigning of farm subsidies and incentives to discourage harmful practices and facilitate SSM adoption.
- Integrate SSM into national climate change mitigation and adaptation policies and strategies, including Nationally Determined Contributions, as well in national policies designed to achieve biodiversity and land degradation neutrality goals. This raises the profile of SSM measures and may help attract international finance to support them. At the regional level, the ASEAN Climate Resilience Network can make this connection by collaborating with the ASEAN Sectoral Working Group on Crops to advance SSM in the region.
- Prioritise efforts to provide pathways to secure land tenure for farmers who do not currently own land. This is crucial to advancing multiple climate-smart land use objectives, and it is particularly important for SSM, as without secure land tenure, farmers have a strong incentive to maximise yields even at the expense of long-term soil health.
- Foster knowledge-sharing on SSM, including technology transfer, at the subnational, national and regional levels, aiming to build expertise on best practices for SSM within Southeast Asia, including approaches tailored to the region's landscapes, major crops and cultural contexts. Platforms developed for this purpose can also support the continued improvement of SSM guidance across ASEAN countries.

Recommendations for development partners and project implementers

- Tailor SSM interventions to the local context, ensuring that the chosen measures meet farmers' needs and are economically viable. Equity and inclusion are key: SSM implementation should not benefit men while excluding or disadvantaging women, for example, and they should ensure that low-income people and marginalised groups can fully participate and benefit.
- Strengthen monitoring of soil health, in collaboration with agricultural extension programmes, and share the information with farmers (e.g. as soil health reports), together with advice on locally appropriate SSM measures. The data should also be used as part of a monitoring and evaluation framework to track the effectiveness of SSM interventions and further improve them.
- Work with businesses that supply agricultural inputs and provide services to farmers (e.g. tilling) to promote SSM measures such as conservation agriculture as well as more efficient input use. Financial incentives and policy support may be needed to ensure the interventions are economically sustainable in the long term.
- Invest in soil restoration early and work with farmers to consider how different farming techniques and inputs will impact soil health in both the short and long term. Preventing early stages of soil erosion will reduce the need for costly rehabilitation efforts.
- Work with local land managers especially Indigenous Peoples and local communities to integrate their knowledge into conventional soil and land management.

Priorities for further research

- Communicate research findings on SSM practices to provide scientific evidence supporting their implementation in the region. This could include building on what has been outlined in the ASEAN Guidelines on Soil and Nutrient Management especially with regards to Good Soil Management Practices.
- Analyse soil health data to identify local, national and regional trends as well as commonalities across ASEAN countries (e.g. in specific landscape types, or in the cultivation of key crops) to inform policy and investment priorities and support agricultural extension programmes.
- Synthesise and expand the evidence base on how national policies in ASEAN Member States, as well as individual SSM projects implemented in each country, have impacted soil quality and land degradation, with a focus on identifying the most effective solutions.
- Build a more robust evidence base on gender and other social equity issues that are relevant to the implementation of SSM strategies, including successful approaches that explicitly address inequities and empower marginalised groups.
- Document and disseminate SSM practices of Indigenous Peoples in ASEAN.

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