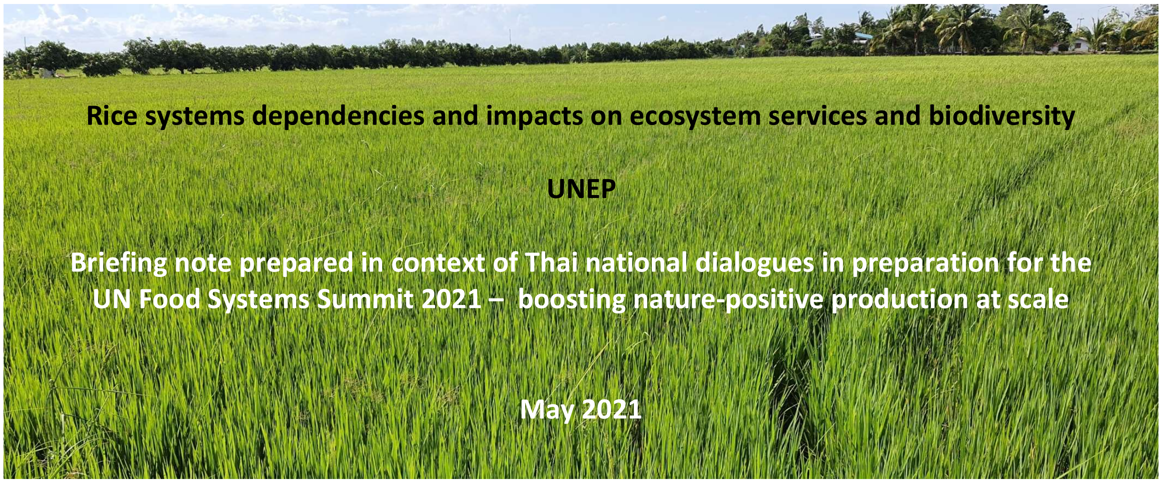

Rice systems dependencies and impacts on ecosystem services and biodiversity

UNEP

Briefing note prepared in context of Thai national dialogues in preparation for the UN Food Systems Summit 2021 – boosting nature-positive production at scale

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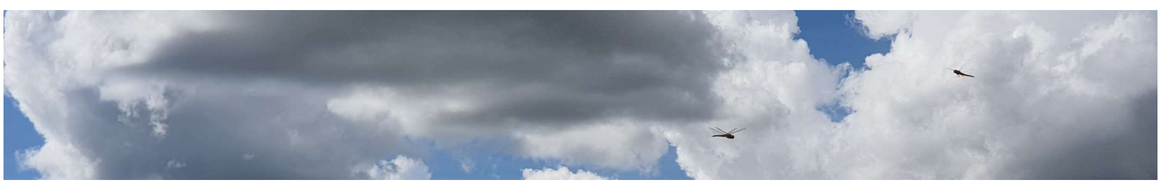
The importance of the rice sector in Thailand cannot be underestimated. Rice is grown on around 46 percent of Thailand's agricultural land, on about 11 million hectares (OAE, 2020). Approximately 4.4 million households produce rice, that is, around 1 in every 5 Thai households produces rice (OAE, 2020). Rice is the main staple food of Thai families, as it is for around half the world's population.

The upcoming UN Food Systems Summit (UNFSS) will explore ways to boost nature-positive production at scale. This underlines the need for sustainable management of existing food production systems to the benefit of both nature and people and the restoration and rehabilitation of degraded ecosystems and soil function. This note summarises key dependencies and impacts of rice production systems on ecosystem services and biodiversity, with a focus on literature and studies related to Thailand. Protecting and enhancing ecosystem services in rice agro-ecosystems would bring benefits for both large populations and the environment, at a scale that the Summit hopes to catalyse.



Rice production is **dependent on ecosystem services,** including freshwater supply and water purification, biological pest control and soil nutrient cycling. These critical ecosystem services benefiting farmers, local communities and society are under threat, in particular due to climate change and the progressive loss of biodiversity. Efforts to address these threats require a **systems approach,** needing action by actors beyond the rice sector and agriculture sector. Findings from scientific studies bring these critical dependencies into perspective:

- **Local climate:** Climate change presents serious threats and challenges to the development of agriculture in Thailand, especially rice production (Sekhar, 2018). In one recent Thai case study, five climate models were applied to emission scenarios RCP 4.5 and 8.5 in various sites; most projected that rice yields will decrease during 2006-2040 (Jintrawet et al, 2017). These changes are related to changes in rainfall patterns and increasing temperatures. Approx. 80 % of Thai rice fields are rainfed (Suwanmontri et al, 2021), and thus vulnerable to uncertain or untimely rainfall. In areas served by irrigation, competition for water resources is high and expected to increase, with restrictions already placed in drier years on rice farming (Ngammuangtueng, 2019). At higher temperatures, rice produces less, or no, grain (Nguyen, 2005). Rice yields in the dry season could be reduced by 10% as a result of a 1 °C rise in night-time temperatures (Peng, et al, 2004).

- **Biological pest control**: Agrobiodiversity in rice landscapes generates complex food webs benefiting both natural pest control and wildlife. Arthropods living in and around rice fields, such as damselflies, dragonflies and spiders, amongst many others, prey on rice pests, such as plant-hoppers and leafhoppers, keeping their numbers in check. Researchers have highlighted the productivity benefits of natural pest control, noting that mostly, tropical rice crops under intensification require no insecticide use (Way and Heong 1994, Heong et al, 2015). Several field studies have indicated that insecticide-treated rice fields have either lower or similar yields than untreated fields (Horgan et al 2016).
- **Nutrient cycling and soil fertility:** In rice fields, high biodiversity promotes trophic linkages which can enrich soil fertility (Edirisinghe and Bambaradeniya, 2006) and enhance rates of decomposition of organic material which is important for plant nutrition (Settele et al, 2018). Studies from the Legato project have shown that Silicon, a crucial nutrient which plants can source through rice straw decomposition, can improve rice crop resistance against pathogens, and prevent the uptake of toxic metals, as well as enhance rice yields (Klotzbücher et al, 2015). Different rice residue management practices were found to significantly influence the efficiency of organic matter decomposers (Schmidt et al. 2015). Earthworms can play a part regulating pathogens such as rice-blast disease (Blanchart et al, 2020) and their activity has been linked to higher rice yields (Choosai et al, 2010). Healthy soils with high biodiversity have an important role not only in producing healthy crops, but also indirectly in human health and nutrition (FAO et al, 2020).

Rice production increases value that people derive from nature, **enhancing ecosystem services.** Depending on the different practices applied to grow rice, and the priorities of the farmer, rice production can boost food production, provide for dietary diversity, generate usable secondary products such as rice straw, harbour a rich variety of wildlife species, sequester or release carbon, and can enhance cultural services. These potential benefits are of interest to many different agencies of government, for improved health and nutrition, environmental sustainability, economic prosperity, as well as agricultural development.

- **Food and raw materials production:** Thailand is self-sufficient in rice, and produces a large surplus for trade, making it one of the top rice exporters in the world, exporting rice grains to around 155 countries in 2020 (Thai Rice Exporters Association, 2021). In many areas of Thailand, rice farming has developed as part of a complex livelihood system. Rice farmers may rotate their fields with other crops, or grow a mix of crops on adjacent fields. Diversified cropping has been found to yield higher risk-adjusted return than growing only rice (Attavanich et al, 2019). Farmers may also grow productive trees on field borders. Livestock can be fed from crop residues, and fish may be reared in flooded fields as the rice is growing. Rice landscapes generate a wide variety of animal protein foods and micronutrient-rich fruits, and vegetables that supplements the diets of farming communities. Wild foods from plants and animals are a critical component in the subsistence system of rice farmers, such as in the Northeast of Thailand (Cruz-Garcia and Price, 2011).
- **Wetland habitat:** Within a single crop rotation, the ecosystem of a rice field encompasses a diversity of habitat states that are ephemeral which provide a variety of niches for diverse life forms (Edirisinghe and Bambaradeniya, 2006) including fish, frogs, crabs, prawns, turtles, mollusks and water birds as well as plant species at the field borders.

- **Pollination:** Rice crops do not depend on insects for pollination. However, integrating flower strips along rice bunds has been suggested as potential option to enhance pest regulation, pollination of other plants, and agritourism in rice production landscapes (Settele et al, 2018).
- **Soil organic carbon storage:** This is a key function of agricultural soils. Organic matter in soils is related to many ecosystem services such as improved soil health, soil drainage, nutrient retention, compaction mitigation and mitigating greenhouse gas emissions. Increasing soil organic content in sandy soils, as found in the less fertile rice paddies of the Northeastern region, can significantly increase yields and contribute to resilience to droughts (Arunrat et al, 2020).
- **Cultural services:** Rice systems also contribute to and can enhance intangible benefits for local populations. Landscape aesthetics form part of local shared cultural heritage. Farmer knowledge and skills in farming, management, herbal medicine, and spiritual rituals are important components of local cultural identity and community networks. Understanding cultural services can help agricultural extension services to develop effective communication methods towards the adoption of sustainable practices (Settele et al, 2018).

Modern intensive agriculture tend to demand trade-offs between provisioning and regulating/supporting ecosystem services, seeking productivity gains to the detriment of other ecosystem services. However, when regulating and supporting ecosystem services are disrupted, food production risks to be seriously affected, with diminishing returns (FAO, 2020). Key current concerns about the **negative environmental impacts** of conventional rice production include:

- **Pesticide use in agriculture**, including in rice production, has raised concerns for farmer and environmental health. Being toxic by design, pesticides can harm organisms other than pests, such as beneficial insects and soil organisms, aquatic life as well as humans (Praneetvatakul et al, 2012). Pesticide intoxication has been identified as a major public health problem in Thailand, caused by intensive use and exposure to pesticides (Tawatsin et al., 2015). A recent study in one central Thai province found that serum cholinesterase levels of rice farmers were unsafe and risky, with 68% of the farmers studied identified as having health risk from using pesticides (Santaweesuk et al, 2020).
- Rice production is a net producer of **greenhouse gas emissions**, mostly methane (CH4) due to flooding practices. Practices such as tillage, straw management, fertilization, irrigation, and crop rotation significantly affect emissions from rice (Arunrat et al 2017). Adaptations to drainage regimes are one of the most promising options for methane mitigation in rice production, and a low-tech option for small-scale farmers, especially in irrigated areas, saving water while maintaining yield (Islam et al, 2018). It has been estimated that CH4 emissions from rice can be reduced by up to 70% by removing rice straw between harvests, alternate wetting and drying techniques and improved fertiliser application (Food and Land Use Coalition, 2019).
- **Rice straw burning** is a practice adopted to clear fields, control weeds and release nutrients for the next crop. However, it also releases CO2 and other harmful gases and is an important source of coarse (PM10) and fine aerosol particles (PM2.5), contributing to air pollution and poor health outcomes. Government initiatives have discouraged burning, through temporary bans and promoting alternative uses. While previous estimates indicate much

higher incidence of burning in the country, it is estimated that currently a quarter (23.0%) of the total rice residues generated nationwide are subject to open burning (Junpen et al, 2018). The remainder is either left in the field or removed for other purposes including animal feed, mushroom production, soil amendments. Innovative ideas for alternative use of rice residues are also emerging, such as raw materials in biodegradable packaging production.

This briefing note has outlined some of the key dependencies of rice production on ecosystems services that are under threat, which services from nature can potentially be enhanced through rice production practices, and the risks and negative impacts that conventional rice practices bring to the detriment of food output, environmental stability and human health. The contributions of ecosystem services and the risks of ecosystem degradation however are not easily incorporated into policy making, as many of these services are economically invisible and are typically external to economic assessments and decisions.

The TEEBAgriFood initiative is engaged in assessing such costs and benefits through an integrated economic analysis, taking into account economic, social, health, environmental factors (see box). Through applied economic valuation techniques and predictive scenario modelling, researchers undertaking a TEEB assessment measure impacts and dependencies on nature over the long term. Presenting these different factors in economic terms helps to highlight costs and benefits that are normally hidden, and identify where trade-offs may exist between different policy objectives. It also helps to reveal where and how production goals can best be adjusted to maximise environmental and health benefits and minimize negative impacts. Assessments can point to where win-win opportunities may exist, by identifying policy options that can generate positive benefits for both livelihoods and the environment. Approaches that achieve multiple sustainable development goals are increasingly important as environmental risks are intensified due to climate change and as public budgets are being stretched by the systemic impacts of the current Covid 19 pandemic.

The Economics of Ecosystems and Biodiversity for Agriculture and Food (TEEBAgriFood)
TEEBAgriFood is an initiative of the United Nations Environment Programme (UNEP) which seeks to make visible the impacts and dependencies of the agri-food value chain on nature. These critical contributions and concerns are often not counted in economic transactions and are often overlooked in decision-making. In many countries, agricultural performance targets still focus on yields and increasing productivity per hectare. TEEBAgriFood can help policy makers recognize, measure, and capture the values of biodiversity and ecosystem services into their policy decision-making and strategies for sustainability of the agrifood system.

In Thailand, the TEEBAgriFood initiative focusses on **organic and sustainable rice production**, with funding from the German government and the European Union, in collaboration with the Office of Natural Resources and Environmental Policy and Planning ONEP, Ministry of Natural Resources and Environment. A multidisciplinary research team led by Khon Kaen University is conducting an assessment of the value of ecosystem services and biodiversity in organic rice production, with first results expected in Q2 of 2021. A second project assessing the commercial rice sector, focusses on the application of Sustainable Rice Platform (SRP) Standard and Indicators in Thai rice landscapes. Thailand joins nine other countries (Brazil, China, Colombia, India, Indonesia, Kenya, Mexico, Malaysia and Tanzania) in piloting the TEEB for Agriculture and Food initiative around the world.

For more information :
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