Tackling emissions from agriculture: a perspective from the Mekong countries

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Key messages

- **Agriculture is culturally and economically important for the Greater Mekong Subregion (GMS) and is also responsible for a significant amount of greenhouse gas emissions.**
- **To complement wider climate change mitigation efforts, there is a need for innovation in the agricultural sector to reduce carbon dioxide, methane, and nitrous oxide emissions.**
- **The three main causes of on-farm emissions in the GMS are rice cultivation (25%), animal husbandry (23% enteric fermentation), and synthetic fertilizer application (15%).**
- **While many innovative solutions already exist for reducing emissions from these activities, a lack of awareness and capacity, and insufficient support from policy frameworks, are holding back their adoption.**
- **For low-emission innovations in the agricultural sector to reach the necessary scale, it is vital to increase their economic attractiveness, to strengthen knowledge about their impacts and ensure they meet the needs of adopters and contribute to livelihoods and wellbeing.**

1. Introduction

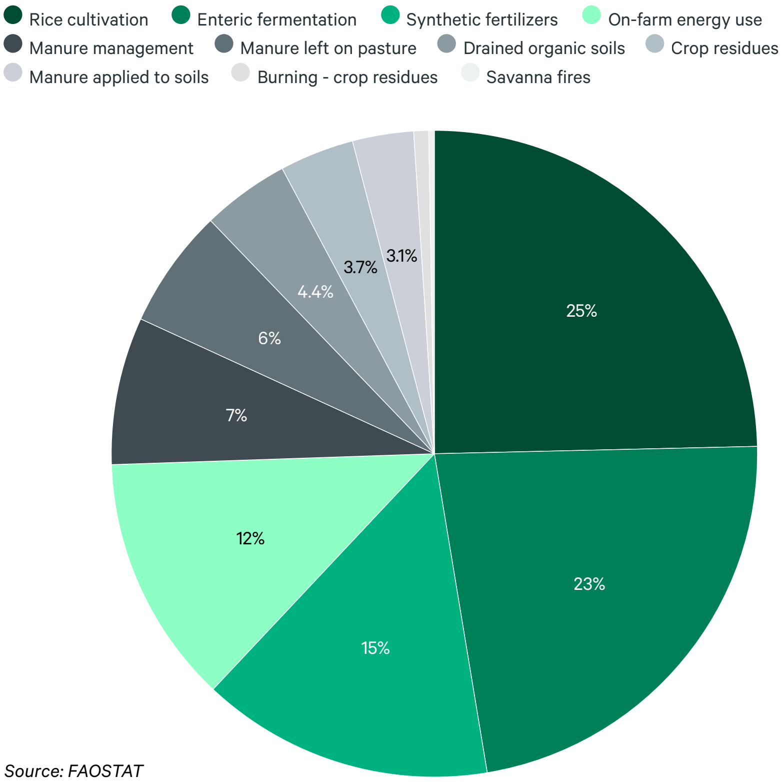
The agricultural sector is of great importance for the Greater Mekong Subregion (GMS), which spans six countries: China, Cambodia, Lao PDR, Myanmar, Thailand, and Viet Nam. In 2021, these countries produced around 40% of the world's rice.[1] But agricultural activities, which include the cultivation of other important crops such as cassava or sugar cane (of which Thailand is the fourth and fifth largest producer in the world), and animal husbandry, generate a significant amount of greenhouse gas emissions. Taking account of only emissions from on-farm activities (excluding transport emissions from and to the farm, for instance), agriculture in the Mekong countries released about 1.1 Gt of CO_2-eq,[1] or about 2 to 3% of global greenhouse gas emissions in 2020. As shown in Figure 1, more than half (63%) of those emissions come from just three categories: rice cultivation (25%), animal husbandry (23% enteric fermentation), and synthetic fertilizer application (15%).

While on-farm emissions in the GMS are minor in comparison to other sectors such as energy, and while on-farm emissions are also significant in other regions (see Figure 2), it is necessary to tackle agricultural emissions in the GMS for several reasons. First, emissions from the agricultural sector did not decrease in recent years and are likely to grow in the future, because decarbonization efforts in other sectors have been prioritized.

IMAGE (ABOVE): Woman rowing boat in the Mekong River Delta, Vietnam

1 See FAOSTAT: https://www.fao.org/faostat/en/#data

Figure 1: Emissions from GMS on-farm activities in CO_2-eq (2020)



Source: FAOSTAT

In China, for example, studies have shown that agriculture is likely to become the country's second largest emitting sector in 2050 (Chen et al., 2022). Second, the large majority of those agricultural emissions are not CO_2 but methane (CH_4) and nitrous oxide (N_2O), accounting for 54% and 32% of CO_2 equivalent emissions in the GMS, respectively. Both gases have a significantly higher warming potential than CO_2 and are usually less well covered by policies and reduction efforts than carbon dioxide emissions. Third, while in other sectors adoption of low-emission policies and solutions such as renewable energy has been increasing, in the agricultural sector adoption of innovative low-emission technologies and practices is relatively low, particularly in the Mekong countries. Below, we examine the socio-economic and policy barriers to adoption and scaling of low-emission agricultural technologies and practices, and present potential high impact solutions and policy options to support them.

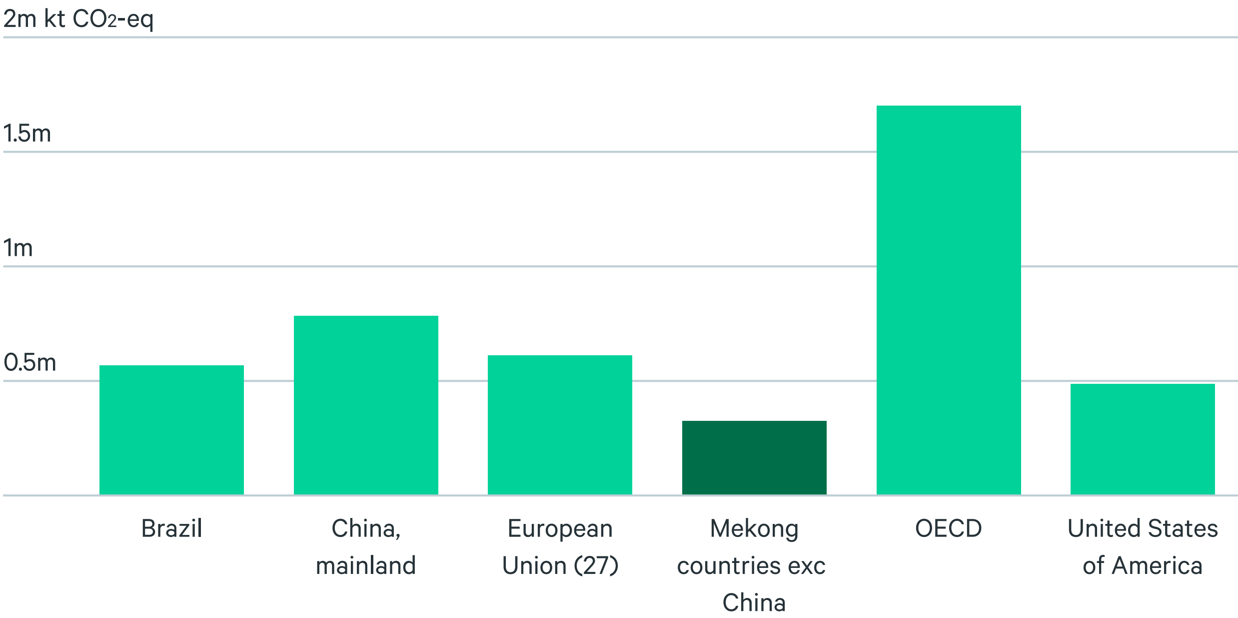
2. Barriers to the adoption of low-emission agriculture

Agricultural activities account for between 12% and 23% of GDP in GMS countries (including forestry and fishery), with China and Thailand, for example, being more economically diversified than Cambodia or Lao PDR.[2] The International Labour Organization estimates that between 24% of the labour force (China) and 58% (Lao PDR) are employed in the agricultural sector in the GMS countries.[3]

At the same time, the FAO estimates that millions of people in the region remain food insecure (FAO et al., 2022), which puts pressure on local food systems to increase output. In addition, some conventional agricultural systems and practices are highly embedded in local traditions and customs, making low-emission alternatives less attractive if they

2 The World Bank Data: Agriculture, forestry, and fishing, value added (% of GDP)
3 The World Bank Data: Employment in agriculture (% of total employment)

Figure 2: Comparing GMS on-farm emissions to other countries and groups (data from 2020)



Note: China illustrated separately for better comparison.
Source: FAOSTAT

fail to fulfil the same socio-cultural functions. These factors make people less inclined to experiment with new technologies and practices, especially when they lack safety nets. In addition, low margins on agricultural sales and food insecurity amplify the consequences of potential harvest losses that might result from experimentation.

Knowledge gaps are another barrier to the adoption of low-emission innovations in the Mekong countries: stakeholders will be more reluctant to embrace low-emission agriculture without strong evidence of what works and what does not and how exactly low-emission technologies or practice will affect soil, plants, and people in a specific place. While there is mounting evidence that many low-emission agricultural technologies and practices, such as precision agriculture, organic fertilizer use, or systems of rice intensification (SRI), have a positive impact on yield and profitability, as well as on soil health and biodiversity, this evidence originates from case studies concentrated in the Global North (and China). Knowledge about the effects and impacts of low-emission agriculture remains scarce in other regions such as Africa and Asia (Bößner et al., 2023).

Another barrier to progress is the lack of training and relevant information for farmers in the region on how to adopt and use new low-emission technologies and practices. Research has shown that stakeholders are often insufficiently informed about such technologies and practices (Bößner et al., 2023), most of which require farmers to learn new skills in order to be mastered. And while adopting a new rice cultivation method, for instance, might have a positive impact on yield and profits in the long term, learning curves and the need to experiment might have negative impacts at first, particularly in the absence of strong scientific or practical evidence.

There are policy barriers, too. Although each of the GMS countries has strategies and development plans in place to tackle emissions and transition towards a low-emission society, many plans lack ambition or are not detailed enough, particularly in the agricultural sector. Concrete, verifiable targets are often missing and only a few policy documents explicitly mention innovative low-emission agricultural technologies and practices. Similarly, dedicated support, such as subsidies and grants to encourage adoption of certain low-emission alternatives, is mostly lacking. It is vital, however, because low-emission solutions and practices are often unable to compete with more established forms of agriculture due to entrenched habits, a lack of scale, and existing financial support to carbon intensive practices such as subsidies for nitrogen fertilizer or fossil fuel consumption. Other policy barriers, including insecure land rights and tenure issues, often add to the challenge of providing financial support for adoption of low-emission solutions.

Finally, there are also structural barriers. For instance, some innovative technologies such as biochar (which can improve soil fertility while sequestering carbon) usually require a rather elaborate supply chain at scale: someone needs to collect the biomass, bring it to a processing centre and then distribute the biochar to consumers. This can be challenging to achieve in the region because, according to estimates, 70–80% of farms are less than 2 hectares in size (Lowder et al., 2016), thus making it difficult to aggregate demand and supply to create the necessary scale for novel technologies and practices.

3. High-potential high-impact solutions

Rice cultivation, livestock rearing, and the use of synthetic fertilizers make up the bulk of agricultural emissions in the GMS thus making these activities important targets for low-emission innovation. There are multiple options to address emissions from these sources.

Emissions from rice cultivation are mainly comprised of methane, which is released by bacteria that decompose organic material while the rice paddies are flooded. Rice alone is responsible for 10% of global methane emissions (Dina, 2022). A group of practices, called system of rice intensification (SRI), which include planting younger seedlings and spacing them more widely, applying organic fertilizer, and practicing alternate wetting and drying (AWD) rather than constant flooding, can reduce methane emissions by well over 50% without negatively affecting yields (Ishfaq et al., 2020; Mboyerwa et al., 2022). Another practice, which involves skipping the traditional method of seeding and growing rice in a nursery first (before transplanting it to fields), is direct-seeded rice (DSR), which can reduce over 90% of methane emissions while also saving water, as case studies have shown (Liu et al., 2022). Researchers are also investigating genetic modifications of rice plants to lower their emission intensity and to make them more drought resistant (Li et al., 2020; Northrup et al., 2021; Su et al., 2015).

Besides those emissions related to growing rice, residual rice straw is often burned on fields after harvest, which emits carbon dioxide as well as methane, and causes air pollution. In Vietnam's Mekong Delta, for instance, 80% of the 29 million tons of rice straw produced annually is burned in the fields (Dina, 2022). Solutions to avoid these emissions include turning these crop residues into agricultural inputs such as biochar or animal fodder (Dina, 2022).

Emissions from livestock are caused by bacteria in the stomachs of ruminants, which break down plants in a process called enteric fermentation that accounts for 30% of global methane emissions (FAO, 2016). Potential interventions to reduce these emissions include optimizing the quantity and composition of feed (by precision feeding, nutrient targeting, ratio dry and wet matter, selection of ingredients), use of feed additives (such as oils, plant derivatives, fungi and algae), and optimizing animal health and breeding to maximize reproduction, food consumption and conversion efficiency, and to minimize diseases that limit productivity (Beauchemin et al., 2022; Palangi et al., 2022). According to recent estimates, deploying these interventions could reduce livestock emissions by up to 30% (OECD & FAO, 2022), though there is a need for more research on their side-effects and long-term implications. It is important to note that even when mitigating enteric fermentation emissions a range of critical issues related to livestock production might remain, such as land use change, deforestation, biodiversity loss, degradation of natural grassland due to overgrazing, water and energy consumption, and health and wellbeing threats to both animals and humans (FAO, 2016; Herrero et al., 2009). Therefore, a shift to nutrient sources with lower emission intensity, such as insects or fungi- and plant-based nutrition, or the switch to monogastric livestock, particularly in countries where meat and dairy consumption exceed potential for sustainable production (as well as health guidelines), would reduce emissions and have a positive impact on the issues noted above (Adegbeye et al., 2020; FAO, 2018; Palangi et al., 2022; Steiner et al., 2020).

In addition to CO_2 and CH_4, nitrous oxide emissions are also a problem. They are mainly caused by the use of synthetic nitrogen-based fertilizer, thus accounting for 2.1% of global greenhouse gas emissions (Menegat et al., 2022). Around 60% of emissions associated with these fertilizers are field emissions. These arise when crops cannot take up any more nitrogen because they are saturated with it, and can be up to 50% of the applied amount (Ladha et al., 2005; Menegat et al., 2022).

Besides emitting a potent greenhouse gas without increasing productivity (Chivenge et al., 2021) the excessive application of nitrogen-based fertilizer also degrades soil and water quality (Pingali, 2012; Srivastava et al., 2020). One approach that optimizes nutrient inputs in relation to crop requirements is site-specific nutrient management (SSNM), which not only increases resource efficiency and productivity, but can also reduce greenhouse gas emissions by between 50 and 80% (Dwyer, 2023).

As well as techniques to improve the precision with which synthetic fertilizers are applied, there are also substitutes such as organic and green fertilizers. Switching to the use of manure as fertilizer, and the use of nitrogen-fixing cover crops such as legumes, are alternatives that can reduce both production and application emissions from fertilizers while still providing all necessary nutrients for productive soils.

Besides the above practices and technologies, there are many other interventions such as agroforestry, biochar applications, and paludiculture (i.e. the growing of crops and shrubbery on peatlands) that can reduce agricultural emissions, often while providing a host of co-benefits such as improved soil health, better water quality and availability, increased biodiversity, and reduced land degradation. It is therefore clear that many solutions exist, but the right policies need to be in place to facilitate their adoption at scale.

4. Policies to support the uptake of low-emission agriculture solutions

To develop effective policies, there is a need to strengthen the knowledge base for low-emission technologies and practices. Policymakers (and international donors) should do this by financing research into location-specific impacts and benefits of different solutions for soil, plants, and humans in GMS countries.

Powerful new information technologies, including drone and satellite imaging and soil sampling, have great potential to increase understanding of the impacts and benefits of different solutions . It is only if people on the ground can trust the positive effects of low-emission agriculture solutions that widespread adoption and scaling will become a reality.

Besides dedicated research programs, policymakers could help to implement multi-stakeholder learning networks, as well as peer-to-peer knowledge platforms where researchers, private sector players and potential adopters can come together to discuss best-practice examples and lessons learned. While peer learning might work best locally, learning networks could also be built transnationally, which would also help stakeholders understand what low-emission agriculture solutions are available and what they can achieve. Most importantly, learning networks would help adopters to gain the skills and competence needed to effectively and profitably embrace low-emission agriculture.

Another option that can support low-emission agriculture is to increase the ambition of existing policy frameworks by adopting concrete, verifiable targets, potentially for each promising technology and practice mentioned above. Moreover, targeted economic support, such as subsidies, grants and tax breaks (while at the same time doing away with counter-productive subsidies to emission intensive practices), could help to make low-emission alternatives more competitive compared to conventional agricultural methods. Other policy options include helping adopters to access tailor-made financial products such as zero interest loans, removing red-tape regulation, and securing land rights to incentivize private sector investment. Policymakers could also establish safety nets for adopters in the form of insurance and compensation policies should crops and harvest fail.

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