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Sustainable Agriculture

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A global-level quantitative synthesis fills current knowledge gaps on the potential of agricultural diversification on ecosystem services and the socio-economic benefits of rice.

Agricultural expansion and intensification following the green revolution significantly contributed to food security in many regions of the world in the second half of the 20th century. However, all this intensification also resulted in habitat and biodiversity loss, soil and freshwater degradation, environmental pollution, and greenhouse gas emissions worldwide[1,2]. There is a great expectation in the society, especially from the governance systems, for designing, implementing and supporting crop management practices that can address tomorrow's needs of addressing global food security while minimizing negative impacts on the environment, worldwide Despite several decades of research, the available empirical evidence on the potential of diversification on ecosystem service provisioning is widely scattered in scope, agronomic and geographic contexts, which is affected by the type and effectiveness of diversification strategy used[3]. However, for most staple crops, it is not known yet as to whether benefits due to agricultural diversification remain for specific regions, diversification practices, and crops.

Now writing in *Nature Food*, He et al[5] performed a quantitative synthesis of 40 years of research on global rice production to understand the effect of diversification practices on yields, economy, biodiversity, and ecosystem services of rice. By using a two-step method, the team performed a quantitative synthesis on the potential of agricultural diversification on environmental and socio-economic aspects of global rice production. First, they conducted a second-order meta-analysis showing that agricultural diversification can maintain soil fertility, nutrient cycling, carbon sequestration and yield. Then they used three individual first-order meta-analyses to close major research gaps on the effect of agricultural diversification on economy, biodiversity, and pest control. The study finds that agricultural diversification in rice production promotes win-win scenarios between yield and other ecosystem services in 81% of the investigated cases with an increased biodiversity by 40%, economic profitability by 26% and reduced crop damage due to pests by 31%.

He et al.'s study also identified knowledge gaps in understanding the spatio-temporal effects of specific rice diversification practices and trade-offs. The study highlights how, despite several decades of research, data availability still limits our understanding of agricultural diversification effects on the socio-economy, environment, and potential trade-offs in staple food production. The current knowledge gaps are due to many different factors and one of them could be the lack of consistent framework and definition of diversification in the scientific literature[6]. Therefore, the stakeholder community should work to build a clear framework and definition about agricultural diversification so that the produced primary knowledge can be easily retrieved and quantified for global policy initiatives and impact investment **(Figure 1)**.

The consideration of economic analysis by He et al.'s study brings added value to the literature because economic viability is one of the key factors affecting a large scale adoption or non adoption of a given practice. Indeed, diversification has been reported as an economically viable alternative for farmers in diversified systems including in agroecological farming[7]. However, widespread adoption of diversified cropping practices needs to be supported by coupling technological advances with socio-cultural and policy changes. This can ultimately transform agri-food systems to address pressing climate, economic, environmental, health and social challenges[8]. This involves three major changes[9–11]: production and transfer/diffusion of evidence-based knowledge and innovation on the socio-economic and environmental sustainability of diversification practices at the scale of the whole agri-food system; identification of socio-technical lock-in that hinders adoption of diversification practices, and improved governance systems for coordination among stakeholders. These major changes will provide suitable conditions for farmers to locally tailor diversification practices based on location specific primary knowledge.

Awareness is raising in the 21st century among the stakeholder community in agriculture to design, re-design and implement new research and policy paradigms that allow building sustainable and resilient agri-food systems which is increasingly advocated by the society today. To this aim, an increasing number of papers in the literature calls for a paradigm shift in research and policy and propose different frameworks and strategies[12],[13]. All this will require shifting paradigms toward valuing and promoting multifunctional agriculture at different spatio-temporal scales with a research agenda that untangles complex agricultural systems under current and future climate and land use changes. To this aim, we need far-sighted thinking that includes mixed crop-livestock and mixed livestock farming as part of agricultural diversification if we want to build sustainable and resilient agri-food systems **(Figure 1)**.

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Competing interests

The author declares no competing interests

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Figure 1. An overview of spatio-temporal agricultural diversification of cultivated and non-cultivated habitats where mixed crop-livestock and mixed livestock farming are part of the agricultural diversification. Future primary research should focus on location specific cases to understand the spatio-temporal variability in diversification effects on ecosystem service provisioning and cost-benefit analysis entailing contrasted cropping systems.