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EDITORIAL

Agricultural landscapes and ecosystem services in South-East Asia—the LEGATO-Project

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The present special feature of Basic and Applied Ecology focusses on the LEGATO project: "**L**and-use intensity and **E**cological en**G**ineering—**A**ssessment **T**ools for risks and **O**pportunities in irrigated rice based production systems" (http://www.legato-project.net/), which aims to advance long-term sustainable development of irrigated rice landscapes against risks arising from multiple aspects of global change. LEGATO is part of the framework programme 'FONA—Research for Sustainability', a funding scheme of the German Ministry of Education and Science—BMBF (http://www.fona.de/en/index.php).

LEGATO quantifies the dependence of the rice-dominated landscapes on ecosystem services (ESS) and the ecosystem functions (ESF) they are generated from. Its focal issues are: (i) the socio-cultural and economic contexts, (ii) local as well as regional land use intensity and biodiversity, and (iii) the potential impacts of future climate and land use change. LEGATO followed the framework of the Millennium Ecosystem Assessment (MA, 2005) by selecting characteristic elements of three MA strands of ecosystem services (ESS) for analysis: (a) Provisioning Services; (b) Regulating Services; and (c) Cultural Services.

As a core output, LEGATO develops generally applicable principles of Ecological Engineering (EE). EE is an emerging discipline, concerned with designing, constructing and monitoring of ecosystems, and aims at developing strategies to optimise ecosystem services through exploiting natural regulation mechanisms instead of suppressing them (see also Gurr, Wratten, & Altieri 2003; Mitsch 2012). For detailed field work, seven regions ($15 \times 15\,km^2$ each) were chosen, three in Luzon/Philippines (see Fig. 1), three in North Vietnam and one in the Mekong delta in South Vietnam. For their locations and further details on their climates, land-uses and soils see Klotzbücher et al. (2015a).

The analysis of soil processes as the basis for rice production is one focal theme of LEGATO research on ***provisioning ESS***. Klotzbücher et al. (2015a) investigated the status of plant-available silicon (=Si_{pa}) in all our research regions–which resulted in a surprisingly clearcut differentiation between Vietnam with low, and the Philippines with high Si_{pa} concentrations in topsoil. These differences can be explained by geo-/pedologic conditions. The authors assume that the large Si_{pa} concentrations in Philippine soils are mainly due to a large Si_{pa} input by weathering processes in these areas of volcanic origin during recent geologic history. In some Vietnamese sites, the concentrations of Si_{pa} were below critical values proposed in literature, and a field experiment conducted at one of the sites showed that addition of Si fertilizers indeed did enhance rice production (Marxen et al., 2015). In that article, the LEGATO researchers also demonstrated that rice straw decomposition is an important source of Si_{pa} in paddy soils. Hence, the removal of rice straw from fields, a frequent practice in the Vietnamese study regions, might contribute to the low Si_{pa} concentrations. Water management might also be an important factor for the silicon supply to plants, because irrigation can be a relevant Si_{pa} source (Klotzbücher et al., 2015b).

One important source of nutrients is the decomposition of organic materials. Schmidt et al. (2015a) studied invertebrate decomposers and showed that they substantially contributed to the decay of rice straw residues in paddy fields and thus might be an important factor influencing soil fertility and site productivity. Their efficiency was highest near the field borders, indicating a positive effect of surrounding landscapes. Furthermore, crop residue management practices were found to significantly influence decomposition by invertebrates as well as their community structure (Schmidt et al., 2015b). Future studies should evaluate in more detail how land management and landscape structure surrounding rice fields contribute to the maintenance of ecosystem services provided by invertebrate decomposers, such as nutrient cycling and soil fertility. This is also relevant as the Vietnamese government plans to promote the merging of fields and farms into larger units to enhance mechanisation opportunities and compensate for a decline in the farming population. The LEGATO results show that such policies entail the risk of losing nutrient cycling ESS, with a subsequent risk of losses in soil fertility and yield and increasing fertiliser demand.

Regulating ESS play a key role in irrigated rice ecosystems. Recently in many cases of core pests reaching outbreak levels the lack of natural enemies has played a key role—with the latter being mainly an effect of insecticide applications.

Fig. 1. LEGATO landscape near Batad within region "PH_3 Ifugao" (compare Klotzbücher et al., 2015a). These Amphitheatre-like terraces are part of the UNESCO world heritage sites of Ifugao province, N-Luzon, Philippines (© J. Settele).

To counteract the detrimental effects of ongoing land use intensification in rice production systems, these need to be managed in a more sustainable manner with the goal to conserve and enhance biodiversity and the provisioning of ecosystem services (Godfray & Garnett, 2014). Westphal et al. (2015) review management options for multiple ecosystem services and evaluate the merits of mass media campaigns and participatory approaches for more sustainable rice production. They conclude that generally, the implementation of flower strips within EE programs is one potential option to enhance pest regulation, pollination and cultural services, such as recreation, in rice production landscapes. However, more experimental studies are needed to identify seed mixtures and to analyse potential interactions between different spatial scales and ecosystem services. Rice farmers should participate in the development, research and evaluation of ecological engineering programs. The authors conclude that comprehensive EE programs are needed, which combine participatory approaches, mass media campaigns and flower strip implementation to motivate farmers and to increase the sustainability of rice production in Asia and to enhance ESS.

Cultural ESS are a frequently underrated component of landscape management. LEGATO investigates the multidimensional values and practices connected with nature or biodiversity relevant for rice cultivation. This is important as resource management and ecological awareness are socio-culturally determined and changes related to land and environment impact on e.g. traditional livelihoods or knowledge. In this regard, one important feature of ongoing LEGATO activities is the transfer of research results which need to be adapted to specific circumstances of local stakeholders (or farmers). For this undertaking the results of the three papers published in the present special feature will constitute important baselines.

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References

Godfray, H. C. J., & Garnett, T. (2014). Food security and sustainable intensification. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *369*, 20120273.

Gurr, G. M., Wratten, S. D., & Altieri, M. A. (Eds.). (2003). *Ecological engineering for pest management: Advances in habitat manipulation for arthropods*. Wallingford, UK: CABI, xi + 232 pp

Klotzbücher, T., Marxen, A., Vetterlein, D., Schneiker, J., Türke, M., Sinh, N. V., et al. (2015). Plant-available silicon in paddy soils as a key factor for sustainable rice production in Southeast Asia. *Basic and Applied Ecology*, *16*, 665–673.

Klotzbücher, T., Leuther, F., Marxen, A., Vetterlein, D., Horgan, F., & Jahn, R. (2015). Forms and fluxes of potential plant-available

silicon in irrigated lowland rice production (Laguna, the Philippines). *Plant and Soil*, *393*, 177–191.

MA/Millennium Ecosystem Assessment. (2005). *Ecosystems and human well-being*. Washington, DC: Island Press. Synthesis.

Marxen, A., Klotzbücher, T., Jahn, R., Kaiser, K., Nguyen, V. S., Schmidt, A., et al. (2015). Interaction between silicon cycling and straw decomposition in a silicon deficient rice production system. *Plant and Soil*, http://dx.doi.org/10.1007/s11104-015-2645-8

Mitsch, W. J. (2012). What is ecological engineering? *Ecological Engineering*, *45*, 5–12.

Schmidt, A., Auge, H., Brandl, R., Heong, K. L., Hotes, S., Settele, J., et al. (2015). Small-scale variability in the contribution of invertebrates to litter decomposition in tropical rice fields. *Basic and Applied Ecology*, *16*, 674–680.

Schmidt, A., John, K., Arida, G., Auge, H., Brandl, R., Horgan, F. G., et al. (2015). Effects of residue management on decomposition in irrigated rice fields are not related to changes in the decomposer community. *PLoS ONE*, *10*(7), e0134402.

Westphal, C., Vidal, S., Horgan, F. G., Gurr, G. M., Escalada, M., Chien, H. V., et al. (2015). Promoting multiple ecosystem services with flower strips and participatory approaches in rice production landscapes. *Basic and Applied Ecology*, *16*, 681–689.