

## Nature bestows agriculture with expensive gifts: do we recognize this enough?\*

A national consultation workshop on developing methodology for assessing the contribution of biodiversity to agriculture, food and nutritional security, and diversification of livelihoods was held recently.

Agriculture is the single largest threat to biodiversity globally<sup>1</sup>. Agricultural expansion and intensification are likely to increase in the wake of the rising population and its impacts on food, nutrition and livelihoods. Despite the central role that biodiversity plays in agriculture, food and nutritional security and in meeting livelihoods, due emphasis has not been paid in quantifying these roles and in exploring how the role played by biodiversity can further be augmented.

This workshop broadly covered two stages of assessing the contributions of biodiversity – methods to assess biodiversity itself with impetus on biodiversity science, and methods to estimate the economic value of these contributions, including that of provision of livelihoods to people. This was supplemented with a discussion on field implementation, where technicalities of on-ground work were examined. About 30 participants from various research institutions working on agriculture and biodiversity across India, including Indian Council of Agricultural Research bureau on plant, animal, fish, insect and microbe research, agricultural scientists, ecologists, economists and data scientists participated in the workshop. This multidisciplinary effort widened the scope of the workshop with different perspectives.

The workshop began with an introduction to the National Mission on Biodiversity and Human Well-being (NMBHWB). This was followed by an overview of the programme on biodiversity and agriculture under the NMBHWB, emphasizing

how biodiversity provides for sustainable intensification of agriculture, food and nutritional security and rural livelihoods. It was recognized that there was a dearth of information available worldwide regarding the contributions of biodiversity to agriculture and the allied fields of forestry and fishery and that there was a need to measure these contributions, however approximate they might be. Some issues – substitutability of resources, opportunity costs of collection, relative importance of resources based on preferences of the people and complexity involved in the interactions between entities in an agroecosystem – that could impede measurement were identified. Functional traits and network theoretical approaches could be used to understand interactions in agroecosystems. A videotaped interview with M. S. Swaminathan emphasized the need for improving the diversity, stability and sustainability of farms, by moving away from monocultures exploring new varieties, and being mindful about water security.

In the second session, the general framework of quantitative methods for assessing the contribution of biodiversity was discussed. Two ways of evaluating this contribution were highlighted – to measure presence or absence of biodiversity which would then provide likelihood of the contributions, or to measure the services provided by biodiversity. For a short-term study, rapid assessment of the former was deemed suitable. Moreover, provisioning and supporting services would be easier to measure than regulating services. It is important to note that these contributions do not simply add up. It would be prudent to identify the prime service in a particular context and evaluate it. For assessing biodiversity, simple index-based measures (species richness, diversity, evenness, dominance, rarity), model-based approaches or landscape metrics as surrogates for biodiversity can be used. In some cases, baseline biodiversity information may already be available. Benefit-transfer methods could then be used to translate existing biodiversity information into measures of ecosystem services. Fuzzy logic-based

methods are available to account for management practices in farms. Besides, sustainability and resilience of farms could be measured in terms of crop heterogeneity, income diversity, energy equivalents of practices adopted, to name a few.

Once biodiversity and/or services have been assessed, the total economic value (TEV) framework for evaluation of ecosystem services can be used to provide monetary estimates. TEV allows for both market and non-market methods. However, due caution is needed in the use of constructed market approaches. Identifying the boundaries of the system is important both in terms of the zone of influence of biodiversity, flow of ecosystem services and its evaluation. It would also be crucial for an emerging concept of payment for ecosystem services, wherein paying farmers for ecosystem services they maintain in their farms is envisioned as a way to enhance their incomes. Some limitations of economic evaluation were identified. Some services like climate mitigation happen at a scale not amenable to economic evaluation; therefore, it is important to retain some biophysical information. The number of people benefitted, for example, whose food and nutritional requirements are met, could also be a meaningful measure.

The role of spatial tools in large-scale analyses, spatially explicit mapping of ecosystem services and rapid assessments using secondary and spatial data were highlighted. While spatial information can be used to obtain coarse-scale data, there can be embedded case studies to obtain fine-scale information. Modelling approaches can be used to understand ecosystem services over different spatial and temporal scales. Space for time substitution methods can be used when temporal information is unavailable or inadequate. The trade-offs between ecosystem services must also be considered, especially that between provisioning and regulating services.

The third session focused on taxon-specific contributions and methods used to assess them. The role of insects in

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pollination and biological control was discussed. Functional diversity was deemed a more meaningful measure than species diversity. Some measures to obtain a functional understanding of a system include Rao's quadratic entropy, species abundance distributions and ordination techniques. It was suggested that habitat requirements of such insects be studied to get insights into management strategies at a landscape level. The role of agriculturally important microorganisms in agro-ecosystems was discussed. Some services that they render were identified – biofertilization, biocontrol, bioremediation (solubility of inorganic compounds), biofortification of crops (for example, Fe and Zn enhancement in maize), composting and alleviation of abiotic stresses. It was proposed that the measures for quantifying contributions of microbial biodiversity should start with N and P estimation in soil and plant, net N mineralization and analysis of microbial DNA using metagenome analysis. Microbial biomass can also be used as an indicator of soil health. Emphasis was laid on the keystone taxa – N-fixers, P-solubilizers and indicator genera. Finally, the importance of crop varieties for a resilient agroecosystem was highlighted. Methods to assess crop diversity and their contributions could include developing an agro-biodiversity index based on healthy diets, sustainable agriculture, current and future use options, and global hunger index scores. Unfortunately, most varieties get noticed only during adversity. Mainstreaming of crop varieties is faced with challenges like yield loss, profitability and marketability of the production. A systematic surveying and collection of these varieties from across the country was also called for.

The penultimate session focused on the contributions of biodiversity to livelihoods. The latent potential of aquaculture in the country was highlighted. Presently, only six species of freshwater fish are being used in aquaculture. Moreover, using wild fish populations for

aquaculture threatens them. Ways to improve aquaculture for livelihoods would depend on taste preferences of people, their nutritional requirement and the available diversity of fish in a region. Live germplasm resource centres can serve as stepping stones for research on new varieties, apart from conservation breeding of threatened species. It was also emphasized that restocking of wild populations would be futile if minimum flows are not maintained in the rivers owing to construction of dams across most rivers of the country. Next, the limitations of estimating contributions of biodiversity to livelihoods in general were discussed. There could be a myriad ways by which farmers may meet their livelihood requirements. A heterogeneous agricultural setting, inconsistent definitions, different survey methods and issues with up-scaling were identified as challenges. Sustainable livelihoods framework could be used to analyse livelihoods which encompass skills, assets and approaches used by individuals and communities. Some standard survey methods include household surveys and CIFOR's multidisciplinary landscape assessment. Cultural indices can be generated based on different use values of a particular species (spread of the use) and the number of sites in which the species is used. A combination of remote sensing and surveys based on transects can be used to generate spatially explicit livelihood benefit maps.

The last session considered the various aspects of field implementation of a typical study. The first step would be selection of sites based on some objective criteria. A hierarchical approach can be followed. After agro-ecological zones have been defined based on broad biophysical variables, more nuanced variables should be used for further site delineation. Other criteria could include land-use land-cover diversity, conservation value, human footprint index and variables pertinent to agriculture such as soil type. It was decided that at least

some of the work of the NMBHWB would be done in aspirational districts identified by NITI Aayog, which are largely based on socio-economic criteria. A protocol for sampling relevant taxa considering seasonality of crops and for socio-economic surveys at the household/village level as deemed suitable would be developed.

To sum up, the workshop covered various foreseeable challenges and opportunities in evaluating the contributions of biodiversity to agriculture, food and nutritional security, and livelihoods. It covered aspects of assessing biodiversity itself, econometric methods, spatial tools and nuances of designing such studies. By being open to the use of new tools, especially spatial tools, and combining them with embedded case studies, it might be possible to upscale our analyses and hence obtain a broader perspective. The next step would be to come up with a detailed protocol that covers the assessment of various taxa and their contributions in the field based on the recommendations from this workshop.

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1. Maxwell, S., Fuller, R., Brooks, T. and Watson, J., *Nature*, 2016, **536**, 143.

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