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REVIEW PAPER

Integrating biodiversity and conservation with modern agricultural landscapes

S. Kumaraswamy · K. Kunte

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Abstract To achieve food security and meet the demands of the ever-growing human populations, farming systems have assumed unsustainable practices to produce more from a finite land area. This has been cause for concern mainly due to the often-irreversible damage done to the otherwise productive agricultural landscapes. Agro-ecology is proclaimed to be deteriorating due to eroding integrity of connected ecological mosaics and vulnerability to climate change. This has contributed to declining species diversity, loss of buffer vegetation, fragmentation of habitats, and loss of natural pollinators or predators, which eventually leads to decline in ecosystem services. Currently, a hierarchy of conservation initiatives is being considered to restore ecological integrity of agricultural landscapes. However, the challenge of identifying a suitable conservation strategy is a daunting task in view of socio-ecological factors that may constrain the choice of available strategies. One way to mitigate this situation and integrate biodiversity with agricultural landscapes is to implement offset mechanisms, which are compensatory and balancing approaches to restore the ecological health and function of an ecosystem. This needs to be tailored to the history of location specific agricultural practices, and the social, ecological and environmental conditions. The offset mechanisms can complement other initiatives through which farmers are insured against landscape-level risks such as droughts, fire and floods. For countries in the developing world with significant biodiversity and extensive agriculture, we should promote a comprehensive model of sustainable agricultural landscapes and ecosystem services, replicable at landscape to regional scales. Arguably, the

S. Kumaraswamy
Robert Bosch Centre for Cyber Physical Systems, Indian Institute of Science, Bangalore 560012, India

S. Kumaraswamy (✉)
Department of Crop Physiology, University of Agricultural Sciences, GKVK Campus, Bangalore 560065, India
e-mail: kumar@cps.iisc.ernet.in

K. Kunte
National Center for Biological Sciences (NCBS), Tata Institute of Fundamental Research (TIFR), GKVK, Bellary Road, Bangalore 560065, India

model can be a potential option to sustain the integrity of biodiversity mosaic in agricultural landscapes.

Keywords Integration of biodiversity · Ecosystem services · Offset mechanisms · Network reciprocity · Incentive schemes and risk proofing · Agricultural landscapes

Introduction

Productive agricultural landscapes are under unsustainable transformation, leading to deterioration of ecosystem integrity and its services. Appropriate approaches and initiatives to revive the ecosystem functions are being intensively debated worldwide (Zhang et al. 2007; Doré et al. 2011). These are important to mitigate the decline and eventual loss of tree cover, poor species diversity, habitat fragmentation and changing land use patterns, which lead to unsustainable usage of natural resources and ultimately reduce productivity in agricultural systems (Atauri and Lucio 2001; Harvey et al. 2006; Bennett and Saunders 2010). Currently the focus has been on managing the inextricable biodiversity and ecosystem services so as to sustain the productivity of highly fragmented agricultural landscapes (Leakey and Tchoundjeu 2001; Chazdon et al. 2009). Over the years, ecosystem services in agricultural landscapes, viz., pollinators, genetic resources for crop improvement, gene banks of land races/wild type crops, habitat for natural predators, beneficial microbes, nutrient cycling capacity, soil fertility and watershed control, have deteriorated (IPGRI 1993; Barzman et al. 1996; Tilman 1999, 2000; Schimel and Bennett 2004; Sinzogan et al. 2004; Galluzzi et al. 2010; Parker 2010). In view of the current trends, the concept of offset mechanisms (compensatory and counter balance approaches to restore the original status of an ecosystem) should be relevant in restoration of biodiversity, resilience building and improving the adaptive capacity to mitigate the impact of climate change (Mendelsohn and Dinar 1999; Carroll et al. 2010). Offset mechanisms can be potential avenues in ‘mitigation banking processes, which is the creation, enhancement, restoration and subsequent preservation of species diversity in agricultural systems to maintain the integrity of the ecosystem and its services. This should enhance the biodiversity value with eventual restoration of ecological functions to sustain the productivity of an agricultural landscape. This type of offset mechanisms and agricultural ecosystem restorations are particularly important in developing countries with significant amount of biodiversity, extensive agriculture, and disturbing levels of income and social inequalities.

Eroding balance in the integrity of ecosystem matrices

Agricultural landscapes in developing countries may be highly heterogeneous with abundant tree cover that provides complementary habitats and resources that may be beneficial both for biodiversity and agricultural systems (Balmford et al. 2005; Acharya 2006; Matson and Vitousek 2006; Scherr and McNeely 2008; Fishcher et al. 2008; Ranganathan et al. 2010; Phalan et al. 2011). The tree cover may be in the form of forest fragments, trees in riparian zones, hedgerows, dispersed shade trees, fallow lands, and roadside shade and fruit trees, and offer habitat complexity. It connects a mosaic of landscapes with considerable native biodiversity, significantly enhances their services, and increases productivity of agricultural ecosystems (Tscharntke et al. 2005; Harvey et al. 2006; Donald and Evans 2006; Sekercioglu et al. 2007). Highly connected agricultural landscapes conserve greater diversity of keystone species compared to landscapes lacking connectivity and/or habitat complexity (Benton et al. 2003; Bennett et al. 2006; Loreau et al. 2003). In addition, agricultural landscapes with abundant tree cover spread across the farms serve as connected buffer habitat zones (Meinzen-Dick et al. 2004; Wallace et al. 2005), contributing to the maintenance of important ecosystem services such as pollination, natural pest management, carbon sequestration, and water and soil conservation (Daily 1997; Leakey and Tchoundjeu 2001; Soto-Pinto et al. 2002). Moreover, conservation of the native tree species diversity in agricultural landscapes offers a potential advantage as hotspots of ecological services. Trees are primary producers, and they may enhance species richness at higher trophic levels (Lee and Barret 2000; MEA 2005). The concept of land sharing (process of integration of biodiversity and conservation on the same land and/or contiguous land area), and sparing (dedicated land area maintained with common interests to separate intensive farming from protected ecosystems at the larger scale) has potential in most agricultural landscapes to enhance the overall biodiversity at all trophic levels with consequent sustenance of ecosystem services (Phalan et al. 2011). Further, the concept can be effectively applied to conserve generalist species in spared land and keystone species in shared farmlands. It facilitates deriving beneficial ecosystem services between farmlands especially in highly fragmented agricultural landscapes (Phalan et al. 2011).

Admittedly, overall biodiversity and ecosystem services contributing to productivity of agricultural landscape have assumed declining trends since the green revolution and industrial farming (Nair 2008; Powell et al. 2013). The current hypothesis is that these have reached irreversible stages of degradation of ecosystem integrity due to increased agricultural monocultures and fragmentation of complementary habitats from the farm to the landscape scales (Nair 2008). The qualitative and quantitative losses of biodiversity vary across the landscape. It is arguably difficult to quantify the changes using common indicators due to farm size variability and limited knowledge of biodiversity amongst farming community (Dale and Beyeler 2001; Perfecto et al. 2009). The historic knowledge on the biodiversity matrix of individual farms could be useful to design effective conservation strategies (Hodgson et al. 2009). In the recent past, faster changes in species composition, selective loss of species in home gardens, forest gardens, hedgerows, pastures and adjoining sacred groves is common in agricultural landscapes. Further, unplanned changes in farmlands also result in depletion of local species, primitive varieties and wild relatives, which are a source of ecosystem services unique to a landscape (Negri 2005; Jarvis et al. 2006). Analysis of such ecological changes will form the basis of understanding local to regional alterations to the species diversity of plants in agricultural landscapes. Hence, a time-integrated analysis at farm to landscape scale has implications to identify the early indicators that explain how ecosystem degradation alters ecosystem services (Daniels and Walker 1996; Swift et al. 2004).

There are several key factors that invigorate species diversity with eventual restoration of ecosystem services: the revival of forest fragments, riparian forests, agro-forestry systems, community-conserved remnant forest patches and establishing landscape connectivity (Nair 2008). It confirms the historical perspective that naturally wooded areas interspersed in agricultural farmlands are beneficial. This also shows that such mixed landscapes are useful for implementing biodiversity conservation initiatives including the recent concepts of land sharing and land sparing aimed at enhancing the mutualistic ecosystem services (Chazdon 2003; Harvey et al. 2006; Linborg et al. 2009; Phalan et al. 2011). At present, ecosystem integrity restoration practices are not designed in a location-specific manner. Interestingly, landscapes that are composed of many small farms often demonstrate a high potential for sustaining native biodiversity along with high economic value in terms of their key ecosystem services (Rosset 1999). These pockets of biodiversity islands vary across agricultural landscapes in size and species. Arguably, mosaics of smaller farmlands are highly suited for implementing conservation initiatives to enhance species composition and retaining native economic species, which may also utilize inputs from traditional knowledge (Chalmers and Fabricus 2007; Reed et al. 2007; Abbona et al. 2007; Singh and Sureja 2008). However, efforts to revive biodiversity of degraded agricultural landscapes through offset mechanisms invariably depend on the profile of land use change and management practices. Furthermore, trends of decline in species associations in a habitat structure and connectedness are critical to assess the success of conservation initiatives (Bennett et al. 2006).

Offset mechanisms: concept to practice

Definition, offset types and scope

Offset mechanisms can be defined as tools, methodologies, advocacy and policy changes that can compensate for damaging agricultural practices and bring about compensatory benefits to the local biodiversity and the people (Anonymous 2010). This necessarily addresses conservation and environmental issues, and the output of the offsets has quantitative and/or qualitative measurability. In the present scenario, revival of species diversity through offsets in agricultural landscapes, with consequent restoration of the ecosystem integrity and services, has special significance.

Offset mechanisms are considered to be flexible, commercially or socially consensus-based options, besides a hierarchy of conservation initiatives, to revive biodiversity in agricultural landscapes (Pretty 1995; Crooks and Ledoux 2000). Offset mechanisms can be categorized as: (i) on-site: self realization to diversify cropping and in situ conservation to support plant diversity for their services by the farmers and other stakeholders (farmers as off setter and farming community initiatives); (ii) off-site: biodiversity repositories in land of commons specifically for enhancing the services of native plant diversity (groups of farmers with common goal/local community motivated farmer groups as off setters) and (iii) off-site through third party and/or voluntary: development of off-site plant diversity repositories by local community groups and/or any stakeholders for the future benefit of the society (Public–private partnership). Operationally, offsets can be: (i) unilateral (landowners as offset developers and providers); (ii) bilateral (developed and provided by a landowner and a group of external developers in public–private operational mode), (iii) independent (e.g. involving bequest value in which outsiders are offset developers and provides) and (iv) bilaterally tradable (offsets supported and paid for landowners by outside stakeholders in exchange of ecosystem services).

On-site offset mechanisms are best suited to revive the ecological integrity at farm scale and may involve little cost. On the other hand, off-site conservation strategies require common guiding rules and may involve very high initial cost. However, achieving conservation elsewhere is difficult due to conflict of interests arising from highly heterogeneous community structure and perceptions of social hierarchies and vulnerability (Scoones 1999).

Usability and limitations

Offset mechanisms have flexibility to achieve success by way of linking to incentive schemes, environmental certification, green awards and crop insurances at various levels. It requires concerted efforts to reform policies to build mutualistic offset schemes, which consider farm to landscape approaches. Mutually agreeable offset mechanisms implemented in a locality help populate the agricultural conservation practices enabling responsible revival and/or integration of plant species diversity to accumulate provisioning and regulatory services (MEA 2005; Jackson and Hodgkin 2007).

Offset mechanisms can be suitably integrated into other complementary conservation initiatives. However, the narrowness of the definition in each offset type can be limiting in a broader approach to conserve spatially dispersed biodiversity of commons. Nonetheless, ingenious tailoring of the offset mechanisms in conjunction with location-specific conservation initiatives may be useful in achieving the integration and revival of biodiversity in agricultural landscapes. It has recently been suggested that context-specific knowledge and innovative, socially equitable approach by smaller land holding farmers may assist the success of conservation initiatives (Mcintyre 2009). In addition, offset mechanisms must consider participatory action research [(PAR: a collective research inquiry, voluntary participation and action of collaborative nature with mutual benefits to the stakeholders (researcher and the beneficiary)] to effectively utilize traditional knowledge on species in agricultural landscapes (Biggs 1989). Arguably, offset mechanisms can make larger impact in reviving the species diversity to restore the ecosystem services. However, several relevant questions that need critical attention include the level of participation by the stakeholders, social powers of participants, gender issues, caste discrimination, social roles within the communities as deterrents, social skills and interactive forces operating at various geographic and political scales. Some of these are major hurdles in designing a framework of common guiding rules for implementing offset mechanisms. A robust offset mechanism can be built through the evolution of consensus-based approaches, network reciprocity (mutual agreeable equity based participation of farming community irrespective of socio-economic status) and negotiation with strong leadership at local to regional levels. It requires mediating institutions, local government bodies, Non-Government Organizations (NGOs) and Self Help Groups (SHGs) as enablers and strong link for awareness and implementation (Rounsevell et al. 2003; Reed 2008).

Offset mechanisms require a critical view to strategically design stakeholder-friendly incentive schemes with consideration of land tax rebate, start-up operational funds, guidelines for contributory funds, award of conservation credit cards for the like-for-like swaps, linking conservation activities to crop insurance, and option to sell biodiversity and carbon credits irrespective of the market price and declaration of species diversity hotspots as reserve bio-banks (Kumaraswamy and Udayakumar 2011). The offset mechanisms and strategies to enhance the species diversity (annual and perennial plant) to revive ecosystem services must be considered at landscape rather than an impractical farm scale. Such a strategic approach can be best applied to fringe/corridors and land of commons for the revival of tree species in spared landscapes. Furthermore, biodiversity-rich smaller farms in a connected landscape can form hotspots and source of keystone species that provide specific ecosystem service/s (Bélair et al. 2010).

Offset mechanisms designed for restorative efforts must also consider resilience building at local to regional scales. The greatest resilience appears to occur in circumstances where stakeholders practice flexibility in terms of adopting offset mechanisms, and are well networked (de Soto 2000; Tittonell et al. 2009). However, the flexibility and networking may be constrained by larger social and economic factors operating at regional scales. This signifies that offset mechanisms designed for local farmland systems must suite cultural and economic profiles of the region as well.

Several conceptually sound and potentially implementable initiatives for integration of species diversity and revival of perennial species in agricultural landscapes have been problematic due to highly fragmented nature of habitats in some areas. This is mainly attributed to the heterogeneous mosaic of interactive farming systems in a landscape with little opportunity for land sparing for conservation activities (Barzman et al. 1996; Sinzogan et al. 2004; Saito et al. 2006; Abbona et al. 2007; Phalan et al. 2011). The restorative concepts in the productive landscapes must consider the mutually inclusive components of the ecosystem, which complement and contribute to revival of the ecosystem services. The ecological complexity per se in agricultural landscapes has been one the major drawbacks to realize success in restorative efforts. Moreover, larger variability across the farms in close proximity has relevance while implanting the offset mechanisms to achieve overall improvement at the landscape scale and ecosystem functions at micro-to-macro scale. It calls for evolving location-specific strategies to restore the landscape functions/services to maintain the balance between the productivity and integrity of ecosystem components.

At present, there is need to define the framework (Table 1) to identify stakeholders who qualify to acquire biodiversity credits and payments under voluntary offset schemes for conserving rare species and habitats unique to farmlands (Folke et al. 2002).The tradable credits for increasing species diversity in farming systems under offset schemes need critical consideration to formulate the rules and guidelines to enhance the biodiversity of commons as part of mitigation banking. While awarding biodiversity credits under offset mechanisms, the cumulative biodiversity value of the restored ecosystem assumes prime importance. Thus, offset mechanisms are time dependent and vary in scale (Pearce and Moran 1994; Pascual and Perrings 2007). This is relevant for large-scale biodiversity enhancement under mitigation banking through participatory action research by the landowners/farming community (Green et al. 2005; Conway 1987; Doré et al. 2011; Kumaraswamy 2012). Network reciprocity amongst the stakeholders with knowledge of landscape-scale biodiversity, conservation skills and leadership abilities has significant role in the evolution of rules, regulations and guidelines (Fig. 1) for offset mechanisms (Nowak 2006; Friedman et al. 2007; Grace et al. 2009). However, the ecosystem-scale approach to integrate biodiversity across the landscape must consider the cultural diversity of the stakeholders to infuse mutual and equitable benefit sharing attitude. Moreover, involvement of stakeholders in the decision making process at various levels of inception, planning, implementation and monitoring will positively impact the participatory process (Chess and Purcell 1999; Reed et al. 2006).

Opportunities and avenues

Carbon offsets provide ideal conditions to develop the framework to quantify species diversity at farm level, stocks and biotic fluxes of carbon, and also resilience of farmlands to adversities of climate change. Incentivized offset schemes can be an avenue to accumulate carbon emission reduction (CER) and biodiversity credits. However, enabling institutional mechanisms to educate and build social capital for the wider acceptance of offset schemes is vital. This is mainly attributed to cultural diversity and economic disparity in agricultural landscapes, especially when this involves smaller landholders in developing countries (Kumaraswamy 2012). The lack of quantitative data and qualitative knowledge on changing agro-biodiversity is one of the critical limitations to design

Table 1 Framework of guidelines and instruments to enhance the biodiversity profile in an agricultural landscape

Criteria and indicators	Ways and means	Tools/initiatives/evaluation modes
Payments for biodiversity credits held by landowners for conserving native rare species on their land Award of graded incentives for the land-owners or tenant farmers to ensure increasing tree cover and adopt biodiversity-friendly cropping systems	The strengthening of alliances among farmers, agronomists, extension workers, foresters, conservation biologists and social scientists to promote ecologically sustainable production systems, and responsibly collaborate to achieve agro-biodiversity conservation and develop evaluation methods	Designing the payments schemes for conservation initiatives aimed at accruing ecosystem services, carbon financing to encourage farmers to retain trees, maintain biodiversity corridors, use of organic fertilizers and adopt eco-agriculture to preserve natural pollinators and predators Policy reforms to provide rebate on land taxes, levies, designing green cards for conservation activities Development of mass education methods, involve schools to promote the conservation initiatives, design modules for participatory research; Explore and adopt conservation-oriented technologies and popularize community knowledge on sustainable farming practices
Policy reforms to refine the existing environmental laws and enforcement to reduce deforestation, regulate tree felling, conserve on-farm tree cover, reduce agrochemical use, and address land tenure issues related common conserved areas (CCAs)	Imposition of eco-taxes Removal of subsidies Green labels to eco-agriculture Good will awards in recognition of conservation initiatives—to individual/s, groups and/or local bodies, etc	Broaden participation in biodiversity-friendly certification schemes for organic foods and forest products Ensure rigorous certification guidelines complying with ecological and socio-economic criteria Strengthening regional conservation initiatives through Participatory Action Research (PAR) Design framework of enforcement of law suitable to location/s Involve stakeholders as partners in government initiatives (offsets) linked to incentive schemes

Table 1 continued

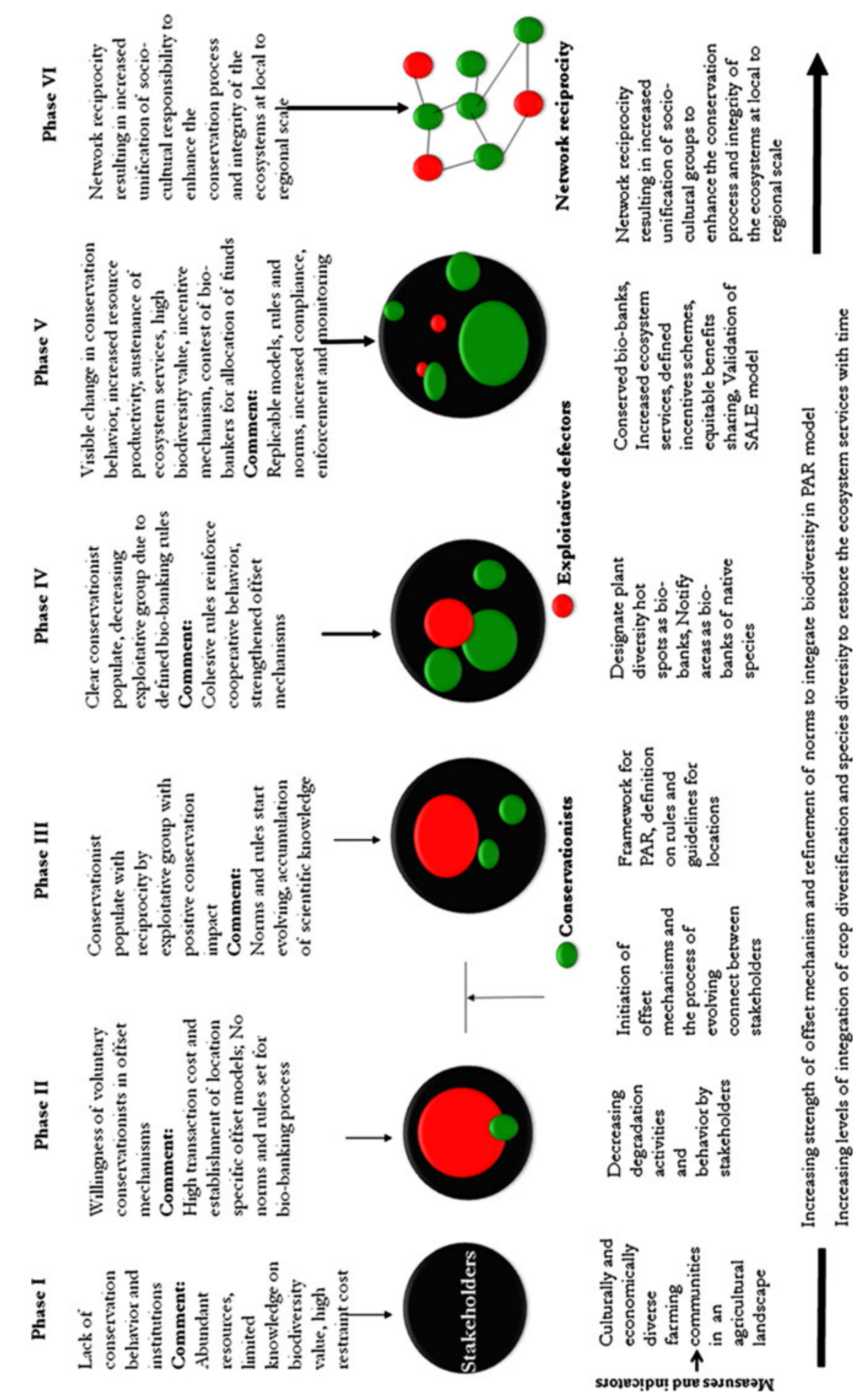
Criteria and indicators	Ways and means	Tools/initiatives/evaluation modes
Leverage local and regional political support for biodiversity conservation and sustainable development via existing conservation initiatives to implement offset schemes	Local to regional scale policy reforms; Design offset mechanisms for like-for-like swap considering the stakeholders' economic status, size of land holding and tenure, access to participate in common conserved areas Increased involvement of women in decision making process and management of offset schemes at farm levels	Resolve tenure issues of common lands (community ownership) to enhance species diversity and ecosystem services Design incentive-based green awards, targeting farms to promote retention of remnant tree cover and increasing trees in the farms Design eco-labels linked to incentive schemes to control the farm produce pricing. Prioritize production input allocation for eco-agriculture practitioners Develop informal green groups at local to regional scale involving stakeholders as monitoring network to prevent selective loss of keystone species diversity

Fig. 1 A conceptual model of 'Sustainable Agricultural Landscapes and Ecosystem Services' (SALES). ▶ This links offset mechanisms to infuse responsible conservation of biodiversity in agricultural landscapes to increase plant species diversity and improve ecosystem services. The model is replicable in agricultural landscapes with various levels of degradation of biodiversity mosaic/induce multiple cropping systems/ restore ecosystem services to benefit the contiguous farms; *Bio-banks*: conserved repositories of plant diversity hotspots in a landscape; *Co-evolution*: Bilateral sharing of ingenuity to derive mutual benefits from a community activity and/or conservation initiative; *Network reciprocity*: Mutually agreeable equity-based participation of farming community irrespective of socio-economic status; *Offset mechanism*: compensatory and counterbalance approaches to restore the original status of an ecosystem; *Participatory action research* (PAR): a collective research inquiry, voluntary participation and action of collaborative nature with mutual benefits to the stakeholders (researcher and the beneficiary)

suitable offset mechanisms (Amgoud and Prade 2009; Doré et al. 2011). Any efforts to revive the biodiversity of agricultural landscapes require documented traditional knowledge of native species at micro to macro scale, which can be used to design location-specific offset mechanisms (Jackson 2002; Altieri 2002; Vandermeer 2003; Malezieux 2012). Admittedly, implementing eco-agriculture as an adaptive mechanism to manage the trade-offs between productivity and biodiversity while sustaining ecosystem services in agricultural landscapes is a challenging task.

The sustainable agricultural landscapes and ecosystem services (SALES) model, which defines the development of guidelines and rules, is illustrated in Fig. 1 to show participatory levels with eventual benefit of network reciprocity. However, lack of leadership skills and conflict of interest arising due to social hierarchy is still a serious limitation while designing broad and replicable offset mechanisms for greater benefits of the stakeholders (Holling 1973; Gunderson and Holling 2002). The SALES model can be a qualitative approach to make necessary amendments to the offset mechanisms. The model is flexible and replicable in any landscape to build robust network reciprocity amongst the stakeholders of different socio-economic status. The pattern of change in the behaviour of the stakeholders is identified at each phase of the model. The success of the model depends on the ingenuity of the stakeholders to identify agricultural landscapes with a mosaic of contiguous ecosystems under various stages of degradation, knowledge of the native species, and the willingness to share or spare the land. The consensus-based development of site-specific framework model should involve stakeholders of various socio-economic and cultural background and local institutions as facilitators. The SALES model is amenable to modification through feedback from participatory action research by the stakeholders. It can also be implemented directly by the stakeholders with appropriate guiding rules to suite location-specific needs to integrate biodiversity for larger impact on accretion of ecosystem services and tradable credits.

Strategically designed offset mechanisms must significantly improve opportunities for the maintenance of soil resources, to minimize soil erosion and degradation, to improve water resources and quality, to sequester carbon through enhanced plant species mosaics above and below the ground, and to improve associated ecosystem services. However, any restoration approach requires extensive mapping of areas to prioritize the degraded landscape zones, wherein implementation of offset mechanisms could be ecologically and economically viable. Moreover, offset-linked policies designed to enhance resilience through greater keystone species diversity must be flexible. Such policy amendments should be in favour of the stakeholders and address governance at multiple levels (Mayer and Tikka 2006). For example, micro-to-macro-scale agricultural landscape restoration through offset schemes should ensure that target restorative elements are well-distributed and connected with due consideration to restore the natural capitol of regional importance.


Phase I
Lack of conservation behavior and institutions
Comment:
Abundant resources, limited knowledge on biodiversity value, high restraint cost
Stakeholders
Phase II
Willingness of voluntary conservationists in offset mechanisms
Comment:
High transaction cost and establishment of location specific offset models; No norms and rules set for bio-banking process
Phase III
Conservationist populate with reciprocity by exploitative group with positive conservation impact
Comment:
Norms and rules start evolving, accumulation of scientific knowledge
Phase IV
Clear conservationist populate, decreasing exploitative group due to defined bio-banking rules
Comment:
Cohesive rules reinforce cooperative behavior, strengthened offset mechanisms
Phase V
Visible change in conservation behavior, increased resource productivity, sustenance of ecosystem services, high biodiversity value, incentive mechanism, contest of bio-bankers for allocation of funds
Comment:
Replicable models, rules and norms, increased compliance, enforcement and monitoring
Phase VI
Network reciprocity resulting in increased unification of socio-cultural responsibility to enhance the conservation process and integrity of the ecosystems at local to regional scale
Conservationists
Exploitative defectors
Network reciprocity
Measures and indicators
Culturally and economically diverse farming communities in an agricultural landscape
Decreasing degradation activities and behavior by stakeholders
Initiation of offset mechanisms and the process of evolving connect between stakeholders
Framework for PAR, definition on rules and guidelines for locations
Designate plant diversity hot spots as bio-banks, Notify areas as bio-banks of native species
Conserved bio-banks, Increased ecosystem services, defined incentives schemes, equitable benefits sharing, Validation of SALE model
Network reciprocity resulting in increased unification of socio-cultural groups to enhance the conservation process and integrity of the ecosystems at local to regional scale
Increasing strength of offset mechanism and refinement of norms to integrate biodiversity in PAR model
Increasing levels of integration of crop diversification and species diversity to restore the ecosystem services with time

Hence, policy amendments (Thompson and Starzomski 2007) need to be spatially targeted to ensure success in regions where ecological restoration is a high priority. It must also facilitate skillful enhancement of native species and composition with additive effects on ecosystem services (Stringer et al. 2006). It is imperative that landscape-specific offset mechanisms be designed and managed at local to regional levels to enhance native biodiversity, which will support sustenance of livelihoods in the long term. However, lack of organizational set-up, governance, and policy framework has been a hurdle in the execution and success of numerous initiatives (Scherr and McNeely 2008). Besides, conserving and enhancing biodiversity in agricultural landscapes will require research and policy reforms that utilize the inputs from stakeholders to put in place a suitable governance set-up.

The above logic is based on the premise that landscapes are heterogeneous with patches of biodiversity hotspots, and restoration in certain locations will arguably contribute to larger conservation goals and broader access to ecosystem services (Malanson and Cramer 1999). This is particularly the case in heavily fragmented and degraded agricultural landscapes indicating the need for spatially explicit offset mechanisms and conservation strategies (Turner 1990; Justus et al. 2008; Gullison et al. 2000; Moilanen and Wintle 2006; Moilanen et al. 2009; Turner and Gardner 1991). Customized incentives may need to be offered in key locations to move away from monocultures and toward the inclusion of native and mixed species, which make up sustainable agricultural practices (Luers 2005; McNeely 1988; Scherr et al. 2007).

Uncertainty in restoring the integrity of agricultural landscapes

Agricultural landscapes with a mosaic of farms and variable biodiversity repositories and ecosystem services pose some uncertainty in implementing successful conservation initiatives. A strategic identification of farms that maintain substantial integrity of biodiversity can be used as keystone models for integration of diverse species at spatial scales tailored for offset mechanisms. Such an approach will help in developing risk-proofing strategies and integrate diversity of key native species to enhance critical ecosystem services. As a first step, it is prudent to locate sustainable farming systems in degraded agricultural landscapes that provide an option to build connectivity. Subsequently, it will be beneficial to generate long-term scientific data on key native species and changes in cropping pattern, so that changes in biodiversity and ecosystem services can be monitored. The farming community, through participatory research process, can validate the data on species occurrence, composition, dispersion and diversity in an agricultural landscape. Crop insurance can be suitably used as an incentive to preserve native species. The economic relevance of insuring agro-biodiversity has been examined in empirical studies across various agricultural landscapes (Folke et al. 1996; Perrings et al. 2006; Baumgartner 2007; Smale 2006; Di Falco and Perrings 2003).

Spatially explicit opportunities and risks can be common in offset mechanisms that vary across the landscape depending on the level of participation and management by the farming community (McCarthy and Possingham 2007; Armitage et al. 2008). Enhancing the ecosystem services of degraded agricultural landscapes is difficult to achieve when too few hotspots of natural diversity are spread too far apart, limiting the opportunity for regeneration that could build connectivity (Crossman and Bryan 2009). However, opportunistic restoration mechanisms adopted by the stakeholders can possibly play a critical role in the enrichment of diversity of native species and strategic introduction of keystone species to stabilize landscape productivity. Such an approach to enhance species composition will improve net positive influence on accretion of ecosystem services in a landscape (Tscharntke et al. 2005; Smale 2006). Further, risk-proofing and restoration mechanisms must have the ability to buffer farmlands against the yearly or longer term impacts of climate change. Negative impacts of climate change may be less severe in connected farms with high keystone and native species diversity and greater resilience to climate change (Hodgson et al. 2009).

Conclusion

The major challenge in the modern agricultural landscapes is to meet the ever-growing demand for agricultural products while simultaneously conserving biodiversity, providing critical ecosystem services and maintaining rural livelihoods. The concept of incentive-based offset mechanisms has tremendous potential and it opens up opportunities to restore the diversity of keystone species, build connectivity and develop hotspots of biodiversity repositories to sustain ecosystem services. Offset mechanisms can also be used to bridge the link between complementary conservation initiatives to design local to region-specific and conservation-oriented farming systems. Further, economic and physical environments characteristic of the stakeholders are critical in building consensus-based local or region-specific conservation initiatives. However, the development of offset mechanisms linked to economic benefits requires robust quantitative and qualitative data on agro-biodiversity. Generation of such data will facilitate policy reforms to incentivize conservation efforts and suitably amend the crop insurance policy. This can help promote the conservation of biodiversity at all trophic levels and eventually build resilient and productive agricultural landscapes.

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