ReNew Opinion Article

Integrated Climate Sensitive Restoration Framework for transformative changes to Sustainable Land Restoration

Shalini Dhyani[1*], Debbie Bartlett[2], Rakesh Kadaverugu[1], Rajarshi Dasgupta[3], Paras Pujari[1] and Parikshit Verma[1]

[1]CSIR-National Environmental Engineering Research Institute, Nagpur 440020, Maharashtra, India
[2]University of Greenwich, Central Avenue, Chatham Maritime, Kent ME4 4TB, UK
[3]Institute for Global Environmental Strategies, 2108-11 Kanagawa, Japan 240-0115

*Corresponding author: Shalini Dhyani shalinidhyanineeri@gmail.com; s_dhyani@neeri.res.in

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Running Title: Integrated climate sensitive restoration approach

Abstract

Sustainable land restoration is the key to restore degraded land, halt biodiversity loss and reinstate ecosystem services for human well-being. Restoration needs to be planned and conducted with due recognition to growing climate uncertainty with an evolved understanding about the future restoration targets. Present opinion article attempts to provide an overview on Integrated Climate Sensitive Restoration Framework that recognizes the local participation in mapping degraded lands, identification of species for supporting species modelling to better understand climate uncertainty. Involvement of citizen science based restoration monitoring tools can contribute to big data analytics for ecological monitoring and policy support. The Framework potentially helps in sustainable land restoration by transformative changes for achieving UN decade on Ecosystems Restoration (2021-2030), SDGs 15 and addressing the post 2020 Global Biodiversity Framework. However, to realize the success, climate finance mechanisms to drive restoration should be seriously considered for reducing bias and enhancing opportunities of equitable sharing in the era of corruption, authoritarianism and regulatory capture.

Keywords: Sustainable land restoration, Climate uncertainty, Transformative changes, Local participation, Climate finance, Ecological Monitoring, Citizen Science

Conceptual implications

- Sustainable land restoration can be improved with local stakeholder involvement and citizen science participatory models.
- Roadmap to fully integrate participatory socio-ecological, citizen science approaches as the core requirements to achieve sustainable land restoration targets in the changing world.
- Funding mechanisms to drive restoration, enhance opportunities for equitable sharing of benefits in the era of corruption, authoritarianism and regulatory capture.
- Mainstreaming citizen science and ubiquitous digital tools to contribute to the big data analytics for monitoring restoration outcomes and supporting policies.

Introduction

Land degradation is a serious global environmental problem and one of the major socio-economic issues that has received huge international attention (IPBES 2018). 29% of global land in different agro-ecological zones categorized as 'land degradation hotspots' has undergone rampant loss of ecosystems services resulting in ecosystem collapse (Cerretelli et al. 2017). The Red List of Ecosystems by IUCN, considers land degradation a mega driver threatening global ecosystems (Keith et al. 2013). The lost ecosystem services due to land degradation are valued at $6.3 trillion per annum, is ~10% of global GDP (Sutton et al. 2016). Global targets to halt and reverse biodiversity loss are not achieved despite of decades of global effort (Watts et al. 2020). Ecosystem restoration is expected to support global conservation efforts for long-term sustainability (Aronson, Sasha 2013). Global adoption of the Sustainable Development Goals (SDGs) has increased political prioritization, particularly of SDG 15 (UN 2015) and with the declaration of "UN decade of ecosystem restoration", 2021-30, has made restoration an international priority (Waltham et al. 2020). Sustainable land restoration approaches will be challenging in global environmental change scenarios and will require new approaches for altered baselines and consequent change in conservation targets (IPCC 2019). Restoration needs to be planned and implemented by acknowledging climate uncertainty to enable resilience (IRP 2019). Defining the desired outcomes, anticipating the trajectories, and measuring the success of restoration projects is going to be even more challenging (Perring et al. 2015). Restoration following the natural course of ecological succession, by careful selection of native and resilient species is relevant to ensure SLR success (Bogers et al. 2006). However, while this can enhance native biodiversity and restore degraded ecosystem services (Beatty et al. 2018) ongoing and in cases extreme environmental change may not continue to support the current native vegetation at many places (Löf et al. 2019). Tree species distribution, will alter in response to climate so, for successful restoration understanding survival rates and contribution to ecosystem services of proposed vegetation assemblages is essential (Bouchard et al. 2019). Considering 'native' species with a broader understanding from phyto-sociological and ecological criteria can help (Thomas 2017). Restoration planning needs to acknowledge the transitions and, wherever feasible facilitate change maintaining key ecosystem services, minimizing species loss by recognizing the functional role of the species in the specific ecosystem rather than focusing on the individuality of species (Mugwedi et al. 2018). An example is the introduction of *Prosopis juliflora* during social forestry programmes in India and Africa which resulted in ground water depletion, desertification and salinity ingress (Kaur et al. 2012; Mwangi, Swallow, 2005). However, while not condoning this introduction, participatory ecosystem assessment in Gujarat found that *P. juliflora* was valued by local people for fuel, fodder, honey and medicinal gum (Bartlett et al. 2017). Restoration ecology urgently requires affordable and replicable approaches for monitoring changes at global scales, with local relevance to ensure successful land restoration (Callaghan et al. 2019). Restoring degraded land is a complex process and there can be no single solution. Achieving target 15.3 "Land Degradation Neutrality" of SDG 15 "Life on Land" by 2030 cannot be fulfilled by modern scientific tools and technology interventions alone. Transformative change to enhance restoration success and mainstream Integrated Climate Sensitive Restoration Framework will require innovations in planning, implementation and monitoring (Cross et al. 2019). Incorporation of indigenous and traditional ecological knowledge and citizen science approaches involving local stakeholders will be essential for restoration success (GEF Secretariat 2019). In the following section a novel, integrated approach is proposed to ensure truly sustainable land restoration (Fig. 1).

Integrated mapping and species selection

In order to achieve reversal of land degradation a full toolkit comprising a diverse range of solutions is needed so, the 'best fit' approach, based on specific agro-climatic zone, socio-economic, biophysical or political conditions should be applied (Rohr et al. 2018) by harmonizing scientific and local views and opinions on land degradation (Stringer, Dougill, 2013). The approach is acknowledged to make significant contribution for successful outcomes (Briassoulis 2019). In the latter part of the last century the key words 'indigenous knowledge' and 'traditional ecological knowledge', originating from anthropology, became common in development and ecological disciplines. As we move into the second decade of the 21st Century we need to acknowledge the increasingly dynamic context where we work (Reyes-García et al. 2018) and for best results restoration efforts must involve local stakeholders. Failure to do this may result in poor choices, for example simply focusing on the number of trees planted rather than on social and ecological outcomes that require meticulous species

selection and multi-stakeholder involvement (Mansourian et al. 2017). Integrating participatory approaches with technological tools is required to develop strong partnerships and synergies between social acceptance, ecological feasibility and economic viability of restoration. Decision support tools can facilitate restoration planning (Laestadius et al. 2011) but can never replace participatory planning and priority-setting. Geospatial analysis partnerships between conservation practitioners, indigenous people, local communities and policy makers can be effective in restoring degraded landscapes and critical ecosystems (Garnett et al. 2018). Recent rapid development in mapping tools *viz.* Enhanced Vegetation Index (EVI), Plant Phenology Index (PPI), Normalized Difference Vegetation Index (NDVI) (Karkauskaite et al. 2017), and biophysical modelling tools (Stoorvogel et al. 2017) have enabled mapping of degraded lands. Bigdata analytical tools, hosted on Google Earth Engine platforms such as *Trends.Earth* (http://trends.earth/docs/en/) have enabled conservationists to quantify trends in land degradation. Growing expansion of monitoring by unmanned aerial vehicle is increasing mapping support to GIS tools by introducing fine landscape details. Participatory GIS brings in additional dimension of public engagement to identify critical degraded areas and integrating cultural values in landscape restoration (Ahmed, Feras 2014; Davies et al. 2015). Capturing local perceptions facilitate interfacing with policy makers and in informed land use planning decisions.
Integrated modeling of habitat suitability and abundance has emerged as a powerful tool (Isaac et al. 2020). The approach of integrating local knowledge in both mapping and species selection is proven to give better results for restoration (Dhyani, Dhyani 2016). Participatory approaches and species distribution modelling tools help in understanding present and future habitat suitability of selected species (Dhyani et al. 2018) and their potential habitats (Gaston et al. 2014). These tools support restoration planning by deriving spatially explicit projections of species (Jarvie, Svenning 2018), planning, implementing and monitoring species introductions in active restoration or rewilding projects (Gbetoho et al. 2017; Seddon et al. 2014). Involving citizen scientists in collection of scientific data by public outreach at local, regional, or wider scale helps generating compelling evidences to missing information on occurrences in places not previously surveyed due to logistical or financial constraints. For instance, the (Global Biodiversity Information Facility, https://www.gbif.org/) provides free and open access biodiversity data sourced by citizen participants worldwide. The additional sampling effort provided by citizens improve the capacity of species modeling to capture important elements about ecological niche, for accurately predicting the potential geographic range of invasive species *etc*. Increasing availability of environmental data, including from citizen scientists (Sullivan, Molles 2016) has resulted in exponential development of species modeling applications.

Integrating stakeholder participation

Identification of areas of degraded land is virtually always done by professionals who are outside the local community. What to an ecologist is a degraded forest, with low tree species diversity, may be viewed by a forester rather differently; cleared areas planted with crops could be an improvement to local farmers. An attempt at 'restoration' must understand these differing values if genuine participation and long term buy in to change is to be successful. While, consultation with local people and their participation in developing plans is often referred to close examination often reveals that terms such as 'co-management' may be little more than lip service (Ahmed, Bartlett 2019). Unless, there is genuine commitment on the part of the professionals to listening and hearing the values of stakeholders and that these can see benefits of being involved then success will be limited and in the worst case undermined.

Restoration requires understanding of the processes that have led to degradation and potential future options. To take a very simple example forest may be degraded by cutting down trees. Only by listening to local people and wider stakeholders can the reason for this be understood - did the trees begin to fail? Did a pest or disease affect them? Or were they harvested in response to economic change? In Bangladesh we found that development that increased demand for bricks caused the local value of timber to rise with obvious consequences. So, how should engaging with stakeholders be done? The first step is to map these and identify links between different groups and 'key contacts'. There are always, wherever in the world you are working, hierarchies which must be respected it is really difficult to build a partnership if someone feels slighted because they feel they were not asked their opinion. The order in which individuals are approached and asked their opinion (rather than being told about the restoration project) is important. A common approach is to go to local people first and, while these may be the most important group if positive land management is to be achieved, officials and elected representatives at all level will be more likely to lend their support if approached first. This first step requires time but is vital to acquiring understanding of the issues that needs to be taken into account. Enable ecosystem services to be evaluated and to begin to build the relationships that can lead to identification what outcomes would provide livelihood benefits so these can be incorporated in the restoration goals (Dhyani et al. 2013). This includes land preparation, identification and mass propagation of potential vegetation for large scale restoration requirements. The co-operation and support of local communities is vital at this stage to enable rapid selection of appropriate species and mass propagation from, for example, the soil seed bank.

Building consensus and developing restoration goals

The success of the approach suggested in this article depends on effectively blending the professional views with the stakeholder's perceptions and developing a proposal that coincides as far as possible with the consensus view. This is likely to involve knowledge transfer and learning between both the groups. There are many good examples of this multidisciplinary approach involving techniques such as Landscape Character Assessment (Bartlett et al. 2017), Remote sensing (Cordell et al. 2017) and ecosystem services (Scholte et al. 2016). Mediation may be required to help those involved to understand the perspectives of others, bringing additional skills to the multidisciplinary team but essential if a genuine 'win-win' is to be achieved.

Post restoration care and monitoring

Millions of hectares of land require restoration and many previous efforts have been less than effective due to lack of, or poor quality, monitoring (Lindenmayer 2020). This can be addressed by adopting an inclusive participatory approach to support the iterative process required for accurate monitoring and feedback of progress to ensure land degradation is mitigated (Xie et al. 2020). Mainstreaming Restoration Assessment Initiative (RAI) can increase citizen science involvement in restoration monitoring networks (Huddart et al. 2016). By linking biotic and abiotic evaluations, the different impacts on restoration outcomes can be unraveled (Johnson et al. 2020). Involving local citizen scientists in generating Before-After-Control-Impact (BACI) monitoring data can supplement expert input to validate restoration success. Standardizing methods can enhance quality of the community generated data to reduce bias. The power of ubiquitous digital tools, *viz.* smartphone-based apps can be harnessed to contribute to the big data analytics for restoration monitoring and supporting policies (Edwards et al. 2018). In many developing and under-developed countries efforts regarding monitoring have been less, despite of large populations living close to high biodiversity areas. One issue is lack of short term benefits from involvement in land restoration, as ecosystem services emerge later in the process. To address this funding mechanisms that include monitoring and costs of initial assessment and restoration actions are required to ensure success. Engagement of, and support from, commercial enterprises are viable options to enhance equitable sharing of monetary benefits for all involved. The para-taxonomist and para-ecologist approach will be helpful to provide livelihood benefits supported by training rather than temporary recruitment of citizen science volunteers. This can greatly improve the flow of information and sustained effective monitoring of restoration by giving status and acknowledging the value of community contributions (Schmiedel et al. 2016) to compliment this role of restoration practitioners will be crucial.

Conclusion

Proposed three tier Integrated Climate Sensitive Restoration Framework approach can help restoring large degraded areas particularly where local communities are dependent on natural resources for subsistence. Integrating scientific tools with local socio-economic knowledge and building long-term partnerships with local people is not currently acknowledged in policies but is required to ensure this approach is included if sustainable restoration of degraded land is to be achieved and the targets are to fulfilled.

When a target area has been identified the steps are:

- Stakeholder analysis, including identifying hierarchies and key contacts, which can be done at the same time as gathering the scientific information,
- Establishing the drivers of degradation by listening to stakeholders, using triangulation for verification, and checking against the data
- Bringing all the information together, communicating results and requesting ideas for action

While, this takes time using a multidisciplinary and gendered team is likely to result in improved long term outcomes for the environment and livelihoods and so contribute to achieving the Sustainable Development Goals. Mainstreaming this integrated framework in global and national policies could empower the next generation of restoration ecologists and practitioners globally to develop more robust quantifiable criteria and indicators for success. The proposed approach bridges the gap between participatory socio-ecology and digital technology, big data and computational modelling to accomplish the goals of sustainable restoration of degraded land across the globe.

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Conflict of Interest Authors declare no conflict of interest

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