A restored Ngituli system in the Shinyanga Region, Tanzania. Photo credit: Lala A. Duguma
Landscape restoration from a social-ecological system perspective?

Lalisa A. Duguma, Peter A. Minang, Mathew Mpanda, Anthony Kimaro and Dieudonne Alemagi

Highlights

- Ecosystem degradation is increasingly creating concerns about the provisions of various services (e.g., food, feed, wood, water, etc.)
- Landscape restoration is being done in different parts of the world with different implementation frameworks
- The Social-Ecological Systems Framework (SESF) provides a good basis for assessing progress made by landscape-scale restoration programmes despite having its own challenges
- The HASHI programme in Tanzania was used to illustrate SESF application at the landscape level

1. Introduction

Millennium Ecosystem Assessment (2005) revealed that around 60% of ecosystem services that are heavily relied on by humans are either degraded or being used unsustainably. This is alarming as the majority of the people who directly depend on such functions and services are the poor, rural communities who are disproportionately being affected by the degradation. The extent of the problem is severe in developing countries where measures to curb the problem are often marred by shortage of resources (e.g., finances, infrastructure, technology) and the required capacity to handle the problems. For instance, land degradation remains a key challenge that is hampering the production potential of rural landscapes. A landscape can be degraded due to a number of reasons, for example, overuse (e.g., exploitation), natural disasters (e.g., landslides, flood effects, drought, etc.), and misuse (e.g., pollution, improper land use practices, etc.). Degradation often occurs when the replenishment potential of the landscape is exceeded by utilization and/or when this feature of the landscape is severely depleted by natural forces such as flooding, fire, landslides, etc. As a result, communities may engage in exploiting nearby resources such as natural forests and biodiversity conservation areas to gain more farmlands that are productive and to extract tree products such as timber and fuelwood to generate additional income to sustain their families (Duguma et al., 2009). What makes the degradation problem even worse is the strong interdependence among the different
ecosystem services. For example, forest clearing for creation of new agricultural lands affects the habitat services provided by the forest and influences the hydrology of the landscape thereby negatively affecting the water supply of the area.

The extent to which the different functions and services could be provided by a landscape depends on its management state. Three possible states of a landscape can be identified: 1) a landscape that is functioning properly and well managed, 2) a landscape that is being degraded due to unsustainable exploitation, and 3) a landscape that is severely degraded where the net worth of restoration outcomes may not be greater than the efforts and resources required to restore it. It is necessary to note that even these categories are very subjective. Of the three landscape states, in this chapter we mainly look at those needing restoration with some inherent restoration potential.

Realizing the degradation problems, a number of restoration actions were taken in different parts of the world ranging from global programmes such as the International Union for Conservation of Nature (IUCN), global forest landscape restoration programme, natural resource management programmes by the Global Environment Facility (GEF), and the Worldwide Fund for Nature (WWF) restoration programmes focusing on local level restoration efforts by the affected communities and national governments. However, most of such efforts have their own frameworks of implementation and evaluation regarding the restoration activities, and thus pose a challenge on how to uniformly assess the progress made by such systems and its sustainability. Another key concern in most restoration programmes is they largely emphasize ecological processes and provide limited space for socioeconomic attributes (Wortley et al., 2013). Recognizing the limitations of such restoration efforts of the past, recent restoration programmes and projects are focusing on inclusive processes where the local communities’ societal/development needs are also taken into account. However, this effort to embrace the societal needs within restoration programmes is not done using a consistent framework. That is why the call for a coherent framework that captures the two dimensions (socioeconomic and ecological) while also guiding the monitoring of landscape management is increasing. In our view, the Social-Ecological Systems Framework (SESF) (Ostrom, 2009) would be a very helpful approach for landscape-level restoration initiatives. Restoration in this context refers to efforts made to bring back the functions that the landscape used to provide before the degradation processes started and hence our emphasis is largely on functional restoration (see Crow, 2014; Olivier, 2014).

In this chapter, we examine how applicable the SESF is to landscape restoration schemes and highlight some of the limitations of the framework under such contexts. We illustrate the applicability and usefulness of the SESF using the HASHI (Hifadhi Ardhi Shinyanga - Shinyanga Soil Conservation) programme in Tanzania as a case study example.

2. Landscape restoration for multiple objectives

The landscape is a complex system (Parrot et al., 2012) composed of biophysical, social, economic, and governance elements. It is the dynamic equilibrium resulting from the interactions between these different components and processes (Meinig, 1979). A landscape comprises a multitude of functions, actors, sectors and units. The functions and the units that provide those functions are often delimited from the perspective of the actors and sectors active within the landscape. Functions here refer to “…the capacity
of natural processes and components to provide goods and services that satisfy human needs directly or indirectly” as defined by De Groot et al. (2002). They are classified broadly as provisioning, regulating, cultural and supporting functions (Millennium Ecosystem Assessment, 2005). Service is defined as “…the aspects of ecosystems utilized directly or indirectly to produce human well-being”, according to Fisher et al. (2009). In managed landscapes, there is often some stake from humans that link with landscape features, components or outputs. Even abandoned areas are associated with a certain type of function/service linked to human interests. This, in most cases, is due to the presence of both ‘active’ and ‘passive’ stakeholders in a given landscape. The former includes communities and institutions currently living/working in the landscape, local governments, and other relevant landscape actors. The latter includes national governments, international organizations and other global community actors whose link with the landscape is through functions such as climate regulation, hydrological effects and biodiversity conservation that often go beyond the ‘boundary’ of the landscape.

The interactions and interdependences among the components in the landscape are strong determinants of the magnitude of functions/services a given landscape could deliver. Interaction is more related to the tradeoffs between the different functions/services, hence, looking more to how the functions/services negatively influence each other. Interdependence, on the other hand, is more in line with ‘symbiotic’ relations between functions/services whereby the extent of a given function/service depends on how well the function(s) it depends on is managed. For example, if a landscape is to deliver ecological functions such as habitat for wildlife, it is necessary to have the woodlands or forests managed properly. There should also be a water source for the animals, the extent of which is determined by the hydrological functions from the components of the landscape. Thus, there is a strong interdependence between habitat management, hydrological functions, wildlife presence and economic benefits from tourism to mention a few. Such objectives on the other hand could also influence each other negatively when wild animals damage crops grown by the farmers/agropastoralists (e.g., Gillingham & Lee, 2003; Wang et al., 2006). Wild animals could also transmit diseases to domestic animals (e.g., livestock) if they interact closely (Daszak et al., 2000; Martin et al., 2011). Running such interdependent functions and dealing with those that interact negatively in the same landscape requires a well-planned management strategy that is considerate of such relationships.

Ostrom (2009) argues that communities may not see the added value of conserving resources if there is abundance or if they believe the resource is severely exhausted. Though this notion is realistic, it seems to be confined to the two extremes under which restoration efforts could possibly happen. At times restoration can also be thought of when supply of products required fails to meet the associated demand especially under conditions where alternative options to satisfy that specific demand are absent or more expensive to choose. This means that communities may not always wait until the resource is exhausted, particularly if there is no alternative. Besides, in areas where people are largely dependent on land resources (e.g., agrarian or pastoral communities in the developing nations), they may engage in restoration efforts even before the level of degradation becomes irreversible. Restoration may happen as far as the inherent restoration potential of the landscape is there (Figure 5.1). To achieve a restoration objective, it requires
resources amounting to the differences between the inherent potential of the landscape and the resources required to achieve the set objective. Such resources are derivatives of the management interventions (practices and technologies), time and any material and financial inputs required to achieve the restoration objective. For example, it is less likely, or at least very expensive, to start restoration in a landscape where the soil parent material is exposed with no capability of supporting regeneration/growth of plants. The context of exhaustion expressed by Ostrom (2009) is also very general in that it does not qualify the extent explicitly. There are some levels of exhaustion that could possibly be rehabilitated while in cases with sever exhaustion (i.e., where the inherent restoration potential is so minimal), restoration may not be possible or at least too costly and time consuming to achieve.

As illustrated in Figure 5.1, efforts required to restore a landscape very much depend on where you start along the degradation trajectory, which largely is based on an in-depth understanding of the resource systems and resource units. Examining the resource systems and resource units helps to understand the current state of the landscape and estimate the restoration efforts required to get the landscape closer to the reference state. Restoration efforts require resources, which are largely determined by a governance system through negotiations and consultations with the actors in and outside the landscape. The governance system (a core component of SESF as discussed in the following section) also includes monitoring frameworks that can help alert the necessary actors to take timely action to sustain or restore functions and services provided by the landscape. Such timely actions could considerably reduce the efforts required to restore a landscape. For instance, restoration trajectory A (Figure 5.1) requires less effort and resources than

Figure 5.1 Hypothetical degradation-restoration schematic in natural resources management at scales such as a landscape. A, B and C represent hypothetical restoration trajectories that respectively might be taking place at \( t_A \), \( t_B \) and \( t_C \). The line represented by Y stands for the reference state. \( Y_A \), \( Y_B \) and \( Y_C \) stand for hypothetical achievable targets for restoration trajectories A, B and C respectively.
trajectories B and C because in the latter two cases the inherent restoration potential of the landscape is less than in the former one. In a landscape affected by deforestation for instance, the reference state is the undisturbed forest and due to specific activities (e.g., excessive timber extraction and charcoal production, slash and burn, mining), forest cover decreases. If at time $t_A$, restoration is not done following trajectory A, additional parcels of forests will be cleared and the degradation will continue, resulting in most functions associated with the forest diminishing. The more delayed the restoration is, the more resources required to achieve results closer to the reference state, and hence the difference between the reference state and what could practically be achievable through restoration, increases. This is largely because there are functions that may not easily rehabilitate in the landscape even after extensive restoration. For instance, wild animals may go extinct if there are no more habitats for them. This is why in Figure 5.1, we see after trajectory A, B or C is taken, the corresponding results achieved $Y_A$, $Y_B$, or $Y_C$ is lower than the original state, $Y$. It is important to note here that through restoration some functions may exceed the reference state case if complementary new technologies are used in the process, but in general this is not a common occurrence.

3. The social-ecological systems: a brief introduction

Berkes and Folke (1998) define social-ecological systems (SES) as nested multi-systems that provide essential services (e.g., food, fiber, energy, water, habitat, etc.) to societies associated with them. Broadly, the definition has a utility perspective and is thus anthropocentric, making the contextualization of functions in a system to be deliberated from the perspective of human benefits. Ostrom (2009) states that resources used by humans are embedded in complex SESs composed of multiple subsystems having their own attributes. Ostrom (2007; 2009) came up with a framework, the SESF that can help address this social and ecological coupling. Some of the components of the framework were borrowed from Agrawal (2001), which attempted to elicit the critical enabling conditions for sustainability of the commons. Binder et al. (2013) examined the extent to which the social and ecological dimensions are addressed in the different frameworks claiming to be addressing SESs and found that SESF is the one that treats the two components at comparable level besides its multi-tiered variables to describe the key components of the SESs. The social system in SESF is mainly addressed through resource users and the governance structure composed of rules and regulations that determine the extent of the right to use the resources. The ecological system on the other hand is captured through the resource systems composed of different resource units.

SESF has six primary components: four core subsystems comprising of resource systems, resource units, governance systems and users; and two elements, i.e., the social, economic and political setting and related ecosystems that help to understand the linkages between the system (landscape in our case), and bigger subnational and national administrative units (Ostrom 2007; 2009). It is the interplay among the six components that yield an outcome that either benefits the society or affects other ecosystems in a given social, economic and political setting. The outcome has a feedback mechanism for each of the four core subsystems, which contribute to potential improved performance of the SES. Each of the core subsystems are again addressed through a number of specific variables (including at least 50 indicators) which can be referenced in Ostrom (2007; 2009)’s work.
4. The application of SESF to the HASHI programme in the Shinyanga Region, Tanzania

The HASHI programme was implemented since 1980s in the Shinyanga Region in response to ecosystem degradation problems. The programme officially closed in 2004 though the project activities continued to be carried out by Natural Forest Resources and Agroforestry Management Centre (NAFRAC) and the community members after its closure. The Shinyanga Region is home to Wasukuma people, and covers approximately 5.4% of the total land area of Tanzania in its pre-2005 extent, but hosts over 80% of the country’s livestock population. Between 1980 and 2003 the region’s population doubled reaching about 2.8 million (Mlenge, 2004). The Wasukuma are agropastoral communities dependent on mix of livestock rearing and sedentary agriculture, relying predominantly on the former one. The area is semiarid and the vegetation type is mostly acacia and Miombo woodlands (Mlenge, 2004). Ngitili is an indigenous fodder management system for the dry seasons using enclosure systems wherein farmers enclose a piece of land with trees, grasses, shrubs and forbs to increase fodder production and supply of tree products (Kamwenda, 2002). Two major types of Ngitili exist: household Ngitili owned by individual families and communal Ngitili that is often managed by a group of people, usually community leaders.

The Shinyanga region has undergone a number of processes in terms of the land use characteristics and the associated practices (Figure 5.2). The period before the 1930s, referred to as the reference state, was when the landscapes in the region were considered sustainably managed, before becoming intensely degraded during the period between the 1930s-1980s due to a number of drivers indicated in Figure 5.2 (the degradation phase). The degradation created huge social and ecological problems, which needed restoration measures using practice and action portfolios shown in Figure 5.2’s restoration phase. As discussed in Duguma et al. (2014) the restoration effort through the HASHI programme received considerable political support at the national level, in particular, with the government making a number of policy provisions (e.g., revisions of land tenure policies) and financial resources mobilization to support restoration efforts.

![Figure 5.2](image-url)

Figure 5.2 Schematic showing elements that characterized the gradual changes in the Shinyanga Region, Tanzania.
4.1 The resource system and the resource units

Resource systems mark a designated area, which encompasses a number of resource units that are governed by certain rules and regulations developed by the community (resource users) and/or by governmental bodies. The expansion after the programme almost covered around 377,756 ha benefiting directly or indirectly approximately 2.8 million people in 833 villages (Monela et al., 2005). HASHI was a multi-sectoral approach addressing woodland reclamation, pasture management, soil conservation and water resource management. Each of the sectors entails resource units such as croplands, pasturelands, woodlands, ponds and mini-dams, that respond to the various needs of the community, for example, providing food, pasture, wood and/or water functions. As the community living in the Shinyanga Region rely strongly on the outcome of the landscapes to meet their basic resource needs (e.g., food, wood, herbal medicines, income sources, etc.) (Mlenge, 2004; Monela et al., 2005), restoring the productivity of the system was mandatory to ensure that the community livelihoods were not threatened. Though so far the system dynamics, particularly the re-emergence of woody species, is being viewed as an achievement, there is a need to examine the expansion limit of such activities as there is a likelihood that the canopy may close at some point in time and limit grass growth. The restoration came with a positive aggregate benefit to the local community estimated at a per capita economic value of around 168 USD per year (Monela et al., 2005).

4.2 The governance system

As an entry point the HASHI programme strongly emphasized empowering local communities to make their voices heard leading to the promotion of the indigenous fodder management practices such as Ngitili together with other agroforestry practices (see Figure 5.2, the restoration phase). This boosted the community’s trust of the programme leading to their self-initiated integration of their local resource management practices into the programme by revamping local institutions such as Dagashida (a local unit tasked with conflict resolution through dialogue involving elders), Baraza le Wazee (an elders council serving as a mediator between the traditional and formal institutions) and Sungusungu (a traditionally organized local unit composed of youth and adults tasked with law enforcement) (Monela et al., 2005). The villages also established village environmental committees, which were trained by the HASHI programme to monitor the restoration activities (Mlenge, 2004). The village environmental committees together with the village elders maintained the links between the local community and the formal institutions like the village government and the district-level authorities and representatives overseeing the project. A considerable number of governmental and nongovernmental organizations took part in this programme including the Ministry of Environment and Natural Resources of Tanzania (by facilitating the programme implementation process at national level including policy reforms), NAFRAC (by implementing the project at regional level), local district authorities (by facilitating project implementation and approval of by-laws proposed at the village level), NORAD (Norwegian Agency for Development Cooperation) (by financially supporting the programme), ICRAF (World Agroforestry Centre) (by providing technical support to the programme from planning to the implementation phase), village governments (by facilitating implementation and monitoring the progress of the programme at the grassroots level), and others. The village environmental committee was the central body in making sure the networks among the
different actors remained intact. In order to encourage communities in managing the resources sustainably, the government enacted the 1997 Land Policy and the 1999 Land and Village Land Acts, which created a framework for local communities to possess land title deeds, and hence, reducing tenure insecurity.

4.3 The users and the interactions
Local communities are the principal users and beneficiaries of restoration efforts though the benefit accrued by a given community largely depended on the level of engagement in implementing the interventions. For instance, in the case of the communal Ngitili, there are specific rules and regulations put in place by the local leaders and the village government to ensure it is only those who engage in the specific management activities that benefit from it. This Ngitili type is actually managed by groups of communities, and thus, portraying a number of strong self-organizing activities. For those not involved in the restoration process, there is an option of paying for the services or products collected from the Ngitili. However, as expressed by the village environmental committees, there are cases of illegal uses, though the majority of the community respects the local norms and values. The village environmental committee and local leaders determine the level of harvest by different users and the Dagashida and Sungusungu make sure this decision is properly implemented on the ground.

4.4 The outcomes
The communities have rules and regulations on how much of the products are to be harvested by whom under what circumstances. This is a strong indicator to avoid overharvesting which later affects the sustainability of the system. The programme ensures there is fair and equitable sharing of the benefits among group members engaged in managing parcels of the landscape. Often the benefits go to public infrastructure (e.g., schools, roads, etc.) and whenever there is any additional remaining cash, it is shared among the members. Discussion with the communities revealed that the current management system of the restoration programme is fair and accountable as there is a monitoring scheme in place. Still, there are concerns in communal Ngitilis on the unequal benefit sharing as reported in Selemani et al. (2012). Tradeoffs should also be considered as parts of the outcome in SESF. The following are some key tradeoffs observed in Shinyanga region. When the tsetse fly problem declined in the area the livestock population increased significantly, hence, resulting in overstocking and overgrazing. Also, due to the clearance of the woodlands and conversion to cotton and other cash crops, wood scarcity increased and thus leading to the exploitation of the remnant woodlands for wood products.

5. Reflections on the applications of the SESF to the HASHI programme
The SESF proved to be a promising analytical tool to understand different characteristics of the landscape. First, the fact that SESF is more or less a holistic diagnostic tool encompassing social, ecological and governance dimensions, makes it a very practical tool for use at the landscape level. Second, its ability to deconstruct the landscape into various components, as highlighted in the core subsystems of the framework, provided a good basis to understand how landscape management is working from both the social and ecological perspectives. With the often-mentioned ‘complexity’ of landscapes, this option of deconstruction makes the SESF an ideal framework to understand landscape
management from multiple perspectives such as the resource systems and resource units, the users, the governance systems, and the interactions among these variables. Third, such deconstruction also helps landscape managers to understand where the strengths and weaknesses are within the landscape, and hence, giving a clue on intervention areas to change any negative future outcomes.

From the application of the framework to the HASHI programme we identified a number of potential areas of future research and for further refinement of the framework in the context of landscape restoration. These are as follows:

1. The SESF is a diagnostic/analytical framework that helps to understand the landscape largely from its current state, and hence, is not a planning tool though it significantly complements the planning processes.

2. Not all the elements in the SESF, as of now, have specific measurable indicators. This poses a challenge when it comes to the metrics for monitoring progress/change in the management of SES landscapes.

3. The SESF puts resource systems and resource units as core subsystems. However, decisions that largely affect land use behaviours are associated with the functions and services the users gain from the landscapes. Importance to resource users appears in SESF as one element in the users subsystem, which in fact, should be given more emphasis.

4. Another context of special interest in contexts like landscapes is the issue of tradeoffs. Actors in a landscape make their collective or individual decisions based on the functions and services the landscape provides. Not every function and service is a priority for all users and often decisions are made based on prioritizations among the benefits also resulting in tradeoffs. The SESF, being such a holistic tool, should have had a component specifically addressing this element.

5. Particularly within the landscape restoration context, drivers of change and historical land use patterns play crucial roles in understanding what is happening in the landscape, when, by whom and under what conditions. Such knowledge is important to define the reference state for the landscape and set the objectives to be achieved based on the landscape’s capacity. However, the SESF in its current framing gives limited emphasis to such drivers of change and how they relate to the context of the specific objectives identified within the SESF.

6. **Concluding thoughts**

Looking at landscapes from multi-tiered, hierarchical processes as in the SESF has a number of advantages particularly in restoration efforts. First, it helps to disaggregate, to some extent, the complexity that is often associated with managing landscapes. Such possibilities of disaggregation help to identify where the challenges to sustainability within the different components of the landscape lie, particularly looking at the four core subsystems, which together make up the SESF. Second, it gives a hint about what level of effort is required, at what point in time to avoid the ‘tragedy of the commons’ in landscapes (Ostrom, 2009). Third, viewing landscapes from the SES perspective brings in the largely underemphasized social and economic dimensions while addressing landscape-level actions. Thus, viewing landscapes from the SES perspective has a number of advantages in promoting successful restoration and sustainable landscape management.
From the Shinyanga case study, the regional restoration programme in Tanzania can be well described using the SESF, though the initial designs of the project were not based on this framework. Nevertheless, some important elements still need further attention to promote the restoration effort in the way it addresses the social and ecological objectives. Such elements include the predictability of the system dynamics, the future investment behaviours, addressing and exploring the tradeoffs, and the efficiency of the restoration scheme in terms of understanding the benefits and costs for further replication. Current assessment of the outcomes are also mostly based on the direct resulting benefits and need to capture the indirect benefits of such restoration schemes and their relation to other regional processes such as mesoclimatic effects and cross-border hydrological impacts. In applying the SESF to the HASHI programme, a number of issues surfaced which need further attention particularly on the way the framework looks at those key indicators; these include 1) the framework in itself is more of an analytical tool than a planning tool, which is more sought after these days especially in view of the increasing resource degradation in many parts of the globe, and 2) the limited emphasis on functions and services, tradeoffs, metrics and drivers of change.

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References


