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Restoration governance: An integrated approach towards sustainably restoring degraded ecosystems

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ABSTRACT

Global ecosystems are increasingly threatened and altered by anthropogenic pressures and multiscale environmental disturbances. These disturbed ecosystems need to be restored to maintain vital ecosystem services. Strategies which do not consider integrated approach of restoration interventions may shift the ecosystems to more degraded states. In this study, we reviewed previously published primary articles to determine and describe the importance of ecosystem restoration governance components, viz. legal, financial, social and technological, and proposed an integrated framework of ecological restoration. We determined that without tracking restoration practices into restoration governance framework, the short-term restoration efforts are less likely to drive the ecosystem towards desired reference site conditions. Success of restoration can typically be observed only after years or decades (depending on the scale of the project and environment), so there should be an accountable institution overseeing the project for this period of time. We recommend integrating governance components from project planning to monitoring and evaluation phase. Further, we propose implementing restoration activities through a stable institutional entity that can foster collaboration and coordination with partners and stakeholders. Integrating components of restoration governance increase the likelihood of the restoration programs to be successful and sustainable, and provides opportunities to learn from the experiences.

1. Introduction

Ecosystem restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed (SER, 2004). It is an important approach for conserving biodiversity, improving ecosystem integrity and remediating land degradation and environmental functions (Aronson and Alexander, 2013; Cairns and Heckman, 1996). Ecosystem restoration aims to return degraded systems to reference site conditions or some setting which is protective, productive, valuable and aesthetically pleasing (Hobbs, 1998; Hobbs and Norton, 1996). Although, restoration practices have addressed problems faced by many practitioners (Young et al., 2005), restoration interventions around the globe are still in need of strengthening. There is increasing interest in developing effective predictive tools and a broader conceptual framework to allow restoration of damaged, degraded and destroyed ecosystems with respect to health, integrity and sustainability (SER, 2004; Suding, 2011; Suding et al., 2004). While restoration methods are essential,

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it is important to know what restoration governance entails. The World Bank (2002) has defined governance as the “rules, enforcement mechanisms and organizations”. Similarly, United Nations Development Program (UNDP) (1997) has defined governance as the exercise of economic, political and administrative authority to manage a country’s affairs at all levels. With these concepts of governance, restoration governance can be defined as the *exercise of legal, economic, social, scientific and administrative authority which can develop and enforce mechanisms to manage degraded ecosystems for their recovery to desirable states.*

In recent years, realization has been made towards redefining the understanding of ecological restoration and considering more integrated approach (Higgs, 1994; Martin, 2017), therefore, it is essential to identify the components of restoration governance which make the restoration interventions more integrated for the future restoration projects. In this connection, this paper identifies, highlights and elucidates the importance of restoration governance components for restoring degraded ecosystems. We have also outlined an integrated approach of governance framework that can make the ecosystem restoration programs practiced across smaller to larger spatial scales, more practical, successful and sustainable.

2. Methodology

In this study, peer-reviewed journal articles and other important publications related to restoration governance were reviewed. The relevant literatures were searched using key words, through online databases and web-based scientific search engines. The information from these searches were used for elaborating the importance of the components and framework of restoration governance. The pertinent manuscripts were selected based on the following two approaches.

For journal articles, we used a web based systematic search up to March 2018 in Web of Science Core Collection (time span all year, indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPSI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC). When we searched “Restoration”, “Governance” and “Ecosystem”, all three words as a “Topic”, we found a total of 204 articles, but some of them were not related to restoration governance. When we used the search key words as “Restoration” and “Governance” both as “Title”, we found 23 research articles. Similarly, when we used “Restoration” as a “Title” and “Governance” and “Ecosystem” both as “Topic”, 51 journal articles were obtained. Since the latter two searches yielded the majority of articles which were relevant to our topic, we accounted 51 primary studies of the latest search to determine the components of restoration governance (Table 1). We selected the components which were addressed in the articles and described those that are essential for making restoration projects successful and sustainable. Of the articles considered, majority had described the importance of governance components in marine, forests and terrestrial ecosystems. Other studies were on river, groundwater and cropland ecosystems. We found substantially fewer articles describing the importance of governance components in restoration of rangeland, freshwater and desert ecosystems. We proposed integrating the components to come up with integrated framework of restoration governance for future restoration interventions.

In addition, web-based search engine http://scholar.google.com/ was fetched using the key words: “restoration governance” and “degraded ecosystems” for considering manuscripts relevant to our topic but not assessed from systematic survey in Web of Science. The information from the later search was used for complementing the description of the key components identified from the systematic search.

3. Need for restoring degraded ecosystems

3.1. Loss of ecosystem services

Every ecosystem consists of a dynamic complex of plant, animal, and microbial communities and the nonliving environment, interacting as a functional unit (United Nations, 1992) and provides humankind with vital services. Ecosystem services are crucial to human wellbeing, and every society depends on these services (MEA, 2005; SER, 1997). Ecosystem services on which human populations depend include: provisioning services supplying food, water, timber, and fiber; regulating services moderating climate, floods, disease, wastes, and water quality; cultural services providing recreational, aesthetic, and spiritual benefits; and supporting services regulating soil formation, photosynthesis, and nutrient cycling. Ecosystem services provided by global terrestrial and aquatic ecosystems are, however, currently threatened by anthropogenic pressures and multiscale environmental disturbances (climate change, multiple disturbance interactions) which have resulted in widespread losses of production and conservation values (Hobbs and Norton, 1996) and altered habitats and distributions of organisms (Chapin et al., 2000). Over the past 50 years, to meet rapidly growing demands for food, fresh water, timber, fiber and fuel, humans have altered ecosystems more rapidly and extensively than in any other period of history (MEA, 2005).

These ecosystem alterations and losses often convert ecological resources to economic resources, which has challenged sustainable development at the local, regional and global levels, and impacted livelihood of poor people, especially in developing countries. For example, if we consider availability of drinking water, it was a free resource in most of the developing countries before 1970s (purely an ecological resource without a price or market) and there was no restriction on how much a person used for household purposes. Nowadays, however, fresh and clean water are scarce as a result of pollution and watershed degradation and most of the people in developing countries, either in rural or urban areas, are purchasing water (converted to economic resource) for their subsistence. Overharvesting and excessive pressure on ecosystems have also changed some renewable resources to non-renewable resources. For example, resources available from forests and grasslands are long-term services which fulfill subsistence need of local people and moderate favorable microclimatic conditions, maintain atmospheric and groundwater balances, regulate nutrient cycles etc. But large-scale clearing of these ecosystems and unregulated harvest of the resources have reduced production capacity and converted the ecosystems to those which provide just short-term benefits. The reduced benefits are concentrated to a limited

Table 1
List of manuscripts highlighting component/s of restoration governance. The articles were assessed from Web of Science (till March 2018) with the search key words: "Restoration" as "Title", and "Governance" and "Ecosystem" both as "Topic". Total manuscripts obtained through the search were 51.

Author	Ecosystem studied	Governance components (major focus)			
		Science, Technology and Information	Social (Collaboration, coordination and participation)	Economical (Financial resources and flow)	Political (Laws, jurisdiction and institutions)
Sayles and Baggio (2017a)	Estuary, coastal and marine	√	√		
Sayles and Baggio (2017b)		√	√		√
Ko et al. (2017)			√		√
Zedler (2017)		√	√		√
Hein et al. (2017)		√	√	√	√
France (2016)			√		
Xie et al. (2015)		√			
Van Dover et al. (2014)		√	√	√	
Weinstein (2008)			√		
Boesch (2006)		√			
Randall (2001)		√	√		√
Lorenzen et al. (2013)		√			
Biedenweg et al. (2017)		√	√	√	√
Root-Bernstein and Frascaroli (2016)			√	√	√
Johnson et al. (2017)	River	√	√		√
Fox et al. (2017)		√	√		√
Zingraff-Hamad et al. (2017)		√	√		√
Chen (2017)			√	√	√
Sheng et al. (2013).		√			
Chazdon et al. (2017)	Forest	√	√	√	√
Chazdon and Guariguata (2016)		√	√	√	√
Adams et al. (2016)			√		
Uriarte and Chazdon (2016)		√	√	√	√
Stanturf et al. (2014)		√	√		
Pinto et al. (2014)			√	√	
Pirard et al. (2014)				√	
Pistorius and Freiberg (2014)		√	√	√	√
Schultz et al. (2012)				√	√
Everard (2015)	Groundwater	√	√	√	
Yin et al. (2013)	Cropland			√	√
Rocha-Nicoleite et al. (2017)	Other terrestrial ecosystems	√	√	√	√
Hodge and Adams (2016)			√		√
Brancalion and Chazdon (2017)		√		√	√
Brancalion et al. (2017)		√	√	√	√
Richardson and Lefroy (2016)		√	√	√	√
Borgstrom et al. (2016)				√	√
Heikkila and Gerlak (2016)		√	√		
Bridgewater et al. (2015)			√	√	√
Zuleta et al. (2015)		√			√
Butler et al. (2015)			√		√
Lee and Krasny (2015)			√		
Berardo et al. (2014)			√		
Gerlak and Heikkilay (2011)		√	√		
Carrion et al. (2011)			√	√	√
Yin and Yin (2010)			√		√
Petursdottir et al. (2013)		√	√		√

(continued on next page)

Table 1 (*continued*)

Author	Ecosystem studied	Governance components (major focus)			
		Science, Technology and Information	Social (Collaboration, coordination and participation)	Economical (Financial resources and flow)	Political (Laws, jurisdiction and institutions)
Ebberts et al. (2018)	Miscellaneous		√		√
Manton and Angelstam (2018)		√			
Brancalion and van Melis (2017)		√	√	√	√
Hychka and Druschke (2017)		√	√		
Akhtar-Khavari and Telesetsky (2016)		√	√		√

number of people and therefore consequently pose costs in socio-economic and political dimensions. The question here is, for how long can we afford the costs of loss in ecosystem services? Now is the time to take actions and restore ecosystems and their vital functions. Human engineered ecosystems (without self-sustaining natural interactions) can't provide life supporting services for the long run, and this was also the lesson learned from Biosphere 2 Research (MacCallum et al., 2004). We have ample examples of wildlife habitat degradation, forest and rangeland loss resulting from anthropogenic pressures (Farris et al., 2015; Haddad et al., 2015; Lamb et al., 2005). Degradation of these resources will ultimately increase the survival cost, and if not restored leads to future adverse environmental situations. Modern societies are advancing with regard to technology and rapidly converting natural ecosystems to anthropogenic systems, but people are inseparable from nature. Though there is disagreement about the spatial distribution of degraded areas, global estimates range from less than 1 billion to over 6 billion ha (Gibbs and Salmon, 2015), negatively affecting the lives of billions of people. In some places, the changes have resulted in significant short-term gains in vital resources (food, water, shelter and clothing) but in other regions, the changes have had fewer positive impacts and many negative outcomes and worsened the situation of people whose subsistence is directly dependent on the ecosystem services (Table 2). In this regard, restoration practices foster the availability of ecosystem services and reduce the conversion of free ecological resources to economic resources. Initiation of effective restoration programs can enhance sustainability and ensure return of ecosystem integrity, health and services.

3.2. Global commitments

Given the depletion and degradation of natural ecosystems across the globe, The Aichi Biodiversity Targets (Conference of Parties: COP-10 of Convention on Biological Diversity, 2010, where 193 countries convened and agreed on 20 targets to reduce global

Table 2
Trends in the world's ecosystem services over the past 50 years.

Services	Trend		
	Declined	Mixed	Increased
Provisioning	Fisheries catch Wild foods Wood fuel Genetic resources Natural medicines and pharmaceuticals Freshwater	Timber Cotton, hemp, silk	Crops Livestock Aquaculture
Regulating	Air quality regulation Regional and local climate regulation Watershed stabilization and erosion control Water purification and waste treatment Pest regulation Pollination Natural hazard regulation	Water regulation Disease regulation	Global climate regulation (carbon sequestration: spatial variation may be observed)
Cultural	Spiritual, cultural and religious values Aesthetic values	Recreation and ecotourism	
Supporting[a]		Nutrient and water cycling Soil formation Primary production	

[a] Supporting services have indirect benefits to people. Changes in supporting services affects provisioning, cultural and regulating services. Since supporting services have variability in trends across geographical areas, we hypothesized these services in the category of mixed (increasing trend in some ecosystems and decreasing in others). (Modified from MEA 2005).

pressures on our natural world) advocated Strategic Goal D, "Enhance the benefits to all from biodiversity and ecosystem services." The Convention specifically emphasized in target 15 that, "by 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15% of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification" (http://www.cbd.int/sp/targets/). Similarly, the Bonn Challenge (endorsed and extended by the New York Declaration on Forests of the 2014 UN Climate Summit) is a core global commitment to restore 150 million hectares of the world's deforested and degraded land by 2020 (launched at a high-level event in Bonn in 2011) and 350 million hectares by 2030 (http://www.bonnchallenge.org/). The Bonn Challenge also includes national priorities such as water and food security and rural development while addressing climate change, biodiversity and land degradation commitments. These targets and commitments can be met successfully when restoration interventions are governed under an integrated framework. In many parts of the world, restoration practices are already underway and these efforts can be accelerated significantly with considering the framework.

3.3. Constraints on current restoration programs

Ecosystem restoration has become a key component in global conservation programs and ecosystem sustainability (Aronson and Alexander, 2013; Choi, 2007). Some restoration projects have shown great success in returning degraded sites to desired reference level conditions (Barral et al., 2015; https://www.nrcs.usda.gov; Schmutz et al., 2014). However, some scientists have reflected that current restoration practices fail to recover original levels of ecosystem structure and function, even after many decades, so restoration practices need to be strengthened (Moreno-Mateos et al., 2012). The latter concerns are due to the following constraints in current restoration programs.

- The cost of ecosystem restoration is not considered as a part of the cost of natural resources extraction and use.
- Not all ecosystems are conceived to provide direct ecological or other benefits to humans. For example, we usually do not regard the value of oxygen produced by a forest during photosynthesis or the decomposition process that occur naturally in ecosystems.
- Many nations do not have strong ecosystem restoration programs, institutional framework or laws requiring restoration of industrial or other disturbances. Policies should be clear to scale up restoration approaches at the government and local levels.

- The technology is necessary for restoration (especially in case of active interventions) but they are inadequate in many developing and even developed countries.
- The science, technology, and regulation of ecosystem restoration must be embedded in a legal, socioeconomic and political system or context for governments at all levels.
- The general public does not participate (or has minimum participation) in restoration of ecosystems disturbed by anthropogenic activities or natural events as they are not aware of the effect of potential disturbances. There is a need to create an awareness system of potential disturbance to involve public at the local and national level.
- Restoration projects are not realistically funded over the true course of time require for proper restoration and monitoring.
- Monitoring and evaluation practices are weak.

4. The solution

4.1. The model of restoration governance

Components of restoration governance must be integrated into ecological restoration activities. The activities should focus to address various temporal and spatial scales, biological feasibility, sociocultural acceptability, financial viability, and institutional tractability (Richardson and Lefroy, 2016). These elements can be grouped into four key components of restoration as: 1) laws, jurisdiction and institutions; 2) financial resources and their adequate availability; 3) collaboration, coordination and participation with stakeholders including the local people; and 4) science, technology and information (Fig. 1). These major components of restoration governance must be integrated with transparency and accountability in both larger or smaller scale restoration programs, in developed and developing countries, for restoration success and sustainability. Effective governance should aim at building cooperation and trust among and between the restoration programs (Baker, 2014) and the stakeholders. Without these components, restoration becomes conceptually narrow and socioeconomically fragmented.

4.2. Key components of restoration governance

4.2.1. Laws, jurisdiction and institutions

Laws, jurisdictions and institutions provide guiding norms, principles and framework for restoration programs. Without developing and strengthening these aspects restoration programs cannot be successfully implemented. Some countries might need formulation of policies or strengthening of existing legal frameworks related to restoration practices. Practical policy reforms can help launch the programs effectively and efficiently (Aronson et al., 2007; GNEB, 2014; Lamb, 2014). Successful reforms should include provisions of integrated approach to restoration interventions. Since the effectiveness of restoration practices have not been evaluated systematically in most restoration projects (Benayas et al., 2009), there is a need of strengthening laws, jurisdictions, policies, operating guidelines and approaches to assess evaluation of restoration actions (Suding et al., 2015). Since monitoring and evaluation

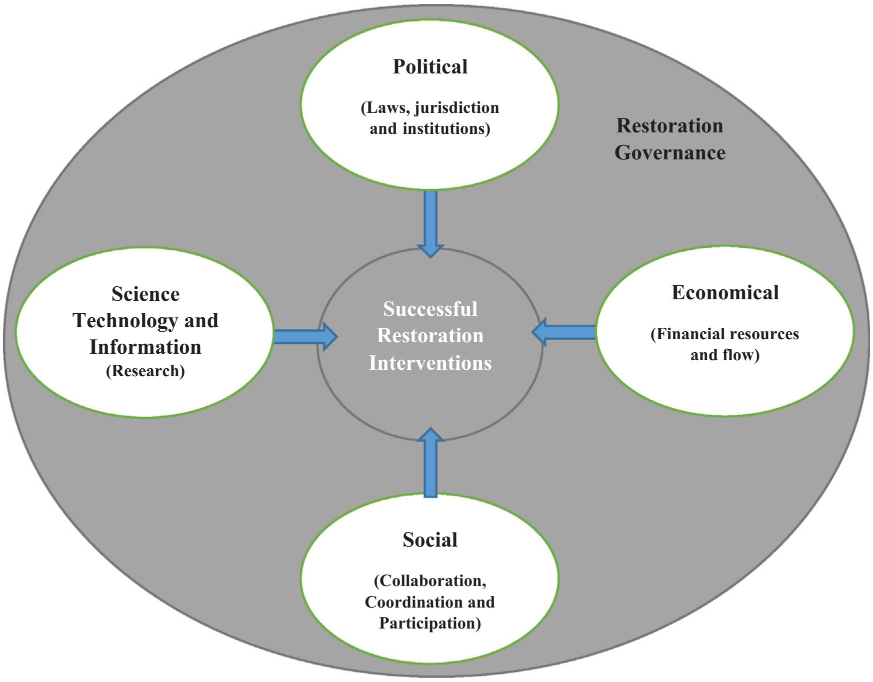

Fig. 1. Integrated model of restoration governance. Irrespective to the scale of restoration projects, the model includes integration of social, economical, political and scientific knowledge in restoration projects to make them sustainable and successful.

are the most critical component of any restoration project (Koebel and Bousquin, 2014), there should be provisions in legal frameworks for before and after project monitoring, and evaluation to assess whether restoration commitments have been fulfilled. For example, the Surface Mining Control and Reclamation Act of 1977 (SMCRA) in the United States, the primary federal law, has provisions for regulating the environmental consequences of surface mining, primarily for coal (SMCRA, 1977). SMCRA has established the regulatory environmental protection programs for the regulation of surface coal mines. It includes the necessity of obtaining a permit for any coal mining, create reclamation performance standards and establish an enforcement program to make sure that all rules and regulation are being followed. The most important result of this federal law is establishment of financial responsibility by creating a reclamation bonding system. SMCRA requires as a condition for obtaining a coal mining permit posting a reclamation performance bond to ensure that regulatory authority will have sufficient funds to reclaim the site if the permittee fails to complete the reclamation plan approved in the permit. SMCRA also requires demonstration of successful post-mining land use (e.g. grazing, wildlife habitat, crop production). This is the first law applicable across the United States requiring specific environmental performance standards in the reclamation of any intentional land disturbance. Pre and post disturbance monitoring helps in building a database of all environmental elements prior to disturbance and compare with the database collected after land restoration. Monitoring of restoration activities during implementation period is essential for keeping track record of the progress. It is also essential to evaluate the specific ecological improvements and total time required for restoring the degraded lands.

Institutions can play a major role in streamlining restoration practices. We suggest countries establish/strengthen a restoration department, managed by government agencies or universities (or established NGOs, local communities or private sectors) to make restoration work accountable over a long period of time and provide technical expertise and assistance. Creating provisions for major supporting or regulatory role by local institutions may be imperative in fostering ownership of the restoration process, instead of making it solely externally driven (Wentink, 2015). For example, in USA, Wyoming Department of Environmental Quality, Land Quality Division is overseeing monitoring of reclamation activities after mining disturbance. This is due to bonding period and phases of bond release reclamation (e.g. requirement to monitor vegetation for 10 years). Support from local institutions and communities help in continuity and minimizes redundancy of practices carried out by the federal government or other organizations. The responsible institution also coherently addresses the variety of actors, participants, stakeholders and perspectives. Since restoration is a long-term process, which might start to show results only after long periods of time (Ferwerda, 2015), local institutions can play the role of taking responsibility and assure transparency over extended periods of time and can form the basis of a bottom-up approach of restoration.

4.2.2. Science, technology and information

Another important component of restoration governance is science, technology and information. The science of ecosystem restoration and land reclamation provides opportunities to link biological, environmental, technological, agricultural and engineering issues within a socially acceptable context (Armesto et al., 2006). Understanding science helps in defining limits of ecological constraints based on the biophysical realities of the site and its surroundings (Miller and Hobbs, 2007). Restoration programs are unlikely to be successful unless and until such activities are supported by scientific research and studies. Scientific knowledge and approaches are required at different levels (e.g., species, community, ecosystems or landscapes) to overcome ecological uncertainty and unrealistic expectations, otherwise such uncertainties can lead to costly and demoralizing failures in restoration (Hobbs et al., 2004). For example, having knowledge of community ecology benefits to the practice of restoration (Palmer et al., 1997). This is also true of soil science, hydrology, climatology, microbiology, agriculture, plant physiology etc. It should be noted that although restoration ideally involves the application of science to practice, there has been little effort carried out to develop this connection (Light and Higgs, 1996). Understanding science helps in determining biological feasibility of restoration practices. Some degraded environments may have reached an alternative equilibrium where the pathway of degradation from that equilibrium and the process of restoring pre-degradation conditions may be very different (what is known as hysteresis effects) and becomes very difficult or almost impossible to restore (Richardson and Lefroy, 2016). For restoring such environments natural and anthropogenic processes as well as interactions among them that causes degradation must be identified and understood prior to designing restoration regimes.

Johnson et al. (2016) illustrated that in some Australian marine waters where invasive sea urchins have destroyed the kelp forests, barren watersheds could not be restored even when the degrading causes (sea urchins) were removed. Similarly, Kondolf (1998) emphasized the importance of science and information while studying the river restoration projects in California. The study reflected that due to lack of understanding of geomorphological and ecological processes during the river restorations, many projects were unnecessary, unsuccessful and detrimental to aquatic habitats. Another example of failure of restoration work due to limited knowledge on ecology is the plantation forestry in Puerto Rico Island to develop and maintain pine stands. Though cultivation practice was started in the 1930s, the solution to successful establishment was determined in 1955 only when the soil from under a pine stand in a similar climate in North Carolina was incorporated into Puerto Rico's soil (Briscoe, 1959). The early unsuccessful attempts were due to lack of mycorrhizal associations that are required for reaching full growth and reproductive potential of the plants.

Inadequate knowledge of restoration science also leads to restoration failure. With some of the documented restoration failure stories, lesson can be learnt for future restoration successes. Reclamation practices in mining lands of the Northern Great Plain areas of United States in early 1970s using Crested Wheatgrass (*Agropyron cristatum*) is taken as a controversial practice of reclaiming degraded lands. Crested Wheatgrass is an introduced species (originally from Russian Siberian steppe habitats) in the area and aggressively competed with native species and dominated the landscape. Crested Wheatgrass invaded landscapes were species poor and, while they provided seasonal grazing for domestic livestock, did not provide suitable wildlife habitat (Schuman, 2002). Therefore, Crested Wheatgrass is no longer permitted as a part of seed mixes for reclamation of mined lands.

Similarly, Appalachian forests in United States are rich in biodiversity, particularly for endemic aquatic salamanders and mussels (Bernhardt and Palmer, 2011). Mining activities such as mountaintop removal and filling adjacent valleys with overburden, mine waste and debris have resulted in a huge threat to forests, birds and aquatic biodiversity in coal mining areas of the Appalachian range (Palmer et al., 2010). Efforts to restore vegetation diversity and ecosystem functions in mined watershed are underway but to date, have not proven successful (Bernhardt and Palmer, 2011). Extensive scientific research and information on soil quality, climate, vegetation establishment (colonization and dispersal), and mechanisms of change and interactions are required to restore these areas.

Technology must be employed appropriately when active restoration programs take place. Trend towards selecting modern technologies does not mean traditional approaches are ineffective in restoration programs. Traditional indigenous knowledge and practices are at the forefront of many restoration programs, particularly in developing countries. That said, gaps that may exist in traditional systems and practices can be filled by proven modern technologies. Similarly, communication of information serves as a means of transparency. The success or failure, particularly the latter, of restoration practices around the globe are not well documented or communicated. But information including failed attempts are needed to improve the effectiveness of ecological restoration. The practitioners should document their experiences and communicate their findings (Nilsson et al., 2016). For many projects, achievements of the restoration practices are not being published or otherwise reported. Historical knowledge and information is of vital importance in recognizing key ecological legacies providing options for restoration practitioners (Higgs et al., 2014) and a valuable lesson for restoration success. The practical knowledge from restoration practitioners, private companies and consultants are always required for formulating future restoration interventions at different scales.

4.2.3. Collaboration, coordination and participation

Active participation of stakeholders, including local people, should be ensured for successful restoration. Since restoration is meant to enhance wellbeing of people (Gann and Lamb, 2006), who are an integral part of nature (Egan et al., 2011), restoration programs should not be viewed in isolation from concerned people's participation and collaboration (Burke and Mitchell, 2007; Geist and Galatowitch, 1999). Both direct and indirect benefits from ecosystems are ultimately to the communities living nearby or associated with the ecosystems. Restoration practitioners should consider giving priority to local and affected communities and should communicate the importance of direct and indirect benefits from ecosystem restoration. Along with the effective local level institutional mechanisms, opportunities for broader societal participation and links should be ensured. Ultimately, the success of ecosystem restoration usually depends on the community's commitment, as well as the extent of their awareness and understanding about restoration. Collaboration and coordination is equally important with other organizations working on restoration. Collaboration provides partnerships, synergy and complementarity on local restoration efforts in a structured way (Wentink, 2015). Siloes are a fundamental challenge in restoration programs which generally needs collaboration and coordination (Sayles and Baggio, 2017b).

It is important to capitalize site-specific synergies and comparative advantages of different support agencies. For example, international organizations might have a strong mandate to cooperate with national government agencies to enable institutional

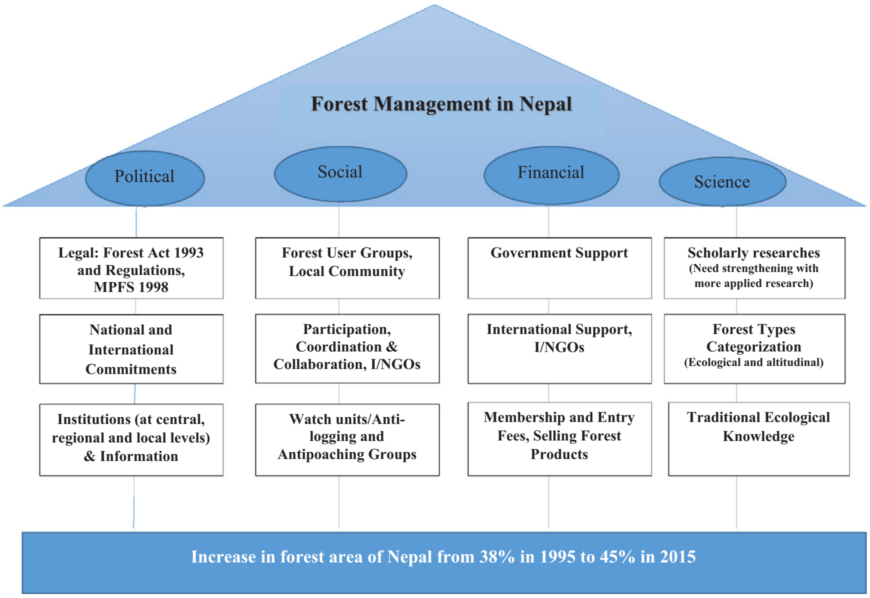

Fig. 2. Diagram showing integrated approach of forest management in Nepal.

relations. The success of environmental and natural resource management is influenced by the degree to which human welfare is incorporated into decision making processes (Farber et al., 2006; Mangun and Henning, 1999). Baker et al. (2014) have pointed out that social and political scientists have paid very limited attention to the study of policies and practices of ecological restoration. Information on societal norms and practices help to increase the extent of investments made in restoration through appealing to international sentiments and commitments (De Groot et al., 2013). Achievement from restoration practices should be clearly linked with demand for local resources and socio-economic development using a bottom up approach. A top-down approach of restoration may not provide sustainable restoration outcomes as it lacks effective dialogue to identify critical knowledge gaps from a technical and practical standpoint (Murcia et al., 2016) and may have to be updated with the local needs. Ensuring people's accountability to restoration practices help in making restoration projects successful. For example, communities (user groups) commitment, participation and involvement in forest conservation have resulted in increase in total natural forest area of Nepal from 38% in 1995 to 45% in 2015 and the overall system of forest management is also under the restoration governance framework (DFRS, 2015; Fig. 2). Local people are determined to conserve and sustainably utilize the forests. The yearly operational plans for forest management are developed and the communities actively lead in implementation of those plans. Moreover, the forest management practice is under the restoration governance framework. Government, NGOs and INGOs provide financial and technical support to carry out different forest management activities. Research is also underway to categorize forests in different ecological regions and discoursing the major causes of forest degradation (there are however, other relevant issues to be considered for future research too). Nepal has efficient forest management policies (the Forest Act 1993, the Master Plan for the Forestry Sector (MPFS) 1988 and the Forest Regulation 1995) and these legal provisions have promoted decentralization and participatory forest management approaches. Government has developed institutional mechanisms in the central, regional and local levels too. These institutions coordinate with local stakeholders to manage the forests in Nepal. China has made great achievements through large scale forest restoration programs and has significantly increased total forest cover, in the past two decades. However, the outcomes are considered as an unsustainable top-down strategy since the restoration programs do not account local environmental conditions and lack involvement of local communities (Xi et al., 2012).

4.2.4. Financial resources

Another important component of restoration governance is availability of secure funding sources and mechanisms for the restoration programs. Economic issues are as important as ecological issues (Wyant et al., 1995) and are a factor in prioritizing restoration projects (Palik et al., 2000) which limits the scope of the work that can be done (Miller and Hobbs, 2007). Clear and unobstructed funding mechanisms make restoration programs potentially successful. In some of the developing countries, funds for ecosystem restoration are allocated in small amount, often diverted and used for other programs rather than for restoration interventions. Furthermore, social constraints and public attitudes might limit funding mechanisms (Miller and Hobbs, 2007). Therefore, sufficient funding should be ensured over an extended period so restoration programs are not just seen as a short-term diversion, delusion and waste of money. Often, international funding support is needed to assist implementation of restoration projects. As such, there is an immediate need to streamline the bureaucratic processes associated with funding applications and strengthen flow of funding mechanisms from international funding sources. It is important to regulate enforcement systems by local and regional (federal) government agencies to make sure companies disturbing land can afford the cost of restoring it and have the obligation to issue a restoration bond, which has sufficient funds to restore the site if the companies fail to complete the approved restoration plan,

Table 3
Key questions on governance components that should be considered before starting restoration projects.

Science, Technology and Information (Research)	Social (Collaboration, coordination and participation)	Economical (Financial resources and flow)	Political (Laws, jurisdiction and institutions)
• Are there adequate ecological data on existing conditions of the degraded ecosystem? Has the degraded ecosystem crossed abiotic and biotic thresholds (hysteresis)? • Are there information available on historical conditions (to help understand dynamics of the ecosystems and determine reference site conditions) and socio-economic conditions of the area? • What is the method of intervention (passive or active) proposed? Are there efficient technologies for their implementation? • Why is the selected intervention approach more appropriate than others? Are there historical evidences or success stories of the approach? • Is database management system ready to keep track of the activities performed? • Can the technologies be transferred for the future restoration activities? • What are the ways of sharing experiences with national and international communities?	• Are societies aware with restoration projects? • Is the natural resource use pattern and intensity (of communities) major cause for ecosystem degradation? • Have local communities shown willingness and commitment to participate on proposed project? What are the best possible ways to assure their maximum involvement? • What provisions do existing project has to motivate the communities towards restoration practices? • Do restoration practices have socioeconomic benefits? • Do restoration activities preserve and promote cultural dimensions (norms, values and perspectives)? • When the restoration is complete, can the area be viewed in the dimension of social justice?	• Are there adequate and sustained financial arrangements for the restoration project? • Is there enough budget to follow up post-restoration activities? • Are there opportunities to link restoration project with long term governmental priorities (governmental budgetary policies, plans etc.)? • Are the communities, private sector and commercial companies (within the provisions of corporate social responsibility) willing to support restoration project? • Do the country has ample provisions to welcome international funds? Can the proposed project be linked with those funding mechanisms?	• Are permissions and approvals required to initiate and implement restoration activities? • Are there efficient and practical national laws, policies and standards for restoration? How the project can be linked with these legislations? • Which provisions in the legislations support existence and extension of restoration project? • Are the institutional arrangements sufficient across regional and local levels? • Do the institutions have provisions of recording and maintaining historical legacies? • Are there standard systems of monitoring and evaluation developed in the proposed project? • Does the nation have framework of national restoration priorities? Can the proposed project be linked with it? • Are there cross cutting policies that conflict with each other? Are there ways of reaching to common understanding? • Are there sufficient provisions to synchronize international laws (usually in case of large transboundary projects?) • Have government ministries extended restoration departments, cubicles in the local and regional levels? • Are there legal provisions for continuing national/international cooperation? • How are international commitments addressed by a country and how it can be link with the proposed project?

even in case the company files for bankruptcy.

Ecological restoration practices are receiving increasing attention throughout the globe, and will be one of the most important fields of applied ecology providing new ideas and opportunities in the coming century (Choi, 2004, 2007; Davis and Slobodkin, 2004; Hobbs and Harris, 2001). Further approaches must take into consideration all the components of restoration governance and should be able to explain ecological integrity, long-term sustainability informed by past and expectations of future, and benefits to society (Suding et al., 2015). Both the developed and developing countries have improved significantly their capacities to manage intact ecosystems and repair damaged, destroyed or degraded ecosystems (Holl et al., 2003; Lamb, 2011; Suding, 2011), however, still there is need of more integrated and transdisciplinary approaches (Clewell and Aronson, 2013; Falk et al., 2006; SER, 2004). Practitioners and other concerned stakeholders should be aware of the questions that usually arise while integrating restoration governance components in their projects (Table 3). Finding answers to these questions during ecological restoration is critical to make the restoration administration, science and practice sustainable.

5. Conclusion

Ecosystem restoration is an emerging and expanding practice across the globe and will most likely increase in importance as the world population and demand for natural resources and sustainability become more critical. Many countries have started restoring ecosystems that are in degradation or have been degraded in the past. Restoration programs become successful only when the restored ecosystems can function properly and provide ecological benefits. The success and sustainability of restoration projects (whether small or large) relies on addressing and integrating components of restoration governance. Site specific legislations, integration of ecological principles and science in restoration programs, adequate funding and unobstructed mechanisms, and ensuring public participation help in making restoration programs promising. Since ecological restoration is an inclusive and integrated phenomenon, consideration of key components of restoration governance from project assessment to evaluation phase increases the possibility of reaching desired or reference site conditions. Similarly, responsible entities are required to look after the restoration activities for longer periods of time and develop continued collaboration with other stakeholders. Such institutions also help in maintaining ecological and environmental databases of pre-disturbance conditions for comparison to data collected from monitoring of environmental elements after restoration of ecosystems. Restoration interventions need to be strengthened for maintaining historical legacy and sustainability. In this context, approaches towards integrating and mainstreaming restoration governance components facilitate developing planned and organized procedures of restoration activities and will be a strong reference for future implications.

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