Monitoring And Assessment of Nature: A Review

Ayodeji K. Ogundana
Department of Geology, Afe Babalola University, Ado-Ekiti, Nigeria
DOI: 10.56201/ijgem.v10.no10.2024.pg60.69

Abstract
Monitoring and assessing the socio-ecological systems involves a lot of complexities. Several innovations is needed for rural communities to understand the relevance of building a resilience socio-ecological system. To this end, the study focused on exploring the various monitoring and assessment methods of the ecosystem giving relevant examples, identification of the nature-based solutions according to forensic search from literature and studying the socio-ecological systems based on climate change. The findings revealed that there are still gaps to fill in the area of building a sustainable resilience and adaptation. This include; insight into the interdisciplinary context on the management of the ecosystem by involving all stakeholders. Furthermore, in-depth study on the use of innovation and technology that could help the local communities in the building of a robust socio-ecological resilience. Thus, making it possible to address the global impact of caused by change in climate

Keyword: *Socio-ecological system, Resilience, Adaptation, Climate, Biodiversity*

1. Introduction

The existence of the social ecology systems can be described to be a form of linking relationship between the ecosystem, society and the resilience of the system is a function of factors which depend solely on the relationship between the human beings and the system [1]. For instance, the urban society and their presence of wildlife around them has an impact on the people. These impacts could be classified into negative or positive. One of the negative impacts could be the several attack on the occupants of residence by animals which could cause a severe damage to people as well as the domestic animals. Also, there could be spread of diseases, destruction of buildings and other infrastructural facilities and most importantly, it could cause nuisance such as defecation on buildings, cars and chairs. In the same vein the presence of urban trees could cause damage of properties in the event of wind and storm and these damages include destruction of powerlines and buckled footpath. However, despite the negative impacts as earlier mentioned, the benefit of urban nature cannot be overemphasized. It has some great benefits which include tourism, energy and added value to the properties. Also, recreation centers which could be bird-watching and ecological benefits such as seed dispersal, shade and pollination process. More so, some of the main benefits of the ecosystem include attenuation of noise, abatement of pollution as well as sequestration of carbon. Some species provide aesthetics which include observation and photography of wild animals and special trees, spiritual insight, relief stress and enhances socialization and most importantly, educational benefits. Efforts are ongoing to investigate the complexity in the patterns of the ecological system as well as the process which exist in the urban space. From studies, three different approaches exist which include classifying cities to be distinctive i.e. social-ecological systems, classifying ecosystem in cities and classifying the functions and services that the urban systems can provide [2]. [3] developed a research field that focused on the merging of the urban processes of exaptation and the

scientific principle behind the resilience during the outbreak of COVID-19. The study elucidated the resilience principles as well as exaptation embedded in the socio-ecological systems. The study further placed the processes of exaptation into the context of continuous renewal using some model as a framework used in the science of resilience to capture the dynamics in the complex adaptive system. The key attribute of resilience integrated in the study include change, diversity, learning and self-organisation. Thus, the result of the study postulated that resilience approach help in promoting the development of new research areas for addressing problems associated with designs involving social-ecological systems. Thus, external disturbances like pandemic will be easy to handle. According to Kilbane [4], building a nature-based resilience solution for socio-ecological systems require the stakeholder's mentality. In this case, there is need for the balancing of the expert knowledge with the ecological information with emphasis on socio-ecological systems as well as the functions of such systems. Thus, there will be transparency and adequate planning for a resilient socio-ecological system, thus bringing sustainable solutions. Thus, the perspective of western researcher's and that of the local experts which reside within the ecological communities are vital in the development of a robust nature-based solutions for resilience and adaptation to the ecological changes [5-7]. This indicates that the human dimensions in building the sustainable resilient and adaptation to socio-ecological system changes is very vital [8-9]. Flood et al. [10] established that building a resilient adaptation for socio-ecological changes especially that of climate and biodiversity is very fundamental. This the study investigated the responsibility of community to challenges. The study was able to unveil the theoretical insights from the perspective of resilience and the diversity in the economy, thus, the community played a great role in building a sustainable adaptation and responding to changes in daily resilience. In a study by Grantham et al. [11], it was reported that the conventional techniques used in water engineering use to have static maintenance as well as optimization in the performance of the system. Thus, making it easy to provide reliable supply of water energy and protection of flood. However, delivering these services has several challenges such as disruption of the freshwater ecosystem, reduction in biodiversity and loss in the ecosystem [12]. Currently, climate change presents recent challenges in the management of the freshwater and the ecosystem. Ecological resilience solutions in the form of designing and managing the systems is currently being provided by climate change [13-15]. Provision of climate information about ecological resilience principles as well as some indicators that can improve the need of the ecosystem within the auspice of water resource engineering management. This study provides the potential guide to climate-adaptive water resource management as well as positive impact to the people and ecosystem in an operating environment. According to [16], in the Anthropocene, it was established that the global economy is faced with several problems ranging from conversion of biosphere to a homogenous and highly interrelated production ecosystem. Thus, the global economy is now characterized by climate change, degradation in the environment as well as social problems. Among them all, climate change has been identified as the top risk producer to the socio-ecological system which will eventually influence the industrial sector. Climate change action loss and biodiversity loss have been identified to be the risks. Based on these problems associated with with climate change action failure and biodiversity loss, the study developed two concepts of insurance to assess the value of insurance of biodiversity/ecosystem. In this case, the resilience values were addressed using the ecosystem without focusing on risk preference. However, the risk aversion was handled using the economic framework indicating that for a neutral person, insurance value was zero.

Meanwhile the conceptual and empirical analyses were carried out and related to the vast socio-cultural issues which exist in the socio-ecological resilience. Furthermore, the study stated that there are inconsistencies in the existing literature on the insurance values in the case of biodiversity and this hardly comply with the resilience theory. Thus, the study proposed that resilience value which has the capacity to reduce the ambiguity associated with the concept of insurance value in the area of biodiversity. This study vividly and succinctly reviewed the existing studies on nature-based solutions built to address the issues of resilience and adaptation to socio-ecological climate change and biodiversity loss. Gaps in the existing solutions were highlighted and way forward was suggested.

2. Identifying and Measuring Socio-ecological Systems

Perng et al. [17] established that the activities of the socio-ecological systems, environments and human beings could cause the ecosystem to shift from a function state to another which in most cases almost undesirable state ensues with limitation to delivery of goods and services. For instance, high fishery to low fishery production activities. However, the studies on the social regimes are scarce compared to the ecological regime. Thus, this study deployed socio-economic parameters to identify the thresholds and trends that existed in six different marine socio-ecological systems in the United States.

The study initially considered the use of additive modelling technique to sort the time of change and linked them regional and national drivers. Also, the environmental index, social index was used to rank the social outcome as well. In the same vein, the innovation brought about by the technology and the change in national regulation occurred with the paradigm shift in the productivity of fisheries, however, the changes in some actual fisheries was determined using the local regional shifts. The study demonstrate that the analysis of the threshold was proficient in the identification of regimes and performance assessment. Thus, it provided a potential insight into a possible means of avoiding unfavourable change and the assessment helps the society in adapting to those changes.

The maturity in conservation biology had expanded its scope from normal ecological focus to the recognition where virtually all problems covers people. In the same vein, actions have been taken using sophisticated and quantitative models. However, this model only concentrated on the ecology and geographic components of conservative problems. This include prediction of the occurrence of specie, optimizing protected zones and mark-recapture. While the most effective off the shelf ecological models are left untapped. Hence, this study addressed this problem by using a modelling framework for the interaction of human-nature by combining the principles of economics as well as social sciences and the ecological models. The method involved the breakdown of the systems into resource user, ecosystem, infrastructure, provider of infrastructure and the system interaction between the elements which caused the corresponding biophysical occurrence. Also, the current behavior of the human society and the rules like the unprotected areas were included. The study concluded that there is an urgent need for models that encapsulate biology conservation which is uniquely developed to handle the complex human socioeconomic behavior rather than adaptation to an ecological model. This study appeared simple but vast in the monitoring and assessing the specifications for socio-ecological models that could help in the field of conservative biology[18].

According to [19], biodiversity management in places like Ecuador, the focus is only based

on utilizing protected regions for the purpose of conservation, however, this method does not seem to synchronize biodiversity interactions with the human beings, rather socio-ecological systems were neglected and these systems are highly beneficial to the people and communities inhabiting there. Based on these aforementioned gaps, the study concentrated on reviewing the traditional examples of adaptive integrated management that also integrated socio-ecological relationship and the essential benefits that this provides to the community in Ecuador. From the study, it was observed that four different principles were consider relevant to the management and assessment of the socio-ecological systems and this include;

(1) Maintenance of diversity and redundancy where the important parameters refer are response diversity and functional redundancy. The former refers to the varying reactions that different traditions or cultures exhibits which include; subsistence practice, institutions and knowledge and the ecological behavior which also include; the different traits and species. However, the component of socio-ecological system is demonstrated in response to a particular disturbance. More so, the functional redundancy includes the cultural and the ecological behavior showing similar and, in most cases, complementary behavior in the ecosystem. This is the reason why several countries especially that of Latin America are megadiverse. This usually increase ecological resilience because biodiversity has the potential to stabilize the production of biomass.

(2) The second principle used in this study is the principle of connectivity management where the species movement, energy and resources are monitored and regulated. a major problem with this principle is the disruption of the habitat by fragmentation. This could cause complete ecosystem degradation activities. A typical example is that individuals who socializes often are usually influenced by the people who interact with them which usually cause the development of mutual understanding about the environment and status of the resources. This example is from a social point of view.

(3) The third principle deals with management of slow variables. In this case, it was reported that the ecosystems in the Amazon zones is characterized by slow variables which have not changed over some decades. This be due to the partial interactions in cultivated areas and natural vegetation which could reduce niches for species.

(4) The fourth principle deals with promoting complex adaptive systems thinking which implies the integration local stakeholders' view to socio-ecological adaptive co-management which was brought about by adaptation to change. "worldview" can be applied which is also a cultural method that work as guide to understand and make reality happen. The worldview could also be referred to as mental custom which consist of certain behaviours and belief. Hence, it is referred to as a relational pattern of representing continuous relationship between culture and nature that are beneficial to the rural community. For instance, it is a believe from there worldview that the soil layer that sustains all life on earth was a living entity as perceived by them. Thus, since maintenance, growth, collapse and reorganization characterized the adaptive cycle of the socio-ecological system. The legacies which exist from the worldview can promote the coordination of the socio-ecological system.

(5) Encourage learning is the fifth principle as highlighted in the study. This helps to harvest wisdom from people and understand the existing collective knowledge about the residents in the community due to the interaction with diversity. Learning means understanding the relationships between human beings and their environment. thus, it could refer to as relational values of biodiversity.

(6) The sixth principle revolves around broaden participation. This calls for integration and inclusions of all stakeholders involve in building the socio-ecological system. The consistent

participation makes it possible to redistribute ecological system that are loaded with complexities in dynamics and this can happen from interaction.

(7) The seventh principle is the promotion of polycentric control. This occur when governance involve actors from various institutions to interact at different levels of public policy making. Formal and informal institutions are both social systems which provide a rule decision as a result of consistent interaction.

All these principles demonstrate the potentials of deploying adaptive co-management to coordinate biodiversity and to rebuild the development of the rural areas.

Furthermore, vulnerability is key to having a robust and sustainable socio-ecological system which involve interlinkages. Thus, [20] presented an optimized framework for the assessment of the vulnerability of a pastoral socio-ecological systems using the interaction between the socio-ecological systems and their respective vulnerabilities. The study used Altay prefecture which is a pastoral region Central Asia as a case study. Ecological vulnerability and socio-ecological vulnerability indices of the region were used to assess and classify the data collected from 2001 to 2018 into five different levels. The result of the ecological vulnerability index showed that the pattern of distribution was heterogenous with evidence of increase from north to south and west to east. However, the socio-ecological index of the western states was observed to be lower compared to the eastern countries. Thus, the result helped in the identification of the areas with high ecological vulnerability index which will be beneficial for grassland ecosystem. Figure 1 showed the regions of the studied area while Figure 2 represent the framework of the vulnerability test.

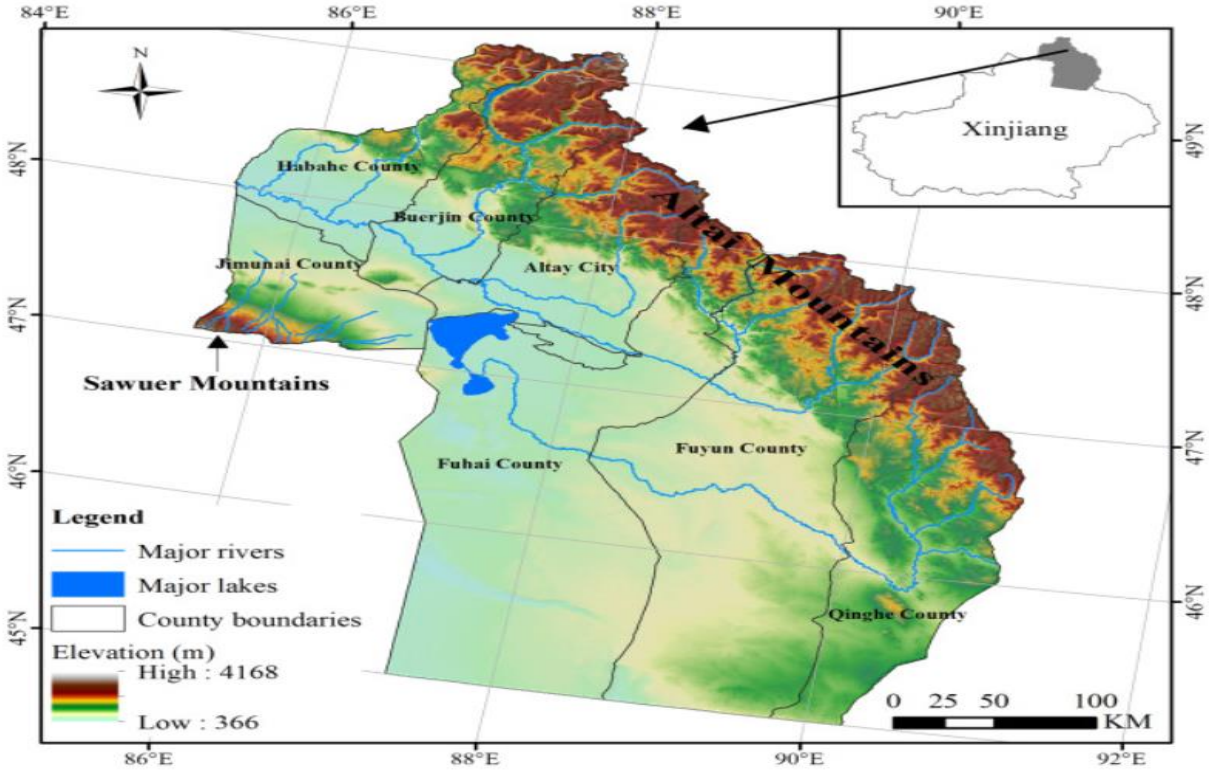

Figure 1: Plot of study area
Source: [20]

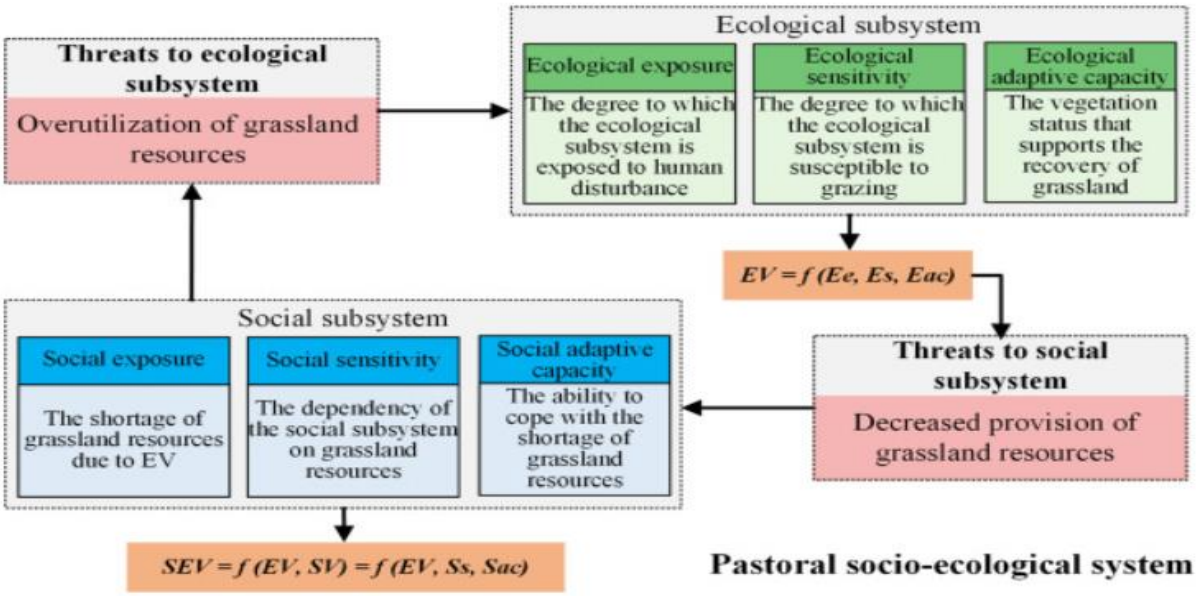

Figure 2: Methodical framework of the socio-ecological vulnerability
Source: [20]

3. Climate Change and Biodiversity Loss

In the past decades, the opinion and policy of science did not capture the surrounding ecosystem. One of the essential natural resources in the ecosystem the ocean. Its biodiversity is important to the hydrosphere which exist on earth. Several changes which have negative impact such as losses on the on human and resources. Climate change and the earth systems such as the biosphere, hydrosphere, geosphere regulates the planet's stability as well as its resilience. These alterations have been made possible by the activities of men. Some of these systems are now under the threat of extinction and loss in nature as well as degradation in the ecosystem. Thus, the impact of climate change has been useful enough to cause harm to human, hence the need to embark on nature-based solutions for adequate resilience and adaptation [21].

Furthermore, this study established that the perspective of the planetary health perceives the human health to be a function of interdependent relationship systems and the ecosystem which represent where they live. Thus, planetary health that involve climate change results in ocean biodiversity loss which have not been fully explored. Thus, climate change cause ocean warming deoxygenation as well as acidification. These problems impact seriously on the biodiversity and the planetary health as well. Furthermore, impacts include effect on the natural and human health systems that include human issues for the services of the ecosystem, security of nutrition, livelihood, research based on pharmaceutical studies disaster risk management, biomedical etc. these impacts on the ocean as well as its biodiversity is critical for building a nature-based solution with effective and reliable resilience and subsequent adaptation.

Climate change and biodiversity loss contribute dangerous threat to the humanity. From the perspective of natural science, they are interrelated in different ways. Climate change influences biodiversity loss and vice versa. Thus, the ecosystem is very critical to building a nature-based solution in order to reduce and adapt to the climate change [22]. Based on this, [23] utilized data from Eurobarometer to study the relationship between climate and

biodiversity related opinions and the input of people from the Europe. The result revealed that climate and biodiversity related cases depend on an individual level and understanding of the behavior concerning protection of the environment with respect to nature protection. Also, it was reported that both climate and biodiversity loss related cases demonstrate that they are both independent according to the regression analysis result. The results helped the European countries in the sense that improvementin food consumption practices can help individuals to play their part excellently, thus helping in fighting climate change and biodiversity loss respectively. According to [24], Anthropocene climate change remains a great threat to the functioning of the biodiversity. However, the influence of the climate change as a result of the human factor could cause temperature rise, variation in seasons, glacial retreat, rise in sea level and agitation by ocean current.

1. Nature-based Solutions for Resilience and Adaptation to Socio-Ecological Changes

The impact of global change in reshaping the socio-ecological systems cannot be overemphasized with continuous threat to the nature and the ecosystem. Hence, landscape integrated with nature and human interactions have always been vulnerable to the changes in the climatic conditions. Thus, the need to find a sustainable solution for the preservation and recovering the affected resources in the ecosystem. The best way to avert this problem or cope with the problem is to encourage embark on socio-ecological resilience using strategies that target the entire ecological system [25].

According to [26], building a nature-based solution to the problems of the ecosystem involves clear definition of the socio-ecological systems and its characteristics as well as the various features which are always used by human. Also, there is a need to identify and elaborate the importance of socio-ecological resilience for several landscapes by focusing on the interrelationship between nature and human. Furthermore, there is also a need to propose a future guideline that will help in promoting and enhancing the socio-ecological resilience. Understanding of these highlighted factors will aid the building a sustainable socio-ecological resilience and subsequent adaptions to global issues.

According to [27], the impact of climate change in coastal areas are in degrees of which some are actually uncertain. The uncertainty increases the level of unpredictability of dynamics of the coastal systems which frustrates the effort of decision makers in managing the complexities. However, making decision around issues ravaging the coastal areas involves managing individual ecosystem with focus on the specific complexities and the interaction between human being and the available structures as well as the needs of the local actors. Thus, using scientific theory and principles will help in reducing the uncertainties as well as quickens the decision-making process to appropriate the defence of the coastal socio-ecological systems. Hence, adaptation to a particular coastal region and improvement in the resilience of the coastal communities.

According to [28], the semi-arid areas are characterized by vulnerability food insecurity since millions of their livestock depend on the rangeland ecosystem practices. Meanwhile, the Aravali range have a fragile arid ecosystem in western India which constitute a barrier against the desertification of the Thar desert. Despite the increment in the biotic pressure, land cover, variation in precipitation, there seem to be no improvement. Thus, the study focused on factors which can will help to improve the management of the ecosystem such as sensitivity, vulnerability and fragility of the system. The study utilized about seventeen indicators as applicable to the environment and the five different themes were used to measure their susceptibility. These include geo-climatic, socio-economic, topography, edaphic and

ecological. More so, the characteristics and the sensitivity were measured as well as the capabilities of the resilience of the regions using the integral method of ecosystem-pressure, sensitivity and resilience (E-PSR). The study concluded by establishing that stability and sensitivity of the ecosystem is possible via effective management of invasion of species and make adjustment in buffer zones which exist in the reserve areas.

4.0 Conclusion

The objective of this study was to reveal the importance of nature-based solution to building a sustainable resilience and adaptation to a socio-ecological environment in the context of climate change. The findings in the study established the importance of harnessing the interactions between the ecosystem and human beings with emphasis on the common value of responsibility in the ecosystem and conservation of biodiversity. Sustainable practices such as digital innovation and technology must be considered for effective maintenance of these interactions. Subsequently, inclusive community-based management is important in building socio-ecological resilience and robust adaptation.

Acknowledgement
The author acknowledged the management of Afe Babalola University for the financial support received in publication of this article.

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