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Ecological and Economic Impacts of REDD+ Implementation in Developing Countries

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Abstract

The REDD+ was introduced into the negotiations under UNFCCC to mitigate climate change and improve the wellbeing of communities through result based payment for reduced emission from forest sector. REDD+ activities were designed to meet an international requirement and policies to privileged for emission reduction payment. Meta-analysis was carried out with the objective to understand ecological and economic impacts of REDD+ through the review of 55 articles and proceedings, and international reports. The analysis revealed that the implementation of REDD+ in developing countries has both ecological and economic benefits. The ecological benefits of REDD+ includes protect biodiversity, regulate climate change by reducing carbon emission from forest sector through sustainable forest management, afforestation/reforestation, and rehabilitation of degraded land, reduce soil erosion, purify water, regulate of water flows and provide numerous wildlife habitats. Its economic benefits also encompass the improvement of human wellbeing through the provision of food and water from protected forest ecosystem, and verified emission reduction payment that generates additional income for forest dependent communities. Effective REDD+ design and implementation reduce carbon emissions from the forest sector, support bio-diversity and provides economic benefits.

Keywords: REDD+, Economic & Ecological -Impact, Emission-Reduction.

Introduction

Reducing emissions from deforestation and forest degradation and the role of conservation, sustainable forest management and enhancement of forest carbon stocks in developing countries (REDD+) was emerged in 2007 as a forest-based climate change mitigation approach under the United Nations Framework Convention on Climate Change (UNFCCC) [37,25,41,42]. It has been introduced to encourage developing countries to contribute to climate change mitigation efforts through reducing greenhouse gas emissions by slowing, halting and reversing forest loss and degradation and increasing removal of GHGs from the earth's atmosphere. It was a mechanism designed to offer payments to countries and projects that could demonstrate progress in the reduction of forest-related CO2 emissions [14,32].

Through the UNFCCC, Parties agreed that REDD+ should be implemented in three phases. Phase I is a readiness phase which includes designing national strategies, policies and measures, and capacity building, etc.), while Phase II is an implementation phase which includes demonstration activities, and Phase III comprises result-based actions that should be measured, reported, and verified (MRV) [2,45,48,49]. National REDD+ strategy or action plan, National forest reference level, National forest monitoring system and Safeguards Information System are preconditions for developing countries to receive result based payment (RBPs) [2,3,45,46].

Projects for REDD+ have been initiated in developing countries a few years ago with multiple actors under the global forest and climate change regime [40]. The study until 2020 on the structures and patterns of REDD+ project in developing countries showed that a few countries have mostly attracted sponsors of REDD+ projects. At the regional level, 43% of all projects have been implemented in South America, 30% in Africa and 25% in Asia [40]. This is due to networks for resource exchange, information flow and partnerships. Although the developing countries are at different levels of implementation there are no common understandings on the ecological and the economic impacts of REDD+ projects. Therefore, this paper systematically reviewed scientific articles and reports and synthesizes the ecological and economic impacts of the REDD+.

Methods

This review paper was based on systematic analysis/review of data from journals, proceedings, thesis and international reports to understand the impacts of REDD+ interventions on the ground, in terms of ecological and economic benefits. This review collects all possible studies related to a given topic with key words such as climate change, REDD+, and biodiversity, economic and ecological impacts using search engines such as Google Scholar, Scopus and Web of Science. Thus, a total of 200 articles were retrieved. The first screening was made based on the publication year and reduced the initial number of documents to 105. Further screening was made by reading the abstracts and reduced the number of papers to 48 for the detail investigation. Only papers that are directly related to the topic and those focusing on developing countries were chosen. The document review was specifically focus on synthesizing and organizing information relevant to the concepts, evolution, ecological and economic impacts of REDD+ implementation in Developing Countries.

Ecological and Economic Impacts of REDD+ Implementation

Ecological Impacts of REDD+

Climate regulation

Concerns over global warming have led both the public and private sectors to promote climate change mitigation through the reduction of carbon (CO2) emissions from deforestation and forest degradation in tropical countries, a concept known as REDD+ [2]. Forests are recognized worldwide for providing all forms of the ecosystem services such as regulation, provision, cultural and supporting services that sustain human wellbeing. Forests play a vigorous role in mitigating climate change by absorbing the atmospheric CO2 and storing it in tree biomass. Though forests remove carbon from the atmosphere, deforestation and forest degradation remain one of the main causes of increasing GHG emissions, contributing 10-17% of the total emissions causing climate change [22,36]. In the 1990s, it was estimated that deforestation, released about 5.8 giga tons of CO2 per year, and a total carbon stored in forests is estimated at 638 giga tons CO2 [48] in which 70-90% of total sequestered carbon accounts to above ground biomass [36]. Reducing emissions from deforestation and forest degradation in developing countries is therefore an important component of a global climate policy framework, and has captured international attention as a potentially effective and low-cost climate change mitigation option [41]. REDD+ through its mitigation activities reduce GHG emissions by avoiding or capturing GHGs before they are emitted into the atmosphere or sequestering those already in the atmosphere by enhancing sinks [10,44].

REDD+ under UNFCCC provides an opportunity for the conservation of forest that has significant roles in climate change mitigation by storing more carbon in tree biomass and resulted in human well-being [15,17]. The reduction in deforestation incentivized by a REDD+ mechanism has the potential to greatly reduce the extinction rate of forest species. Greater levels of REDD+ finance would lead to greater reductions in deforestation and forest degradation, greater climate change mitigation and greater provision of result based payment [11]. According to [23,43] REDD+ is a climate change mitigation mechanism under the UNFCCC through which forest removing and releasing large amounts of atmospheric carbon, absorbing or reflecting solar radiation, cooling through evapotranspiration and producing cloud-forming aerosols. It is the global response to the threat of climate change in order to keep a global temperature rise well below 2°C of the pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5°C.

In general, emissions of greenhouse gases from forest land can be reduced by slowing down the rates of deforestation and forest degradation, covered by REDD+ eligible activities. Another option would be some form of reduced impact logging in commercial logging, under the REDD+ eligible activity of sustainable management of forests. Removals of greenhouse gases (CO_2) from the atmosphere can be achieved through various forest management options, such as replanting degraded or deforested areas or enrichment planting, but also by letting forest land regenerate naturally. Care must be taken to differentiate between what is a purely ecological process of regrowth and what is induced or enhanced through some management intervention.

Biodiversity conservation

REDD+ provides an opportunity for adapting resilience-oriented ecosystem management, and ensure biodiversity conservation, flow of ecosystem services for sustainable economic development for local communities live in and around the forest [28,39]. REDD+ has the potential to deliver enormous benefits for biodiversity conservation because forests in the developing world harbor much of the world's terrestrial and freshwater biota, and are also threatened by ongoing deforestation and forest degradation. The mechanisms REDD+ contribute to biodiversity conservation are reducing deforestation and forest degradation, ecosystems preservation, the recovery of forest structure, increasing ecological niches, resources and habitats loss of species. According to [5], REDD+ can improve forest ecosystem stability, enhancing landscape connectivity and boost biodiversity conservation by preserving genetic and species diversity. For example, landscape corridors can be enhanced through afforestation and reforestation of diverse native species. New forests (afforestation/reforestation) can increase connectivity between existing forest fragments and provides biodiversity conservation benefits at no extra cost. Thus REDD+ can decrease the fragmentation of large intact forest ecosystems, maximize resilience, and support the establishment and maintenance of ecological corridors. Evidence show that forests with high levels of biodiversity are more resilient to climate change and other pressures.

Reducing deforestation and forest degradation through REDD+ incentivize mechanisms has the potential to reduce the extinction rate of forest species. Results based payments through REDD+ finances lead to greater reductions in deforestation, greater climate change mitigation and greater provision of biodiversity

co-benefits. REDD+ mechanism is likely to also incentivize reduced degradation, carbon stock enhancement, and sustainable management of forests [11,45,47]. Incentivizing these other activities could shift the suite of countries participating in REDD+, and could have more ambiguous impacts on biodiversity. For example, biodiversity concerns with a REDD+ mechanism have centered on possible afforestation/reforestation and carbon stock enhancement provisions. Unless safeguards in the UNFCCC are retained, loopholes in the definition of a forest could result in the conversion of degraded but biodiversity natural forests [38] or biologically significant non-forest habitats [35] to timber or biofuel plantations with limited value for biodiversity. Through its Cancun safeguards principles a proposed REDD+ activities should: take into account the multiple functions of forests and other ecosystems; be consistent with the conservation of natural forests and biological diversity; not be used for the conversion of natural forests but instead should be used to incentivize their protection; and be used to enhance other social and environmental benefits [17,48].

REDD+ has gets significant attention in the conservation science community. However, studies on biodiversity outcomes are scarce and understanding REDD+ impacts on biodiversity are limited to indirect measures. For example, the impacts of REDD+ on biodiversity by different authors were highlighted and discussed in terms of number of native trees established or the area planted and none reported of the new species restored within the area covered which would indicate that forest was successfully being restored, or measured changes in deforestation pressure on nearby forests.

Watershed Protection

REDD+ are important potential ecological co-benefits that include the maintenance and restoration of hydrological functions, local climate regimes, soils, and native species assemblages through both direct and indirect effects [41,44]. Many of the co-benefits of REDD are best understood within the context of watersheds, the natural drainage units of the landscape. The output of water, energy, and minerals from a watershed is regulated by the ecosystems that occupy it and therefore strongly influenced by REDD interventions. When forests that would have been lost or degraded are retained or restored through REDD+, protection and enhancement of carbon stocks is not the only benefit. Other benefits linked to the improved condition of forests can include cleaner water and a lower risk of flood and drought, conservation of fertile soils, larger numbers of rare and threatened plant and animal species and a larger supply of non-timber forest products [4, 22].

In general, countries interested in REDD+ are required to promote forest conservation and other environmental co-benefits, which highly contribute to biodiversity conservation and forest ecosystem services provision. A properly designed REDD mechanism is widely seen as a cost-effective approach to simultaneously conserve forests, slow climate change, protect biodiversity, foster sustainable development, and maintain important ecological services provided by healthy forest ecosystems.

Table 3: Ecological Impacts of REDD+ Implementation

REDD+ Activities	Impacts	Authors	Methodology
Reducing emissions from Deforestation	Regulate climate change by reducing carbon emissions; Restore hydrological functions, reduce soil erosion and conserve native species; Reduced evapotranspiration, rate of forest loss and Protect and restore landscape level functions performed by species such as pollination and seed dispersal.	[4,10, 16,22,32,41,44]	Satellite observations, used to calculate net source and sink, Open Source Impacts of REDD+ Incentives Spreadsheet model (“OSIRIS), to simulate national participation, deforestation, and species extinction rates under REDD+ across Empirically derived mechanism from incentives
Reducing emissions from forest degradation	Restrict selective logging that can reduce soil compaction; forest fragmentation, enhance biodiversity and Reduce the rate and/or intensity of forest degradation due to unsustainable logging, fire and coffee management.	[21,23,26,32,43]	Review of relevant REDD+ pilot documents, Satellite images of high resolution to detect degradation, Detected based on the scope, reference level and proposed options during the design of a project

Conservation of forest carbon stocks	Increase regeneration and restoration of native forest, sequestering carbon in re-growing forests in approaches; Improved habitat for terrestrial and aquatic biodiversity/purify water, and serve as habitat for diverse flora, fauna, and microbial communities and Establish long-term commitments to forest conservation.	[10,20,36,43]	Open Source Impacts of REDD+ Incentives Spreadsheet model ("OSIRIS), to simulate national participation, deforestation, and species extinction rates under REDD+ across its activities
Sustainable management of forests	Increases in the carbon density of tropical forests; Lower annual stream discharge and flood risk, less surface run-off and associated soil erosion/ most secure ways of protecting soil resources; Reduced impact logging techniques, which can reduce the carbon emissions associated with logging; Increasing the health of ecosystems and improving water quality; Reduce the impacts of logging on insect and vertebrate populations and Increase area of forest land under sustainable management.	[4,7,9,26,39,43]	Focus group discussions, meetings, and community consultation and review of program documents of forestry user groups that participated in the REDD+ pilot, Field visit, semi-structured interview, project review Quantitative data collected through questioners and analyzed By developing framework based on different dimensions
Enhancement of forest carbon stocks	Increases in the area of forest that helps to sequester more carbon from atmosphere; Loss of nutrients and sediments to streams should decline; Tree plantations could play an important role in restoring biodiversity in degraded lands; Increase area under reforestation and afforestation; Allowed degraded forests to regenerate and Increase area of degraded forest under enrichment planting.	[26,39,43]	Focus group discussions, meetings, and community consultation and review of program documents of forestry user groups that participated in the REDD+ pilot Field visit, semi-structured interview, project review etc

Economic Impacts of REDD+

In developing countries, local communities have been depending on forests resources to improve their wellbeing for a century. Now a days forest resources has been increasingly recognized as encouraging options to improve the livelihoods of rural communities that helps to achieve sustainable forest management of the world through the introduction of REDD+ implementation [29,34]. REDD+ strategy gained international attention as performance-based payment mechanism for verified reduced carbon emissions and thus it aimed to engage communities in emission reduction through performance-based principles to provide economic incentive for sequestered and stored carbon in the different forest pools [1,12, 18,19]. Given the great potential of forests to sequester carbon, it makes economic sense to pay local communities to conserve forests and the carbon stock they hold carbon dioxide [27]. The success of REDD+ may rely on the

motivation of local forest managers to move from current practices of forest management to model of REDD+ activities, which conserves and/or enhances forest carbon stock. Thus, REDD+ is a financial incentive mechanism that will provide incentives to developing countries to reduce forest-related GHG emissions and to increase GHG removals from the atmosphere by forests. The five activities that will be incentivized by the REDD+ mechanism are: reducing emissions from deforestation; reducing emissions from forest degradation; conservation of forest carbon stocks; sustainable management of forests; and enhancement of forest carbon stocks.

REDD+ could affect the livelihoods of forest-dependent communities through reducing poverty by providing local households income from carbon credit payments, and offer other co-benefits such as improved land tenure or carbon ownership. Co-benefits of REDD+ (e.g. alleviating poverty, improving governance, and conserving biodiversity and providing other environmental services) have always been part of the REDD debate, but with REDD+ the possibility for co-benefits are greatly enhanced [5,6,13]. Though REDD+ provide a stable income and guaranteed payments, it has limited contribution for economic growth. REDD+ implementation is also subject to inflation and it restricts opportunities for downstream industries. REDD+ implementation, opposed to the business-as-usual option, is furthermore dependent on external financing and might constrain future livelihood options. Other potential socio-economic risks of REDD+ implementation are: Reduced tax income; the risk of government investments being diverted elsewhere, rural-to-urban migration; and changing political-economic ties [29].

REDD+ is unlikely to be a driver of poverty alleviation, but it may help in diversifying incomes. According to [13], terrestrial emissions reduction efforts could provide financial incentives for shifting cultivators and extensive cattle ranchers. On the other hand, growers of commercial crops or those cutting trees for high-value timber are most likely not able to be compensated by REDD+ for the profits foregone by abandoning forest related economic activities. According to [13] even smallholder intensive agro-forestry is usually more profitable than REDD+ payments. Deforestation and forest degradation are accompanied by the loss of numerous vital ecosystem services that provide a variety of income possibilities, material welfare, livelihoods, security, resiliency, social relations, health, and freedom of choices and actions [24]. Their loss threatens human societies worldwide, and not just in the regions where deforestation occurs. Reducing emissions from forested landscape through sequestering and accumulating more carbon are targets to economical benefit developing countries, and forest dependents communities [8]. REDD is a carbon financing mechanisms which aims to reduce carbon emissions from forests by providing financial incentives through result based payment for developing countries to conserve forests [33]. REDD is a carbon financing program which aims to reduce carbon emissions from forests by providing financial incentives to developing countries to conserve forests [33]. In general, REDD+ increased availability of forest based job opportunities, livelihoods and income and also lead to wider social benefits through land tenure clarification, enhanced participation in decision-making and better governance. Since 2007, REDD+ pilot projects and programs have emerged across the developing countries to received verified emission reduction payment. Projects for reducing emissions from deforestation and forest degradation (REDD+) have been initiated in developing countries a few years ago with multiple actors under the global forest and climate change regime [40]. The study in 57 countries by using 480 REDD+ projects showed that concentrated polycentric networks across several dominant actors. Until 2020 the study on the structures and patterns of REDD+ project in developing countries (Asia, Africa and South America), showed that a few countries, such as Brazil, Columbia, China, Indonesia, and Peru have mostly attracted sponsors of REDD+ projects. At the regional level, 43% of all projects have been implemented in South America, 30% in Africa and 25% in Asia [40]. This is due to networks for resource exchange, information flow and partnerships.

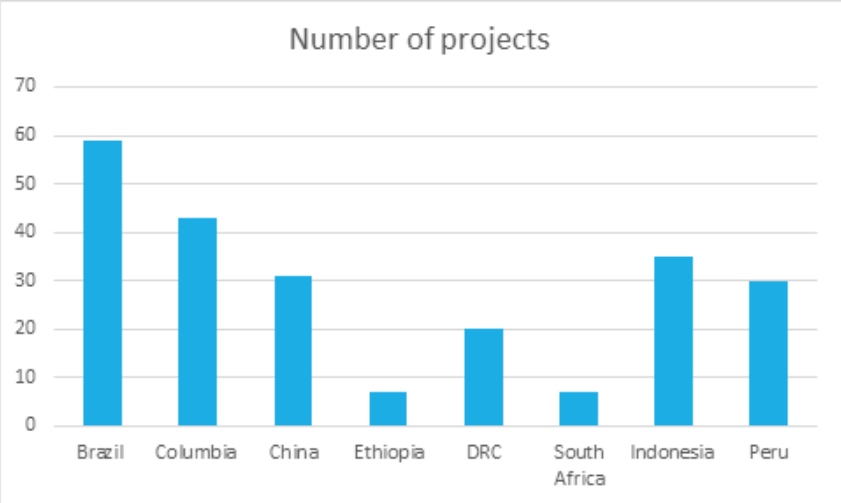

Figure 1: The structures and patterns of REDD+ project in developing countries

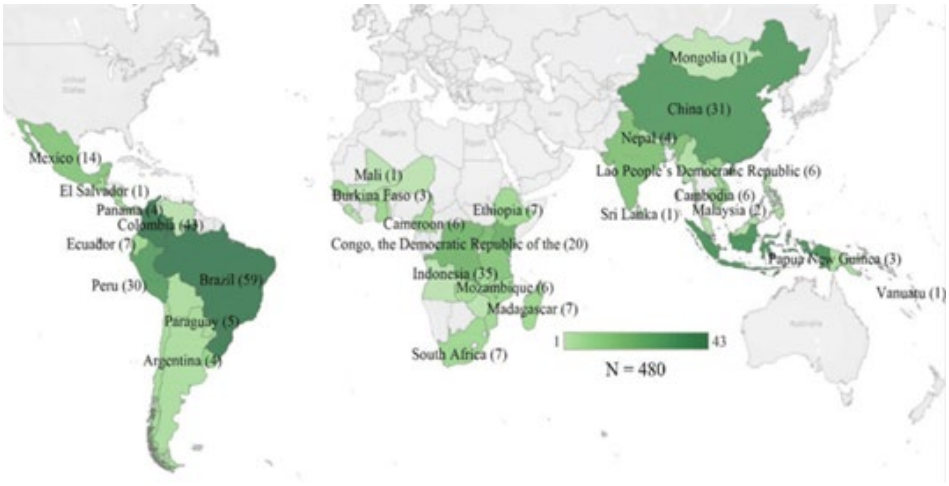

Figure 2: Geographic distribution of global REDD+ projects in developing countries [40].

The Forest Carbon Partnership Facility (FCPF) is a global partnership of governments, businesses, civil society, and indigenous people's organizations focused on reducing emissions from the forest sector. FCPF works with 47 developing countries across Africa, Asia, and Latin America and the Caribbean, along with 17 donors that have made contributions and commitments totaling $1.3 billion. So far 15 developing countries signed an agreement to receive $720 million payment for nearly 145 million tons of verified emission reductions achieved through FCPF. The funding will be delivered as results-based payments through 2025 in Chile, Costa Rica, Côte d'Ivoire, Democratic Republic of Congo, Dominican Republic, Fiji, Ghana, Guatemala, Indonesia, Lao PDR, Madagascar, Mozambique, Nepal, Republic of Congo, and Vietnam [30].

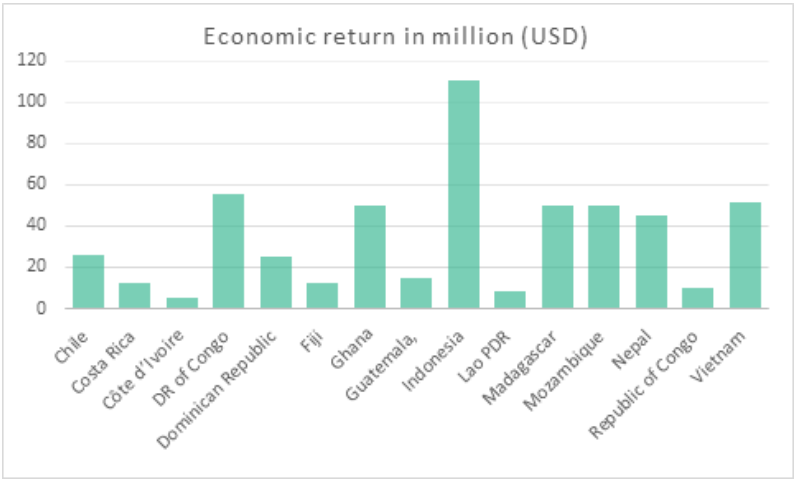

Figure 3: REDD+ Economic Return for few countries

Table4: Economic Impacts of REDD+

REDD+ Activities	Impacts	Authors	Methodology
Reducing emissions from Deforestation, forest degradation, conservation of forest carbon stocks, Sustainable management of forests & Enhancement of forest carbon stocks	Improve the livelihoods of rural communities by generate alternative income opportunities	[29,34]	By examining & evaluation of pilot REDD+ project via field survey
	Provide economic incentive for carbon sequestration in forests		
	Generating additional revenues to local	[1,12,19]	By examining cases of REDD+ projects (Brazil, Mexico and Bolivia etc)
	Communities through alternative agricultural practices		Survey and interview REDD+ stakeholder
	REDD+ provide a stable income and guaranteed payments		Interview-stakeholder's/survey questionnaires'
	Provide sufficient financial incentives for forest conservation in the humid tropics for shifting cultivators and extensive cattle ranchers		Sustainable livelihood approach (used indicators such as malnutrition rates, poverty levels, or the availability of employment or natural resources
	Create employment opportunities, Improved production potential and the provision of new opportunities for export	[6,13,31]	

Conclusion

The global increase in greenhouse gases and its impacts due to human action disrupt our planet. Carbon emission from forest sector is high next to industry due to deforestation and forest degradation in developing countries aggravated by human action. The destruction of global forests has increased concentrations of CO2 in the atmosphere that can cause climate change which disrupt environment as well as human wellbeing. In response to emission reduction from forest sectors, policymakers have been actively negotiating through UNFCCC with the aim to provide a financial incentive to governments, businesses and communities in developing countries to maintain carbon stock of forest ecosystem. As a results, REDD was initially limited to reducing emissions from deforestation in developing countries, but the concept soon expanded to include forest degradation. The Bali Action Roadmap further broadened from REDD to REDD+ to include the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks in developing countries. REDD+ is a climate change mitigation mechanism where developing countries are incentivized through result-based payments for reduced carbon emissions from forest sectors. The effective and transparent carbon accounting systems, the development of four REDD+ elements (National REDD+ Strategy, National Forest Reference Level, National Forest Monitoring System and Safeguards Information System), incentive mechanisms and engagement of relevant stakeholders that motivate both national and sub-national actors are seen as a requirement to successfully implement REDD+ at different scale.

The ecological and economic impacts of REDD+ implementation was recognized through systematic review of a scientific literatures such as journal, proceeding and international report. As most of the authors indicated in their study, the ecological impacts of REDD+ includes regulate climate change, restore hydrological function by improving water quality, reduce soil erosion and evapotranspiration, and reduce deforestation and forest degradation due to industrial & agriculture expansion. Increase regeneration and restoration of forest, increase carbon sequestering potential through afforestation/reforestation, rehabilitation of degraded area which helps to increase the health of forest ecosystem services as well as improve habitat for terrestrial and aquatic ecosystem, and conserve biodiversity that maintain the function of natural resources. Different authors have been highlighted the economic impacts of REDD+ during its implementation and result based payment phases. Some of the benefits include wellbeing of local communities improved; generate incomes through result based payments, create job opportunity and alleviate poverty. However, the ecological and economic impacts of REDD+ implementation in developing countries is not quantitatively described. There is also little study on carbon outcome measurement to understand REDD+ effectiveness and biodiversity outcomes focus on matching interventions to biodiversity threats on species/ecosystems to

be conserved and monitoring for best management. In general, forest ecosystems through the introduction of REDD+ are playing an important role in climate change mitigation and livelihoods improvement in which developing countries are rewarded verified result based payments for any emissions reduced against references level. To realize REDD+ ecological and economic benefits:

✓ The flow of information's and resources allocations to all developing countries interested to implement REDD+ should be encouraged, strengthen and sustained to meets the objectives of REDD+; and

✓ The ecological and economic benefits of REDD+ needs to be quantified by scholars to bridge information/research gap.

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