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Sustainable land management policy to address land degradation: linking old forest management practices in Senegal with new REDD+ requirements

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Prior to the UN Policy framework REDD+, the Government of Senegal (GoS) initiated for many decades, important land management programs to address deforestation and land degradation which affects the country's food production, ecosystem benefits and livelihoods. A lot of investment and policies have been implemented in various ecologies to improve tree cover and ecosystem services. Reviewing and analyzing the past and present tree recovery actions that are consistent with REDD + policy, this paper explores the way REDD + initiative could play a role in consolidating land management strategies in non-forested area. We use a method based on the wide range of experience of the Senegalese Forest Service, forest development projects and NGOs involved in the management of natural resources and a review of seven selected forestry projects/programs through the country, We found many opportunities for Senegal in implementing REDD + activities (e.g., tree plantation, agroforestry, bush fires management, soil erosion control, sustainable intensification, ecosystem (carbon) and socio-economic (livelihoods) services, *etc.*). Based on the lessons learned from early land restoration and management projects, the REDD + program could take stock from existing tools and frameworks to advance the agenda and leap in the country's preparedness as a REDD + country. For that, the national context dictates an expansion of REDD scope 5 (enhancement of forest carbon stock) to AFOLU and afforestation/reforestation and trees outside of forest, which means moving REDD + from LULUCF to AFOLU. The GoS needs to address two (02) key areas: 1) the land ownership issue by pursuing the land tenure reform and integrate regulations about who has access to land, who can benefit from land use services and how the benefits sharing and carbon rights must be organized and; 2) the promotion of more engagement of local communities in forest resource management through community forestry and the sustainable practices of agriculture, forestry and agroforestry.

KEYWORDS

REDD+, land management, land policy, afforestation, land degradation, Senegal, agriculture, AFOLU

1 Introduction

Various forms of land degradation, from deforestation to agricultural land use, are the largest sources of greenhouse gas emissions in Africa. The AFOLU sector (Agriculture, Forestry and Other Land Use) alone accounts for more than 80% of the total emission of carbon in Africa (IPCC 2019) In the Sahel Land degradation also creates a range of non-emissions limitations for sustainable land management, including lowered productivity, loss of biodiversity, and diminished ecosystem services (Aubert et al., 1947) (Mbow, 2017). In this region, natural resources significantly contribute to household and national incomes and support livelihoods, especially in communities that are vulnerable to land degradation and climate change (Bishop and Garzon, 2003). In the last several decades, the Government of Senegal (GoS) has developed policy and program initiatives broadly aimed at mitigating land degradation through interventions in several sectors (Senegal, 1981) (Senegal, 1993). These different initiatives have included efforts to reduce deforestation with emphasis on achieving outcomes related to increasing national food security, improving environmental health, and supporting human wellbeing (Senegal, 1981) (Senegal, 1993). Within a broad portfolio of actions, these programs have included measures targeted at tree cover conservation and improved ecosystem services even prior to the recent emergence of the UN REDD + policy framework. However, prior to REDD+, the GoS's policy objectives were focused broadly on maintaining land productivity, providing counter-measures to drought, control of soil erosion, and managing wood energy supply for a growing population rather than mitigation of emissions and adaptation to climate change (Senegal, 1989); (Breemer et al., 1993). A priority question for the GoS now is how to integrate new REDD + priorities which are more narrowly focused on forests and greenhouse gas emissions mitigation with ongoing and long-standing policies and programs which are in place now, and which have been largely focused on overall land degradation. Moreover, the challenge facing government policymakers and planners is how to include the global emissions and climate change mitigation objectives of REDD+ within programs that are primarily aimed at national economic development.

The central question in the review presented here stems from this question as to whether past and ongoing land degradation policies and new REDD + policies in Senegal can be integrated, supporting both international climate change mitigation and national economic development.

The focus of this paper is to explore how the international REDD + initiative, which is principally focused on forest actions, can be implemented within Senegal's existing national context, which has been more oriented toward general land degradation mitigation for purposes of economic development rather than climate change mitigation. Further the paper also examines the way REDD + as currently conceptualized around Land Use Land Use Change and Forestry (LULUCF) could be more broadly aimed at influencing land management in non-forest land, including agriculture and other uses (AFoLU) and thus support the existing aims for sustainable development in rural landscapes of the country. We explore a "no regrets REDD" model whereby REDD + can be achieved in Senegal by building on existing programs, without creating an entirely new institutional framework, yet also using REDD + to strengthen existing programs, particularly related to forests and tree-based systems as livelihood systems and the forestry sector. We explore how attributes of existing programs could benefit new actions and interventions that support REDD + objectives for emissions reductions and carbon sequestration. Across the Africa continent, the Forest Carbon Partnership Facility (FCPF) is supporting 18 countries, the Climate Investment Funds' Forest Investment Program (CIF FIP) is operating in 23 countries, and 35 are enrolled in the UN-REDD program. Yet Senegal is not part of any of these initiatives Therefore, it is also important to consider the limits of the old land degradation activities on forest management practices and to examine how these limits can be addressed with a national REDD + initiative. Overall, the paper is addressing the issue of 1) the mismatch between old policy and new REDD +, and 2) analyze possibilities to integrate or potentially bridge both.

2 Methodology and approach

This paper is an attempt to contribute theoretical and empirical evidence with lessons from early land restoration and management projects for the country and lightening its way forward to implement the UN REDD mechanism. It tries to respond to the question of how does a country like Senegal integrate REDD into its current institutional framework and how REDD can get implemented in the context of other policies in place in Senegal. The method is based on the wide range of experience of the Senegalese Forest Service, forest development projects and NGOs involved in the management of natural resources. It is based upon a review of seven selected forestry projects/programs through the country to investigate how they were implemented, what aspects of REDD + did they covered and assess the gap that needs to be addressed if future projects should comply with the REDD + program. Literature and reports available for these projects/programs are used to review the cross-cutting issues and lessons learned.

Our method of analysis has two overarching focal points: 1) The first focal point in the method is an examination of the current policies in place for land degradation management and mitigation and how they could be supportive of element of the five REDD + scope areas, or how REDD + could enhance these existing policies and their implementation activities. In essence here we examine the potential for modification and enhancement of current programs to accommodate REDD+. 2) As the second focal point, we also examine how modifications in REDD + could be made to accommodate their linkages as contributions to improving current programs.

We identified criteria to determine the documents to be included in this study and they include the type of study, the sources and the area of intervention. Therefore, the documents must include evaluation reports, government policies, strategic plans, or letters and they must be provided by government agencies, the Senegalese Forest Service, forest development projects and sources from NGOs involved in the management of natural resources and the selected forestry projects/programs through the country.

3 Land degradation in Senegal

3.1 General overview of types of land degradation in Senegal

A complete systems-level understanding of land degradation in Senegal is limited by the paucity of data and analysis of the complex array of factors and dynamics that occur across scales. Because Senegal is directly situated within a pronounced Sudano- Sahelian climate and environmental gradient, the drivers, rates and spatial extent of degradation vary within and between eco-geographic zones. This leads to complex interactions between social, economic and ecological processes that have not been well documents, studied nor analyzed. Despite advances in the use of large scale remote sensing (Verdoodt et al., 2013), comprehensive wide-area assessment of land degradation has been challenging and not been adequately done (Dubovyk, 2017) (Verdoodt et al., 2013). Although limited and isolated studies exist (Diouf et al., 2002), a nationally comprehensive assessment is still lacking. This is a serious limitation to the availability of a consistent baseline and a clear understanding of the conditions of the most significant land degradation drivers, without which it is difficult to design effective and targeted interventions (Mbow et al., 2015). However, the Land Degradation Assessment (LADA) (2006–2013), a UNEP funded project for FAO and other similar studies (Ribot, 2002) attempted to provide basic information on land degradation to identify potential areas for conservation that can be used as initial REDD + implementation sites. Sonneveld *et al.* (Sonneveld et al., 2010), estimated that 34% of Senegal non-built land is considered degraded. Of this, 4.5% is slightly degraded, 24% is moderately degraded, and 5.6% is heavily degraded (Sonneveld et al., 2012). Degraded land represents 58% of the 9 015 000 ha of agricultural land (Ndiaye et al., 2013) (Sonneveld et al., 2010).

Various studies concluded that essentially all production systems (rainfed crops, recession crops and lowlands or even livestock) in the country are affected by land degradation, with the North (Senegal valley and Sylvo-pastoral zone) and Center Western (Peanut basin) most affected. Although it is difficult to detangle natural from anthropogenic drivers of land degradation, human activities, mostly agriculture and extensive charcoal production, are considered to be responsible for at least 11% of degraded land (Sonneveld et al., 2011), As suggested by Leakey (Leakey and Hoffman, 2013) (Leakey, 2018), land degradation seriously affects rural households' income because the resulting decline in land productivity exacerbates household food security (Kelly et al., 1996). Land degradation removes habitat and tree cover, leads to a loss of biodiversity and causes negative changes to microclimate, thus facilitating desertification. Tree cover loss exacerbates climate change by increasing greenhouse gas emissions (Mbow, 2017).

3.2 Land degradation drivers

In Senegal, four factors are mostly considered as the major drivers of land degradation: 1) general loss of land productivity and soil fertility decline, 2) water induced soil erosion, 3) wind erosion, and 4) salinization.

Loss of productivity and declining soil fertility: As the largest or most important form of land degradation, loss of productivity is a direct consequence of several combined factors that influence nutrients and biogeochemistry. Overgrazing and agricultural intensification, reduction of fallow periods (Reinwald, 1997) shorten the soil regeneration period (Sonneveld et al., 2011) because they do not give enough time for regeneration. These factors combined with widespread adoption of monoculture cultivation systems (especially ground nuts) reduce the overall productivity of both forest and non-forest lands by removing vegetation cover, especially woody perennials, for agricultural purposes. The production of charcoal contributes significantly to vegetation loss. Exacerbating this, rapid population growth is leading to an intensive use of land. Wildfires and bush fires are another form of land degradation that directly affects productivity through nutrient effects, even while there may be an immediate but short-term increase in productivity. It accounts for 25% of the main drivers of forest lost (Senegal and ANSD, 2014) and affects a large area, especially in the South and Eastern part of the country. 907 656.2 ha is affected by early fires and 108 918.7 ha by late fires between 2005–2010. Hunting is among the causes of these fires along with charcoal production which is another big challenge and driver of land degradation. Wood and charcoal are the main source of primary cooking energy and fuel for at least half of the national population and are used by 50.4% and 14.8% of Senegalese households respectively (Riccardo et al., 2013).

Water-induced soil erosion is among the other outcomes of degradation and affects the structural integrity of the soil and land, as a result from the loss of the top-soil layer. This creates a landscape with large areas of exposed outcrops, where water infiltration is reduced, and diminishing soil moisture retention during dry periods. This process also reduces the soil capacity to regulate water flows which leads to an increase of water runoff during high rainfall events. The problem is seen all over the African tropical countries that are affected by the monsoon: despite the highly variable and decreasing rainfall trend (Mbow, 2017) overall, when rain events occur they can seriously affect soil erosion, thus exacerbating the effects of erosion on soil physical structure. Many parts of the country's peanut basin are affected by top soil loss due to runoff, especially the Regions of Kaolack, Fatick, Tambacounda, Kolda and Thies.

Wind erosion also affects soil physical structure in areas where the ground is exposed to wind due to low vegetation cover, and occurs predominantly in these following areas: 1) the North-west coastline of the "Niayes" region from Dakar to Saint-Louis; 2) the area bordering the Senegal river basin; 3) the sandy Ferlo area, and 4) the central-north area (North of the Peanut basin) (Sonneveld et al., 2011).

Salinization is a form of land degradation that toxifies the soil. Agricultural land in the Peanut Basin, mostly the Region of Fatick, Kaolack and rice paddy region in the River Valley are affected by soluble salt excess. Nationally, the area affected is estimated to 1 700 000 ha (Van Den Breemer et al., 1995).

The types of land degradation show that agriculture and forestry are the major sectors affected (Supplementary Table S1), contrasting with their potential for reforestation and forest conservation; which make REDD + activities more relevant to reduce the consequences of this type of land degradation.

Photo 1 Soil affected by to wind erosion (Northern Peanut Basin)

Photo 2 Salinity in the Central Peanut Basin

Photo 3 Gully erosion in the Central Peanut Basin

Photo 4 Gully erosion in the Dagana (River valley)

FIGURE 1
Drivers of land degradation.

The impacts/outcomes of these land degradation drivers that are forest-related or tree-related can be addressed in all the most affected areas especially in the Sylvo pastoral zone, the Senegal Valley and the Peanut basin where tree loss is important and where, also, tree-based restoration would be an important activity to develop (Supplementary Table S1).

The occurrence of these different types of land degradation is represented in the following land degradation sensitivity map (Figure 1).

3.3 Forest-related land degradation mitigation programs: reforestation policies

The Government of Senegal initiated a national reforestation/afforestation campaign policy since 1979 but formalized by law in 1983. This action engaged all segments of society for reforestation activities with a focus on restoring and improving vegetation cover. The major objective of the campaign was then to increase the extent and density of vegetation cover and biological diversity, to meet the needs of the population for services and products offered by the restored forest ecosystems. In addition to reforestation activities, other landscape restoration actions were initiated, such as coercive methods of conservation in a forest environment and assisted regeneration of small trees in agricultural lands. This campaign developed within the context of rapidly increasing land degradation rates, especially between 2007 and 2017 although the types of degradation were site-specific.

4 Senegal's land degradation mitigation programs and policies

Recognizing the severity of land degradation and forest losses, the Senegalese Government tried to develop a land degradation and climate change mitigation framework of policies and programs that would target the most important drivers and preconditions. This prevention-focused system identifies conditions under which land degradation occurs and seeks comprehensive mitigation assessments to identify measures and interventions defined by best practice and evidence-based decision-making, with input from policymakers, stakeholders and the research community (Sonneveld et al., 2010). The framework has been pushed at both regional and national levels.

4.1 The policy context: Regional, national forest and land

At the regional level, Senegal has participated in various intervention activities and programs coordinated throughout West Africa by the Economic Community of the West African States (ECOWAS). They include the CILSS initiative (Permanent Interstate Committee to Drought Control in the Sahel), the Sahara and Sahel Observatory (OSS), the Great Green Wall (GGW) (Mbow, 2017) and currently the National Forestry Investment Plan (PNIF: 2018–2022). The ECOWAS program has been initiated to support

the implementation of the West Africa Forest Convergence plan (PCFAO) whose objective is to mobilize West African countries out of their current state of ecological, social and economic stagnation. With some West African countries already engaged in REDD, efforts are now moving ahead from the readiness stage to making performance-based payments for REDD+. Therefore, Senegal can take this ECOWAS program as an important opportunity to join REDD + and contribute not only to tackle its own land degradation and climate change issues but also the transboundary issues that the west African countries are facing in achieving efficient and sustainable forest and land management.

At the national level, the first national policy-oriented actions were formulated through the Forestry Development Master Plan (*Plan Directeur de Développement Forestier*- PDDF). Focusing on the development of rural forestry, this plan was launched in 1981. Its main objectives were: 1) to maintain forest productivity and protect natural land ecosystems and other biotic systems; 2) to increase domestic timber production for construction, industry and export; 3) to supply urban and rural populations in fuel and other products from forests and trees; and 4) to integrate arboriculture into the agrarian system and improve living conditions in rural areas (Diallo, 1992). The PDDF is followed in 1993 by the adoption of the Senegalese Forest Action Plan [SFAP]. This plan encourages a participatory approach that heralded an enthusiasm among local people to participate in forest resource conservation and natural resource management (UN, 2015).The SFAP is followed in 2005 by the Senegalese National Forest Policy (2005–2025). The NFP for 2005–2025 is a key program to ensure sustainable management of forests and its biological diversity while maintaining socio-economic balance by guaranteeing delivery forestry-based value in goods and services to local communities. It has several important strategic objectives: 1) Increasing sustainable management of forests and wildlife resources, 2) Building capacity of local communities and other stakeholders, 3) Strengthening the forest sectors and forest officers, and 4) Increasing involvement of private sector in forestry.

Along with these policies, the Government of Senegal decided in the mid-2000s to create national agencies to supervise a reversal of the deforestation process with focus primarily on forestry and its emerging problems. Two are most relevant to climate change policy: the first one is the National Agency for the Great Green Wall (ANGMV), which links national objectives to regional efforts. This agency is a national respondent to an African initiative whose objectives are to improve life and resilience in the drylands that surround the Sahara region. The second one is the National Agency of Eco-villages (ANEV), the first national government program that aimed at transitioning the country's 14,000 villages into models of ecologically, socially, economically and culturally sustainable living.

On another hand, there is the National Strategy for Economic and Social Development (NSESD, 2013–2017) which is the basis for the development of the Plan Senegal Emergent (PES, 2014–2018, 2018–2035). This PES promotes a strategic vision considering the environment at all levels of planning, either local or sectorial, by targeting three major objectives: 1) mitigate climate change effects on ecosystems; 2) reinforce the management capacities of the environment and the natural

resources; 3) promote green economy and create green jobs. The Emerging Senegal Plan (ESP) is the main reference framework for economic and social policy. This Emerging Senegal Plan (ESP) is the main reference framework for economic and social policy. Within the framework of this PSE, there is an environmental pillar cold the green PSE which aims at the sustainable reforestation of the national territory and reduce the degradation of the environment and natural resources.

All these old and current policies and programs had contributed to efforts in reducing deforestation and degradation but they were not efficient enough to keep the rates very low. However, they can be an important step in moving the country from its current institutional framework of environmental policies into climate change mitigation and REDD. Consequently, like in many other African countries, Senegal cannot just start up a new REDD program and create a whole new line of policies and institutional arrangements focused on one Convention.

The REDD + framework is the latest, and perhaps the most visible, international initiative for policy development. Although national policies have offered an important framework for the forestry sector, Senegal has not yet engaged a substantial investment in REDD + actions or projects. The only pilot REDD + project, implemented in the Bandafassi (southeastern) region aims at increasing the capacity of rural people to adapt to the adverse effects of climate hazards by promoting processing of Non-Timber Forest Products as an alternative source of income for rainfed agriculture. It will also enhance the value chain of some of these NTFP such as honey, shea, tamarin and baobab with improved methods of harvesting, processing, packaging and storing to secure better product quality. To distinguish them from common-property resources whose NTFPs are often protected by laws on harvesting and trade rules, these products of indigenous tree species have also been described as "Agroforestry Tree Products (AFTPs)" when grown or cultivated on private land (Leakey, 2012).

Under various national and regional policies, the GoS has implemented several high-profile projects to address either desertification, forest and land degradation, or promote sustainable management of natural resources. Some of these have proven to be quite successful. Most of them, however, addressed the broader issues of land degradation and land productivity improvements. This focus has been largely a response to the important needs of local communities whose lands have been under severe and increasing degradation pressures and this situation is directly affecting their livelihoods. Many of these projects are implemented to support economic objectives. Hence a number of them targeted agriculture and non-forest landscapes, particularly degraded and heavily used marginal land rather than natural ecosystems. Indeed, even under some of the more important forestry programs in recent years, specific project implementation and expenditure of resources have emphasized non-forest lands. Some projects have used tree planting and restoration of woody vegetation in their operations to stabilize or control the types of land degradation specified in Section 1 above. But the key priorities have focused on occupied land over natural ecosystems, non-forest land over forest land, and economic outcomes over GHG mitigation outcomes.

At the same time, the concept of sustainable development in policy and practice is used to establish a platform that includes forest management goals into most of the economic development policies and programs, especially those focusing on natural resources and land management.

The following Supplementary Table S2 provides an overview of a selection of these projects, with a focus on the REDD + aspects they covered as well as the gap that can be filled by REDD interventions. These projects include CODEVAL, PROGEDE, PROGERT, PRECOBA, PREFER, PREVINOBA, or the CLT Nord.

The objectives of CODEVAL [*Projet de Renforcement des Capacités pour le Contrôle de la Dégradation des Terres et la promotion de leur Valorisation dans les zones dégradées*] were to provide capacity building to the Water and Forestry Officers and local actors to control land degradation and promote sustainable land management.

The PROGEDE 2 [*Projet de Gestion Durable et Participative des Énergies Traditionnelles et de Substitution*] aimed at reducing deforestation and carbon emissions in target areas and promoting a forest's participatory management for wood energy production to meet households domestic fuel needs.

The PROGERT [*Projet de Gestion et de Restauration des Terres dégradées du Bassin Arachidier*] promotes sustainable land management at the landscape level to combat land degradation and reduce poverty.

PRECOBA [*Projet de Reboisements Communautaire dans le bassin arachidier- Community Groundnut Reforestation Project*] is a project that intervene in massive plantations, control plot system, windbreak and hedgerows plantations. It defines a forest intervention methodology in rural areas.

PREFER [*Projet de réhabilitation des forêts et des espaces ruraux-Forest and rural area rehabilitation project*] focused on promoting carbon sequestration and reducing greenhouse gases emissions through sustainable management of forests.

PREVINOBA [*Projet de Reboisement Villageois dans le Nord du Bassin Arachidier-Village Reforestation Project in the Northern Groundnut Basin*] intervenes in advancing sustainable land use and tackling soil erosion by organizing farmers plant trees along and in their fields and promoting agroforestry.

Project (CTL Nord) [*Projet de conservation des terroirs du Littoral/secteur Nord - Littoral/North Area Territorial Conservation*] protected the vegetables potential of the Gandiolais zone by fixing the sand and promoting community participation.

To contribute to mitigation actions in the forest sector, developing countries are encouraged to undertake five major activities as described in paragraph 70 of the AWG/LCA outcome: Decision 1/CP.

(a) Reducing emissions from deforestation
(b) Reducing emissions from forest degradation
(c) Conservation of forest carbon stocks
(d) Sustainable management of forest
(e) Enhancement of forest carbon stocks.

As shown in the following Supplementary Table S2, all selected projects are very limited in covering these aspects. However, this represents a transition from a review of forest related current programs and their relationship to REDD.

4.3 A national context and framing REDD + programming

There is not yet a National REDD + framework strategy *per se* but the process of adhesion to UN REDD was also set in motion, through the appointment of a national REDD Focal Point at the Ministry of Environment and Sustainable Development, and the transmission of a letter expressing Senegal's interest to join UN REDD to the UN REDD Secretariat.

However, these policies and projects provide the national context for climate change mitigation and REDD + programming in Senegal. The principle of implementing country-specific climate change mitigation programs within their national context has become an increasingly important aspect of provisions in the Paris Agreements from the UNFCCC Conference of the Parties in 2015. The principle recognizes differences among countries in how they respond to their international obligations. In the case of REDD+, developing country Parties are encouraged to contribute to mitigation actions in the forest sector by undertaking certain activities, "as deemed appropriate by each Party and in accordance with their respective capabilities and national circumstances" (UNFCCC, 2010).

Furthermore, as countries move forward to implement national forest monitoring systems, they are encouraged by decisions of the COP (*cf.* 11/CP.19) to build on existing systems. In Senegal, the national context includes two elements: 1) existing and forward-planning priorities for land management, including forest land and non-forest lands, 2) a foundation of capacities based on success and experience from prior and on-going projects.

The main objective of the GoS land policies, programs and projects has been to mitigate land degradation overall (broader landscape-wide priorities than forests alone), with policy objectives to support broader aims of economic development and environment. However, there are salient aspects that relate directly to climate change mitigation and adaptation measures consistent with emerging new international frameworks. Moreover, many of the previous project investments have provided useful outcomes for national REDD + programming, and could be part of a Senegal national action plan and strategy. For example, PROGEDE provided necessary human resources capacities and training to control land degradation to the Water and Forestry Service Officers and local actors. It also elaborated a methodological tool for monitoring and evaluation through deployment of a Forestry and Ecological Information System that has been used by other projects.

PREVINOBA developed a stakeholder engagement model for local communities for disseminating tree and forest management best practice. It emphasized a participatory approach to community-based forest management and devoted considerable attention to the barriers that local communities have to overcome before being able to sustainably manage their natural resources themselves (Diallo, 1992). With its effect of increasing tree density from 9 trees per hectare before implementation to 27 trees per hectare (Diouf et al., 2002), it has demonstrated the importance of engaging communities in reforestation and forest conservation projects.

The PROGERT success is mostly based on finding and implementing common objectives between the needs of local

populations and project objectives. It also created favorable conditions for the development of locally-owned initiatives, especially with the context of emerging decentralization of forest law and policy. The continuous efforts to build on and evaluate the forest policy framework played an important role since 1990, laying the groundwork for success of this and other projects.

Considering this situation, and the high rate of land degradation with potential area for reforestation, the country should pay more attention to REDD + to set out its responses to climate change while achieving the relevant Sustainable Development Goals, especially SDG 15 for which the recently proposed indicator to assess achievements for countries is "the proportion of land that is degraded over total land area" (Mbow et al., 2008). At the meantime, the country is currently preparing its commitment and through the African Landscape Forest Restoration 100 (AFR100) initiative, many multiple national initiatives, programs and action plans are initiated to control desertification, promote reforestation, community-based natural resources management, and integration of NRM into agriculture. Some of these initiatives and other programs are related to REDD while others are indeed opportunities to link to some existing programs, with some modifications to be made to accommodate REDD.

Therefore, the following conceptual model (Supplementary Figure S2) puts REDD+ in the center for its potential role to improve some aspects of the selected projects. Through various direct or indirect dimensions, REDD + could improve capacity building, livelihoods and enhance agricultural productivity. Consequently, it will have a positive impact on the National REDD + Strategy or action plan through a revision of policies, laws and regulations, analyses of land degradation drivers, stakeholder engagement.

Supplementary Figure S2 shows that most of the different projects have national REDD + plus elements. Therefore, this pulls together a specific framework for moving on REDD+ in the Senegal context where on-forest land, reforestation and restoration through the new concept of forest landscape restoration (FLR) can be used. Within this framework, bridging forest and agriculture land and agencies together, along with carbon sequestration are key elements that REDD+, as a land degradation mitigation tool that also allows for adaptation actions, can bring in the Senegal context.

5 Opportunities and challenges for REDD in the Senegal national context

Under the current dialog on REDD, not all degraded land or restoration activities would be included in its scope. However, there are opportunities for Senegal to implement a program of REDD + activities that could contribute to, and perhaps expand, the scope of REDD + activities to be relevant in its national context.

Key projects and policies selectively identified have defined the context for land management and restoration in Senegal. A backdrop on the way Senegal could engage a "no-regrets" REDD + strategy is also provided. Policies and activities that aimed at reducing land degradation in general can be important anchor points for policies and activities that also embrace climate change mitigation and REDD + programming. The "no-regrets" strategy

aimed at creating programs under REDD that embrace, catalyze, and support ongoing activities that would enhance land management and governance, including increasing carbon stocks, regardless of how REDD + specifically emerges in the international dialog. For developing countries like Senegal, the leverage of REDD against a backdrop of existing development priorities can be an efficient and effective strategy. For this reason, Senegal's REDD + development can rely on the strong forest, land and land degradation policies and initiatives. Therefore, REDD + should be part of the overall national capacity building and policy making agenda in light of other ongoing needs (e.g., sustainable forest management in general) and could be applied through an effective integration of forestry with agriculture, technically as well as institutionally.

In the technical side, it will consist of developing a strategy for Trees Outside of Forests, Agroforestry, and develop a multi-functional agriculture (Leakey, 2018). The development of a multi-functional agriculture that integrate TOF and agroforestry in the strategy for a REDD mechanism will therefore require measuring and assessing TOF landscapes.

The institutional side is about strengthening by building bridges and cooperation between forestry and agricultural agencies in the GoS.

Integration of forest, non-forest and tree interventions into an existing policy framework that prioritizes general land degradation can make carbon and climate mitigation-focused objectives more likely to succeed. There is clear evidence that inclusion of tree-based systems even in agricultural landscapes, such as agroforestry, increases productivity and enhances livelihoods (Reed et al., 2017). Further it is notable that increasing the abundance of woody biomass outside the official recorded forest areas can be an effective intervention to conserve forests. For instance, increasing community-based woodlots for sustainable charcoal on farms can reduce the pressure on the forest estate.

To realize an integrated, no-regrets program of activities in Senegal it will require a modification of the five core objectives of REDD to mesh with the existing national context. Enhancing carbon stocks can be an important element of both the existing REDD + scope of activities and Senegal's national programs. However, in the Senegal context, there is considerable opportunity in expanding the five-part scope to include some aspects of agriculture, taking into consideration a broadening of REDD + to be more inclusive of AFOLU (Agriculture, Forestry and other Land Uses), particularly in terms of integrating systems of trees outside of forests and Agroforestry. REDD activities will therefore remain consistent with the long standing programs that are aimed an economic development and livelihoods. In other words Agroforestry enables both the economic aspects of programs in land degradation currently as well as bringing in carbon sequestration.

Moreover, with considerable existing activities and experience based at the subnational level in Senegal (i.e., project-based), we consider that the scale of REDD + would be started at the project level, building up in scale to a national level as a specific pathway from readiness level 1 to readiness level 3; readiness being measured by a country's technical and institutional capacity to get engaged in REDD +. In other words, as a modality for achieving readiness level 1, Senegal could immediately build capacity by attaching REDD + components to some key existing subnational activities and projects. This will be possible by engaging and providing training to local

communities through all three stages of REDD + activities: readiness, implementation and results-based payment. At the same time, a program of subnational activities would help build capacities for decentralized governance and community-based management of the land and carbon resources.

An optimal place to start is an assessment to match areas of potential REDD + priority (i.e., places with high threat of emissions, or potentials for sequestration) with existing projects and programs, including in agricultural landscapes. It would also be useful to define areas that have high potential for REDD + interventions and investments, but that are currently not priority sites for current land restoration activities but could be identified because dual objectives supplement or enhance current program investments. To make this selection, a national inventory of sources and sinks of carbon is necessary. This would provide information on sources of carbon emissions subjected to degradation that are more suitable for REDD interventions. The estimation of degraded land show that more than 5 000 000 ha (Ndiaye et al., 2013) (Sonneveld et al., 2010) are affected and most of these areas are potentials area of reforestation. They include.

- degraded agriculture and pasture lands, suitable for plantation forestry;
- harvested and degraded forests, suitable for forest landscape restoration (FLR), and
- existing forest land that could be placed into a conservation plan.

Land degradation is due to forest degradation and expansion of agricultural land. For example, Mbow *et al* investigated the role of agricultural practices in tree losses in the peanut basin of Senegal (Minang et al., 2014) (Mbow et al., 2008) and found that the rapid environmental degradation witnessed in Eastern Saloum is caused by the conversion of forest and savanna areas to agricultural land during the last 20–30 years, a combination of decline in precipitation, soil degradation, a diversity of policies with little concern for the environment. Clearly a priority should be given to activities in landscapes that have been degraded by agriculture–either forest or non-forest–with interventions as tree conservation or reforestation to enable reductions of emissions from an agreed country baseline. Emerging examples in Kenya, Ghana and Cameroon demonstrate that agroforestry projects in non-forest land degraded by agriculture can have significant influence in reducing deforestation and forest degradation (Van Den Breemer et al., 1995). Tree planting in agricultural land will contribute to avoid degradation of these systems, reduce carbon loss and can therefore become eligible actions within REDD+.

In addition to the government initiatives, communities are adopting different strategies depending on the type of degradation, available resources and technology. For example, in the Peanut Basin, communities' coping strategies to increasing land degradation and fertility loss is to expand the cultivated area and reduce fallow time (Planchon and Dieye, 2002). However, this is a short-term and unsuitable strategy. Government-supported interventions within a REDD + program provides opportunities to build strong co-management models that increase agroforestry and enhance land productivity. Therefore, to implement REDD + activities

in the Senegal context successfully, two (02) key areas need to be taken into consideration: land tenure and community participation.

5.1 The land tenure issue

Evidence shows that land for which there are secure property rights presents more interest because it "is far more likely to be farmed sustainably than land with insecure property rights. In the latter case, farmers can easily be dispossessed by more powerful agents, including governments" (Barbier, 1997). Analyzing the economic determinants of land degradation in developing countries, Barbier (1997) argues that "farmers without well-defined land rights do not have the incentive to invest in agroforestry systems" (Schroth et al., 2004) or even in carbon project (Barbier, 1997). In the Senegal context, most of the land are classified as state-owned according to the National Domain Law. With the decline in soil fertility, especially in the Peanut Basin, some farmers have migrated in the south, a migration that initiates a competition for new farm land, opening up new areas for agriculture by clearing forests and woodlands which ultimately constitutes a threat to REDD +.

Land tenure is also considered as a major indirect cause of accelerated erosion and the failure of farmers to adopt soil conservation measures is related to tenure insecurity (Ribot, 2012). A Senegalese case study showed that the lack of clarity about the land tenure and land allocation led to increased clearing of forests (Verdoodt et al., 2013). The primary ways by which people can access to land are inheritance, leasing, borrowing, land purchase, and allocations from territorial collectivities and most of land rights is informal. Indeed, a small portion of land holders has a paper showing the ownership rights of their land. As in most African countries and despite the existence of a formal law, inheritance is still the main mode of access to land. Accordingly, many farmers do not have paper that certifies the ownership of the land they exploit. A recent survey (Mbaye et al., 2018) showed that overall, 93% of land owners in rural areas have no certification of their land by the government. Therefore, there is an important need of a tenure security to insure a long-term investment that can facilitate farmer's access to credit.

The contradiction between customary and statutory tenure systems creates a big obstacle to afforestation and reforestation carbon storage (Unruh, 2008). The government of Senegal would benefit from pursuing the land reform process started through the National Land reform Commission and create a legal framework that facilitates REDD projects implementation. This ongoing national land tenure reform would integrate regulations about who has access to land, who can benefit from land use services and how the benefits sharing and carbon rights are organized.

5.2 Engaging local communities

The "no regrets REDD" model mentioned in the introduction provides a way to catalyze an ongoing transition in Senegal from centralized land management to more local management and

governance by leveraging the rather well-developed knowledge base, tools, protocols and finances that the REDD + framework has created. Therefore, local population's commitment must be taken into consideration since most programs and associated protections have not addressed the needs and aspirations, of source-dependent rural populations and they remain seriously unrepresented as well as under-represented in forestry matters (Recha et al., 2016). This engagement must be analyzed at different levels: at the social (livelihoods), economic and technical level. As demonstrated in the previous sections, many forest programs have synergies with REDD + especially in terms of 1) engaging local communities in improving land degradation control and forest management (CODEVAL); 2) reducing emissions and increase carbon stocks (PROGEDE); 3) restoring soil degradation and capacity building for local communities in reforestation/afforestation and preserving natural resources (PREVINOBA). However, attention should be drawn to the "either or" aspects of the tradeoff and the possibilities of converting these 'trade-offs' into 'trade-ons' by implementing multifunctional agriculture through the cultivation of socially-modified indigenous tree species (Leakey, 2018). For example, in the Southern part of the country, especially in the Medina Yoro Foula region, reducing deforestation means for poor farmers limited possibility to acquire new lands for agriculture and there is an impoverishment of soil with not subsequent support of soil fertility amendment. This is where an improved policy framework is needed because without sustainable intensification policy actions to reduce deforestation would not provide satisfactory results.

In the social and economic side, for a REDD + initiative to succeed, it must include alternatives livelihood opportunities for local communities, especially when they are forest-dependent people since the expansion of small-scale subsistence agriculture, can be an important cause of deforestation and forest/land degradation. Developing social capital, capacity building and promoting collective action through community-based organizations are key factors that need to be integrated (Skole et al., 2013) because individual action cannot bring much change (Recha et al., 2016). Communities need to have a way to bring collective action, for example, to up-scale, and pose the way they use resources, access to services and also show how their collective contribution can transform the system in their particular area. REDD + strategies must be adapted to best suit community needs and interests. The development of social capital creates the conditions and a favorable environment to improve local livelihoods which are incentives for local communities to contribute reduce emissions from land degradation through REDD + initiatives. One other reason to involve local communities is the great amount of knowledge and experience they have and which need to be used from planning to inception and the implementation activities to recover degraded lands (Mbow, 2017). Rural people, especially farmers usually "plant trees on their farms or allow trees to remain on their farms because they recognize that trees provide multiple benefits to their households" (Holck, 2008) (Leakey, 2018). As mentioned in the previous section, many reforestation and agroforestry programs have been initiated in the country. Although significant results have been achieved, some of those projects and programs failed because farmers were "asked to make immediate investments on scarce land and labor to plant and protect trees with the uncertain hope that the trees will begin to produce benefits five to 15 years later". With REDD+, it is possible to link tree planting with near-

term payments through the emerging C markets and the additional payments from other tree products coming online in subsequent years which has the potential to positively affect millions of lives (Holck, 2008). Ultimately, the role of local communities is crucial in implementing REDD + activities.

In the technical side, it is also important to involve local communities in forest monitoring and management as a strategy to improve biodiversity conservation efforts and local livelihood especially in developing countries (Evans and Guariguata, 2008). To benefit from REDD opportunities, there is a requirement to develop scientifically sound and technically rigorous measurements and monitoring methods that can be implemented on the ground. They must be not only simple but also gain the trust and credibility demanded by buyers and investors" (Holck, 2008). In conformity with Decision 4/C15 in its article 3, local communities are given an important role to play in the monitoring and reporting. Technically, there is a rich body of literature on participatory or community-based monitoring of natural resources (Fry, 2011) and a subject of current disagreement is the use of advanced technology by local communities. Fry (Fry, 2011) points this out in his review of community forest monitoring potentials for REDD (Herold and Skutsch, 2011). Herold and Skutsch (Herold and Skutsch, 2011), Skutsch et al. (Skutsch et al., 2009), Abrell et al. (Abrell et al., 2009) have advocated the use of technologies by communities, such as GPS and GIS mapping while others (Danielson et al., 2005) remain less convinced. Similarly, there is some question as to whether local people can make measurements that are accurate and precise enough to be acceptable for scientific application (Fry, 2011). Fry (2011) provides an organization structure to evaluate community measurement that includes accuracy as one of three elements, along with cost and sustainability and cultural relevance. There may accuracy and precision issues when non-professionals engage in scientific activities (Holck, 2008). Other studies have focused on the capacity of local communities to assess forest biodiversity and forest disturbance. Holck (Holck, 2008) mentioned the increased focus of international forest policies in involving local communities in forest monitoring and management; this involvement being considered as a strategy to improve biodiversity conservation efforts and local livelihoods especially in developing countries. Ultimately, there are case studies that confirm that locally based, participatory monitoring must be simple to be successful: but how simple can the monitoring systems be and still maintain scientific validity? Danielsen et al. (Danielson et al., 2005) conclude that there is a major gap in understanding the comparability of data between scientifically and locally-collected data. Based on the few comparisons of scientific and local monitoring that have been conducted, the minimum amount of data to be collected by local monitoring programs to generate the same results as scientific methods appears to be high (Fry, 2011) As an example, Larrazàbal et al (Larrazabal et al., 2012) demonstrated from the Kyoto Think Global Act Local (KTGAL) project's example that communities are capable of generating data that can meet the standards of the IPCC methodology. They found the data accurate and reliable as "there were no significant differences in the estimate of mean stock or in the confidence level between the experts' measurements and the communities" (Larrazabal et al., 2012).

6 Discussion

6.1 Lessons learned for REDD from early land restoration and management projects

Land degradation is occurring in different ways, has various impacts and severity depending on the region and the causes whether natural or human induced factors. The consequences on human, natural resources, productivity and economy are very obvious. They impact livelihood systems, watersheds and river basins and carbon storage. It has been proved that reforestation is an important method to restore degraded land not only because of its potential to increase land productivity and agricultural production but also the high potential of carbon sequestration that can be fixed in terrestrial ecosystem to avoid and/or reduce carbon emissions.

A comparison of the non-forested area addressed by land rehabilitation programs and remaining whole area affected by land degradation in the Senegal shows the important role REDD + can play to enhance government efforts in restoring degraded land. This role is also important with carbon sequestration as a target to reduce emission, although carbon is only one aspect of potential benefits from REDD +. Using a landscape approach, REDD should be broadened for more inclusion of systems of Trees Outside of Forests. This will further move the strategy from LULUCF to AFOLU. This implies more consideration of the technical path for landscape-focused restoration that includes TOF as well as the institutional path on existing policies and programs that drive enhanced livelihoods and economy by reversing degradation to promote "nature-based solutions" (UNDP, 2018).

Regarding the REDD opportunities for climate change mitigation, carbon sequestration is seen as a big component. All trees species are sequestering carbon naturally but at a slower or faster rate depending upon various factors including the type of tree species. Therefore, to restore degraded land with tree plantation, the selection of species to be used must be based on cultural and economic as well as environmental factors. Species should be selected based on their adaptability to the biophysical conditions and the culture in the area. They also must meet the needs of the local populations environmentally as well as in the economic side. In addition to their participation in both the decision-making process and the forest resources conservation, local small holders should be able to make economic benefits from the species and capture "trade-ons" through the reversal of the cycle of land degradation and social deprivation (Leakey and Hoffman, 2013) (Leakey, 2018). These benefits are among the major factors influencing a positive participation in forest conservation and restoration programs. Ultimately, the "species chosen should be locally desirable and saleable" (Holmes Cheyre, 2016). Indeed, smallholders and communities will likely choose locally adapted and accepted income-generating trees that yield multiple products. An example from West African Savannah has shown that it is common for farmers to retain useful trees, which means that they are difficult to fell and resistant to fire when preparing a plot for cropping (Barbier, 1997). Some studies in Panama and elsewhere has shown that choosing species that serve livelihood purposes was key to local farmers' participation in a reforestation initiative (Reubens et al., 2011). Therefore, we should pay special attention on tree selection and focus on species performing a wide range of functions including

biodiversity conservation, livelihoods and communities' empowerment. Preferences of local stakeholders should be properly considered during the selection to ensure both ecological suitability and efficiency of tree planting efforts. To combat land degradation, the REDD mechanism has an important role to play in the Senegalese context. Representing 34% of the country's surface and 58% (5 228 700 ha) of the 9 015 000 ha agricultural land, land degradation in the country can be addressed with more efficiency and effectiveness through REDD projects. A review of selected projects has shown a very big evolution of local views on the role of the tree in the fields and for the environment in a general way. There is also a more involvement of local communities in forest resource management through government interventions in the use of forests and trees. Building on these achievements, the REDD agenda offers a good opportunity to restore land degradation in Senegal and increase the chances of the country to meet its objectives in reducing emissions through the Nationally Determined Contribution. Reversing land degradation requires sustainable land use planning which should be based on detailed up-to-date information on landscape attributes because types of land degradation are very diverse. Therefore, a landscape or ecogeographic approach is very straightforward to determine and select potential areas for tree conservation. For this purpose, recent success in remote sensing can be useful in land degradation detection and measurement to identify and map the different types of degradation, helps prioritize land restoration over huge areas to facilitate REDD interventions.

6.2 How to integrate REDD into Senegal's current institutional and policy framework

Several challenges need to be addressed for the country including both the technical and institutional sides. Technically, there are some challenges that could be quickly overcome with capacity building. Indeed, most forest service agents who implement field activities are only trained for repression rather than inclusive management skills. Thus, they are rather concerned about the police activities which generate significant incomes. However, an alternative should be to empower local people in the management of the forest resources in their land. An example from the Decentralization-Local Governance program (DGL-Félo), in the department of Medina Yoro Foula, demonstrated the effectiveness and relevance of the full empowerment of people in the management of the forest resources and these trained populations, supervised by experienced technicians of the forest service. It also ensured an efficient and appropriate management of the resources of their soil. However, it was unfortunate that the process was not completed with the end of the program and the REDD + mechanism could learn from these failures and provide alternatives for continuation.

On another hand, for a landscape approach over a sector approach, local people have an important role to play especially in measuring and monitoring. Therefore, with a minimum training, they will be able to do the tree measurements in their own farms.

Regarding the institutional aspects, the reforms and new policies were not able to reduce significantly the high rates of deforestation and degradation because of some limits of forest governance in Senegal. Indeed, from a policy perspective, governance is an important factor to

promote participation, accountability, and transparency in natural resource management (Colchester, 2006) (Ribot, 2012). It is a set of principles based primarily on three considerations: i) public participation or the inclusion of all parties in the decision-making process; ii) equitable access to resources; iii) and the rule of law. However, in the Senegal case, our analysis of forest governance is based on examining: a) the management of the factors that likely empower citizen participation in decision-making processes in the management of forest resources; b) the level of consideration of the needs and interests of all users of forest resources at the local level and their capacity to benefit from these resources; c) and finally, the mechanisms guaranteeing the security of tenure and the exploitation of its resources. The results of such analysis show that, regarding public participation, good progress is made with the code of local collectivities that had conferred more power to the departments and communes on natural resource management. Within the REDD framework, not only all categories of people must be involved, but also, these communities must be provided with financial resources to do their activities. These include organizing meetings (fora or public hearings) at the local level to gather the opinions and feelings of different segments of society before major council meetings and to organize similar meetings to share board decisions. Also, to fully exercise their prerogatives in the field of natural resources management, the priority must be to strengthen territorial communities by providing a continuous and recurrent capacity building.

Also, the new Forest Code recently enacted in Senegal stipulates a distribution of revenues from the exploitation of forest resources (state revenues) between the State and local authorities. Thus, binding transparency mechanisms should be put in place to ensure that at least some of these resources are reinvested in forest management at the local level.

6 Conclusion

This study reveals the opportunities for the country to participate in the REDD + mechanism. However, some policies change are needed and specific recommendations for the Senegal context include.

- The experience of the reviewed projects programs shows that the scale of REDD can be project-based at first and later goes beyond to a national level;
- Insights from these projects also show that the national context dictates expanding REDD scope 5 (enhancement of forest carbon stock) to AFOLU and afforestation/reforestation and trees outside of forest. For this purpose, the broadening could be thought of as moving REDD from LULUCF to AFOLU which has some potential. Indeed, this will touch the notion of trees outside of forests (TOF) which is interesting for two main reasons: 1) it is not widely discussed in the context of forests and it should be, and 2) usually it is discussed under the

ministries of Agriculture rather than Forestry where REDD usually sits in the policy and government dialogs.

Future research are required in these following areas.

- define areas that have high potential for REDD + interventions and investments;
- scientific outcomes to sustain revision of policies, laws and regulations for REDD
- analyses of land degradation drivers, stakeholder engagement, institutions and governance

Author contributions

Conceptualization, MD and CM; methodology, MD; CM and DS; software, MD; validation, MD, CM; DS and BB; formal analysis, MD and CM; investigation, MD; resources, MD; data curation, MD and BB; writing—original draft preparation, MD; writing—review and editing. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

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