Eucalyptus in Cameroon – Photo credit: Bertus Buizer

Agriculture, Conservation and Poverty:

Is Agroforestry Cameroon's solution?

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Abstract

2020 is a year in which human beings have been fighting against a global pandemic, Corona (COVID-19). Some measures have been taken so as to prevent a further spread of the disease but to avoid further pandemics and further effects of climate change, we must stop being self-centred and focus on how to conserve our nature rather than destroying it in the course of trying to satisfy our own needs. What if there is a way to do both? Conserving our nature while satisfying our needs? Agroforestry is the way. For the natural world we rely on for survival; the air we breathe, the clean water we drink, our food security, our life support system are all parts of nature. Therefore, this is our opportunity for a new balance with

nature, one that recognises that our future is intimately connected with all other life on earth, build back balance build back life.

Recognizing biodiversity conservation as the key stepping stone, the overall objective of my study project is to assess the contribution of agroforestry in the reduction of environmental damage, the promotion of sustainable agriculture through ; the restoration of soil fertility, the biological prevention and control of pests and diseases in agriculture , the diversification of agricultural products and the generation of more surpluses in the agricultural products, the production of woods for fuel, service and construction, the reduction of the greenhouse effect and ultimately, the promotion of peaceful coexistence between farmers, breeders and foresters in Cameroon through the improvement of knowledge on agroforestry practices adapted to the area. Specifically, the existing agroforestry systems in the hunting interest zones were identified and characterized, the conflicts in the use and occupation of land were identified, the problems faced in the agricultural and forestry sector were identified, as well as the perception of local people on the role of agroforestry in the resolution of these conflicts. This paper aims to examine the research trends in agroforestry and the current state of knowledge, as well as the drivers for agroforestry development in Cameroon.

INTRODUCTION

Except in the small rift countries such as the Rwanda or Burundi, Cameroon is the regional country where the agricultural development is the most important. This, together with a strong pressure from hunting, old logging and mining development newer, causes considerable pressure on natural resources. One of the principal challenge in the sustainable management of the natural resources situated in this region dominated by agriculture is to know how to reconcile the imperatives of biodiversity conservation to those of the socio-economic development of the populations living in the interior and the surrounding of those spaces and whose survival depends on it. In order to safeguard and enhance this biodiversity, a large network of protected areas has been put in place over time, first in the savannah region then in the forest south. Protected areas are at the heart of biodiversity conservation strategies: their objective is the long-term protection of the natural heritage and biological resources which form the basis of the economies of countries. If in some countries the consensuses resulting from this question is applied and result in measurable progress at the economic and social level, and produce changes in the traditional activities of rural communities, in others their application has not yet reached the expected results (Civil-Blanc, 2007). Cameroon is one of the countries where, despite a good number of efforts made recently by organizations to fuel these changes, the degradation of ecosystems continues to negatively influence both the environment and the economy and the lives of all the general population (Redford et al, 2007; Tchamba et al., 2013). As the objectives of conserving this protected area do not always match the different pressures exerted there, the simultaneous presence of farmers, breeders and wild animals in the hunting interested zones generates numerous conflicts between the users of the space with consequences for the maintenance of biodiversity in the hunting interested zones. In fact, on the agricultural level, cultivation techniques are not protective of the environment.

However, agroforestry practices can be a solution, as is the case for many other countries. According to Diane Russel (2010), the new conservation approaches challenges us to go beyond protected areas to conservation of a matrix of land uses. Promoting the use of trees and woody species in landscapes and farms is a frequently used but under-studied aspect of this approach. In theory this will bring greater biodiversity, ecological and social benefits than small scale projects. To link agricultural land uses and natural forests, the integration of trees in landscapes and on farms including social, cultural, and policy issues of tree choice, use and management must be part of the equation. The fight against erosion (Atangana et al., 2014), the limitation of evapotranspiration (Bellow and Nair, 2003), the diversity of consumable products (Civil-Blanc, 2007), crop rotation and the sedentarization of farmers with which it is accompanied are the positive results of this association of crops and trees (ICRAF, 2011).

This article shows how agroforestry emerged as a solution to feed a growing population, improve livelihoods of farmers including the whole population and enhance conservation within the environment because it was seen as a more sustainable land use option than crop production and because it could ‘ buffer ‘ the terrain around protected areas.

BACKGROUNG

1) Theoretical background on agroforestry

Agroforestry is defined as agriculture that incorporates trees. However, this definition is oversimplified. Agroforestry is in fact much more complex. Geographic information system data show that 43% of all agricultural land, globally, is used for agroforestry, which is more than 1 billion hectares. Agroforestry is generally said to be a ‘new term for an old practice’, since the name was not recognized in the literature until the mid-1970s, but it has been in practice for a much longer period of time. Agroforestry is a collection of land-use practices, systems, and technologies that integrates woody perennials into crop- and animal-based agricultural practices. The main requirements for agroforestry are that at least two plants or animal species are included in the land-use system and one of these should be a woody perennial. Moreover, there are economic and ecological interactions between two or more production systems, such as tree-crop, tree-livestock, or tree-fish. Compared with intensified agriculture systems, the cycle of agroforestry systems may take one or more years and be more complex structurally, economically, ecologically, and functionally.

2) Theoretical background on agroforestry development in Cameroon

Agroforestry agriculture is the mainstay of the Cameroonian people. The fact that agriculture has always occupied a prominent position in Cameroon’s development plans shows the importance the nation attaches to it. Agro forestry techniques aim to ensure smallholder households increase their use of trees in agricultural landscapes to improve food security, nutrition, income, health, shelter, social cohesion, energy resources and environmental sustainability. But lack of technology and knowledge of farming techniques to deal with challenges such as soil erosion, the Sahel environment, drought and torrential rainfall threaten the livelihoods of many. On 28 November 1990 Cameroon formalized an

agreement with the Peace Corps, asking Volunteers to provide qualified manpower to contribute in building the capacities of local communities in natural resource management.

Furthermore, in 1991 Cameroon's Agroforestry and Permanent Farming Systems project was introduced in the West region, and in 1999 its services were extended to the North region. Volunteers placed within the domain of agroforestry were to assist farmers with knowledge on how to maximize output while at the same time avoiding practices that result in soil erosion and further desertification. The project began with 21 Volunteers in 1999, rose to 26 the following year and declined to 16 in 2001, but has remained at an average of 20 Volunteers annually. Agro forestry has changed the livelihood of most Cameroonian farmers as two decades later after its introduction, more than 100 000 farmers that have embraced the scheme across the country and are reaping the benefits. The option of integrating agroforestry into the farming system around the national territory is the only way out for farmers to sustain their livelihoods and has increased income of farmers a tenfold. For example a farmer who plants bitter-kola or bush mangoes for instance will get income from these products.

However, today Cameroon faces three serious and linked problems: environmental degradation, population growth and resource depletion. As in other parts of the world, soil erosion, desertification, forest depletion, air pollution, global change and other problems are seriously threatening the Cameroon environment, economy and society. Furthermore, the colonial-era policies make lands unavailable to a farmer, and thus, people consider every inch of land a precious resource to be diligently safeguarded and meticulously managed. Consequently, agroforestry has been advocated as one land-use system that can protect the environment and control soil and water erosion (Zhang et al., 2008). Agroforestry has also been used to increase the land area available to agriculture through reclamation of marginal land and to increase agricultural productivity. There is an urgent need to meet the dramatically increasing basic food requirements and to solve timber-shortage problems. Current land development policies advocate the provision of shelter, intercropping of trees and agricultural crops and the control of soil erosion (Dai, 2010). Significant progress in the development of large scale agroforestry systems has been made in other countries, especially with respect to stabilization of active sand dunes, and establishment of shelterbelt and alley-cropping or intercropping systems, amongst others and this progress is needed in Cameroon.

Moreover, in a number of countries there have been attempts to harness agroforestry potential by improving the coordination of national activities, through the development of national information networks. New opportunities for agroforestry are also emerging, such as within the miombo woodlands (savannah) of central, eastern and southern Africa. This area covers 3 million km^2 over 11 countries and contributes to the livelihoods of some 100 million low-income persons. Similar is the expansion of natural regeneration of dry degraded land in the Sahelian area of Africa with the potential to mitigate climate change and increase rural income; in Niger, new legal conditions encouraged farmers to manage natural tree regeneration, leading to over 5 million hectares of newly generated parkland systems. Also, in the United States, where agroforestry is not universally adopted, there is growing recognition of its ability to help farmers, ranchers, woodland owners and indigenous people

to integrate productivity and profitability with environmental stewardship, culture and traditions.

My research has been primarily focused on the optimizing of agricultural production and environmental benefits through agroforestry frameworks, thereby assisting in improving the economic, social and policy context, so that incentives for practicing agroforestry are strengthened. Case studies discussed in this article are summarized in table 1.

Title and researcher: how could agroforestry promote peaceful coexistence between foresters (including wildlife), farmers and herders in Cameroon? ; Jose Elvire Djiongo Boukeng

Key findings:

- Agroforestry systems are heterogeneous in space within the hunting interested zones. Six types of agroforestry systems are practiced by farmers. These are: 1) home gardens, 2) scattered plantings, 3) living hedges, 4) fallows, 5) wooded parks and 6) windbreaks. The difference between these systems is in the composition in terms of tree production, crops and livestock. The system can therefore be of the agrosilvicultural type (association of crops with trees on the same land management unit), agrosyslvopastoral (association of trees and animals with crops) or sylvopastoral (association of animals with trees).
- The majority of recorded conflicts are due to attacks by wildlife on crops; Two types of conflicts have been identified: human wildlife conflicts which result in the attacks of wild fauna on crops, and agro-pastoral conflicts due to attacks by cattle, specifically oxen on crops. Sixty-five percent of the respondents recorded crop attacks by wild animals, and 35% were victims of crop attacks by oxen. These percentages between farmers differed significantly. These attacks occurred in all the villages selected for the study and the percentages of peasants reporting attacks did not vary significantly from one village to another.
- The study was made in 10 villages selected randomly, In the South by the Boumedjé-Waté trail until it meets the Mayo Pounko, In the North by the Bénoué stream from its tributary with the Faro to the Badoudi village, West by Mayo Faro to its tributary with Bénoué, East by the track going from Tsorké to Badoudi passing through Koubadjé and Djamboutou
- The damage period spanned almost the entire year, both in the dry season (November to April) and in the rainy season (May to September). However, it should be noted that the majority of damage was recorded during the rainy season between August, September and October. A peak is noted in September when the crops are mature.
- According to the majority of farmers, agroforestry systems contribute to conflict reduction. For 91% of those surveyed, the practice of agroforestry allowed soil fertilization, thereby improving agricultural productivity. Seventy-one percent of those interviewed think agroforestry is beneficial because trees provide shade for crops, animals and humans. The other advantages were the production of fodder for livestock during the dry season (49%), the sedentarization of farmers (44%), the production of firewood (44%), the reduction of attacks on crops by animals (32%), crop diversification (26%) and other benefits (11%), such as the production of edible fruits and vegetables from the trees left in the fields, the reduction of erosion and the reduction of wind speed.
- The practice of agroforestry did not only have advantages according to the farmers interviewed. The first drawback cited by farmers (69%) was the lack of training and information. Indeed, farmers have empirical knowledge of agroforestry systems and

most of them practice traditional agroforestry systems. There is therefore a real lack of supervision of these peasants by the structures competent in agroforestry.

- The second and third disadvantages were the high cost of installation (46%) and the lack of plants (30%), respectively. The peasants here refer to the installation of a living hedge, a wooded park or an orchard which basically requires the purchase of selected seedlings and labour for the picketing.

Case Studies

Title and researcher: people, trees and parks: Is Agroforestry in or out? ; ALAM (Agroforestry in landscape mosaics)

Key findings:

- First, it is important to note that trees are highly valuable resources renewable if managed correctly and their care, management, and use must be given much more attention in conservation planning. Trees provide food, medicines, fuel, construction materials, and many other services. Most attention and resources in conservation go to wildlife, particularly in Africa, while many indigenous trees are disappearing from the landscape. This conservation element needs to be integrated into agroforestry strategies.
- In Southwest Cameroon conservation areas, NGO attempts to domesticate indigenous species were thwarted by poor planning and lack of communication with the local population. In both places, extension efforts relied heavily on one extension method: organizations target groups and transmit technologies through a series of "social links." Potential bottlenecks include the inorganic nature of many groups, weak links and diluted information, insecure/non-transparent relationships and roles within groups and between links, poor feedback, NGOs' inability to provide long-term commitments because of short-term funding, and the possibility that the "farmer group" is not the best unit for communication and development.
- In addition, ever-changing policies on use of the forest resources mean that residents must employ "quick and dirty" exploitation methods as there is no security of use. Some attempts to stabilize this situation are being made, but the issue of wages is not part of the equation. Increasing tree planting on farms may be difficult for many reasons. Extreme poverty leads many in the villages studied to conclude that tree planting is not a worthwhile pursuit. While they acknowledged that trees could provide both fuel and income in the future, farmers repeatedly pointed out that crops could do both of these much sooner. Without examples, they are reluctant to believe that trees will appreciably improve their futures, and some villagers frankly admitted that they would rather take steps that will better their own lives rather than those of their children. Even though most men interviewed were only in their early 30s, they doubted they would be alive to reap the benefits of trees maturing 10 to 15 year in the future.
- For agroforestry to be an effective part of a conservation and livelihood strategy, many technical and social issues have to be addressed at the same time. Agroforestry should not be touted as means in itself to release pressure on protected areas or provide substitute benefits to populations. Projects and extension systems need to increase the available range of options in terms of species for testing and commercialization, and design more flexible interventions that make information accessible to both men and women.
- If agroforestry is to contribute positively to conservation and protected areas management, there has to be spatial and social complementarity. There are many

biophysical questions concerning the impact of different sorts of trees and spatial arrangements of trees on wildlife as well as on crops. For example, management of wildlife and pathogens crossing boundaries between agriculture/agroforestry and natural forests entails the social challenges of creating adequate institutional arrangements.

- Managing tree populations over landscapes will require farmers and foresters working together to enrich, diversify, maintain genetic health, and promote regeneration. As we see, this may often mean working in a "rough policy terrain," as the jurisdictions of institutions intersect with different objectives, levels of power and influence, and conceptual models.
- Agroforestry also changes emphasis with different stakeholders. Conservationists like indigenous trees and large mammals, but farmers often like fast-growing exotics and do not like large mammals or even small ones in their fields. Farmers would like to make money from trees and tree products but forest policies inhibit them from doing so. Conservationists want to protect trees, yet forest policies have not succeeded in doing so, at least in Africa. As community forestry takes hold and co-management arrangements are implemented, it will take careful site based study to devise appropriate solutions.
- The whole issue of rural development moving beyond livelihood security to sustained economic growth in poor regions has to be tackled. Much of the conservation literature assumes that migration to areas around protected areas is bad. Perhaps migrants are people with skills who can bring about development in these marginal areas. In any case, it is often hard to determine who is a "migrant" and who is local. Specifically, migrants may bring new agroforestry management, product development, and market systems to contribute to regional livelihood and tenure solutions. Continued disempowerment and weakness of local populations means continued non-resolution of ownership, control, and access. But in areas of high population density (e.g., Mabira Uganda) there may be a need to help young people find livelihoods elsewhere.
- Another key area of research concerns options for high-value trees around protected areas. Branding high- value tree crops (coffee, cocoa, tea, nuts) found in biodiverse areas for high-end consumer sales is one option for increasing agroforestry's value to local producers.
- Finally, we see a need to take a regional and systems approach that is not necessarily ecoregional: Lack of conservation in one area may lead to lack of a sustainable development in another area. A case in point is the pillaged forests of the Democratic Republic of Congo leading to lack of incentive for a smallholder sustainable timber industry in Kenya and Uganda where the demand for wood is high and forests are shrinking. Agroforestry and protection thus can be very spatially separated but united by market and political forces.

THEORETICAL AND CONCEPTUAL FRAMEWORK

This section presents key concepts used in formulating my research strategy. It draws on a number of theoretical points that form a baseline of my research questions.

Agroforestry impact on national/local development must be determined empirically

The potential of agroforestry to contribute to sustainable development has been recognized in international policy meetings. The UNFCCC and the Intergovernmental Panel on Climate Change (IPCC) increasingly acknowledge it as a component of climate-smart agriculture. During the 2011 Conference of the Parties (COP) meeting in Durban, agroforestry was frequently mentioned as having a strong potential for climate change adaptation and mitigation. Also, National Adaptation Plans of Action (NAPAs) and Nationally Appropriate Mitigation Actions (NAMAs) talk of agroforestry as an important component in agricultural sector actions. This is beyond doubt insofar as, in tropical and equatorial countries, the fragility of the soils, the very high light on the ground, the production of fodder for livestock and the presence of labour family are factors favourable to the association of crops on several floors on the same unit of plot (Levassaeur, 2003). The fight against erosion (Atangana et al., 2014), the limitation of evapotranspiration (Bellow and Nair, 2003), the diversity of consumable products (Civil-Blanc, 2007), crop rotation and the sedentarization of farmers with which it is accompanied are the positive results of this association of crops (ICRAF, 2011). In fact agroforestry is significant in the production of both local commodities (such as fuelwood, timber, fruit and fodder) and global ones (such as coconut, coffee, tea, cocoa, rubber and gum). It can also play a strategic role in helping many countries meet key national development objectives, especially those related to poverty eradication, food security and environmental sustainability. In towns and villages, its positive outcomes can be seen in food, fuel-wood and watershed management, contributing to a more resilient food system. When designed and implemented correctly, agroforestry combines the best practices of tree growing and agricultural systems, resulting in more sustainable use of land.

For example, agroforestry helps:

- Protect and sustain agricultural productivity
- Ensures food diversity and seasonal nutritional security
- Diversify rural incomes
- Strengthen resilience to climatic fluctuations
- Helps perpetuate local knowledge and social and cultural values

Raising awareness of the benefits of agroforestry is critical

Overdependence on conventional agricultural methods and inadequate knowledge of sustainable approaches restrict the interest of policy-makers in agroforestry development. Limited dissemination of ideas and information prevents the spread of agroforestry systems and in many countries these systems are seldom included in the curricula of agriculture or forestry schools. As Cullen et al. (2004, p. 425) put it in relation to creating agroforestry buffer zones, "selection and design of agroforestry practices around forest fragments must be discussed carefully with each farmer. The goal is to plan with farmers and not for the farmers." They emphasize the importance of trust in crafting agroforestry projects.

The regulations/policies are restrictive

Forest conservation models have created perverse incentives whereby protection of indigenous trees has meant that people rarely plant them due to their desire to avoid entanglements with the state. It is thus critical to understand and integrate the motives and workings of the state and powerful non-governmental organizations (NGOs) into strategies. As in china, the government should devotes a significant amount of attention and resources to overall afforestation efforts. Additional environmental agroforestry projects should be implemented and the reformation of policies should begin.

Environmental protection must be prioritized

Decision making in conventional conservation practice is predominately based on the assumption that ecosystems are constantly and inevitably damaged by human action (Adams & McShane, 1992; Cronon, 1995; Fairhead & Leach, 1995, 1998; Escobar, 1998). Fairhead and Leach (1995), for example, suggested that externally driven agroforestry initiatives are "constructed (and their funding justified) against a backdrop of decline" (p. 80). This approach to conservation may reinforce ideas of inevitable human destruction of natural resources and exclude particular human/environment histories. An emerging body of research suggests that it is better to view people as an integral and perhaps even beneficial part of ecosystem functioning than as foreigners responsible for its destruction (Cronon, 1995; 175 Dove, Sajise, & Doolittle, 2004). Nuanced studies of the relationship between agriculture and biodiversity through in-depth local studies have shown that complex, composite agricultural systems can play an important role in maintaining regional biodiversity. For example; In China, The primary orientation of most agroforestry systems in China is environmental protection, particularly in the 'Three-North' project (Ma, 2004). The purpose of planting perennial woody species is to prevent desertification, sandification, wind erosion and, in the long term, to ameliorate land degradation. Most research on these systems, therefore, has been focused on understanding the effect of agroforestry systems

on the modification of microclimate, amelioration of soil conditions, minimization of natural disasters, and crop yield (Zhang *et al*., 2008; Dai, 2010; Sun *et al*., 2010).

Government cooperation is an important factor in the settlement of agroforestry's barriers

The Government is one distinct factor that strongly influences agroforestry development in a country. The main obstacles to agroforestry development and expansion and the solutions to these obstacles are more develop in the following lines. The government can help in the implementation of these solutions and hence contributing to the development of agroforestry through the points listed below:

- Delay return on investment and under-developed markets

For agroforestry to better address the needs of poor populations, Most agroforestry research projects should be funded by the central government within the 5-year planning system. For example, In China an integrated farm- forestry project in Huang-Huai-Hai Plain, which is within the North Central China Plain, in the Huang, Huai and Hai watersheds, has been a key national project in the sixth (1980–1985), seventh (1986–1990) and eighth (1991–1995) 5-year plans of the central government. During the sixth and seventh 5-year plans, the government invested 12 billion Yuan RMB [US $1 = 3.78 Yuan before 1987 and 8 Yuan after 1993] on this project alone. Thereby solving the problem of the difficulty many farmers face in investing in activities that have a delayed financial return and which force many farmers to rule out agroforestry as a viable option. Furthermore market information systems introduced in some countries, should include tree products. As such, markets for tree products will be both more efficient and more developed than for crop and livestock commodities and value chains related to agroforestry systems will receive more support.

- Emphasis on commercial agriculture

Agricultural policies can discourage farmers from practising agroforestry. Incentives for agriculture often promote certain agricultural models, such as monoculture systems, and tax exemptions are usually aimed at industrial agricultural production. In Cameroon, for instance, incentives are currently encouraging the rapid extension of oil palm plantations in vast areas of the Cameroonian Amazon. Agricultural product price supports or favourable credit terms which are granted for certain agricultural activities but hardly ever for trees, are also discouraging agroforestry adoption. By including agroforestry in the benefit package the system will be encouraged, agricultural production will become less economically dependent on imports and ecologically sustainable.

- Inadequate research and extension services

Extension of agroforestry technologies that are based on experiments with exotic species and intensive technologies assessed in very different conditions and transferred to another place is usually not relevant. Research aimed at developing new planting material sometimes pays no attention to studying the symbiotic relationships between species and interactions between species and soils. In South Cameroon, for instance, the introduction of a planted fallow system was unsuccessful because farmers were not facing problems of access to land or shortage of wood; they therefore saw no reason to shift to a new land use. Similarly, alley cropping systems did not spread to drier areas from the humid region of West Africa where they were tested successfully. Research and extension systems should not concentrate solely on the biological efficiency of the technology, but must analyse the economic viability, in terms of yields and labour-related costs of the solutions they propose, as well as their social acceptability. It is essential that research and extension programmes involve stakeholders to ensure that the programmes are relevant, applicable and practical. And it is more essential that the government favours those programmes through funding and the spreading of up to date information.

- Ignorance on the advantages of agroforestry

Lack of knowledge, different labour requirements and less established markets lead to more uncertainties with agroforestry systems. In turn, this leads to scepticism on the part of professionals and advisers, who may restrict access to information and training in agroforestry systems and the development of workable technical and business models. In developing countries, seed collection, propagation and multiplication methods, as well as vegetative propagation, are poorly known, and farmers often have no option but to protect or transplant trees that have germinated spontaneously. Moreover, because advanced propagation methods are not disseminated there are many missed opportunities to reduce the time needed to full production. Some promising ways of managing trees on farms (such as intercropping systems for soil health or introduction of improved fallows) should be introduced with the government support to the vast majority of farmers with more nurseries providing a range of native multipurpose trees. Also, new technology and up-to-date information needs to be continuously brought to bear upon local situations, in order to promote the further development of agroforestry and associated economic spin-offs.

- Adverse regulations

Government policies in Africa are focused heavily on alleviating poverty for the "poorest of the poor" (see, e.g., Government of Uganda, 2001, 2002). For

agroforestry to better address the needs of poor populations, policy makers will need to look more toward initiatives involving communal lands. There are opportunities around protected areas to create tree plots through planting or, more efficiently, natural regeneration, that could be harvested and sold and to use the resulting profit to enhance school and community buildings.

- Unclear status of land and tree resources

In Cameroon, a 1974 land law gave all citizens the right to register and own land, but the procedures involved in obtaining land certificates are too complicated for many rural people. As a consequence, most farmland in rural areas is obtained through informal customary land rights, while legally owned by the state, creating a sense of insecurity. In addition, trees growing on land with no title also belong to the state. In those conditions, why would farmers have any interest in planting or managing trees on farms? Yet, if potential returns can be made with little investment, farmers may plant trees whatever the land tenure rules; right of tenure, while being a parameter, has to be balanced with profit expectations. In some cases, forest regulations inhibit tree growing on farms by restricting the harvesting, cutting or selling of tree products and certain tree species; or forest services may control the management and harvesting of trees through permits so that farmers who introduce trees into fields are not free to manage the tree products as they wish. In turn, the permits may be difficult to obtain because of bureaucracy, or harvesting may be forbidden altogether. Although sometimes well intentioned, such protective measures, when applied to agricultural landscapes, discourage farmers from planting and protecting new seedlings that emerge. Hence, Development and conservation practitioners could also work together to enhance understanding of tenure and forest laws, to promote fair wages, and to publicize positive examples of agroforestry interventions at the grassroots level.

- Lack of Coordination between sectors

In many countries, in principle, agroforestry is regarded as belonging to “all sectors”, but in practice, it belongs to none and rarely occupies a special line in a governmental body or has its own policy space. It falls between the agriculture, forestry and environment departments, with no institution taking a lead role in the advancement of agroforestry or its integration. In Malawi, for example, although agroforestry is clearly highlighted as a technical solution in both the Forestry Act of 1997 and the National Environment Policy since 2004, agricultural policies still support the extension of cropland, while forestry policy promotes conservation and full afforestation. In conclusion, the harmonization and synchronization of policies and programmes require a combination of policy attention across the departments in charge of rural development, land use, agriculture, forestry, environment, finance and commerce, at both national and local level.

MY RESEARCH FINDINGS

I started with baseline questions about agroforestry development:

- Does agroforestry provide safe and nutritious food to a population that will likely grow more and more in the upcoming years?

- Does agroforestry improve livelihood of farmers including people living in or around the protected areas?
- Does agroforestry play an important role in environmental protection?

Using my conceptual framework I added these questions:

- What is the effect of agroforestry systems on the modification of microclimate, amelioration of soil conditions, minimization of natural disasters, and crop yield?

The key findings that emerge on my research are elaborated on the following pages;

Agroforestry as a key to sustainable agriculture

The agricultural sector is expected to provide safe and nutritious food to a population that will likely grow more and more in the upcoming years. Not only will there be more mouths to feed, but as the population of a country grows, the demand for food such as meat and dairy products will increase too. And the agricultural sector could not be able to provide the adequate amount of food for these people due to the increase in soil erosion (the removal of the top soil layer) on the farming lands because of the excessive use of fertilizers which hinders the quality of the farm lands there by making sustainable productivity of crops impossible. Also, the provision of safe and nutritious food could not be possible because of the excessive use of fertilizers which induce chemicals in the food we eat hence affecting the population's health in a long term and leading to a decrease in the nutrients gain from the consumption of this food.

China as a reference

As one of the most populated nations, China has practiced agroforestry for many centuries. For example, during the Han Dynasty (206 bc to ad 220), administrators recommended that forests be developed to accommodate livestock husbandry and crops according to varying site conditions (Zhu *et al.,* 1991b). A detailed review on the ancient practice of agroforestry in China can be found in You (1991). In 1974, after a month-long tour, Dr. Jack C. Westoby from the United Kingdom concluded that China had succeeded in effectively integrating agriculture and forestry (Westoby, 1989). Gold and Hanover (1987) echoed that one of the most extensive systems of tree-crop integration in the world is found in the northern provinces of the People's Republic of China. This proves the effectiveness of agroforestry systems to feed a growing population thereby providing a safe and nutritious food to that population. Agroforestry not only an essential step for reversing environmental deterio increases agricultural productivity but also expands ration.

In addition, to address this issue, China initiated the variety of production from the land to meet 'Grain-for-Green' program in 1999 as an approach providing people's basic needs and promoting the development conservation program and as an ambitious conservation program designed to mitigate and prevent flooding and soil erosion. It is an example of Payment for ecosystem services which is helping to solve environmental issues in China. The program is designed to retire farmland that is susceptible to soil erosion, although some farmers may go back to farming the land after the program ends. China started the **Grain for Green** program in the western parts of the country for example Shanxi Province. These areas were known for their rather poorly performing economy that was affiliated with an endangered ecological environment. The environment was being further damaged by soil erosion which was a result of cultivation on sloping land as people were changing forests into farmland. The Grain-for Green programme is the extensive extension system and the biggest land-use transition, watershed manage links among research, extension and production meant and poverty alleviation programme, involving units promoting the

transfer of knowledge from the largest population in the Chinese and global his research to practitioners, while financial incentives tory. The programme covers 25 provinces/regions/ and preferential policies greatly encourage farmers' participation in agroforestry development. Research has found that with minimal extra cost, Grain for Green can promote biodiversity by planting mixed forests.

To conclude, if a more intensive research is done concerning this program with the provision of extra-funds from the government, the grain-green programme can be implemented in Cameroon too so as to favour sustainable agriculture and biodiversity.

Agroforestry as an option to alleviate poverty

Agroforestry systems prove successful and sustainable only when they have direct benefits for farmers. Farmers can benefit both directly and indirectly from agroforestry through the mixing of perennials and annuals trees species on a plot of land. This practice will bring out positive modification on environmental conditions and an increase in the land-use efficiency. In addition, this provides short- and long term returns and multiple outputs, enabling farmers to have a sustainable and stable income. Agroforestry practices also extends fodder, fuel wood and timber supply which are important sources of income to farmers. In China , precisely in Dafan village, Wangaiao commune, for example, there were 2670 people and about 167 ha of cultivated land in the same period (1960s–1980s); and a total of 32,500 paulownia trees were planted on farms producing 15,000 m^3 of total standing timber (Wu, 1992). Of this, 5400 m^3 of logs had been harvested by the late 1980s with a total value of 2.7 million Yuan (RMB).

Moreover, there is no agroforestry success story if incomes decrease considerably, even if it is only for a temporary initial phase. In most situations, farmers may not be willing to wait out a lengthy investment phase before realizing revenues. Strategies need to be put in place for the benefits of those farmers who decide to adopt agroforestry practices. Strategies to fill the initial gap are often necessary to the adoption of agroforestry systems. For example, in Rio Grande do Sul, Brazil, smallholders planting bananas in association with palm trees sell the fruit for a higher value through better marketing channels, thus offsetting the lower yields that result from not using chemical inputs. Also, short term income can be maintained by introducing low tree densities while intensifying agricultural practices and later, the tree products and services will increase income with the aim of raising the overall productivity. Furthermore an agroforestry system that aim to create benefits to farmers is the one where a temporal sequence of different crops ensures that some annual commodities are harvested at all stages of tree development (for example, light demanding crops while trees are still small, and more shade-tolerant crops at a later stage).

However, In order to promote the development in Cameroon and associated economic spin-offs, new technology and up-to-date information needs to be continuously brought to bear upon local situations. We also need to create awareness on the importance and advantages of agroforestry to the Cameroon population thereby

encouraging farmers through the supply of seedlings, although this may create a culture of dependency.

Agroforestry and its impact on ecological services

Almost 12 million hectares of land in Cameroon are degraded, two-thirds of which are in the northern regions impacting mostly on the poorest segment of the population epitomized by food crises, economic decline and ecological consequences. The situation is largely blamed on human activities, notably agriculture and livestock development. The Far North, North, Adamawa, North West and West Regions stand out as the most affected. In effect, the phenomenon has attained disturbing levels over the years, triggering a vicious circle of environmental degradation, leading to impoverishment, food insecurity and mass migration in the very dry areas of the North and the Far North Regions.

Also, through the National Action Plan for the Fight against Desertification, studies have established the causes and impacts of desertification as well as the responses and strategies put in place. In spite of all the responses and strategies put in place, all that has been achieved remains mitigating. Action against desertification are expected to go the extra mile as the country continues to bleed under the weight of land degradation. Of recent, as indicated by a specialized study; some parts of Cameroon witnessed the worst effects of desertification and land degradation. The Bamboutos Division, witnessed high level of water shortages; in Bui Division, almost all the run offs and water sources dried off. The story was same for Donga Mantung whose water tables dropped by almost 50 per cent in the past 25 years. In the Northern part of the Cameroon, wild fires have increased, the cutting of wood for fuel doubled and conflict between locals and migrant pastoralists from neighbouring countries ensued among others. These examples and much more are clear indications of the effects of desertification and land degradation which are calling for action to be stepped up. Afforestation programmes for provision of fuels and construction wood as an immediate solution to the energy crisis are therefore desperately needed.

Moreover, the government needs to devote a significant amount of attention and resources to afforestation programmes in Cameroon and additional environmental agroforestry projects have to be implemented. For example, in China, at least five key agroforestry-based ecological protection projects were established during the 1980s and early 1990s. These are: (i) the 'Three-North' afforestation or the Great Green Wall project; (ii) the establishment of protection forest systems in the mid-upper reach of the Yangtze river; (iii) afforestation for coastal land protection; (iv) plains greenization; and (v) control of sandstorms in northern China. These five ecological projects are among the eight largest afforestation projects in the world, based on scale and investment (Zhang *et al.,* 1993); four of these nationally supported projects are partly or entirely located in the temperate region. In effect, many experts are looking at some combination of bio-energy with carbon capture, commonly known as BECCS as one way to reduce atmospheric carbon levels, a recent study conducted at the University

of Exeter found that **regenerating forests** might be a better option. Forests absorb carbon dioxide from the air, which they turn into leaves, bark, roots and branches, effectively locking the carbon in for the life of each tree. But mankind has been destroying forests for centuries to make room for agriculture and for cities and towns and, in the process, removing this natural mechanism for maintaining the carbon balance between the Earth, its atmosphere and its oceans. One way to push back against this is to **restore** forests. That is exactly what agroforestry projects intends to do. Rodrigo Medeiros, vice president of CI's Brazil office, said, "Protecting the Amazon is not something we should think in the future - we have to do it now."

Furthermore, in order to protect the environment, agroforestry projects that will make use of an innovative planting strategy which requires a diverse mix of a high number of tree species dispersed over every square acre of degraded land needs to be implemented by practitioners. This will both provide **bio-diversity** in the reforested area and allow for "survival of the fittest, determining which species will thrive where. Studies performed in 2014 by the Food and Agriculture Organization and Biodiversity International, found that this approach produced forests that were particularly robust, exhibiting the ability "to survive drought conditions for up to six months **without irrigation**." The diversity has an **added bonus**; a recent study coming out of China found that a forest with a mix of species could store as much as twice the amount of carbon as a monoculture forest.

To conclude, I suggest that two distinct afforestation programmes need to be implemented in different regions of Cameroon. One afforestation programme should be implemented in the Far north, North and Adamawa regions that will seek to protect the existing forest and grassland vegetation. It could be achieved by means of plantings, air seeding, 'closing' of hillsides and deserts to allow trees and grasses to re-establish, through the establishment of shelterbelts for farmland and pastureland so as to promote sand dune stabilization and soil and water conservation, and to minimize the shortage of fuelwood and timber (Ministry of Forestry PRC, 1986b). Short- and long-term combinations of multi- purpose, multi-story and diverse species could be used and the project could be divided into different phases just as the three north afforestation programme in china but with distinct agroforestry systems and practices due to the change in the soil type and tree species. Also on my point of view, a different afforestation programme in the North-West and West regions need to be implemented. In this programme, farmland shelterbelts and intercropping should be encouraged with the combination of the planting of trees on the farm, and along roadside, irrigation channels and village plantations. Agroforestry has been well developed and favoured in most of the regions because of its diversity, sustainability, productivity and protective qualities. In addition, poplar afforestation and planting of species with high economic value should be established where ecologically-sound technology is applied so as to favour the shelterbelt grids on farms and the diversification of tree species. These shelterbelts play a very important role in improving farmland microclimatic conditions avoiding natural calamities, safeguarding high and stable yields of agricultural crops, and increasing farmer income. In China, for example, it has been observed that 3 to 25 times tree height away from the tree row, wind velocity can be reduced by 28–32%, relative air

humidity can be increased by 5.8–12.1%, evaporation can be decreased by 15–20%, and soil moisture content can be increased by 15–25%. Shelterbelt plantations also promoted the downward movement of soil salt to below 30 cm from the soil surface in saline–alkaline soil regions with semi-arid climates (Dai *et al*., 2000). Correspondingly, yield increases averaged 16% for maize, 36% for soybean, 43% for sorghum and 44% for millet (Ministry of Forestry PRC, 1986b; Zhang *et al.,* 1993). The overall success of this project can be found in the establishment of preferential policies, the active participation of local farmers, the voluntary tree planting campaigns, and the guidance of science and technology (Zhang *et al.,* 1993).

CONCLUSION

The lessons from these studies complement others in agroforestry and conservation, notably agroforestry conflicts amongst farmers, foresters and livestock from Jose elvire (2015) and Trees, people and parks from Diane Russell (2010). This article mainly focuses on the methods on how to promote agroforestry development and on the main role of agroforestry in the socio-economic, environmental and political aspects in Cameroon. Overall, to promote agroforestry development preferential policies need to be put in place to encourage farmers participation in agroforestry development, to eliminate legal and institutional constraints on agroforestry , to support positive outcomes of agroforestry such as public ecosystem services , to compensate farmers for the delays in returns thereby providing a sound and integrated arrangement of regulations, economic incentives and information to be designed and applied by all stakeholders. In addition, one of the major driver of agroforestry, is the lack of access to mineral fertilizers, because of the high price and lack of subsidy. This is the situation in many African countries including Cameroon. In other places, a lack of well-defined land boundaries may also be an incentive for farmers to plant trees as live fencing – also a form of agroforestry – to create private areas and reduce conflicts. To conclude, if the opportunity to further my studies in agroforestry, I will be one of the leading actors and promoters of agroforestry systems in Cameroon and also play a significant role in creating awareness of agroforestry practices that produce a relatively higher-value product, such as fruits. With new agroforestry systems, such as improved tree fallows and fodder shrubs, where the demand level is high.

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