Estimating the Economic Value of Forest, Banana Plantations and Beans Cultivation in Southern Rwanda

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Abstract

People need to learn the difference between prices and values of forest plantation and cropping systems. The present study was conducted in Southern Province, Huye district in 2013, and estimated the economic values of forest plantation, banana plantation and bean cropping. Elaborated questionnaire was used where the targeted respondents were farmers, whom were interviewed to value farming activities from the beginning to the harvest and marketing. To evaluate the cost benefits of forest plantation, three cooperatives were interviewed which invest in forest plantation.

The results indicated that forest and banana plantations are more beneficial than bean cropping. The net benefits for a period of 10 years were 22 million Rwf for forest plantation, 19.7 million for banana plantation and a loss of 471,800 Rwf for bean cropping. In addition to net benefits of forest plantation, non-marketed ecological functions of forest ecosystems have to be considered, such as climate regulation and carbon sequestration, soil stabilization and erosion control, recreation and tourism, biological diversity conservation, and watershed services. From these economic benefits and ecological functions played by forest ecosystems, we encourage afforestation activities because they are highly profitable.

Keywords*: Forest, Harvest, Cost, benefit, Ecosystem, Agriculture.*

1. Introduction

The services of ecological systems and the natural capital stocks that produce them are critical to the functioning of the Earth's life-support system. They contribute to human welfare; both directly and indirectly, and therefore represent part of the total economic value of the planet (Costanza et al., 1997). Forests and woodlands are extremely important ecosystems (Gonzalez et al., 2010). So, forest ecosystem goods and services, and the natural capital stocks that produce them, make significant direct and indirect contributions to national economies and human welfare (Wu et al., 2007). However, it is almost impossible to value the importance of natural forest ecosystems to human well-beings and their belongings (livestock). Forests provide humans with raw materials for food, shelter and fuel (Douglas, 2001; Porras et al., 2001). There is a strong interaction between forest components and decomposers to purify air and water, regulate climate and recycle nutrients and wastes (Douglas, 2001). Forests are thought to house, directly or indirectly, all forms of life (Pearce, 2001). Confidently, from these evidences it can be suggested that without these goods and services delivered by forest ecosystems life would not be possible (Pearce, 2001). Proudly, forests worldwide are known to be critically important habitats in terms of the biological diversity they contain and in terms of the ecological functions they serve (the Secretariat of the Convention on Biological Diversity, 2001). However, these goods and services are not economically valued (Pearce, 2001), because forests are considered as common resources, not property right and this may lead to the tragedy of common (Notes of Environment Impact Assessment, 2013).

The world forest ecosystems are estimated to cover 3, 952 million hectares with Europe owning a big proportion (25.3%) and the lowest is held by Oceania (5.2%) (FAO, 2006; Nsabimana, 2009). In 1850, tropics covered the majority of the forests with 2675 hectares (Malhi et al., 1999; Nsabimana, 2009). This area declined to 1756 in 1990 (FAO, 2001; Nsabimana, 2009). In Rwanda, the data on forests is summarized into three parameters (geographical distribution, plant species composition and the historical land use changes) (FAO, 1993, 2000; Nsabimana, 2009). In Rwanda, the forests are either natural or anthropogenic. Rwandan forests covered 30% of the total area in 1930 and this was estimated to be 10.1% (MINITERE and CGIS-NUR, 2007; Nsabimana, 2009). Seriously, the surface covered by forest reduced but, fortunately, the governmental politics favors the forest plantations. The deforestation was accelerated by an increasing demand of agricultural land, pastoral farms, urbanization, and firewood (MINITERE, 2003; Nsabimana, 2009).

The global forest assessment conducted by FAO in 2010 revealed that the rate of deforestation is worryingly higher.

Greater economic, social, cultural and environmental value of forests means that the increasing rates of deforestations in Africa and all over the world must attract our attention as conservations (FAO, 2001). The deforestation in years 1990 to 2000 was estimated to be greater than 50 million hectares, nearly 0.8% per year (FAO, 2001). This forest decline is more remarkable in developing countries (FAO, 2001). These Third World nations are characterized by higher population growth. This means that, with poverty, these countries satisfy their human needs by clearing forests for agricultural lands, as these countries rely almost only on agriculture and their agricultural technology is poor (FAO, 2001). This implies that these people will need a big area because their crop production is small (Douglas, 2001).

Deforestation will increase and both biotic and abiotic factors will be negatively affected. The value of the forest is recognized all over the world. Therefore, when nations convened and signed the United Nations Framework Convention on Climate Change (UNFCCC) and Kyoto protocol, reforestation was the main element of their agenda (Bonan, 2008; Nsabimana, 2009). The main aim of these convention and protocol was to encourage reforestation, forest preservation, to stabilize, or to reduce if possible, atmospheric greenhouse gas concentrations and mitigate the climate change (Luyssaert et al., 2007; Bonan, 2008; Nsabimana, 2009). Further, because of industrial revolution, the CO_2 gas concentration knows enormous rising. By photosynthesis, plants are able to absorb at least 120Pg C per year (Nsabimana, 2009). The countries with a surplus of forests, therefore producing a high quantity of O_2 will receive some revenues from those countries with less forest. This is what is commonly known as carbon credit. A carbon credit is simply defined as a certificate showing that a government or a company has paid to have a certain amount of CO_2 removed from the environment (The Collins English Dictionary, 1979). According to Kyoto Protocol, emission allowances are called caps, quotas or generally assigned amount units (AAUs) and they are expressed in terms of metric ton of CO_2 or any other CO_2 equivalent greenhouse gas (CO_2e) (www.Wikipedia.Com, 2013).

The burning of fossil fuels is the main source of GHG emissions for industries relying on fossil fuels. The major GHGs emitted by these industries are carbon dioxide, methane, nitrous oxide, and hydrofluorocarbons. The main goal of carbon credit is to allow market mechanisms to drive industrial and commercial processes in the direction of low emissions or less carbon intensive approaches than those used when there is no coast to emitting greenhouse gases into the environment (www. Wikipedia. Com, 2013). This is to mitigate the growth in concentrations of GHGs. Operators that have not used up to their AAUs can sell unused allowances as carbon credit, whereas companies or governments that are about to exceed their quotas can buy the extra allowances as credits (Pearce, 2001). This carbon market will encourage less industrialized countries in gaining money from industrialized countries. Finally, ending this introduction we wish to make a short list of above and other functions provided by forests. Apart from carbon credit, there are other many roles played by natural and anthropogenic forests such as soil stabilization and erosion control. Forest vegetation helps stabilize soils and reduce erosion and sedimentation (Douglas, 2001). The associated values with soil stabilization primarily reflect the costs associated with sedimentation (Douglas, 2001). For instance, values range from 1.94 USD per ton in Tennessee to 5.5 USM million annually in Oregon Willamette Valley (Douglas, 2001).

Most importantly, forests are house for a biological diversity. This is important for many reasons, a storehouse of genetic material that can be used to selectively breed plants and animals, its contribution to natural pest and disease control and its ability to provide valuable pharmaceutical products (Douglas, 2001). It would cost more than 7 USD per acre to replace the pest control services of birds in forests with chemical pesticides (Douglas, 2001).

Further, forests radically play, due to their beauty, a recreation and tourism roles. Scenic beauty and recreational amenities associated with forests make them popular recreation destinations. Economically, recreational activities on national forests alone contribute 110 USD billion annually to this nation's GDP (Douglas, 2001). Herein we shall remind that a good or a service has a value if it increases human well-being and this implies that goods and values have no value in their own right (Douglas, 2001) and because ecosystem services are not fully 'captured' in commercial markets or fully quantified in terms comparable with economic services and manufactured capital, they are often given too little weight in policy decisions (Costanza et al., 1997).

Furthermore, forests play function in watershed services. Forested watersheds capture and store water, thus contributing to the quantity of water available and the seasonal flow of water (Douglas, 2001). Therefore, forests also help purify water by stabilizing soils and filtering contaminants (Douglas, 2001). The quantity and quality of water flowing from forested watersheds are important to agriculture, hydropower, municipal water supplies, recreation and habitat for fish and other wildlife species (Douglas, 2001). Estimates of water quantity values focus mainly on stream flow and range 0.26 per acre-foot for electricity generation to as much as 50 USD per acre-foot irrigation and municipal use (Douglas, 2001). Therefore this paper estimates the economic value of forest plantation, banana plantation and bean cropping, using case studies from Southern Rwanda.

2. Material and Methods

2.1 Data collection

The present study was conducted in Southern Province, Huye District. An elaborated questionnaire was used. The address of the respondent was mentioned. The residence place and the coordinate, like the telephone number, were asked. To know if the respondent has some knowledge about forest and agriculture values, the work or daily activity was noted. All people interviewed were farmers (private farmers, cooperatives) and their education levels were mentioned. Education levels were mentioned to be confident of the responses provided by the respondents. The questionnaires were distributed to the farmers in Southern Province, Huye district. Other people were met at their working places, living places and/or on the way.

The farmer was asked whether she/he is the owner of the cultivated land and or if the farm is rent. If the farm is rent, the amount of money to rent was requested. The type of the crop was mentioned. The area of the farm was asked to compare the benefits and the cost. The farmer was asked the number of harvests per year. The materials, machines, machetes, hoes, and others used for cultivating were asked. We asked an amount of money spent to prepare one land hectare. The quantity of seed in kilograms to plant one hectare and the cost of one kg were asked. We asked quantity and the type (chemical fertilizer, compost/manure) of fertilizer used per hectare and the cost of one kg of fertilizer. We asked the cost of one kg of those two types of fertilizers. We also asked the expenses for the works on the field, like to weed out or to water. The respondents were asked if they use pesticides and the names of pesticides. The farmers were required the cost of pesticides used in controlling pests. We further asked the farmer about the cost of harvesting and post harvesting activities on one hectare. We also asked the quantity of harvest on a hectare. If it was a plantation of bananas, we asked the numbers banana fruits harvest per hectare and the weight of one banana. The farmers were requested to tell the harvest when they apply both manure and chemical fertilizers at once. Farmers were also asked their production when they use only manure and the production when they do not use fertilizer. The cost of one kg was also asked for each type of harvest. The farmers were finally asked the effects of both rain and drought on their crop yields.

The questions related to forest plantation activities and costs were addressed to three cooperatives namely ABAKUNDAGITI, and two groups all called TURENGERE IBIDUKIKIJE, which invest in forest plantations. An amount of money spent to prepare one land hectare for forest plantation was asked. Information on the cost of one seedling and how many are used per hectare was requested to the respondent. The respondent also informed on the cost of management and harvesting activities on one hectare. The quantity of charcoal, firewood, or timber harvested on one hectare was asked to the respondent, and asked an amount of money spent to prepare charcoal per hectare.

2.2 Data analysis

All collected data on the questionnaires was computed in a database and we performed calculations: Cost of land preparation (CLPH), Pesticide cost per hectare (PEC), Seeds cost per hectare (SC), Planting cost per hectare (PC), Crop management cost (CMC), Crop protection cost per ha (CPC), Harvesting and post-harvest cost (HPC), Fertilizer cost (FC). Formula were also computed to calculate Total harvest cost (THC), Total Harvest Cost with Organic fertilizer (THCOF), Total Harvest cost with both fertilizers (THCBF), called Total Harvest Cost With Heavy rain (THCWHR), Total Harvest Cost with Drought (THCWD), Total input cost (TIC), Total yield cost=Gross Income (TYC). We also used formula calculating Net benefit = Net Income (NB), Net benefit with organic fertilizer (NBOF), Net benefit without fertilizer (NBWF), Net benefit with both fertilizers (NBBF), Net benefit with heavy rainy period (NBHR), and Net benefit with drought period (NBD).

3. Results

Forest and banana plantations are more profitable that bean cropping (Tables 1 and 2). The net benefit was 1.97 million Rwf for banana plantation and a loss of 47,180 Rwf for bean plantation per year. Heavy rain and drought periods affect negatively the net benefits for bean (Table 1). Heavy rain increases the net benefit of banana plantation while drought periods reduce the net benefits of banana production (Table 1). Cropping without fertilizer reduces the considerably the net benefit of banana production while it increase three time the loss due bean cropping (Table 1). We considered that bean is cultivated and harvested 2 times per year, and thus two multiplied all parameters. Negative values indicate a net loss. When these costs are to be compared to forest plantation, the cost and benefits of were estimated for 10 years because a forest is mature and ready to be harvested after 10 years. For a period of 10 years net benefit was 22.02 million Rwf for forest plantation, 19.7 million Rwf for banana plantation, while bean crop resulted in a loss of 471,800 Rwf (Table 2). Costs were estimated in 10 years because a forest is harvested after 10 years. Cost for banana and bean are estimated from those in Table 1. Negative values indicate a net loss. Heavy rain and drought seasons do not affect the net benefits for forest plantation, while fertilizer is not applied in forestry (Table 2).

4. Discussion

Results indicated that forest and banana plantations are more profitable than bean cropping (Tables 1 and 2). Net benefits are also influenced by climatic conditions and fertilizer application (Table 2). Forest plantation is the most beneficial because it demands less work and do not need more care like beans and bananas. For instance, forest plantation is not fertilized and after planting it does not require further follow up or management, whereas bean and banana will need regular management practices.

The estimated values of beans and bananas are showed without looking at other negative impacts their cultivation will have on the environment, like negative effects of fertilizers on biotic and abiotic factors. Another parameter should be the effect of land clearing (land preparation) that precedes the act of digging the soil. Biodiversity is also negatively affected when lands are disturbed during cultivation activities. These activities will also have a negative impact on hydrology and climate.

The benefits generated by forest plantations ignore goods and services provided by the forests. Forest plantation also plays a great role in climate change mitigation, accumulating greenhouse gases, mainly the atmospheric carbon dioxide, while cropping systems contribute to greenhouse gas emission (Douglas, 2001; Nasi, 2002). Forests provide raw materials for food, fuel and shelter (Douglas, 2001). Further, in forest ecosystem components such as microorganisms, soils and vegetative cover interact to purify air and water and recycle nutrients and wastes (Douglas, 2001). Clearly, without these and other many ecosystem goods and services, life would not be possible (Douglas, 2001).

A serious problem we are facing as conservationists people do not understand economical values of forests. This is because some ecological functions are unmarketed, that is, there is an illusion that their price is zero (Pearce, 2001). Because ecosystem services are not fully 'captured' in commercial markets or fully quantified in terms comparable with economic services and manufactured capital, they are often given too little weight in policy decisions (Costanza et al., 1997). This may be the reason why conservation (afforestation) competes with conversion (deforestation), and deforestation wins (Pearce, 2001). Undoubtedly, this is because the values of conversion are marketed, while conservation values appear to be low or zero (Pearce, 2001). This is one of the leading forces of deforestation due to population increases and the consequent demand for land for food production and economic incentives (Pearce, 2001).

People will need to overcome the weakness of confusing prices and values and remember, however that economically, the goods and services provided by forests are annually estimated at 33 trillion USD annually (Costanza et al., 1997). Climate regulation and food production have been estimated to account for approximately 75% of that sum (Douglas, 2001). Further, through climate regulation and carbon sequestration, trees trap moisture and cool the Earth's surface (Douglas, 2001) and this has an important economic value (Costanza, 1997). Additionally, trees capture atmospheric CO_2, thereby reducing global warming. The US forest service estimates that such carbon sequestration services yield benefits of 65 USD per ton, which totals to 3. 4 USD billion annually for all US forests (Costanza et al., 1997).

Further, because of industrial revolution, the CO_2 gas concentration knows enormous rising. By photosynthesis, plants are able to absorb at least 120 Pg C per year (Nsabimana, 2009). The countries with a surplus of forests, therefore producing a high quantity of O_2 will receive some revenues from those countries with less forest. This is what is commonly known as carbon credit. A carbon credit is simply defined as a certificate showing that a government or a company has paid to have a certain amount of CO_2 removed from the environment (The Collins English Dictionary, 1979). According to Kyoto Protocol, emission allowances are called caps, quotas or generally assigned amount units (AAUs) and they are expressed in terms of metric ton of CO_2 or any other CO_2 equivalent greenhouse gas (CO_2e) (www. Wikipedia. Com, 2013).

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Furthermore, this discussion cannot leave besides the function of forests in water shed services. Forested watersheds capture and store water, thus contributing to the quantity of water available and the seasonal flow of water (Douglas, 2001). Therefore, forests also help purify water by stabilizing soils and filtering contaminants (Douglas, 2001). The quantity and quality of water flowing from forested watersheds are important to agriculture, hydropower, municipal water supplies, recreation and habitat for fish and other wildlife species (Douglas, 2001). Estimates of water quantity values focus mainly on streamflow and range 0.26 per acre-foot for electricity generation to as much as 50 USD per acre-foot irrigation and municipal use (Douglas, 2001). The economies of the Earth would grind to a halt without the services of ecological life-support systems, so in one sense their total value to the economy is infinite (Costanza et al., 1997). However, it can be instructive to estimate the 'incremental' or 'marginal' value of ecosystem services (the estimated rate of change of value compared with changes in ecosystem services from their current levels). Some of above goods and services are rejected by some people because of different reasons. This neglect may ultimately compromise the sustainability of humans in the biosphere (Costanza et al., 1997).

Table 1. Average costs and benefits of banana plantation and bean cropping (Rwf. $ha^{-1}.yr^{-1}$).

Parameters		**Banana**	**Beans**
CLPH	Cost of land preparation per hectare	52, 500	80,000
SC	Seeds cost per hectare	1, 160, 000	34,567
PC	Planting cost per hectare	27,500	45,333
FC	Fertilizer cost	18,250	29,200
CMC	Crop management cost	16,250	51,333
HPC	Harvest and post harvest cost	6,250	77,200
THC	Total harvest cost	3,250,800	270,453
THCOF	Total harvest cost with organic fertilizer	3,250, 800	270,453
THCWF	Total harvest cost without fertilizer	1,625,400	163,333
THCWHR	Total harvest cost with heavy rain	3,900,960	141,387
THCWD	Total harvest cost with drought	2,438,100	80,067
TIC	Total input cost	1,280,750	317,633.3
TYC	Total yield cost = Gross income	3,250,800	270,453
NB	Net benefit = Net income	1,970,050	-47,180
NBHR	Net benefit with heavy rain period	2,620,210	-176,246.7
NBD	Net benefit with drought period	1,157,350	-237,566.6
NBWF	Net benefit without fertilizer	344,650	-154,300
CPCO	Crop production cost	67	332.1

Table 2. Costs and benefits of banana and bean cropping and forest plantation (Rwf. $ha^{-1}.10yrs^{-1}$).

Parameters		**Banana**	**Beans**	**Forest**
CLPH	Cost of land preparation per hectare	52 5000	800,000	600,000
SC	Seeds cost per hectare	11,60 0,000	345,670	55,550
PC	Planting cost per hectare	275,000	453,330	38,885
FC	Fertilizer cost	182,500	292,000	0
CMC	Crop management cost	162,500	513,330	4,247,740
HPC	Harvest and post harvest cost	62,500	772,000	12,130,000
THC	Total harvest cost	32,508,000	270,453	39,095,000
THCOF	Total harvest cost with organic fertilizer	32,50 8,000	2,704,530	Not applicable
THCWF	Total harvest cost without fertilizer	16,254,000	1,633,330	39,095,000
THCWHR	Total harvest cost with heavy rain	39,009,600	1,413,870	39,095,000
THCWD	Total harvest cost with drought	24,381,000	800,670	39,095,000
TIC	Total input cost	12,807,500	3,176,333	17,073,175
TYC	Total yield cost = Gross Income	32,508,000	2,704,530	39,095,000
NB	Net benefit = Net Income	19,700,500	-471,800	22,021,825
NBHR	Net benefit with heavy rain period	26,202,100	-1,762,467	22,021,825
NBD	Net benefit with drought period	11,573,500	-2,375,666	22,021,825
NBWF	Net benefit without fertilizer	3,446,500	-1,543,000	22,021,825

5. Conclusion

The findings from this study suggest that people gain more money when they rely on *Eucalyptus* and banana plantations than cultivating beans. The difference is found when we compare the costs and benefits of all activities involved in each crop or plantation. Net benefit after 10 years was estimated to 22.02 million Rwf/ha for forest plantation, 19.7 million Rwf/ha for banana plantation and a loss of 471,800 Rwf/ha while cultivating bean. This study has investigated net benefits in different conditions mainly the use or nonuse of manure and chemical fertilizers and climatic conditions (heavy rain and drought). This study recommends reforestation because it is both ecologically and economically the most important.

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