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Shifts in farming systems on land-use land-cover and biosphere reserve management in Southwestern Ethiopia

Mezgebu Senbeto Duguma *

Bako Agricultural Research Center, Oromia Agricultural Research Inistitute, Oromia, Ethiopia.

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Abstract

Sustainable agricultural development and land-use systems require the elaboration and design of proper development options, and also land use changes for agro-ecosystems. This project aimed to assess shifts and development options of major farming systems, and if and how the biosphere reserve establishment and its management have changed the natural and agricultural landscape components, and/or the forest coverage of the Yayo Coffee Forest Biosphere Reserve. Focus group discussions, satellite image analysis, secondary information and personal observations were used to collect data in the four (4) kebeles (PAs) in the biosphere reserve. The result revealed that forest areas showed trends of increment as 5650.11ha, 6562.08ha and 6949.62ha in 1986, 2006 and 2016 respectively, and other green vegetation somewhat increased from 1778.76ha in 1986 to 1944.54ha in 2016. Farmlands and others decreased from 2314.35ha in 1986 to 849.24ha in 2016. Areas of natural forest decreased from 80,000 to 69,100 hectares between 2007 and 2016, while areas of plantation coffee increased from 14,720 to 34,100 hectares in the same periods. The development options such as woodlots, live fences and coffee plantations have been used to compensate services of natural forest and to address local communities' needs. Therefore, this study concludes that the shifts and modifications in the natural landscape and ecosystem functioning to intensify certain provisioning services, for example implementation of woodlots and plantation coffee have resulted declining in agro-biodiversity and ecosystem services. Therefore, this study recommends sustainable development options and diversified farming systems need be considered in the land use changes.

Keywords: Biodiversity; Biosphere Reserve; Development Options; Forest Management; Land Use Changes

1. Introduction

Agricultural production is the main function of an agricultural system and since the economic viability can only be ensured if ecological processes are maintained, sustainable agricultural development requires the elaboration and design of proper development options for agro-ecosystems [1]. In Ethiopia, agriculture is complex, involving substantial variations in farming systems' components such as crops, trees/shrubs and livestock across the country's different regions and ecozones. However, there is an ongoing debate between scientists and policy makers about the different approaches and strategies to improve food security in the world including Ethiopia. According to Abebe and Bongers and Seyoum with his colleagues, raising production levels and focusing on fewer crops are essential aspects to ensure adequate food availability and to increase household incomes [2, 3]. However, [4, 5, 6] argued that sustainable development can only be achieved through livelihood insurances of Ethiopian farmers based on agricultural diversification and their related ecosystem services. There are dynamic trends of ecosystem services and multiple agro-biodiversity practices throughout the various ecological zones and agricultural landscapes [7].

Biosphere reserves attempt to reconcile environmental protection with sustainable development. However, according to [8], the reality of implementing dual 'conservation' and 'development' goals of the biosphere reserve model by

* Corresponding author: Mezgebu Senbeto Duguma

UNESCO's man and the biosphere (MAB) programme is challenging. Fragmentation of natural and cultural landscapes by anthropogenic actions in most tropical rain forests are likely to cause significant changes in agro biodiversity and ecosystem functioning [9]. We know very little about specific impacts on the ecosystem functioning by different human actions in tropical rain forests, but we do know that ecosystems are affected by changes in species numbers and composition in regard to different cropping systems [10]. Much of the increase in crop production in the past decade has been facilitated by the expansion of agricultural land into forested areas and an increased use of inter-cropping or double-cropping [3]. The expansion of cultivated area is likely to require further infrastructure development and result further negative environmental implications as a result of additional deforestation. Consequently, obtaining higher yield margins in a sustainable way is the major challenge for Ethiopia's agricultural systems. Moreover, concerning natural resources conservation, the ecosystem values of those different farming systems are not well accounted for decisions. Although science can contribute to effective decision making by clearly classifying ecosystem services and describing their links to ecosystem processes, final decisions concerning biodiversity and other natural resources are inevitably socio-political, and embedded within a particular cultural context [11].

Agricultural approaches, which incorporate shrubs, trees, livestock and crops may have advantages in ecosystem services provisioning, crop diversification and food security [12], thereby conserving biological diversity [13]. In most developing countries like Ethiopia, a significant proportion of the diverse food naturally available, especially fruits and vegetables, has been neglected [14]. The reason for that is mainly due to promoted technological options focus on only few staple foods to address local food security and hunger. Specifically, in Yayo biosphere reserve, where the community is living within the biosphere, the action of agricultural land expansion has been seen as a common activity regardless of their impacts on the biosphere reserve. Additionally, the documentation of its nomination [15, 16], indicated that, most parts of the forest and its agro-ecosystems has not been adequately studied and important information is expected to be revealed with further research. Despite this, there is a limitation of work done regarding the trends of land use land cover changes of the farming systems and contributions of those farming systems for sustainable conservation of the biosphere reserve which needs further evidence through research [17].

2. Materials and methods

2.1. Description of the Study Area

The research was conducted in the Yayo Coffee Forest Biosphere Reserve areas (specifically in Wabo and Bondawo Magala kebeles of Yayo district and Wangegne and Gaba kebeles of Hurumu district) which is situated in Ilu Abba Bora Zone of the Oromia National Regional State, Southwestern Ethiopia (Fig. 1). The Kebeles were purposely selected due to their proximity to the biosphere reserve and consisting of more forest areas of the biosphere reserve. The study area is located between 8°21' - 8°26' N and 35°45' - 36°03'E. The forest area is characterized by a rolling topography, and is separated by small streams and two major rivers, Geba and Dogi. The altitudes of the study area range between 1200 m at lower river valleys to 2000 m a.s.l. The mean annual temperature is about 20°C. The mean annual rainfall is 2100 mm year^{-1}, with high variation from year to year, ranging from about 1400–3000 mm year^{-1}. The rainfall pattern is uni-modal, with a dry season between November and February and then gradually increasing to the rainy season between May and October. There are five major land-use types in the study area: forest (55.5%), agriculture (35.5%), grazing land (4.3%), wetland (2.2%), and settlement and others (2.5%) [18].

The biosphere reserve is part of the center of origin for the most popular coffee in the world: Coffee arabica [19]. Yayo is also the largest and most important forest for the conservation of the wild populations in the World. The area plays a key role in the conservation of natural and cultural landscapes, and it has three different management zones, namely: core area, buffer zone, and transition area. The transition zone alone, where agricultural activity is dominated has 70.5% of total area of the biosphere reserve [16].

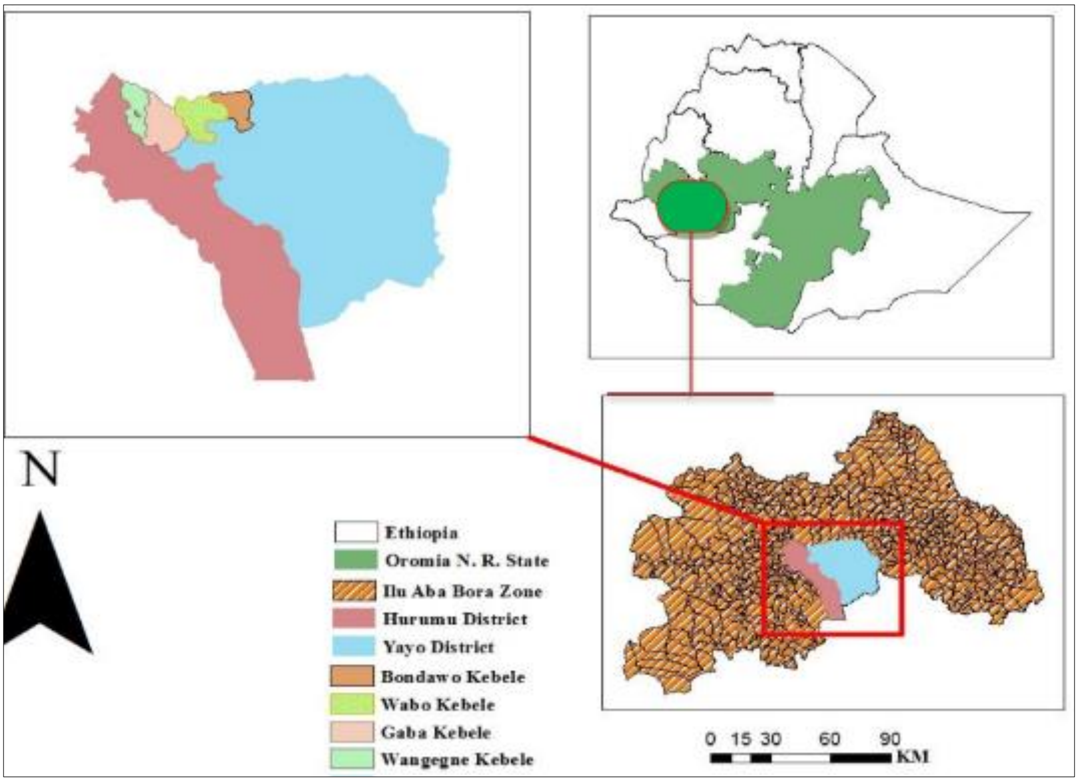


Figure 1 Map and location of study site, July, 2022

2.2. Collection of supporting data

Preliminary data was collected from different concerned authorities/sectors/offices in the area such as agricultural offices of Yayo and Hurumu districts, Oroimia forest and wild life enterprise office of Ilu Aba Bora branch and Environment and coffee forest forum office of Yayo area. Field observations and supporting documents, official reports and other relevant secondary data, published and unpublished, were also considered whenever available and relevant to assess different development options and land-use and land-cover changes as a consequences of shifts in land use systems. Tangible values, opportunities and challenges in the biosphere reserve areas have been assessed through this method.

2.3. Group discussions and key informant interviews

In the four villages (Bondawo Magala, Wabo, Gaba and Wangegne) in the Yayo and Hurumu districts, 8 focus group discussions (FGDs) and a total of 12 key informant interviews were undertaken to collect information about expectations, development options and activities, opportunities and drawbacks of them towards the BR management and potential needs of the local community.

2.4. Acquisition and analysis of satellite images for land use land cover change

Imagery acquired by sensors of Landsat Thematic Mapper, Enhanced Thematic Mapper Plus and Operational Land Imager and Thermal Infrared Sensor satellites between path 170 and row 54 were used. The images were downloaded freely from USGS (United States Geological Survey) data portal (https://earthexplorer.usgs.gov/, https://landsatlook.usgs.gov/viewer.html and glcfapp.glcf.umd.edu/ accessed on May 22/2017). All the images used were of low or no cloud cover and acquired during dry seasons of the years between 1986 and 2016. The selected months of the year were not only suitable for obtaining cloud free images, but also assumed that confusion in spectral signatures of forest and non-forest green vegetation such as agricultural crops and grasslands could be minimized and the contrast between forest and non-forest land uses is maximized during dry seasons.

In the study area, the temporal and areal dynamics of various land cover categories across 1986-2016 have been analyzed. For this purpose, three images of 1986, 2006 and 2016 were done for change detection and finally the overall change (1986-2016) has been assessed. Before using the available satellite images obtained freely from USGS portal, image preprocessing like geometric correction, layer stacking, registration correction were applied to all images using

ENVI version 5.1 software. Atmospheric correction was applied to all images using Quick Atmospheric Correction (QUAC) module in ENVI version 5.1. All satellite images were clipped (sub-set) via regions of interests for covering only the study area. In order to interpret and discriminate the surface features clearly, all satellite images were composed using Red, Green and Blue (RGB) color composition. All images were corrected to Universal Transverse Mercator (UTM) zone 37N, datum WGS-84 and co-registered with less than 0.5 pixel mean square error for all images.

At initial stage of classification procedures, performance of Maximum Likelihood (ML) and Support Vector Machine (SVM) were tested. Confusion matrix were used to assess classification accuracy of User's and Producer's accuracies, overall accuracy and the kappa coefficient were calculated by using ENVI version 5.1 for each of the classified images. Land cover classes were described for more clarity (Tab. 1).

Table 1 Descriptions of Land cover classes

No.	Land cover type	Description
1	Forest	Dense natural forests, Semi-forest coffee, Plantation coffee, Plantation forests.
2	Other green Vegetation	Sparse forests, homegardens, woodlots, chat plots, forest parks of both natural and plantation tree species, forest gardens grow near and around homesteads, roadsides forests, riverbanks, live fences, and patches of coffee and farm land trees.
3	Farmland and others	Agricultural lands for cereal crops (maize, sorghum, millet, teff and etc.), pulses and horticultural crops, fallow lands, settlements, roads, grazing lands, bare lands and lands occupied by other constructions.

Description of the standards applied to classify forest cover types were made by stakeholders, key informants, forestry experts and experts of natural resources. Land cover changes were analyzed applying various change detection techniques (supervised classification, visual comparison of features and confusion matrix analysis) following recommendations by Mausel [20]. The authors suggest that good change detection research should provide information on: 1) area change and change rate 2) spatial distribution of changed types 3) change trajectories of land cover types and 4) accuracy assessment of change detection results as cited by Feyisa [21]. Major contributors of changes especially emphasis to forest cover, were identified. The change analyses were undertaken in the ranges of 1986-1996, 1996-2006 and 2006-2016 years.

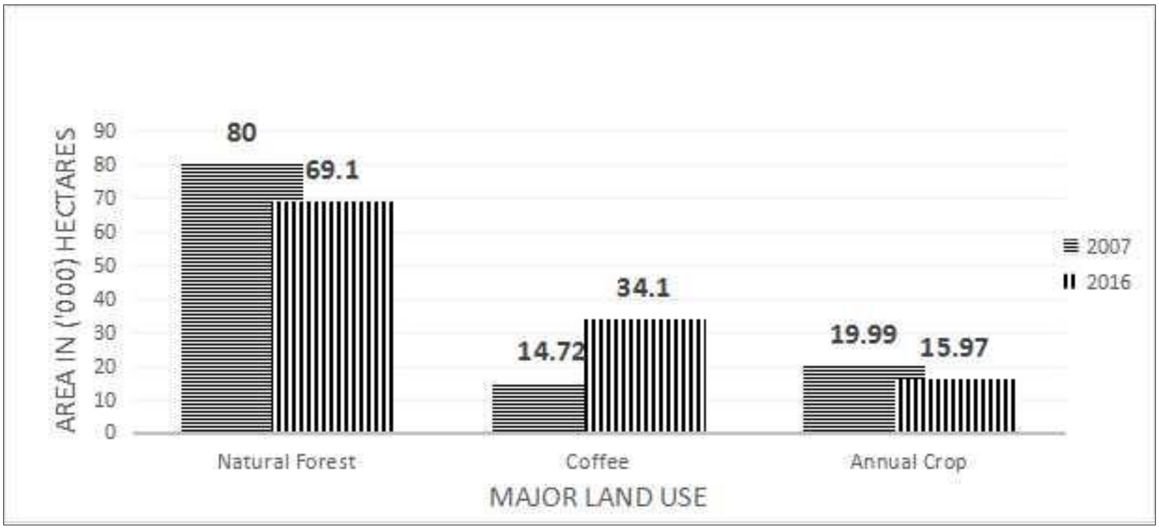
3. Results and discussions

3.1. Land-use Land-cover Changes

3.1.1. Secondary data analysis for Land-use Land-cover Changes (LULC)

Secondary data assessed on land use land cover changes from both districts indicated that natural forest area and annual crop production areas have been decreasing while coffee production area has been increasing rapidly since 2007. This result is in line with Muhamad and his colleagues finding which puts that communities living close to forest resources will have negative impacts on forest biodiversity management [22]. The following graph shows the changes in natural forest, coffee and annual crop areas between 2007 and 2016, according to the reports from 2007 to 2016 of the agricultural offices of Yayo and Hurumu districts (Fig. 2).

From the graph, we can conclude that areas of natural forest decreased from 80,000 to 69,100 hectares between 2007 and 2016, while area of coffee increased from 14,720 to 34,100 hectares in the same periods. Although this study was aimed to see different reports on the trends of LULC from 1987, there is no documented information found before 2007, and this limitation pushed the study to use satellite image classification to show the magnitudes of total forest cover changes.



Data source: Office of Agriculture and Rural Development in Yayo and Hurumu Districts, 2017.

Figure 2 Major land use size changes

3.2. Results of Land cover classification images

The results of satellite image classifications showed that there was increasing trends of forest and other green vegetation while areas of farm lands and others have been decreasing (Fig. 3). Accordingly, size of forest areas showed 5650.11ha, 6562.08ha and 6949.62ha in 1986, 2006 and 2016 respectively, and other green vegetation increased from 1778.76ha in 1986 to 1944.54ha in 2016. However, size of farmlands and others decreased from 2314.35ha in 1986 to 849.24ha in 2016 (Tab. 2). This phenomenon indicated that farm lands have been gradually shifted to forest and other green vegetation land use systems, and the result agrees with Cassano and his colleagues finding which indicated forest areas will increase as far as management is intensified [13].

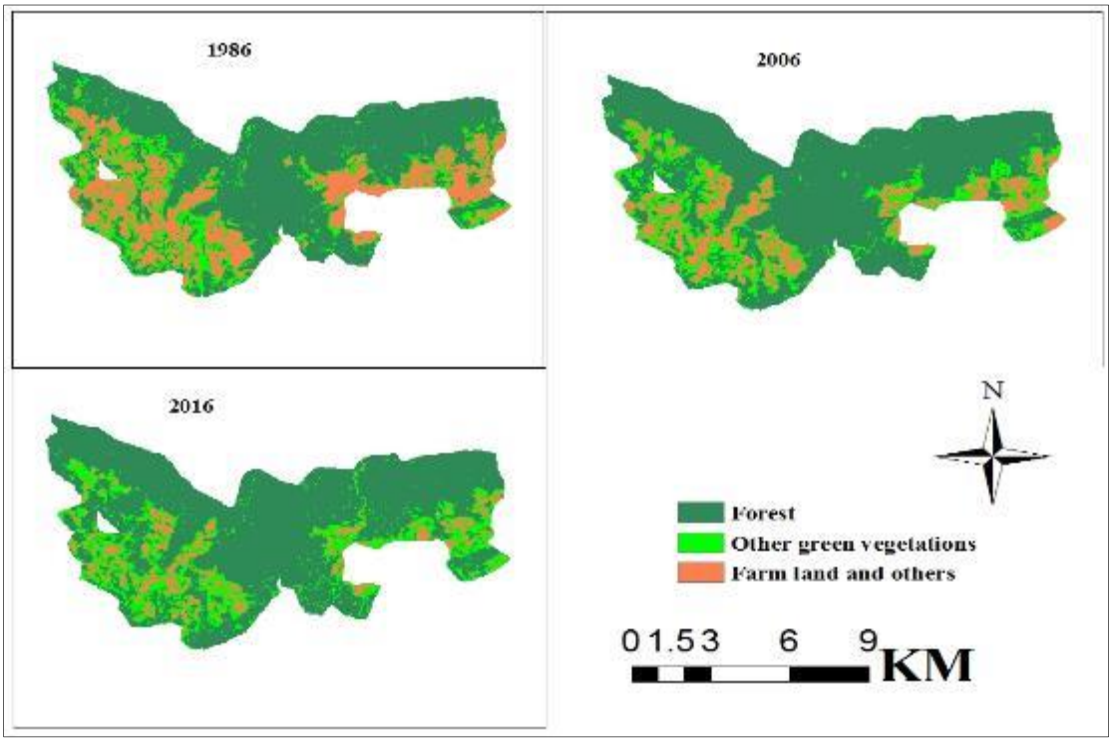


Figure 3 Land cover change classification images of 1986, 2006 and 2016

This finding indicated that over the recent years there has been growing interest to strengthen and intensify local food production and income generation in order to mitigate the adverse effect of local food shocks and food price volatilities

(Tab. 2) which is in line with Duguma and Keenan findings [23, 24]. Furthermore, according to the key informants and focus group discussions much attention towards home and forest gardens dominated by coffee is becoming encouraged farming systems. This result also agrees with Mills, Estrada, and Milner findings [17, 25, 26]. This has been used as a strategy to enhance household food security and nutrition which has been supported by different stakeholders and organizations like Offices of Agriculture and Rural Development at different levels, Environment Coffee Forest Forum, and Oromia Forest and Wildlife Enterprise in the study area. Even though home and forest gardens are an integral part of local food systems and the agricultural landscape of developing countries in general [27], and in Yayo biosphere reserve in particular, the biodiversity and agro-ecosystems are still under threat [28].

Table 2 Size of land cover changes classified by ENVI 5.1

Land cover type	**Areas in hectare by different years**			
	1986	2006	2016	Difference (2016-1986)
Forest	5650.11	6562.08	6949.62	1299.51
Other green vegetation	1778.76	1819.14	1944.54	165.78
Farm lands and other land uses	2314.35	1361.88	849.24	-1465.11

The overall classification accuracy over the periods of 1986, 2006 and 2016 was 94.25%, 98.00% and 97.26% with kappa coefficient of 90.48%, 89.13% and 86.30% respectively (Tab. 3). This result is in agreement with the argues of Fitzgerald and Lees (1994) that, the values of K ranges between 0 (no agreement) and 1 (complete agreement). These values are poor agreement when K < 0.4 (40%), good agreement when K values are between (0.4 or 40% ≤ K ≤ 0.75 or 75%) and excellent agreement when K > 0.75 (75%).

Table 3 Producer's and User's classification accuracy by year (%)

Land cover type/classes	**1986**		**2006**		**2016**	
	Producer Acc. (%)	User Acc. (%)	Producer Acc. (%)	User Acc. (%)	Producer Acc. (%)	User Acc. (%)
Forest	98.26	95.64	99.6	98.77	99.54	97.65
Other green vegetation	59.46	79.04	70.09	84.54	63.13	87.07
Farm lands and other land uses	100	100	95.74	95.07	99.45	98.71
Overall accuracy (%)	94.25		98.00		97.26	
Kappa Coefficient (%)	90.48		89.13		86.30	

3.3. Development options of agricultural landscapes in the Yayo Biosphere Reserve Live-fences, woodlots and coffee plantation (Forest gardens)

The results of key informant interviews and group discussions showed that small-scale woodlot, and expanding coffee plantation are the most profitable and conservative farming practices followed by live-fences and boundary plantings inside and outlier of homesteads and in other agricultural farm lands (Fig 4; Fig. 5), which is in line with Pulido and Renjifo finding [28]. With the majority of ecosystem services declining or and with a challenging future ahead, it is clear that we need to find locally accepted, more resilient ways of managing our ecosystems [13, 24, 29]. To establish sustainable rural landscape management with alternative sources of preferable ecosystem services that fulfills conservation objectives and reduces poverty, preferences and perceptions of the local people regarding particular landscape elements are indispensable. Therefore, local ecological restoration strategies and sustainable management actions according to reported in Bullock [30], for increasing the provision of ecosystem services as well as reversing biodiversity losses are vital.

According to the nomination document of Yayo Biosphere Reserve, Gole [16], the buffer zone size of the biosphere reserve in 2009, which is composed of semi-coffee forest systems managed by individual farmers, is expected to expand outwards into the transition area by doubling its size through planting programs for coffee and indigenous shade trees. However, explaining any consideration about the agro-biodiversity loss and agro-ecosystem services are interrelated and must be considered in any of the development options. By doing so, in line with the findings of Reed and Egunyu [29], the current changes in biodiversity and ecosystem services in terrestrial ecosystems, which are being driven by the synergistic interactions between the loss of native vegetation and land-use intensification can be solved. These can realign the agendas of biodiversity conservation, thereby fostering multi-functionality [31, 32].

Figure 4 Woodlots of *Eucalyptus camaldulensis*, which is only a single species

Figure 5 Live fences of different species which is better for homegardens and forest management

3.4. Multi-purpose cooperatives (MPC) and Non-timber forest product producers

The data from the Environment and Coffee Forest Forum located in Yayo, ECFF (2017), explains that there are 28 different MPC groups who have been doing on different areas of Medicinal plant collections, agroforestry, non-timber forest productions (NTFP) and seedling production of different multi-purpose tree/shrub, coffee and fruits. This is one of the development options in the biosphere reserve, and the result agrees with finding [33]. For the success of these strategies, the ECFF and its partners (such as: Oromia Forest and Wildlife Enterprise (OFWE), Oromia Bureau of Agriculture (OBoA), Oromia Cooperatives Promotion Agency (OCPA), Oromia Livestock Development and Health Agency (OLDHA) and their respective offices at Zonal and woreda/district level, and other International Organizations) are working together, and they have been establishing new Cooperatives while strengthening the former ones (Fig. 6).

Figure 6 Pictures of different MPC practicing various agroforestry practices. Pictures taken by the author during data collection, March, 2017, Bondawo Kebele, Yayo BR

3.5. Advisory board and management units

The result illustrated that, to boost and achieve the development options of the biosphere reserve, there are different locally considered management units. From the terminal report of ECFF (2016), there are total of 6 woredas (districts) and 35 kebeles surrounding the biosphere, and there is a management unit composing 3 members at each Kebele. They operate different meeting and discussions on the development options, progresses, and challenges of the biosphere reserve management in their respective woredas while woreda administration chairs the quarter review meeting. Therefore, this biosphere reserve management unit has 105 members which evaluate strategies of the forest and agricultural landscape management at local level.

3.6. Soil and water conservation structures

As far as this conservation activity is national strategy of Ethiopia, in the study area there is high consideration towards the development of soil and water conservation structures and Vetivar grass strips in farm lands (Fig. 7). This activity could help to control erosion risks, and to get some forage and fuel-woods from crop farms which could also compensate uses of natural forest resources.

Figure 7 Pictures of Soil and Water conservation structures being practiced in Yayo BR taken by author, March 2017

4. Conclusion and recommendations

Land use systems in the Yayo Coffee Forest Biosphere Reserve have substantial social, economic, ecological and environmental importance. The species compositions, management actions and changes in the farming agro-ecosystems could affect the biosphere reserve management towards sustainable development negatively and/or positively. Ecosystems and the services they provide are critically important to human well-being and economic prosperity. This general truth underline that people and their environment are inseparable. But humans have been modifying the natural landscape and ecosystem functions to intensify certain provisioning services such as food supply on the expense of other for example regulating services regardless of its sustainability. The local communities seem to be aware of the advantages of the biosphere reserve and they are using and practicing some conservation activities, such as: expansion of plantation coffee, home and forest gardens, using woodlots and live fences which could compensate the consumption of some forest resources for different purposes. However, these local conservation measures have resulted lower agro-biodiversity level, and consequently their agro-ecosystem services are being declined in most cases in the study area. If local communities find themselves on the losing end of conservation measures, they will tend to overharvest the available resources to satisfy their basic needs.

By addressing management actions and making decisions now, we will have positive consequences far into the future of biodiversity, ecosystem services and human well-being. In general, favoring people living in the Yayo coffee forest biosphere reserve in farming systems' development options will promote prospective biodiversity conservation and help to maintain various ecosystem services as long as peoples' needs will be accommodated, and also conservation and management activities in the study area need to be supported and/or initiated on the bases of human wellbeing and their healthy and diversified environment.

Compliance with ethical standards

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References

[1] Liang, W., 1998. Farming systems as an approach to agro-ecological engineering. *Ecological Engineering*, *11*(1), pp.27-35.

[2] Abebe, T., Wiersum, K.F. and Bongers, F., 2010. Spatial and temporal variation in crop diversity in agroforestry homegardens of southern Ethiopia. *Agroforestry systems*, *78*(3), pp.309-322.

[3] Seyoum, A., Dorosh, P.A. and Asrat, S.T., 2012. Crop production in Ethiopia: Regional patterns and trends.

[4] Sandifer, P.A., Sutton-Grier, A.E. and Ward, B.P., 2015. Exploring connections among nature, biodiversity, ecosystem services, and human health and well-being: Opportunities to enhance health and biodiversity conservation. *Ecosystem Services*, *12*, pp.1-15.

[5] Potschin, M. and Haines-Young, R., 2013. Landscapes, sustainability and the place-based analysis of ecosystem services. *Landscape Ecology*, *28*(6), pp.1053-1065.

[6] Abate, T., Shiferaw, B., Gebeyehu, S., Amsalu, B., Negash, K., Assefa, K., Eshete, M., Aliye, S. and Hagmann, J., 2011. A systems and partnership approach to agricultural research for development: Lessons from Ethiopia. *Outlook on agriculture*, *40*(3), pp.213-220.

[7] Dörschner, T. and Musshoff, O., 2015. How do incentive-based environmental policies affect environment protection initiatives of farmers? An experimental economic analysis using the example of species richness. *Ecological Economics*, *114*, pp.90-103.

[8] Coetzer, K.L., Witkowski, E.T. and Erasmus, B.F., 2014. Reviewing Biosphere Reserves globally: effective conservation action or bureaucratic label?. *Biological Reviews*, *89*(1), pp.82-104.

[9] Yakob, G. and Fekadu, A., 2016. Diversity and Regeneration Status of Woody Species: The Case of Keja Araba and Tula Forests, South West Ethiopia. *Open Access Library Journal*, *3*(04), p.1.

[10] Burkhard, B., Müller, A., Mueller, F., Grescho, V., Anh, Q., Arida, G., Bustamante, J.V.J., Van Chien, H., Heong, K.L., Escalada, M. and Marquez, L., 2015. Land cover-based ecosystem service assessment of irrigated rice cropping systems in southeast Asia—an explorative study. *Ecosystem Services*, *14*, pp.76-87.

[11] Wallace, K.J., 2007. Classification of ecosystem services: problems and solutions. *Biological conservation*, *139*(3), pp.235-246.

[12] Kahane, R., Hodgkin, T., Jaenicke, H., Hoogendoorn, C., Hermann, M., Hughes, J.D.A., Padulosi, S. and Looney, N., 2013. Agrobiodiversity for food security, health and income. *Agronomy for sustainable development*, *33*(4), pp.671-693.

[13] Cassano, C.R., Barlow, J. and Pardini, R., 2014. Forest loss or management intensification? Identifying causes of mammal decline in cacao agroforests. *Biological Conservation*, *169*, pp.14-22.

[14] Daw, T., Brown, K., Rosendo, S. and Pomeroy, R., 2011. Applying the ecosystem services concept to poverty alleviation: the need to disaggregate human well-being. *Environmental Conservation*, *38*(4), pp.370-379.

[15] Assefa, A.D., 2010. Local Institutions and Their Influence on Forest Resource Management in Southwest of Ethiopia : Addis Ababa.

[16] Gole, T.W., Feyera, S., Kassahun, T. and Fite, G., 2009. Yayu coffee forest biosphere reserve nomination form. *Ethiopian MAB National Committee, Addis Ababa*.

[17] Mills, M., Álvarez-Romero, J.G., Vance-Borland, K., Cohen, P., Pressey, R.L., Guerrero, A.M. and Ernstson, H., 2014. Linking regional planning and local action: Towards using social network analysis in systematic conservation planning. *Biological Conservation*, *169*, pp.6-13.

[18] Gole, T.W., Borsch, T., Denich, M. and Teketay, D., 2008. Floristic composition and environmental factors characterizing coffee forests in southwest Ethiopia. *Forest Ecology and Management*, *255*(7), pp.2138-2150.

[19] Gole, T.W., 2003. Vegetation of the Yayu forest in SW Ethiopia: impacts of human use and implications for in situ conservation of wild Coffea arabica L. populations. Cuvillier.

[20] Lu, D., Mausel, P., Brondizio, E. and Moran, E., 2004. Change detection techniques. *International journal of remote sensing*, *25*(12), pp.2365-2401.

[21] Feyisa, G.L., Kebebew, Z., Ali, K.H., Kanke, H.D. and Nelson, A., 2015. RETRACTED: Remote Sensing Techniques for Accurate and Consistent Detection of Small-Scale Changes in a Tropical Forest: Exploring Details of Forest Cover Dynamics Using Multi-Temporal Landat Imagery. *Natural Resources*, *6*(12), p.583.

[22] Muhamad, D., Okubo, S., Harashina, K., Gunawan, B. and Takeuchi, K., 2014. Living close to forests enhances people' s perception of ecosystem services in a forest–agricultural landscape of West Java, Indonesia. *Ecosystem Services*, *8*, pp.197-206.

[23] Duguma, L.A., 2013. Financial analysis of agroforestry land uses and its implications for smallholder farmers livelihood improvement in Ethiopia. *Agroforestry systems*, *87*(1), pp.217-231.

[24] Keenan, R.J., 2015. Climate change impacts and adaptation in forest management: a review. *Annals of forest science*, *72*(2), pp.145-167.

[25] Estrada, A., Saenz, J., Harvey, C., Naranjo, E., Muñoz, D. and Rosales-Meda, M., 2006. Primates in agroecosystems: conservation value of some agricultural practices in Mesoamerican landscapes. In *New Perspectives in the Study of Mesoamerican Primates* (pp. 437-470).

[26] Milner-Gulland, E.J., 2012. Interactions between human behaviour and ecological systems. *Phil. Trans. R. Soc. B*, *367*(1586), pp.270-278.

[27] Garbach, K., Milder, J.C., Montenegro, M., Karp, D.S. and DeClerck, F.A.J., 2014. Biodiversity and ecosystem services in agroecosystems. *Encyclopedia of agriculture and food systems*, *2*, pp.21-40.

[28] Duguma, Mezgebu Senbeto, Debela Hunde Feyssa, and Lisa Biber-Freudenberger. 2019 Agricultural Biodiversity and Ecosystem Services of Major Farming Systems: A Case Study in Yayo Coffee Forest Biosphere Reserve, Southwestern Ethiopia. *Agriculture 9,* no. 3: 48*.*

[29] Reed, M.G. and Egunyu, F., 2013. Management effectiveness in UNESCO Biosphere Reserves: Learning from Canadian periodic reviews. *Environmental science & policy*, *25*, pp.107-117.

[30] Bullock, J.M., Aronson, J., Newton, A.C., Pywell, R.F. and Rey-Benayas, J.M., 2011. Restoration of ecosystem services and biodiversity: conflicts and opportunities. *Trends in ecology & evolution*, *26*(10), pp.541-549.

[31] Plieninger, T., Dijks, S., Oteros-Rozas, E. and Bieling, C., 2013. Assessing, mapping, and quantifying cultural ecosystem services at community level. *Land use policy*, *33*, pp.118-129.

[32] Pulido-Santacruz, P. and Renjifo, L.M., 2011. Live fences as tools for biodiversity conservation: a study case with birds and plants. *Agroforestry systems*, *81*(1), pp.15-30.

[33] Feyssa, D.H., Abdeta, C., Berhan, T. and Sharma, M., 2015. Medicinal plants use and conservation practices in Jimma Zone, South West Ethiopia. *International Journal of Biodiversity and Conservation*, *7*(3), pp.202-210.