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Review Article

Biosphere Reserves in the Southwest of Ethiopia

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Forests that have a wide ecological gradient, diversity, and significant cover are confined in the southwestern part vis-à-vis other parts of Ethiopia, while the country is fronting biodiversity losses. The intention of this paper is comparative assessment of Majang, Kafa, Sheka, and Yayo biosphere reserves, located in the southwest of Ethiopia, regarding their status of plant diversity, challenges, and efforts of conservation. To this end, an extensive review of different journals, articles, and proceedings was made. Relevance to the objectives of the review was a selection criterion for sources inclusion. Consequently, the review indicates that all the biosphere reserves contained myriad plant biodiversity, specifically the "hotspot" of Afromontane rainforest biodiversity, with some degree of dissimilarities among them. For instance, the values of Shannon index illustrated a decreasing order in plant diversity as Sheka followed by Kafa, Yayo, and Majang biosphere reserve. Besides, out of the top ten documented plant families, the species richest families are Rubiaceae (15) in Yayo, *Asteraceae* (12) in Kafa, *Euphorbiaceae* (11) in Majang, and *Asteraceae* (11) in Sheka biosphere reserve, while the least species found in the families are as follows: *Aspleniaceae* and *Sapindaceae* in Majang; *Poaceae*, *Solanaceae*, and *Araceae* in Sheka; *Celastraceae* and *Piperaceae* in Kafa; and *Fabacae* and *Solanaceae* in Yayo. However, many challenges were encountered in all the biosphere reserves. The driving force behind is commercial coffee-tea plantation, agriculture expansion, overgrazing, firewood, charcoal, and other factors. Hence, to reduce forest conversion and biodiversity loss, the government of Ethiopia is creating conservation mechanism like the establishment of the protected area and biosphere reserve which is controlled and managed by the community and the government.

1. Introduction

Ethiopia is a center for abundant biodiversity attributable to its wide ranges of topographical diversity [1, 2]. This diverse physiographic feature has contributed to various ecosystems' formation which put Ethiopia in the top 25 biodiversity-rich countries of the world [3]. For example, about 6500 to 7000 species of higher plants are estimated to exist in Ethiopia, of which about 12 percent species are endemic [1, 3, 4].

Basically, forest in the southwest of Ethiopia has relatively high forest cover as compared to other parts of the country, about 56 percent of the country's forest cover [5–7]. These lands have an altitudinal range from 900 to 2700 m.a.s.l. and form the upper catchments of several rivers, such as *Baro-Akobo* and *Omo*. A large number of endemic plants are in the Afromontane forest which include wild plants with considerable economic value such as *Coffea arabica*, *Aframomum corrorima*, and *Piper capense* [6, 8, 9]. These forests are playing roles in not only water regulation of the rivers but also biodiversity conservation. In other words, they are biodiversity hotspot of global interest forests [10]; for instance, according to [11], *Coffea arabica* is a flagship species in the *Kafa* biosphere reserve.

However, nowadays, Ethiopia is facing biodiversity losses, interalia, linked with commercial and subsistence cultivations [12]. The most important reason behind the rapid deforestation rate is increasing human population growth with subsequent high demand of land for agriculture and grazing, firewood, charcoal, timber, and other purposes [7, 13–15]. Besides, inappropriate investment activities like

commercial tea and coffee plantations confounded with lack of land use policy are also contributing factors [16–18].

In connection to the challenges of forest conservation in the southwestern; Ethiopia has been taking measures to rehabilitate degraded forests and conservations of natural forests [19, 20]. Protected area and biosphere reserve were the main conservation mechanisms. In view of that, four biosphere reserves called *Majang*, *Kafa*, *Sheka*, and *Yayo* were established in the area from 2010 to 2017. The central objectives of these biosphere reserves are biodiversity conservation, research, and development function to meet the local people's needs and henceforth improve their quality of life [21, 22]. Therefore, this paper addresses comparative appraisal of these biosphere reserves on their status of plant biodiversity, challenges, and conservation efforts.

2. History and Definition of Biosphere Reserve

2.1. History of Biosphere Reserves. The first international biosphere reserve congress was held in Minsk, Belarus, since 1983 jointly covered by UNESCO and UNEP which gives rise to an "action plan for biosphere reserves." The second international congress was held in 1995 in Seville, Spain, on "biosphere reserves", and biosphere reserves were visualized as guides to the twenty-first century, "showing a way to a sustainable future" [23]. In this conference, the three most important tasks were identified as conservation, development, and logistic support [24].

The third world congress of biosphere reserves was held in 2008, Madrid, Spain, which is called "Madrid action plan for biosphere reserves." It strengthens the Seville strategy and rises biosphere reserves to be an international designated area dedicated to sustainable development in future generations [25]. More specifically, biosphere reserves have immense impacts on socioeconomic-related concern and hence play a significance role in poverty reduction and implementation of Sustainable Development Goals (SDGs). Obviously, biosphere reserves are sources of hope for local communities, recognized as a viable option for enhancing their income generation mechanism [26].

The worldwide network of biosphere reserves provides a global framework for education and research, as well as the manifestation and attainment of sustainable resource use [27]. Nowadays, there are 699 biosphere reserves in 120 countries of the world. Out of the total biosphere reserves, 79 are found in 29 African countries of which Ethiopia has 5 biosphere reserves. *Kafa* besides *Yayo*, *Sheka*, Lake *Tana*, and *Majang* was nominated since 2010, 2012, 2015, and 2017, respectively [27].

From historical perspectives of biosphere reserve establishment, the first country that established and registered biosphere reserves was the Democratic Republic of Congo since 1976. In general, the foundation of biosphere reserves illustrated a nearly linear increment from 1976 to 2018 (Figure 1), this is due to the desire to achieve sustainable development, and each country understands the benefits of biosphere reserves in conservation and sustainable management of forest resources [27].

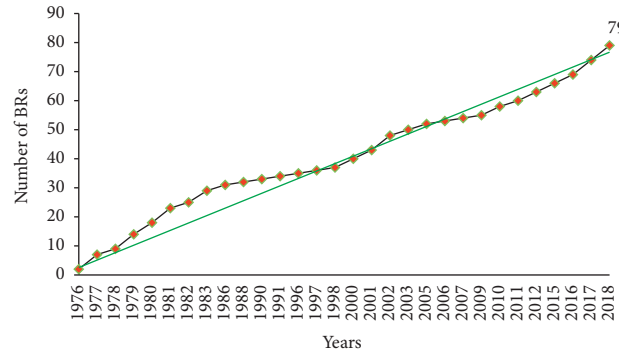

Figure 1: Biosphere reserves establishment history in Africa. Source: http://www.unesco.org.

2.2. Definition of Biosphere Reserve. In broader sense, *biosphere reserve* is an area established to conserve the biological and cultural diversity of a region while promoting sustainable economic and social development. According to Ishwaran [25], biosphere reserve is described as a place where people and nature coexist and interact with each other for their mutual benefits. All members of society, including local communities, environmental groups, and economic parties, are involved and work together to address conservation and development issues. Any place is given such title, biosphere reserve, by UNESCO as part of the Man and Biosphere (MAB) Programme [27].

The requirements of biosphere reserves should, explicitly, fulfill three basic functions: *conservation function*: this is conservation of cultural diversity and biodiversity: species, genetic, and ecosystem variation; *development function*: this encourages economic and human development; *logistics function*: this supports research, monitoring, demonstration projects, and information exchange related to local, national, and global conservation and developments [22, 25, 27].

2.3. Description of Biosphere Reserves in Southwestern Ethiopia

The Kafa Biosphere Reserve is located in the *Kafa* zone administration of the Southern Nations, Nationalities, and People's (SNNP's) Region State of Ethiopia (Figure 2). It spans 540,713.1 ha and stretches across boundaries of 10 districts, namely, *Adiyo*, *Bita*, *Chena*, *Chetta*, *Decha*, *Gesha*, *Gewata*, *Gimbo*, *Aylem*, *and Tello*, 250 rural *kebele* administrations, and 25 urban towns. This forest is the home of *Coffee arabica* and holds 5000 wild varieties of coffee [28].

The Majang Biosphere Reserve is located in the *Majang* zone of the Gambella People National Regional State. It covers a total area of 224,925 ha of forest, woodland, agricultural land, and rural and town settlements. It is a unique biogeography and shares border with the *Illubabor* zone of Oromia Regional State and *Sheka* and *Bench-Maji* zones of the Southern Nations, Nationalities, and People (SNNP) (Figure 2) [18, 29].

The Sheka Biosphere Reserve is located in the *Sheka* zone of the SNNP's regional state. It covers 238,750 ha of

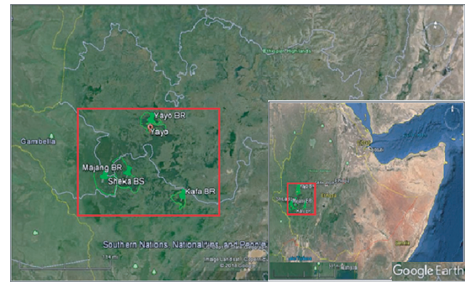

Figure 2: Map of the biosphere reserves in Southwestern Ethiopia.

forest, bamboo thickets, wetlands, agricultural land, rural settlements, and towns. It shares border with the *Illubabor* zone, *Kafa*, and *Bench-Maji* zone of the SNNP regional state [30].

The Yayo Biosphere Reserve is located in Illubabor and *Buno Bedele* zones of Oromia Regional State, southwest of Ethiopia. It covers 167,021 ha and stretched over six districts: *Doreni*, *Yayu*, *Bilo Nopa*, *Algie Sachi*, *Hurumu*, and *Chora* [26].

2.4. Zonation of a Biosphere Reserve in Southwest Ethiopia. Biosphere reserves aim to manage resources in an integrated manner by taking protection into consideration for sustainable utilization and resource planning. This is tangible through classifying biosphere reserves into three such as core, buffer, and transition zones [25, 31]. This classification is considered in all the biosphere reserves found in Ethiopia, for conservation and sustainable management of resources [32]. Accordingly, in relation to the concepts of zonation, core, buffer, and transition zone and their size of distribution of all the biosphere reserves are presented in Figure 3. The total area coverage of all biosphere reserves is estimated to be 1.2 million hectares (ha), of which the *Kafa* is the largest and *Yayo* is the smallest biosphere reserve in the southwest of Ethiopia.

Core zone: every biosphere reserve must contain one or more core areas. These have strong legal protection and serve as a shelter for wild plants and animals free from any human disturbances. Activities that are allowed in this zone are monitoring, research, and traditional nondestructive uses, while activities like agriculture, settlement, grazing of domestic animals, and harvesting products are not allowed [25, 31]. In southwest of Ethiopia, biosphere reserve zones differ in their size of coverage; for instance, the core zone is the smallest in cover as compared with the other zones (Figure 3).

Buffer zone: this zone is the guard keeping of the core zone by enclosing and protecting from the anthropogenic impacts. This zone functions as essential ecological corridors, connecting the core zone to the transitional zone. Activities that are allowed in the buffer zone include tourism, recreation, research, and education training.

Transition zone: in this zone, people are allowed to live and make livings. In this zone, local residents, NGOs, scientists, cultural groups, economic stakeholders, and others work together to manage and sustainably develop the area's resources. Activities like farming, fishing, tourism, beekeeping, settlements, urban and villages, industry, and enterprise are permitted in this zone [25, 31]. The transitional zone comprises the largest cover as compared to the total area of the biosphere reserves in Southwestern Ethiopia (Figure 3).

3. Status of Biodiversity's in the Biosphere Reserves

Regardless of their biological diversity, many other tropical biosphere reserves, *Sheka*, *Majang*, *Kafa,* and *Yayo,* have plenty of biological entities and several ecological services. These areas are endowed with many plant diversities such as coffee, spices, and medicinal plants. *In situ* preservation of biodiversity can be best ensured under the protection of the entire biosphere reserve ecosystems [32].

According to many study findings, the biosphere reserves, namely, *Majang*, *Sheka*, *Kafa*, and *Yayo*, encompass diverse plant species. As in Table 1, the values of the Shannon index illustrated a decreasing order of the biosphere reserves: *Sheka followed by Kafa*, *Yayo*, and *Majang* in plants' diversity. These differences could be associated, but not limited, to dissimilarity in sociocultural and environmental factors, as well.

All the biosphere reserves hold diverse plant families. But family richness varied between biospheres reserves. For instance, among the top ten plant families, the highest species found in the families are Euphorbiaceae (11) *in Majang*, Asteraceae (11) *in Sheka*, Asteraceae in *Kafa* (12), and Rubiaceae (15), respectively, while the least species found in the families are Aspleniaceae and Sapindaceae *in Majang*, Poaceae, Solanaceae, and Araceae in Sheka, Celastraceae and Piperaceae in Kafa, and Fabaceae and Solonaceae in Yayo (Table 2). The difference in plant family richness may be due to environmental aspects including slope, altitude soil, and anthropogenic factors [7, 32].

4. Challenges of Biosphere Reserves Conservation in the Southwest of Ethiopia

4.1. Deforestation and Forest Degradation. The forest cover of the southwestern biosphere reserves has been declining at an alarming rate due to the combined effects of different

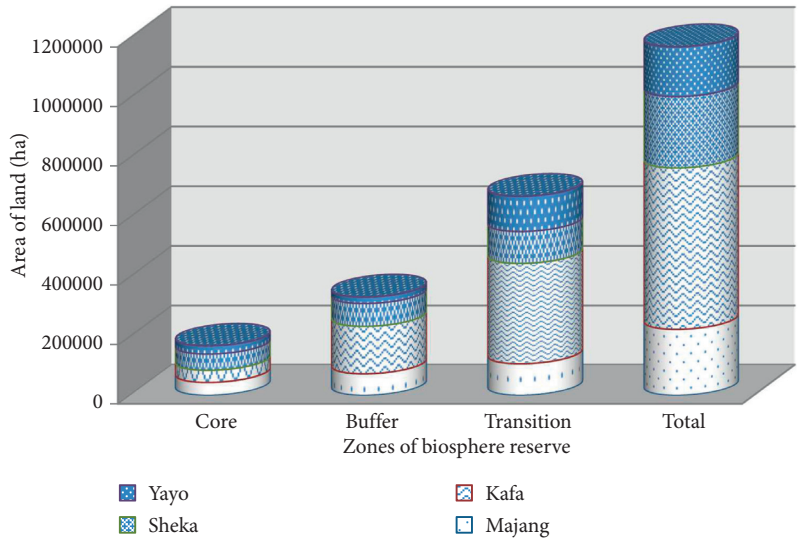

Figure 3: Size of the zone in all biosphere reserves in Southwestern Ethiopia. Source: [29, 33].

Table 1: Plant diversity in the biosphere reserves of Southwest Ethiopia.

Biosphere	No. of families	No. of species	Shannon index	Sources
Majang	71	198	2.80	[34]
Sheka	95	374	3.70	[6, 7, 13]
Kafa	73	285	3.37	[7, 35, 36]
Yayo	72	221	2.83	[7, 32]

factors. The causative factors of deforestation have their roots in different sectors of anthropogenic and natural. Based on different findings, the main driving forces behind in all biosphere reserves are commercial plantation (coffee and tea) by investors, agriculture expansion, settlement, fuelwood extraction, illegal logging for timber, and farm tools (Table 3) [17, 18, 38, 39].

The causes of deforestation in all biosphere reserves were largely subjugated to investment and agriculture-related land expansion. Different findings indicated that more than 60 percent of the forestland covers were changed to investment land (plantation of coffee and tea) agricultural crops in all biosphere reserves of Southwestern Ethiopia (Table 3) [38]. More fragmented forests are found in the transition zone and near edges of buffer zone boundary since they are more prone to human impacts or activities [39].

A number of specific studies have been undertaken which provide some indication on the rate of deforestation in Southwest Ethiopia [40–43]. For example, Demel et al. 2010 [44] attempted to forecast future land cover changes resulting from human population increase in the *Baro-Akobo* basin, and it was estimated that on average 1.77 million ha of high forest is cleared annually between 1987 and 2010 for agricultural activities (Table 4).

In North Bench, Sheko and Yeki districts in the SNNP region and Dima district in Gambella region, about 46,940 ha of forest land was converted between 1987 and 2005 for agricultural activities in the adjacent of *Sheka* biosphere reserve [42]. Moreover, in *Gesha*, *Masha*, *Anderacha*, *Yeki*, *Sheko*, and North *Bench* districts in SNNP region, about 61,00 ha of forest land was lost between 1987 and 2005 because of NTFPs exploitation (Table 4) [43]. Recently, over 2455 ha of forest land has been leased for investors working on plantations of coffee and spices in the *Sheka* biosphere reserves [45]. Besides, recently, about 19,165.83 ha of forest land in Majang biosphere reserve surrounding has been leased for plantation of tea before the establishments of *Majang* biosphere reserves [18].

4.2. Loss of Plant Biodiversity. Considerable cover of the moist Afromontane vegetation and biodiversity occurs in the remnant forests of Southwestern Ethiopia [46]. Conversely, the conversion of biosphere reserves into semiforest coffee system and other land uses has influenced and will have prolonged impacts on the diversity of the moist forest, if management measures are not carried out. Floristic composition or species diversity was severely changed in the southwest remnant forest blocks which include all the biosphere reserves [13, 32].

A significant number of native trees species were threatened as a result of heavy exploitations. For example, different scholars [10, 32, 35, 47, 48] reported that *Prunus africana*, *Cordia africana*, *Afrocarpus falcatus*, and *Dracaena afromontana* are endangered species in all biosphere reserves' surroundings. Moreover, currently coal mining and fertilizer factories have been established in *Yayo* biosphere reserves which have a negative impact on biodiversity resources through site clearing, excavation, drilling, and earthworks involved. More specifically, it is causing wild coffee extinction and loss of another biodiversity [49].

Table 2: Top ten species-rich plant families in the biosphere reserves (BRs) of Southwestern Ethiopia.

No.	*Majang BR*	*Sheka BR*	*Kafa BR*	*Yayo BR*
1	Euphorbiaceae (11)	Asteraceae (11)	Asteraceae (12)	Rubiaceae (15)
2	Moraceae (10)	Rubiaceae (10)	Rubiaceae (11)	Orchidaceae (14)
3	Rubiaceae (9)	Euphorbiaceae (9)	Euphorbiaceae (10)	Euphorbiaceae (11)
4	Fabaceae (8)	Fabaceae (8)	Fabaceae (9)	Moraceae (10)
5	Asteraceae (7)	Celastraceae (8)	Aspleniaceae (8)	Amaranthaceae (9)
6	Sapotaceae (7)	Moraceae (7)	Orchidaceae (8)	Celastraceae (8)
7	Celastraceae (7)	Lamiaceae (7)	Poaceae (7)	*Asteraceae* (8)
8	Aspleniaceae (6)	Poaceae (6)	Labiatae (7)	Acanthaceae (8)
9	Acanthaceae (6)	Solanaceae (6)	Celastraceae (6)	Fabaceae (7)
10	Sapindaceae (6)	Araceae (6)	Piperaceae (6)	Solanaceae (7)

Note. The number in the bracket indicates the total species found in the family. Sources: [32, 34, 35, 37].

Table 3: Major drivers of deforestation (%) in the biosphere reserves of Southwest Ethiopia.

Major drivers of deforestation	Majang	Kafa	Sheka	Yayo
Investment (coffee and tea)	40	43	39	26
Agriculture expansion	29	27	31	38
Settlement	14	13	15	16
Fuelwood and timber	11	12	10	14
Farm tools	5	4	3	4
Natural disturbance	1	1	2	2

Source: [17, 38, 39].

Table 4: Estimated rates of deforestation in the Southwestern Ethiopia.

Period	Deforestation rate (%)	Area	Sources
1987–2010	1.6	Baro-Akobo basin	[44]
1987–2005	1.2	N. Bench, Sheko, Yeki, and Dima	[42]
1987–2005	1.5	Gesha, Masha, Yeki, Sheko, N. Bench, and Anderacha	[43]

5. Conservation Effort in the Southwest of Ethiopia

The last remaining cloud forests in Southwest Ethiopia contain different endemic species including *Coffea arabica* [34, 35, 50]. To conserve or reduce deforestation and forest degradation of the remained Afromontane rainforest, the governments of Ethiopia and different stakeholder participated in the establishment of biosphere reserves [17]. For instance, high deforestation (1035.8 ha) occurred during 2005–2009 and lesser deforestation was experienced in 2010–2013 (22.23 ha) before and after the establishment of *Yayo* biosphere reserves, respectively (Figure 4).

With regard to biosphere reserve establishment, nowadays, the REDD + project involves three regional states of Ethiopia (Oromia, SNNP, and Gambella) for conservation and sustainable development through reduction emission from deforestation and degradation, forest conservation, sustainable forest management, and enhancing forest carbon stock [51]. However, it requires strong local people participation and women inclusion during the intervention. Similarly, it needs creation of forest base livelihood and income diversification mechanism. Thus, the local people will benefit and minimize their forest dependency in the biosphere reserve surrounding [17, 52].

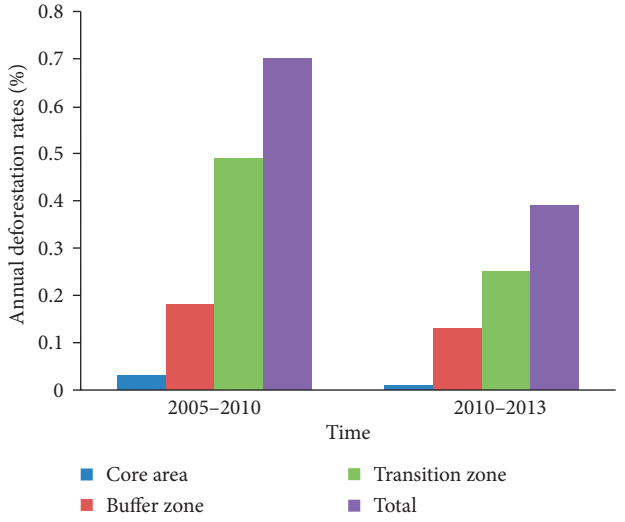

Figure 4: Annual deforestation rate before and after establishments of *Yayo* biosphere reserves. Source: [17].

6. Conclusion

Regardless of its biological diversity, many other tropical biosphere reserves, Sheka, Majang, Kafa, and Yayo, have plenty of biological entities and Afromontane biodiversity "hotspot" (endemic species, coffee, spices, and medicinal

plants) delivers several ecological services. However, the forest cover has decreased due to increasing human population growth with a very high demand of land for subsistence agriculture and grazing land, forest resources for firewood, charcoal, timber, construction, and many other purposes. The conversion of coffee forest or biosphere reserves into semiforest coffee system and other land uses has influenced and will prolong impacts on losing of biological entity. To conserve this, the governments of Ethiopia and different stakeholder participated in the establishment of biosphere reserves. With regard to biosphere reserve establishment, nowadays, the REDD + project involves three regional states of Ethiopia (Oromia, SNNP, and Gambella) for conservation and sustainable development of the ruminant forest through REDD + mechanism. However, it requires local people participation and as well as women inclusion during the project intervention. Similarly, it needs creation of forest base livelihood and income diversification mechanism. Thus, the local people will be benefited and minimize their forest dependency in the biosphere reserve surrounding. Finally, to reduce the forest conversion, the government of Ethiopia is creating conservation mechanism like the establishment of the protected area and biosphere reserve which is controlled and managed by the community and the government.

Data Availability

The data used to support the findings of this study are available from the corresponding authors upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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