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*Review Article*

# A Review on Bamboo Resource in the African Region: A Call for Special Focus and Action

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The African region has untapped bamboo resource potential with immense socioeconomic, cultural, and ecological significances. Despite the long history of bamboo in the region, its contribution is at the infant stage. Therefore, the present study aimed at reviewing the existing literature supported by research experience on bamboo resource in the region. The review process mainly focused on four main specific objectives. These include (1) review extensively African countries that owned the resource and identify the species in each country, (2) identify and document species, generic, and taxonomic tribes of each bamboo species, (3) assess and report bamboo area coverage from available nations, and (4) highlight the existing experiences of special opportunities, challenges, and successful achievements on bamboo resource in representative African countries. The review process found out that a total of 4.56 million ha total bamboo area and 115 bamboo species are reported from 48 African countries. Hence, the African region shares 12.3% of the global bamboo resource and contributed 7.3% of the total bamboo species. Of this, 89.6% of the region is endowed with indigenous bamboo species. Among indigenous species, *O. abyssinica* is the most widely distributed in 38 African countries. Madagascar ranked first with 37 indigenous species, while Ethiopia led by 25 introduced bamboo species. Nowadays, Ethiopia has 1.44 million ha total indigenous bamboo area coverage, which accounted for 31.6% of the African region and 3.89% of the world total. Therefore, more detail and comprehensive research on species taxonomy, resource base inventory, silvicultural applications, and socioeconomic study is recommended.

## 1. Global Bamboo Resource Overview

Bamboo belongs to the subfamily *Bambusoideae* and family Gramineae or Poaceae [1–3]. Various sources speculated the origin of bamboo in the evolutionary line of plant kingdom. However, Clark estimated that bamboo origin was traced back probably some 30–40 million years ago [4]. It is one of the most important forest resources with immense socioeconomic, cultural, and ecological significances since ancient times. For instance, indigenous bamboo resource in Ethiopia has been used for different traditional uses including house construction, fencing, production of handicrafts and other household utensils, animal feed, edible shoots for human consumption, and many other uses. In the human history, bamboo cultivation and utilization in ancient China traced back to about 6000 years [5]. As early as 3000 years before, edible bamboo shoot has been used as a popular and delicious dish in China [6]. Nowadays, there are 1575 bamboo species [1] belonging to about 90 genera across the world [4, 7]. The bamboo resource further covers a total area of about 37 million ha worldwide or around 1% of the global forest resource [7]. Its annual production also accounted for more than 20 million tons [8] and contributed $60 billion to the global economy [9]. In relation to this, bamboo resource is widely distributed around the world in diverse climatic and ecological settings. Its range covers from tropics, subtropics, and temperate to frigid zones [4, 10–12] approximately in 50°N–47°S [4]. The altitudinal ranges also vary from the sea level up to a higher elevation, i.e., 4500 m above the sea level [1].

As a whole, the global distribution of bamboo resource can be classified into four major geographic regions [10–12] (Figure 1). These major bamboo regions comprise the Asia-Pacific region with more than 900 species [10, 11], American region with over 500 species [4], and the African region with 43 species [13–15]. The African region comprises the mainland Africa and the associated islands surrounding the continent including Comoros, Madagascar, Mauritius, Réunion, São Tomé and Príncipe, and Seychelles. These regions are specifically located at 51°N–42°S [12], 40°N–47°S [10–12], and 16°N–22°S [10, 11, 16] in their respective orders. By contrast, European, North American, and Australian regions are emerged due to the introduction of many bamboo species from Asia, Africa, and South America mostly for gardening, ornamentals, and other uses [10–12].

In this insight, approximately 80% of the bamboo resource is found in the Asia-Pacific region [10, 11]. Of this, more than 59% of the Asia-Pacific region [3, 10, 11] and 33.9% of the world bamboo species are found in China [1, 3]. Currently, 534 bamboo species that belong to 34 genera are found in China [3] with the total area coverage of 7 million ha [11, 16]. In contrast, the African region has very little bamboo resource in terms of species diversity and area coverage almost entirely limited to tropical zones [4]. It comprises 7% of the world bamboo resource with total area coverage of over 2.8 million ha within six nations [7]. Therefore, it needs urgent call for special focus and action for the sustainable development and promotion of bamboo resource in the African region. This comprises (1) review extensively African countries that owned the resource and identify the species in each country by their scientific names, (2) identify and document bamboo species including their description and generic and taxonomic tribes of each bamboo species, (3) assess and report bamboo area coverage from African nations that have available information, and (4) highlight special opportunities, challenges, and successful achievements on bamboo resource in representative African countries.

## 2. Materials and Methods

A comprehensive and detail literature review was carried out from 108 published and accessed bibliographical sources. These included 54 scientific journals, 15 books, 19 official documents from various nations and/or organizations and working studies, 11 workshop proceedings, manuals, and newspapers, 4 online accessed resources, and 5 academic theses. The review process encompassed both African countries and islands surrounding the mainland Africa. Consequently, the total area covered wider and diverse geographical locations and settings, altitudinal ranges, climatic conditions, and socioeconomic and cultural diversities and lifestyles. At the same time, the perception, experience, and knowledge of local people and nations focus towards bamboo resource are considerably varied. With this in mind, available data in each country were reviewed in detail, bamboo species were identified, and a species list was documented. Thereafter, the scientific names and their synonymous if any were listed down and particular references are cited. After that, the generic names are identified and grouped under taxonomic tribes following different references. In the same way, regarding to the total bamboo area coverage in the region, data from available countries were extensively reviewed, and then, the countries list, bamboo area, and bamboo area to forest area coverage as well as percentage share are presented. The existing practical experiences on widely distributed, commonly used, and potentially high species are selected as representative species and extensively reviewed. Last, special opportunities, major challenges, and successful achievements are assessed from typical countries so as to strengthen the resource development and promotion in the region.

## 3. Origin and Distribution of Bamboo Resource in the African Region

Our extensive literature review showed that a total of 115 bamboo species are widely distributed among 48 countries in the African region (Table 1). This accounted for 7.3% of the global bamboo species and covered 82.8% of the African region. This covered vast areas which extend from western coast at Senegal to the eastern part at Mauritius, while it stretched from Morocco in the north to South Africa in the southern part. Out of the indigenous bamboo species, *Oxytenanthera abyssinica* is widely distributed among 38 countries, while *Olyra latifolia* is found within 30 countries. These are followed by *Oldeania alpina* and *Oreobambos buchwaldii*, which are further recorded among 13 and 10 African countries, respectively. In the same way, 5 countries have *Guaduella oblonga*, while *Bambusa vulgaris, Guaduella densiflora*, and *Hickelia africana* are recorded among the 3 African countries, each. Regarding to introduced bamboo species, *Bambusa vulgaris* is widely distributed among 20 African countries, followed by *Dendrocalamus giganteus* within 10 countries. Also, *D. asper* and *D. strictus* are equally found in 6 countries, each (Table 1).

In relation to bamboo genera, the genus *Bambusa* contained 25 bamboo species, which accounted for 21.7% of the total recorded species in the region (Table 2). This is followed by the genus *Nastus* and *Dendrocalamus* with 12 and 11 bamboo species, respectively. Similarly, 6 bamboo species are classified under the genus *Guaduella*, whereas 5 species are recorded under the genus *Yushania.* The genera *Cephalostachyum* and *Hickelia* followed with 4 species, each.

In the same way, a total of 35 bamboo genera are recorded in the African region, which are classified under five taxonomic tribes (Table 3). Of these, the tribe *Bambuseae* comprised a total of 19 (54.3%) bamboo genera, followed by *Arundinarieae* with 11 taxonomic genera. On the other hand, three tribes, namely, *Guaduelleae, Olyreae*, and *Puelieae,* contained one bamboo genera, each. In contrast, there is no concrete information available to group the remaining two bamboo genera to a given tribe and hence requires a further taxonomic study. In line with this, tribe *Bambuseae* is distributed among the 45 African nations and *Olyreae* is distributed among 30 nations (Table 3).

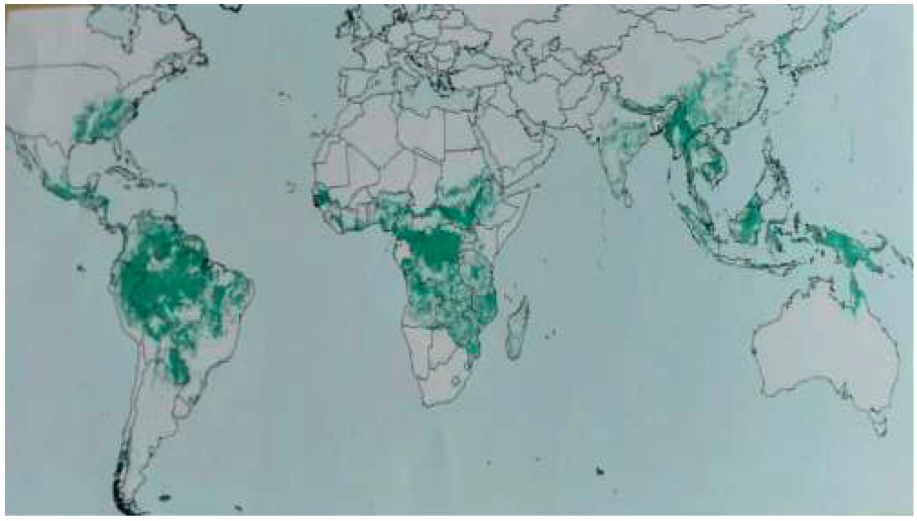

Figure 1: Global bamboo resource distribution among the four major geographic regions (source: [12]).

Furthermore, comprehensive literature review confirmed that the distribution of bamboo resource in the African region can be classified broadly into two parts. These are the mainland Africa and the associated six islands surrounding the continent (Comoros, Madagascar, Mauritius, Réunion, São Tomé and Príncipe, and Seychelles). The review process reported that mainland Africa has 83 bamboo species belonging to 30 genera (Table 4). Out of these species, 20 bamboo species are indigenous (native) to the region. The remaining 63 species are mainly introduced (exotic) from other regions (Asia-Pacific, America, or Africa itself). On the other hand, the six islands comprise 50 species. Among these, 40 bamboo species are indigenous, while 10 of them are introduced from elsewhere. Therefore, majority of the bamboo species (72.2%) are introduced to the mainland Africa at various times. By contrast, more diverse indigenous bamboo species (34.8%) are found within the six associated islands. This clearly shows that the mainland Africa has less rich and diverse indigenous compared to introduced bamboo species.

In the same way, a total of up to 45 bamboo species are reported from each country (Table 5). In terms of species origin, bamboo species are classified as indigenous to Africa or introduced from elsewhere. Among these, 22 countries have only indigenous (native) bamboo species, 5 countries have only introduced (exotic) species, while 21 countries owned both species. This reflects that 89.6% of the region is endowed with indigenous bamboo species. From indigenous species, Madagascar ranked first with a total of 37 bamboo species (refer Table 1), followed by Cameroon with 10 species (Table 1). This clearly shows that the species diversity and distribution at Madagascar is much richer than the mainland Africa [4, 12]. Ghana and Tanzania also comprise 8 and 6 species, respectively (Table 1). On the other hand, Ethiopia ranked first with a total of 25 introduced bamboo species, followed by Togo with 20 species. Ghana and Kenya each contains with a total of 16 introduced species, whereas Nigeria and Sudan follow with 12 and 10 bamboo species, respectively.

## 4. Status and Potential of Bamboo Resource in the African Region

The status and potential of bamboo resource in the African region is reviewed from different sources. According to the reports, the data are only available from 12 African countries. In this insight, 12.3% of the global bamboo resource is contributed by the African region. This indicated that bamboo development in the region is slightly improved as compared to 7% of total bamboo resource reported by FAO [7]. Ethiopia shares 31.55% of the total bamboo resource in the African region, followed by Senegal (14.49%) and Ghana (8.77%) (Table 6). Similarly, the bamboo to forest area coverage accounted for 11.51%, 7.99%, and 4.28% in their respective orders. However, the figure reported from Nigeria (34.88%) is an overestimated data and hence not yet verified [7]. By contrast, available data from Cameroon [23] and Zimbabwe (FAO (2001) cited in FAO [7] are also incomplete and do not represent the entire countries' resource. But, the intention to include these data is to show the resource potential and thereby to give more focus to the region. In the same way, the bamboo resource reported from other countries in the region (Tables 1 and 2) is not well known and estimated. Therefore, we concluded that due attention should be given to the status and potential of bamboo resource in the African region.

## 5. Overview on Indigenous Bamboo Species in Ethiopia

Out of the total recorded indigenous bamboo species in the African region (60 species), two indigenous bamboo species (*O. abyssinica* and *O. alpina*) are widely distributed and commonly used in the region, and their origin also traced

Table 1: Origin and distribution of bamboo resource in the African region.

| No. | List of countries | Origin and distribution of bamboo resource in the African region | | Reference |
|---|---|---|---|---|
| | | Indigenous (native) species | Introduced (exotic) species | |
| 1 | Algeria | | *Pseudosasa japonica* | INBAR [17] |
| 2 | Angola | *Guaduella densiflora, Guaduella dichroa, Olyra latifolia, Oreobambos buchwaldii,* and *Oxytenanthera abyssinica.* | | Ohrnberger [1], Bystriakova et al. [18], INBAR [17], Clayton et al. [19] |
| 3 | Benin | *O. latifolia* and *O. abyssinica.* | *Bambusa vulgaris, Dendrocalamus asper,* and *D. giganteus.* | Ohrnberger [1], Bystriakova et al. [18], zhou [16], Inada and Hall [20], INBAR [17], Clayton et al. [19] |
| 4 | Burkina Faso | *O. latifolia* and *O. abyssinica.* | *B. vulgaris* | Inada and Hall [20], INBAR [17], Clayton et al. [19] |
| 5 | Burundi | *Oldeania alpina, O. latifolia, O. buchwaldii*, and *O. abyssinica.* | | Phillips [2], Bystriakova et al. [18], Inada and Hall [20], INBAR [17], Clayton et al. [19] |
| 6 | Cameroon | *G. densiflora, Guaduella humilis, Guaduella macrostachys, Guaduella marantifolia, Guaduella oblonga, O. alpina*, *O. latifolia, O. buchwaldii*, *O. abyssinica*, and *Puelia atractocarpa.* | *B. vulgaris* (*B. vulgaris* var. *vittata* (yellow variety)), *Ochlandra travancorica*, and *Phyllostachys aurea.* | Phillips [2], Grimshaw [21], Ohrnberger [1], Bystriakova et al. [18], INBAR [22], Ingram et al. [23], INBAR [17], Clayton et al. [19] |
| 7 | Central African Republic | *O. latifolia* and *O. abyssinica.* | | Ohrnberger [1], Bystriakova et al. [18], INBAR [17], Clayton et al. [19] |
| 8 | Chad | *O. abyssinica* | | KFRI [24], INBAR [17], Clayton et al. [19] |
| 9 | Comoros | *O. latifolia* and *Sirochloa parvifolia.* | | Ohrnberger [1], INBAR [17] |
| 10 | Cote d'Ivoire | *G. oblonga, O. latifolia*, and *O. abyssinica.* | *B. vulgaris* | Ohrnberger [1], Bystriakova et al. [18], INBAR [17], Clayton et al. [19] |
| 11 | Democratic Republic of Congo | *O. alpina, O. latifolia, O. buchwaldii*, and *O. abyssinica.* | *B. vulgaris* and *D. asper.* | Phillips [2], Ohrnberger [1], Bystriakova et al. [18], Inada and Hall [20], INBAR [17], Clayton et al. [19] |
| 12 | Egypt | | *B. multiplex* (*B. nana*) and *B. vulgaris.* | Moustafa et al. [25] |
| 13 | Equatorial Guinea | *O. latifolia* and *O. abyssinica.* | | INBAR [17] |
| 14 | Eritrea | *O. abyssinica* | | Phillips [2], Ohrnberger [1], Bystriakova et al. [18], Clayton et al. [19] |
| 15 | Ethiopia | *Gigantochloa felix, O. alpina, O. latifolia*, and *O. abyssinica.* | *B. balcooa, B. bambos, B. emeiensis, B. multiplex, B. multiplex* 'Albovariegata,' *B. oldhamii, B. pachinensis, B. tulda, B. vulgaris* (*B. vulgaris* var. *green* (green variety), *B. vulgaris* var. *striata*, and *B. vulgaris* var. *vittata*), *D. asper, D. barbatus, D. brandisii, D. giganteus, D. hamiltonii, D. latiflorus, D. membranaceus, D. peculiaris, Gigantochloa apus, Gigantochloa atter, Gigantochloa sumatra, Guadua amplexifolia, Guadua angustifolia, Phyllostachys edulis, Schizostachyum jaculans*, and *Thyrsostachys siamensis.* | Phillips [2], Embaye [14], Ohrnberger [1], Embaye [13], Fu et al. [11], Jiang and Liu [12], Chen et al. [10], Huojin [15], INBAR [17], Clayton et al. [19] |
| 16 | Gabon | *G. densiflora, G. marantifolia*, and *G. oblonga.* | | Ohrnberger [1] |
| 17 | Gambia | *O. latifolia* and *O. abyssinica* | | Ohrnberger [1], Bystriakova et al. [18], INBAR [17], Clayton et al. [19] |

Table 1: Continued.

| No. | List of countries | Origin and distribution of bamboo resource in the African region | | Reference |
|---|---|---|---|---|
| | | Indigenous (native) species | Introduced (exotic) species | |
| 18 | Ghana | *B. bambos, B. multiplex, B. pervariabilis, B. vulgaris* (*B. vulgaris* var. *green* and *B. vulgaris* var. *vittata*), *D. strictus, G. macrostachys, O. latifolia*, and *O. abyssinica.* | *B. burmanica, B. heterostachya, B. oldhamii, B. textilis, B. ventricosa, D. asper, D. barbatus, D. brandisii, D. giganteus, D. latiflorus, D. membranaceus, Gigantochloa albociliata, G. angustifolia, Guadua chacoensis, P. edulis*, and *T. siamensis.* | Ohrnberger [1], Bystriakova et al. [18], Inada and Hall [20], Appiah-Kubi et al. [26], INBAR [27], Clayton et al. [19] |
| 19 | Guinea | *G. oblonga, O. latifolia*, and *O. abyssinica.* | *B. vulgaris* | Ohrnberger [1], Bystriakova et al. [18], INBAR [17], Clayton et al. [19] |
| 20 | Guinea-Bissau | *O. latifolia*, and *O. abyssinica* | | |
| 21 | Kenya | *Hickelia africana, O. alpina, O. latifolia, O. buchwaldii*, and *Pseudosasa amabilis* | *B. bambos*, *B. lako*, *B. nutans*, *B. tulda*, *B. vulgaris* (*B. vulgaris* var. *vittata*), *D. asper*, *D. brandisii*, *D. giganteus*, *D. hamiltonii*, *D. membranaceus*, *D. strictus*, *O. abyssinica, P. edulis*, *P. nigra* var. *henonis*, *Schizostachyum pergracile*, *Shibataea kumasaca*, and *T. siamensis.* | Kigomo and Kamiri [28], Grimshaw [21], zhou [16], Fu et al. [11], Jiang and Liu [12], Kigomo [29], Inada and Hall [20], KFRI [24], Chen et al. [10], INBAR [17], Clayton et al. [19] |
| 22 | Lesotho | *O. abyssinica, Bergbambos tessellata*, and *Thamnocalamus* sp. | | Ohrnberger [1], Bystriakova et al. [18], INBAR [17] |
| 23 | Liberia | *G. oblonga, O. latifolia*, and *O. abyssinica.* | | Ohrnberger [1], Inada and Hall [20], INBAR [17] |
| 24 | Libya | | *B. vulgaris* | |
| 25 | Madagascar | *Cathariostachys capitata, Cathariostachys madagascariensis, Cephalostachyum chapelieri, Cephalostachyum perrieri, Cephalostachyum* sp., *Cephalostachyum viguieri, Decaryochloa diadelpha, Hickelia alaotrensis, Hickelia madagascariensis, Hickelia perrieri, Hitchcockella baronii, Nastus ambrensis, N. aristatus, N. decaryanus, N. elongatus, N. emirnensis, N. humbertianus, N. lokohoensis, N. madagascariensis, N. manongarivensis, N. perrieri, N. tsaratananensis, Ochlandra capitata, O. latifolia, Perrierbambus madagascariensis, Perrierbambus tsarasaotrensis, Schizostachyum perrieri, Sirochloa parvifolia* (*Schizostachyum bosseri*), *Thamnocalamus ibityensis, Thamnocalamus* sp., *Yushania humbertii, Y. madagascariensis, Y. perrieri, Yushania* sp., *Valiha diffusa, V. perrieri* , and *Valiha* sp. | *B. multiplex*, *B. spinosa, B. vulgaris* (*B. madagascariensis, B. vulgaris* var. *green,* and *B. vulgaris* var. *vittata*), *D. asper*, *D. giganteus*, *D. strictus, Gigantochloa* aff. *pseudoarundinacea*, and *P. aurea.* | Ohrnberger [1], Bystriakova et al. [18], Inada and Hall [20], King et al. [30], INBAR [17], Clayton et al. [19] |
| 26 | Malawi | *O. alpina, O. latifolia, O. buchwaldii*, and *O. abyssinica.* | | Phillips [2], Grimshaw [21], Ohrnberger [1], Bystriakova et al. [18], Sosola-Banda and Johnsen [31] |
| 27 | Mali | *O. abyssinica* | | Inada and Hall [20], INBAR [17] |
| 28 | Mauritius | Probably *B. tessellata* | *B. multiplex* and *D. giganteus.* | Ohrnberger [1], INBAR [17] |
| 29 | Morocco | | *P. japonica* | INBAR [17] |

Table 1: Continued.

| No. | List of countries | Origin and distribution of bamboo resource in the African region | | Reference |
|---|---|---|---|---|
| | | Indigenous (native) species | Introduced (exotic) species | |
| 30 | Mozambique | *O. latifolia, O. buchwaldii*, and *O. abyssinica.* | *B. bambos, B. vulgaris* (*B. striata*), *D. hamiltonii*, and *D. strictus.* | Ohrnberger [1], Bystriakova et al. [18], INBAR [17], Clayton et al. [19] |
| 31 | Niger | *O. abyssinica* | | INBAR [17] |
| 32 | Nigeria | *G. densiflora, G. humilis, O. latifolia*, and *O. abyssinica.* | *B. vulgaris, Brachystachyum stellatus, Dayeteng* spp., *D. giganteus, D. sinicus, Fargesia robusta, Gelidocalamus stellatus, Nuomizhu xiaoyeteng, P. edulis* (*P. heterocycla* var. *pubescens*), *Pleioblastus fortunei, Shibataea chinensis*, and *Y. baishazuensis.* | Ohrnberger [1], Bystriakova et al. [18], INBAR [17], Clayton et al. [19] |
| 33 | Republic of Congo | *G. marantifolia, O. alpina, O. latifolia*, and *O. abyssinica.* | | Ohrnberger [1], Bystriakova et al. [18], INBAR [17], Clayton et al. [19] |
| 34 | Réunion | *N. borbonicus* | *D. giganteus* | Inada and Hall [20], INBAR [17] |
| 35 | Rwanda | *O. alpina* and *O. abyssinica.* | *B. vulgaris* | Phillips [2], Inada and Hall [20], INBAR [17], Clayton et al. [19] |
| 36 | São Tomé and Príncipe | *O. latifolia* and *O. abyssinica.* | *B. balcooa* and *B. vulgaris.* | INBAR [17], Haroun et al. [32] |
| 37 | Senegal | *O. latifolia* and *O. abyssinica* | | Phillips [2], Ohrnberger [1], Bystriakova et al. [18], Inada and Hall [20], INBAR [17], Clayton et al. [19] |
| 38 | Seychelles | | *B. multiplex, B. vulgaris, D. giganteus, D. strictus*, and *P. nigra.* | Zhou [16], INBAR [17] |
| 39 | Sierra Leone | *G. oblonga, O. latifolia*, and *O. abyssinica.* | *B. vulgaris* | Ohrnberger [1], Bystriakova et al. [18], INBAR [17], Clayton et al. [19] |
| 40 | South Africa | *O. abyssinica* and *B. tessellata.* | *B. balcooa* | Ohrnberger [1], Bystriakova et al. [18], Inada and Hall [20] |
| 41 | South Sudan | *O. alpina* and *O. abyssinica.* | | Ohrnberger [1], Bystriakova et al. [18], Clayton et al. [19] |
| 42 | Sudan | *O. alpina, O. latifolia*, and *O. abyssinica.* | *B. polymorpha, B. teres, B. tulda, B. vulgaris, D. giganteus, D. hamiltonii, D. longispathus, D. strictus, S. pergracile*, and *Melocanna baccifera.* | Phillips [2], Ohrnberger [1]; Bystriakova et al. [18]; zhou [16]; INBAR [17]; Clayton et al. [19] |
| 43 | Swaziland | *O. abyssinica* | | INBAR [17] |
| 44 | Togo | *B. bambos, B. multiplex, B. vulgaris* (*B. vulgaris var. striata*), *O. latifolia*, and *O. abyssinica.* | *B. beecheyana, B. birmanica, B. dissimulator, B. edulis, B. oldhamii, B. nutans, B. polymorpha, B. spinosa, B. ventricosa, B. warmin, D. brandisii, D. latiflorus, D. membranaceus, D. strictus, G. albociliata, Gigantochloa bali white, Gigantochloa luteostriata, Gigantochloa malay dwarf, G. angustifolia*, and *G. chacoensis.* | Ohrnberger [1], Bystriakova et al. [18], Kokutse et al. [33], INBAR [17], Clayton et al. [19] |
| 45 | Uganda | *H. africana, O. alpina, O. latifolia, O. buchwaldii*, and *O. abyssinica.* | *D. asper* | Ohrnberger [1], Bystriakova et al. [18], zhou [16], Inada and Hall (2008), Ingram et al. [23], INBAR [17], INBAR [34], Clayton et al. [19] |
| 46 | United Republic of Tanzania | *B. vulgaris* (*B. vulgaris* var. *green* and *B. vulgaris* var. *vittata*), *H. africana, O. alpina, O. latifolia, O. buchwaldii*, and *O. abyssinica.* | | Grimshaw [21], Ohrnberger [1], Bystriakova et al. [18], zhou [16], Inada and Hall [20], INBAR [17], Clayton et al. [19] |
| 47 | Zambia | *O. alpina, O. latifolia, O. buchwaldii*, and *O. abyssinica.* | | Ohrnberger [1], Bystriakova et al. [18], zhou [16], INBAR [17], Clayton et al. [19] |
| 48 | Zimbabwe | *O. latifolia, O. buchwaldii*, and *O. abyssinica.* | | Ohrnberger [1], Bystriakova et al. [18], INBAR [17], Clayton et al. [19] |

Table 2: A complete checklist and the scientific names of bamboo species in the African region.

| No. | Species name |
|---|---|
| 1 | *Bambusa balcooa* Roxb. |
| 2 | *Bambusa bambos* (L.) Voss and ∗ *Bambusa arundinacea* (Retz.) Willd. |
| 3 | *Bambusa beecheyana* Munro |
| 4 | [+]*Bambusa birmanica* |
| 5 | *Bambusa burmanica* Gamble |
| 6 | *Bambusa dissimulator* McClure |
| 7 | *Bambusa emeiensis* L. C. Chia and H. L. Fung |
| 8 | *Bambusa heterostachya* (Munro) Holttum |
| 9 | *Bambusa lako* Widjaja |
| 10 | *Bambusa multiplex* 'Albovariegata' and ∗ *Bambusa multiplex* 'Silverstripe' Fernleaf' |
| 11 | *Bambusa multiplex* (Lour.) Raeusch. ex Schult. f., ∗ *Bambusa multiplex f. alphonse-karrii* (Mitford ex Satow) Nakai, or *Bambusa multiplex* Roxb. |
| 12 | *Bambusa nutans* Wall. ex Munro |
| 13 | *Bambusa oldhamii* Munro |
| 14 | *Bambusa pachinensis* Hayata and ∗ *Bambusa textilis* var. *fusca* McClure |
| 15 | *Bambusa pervariabilis* McClure |
| 16 | *Bambusa polymorpha* Munro |
| 17 | *Bambusa spinosa* Roxb and ∗ *Bambusa blumeana* Schult. f. |
| 18 | *Bambusa teres* Munro |
| 19 | *Bambusa textilis* McClure |
| 20 | *Bambusa tulda* Roxb. |
| 21 | *Bambusa ventricosa* McClure |
| 22 | *Bambusa vulgaris* Schrad. ex J. C. Wendl., ∗ *Bambusa madagascariensis* Rivière and C. Rivière, *Bambusa striata* Lodd. ex Lindl., [+]*Bambusa vulgaris* var. *green*, *Bambusa vulgaris* var. *striata* (Lodd. ex Lindl.) Gamble, and *Bambusa vulgaris* var. *vittata* Rivière and C. Rivière |
| 23 | [+]*Bambusa warmin* |
| 24 | *Bergbambos tessellata* (Nees) Stapleton and ∗ *Thamnocalamus tessellatus* (Nees) Soderstr. and R. P. Ellis |
| 25 | [+]*Brachystachyum stellatus* |
| 26 | *Cathariostachys capitata* (Kunth) S. Dransf. |
| 27 | *Cathariostachys madagascariensis* (A. Camus) S. Dransf. |
| 28 | *Cephalostachyum chapelieri* Munro |
| 29 | *Cephalostachyum perrieri* A. Camus |
| 30 | *Cephalostachyum* sp. |
| 31 | *Cephalostachyum viguieri* A. Camus |
| 32 | *Dayeteng* spp. |
| 33 | *Decaryochloa diadelpha* A. Camus |
| 34 | *Dendrocalamus asper* (Schult. Schult. f.) Backer ex K. Heyne |
| 35 | *Dendrocalamus barbatus* Hsueh and D. Z. Li |
| 36 | *Dendrocalamus brandisii* (Munro) Kurz and ∗ *Bambusa brandisii* Munro |
| 37 | *Dendrocalamus giganteus* Munro |
| 38 | *Dendrocalamus hamiltonii* Nees and Arn. ex Munro |
| 39 | *Dendrocalamus latiflorus* Munro |
| 40 | *Dendrocalamus longispathus* (Kurz) Kurz |
| 41 | *Dendrocalamus membranaceus* Munro |
| 42 | *Dendrocalamus peculiaris* Hsueh and D. Z. Li |
| 43 | *Dendrocalamus sinicus* L. C. Chia and J. L. Sun |
| 44 | *Dendrocalamus strictus* (Roxb.) Nees |
| 45 | *Fargesia robusta* T. P. Yi |
| 46 | *Gelidocalamus stellatus* T. H. Wen |
| 47 | *Gigantochloa albociliata* (Munro) Kurz |
| 48 | *Gigantochloa apus* (Schult. f.) Kurz |
| 49 | *Gigantochloa atter* (Hassk.) Kurz |
| 50 | [+]*Gigantochloa bali white* |
| 51 | *Gigantochloa felix* (Keng) Keng f. and ∗ *Oxytenanthera felix* Keng |
| 52 | *Gigantochloa luteostriata* Widjaja |
| 53 | [+]*Gigantochloa malay dwarf* |
| 54 | [+]*Gigantochloa sumatra* |
| 55 | *Gigantochloa verticillata* (Willd.) Munro and ∗ [+]*Gigantochloa aff. pseudoarundinacea* |
| 56 | *Guadua amplexifolia* J. Presl in C. B. Presl |
| 57 | *Guadua angustifolia* Kunth |

Table 2: Continued.

| No. | Species name |
|---|---|
| 58 | *Guadua chacoensis* (Rojas Acosta) Londoño and P. M. Peterson |
| 59 | *Guaduella densiflora* Pilger ap. Engler |
| 60 | *Guaduella dichroa* T. A. Cope |
| 61 | *Guaduella humilis* W. D. Clayton |
| 62 | *Guaduella macrostachys* (K. Schumann) Pilger |
| 63 | *Guaduella marantifolia* Franchet |
| 64 | *Guaduella oblonga* Hutchinson ex W. D. Clayton |
| 65 | *Hickelia africana* S. Dransf. |
| 66 | *Hickelia alaotrensis* A. Camus |
| 67 | *Hickelia madagascariensis* A. Camus |
| 68 | *Hickelia perrieri* (A. Camus) S. Dransf. |
| 69 | *Hitchcockella baronii* A. Camus |
| 70 | *Melocanna baccifera* (Roxb.) Kurz and ∗ *Melocanna bambusoides* Trin. in K. P. J. Sprengel |
| 71 | *Nastus ambrensis* A. Camus |
| 72 | *Nastus aristatus* A. Camus |
| 73 | *Nastus borbonicus* J. F. Gmel. |
| 74 | *Nastus decaryanus* A. Camus |
| 75 | *Nastus elongatus* A. Camus |
| 76 | *Nastus emirnensis* (Baker) A. Camus |
| 77 | *Nastus humbertianus* A. Camus |
| 78 | *Nastus lokohoensis* A. Camus |
| 79 | *Nastus madagascariensis* A. Camus |
| 80 | *Nastus manongarivensis* A. Camus |
| 81 | *Nastus perrieri* A. Camus |
| 82 | *Nastus tsaratananensis* A. Camus |
| 83 | [+]*Nuomizhu xiaoyeteng* |
| 84 | *Ochlandra capitata* (Kunth) Camus |
| 85 | *Ochlandra travancorica* (Bedd.) Gamble |
| 86 | *Oldeania alpina* (K. Schum.) Stapleton, ∗ *Arundinaria alpina* K. Schum., *Yushania alpina* (K. Schum.) W. C. Linor, and *Sinarundinaria alpina* (K. Schum.) C. S. Chao and Renvoize |
| 87 | *Olyra latifolia* L. |
| 88 | *Oreobambos buchwaldii* K. Schum. |
| 89 | *Oxytenanthera abyssinica* (A. Rich.) Munro and ∗ *Oxytenanthera braunii* Pilg. |
| 90 | *Perrierbambus madagascariensis* A. Camus |
| 91 | *Perrierbambus tsarasaotrensis* A. Camus |
| 92 | *Phyllostachys aurea* (André) Rivière and C. Rivière |
| 93 | *Phyllostachys edulis* (Carrière) J. Houz, ∗ *Phyllostachys pubescens* (Pradelle) Mazel ex J. Houz., *Phyllostachys heterocycla* var. *pubescens* (Pradelle) Ohwi, or *Bambusa edulis* Carrière |
| 94 | *Phyllostachys nigra* var. *henonis* (Mitford) Rendle |
| 95 | *Pleioblastus fortunei* (Van Houtte) Nakai and ∗ *Sasa pygmaea* (Miq.) Rehder |
| 96 | *Pseudosasa amabilis* (McClure) Keng f. and ∗ *Arundinaria amabilis* McClure |
| 97 | *Pseudosasa japonica* (Siebold and zucc. ex Steud.) Makino ex Nakai |
| 98 | [+]*Puelia atractocarpa* |
| 99 | *Schizostachyum jaculans* Holttum |
| 100 | *Schizostachyum pergracile* (Munro) R. B. Majumdar in S. Karthikeyan et al. and ∗ *Cephalostachyum pergracile* Munro |
| 101 | *Schizostachyum perrieri* A. Camus |
| 102 | *Shibataea chinensis* Nakai |
| 103 | *Shibataea kumasaca* (Zoll. ex Steud.) Makino |
| 104 | *Sirochloa parvifolia* (Munro) S. Dransf., ∗ *Schizostachyum parvifolium* Munro, or *Schizostachyum bosseri* A. Camus |
| 105 | *Thamnocalamus ibityensis* (A. Camus) Ohrnb. |
| 106 | *Thamnocalamus* sp. |
| 107 | *Thyrsostachys siamensis* Gamble |
| 108 | *Valiha diffusa* S. Dransf. |
| 109 | *Valiha perrieri* (A. Camus) S. Dransf and ∗ *Ochlandra perrieri* A. Camus |
| 110 | *Valiha* sp. |
| 111 | *Yushania baishazuensis* Z. P. Wang and G. H. Ye |
| 112 | *Yushania humbertii* (A. Camus) Ohrnb and ∗ *Yushania ambositrensis* (A. Camus) Ohrnb. |
| 113 | *Yushania madagascariensis* (A. Camus) Ohrnb and ∗ *Yushania marojejyensis* (A. Camus) Ohrnb. |
| 114 | *Yushania perrieri* (A. Camus) Ohrnb. |
| 115 | *Yushania* sp. |

*Note.* Most recently accepted scientific names are provided in the bamboo species checklist following Phillips [2], Ohrnberger [1], Wu et al. [3], Inada and Hall [20], INBAR [17], and Clayton et al. [19]. The most commonly used taxonomic synonyms and varieties are indicated with asterisks. Incomplete scientific names due to inadequate information are further illustrated with cross marks.

Table 3: A checklist of bamboo genera classified into taxonomic tribes in the African region.

| No. | Major taxonomic tribes and their respective bamboo genera in the African region | | Total number of nations |
|---|---|---|---|
| | | *Tribe. Arundinarieae* | 19 |
| | Genus name | Distribution of each genus in the African nations | |
| 1 | *Bergbambos* | Lesotho | 1 |
| 2 | *Brachystachyum* | Nigeria | 1 |
| 3 | *Fargesia* | Nigeria | 1 |
| 4 | *Gelidocalamus* | Nigeria | 1 |
| 5 | *Oldeania* | Burundi, Cameroon, Democratic Republic of Congo, Ethiopia, Kenya, Malawi, Republic of Congo, Rwanda, South Sudan, Sudan, Uganda, United Republic of Tanzania, and Zambia | 13 |
| 6 | *Phyllostachys* | Cameroon, Ethiopia, Ghana, Kenya, Madagascar, and Nigeria | 6 |
| 7 | *Pleioblastus* | Nigeria | 1 |
| 8 | *Pseudosasa* | Algeria, Morocco and Kenya | 3 |
| 9 | *Shibataea* | Kenya and Nigeria | 2 |
| 10 | *Thamnocalamus* | Lesotho and Madagascar | 2 |
| 11 | *Yushania* | Madagascar | 1 |
| | | *Tribe. Bambuseae* | 45 |
| 12 | *Bambusa* | Benin, Burkina Faso, Cameroon, Cote d'Ivoire, Democratic Republic of Congo, Egypt, Ethiopia, Ghana, Guinea, Kenya, Libya, Madagascar, Mozambique, Mauritius, Mozambique, Nigeria, Rwanda, São Tomé and Príncipe, Sierra Leone, Seychelles, South Africa, Sudan, Togo, and United Republic of Tanzania | 24 |
| 13 | *Cathariostachys* | Madagascar | 1 |
| 14 | *Cephalostachyum* | Madagascar | 1 |
| 15 | *Decaryochloa* | Madagascar | 1 |
| 16 | *Dendrocalamus* | Benin, Democratic Republic of Congo, Ethiopia, Ghana, Kenya, Madagascar, Mauritius, Mozambique, Nigeria, Réunion, Seychelles, Sudan, Togo, and Uganda | 14 |
| 17 | *Gigantochloa* | Ethiopia, Ghana, Madagascar, and Togo | 4 |
| 18 | *Guadua* | Ethiopia, Ghana, and Uganda | 3 |
| 19 | *Hickelia* | Kenya, Madagascar, Uganda, and United Republic of Tanzania | 4 |
| 20 | *Hitchcockella* | Madagascar | 1 |
| 21 | *Melocanna* | Sudan | 1 |
| 22 | *Nastus* | Madagascar | 1 |
| 23 | *Ochlandra* | Madagascar | 1 |
| 24 | *Oreobambos* | Angola, Burundi, Democratic Republic of Congo, Kenya, Malawi, Mozambique, Uganda, United Republic of Tanzania, Zambia, and Zimbabwe | 10 |
| 25 | *Oxytenanthera* | Angola, Benin, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Cote d'Ivoire, Democratic Republic of Congo, Equatorial Guinea, Eritrea, Ethiopia, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Malawi, Mali, Mozambique, Niger, Nigeria, Republic of Congo, Rwanda, São Tomé and Príncipe, Senegal, Sierra Leone, South Africa, South Sudan, Sudan, Swaziland, Togo, Uganda, United Republic of Tanzania, Zambia, and Zimbabwe | 38 |
| 26 | *Perrierbambus* | Madagascar | 1 |
| 27 | *Schizostachyum* | Ethiopia, Kenya, and Madagascar | 3 |
| 28 | *Sirochloa* | Comoros and Madagascar | 2 |
| 29 | *Thyrsostachys* | Ethiopia, Ghana, and Kenya | 3 |
| 30 | *Valiha* | Madagascar | 1 |
| | | *Tribe. Guaduelleae* | 10 |
| 31 | *Guaduella* | Angola, Cameroon, Cote d'Ivoire, Gabon, Ghana, Guinea, Liberia, Nigeria, Republic of Congo, and Sierra Leone | 10 |
| | | *Tribe. Olyreae* | 30 |
| 32 | *Olyra* | Angola, Benin, Burkina Faso, Burundi, Cameroon, Central African Republic, Comoros, Cote d'Ivoire, Democratic Republic of Congo, Equatorial Guinea, Ethiopia, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Madagascar, Malawi, Nigeria, Republic of Congo, São Tomé and Príncipe, Senegal, Sierra Leone, Sudan, Togo, Uganda, United Republic of Tanzania, Zambia, and Zimbabwe | 30 |
| | | *Tribe. Puelieae* | 1 |
| 33 | *Puelia* | Cameroon | 1 |
| | | *Tribe.* Others | 1 |
| 34 | *Dayeteng* | Nigeria | 1 |
| 35 | *Nuomizhu* | Nigeria | 1 |

*Note.* Listed bamboo genera are classified into each taxonomic tribe following Ohrnberger [1], Wu et al. [3], Inada and Hall [20], INBAR [17], and Clayton et al. [19].

Table 4: A summary of bamboo resource diversity and distribution in the African region.

| African region | Species | | | | Genera | | | |
|---|---|---|---|---|---|---|---|---|
| | Indigenous | Introduced | Total | | Indigenous | Introduced | Total | |
| Mainland Africa | *B. bambos, B. multiplex, B. pervariabilis, B. vulgaris, B. tessellata, D. strictus, G. felix, G. densiflora, G. dichroa, G. humilis, G. macrostachys, G. marantifolia, G. oblonga, H. africana, O. alpina, O. latifolia, O. buchwaldii, O. abyssinica, P. amabilis, P. atractocarpa*, and *Thamnocalamus* sp. | 21 | *B. balcooa, B. bambos, B. beecheyana, B. birmanica, B. burmanica, B. dissimulator, B. emeiensis, B. heterostachya, B. lako*, *B. multiplex* 'Albovariegata', *B. multiplex, B. nutans, B. oldhamii, B. pachinensis, B. polymorpha, B. spinosa, B. teres, B. textilis, B. tulda, B. ventricosa, B. warmin, B. vulgaris, B. stellatus, D. asper, D. barbatus, D. brandisii, D. giganteus, D. hamiltonii, D. latiflorus, D. longispathus, D. membranaceus, D. peculiaris, D. sinicus, Dendrocalamus* spp., *F. robusta, G. albociliata, G. angustifolia, G. chacoensis, G. stellatus, G. albociliata, G. apus, G. atter, G. bali white, G. luteostriata, G. malay dwarf, G. sumatra, G. amplexifolia, G. angustifolia, M. baccifera, N. xiaoyeteng, O. abyssinica, O. travancorica*, *P. nigra* var. *henonis*, *P. aurea, P. edulis, P. fortunei, P. japonica, S. pergracile, S. jaculans, S. chinensis, S. kumasaca, T. siamensis*, and *Y. baishazuensis* | 63 | **78** | *Bambusa, Bergbambos, Dendrocalamus, Gigantochloa, Guaduella, Hickelia, Oldeania, Olyra, Oreobambos, Oxytenanthera, Pseudosasa, Puelia*, and *Thamnocalamus* | 13 | *Bambusa, Brachystachyum, Dayeteng, Dendrocalamus, Fargesia, Gelidocalamus, Gigantochloa, Guadua, Melocanna, Nuomizhu, Ochlandra, Oxytenanthera, Phyllostachys, Pleioblastus, Pseudosasa, Schizostachyum, Shibataea, Thyrsostachys*, and *Yushania* | **19** | **27** |

Table 4: Continued.

| African region | Species | | | | | Genera | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Indigenous | | Introduced | | Total | Indigenous | | Introduced | | Total |
| Six islands | *B. stellatus, C. capitata, C. madagascariensis, C. chapelieri, C. perrieri, Cephalostachyum.* sp., *C. viguieri, D. diadelpha, H. alaotrensis, H. madagascariensis, H. perrieri, H. baronii, N. aristatus, N. borbonicus, N. decaryanus, N. elongatus, N. emirnensis, N. humbertianus, N. lokohoensis, N. madagascariensis, N. manongarivensis, N. perrieri, N. tsaratananensis, N. ambrensis, O. abyssinica, O. capitata, O. latifolia, P. madagascariensis, P. tsarasaotrensis, S. perrieri, S. parvifolia, T. ibityensis, Thamnocalamus* sp., *V. perrieri, V. diffusa, Valiha* sp.,*Y. humbertii, Y. madagascariensis, Y. perrieri*, and *Yushania* sp. | 40 | *B. balcooa, B. multiplex, B. spinosa, B. vulgaris, D. asper, D. giganteus, D. strictus, G. aff. Pseudoarundinacea, P. aurea*, and *P. nigra* | 10 | **50** | *Brachystachyum, Cathariostachys, Cephalostachyum, Decaryochloa, Hickelia, Hitchcockella, Nastus, Ochlandra, Olyra, Oxytenanthera, Perrierbambus, Schizostachyum, Sirochloa, Thamnocalamus, Valiha*, and *Yushania* | 16 | *Bambusa, Dendrocalamus, Gigantochloa*, and *Phyllostachys* | **4** | **20** |
| | **Total** | **58** | | **65** | **115** | | **25** | | **19** | **35** |

back within the region. In this case, *O. abyssinica* is well known among 38 (79.2%) African nations, followed by *O. alpina* with a total of 13 (27.1%) African countries. On the other hand, 27.1% of the nations contain both species. For example, their total area coverage only from Ethiopia is 1.44 million ha [35], suggesting that a huge resource potential is found in the region. Their tremendous socioeconomic, cultural, and ecological uses commonly practiced by the local people are also cited as a model for bamboo resource utilization. Among others, Ethiopia is well-known for the untapped resource potential and wider distribution of these species in different agroecologies. There are also relatively more previous works carried out, and better information is comparatively available for these species. With this understanding, detail literature review on general background, biology, origin and distribution, status and resource potential, multipurpose uses, and silvicultural applications of *O. abyssinica* and *O. alpina* are extensively conducted and provided from Ethiopia. Figures and photos are further provided by the corresponding author from his previous professional experience in forestry research at the national research system particularly for indigenous bamboo species.

### 5.1. *Oldeania alpina (K. Schum.)*

Common name: highland/alpine/African alpine bamboo [2, 4]

Local name: Kerkeha in Amharic and Lemen in Affan Oromo languages [2, 39].

Synonymous: *Arundinaria alpina* K. Schum., *Yushania alpina* (K. Schum.) W. C. Lin, and *Sinarundinaria alpina* (K. Schum.) Chao and Renv [2, 4, 17]

Description: it grows up to a maximum height of 17 m and diameter of 13 cm from a stout branching rhizome [4]

Table 5: A summary of the origin and distribution of bamboo resource in the African region.

| List of countries | Origin of bamboo species | | |
|---|---|---|---|
| | Indigenous | Introduced | Total |
| Algeria | | 1 | **1** |
| Angola | 5 | | **5** |
| Benin | 2 | 3 | **5** |
| Burkina Faso | 2 | 1 | **3** |
| Burundi | 4 | | **4** |
| Cameroon | 10 | 3 | **13** |
| Central African Republic | 2 | | **2** |
| Chad | 1 | | **1** |
| Comoros * | 2 | | **2** |
| Cote d'Ivoire | 3 | 1 | **4** |
| Democratic Republic of Congo | 4 | 2 | **6** |
| Egypt | | 2 | **2** |
| Equatorial Guinea | 2 | | **2** |
| Eritrea | 1 | | **1** |
| Ethiopia | 3 | 25 | **28** |
| Gabon | 3 | | **3** |
| Gambia | 2 | | **2** |
| Ghana | 8 | 16 | **24** |
| Guinea | 2 | 1 | **3** |
| Guinea-Bissau | 2 | | **2** |
| Kenya | 5 | 16 | **21** |
| Lesotho | 3 | | **3** |
| Liberia | 3 | | **3** |
| Libya | | 1 | **1** |
| | Indigenous | Introduced | Total |
| Madagascar * | 37 | 8 | **45** |
| Malawi | 4 | | **4** |
| Mali | 1 | | **1** |
| Mauritius * | 1 | 2 | **3** |
| Morocco | | 1 | **1** |
| Mozambique | 3 | 4 | **7** |
| Niger | 1 | | **1** |
| Nigeria | 4 | 12 | **16** |
| Republic of Congo | 4 | | **4** |
| Réunion * | 1 | 1 | **2** |
| Rwanda | 2 | 1 | **3** |
| São Tomé and Príncipe * | 2 | 2 | **4** |
| Senegal | 2 | | **2** |
| Seychelles * | | 5 | **5** |
| Sierra Leone | 3 | 1 | **4** |
| South Africa | 2 | 1 | **3** |
| South Sudan | 2 | | **2** |
| Sudan | 3 | 10 | **13** |
| Swaziland | 1 | | **1** |
| United Republic of Tanzania | 6 | | **6** |
| Togo | 5 | 20 | **25** |
| Uganda | 5 | 1 | **6** |
| Zambia | 4 | | **4** |
| Zimbabwe | 3 | | **3** |

*Note.* The six islands surrounding the mainland Africa are indicated with asterisks. The species list for each country is in Table 1.

Rhizome type: there is a controversial issue on the rhizome type of *O. alpina* (Figure 2(a)). It is either monopodial or leptomorph rhizome type [2] or pachymorph or sympodial rhizome type [4, 29]. According to Meredith [4], some of the rhizome necks are exceptionally elongated and exhibit a spreading habit instead of forming a dense clump [4]. Such loose clump-forming pachymorph rhizome makes the species improperly considered under the running or creeping rhizome type, i.e., monopodial rhizome type [29].

Culms sheaths: the culm sheath (Figure 4(a)), which is covered with dense hairs, contains reddish-brown bristles and fimbriate auricles at the tip part [2]

Table 6: Status and potential of bamboo resource in the African region.

| Country | Bamboo area (1000 ha) | Bamboo area (%) | Forest area (1000 ha), GFRA (2015) | Bamboo to forest area (%) | Year of available data | Reference | Remark |
|---|---|---|---|---|---|---|---|
| Cameroon | 5 | 0.11 | 18816 | 0.03 | 2010 | Ingram et al. [23] | Data only from northwest of Cameroon. |
| Congo | 102 | 2.24 | 22334 | 0.46 | 1988 | UNDIO [39, 42] cited in FAO [7] | |
| Ethiopia | 1439 | 31.55 | 12499 | 11.51 | 2018 | Zhao et al. [35] | |
| Ghana | 400 | 8.77 | 9337 | 4.28 | 2015 | INBAR [27] | |
| Kenya | 131 | 2.87 | 4413 | 2.97 | 2018 | Zhao et al. [35] | |
| Nigeria | 1590 | 34.86 | 6993 | 22.74 | 2007 | FAO [7] | Overestimated and not verified. |
| Rwanda | 17 | 0.37 | 480 | 3.54 | 1985 | FRA (1985) cited in FAO [7] | |
| Senegal | 661 | 14.49 | 8273 | 7.99 | 2010 | FAO [36] | |
| Sudan | 31 | 0.68 | 19210 | 0.16 | 2010 | FAO [36] | |
| Uganda | 54.6 | 1.20 | 2077 | 2.63 | 2018 | Zhao et al. [35] | |
| United Republic of Tanzania | 128 | 2.81 | 46060 | 0.28 | 2010 | FAO [7] cited in FAO [36] | |
| Zimbabwe | 3.2 | 0.07 | 14062 | 0.02 | 2001 | FAO (2001) cited in FAO [7] | |
| Total | 4561.8 | 100 | 164554 | 100 | | | |

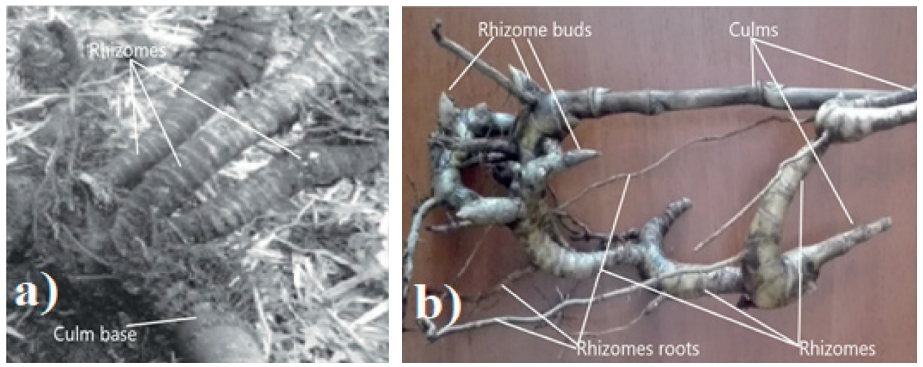


Figure 2: Rhizome type of (a) *O. alpina* (source: [37]) and (b) *O. abyssinica.* Clumps and culms: it is characterized by erect, thick-walled, and hollow culm bamboo species (Figures 3(a) and 3(b)).

Flowering pattern: the flowering pattern of *O. alpina* (Figure 5) is sporadic flowering [29, 39]. This means only some individuals or clumps within the bamboo forest are flowered, produce seeds, and eventually died, while the rest part of the bamboo forest is alive [39]. Yet, Kigomo [29] reported that after the flowering of the species, seeds are produced and still the flowered clumps are alive instead of dying.

Inflorescence: the paniculate inflorescence is loose to fairly compact in appearance. The shape of the spikelet, which is comprised 4–11 flowers, ranged from linear to linear-elliptic [2]. The author also noted that lanceolate to oblong-shaped lemmas on each spikelet are covered with hairs.

Distribution: *O. alpina* is found in montane forest often on volcanic soils, with *Podocarpus* in upland rainforest and with *Juniperus* in drier forest frequently planted along roads and in villages [2]. The species, which is indigenous to equatorial Africa, can grow in full sunlight but can also be found within a minimum temperature of −4 C [4]. It is distributed in Gojam, Shewa, Kefa, Gamo Gofa, Sidamo, and Bale regions (Figure 6) at the altitudes ranging from 2200 m to 4000 m above the sea level [2].

Silvicultural application: despite the limited availability of seeds, the species is propagated by seeds as shown in Figure 7(a) [40] or collected seedlings from the wild at nursery. The species is also vegetatively propagated through offset cutting, culm cutting [29, 41], culm layering, branch cutting, rhizome cutting [41], and macroproliferation [29, 39].

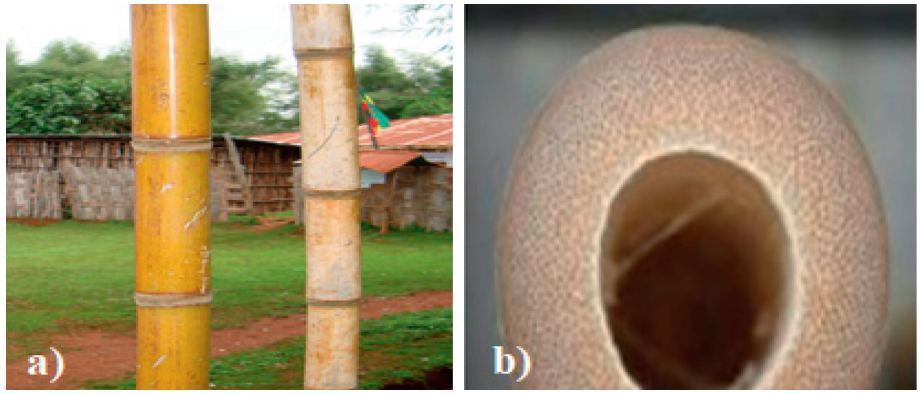


Figure 3: *O. alpina* standing culms (a) and thick and hollow culm (b).

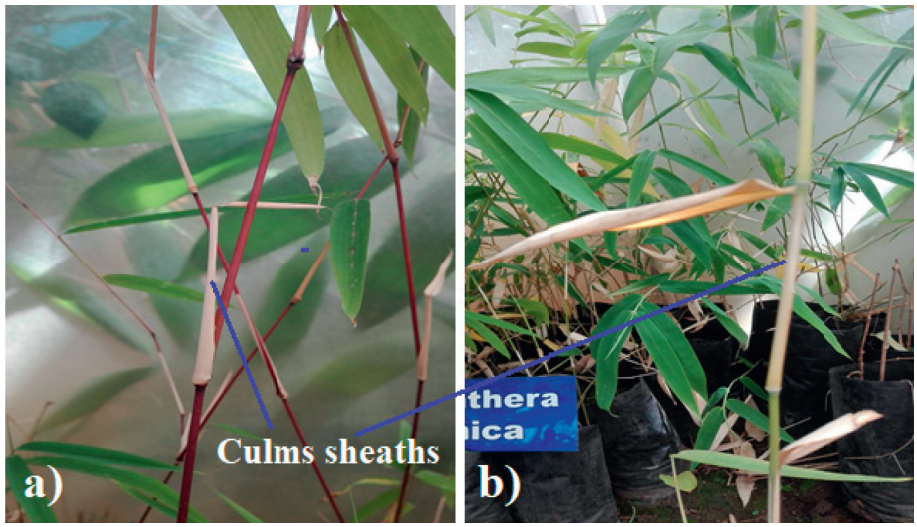


Figure 4: Culms sheaths of (a) *O. alpina* and (b) *O. abyssinica*. Leaves: linear lanceolate-shaped leaf blade is extended from the culm sheath.


Figure 5: Bamboo mass flowering and seed production of (a) *O. alpina* in Hula district of Sidama Zone, SNNPR in 2017 and (b) *O. abyssinica* (source: [38]).

Once seedlings are raised at nursery or green house (Figure 8(a)), weeding, hoeing, fertilizer application, supervision of insect and pest, and acclimatization (hardening) are carried out. Following this, seedlings are safely transported to prepared plantation sites and planted with or without the application of organic manure. Once established, the survival rate and growth performance of seedlings are supervised and dead seedlings are replaced. Hereafter, various plantation managements including thinning, fertilizer application, selective cutting, regular weeding and cleaning, soil loosening, supervision of insect pests and diseases, and controlling animal browsing, rodent damage, and fire outbreaks are conducted.

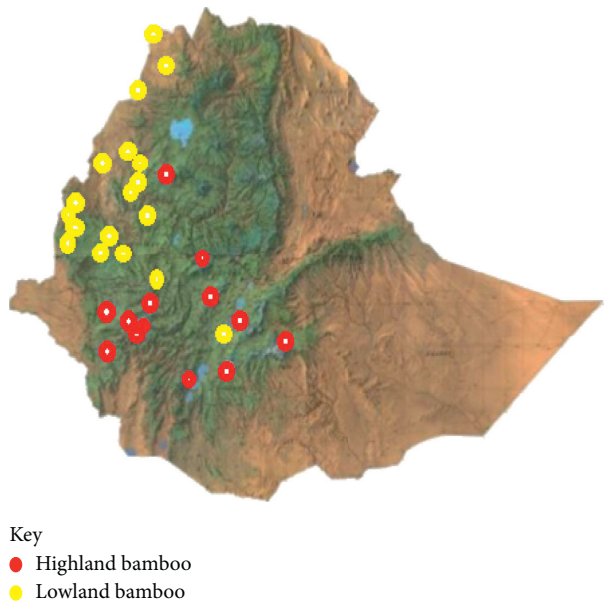


Figure 6: Geographical distribution of *O. alpina* and *O. abyssinica* in Ethiopia. Origin: indigenous to Ethiopia and endemic to Africa [13, 14].


Figure 7: Fresh collected seeds of (a) *O. alpina* from Hula district and (b) *O. abyssinica* from Assosa district after mass flowering and fruiting in 2017.


Figure 8: *O. alpina* (a) and *O. abyssinica* (b) seedlings at CEE-FRC greenhouse in January 2021, Addis Ababa.

Figure 9: Bamboo charcoal making in Ethiopia (source: [22]).

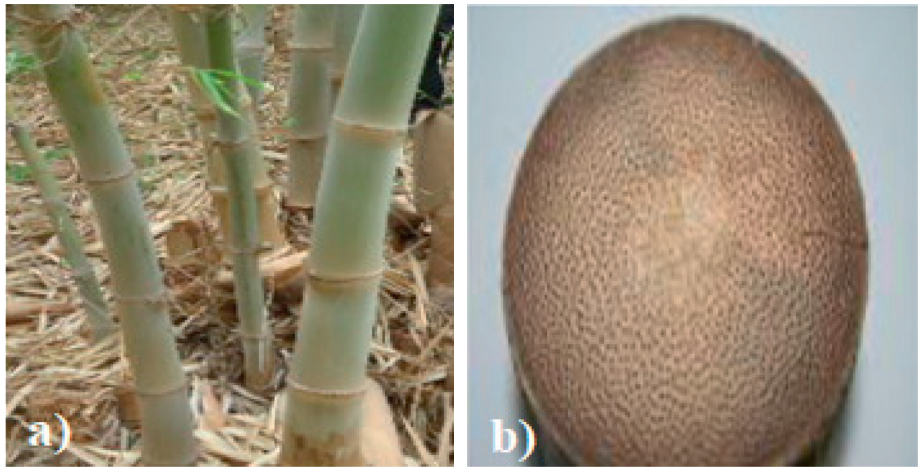


Figure 10: *O. abyssinica* standing culms (a) and thick and solid culms after maturation (b).

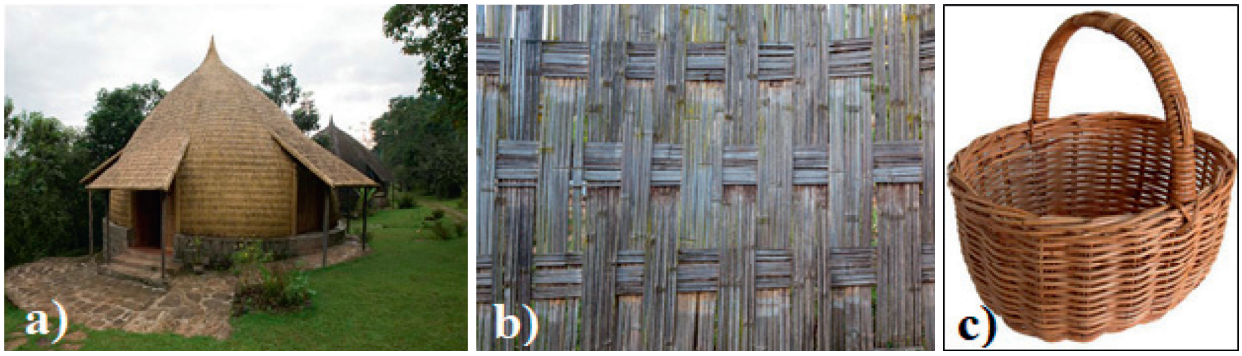


Figure 11: Traditional use of bamboo for (a) house construction, (b) fencing, and (c) household utensils (e.g., basket).

Uses: traditional house construction and fencing, furniture and household utensils, farming tools, livestock fodder and traditional medicine, production of handicrafts (basketry, mats, hats, and decorative items), water pipes, weaving, beehive, musical instruments and weapons, walking sticks, furniture, and other household utensils. In recent years, various industries and factories are emerged on processing and production of bamboo products. Some of these products are production of toothpicks and chopsticks, parquet flooring, window blinds, curtains, bioenergy (charcoal and briquettes (Figure 9)), and other related products for local and international market.

*5.2. Oxytenanthera abyssinica (A. Rich.) Munro*

Common name: lowland bamboo [2, 13, 14, 42]

Local name: Shimel in Amharic and Shimalla in Affan Oromo [2, 42]

Synonymous: *Bambusa abyssinica* A. Rich. [2, 13, 14]

Description: *O. abyssinica* grows up to a height of 13 m and a diameter of 10 cm [2]

Rhizome type: the species is a solid clump-forming bamboo and classified under the sympodial or pachymorph rhizome type [2, 4, 29, 42]. It is

characterized by a short-necked rhizome type, and each new rhizome turns up ward and sprouts to shoot and eventually develops into a young culm (Figure 2(b)).

Culms: it has an erect or ascending culm with a height of 3–13 m and a culm diameter of 5–10 cm [2]. Unlike most of the bamboo species, it has semisolid culm (Figures 10(a) and 10(b)) during the early stage of development but solid after maturation [2, 4, 29, 42]. During the early young stage, the culm is silky and hairy, while shiny with various colors after maturation [2].

Culms sheaths: it is covered with brown hairs with leaf blade at its tip part (Figure 4(a)). However, the sheath further consists of a few deciduous setae on the shoulders but without auricles [2].

Leaves: narrow lanceolate-oblong leaf blade is attached to culm sheath with a very short petiole or pseudopetiole [2]

Flowering pattern: the flowering pattern of *O. abyssinica* is gregarious flowering (Figure 5(b)), i.e., mass flowering followed by mass death of the whole bamboo forest after seed production [38, 42]. Still other findings report that the species has both flowering patterns, i.e., cyclical gregarious flowering and unpredictable sporadic flowering [29, 42]. This suggests that there is no consistency of data on the flowering intervals of these species, and it varies among different sources. Therefore, detail and long-term study on flowering phenomena needs special attention.

Inflorescence: this species has an inflorescence with a spiky globose head and characterized by narrow lanceolate-shaped spikelet [2]. In addition, the same author noted that the fertile lemmas have comparable length to the spikelet unlike the sterile lemmas with a shorter size.

Distribution: the species is widely distributed in lowland regions of western and northwestern parts of Ethiopia [43] in Tigray, Gonder, Gojam, and Welega regions as shown in Figure 6 [2]. *Oxytenanthera abyssinica* is found in savanna woodland, favoring river valleys, often forming extensive stands at the altitudes ranging from 1200 m to 1800 m above the sea level [2]. Yet, Meredith [4] explained that it is distributed throughout tropical Africa at altitudinal ranges from near the sea level to 2000 m in savannahs and on hillsides. Its annual rainfall ranges 700–1000 mm, which is concentrated over a period of three to four months with the mean annual temperature of above 30 C [42]. The species can grow at a minimum temperature of −1 C and prefers moist conditions along waterways [4]. However, this author further found out that *O. abyssinica* can grow in full sunlight, and it is also drought resistant and may be deciduous in hot and dry conditions. The species is easily adaptable to poor soils and provided as a buffer zone for desert areas. The species form either a large area pure forest or they are found as middle and lower layers in the mixed forest associated by other species in the mountainous areas.

Origin: indigenous to Ethiopia and endemic to Africa [13, 14]

Silvicultural application: the species is propagated by seeds as shown in Figure 7(b) [29, 40, 44–47] or collected seedlings from the wild at nursery. There is also better availability of *O. abyssinica* seeds, higher seed germination, and better greenhouse performance of seedlings compared to *O. alpina* (Figure 8)(b) [40]. In addition, the species is vegetatively propagated through offset cutting, macroproliferation [29, 42], and tissue culture [48]. Once seedlings are raised at nursery or green house, weeding, hoeing, fertilizer application, supervision of insects and pests, and acclimatization (hardening) are carried out [46]. Following this, seedlings are safely transported to prepared plantation sites and planted with or without the application of organic manure. Once established, the survival rate and growth performance of seedlings are supervised and dead seedlings are replaced. Hereafter, various plantation managements including thinning, fertilizer application, selective cutting, regular weeding and cleaning, soil loosening, supervision of insects, pests, and diseases, and controlling animal browsing, rodent damage, fire outbreaks are conducted.

Uses: traditional house construction and fencing, furniture and household utensils, farming tools, edible shoot production, livestock fodder and traditional medicine, production of handicrafts (basketry, mats, hats, and decorative items), water pipes, weaving, beehive, musical instruments and weapons, walking sticks, furniture, and other household utensils. In recent years, various industries and factories are emerged on processing and production of bamboo products. Some of these products are production of toothpicks and chopsticks, parquet flooring, window blinds, curtains, bioenergy (charcoal and briquette), and other related products for local and international market.

## 6. Opportunities and Challenges on Bamboo Resource in the African Region

*6.1. Opportunities.* Our extensive literature review indicated that bamboo resource has some tremendous opportunities for its development and promotion in the region. The African region has untapped bamboo resource potential with immense socioeconomic, cultural, and ecological significances to local people (Figures 11(a)–11(c)). At the same time, due to its fast growth rate, high biomass production, and short rotation period, bamboo resource is one of the most promising and suitable species to replace the forest resource. In recent years, emerging community-based bamboo processing cooperatives, enterprises, and industries for different end products are some of the opportunities. Some of these products are production of baskets, mats, toothpicks and chopsticks, parquet flooring, window blinds, curtains, and other related products for local and international market. Bamboo biomass also can provide a sustained source of feedstock for bamboo-based bioenergy

production. Thus, bioenergy is produced by the conversion of bamboo biomass into solid fuels (firewood, charcoal, and briquette for cooking, heating, and lighting), liquid fuels or biofuels (bioethanol and biomethane production), and biogas (to produce power or electricity) [49]. Its suitability to replace the role of forest products such as timber and wood is its best potential value. For instance, bamboo culms are commonly served as scaffoldings and replaced the role of iron steel or wood functions [50]. Nowadays, timber harvesting, bamboo poles, and scaffoldings are emerging opportunities for bamboo resource development. Selling of bamboo culms is one of the attractive income generating activities in the bamboo sector in Ethiopia. According to Lou [8], the global bamboo trade is estimated to be between $1.5 and 2.5 billion. Out of $18 million exports of bamboo products in African, Ethiopia contributes $0.23 million, which is accounted for about 0.02% of the global exports [51]. The same study also reported that bamboo pole, which is the most exported bamboo commodity, accounted for about $0.23 million. A total of 89,845 highland bamboo poles are produced by the smallholder households for house construction, furniture production, handcraft making (bed, table, chair, shelve, and mat), fencing, and household utensils [52]. In turn, the average total annual income from bamboo in Sidama, Awi, and Sheka is 2235, 2084, and 284 Birr, respectively [53]. In the same way, out of the average annual 21000 bamboo culms supply, an average annual $6738 net income is earned at Addis Ababa market [54]. Edible bamboo shoots are one of the most important sources of daily dish with rich sources of nutritional contents. For instance, the nutritional analysis of indigenous bamboo species in Ethiopia (*A. alpina* and *O. abyssinica*) indicated that both species have almost comparable moisture content, ash, crude fiber, protein, fat, and mineral (iron, zinc, and sodium) composition [55]. By contrast, the same authors found that tannin and phytate contents in *O. abyssinica* and HCN in *A. alpina* are low. Thus, bamboo shoots production is one of the most promising species to ensure food security especially in the rural setting. Associated with this resource base assessment, introducing new species from elsewhere, propagation, utilization, and management practices of the bamboo resources are enhanced from time to time. On the other hand, it has a high potential to sink a considerable amount of carbon and hence confront climate change across the globe. For instance, literature review from various previous studies reported that mean carbon storage rate ranges from $30\,\mathrm{Mg\,ha^{-1}}$ to $121\,\mathrm{Mg\,ha^{-1}}$, while the mean carbon sequestration potential is $6–13\,\mathrm{Mg\,ha^{-1}\,yr^{-1}}$ [56]. Similarly, the carbon sequestration potential of Moso bamboo is 43 tone $\mathrm{ha^{-1}}$ [8]. This, in turn, plays a paramount importance in the Clean Development Mechanism (CDM) and Climate Resilient Green Economy (CRGE).

*6.2. Challenges and Constraints.* Despite immense opportunities of the resource, there are critical challenges faced to the bamboo resource in the African region. Our extensive literature review reported that data are almost unavailable, fragmented, inconsistent, and even contradictory [7]. For instance, the study further noted that out of 7 introduced bamboo species in Algeria, only 1 species is identified and included during this review. In addition, the resource is marginalized and neglected by development practitioners so that its utilization is restricted to traditional and cultural uses in the rural setting. Its importance and use are limited to hut construction, fencing, production of handicrafts (basketry, mats, hats, and decorative items), water pipes, furniture, and other household utensils. Among others, common occurrence in the river banks, stream banks, pocket areas, hillsides, between fields and abandoned areas, degraded areas, and planted as hedges are some of the existing evidences. Due to this reason, there are limited management practices, and hence, depletion of bamboo resource is the major concern in potential areas. Likewise, the resource is gradually declining due to various human-induced and natural factors. These include agricultural expansion or shifting cultivation, high fuel wood demand, construction and human settlement, and other associated factors [7, 13, 14, 36, 39, 42]. Uncontrolled and/or deliberate forest fire in the dryland areas, overgrazing/over browsing by livestock particularly during dry seasons in lowland areas (*O. abyssinica*) or in limited feed resource in the highland areas (*O. alpina*), and overharvesting the resource further aggravate the problem. Furthermore, limited availability of seeds; difficulty in seed collection, processing, and handling; low seed viability; and poor seed storage characteristics are the practical problems in bamboo large-scale propagation using seeds [40, 47]. The problem is even more complicated with mass flowering and death of bamboo (Figures 5(a) and 5)(b), flowering at longer intervals, and unpredicted flowering [29, 38, 39, 42]. Overall, all the aforementioned limitations influence the small-scale and large-scale plantation expansion and development, sustainable use and management, as well as genetic resource conservation of the species. Therefore, it needs urgent call for special focus and action for the sustainable development and promotion of bamboo resource in the African region.

## 7. Successful Achievements on Bamboo Resource in the African Region

Despite the long history of bamboo resource in the African region, bamboo processing and utilization are at the infant stage. However, bamboo processing and utilization in Ethiopia have some base and more competitive than other African countries [57]. The same author reported that there are above 100 bamboo furniture enterprises in Ethiopia with high quality and well-designed products. This author also noted that four modem enterprises produce bamboo floor, door, curtain, charcoal, and other products in Ethiopia. Currently, some successful achievements have been conducted on bamboo development and promotion in the region. First, an international intergovernmental organization, i.e., International Network for Bamboo and Rattan (INBAR) was established in 1997 between China and Africa for the sustainable development of bamboo and rattan in Africa [12]. With this opportunity, 40 African countries are involved in this international cooperation and exchange between China and bamboo-growing countries [27]. Following

this cooperation, several African nations have participated on short-term and long-term training and awareness raising opportunity on bamboo propagation, cultivation, and bamboo management. In relation to this, developing national bamboo policy in Kenya [58], national bamboo strategy and action plan in Ethiopia [51] and Uganda [59], as well as bamboo policy integration analysis in Ghana [60] are typical actions of bamboo development, promotion, and commercialization in the African region. In the same way, resource base inventory, introduction of new species from bamboo potential regions, propagation, cultivation, management, and sustainable utilization of bamboo resource in the African region become more strengthened. In relation with better awareness raising on bamboo development and promotion, some bamboo processing enterprises, cooperatives, and private industries and factories are emerged, providing various bamboo end products to either local or international markets. For instance, Bamboo Star Agro-Forestry Company and other bamboo factories and enterprises in Ethiopia are recently emerged and established for processing and producing bamboo endproducts either for local or international markets. Some of these products are production of toothpicks, chopsticks, and household furniture (table, door, and chair). Bamboo culms for scaffolding, casting concrete flooring, building and construction industry, pulp and paper production, laminated boards, and timber production by replacing forest wood in Africa are still new emerging experiences and skills. Furthermore, considering its immense socioeconomic, cultural, and ecological significances, various mega research projects have been initiated and implemented by some African countries. Among these, research projects on bamboo propagation, cultivation, management, and sustainable utilization as well as mass flowering and death of indigenous bamboo species in Ethiopia have been initiated and implemented formerly by the Ethiopian Institute of Agricultural Research (EIAR) and recently succeeded by Ethiopian Environment and Forest Research Institute (EEFRI) as typical model examples. In line with this, 25 bamboo species are introduced from different countries [15], and species adaptation trail has been conducted at different agroecologies [61, 62]. These species are *Dendrocalamus asper, D. hamiltonii, D. membranaceus, Bambusa vulgaris* var. *green, B. vulgaris* var. *vittata*, and *Bambusa balcooa* [61]. Of these, *D. hamiltonii, D. membranaceus* [61, 62], *D. asper*, and *Bambusa vulgaris* var. *green* [37] are the best adapted species at field. Similarly, related bamboo research studies are carried out by different researchers and professionals on indigenous and/or introduced bamboo species. Some of these are bamboo resource base assessment [35], seed propagation [40, 44–47], seedling performance [44–46, 63], utilization and management [37, 61, 64–66], vegetative propagation [41, 48, 67, 68], nutritional contents of shoots [55], and their physicochemical features [69, 70] of *O. alpina* and/or *O. abyssinica* edible shoots. Other research outputs include suitability of bamboo species for construction [50, 71–73], paper and panel boards [73, 74], furniture [39, 42, 70–74], and handcrafts [39, 42, 73, 74], industries, chemical and biochemical industries [75], as well as bioenergy production (charcoal and briquette) and durability of bamboo culms against biodegradable agents and its control measures [76, 77]. Moreover, comprehensive socioeconomic assess mentions indigenous bamboo species [52, 54, 78–91], and multiplication, prescaling up, and promotion of successfully adapted introduced bamboo species (e.g., *Dendrocalamus hamiltonii)* [61] are further achievements of bamboo research in Ethiopia. On the other hand, similar or related bamboo research studies have been conducted in different African countries at different times by different professionals. Some of these are Benin [92], Cameroon [23], Ghana [26, 93–97], Kenya [21, 24, 28, 29, 35], Nigeria [98–102], Malawi [31], Tanzania [103], Togo [33], and Uganda [35, 104, 105].

## 8. Conclusion and Recommendations

Our extensive literature review clearly showed that the African region has untapped bamboo resource potential with immense socioeconomic, cultural, and ecological significances. However, this resource is depleted as a faster rate associated with human-induced and natural factors. In addition, there are no reliable and accurate resource base data due to the lack of well-defined definition and comprehensive resource base inventory in the region. Hence, the information is inaccessible, fragmented, inconsistent, and even contradictory. Therefore, comprehensive research and accurate baseline information on bamboo resource is still required as a foundation for policy and management decisions. Similarly, most of the bamboo resource in the region is either public or state property, so that special focus and appropriate management intervention are not practiced. Hence, the ownership right on bamboo resource and associated land is also clearly specified and certified. At the same time, various silvicultural applications such as propagation, stand density management, fertilizer application, research on mass flowering and death of bamboo and its longer flowering cycle, and preharvesting and postharvesting technologies should be implemented for higher bamboo end products (timber, bioenergy, and edible shoot). Similarly, genetic resource conservation of bamboo species through ex situ conservation (e.g., seed storage in cold room at +5 C) and in situ conservation (establishing bamboo botanic garden at field) is also practiced despite the little effort. In line with this, establishing bamboo research institutions and stakeholders, community-based bamboo cooperatives and enterprisers, bamboo industries and factories, as well as small-scale and large-scale bamboo investors/farmers in plantation development should be further strengthened on bamboo resource development and promotion in the region.

## Conflicts of Interest

The authors declare that there are no conflicts of interest.

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