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

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Received 3 September 2020; Revised 16 February 2021; Accepted 25 February 2021; Published 8 March 2021

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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).
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
| No. | List of countries          | Origin and distribution of bamboo resource in the African region | Reference               |
|-----|---------------------------|----------------------------------------------------------------|------------------------|
| 1   | Algeria                   | *Guaduella densiflora, Guaduella dichroa, Olyra latifolia, Oreobambos buchwaldii, and Oxytenanthera abyssinica.* | INBAR [17]             |
| 2   | Angola                    | *O. latifolia and O. abyssinica.*                               | Ohnberger [1], Bystriakova et al. [18], INBAR [17], Clayton et al. [19] |
| 3   | Benin                     | *O. latifolia and O. abyssinica.*                               | Phillips [2], Bystriakova et al. [18], INBAR [17], Clayton et al. [19] |
| 4   | Burkina Faso              | *O. latifolia and O. abyssinica.*                               | Phillips [2], Bystriakova et al. [18], INBAR [17], Clayton et al. [19] |
| 5   | Burundi                   | *O. latifolia and O. abyssinica.*                               | Phillips [2], Bystriakova et al. [18], INBAR [17], Clayton et al. [19] |
| 6   | Cameroon                  | *B. vulgaris (B. vulgaris var. vittata (yellow variety)), Ochlandra travancorica, and Phyllostachys aurea.* | Phillips [2], Bystriakova et al. [18], INBAR [17], Clayton et al. [19] |
| 7   | Central African Republic  | *O. latifolia and O. abyssinica.*                               | Phillips [2], Bystriakova et al. [18], INBAR [17], Clayton et al. [19] |
| 8   | Chad                      | *O. abyssinica*                                               | KPRI [24], INBAR [17], Clayton et al. [19] |
| 9   | Comoros                   | *O. latifolia and Sirochloa parvifolia.*                        | Ohnberger [1], INBAR [17], Clayton et al. [19] |
| 10  | Cote d’Ivoire             | *O. oblonga, O. latifolia, and O. abyssinica.*                 | Phillips [2], Ohnberger [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.* | Phillips [2], Ohnberger [1], Bystriakova et al. [18], 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], Ohnberger [1], Bystriakova et al. [18], Clayton et al. [19] |
| 15  | Ethiopia                  | *Gigantochloa felix, O. alpina, O. latifolia, and O. abyssinica.* | Phillips [2], Embaye [14], Ohnberger [1], Bystriakova et al. [18], INBAR [17], Clayton et al. [19] |
| 16  | Gabon                     | *G. densiflora, G. marantifolia, and G. oblonga.*             | Ohnberger [1]          |
| 17  | Gambia                    | *O. latifolia and O. abyssinica.*                               | Ohnberger [1], Bystriakova et al. [18], INBAR [17], Clayton et al. [19] |
| No. | List of countries | Origin and distribution of bamboo resource in the African region | Introduced (exotic) species | Reference |
|-----|------------------|---------------------------------------------------------------|-----------------------------|-----------|
| 18  | Ghana            | B. bambos, B. multiplex, B. perversibilis, 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. | 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] |
| 21  | Kenya            | Hickelia africana, O. alpina, O. latifolia, O. buchwaldii, and Pseudosasa amabilis. | B. vulgaris | Ohrnberger [1], Bystriakova et al. [18], INBAR [17], Clayton et al. [19] |
| 22  | Lesotho          | O. abyssinica, Bergbambos tessellata, and Thannmocalamus sp. | Cathariostachys capitata, Cathariostachys madagascariensis, Cephalestachyum chapelferi, Cephalestachyum perrieri, Cephalestachyum sp., Cephalestachyum vigueri, Decaryochloa diadelpha, Hickelia aalaotrensis, Hickelia madagascariensis, Hickelia perrieri, Hitchcockella baronii, Nastus ambrensis, N. aristatus, N. decaryanus, N. elongatus, N. emrinensis, N. humbertianus, N. lokhoensis, N. madagascariensis, N. manongariensis, N. perrieri, N. tsaratanganensis, Ochlandra capitata, O. latifolia, Perrierbambus madagascariensis, Perrierbambus tsarasaotrensis, Schizostachyum perrieri, Sirochloa parvifolia (Schizostachyum bossleri), Thannmocalamus ibityensis, Thannmocalamus sp., Yushania humbertii, Y. madagascariensis, Y. perrieri, Yushania sp., Valiha diffusa, V. perrieri, and Valiha sp. | 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] |
| 23  | Liberia          | G. oblonga, O. latifolia, and O. abyssinica. | B. vulgaris | Ohrnberger [1], Bystriakova et al. [18], INBAR [17], Clayton et al. [19] |
| 24  | Libya            | Cathariostachys capitata, Cathariostachys madagascariensis, Cephalestachyum chapelferi, Cephalestachyum perrieri, Cephalestachyum sp., Cephalestachyum vigueri, Decaryochloa diadelpha, Hickelia aalaotrensis, Hickelia madagascariensis, Hickelia perrieri, Hitchcockella baronii, Nastus ambrensis, N. aristatus, N. decaryanus, N. elongatus, N. emrinensis, N. humbertianus, N. lokhoensis, N. madagascariensis, N. manongariensis, N. perrieri, N. tsaratanganensis, Ochlandra capitata, O. latifolia, Perrierbambus madagascariensis, Perrierbambus tsarasaotrensis, Schizostachyum perrieri, Sirochloa parvifolia (Schizostachyum bosseri), Thannmocalamus ibityensis, Thannmocalamus 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. 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] |
| 25  | Madagascar       | O. alpina, O. latifolia, O. buchwaldii, and O. abyssinica. | B. multiplex and D. giganteus. | Phillips [2], Grimshaw [21], Ohrnberger [1], Bystriakova et al. [18], Sosola-Banda and Johnsen [31] |
| 26  | Malawi           | O. alpina, O. latifolia, O. buchwaldii, and O. abyssinica. | B. multiplex and D. giganteus. | Phillips [2], Grimshaw [21], Ohrnberger [1], Bystriakova et al. [18], Sosola-Banda and Johnsen [31] |
| 27  | Mali             | O. abyssinica | B. multiplex and D. giganteus. | Phillips [2], Grimshaw [21], Ohrnberger [1], Bystriakova et al. [18], Sosola-Banda and Johnsen [31] |
| 28  | Mauritius        | Probably B. tessellata | B. multiplex and D. giganteus. | Phillips [2], Grimshaw [21], Ohrnberger [1], Bystriakova et al. [18], Sosola-Banda and Johnsen [31] |
| 29  | Morocco          | | | Phillips [2], Grimshaw [21], Ohrnberger [1], Bystriakova et al. [18], Sosola-Banda and Johnsen [31] |
Table 1: Continued.

| No. | List of countries       | Indigenous (native) species | Introduced (exotic) species                                                                 | Reference                                      |
|-----|-------------------------|-----------------------------|-------------------------------------------------------------------------------------------|------------------------------------------------|
| 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               | B. vulgaris, Brachystachyum stellatus, Dayeteng spp., D. giganteus, D. sinicus, Fargesia robusta, Gelidocalamus stellatus, Nuomizhu xiaoyeget, P. edulis (P. heterocyla var. pubescens), Pleioblastus fortunei, Shibataea chinensis, and Y. baishazuenensis. | Ohrnberger [1], Bystriakova et al. [18], INBAR [17], Clayton et al. [19] |
| 32  | Nigeria                 | G. densiflora, G. humilis, O. latifolia, and O. abyssinica. | B. bambos, B. vulgaris (B. striata), Dayeteng spp., D. giganteus, D. sinicus, Fargesia robusta, Gelidocalamus stellatus, Nuomizhu xiaoyeget, P. edulis (P. heterocyla var. pubescens), Pleioblastus fortunei, Shibataea chinensis, and Y. baishazuenensis. | 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. | B. multiplex, B. vulgaris, D. giganteus, D. strictus, and P. nigra.                         | 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 Principe   | O. latifolia and O. abyssinica. | B. balcooa and B. vulgaris.                                                              | INBAR [17], Haroun et al. [32]                |
| 37  | Senegal                 | O. latifolia and O. abyssinica | B. multiplex, B. vulgaris, D. giganteus, D. strictus, and P. nigra.                       | Phillips [2], Ohrnberger [1], Bystriakova et al. [18], Inada and Hall [20], INBAR [17], Clayton et al. [19] |
| 38  | Seychelles              | G. oblonga, O. latifolia, and O. abyssinica. | B. vulgaris                                                                             | 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. | B. polymorpha, B. teres, B. tuldta, B. vulgaris, D. giganteus, D. hamiltonii, D. longispathus, D. strictus, D. pergracile, and Melocanna baccifera. | Ohrnberger [1], Bystriakova et al. [18], Inada and Hall [20], Ohrnberger [1], Bystriakova et al. [18], Clayton et al. [19] |
| 42  | Sudan                   | O. alpina, O. latifolia, and O. abyssinica. | B. multiplex, B. vulgaris, D. giganteus, D. strictus, and P. nigra.                       | Zhou [16], INBAR [17], Clayton et al. [19] |
| 43  | Swaziland               | O. abyssinica               | B. beechevanya, B. birmanica, B. dissimulato, B. edulis, B. oldhamii, B. nutans, B. polymorpha, B. spinosa, B. ventricosa, B. warmin, B. brandisi, D. latiflorus, D. membranaceus, D. strictus, G. abilocia, Gigantochloa bali white, Gigantochloa luteostrata, Gigantochloa malay dwarf, G. angustifolia, and G. chacoensis. | INBAR [17] |
| 44  | Togo                    | B. bambos, B. multiplex, B. vulgaris (B. vulgaris var. striata), O. latifolia, and O. abyssinica. | B. multiplex, B. vulgaris, D. giganteus, D. strictus, and P. nigra.                       | 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 | O. alpina, O. latifolia, O. buchwaldii, and O. abyssinica. | D. asper                                                                                | 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. | D. asper                                                                                | Ohrnberger [1], Bystriakova et al. [18], Zhou [16], INBAR [17], Clayton et al. [19] |
| 48  | Zimbabwe                | O. latifolia, O. buchwaldii, and O. abyssinica. | D. asper                                                                                | 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 bceheyana* 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.) Raeschn. ex Schult. f., *Bambusa multiplex* f. *alphonse-karrii* (Mitford ex Satow) Nakai, or *Bambusa multiplex* Roxb. |
| 12  | *Bambusa mutans* Wall. ex Munro |
| 13  | *Bambusa oldhamii* Munro |
| 14  | *Bambusa pachinensis* Hayata and *Bambusa textilis* var. *fusca* McClure |
| 15  | *Bambusa pteriariabilis* 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* Lodde ex Lindl., *Bambusa vulgaris* var. *green*, *Bambusa vulgaris* var. *striata* (Lodde 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 madagascariensis* (A. Camus) S. Dransf. |
| 27  | *Cathariostachys capitata* (Kunth) S. Dransf. |
| 28  | *Cephalostachyum chapeliieri* 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 lateosira* 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 lakoheoensis* A. Camus |
| 79  | *Nastus madagascariensis* A. Camus |
| 80  | *Nastus manongarivensis* A. Camus |
| 81  | *Nastus perrieri* A. Camus |
| 82  | *Nastus taratananensis* A. Camus |
| 83  | *Nuomizhu xiaoyeteng* |
| 84  | *Ochlandra capitata* (Kunth) Camus |
| 85  | *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 |
| 86  | *Olyra latifolia* L. |
| 87  | *Oreobambos buchwaldii* K. Schum. |
| 88  | *Oxytenanthera abyssinica* (A. Rich.) Munro and *Oxytenanthera braunii* Pilg. |
| 89  | *Perrierbambus madagascariensis* A. Camus |
| 90  | *Perrierbambus tsarasaotrensis* A. Camus |
| 91  | *Phyllostachys aurea* (André) Rivière and C. Rivière |
| 92  | *Phyllostachys edulis* (Carrière) J. Houz., *Phyllostachys pubescens* (Pradelle) Mazel ex J. Houz., *Phyllostachys heterocycla* var. pubescens (Pradelle) Ohwi, or *Bambusa edulis* Carrière |
| 93  | *Phyllostachys nigra* var. *henonis* (Mitford) Rendle |
| 94  | *Pleioblastus fortunei* (Van Houtte) Nakai and *Sasa pygmaea* (Miq.) Rehder |
| 95  | *Pseudosasa amabilis* (McClure) Keng f. and *Arundinaria amabilis* McClure |
| 96  | *Pseudosasa japonica* (Siebold and zucc. ex Steud.) Makino ex Nakai |
| 97  | *Puelia atractocarpa* |
| 98  | *Schizostachyum jaculans* Holtum |
| 99  | *Schizostachyum perigracile* (Munro) R. B. Majumdar in S. Karthikeyan et al. and *Cephalostachyum perigracile* Munro |
| 100 | *Schizostachyum perrieri* A. Camus |
| 101 | *Shibataea chinensis* Nakai |
| 102 | *Shibataea kumasaca* (Zoll. ex Steud.) Makino |
| 103 | *Sirochloa parvifolia* (Munro) S. Dransf., *Schizostachyum parvifolium* Munro, or *Schizostachyum bosseri* A. Camus |
| 104 | *Thamnocalamus ibitensis* (A. Camus) Ohnrb. |
| 105 | *Thamnocalamus sp.* |
| 106 | *Thysrostachys siamensis* Gamble |
| 107 | *Valiha diffusa* S. Dransf. |
| 108 | *Valiha perrieri* (A. Camus) S. Dransf and *Ochlandra perrieri* A. Camus |
| 109 | *Valiha sp.* |
| 110 | *Yushania baishazuensis* Z. P. Wang and G. H. Ye |
| 111 | *Yushania humbertii* (A. Camus) Ohnrb and *Yushania ambositrensis* (A. Camus) Ohnrb. |
| 112 | *Yushania madagascariensis* (A. Camus) Ohnrb and *Yushania marojejyensis* (A. Camus) Ohnrb. |
| 113 | *Yushania perrieri* (A. Camus) Ohnrb. |
| 114 | *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.
| No. | Tribe | Genus name | Distribution of each genus in the African nations |
|-----|-------|------------|---------------------------------------------------|
| 1   | Bergbambos | Lesotho | 1 |
| 2   | Bambusa | Benin, Burkina Faso, Cameroon, Cote d’Ivoire, Democratic Republic of Congo, Egypt, Ethiopia, Ghana, Guinea, Kenya, Libya, Madagascar, Mozambique, Mauritius, Mozambique, Nigeria, Rwanda, Sao Tome and Principe, 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, Reunion, 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, Sao Tome and Principe, 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  | Valia | Madagascar | 1 |
| 31  | Guadua | Angola, Cameroon, Cote d’Ivoire, Gabon, Ghana, Guinea, Liberia, Nigeria, Republic of Congo, and Sierra Leone | 10 |
| 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, Lesotho, Liberia, Malawi, Mali, Mozambique, Niger, Nigeria, Republic of Congo, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, Sudan, Togo, Uganda, United Republic of Tanzania, Zambia, and Zimbabwe | 30 |
| 33  | Puelia | Cameroon | 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 | Introduced | Total | Genera |
|----------------|---------|------------|-------|--------|
| 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 Thanamocalamus sp. | | | |
| | Bambusa, Bergbambos, Dendrocalamus, Gigantochloa, Guaduella, Hickelia, Olدارnia, Olyra, Oreobambos, Oxytenanthera, Pseudosasa, Puelia, and Thanamocalamus | | | |
| | 21 | | | |
| | | | | 78
| | | | | 13
| | | | | 19
| | | | | 27
| | | | | Bambusa, Brachystachyum, Dayeteng, Dendrocalamus, Fargesia, Gelidocalamus, Gigantochloa, Guaduella, Hickelia, Olyra, Oreobambos, Oxytenanthera, Pseudosasa, Puelia, and Thanamocalamus | | | |
| | | | | 13
| | | | | | 19
| | | | | | 27
| | | | | | 19
| | | | | | 27
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]
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 5: A summary of the origin and distribution of bamboo resource in the African region.

| List of countries | Indigenous | Origin of bamboo species | Introduced | Total |
|-------------------|------------|--------------------------|------------|-------|
| Algeria           | 1          |                          | 1          | 1     |
| Angola            | 5          |                          | 5          | 5     |
| Benin             | 2          |                          | 3          | 5     |
| Burkina Faso      | 2          |                          | 3          | 5     |
| Burundi           | 4          |                          | 1          | 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          |       |
| 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 Principe * | 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.
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 2200m to 4000m 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].

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**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] |
| 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**                  | **100**                | **FAO** |

**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)).
Once seedlings are raised at nursery or greenhouse (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.
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 Afan 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
Origin: indigenous to Ethiopia and endemic to Africa 

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 significance 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 scaffolding and replaced the role of iron steel or wood functions [50]. Nowadays, timber harvesting, bamboo poles, and scaffolding 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, handicraft making (bed, table, chair, shelves, 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 $6738 net income is earned at Addis Ababa market [54]. Edible bamboo shoots are one of the most important sources of daily diet with rich sources of nutritional contents. For instance, the nutritional analysis of indigenous bamboo species in Ethiopia (A. alpina and O. abyssinica) indicated that both species have almost comparable moisture content, ash, crude fiber, protein, fat, and mineral (iron, zinc, and sodium) composition [55]. By contrast, the same authors found that tannin and phytate contents in O. abyssinica and HCN in A. alpina are low. Thus, bamboo shoots production is one of the most promising species to ensure food security especially in the rural setting. Associated with this resource base assessment, introducing new species from elsewhere, propagation, utilization, and management practices of the bamboo resources are enhanced from time to time. On the other hand, it has a high potential to sink a considerable amount of carbon and hence confront climate change across the globe. For instance, literature review from various previous studies reported that mean carbon storage rate ranges from 30 Mg ha$^{-1}$ to 121 Mg ha$^{-1}$, while the mean carbon sequestration potential is 6–13 Mg ha$^{-1}$ yr$^{-1}$ [56]. Similarly, the carbon sequestration potential of Moso bamboo is 43 tone 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 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 modern 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 AgroForestry 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 handicrafts [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 enterprises, 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.
References

[1] D. Ohrnberger, The Bamboos of the World: Annotated Nomenclature and Literature of the Species and the Higher and Lower Taxa, Elsevier, Amsterdam, Netherlands, 1999.

[2] S. Phillips, “Poaceae (Gramineae),” in Flora of Ethiopia Volume 7.1, Heiberg and S. Edwards, Eds., pp. 3–6, Uppsala University, Uppsala, Sweden, 1995.

[3] Z. Wu, P. H. Raven, and D. Hong, Flora of China, Vol. 22 (Poaceae), Science Press, Beijing and Missouri Botanical Garden Press, St. Louis, MO, USA, 2006.

[4] T. J. Meredith, Bamboo for Gardens, Timber Press, Portland, OR, USA, 2001.

[5] M. Fu, Sustainable Management and Utilization of Sympodial Bamboos, China Forestry Publishing House, Beijing, China, 2007.

[6] Z. Peng and X. Wan, “Bamboo culture,” in Bamboo and Rattan in the World, Z. Jiang, Ed., pp. 246–256, China Forestry Publishing House, Beijing, China, 2007.

[7] FAO, World Bamboo Resources: A Thematic Study Prepared in the Framework of the Global Forest Resources Assessment 2005, Non-Wood Forest Products No. 18, Food and Agriculture Organization of the United Nations, Rome, Italy, 2007.

[8] Y. Lou, “Comprehensive benefits of Bamboo forests,” in Bamboo and Rattan in the World, Z. Jiang, Ed., pp. 106–114, China Forestry Publishing House, Beijing, China, 2007.

[9] UNDPI, “Bamboo: Africa’s untapped potential,” AfricaRenewal, vol. 30, no. 1, 2000.

[10] X. Chen, J. Dong, H. Dai et al., Technical Manual on Asian Tropical Bamboo Shoots Production, Processing and Marketing, China Forestry Publishing House, Beijing, China, 2010.

[11] M. Fu, J. Xie, B. Zhou, Z. Li, and X. Xiao, Technical Manual on Symopodial Bamboos Cultivation, China Forestry Publishing House, Beijing, China, 2007.

[12] Z. Jiang and X. Liu, “Introduction,” in Bamboo and Rattan in the World, Z. Jiang, Ed., pp. 2–9, China Forestry Publishing House, Beijing, China, 2007.

[13] K. Embaye, “The indigenous bamboo forests of Ethiopia: an overview,” AMBIO: A Journal of the Human Environment, vol. 29, no. 8, pp. 518–521, 2000.

[14] K. Embaye, “The Indigenous Bamboos of Ethiopia: a call for attention and action,” Walia: journal of the Ethiopian Wildlife and Natural History Society, vol. 20, pp. 3–8, 1999.

[15] H. Huojin, Monograph on Bamboo Resources and Utilization Techniques, Ministry of Environment and Forest, Mishufen Printing Press, Addis Ababa, Ethiopia, 2014a.

[16] F. Maina, Selected Works of Bamboo Research and the Picture of Bamboo, The Bamboo Research Editorial Committee, Nanjing Forestry University, Nanjing, China, 2005.

[17] INBAR, “World checklist of bamboos and rattans,” INBAR Technical Report No. 37, INBAR, Beijing, China, 2016.

[18] N. Bystraikowa, V. Kapos, and I. Lysenko, BambooBiodiversity, UNEP-WCMC/INBAR, Cambridge, UK, 2004.

[19] W. D. Clayton, M. S. Vorontsova, K. T. Harman, and H. Williamson, Grass Base-The Online World Grass Flora, http://www.kew.org/data/grasses-db.html, January 2020.

[20] T. Inada and J. B. Hall, “Oxytenanthera abyssinica (A. Rich.) Munro,” in PROTA (Plant Resources of Tropical Africa/ Ressources végétales de l’Afrique tropicale), Wageningen, D. Louppe, A. A. Oteng-Amoako, and M. Brink, Eds., http://www.prota4u.org/search.asp, March 2018.

[21] J. M. Grimshaw, “The afromontane bamboo, Yushania alpina, on Kilimanjaro,” Journal of East African Natural History, vol. 88, no. 1, pp. 79–83, 1999.

[22] INBAR, Bamboo as Sustainable Biomass Energy. Newsletter No. 2, INBAR, Beijing, China, 2010a.

[23] V. Ingram, J. C. Tieghong, E. M. Nkamgna, J. P. Eyeye, and N. Ngawel, Bamboo Production to Consumption System in Cameroon, (Working Paper No. 50), CIFOR/INBAR, Yaounde, Cameroon, 2010.

[24] KFRI, Status of Bamboo Resources Development in Kenya, Kenya Forestry Research Institute (KFRI), Nairobi, Kenya, 2008.

[25] S. F. Moustafa, O. G. Mohamed, M. M. Fathy et al., “Botanical and genetic characteristics of certain Bambusa species cultivated in Egypt,” World Journal of Pharmacy and Pharmaceutical Sciences, vol. 3, no. 6, pp. 2075–2100, 2014.

[26] E. Appiah-Kubi, F. W. Owusu, S. L. Tekpetey, C. Essien, and H. Seidu, “Investigating the mechanical properties of some bamboo species for efficient utilization in Ghana,” Journal of Bamboo and Rattan, vol. 13, pp. 81–89, 2014.

[27] INBAR, “Bamboo for Africa: a strategic resource to drive the continent’s green economy,” Policy Synthesis Report No. 2, INBAR, Beijing, China, 2015.

[28] B. N. Kigomo and J. F. Kamiri, “Observations on the growth and yield of Oxytenanthera abyssinica (A. Rich) Munro in plantation,” East African Agricultural and Forestry Journal, vol. 51, no. 1, pp. 22–29, 1985.

[29] B. N. Kigomo, Guidelines for Growing Bamboo. KEFRI Guideline Series: No. 4, KenyaForestry Research Institute (KEFRI). Downtown Printing Works Ltd., Nairobi, Kenya, 2007.

[30] T. King, H. L. L. Randrianarimanana, L. H. F. Rakotonirina et al., “Large-culmed bamboos in Madagascar: distribution and field identification of the primary food sources of the critically endangered greater bamboo LemurProlemur simus,” Primate Conservation, vol. 27, no. 1, pp. 33–53, 2013.

[31] B. G. Sosola-Banda and F. H. Johnsen, “Rural livelihoods on Bamboo handicraft making and culm vending in Mvera, Malawi,” Journal of Bamboo and Rattan, vol. 4, no. 1, pp. 93–107, 2005.

[32] R. Haroun, A. H. Barrencua, and A. D. Abreu, “Mangrove habitats in São Tomé and Principe (Gulf of Guinea, Africa): conservation and management status,” in Threats to Mangrove Forests, Coastal Research Library 25, C. Makowski and C. W. Finkl, Eds., Springer International Publishing AG, Part of Springer Nature, Basingstoke, UK, pp. 589–605, 2018.

[33] A. Randrihaingo, K. Adjonou, A. Guelly, and K. Kokou, “Bamboo resources in Togo,” International Journal of Biological and Chemical Sciences, vol. 8, no. 2, pp. 481–493, 2014.

[34] INBAR, “Properties of East African bamboo: the physical, mechanical, chemical and morphological test results of three East African bamboo species,” INBAR Working Paper No. 80, Beijing, China, 2019.

[35] Y. Zhao, D. Feng, D. Jayaraman et al., “Bamboo mapping in the Kilimanjaro,” AMBIO: A Journal of the Human Environment, vol. 27, no. 1, pp. 33–53, 1999.

[36] J. M. Grimshaw, “The afromontane bamboo, Yushania alpina, on Kilimanjaro,” Journal of East African Natural History, vol. 88, no. 1, pp. 79–83, 1999.
Environment and Forest Research Institute (EEFRI), Addis Ababa, Ethiopia, 2016b.

[38] D. Sertse, T. Disasa, K. Bekele et al., “Mass flowering and death of Bamboo: a potential threat to biodiversity and livelihoods in Ethiopia,” Journal of Biodiversity and Environmental Sciences, vol. 1, no. 5, pp. 16–25, 2011.

[39] UNIDO, Bamboo Cultivation Manual. Guidelines for Cultivating Ethiopian Highland Bamboo, Eastern Africa Bamboo Project, United Nations Industrial Development Organization (UNIDO), Vienna, Austria, 2009a.

[40] T. Bahru, Y. Mulatu, and B. Kidane, “Germination ecology of Arundinaria alpina (K. Schum.) and Oxytenanthera abyssinica (A. Rich.) Munro seeds: indigenous bamboo species in Ethiopia,” International Journal of Biodiversity, vol. 2015, Article ID 323128, 8 pages, 2015.

[41] T. Hunde, Y. Adane, and M. Adilo, “Assessment of different vegetative propagation techniques on rooting and shooting ability of Arundinaria alpina,” Ethiopian Journal of Natural Resources, vol. 7, no. 1, pp. 131–139, 2005.

[42] UNIDO, Bamboo Cultivation Manual. Guidelines for Cultivating Ethiopian Lowland Bamboo, Eastern Africa Bamboo Project, United Nations Industrial Development Organization (UNIDO), Vienna, Austria, 2009b.

[43] S. Nune, “Short notes on bamboo,” in Kosso, A Quarterly Newsletter of the Ethiopian Foresters’ Association, pp. 2–5, Ethiopian Foresters’ Association (EFA), Addis Ababa, Ethiopia, 2001.

[44] D. A. Ayana, “Seed Characteristics of Lowland Bamboo (Oxytenanthera abyssinica (A. Rich.) Munro)) as affected by site and position of fruit on the culm,” M.Sc. thesis, Hawassa University, Shashemene, Ethiopia, 2006.

[45] D. A. Ayana, A. Gure, and E. Embaye, “Flowering and causes of seed defects in lowland bamboo (Oxytenanthera abyssinica): a case study in Benishangul Gumuz Regional State, Northwestern Ethiopia,” International Journal of Life Sciences, vol. 4, no. 4, pp. 251–259, 2015.

[46] T. Bahru, Y. Mulatu, and B. Kidane, “Provenance variation on early survival rate and growth performance of Oxytenanthera abyssinica (A. Rich.) Munro seedlings at greenhouse: an indigenous lowland bamboo species in Ethiopia,” International Journal of Energy Research, vol. 2018, Article ID 5713456, 2018.

[47] T. Bahru, B. Kidane, A. Araya et al., “Effects of germination sites on germination percentage, germination energy and germination value of the lowland Bamboos seeds,” in Forestry and Forest Products in Ethiopia, Proceedings of the National Workshop on Forestry Research Technologies Dissemination 29–31 May 2012, Hiray Hall, W. Tadesse, G. Desalign, and A. Yirgu, Eds., pp. 85–95, Ethiopian Institute of Agricultural Research (EIAR), Addis Ababa, Ethiopia, 2012.

[48] B. Kahsay, F. Mekibib, and A. Teklewold, “In vitro propagation of Oxytenanthera abyssinica (A. Rich. Munro) from seed culture,” Biotechnology Journal International, vol. 18, no. 2, pp. 1–13, 2017.

[49] R. Sharma, J. Wahono, and H. Baral, “Bamboo as an alternative bioenergy crop and powerful ally for land restoration in Indonesia,” Sustainability, vol. 10, no. 12, p. 4367, 2018.

[50] M. Abegaz, N. Juju, and B. Oluma, “Oxytenanthera abyssinica bamboo stems as reinforcement steel bar in concrete,” Ethiopian Journal of Natural Resources, vol. 7, no. 1, pp. 95–109, 2005.

[51] EBSDAP, 2019–2030 Ethiopian Bamboo Development Strategy and Action Plan, Environment, Forest and Climate Change Commission of Ethiopia & International Bamboo and Rattan Organisation (INBAR), Addis Ababa, Ethiopia, Beijing, China, 2020.

[52] T. Teshale, T. Woldeamanuel, T. Bekele, A. Alemu, and J. Pretzsch, “Market channels for highland bamboo poles originated from Hula district, Sidama zone southern Ethiopia,” Small-Scale Forestry, vol. 16, no. 3, 2017.

[53] T. Endalamaw, A. Lindner, and J. Pretzsch, “Indicators and determinants of small-scale bamboo commercialization in Ethiopia,” Forests, vol. 4, no. 3, pp. 710–729, 2013.

[54] Z. Mekonnen, A. Worku, T. Yohannes, M. Alebachew, D. Teketay, and H. Kassa, “Bamboo resources in Ethiopia: their value chain and contribution to livelihoods,” Ethnobotany Research and Applications, vol. 12, pp. 511–524, 2014.

[55] Y. Mulatu, T. Bahru, B. Kidane, A. Getahun, and A. Belay, “Proximate and mineral composition of indigenous bamboo shoots of Ethiopia,” Green Journal of Agricultural Sciences, vol. 9, no. 2, pp. 215–221, 2019.

[56] A. J. Nath, R. Lal, and A. K. Das, “Managing woody bamboos for carbon farming and carbon trading,” Global Ecology and Conservation, vol. 3, pp. 654–663, 2015.

[57] H. Huojin, “Some proposals for developing Ethiopian bamboo industry,” in Suggestions for the Development of Agriculture and Forestry in Ethiopia, pp. 50–54, China Agriculture Expertise Team in Ethiopia, Addis Ababa, Ethiopia, 2014b.

[58] NRB, National Bamboo Policy, 2019, Ministry of Environment and Forestry, Nairobi, Kenya, 2019.

[59] UNBSAP, 2019–2022 Uganda National Bamboo Strategy and Action Plan, Ministry of Water and Environment of Uganda & International Bamboo and Rattan Organisation (INBAR), Kampala, Uganda & Beijing, China, 2020.

[60] INBAR, “Bamboo Policy Integration Analysis in Ghana,” INBAR, Beijing, China, INBAR Working Paper No. 83, 2020.

[61] Y. Mulatu, A. Alemayehu, and Z. Tadesse, Bamboo Species Introduced in Ethiopia: Biological, Ecological and Management Aspects, Ethiopian Environment and Forest Research Institute (EEFRI), Addis Ababa, Ethiopia, 2016a.

[62] R. Terefe, D. Samuel, M. Sanbato, and M. Daba, “Adaptation and growth performance of different lowland bamboo species in Bako, West Shoa, Ethiopia,” Journal of Natural Sciences Research, vol. 6, no. 9, pp. 61–65, 2016.

[63] K. Embaye, L. Christersson, S. Ledin, and M. Weih, “Bamboo as bioresource in Ethiopia: management strategy to improve seedling performance (Oxytenanthera abyssinica),” Bioresource Technology, vol. 88, no. 1, pp. 33–39, 2003.

[64] S. Gebrekidan, L. Tiki, and Y. Mulatu, “Indigenous knowledge on highland bamboo (Yushania alpina) management and utilization practices in Kokosa Woreda, South East Ethiopia,” Scientific Research and Essays, vol. 13, no. 11, pp. 111–122, 2018.

[65] INBAR, Study on Utilization of Lowland Bamboo in Benishangul Gumuz Region, Ethiopia, INBAR, Beijing, China, 2010b.

[66] U. Teshoma, “Carbon storage potential of Ethiopian highland bamboo (Arundinaria alpina (K. schum.): a case study of Adiyo Woreda, South West Ethiopia,” International Journal of Environmental Sciences & Natural Resources, vol. 16, no. 5, pp. 001–011, 2019.

[67] Y. Kebede, Z. Tadesse, A. Getahun, and Y. Mulatu, “Vegetative propagation techniques of highland bamboo (Yushania alpina) in Amhara Region, North-Western Ethiopia,” World Scientific News, vol. 61, no. 2, pp. 122–136, 2017.
[68] Y. Mulatu and A. Alemayehu, Propagation of Bamboo Species in Ethiopia: Based on Practical Field Experience and Research, Ethiopian Environment and Forest Research Institute (EEFRI), Addis Ababa, Ethiopia, 2016.

[69] S. Feleke, K. Tesfaye, and A. Tebeje, "Physicochemical characteristics of bamboo shoots from Yushania alpina and Oxytenanthera abyssinica growing in Ethiopia," in Forestry and Forest Products in Ethiopia. Proceedings of the National Workshop on Forestry Research Technologies Dissemination 29–31 May 2012, W. Tadesse, G. Desalign, and A. Yirgu, Eds., pp. 294–300, Hiruy Hall, Ethiopian Institute of Agricultural Research (EIAR), Addis Ababa, Ethiopia, 2012.

[70] O. Obsa, M. Kassa, and L. Tajebu, "Physicochemical properties of bamboo (Arundinaria alpina) based agroforestry practice in Dawuro Zone, South West Ethiopia," Journal of Biology, Agriculture and Healthcare, vol. 5, no. 9, pp. 104–109, 2015b.

[71] S. Kelemwerk, "Influence of growing locations and culm positions on physical and mechanical properties of lowland bamboo (Oxytenanthera abyssinica)," in Forestry and Forest Products in Ethiopia. Proceedings of the National Workshop on Forestry Research Technologies Dissemination 29–31 May 2012, Hiruy Hall, W. Tadesse, G. Desalign, and A. Yirgu, Eds., pp. 317–327, Ethiopian Institute of Agricultural Research (EIAR), Addis Ababa, Ethiopia, 2012.

[72] S. Kelemwerk, "Effects of anatomical characteristics of Ethiopian lowland bamboo on physical and mechanical properties," China Association for Science and Technology, vol. 8, no. 3, pp. 32–43, 2009.

[73] S. Kelemwerk, P. M. Tahir, W. E. Ding, and R. Sudin, "The effects of selected anatomical characteristics on physical properties of Ethiopian highland bamboo Arundinaria alpina K.Schum. (Poaceae)," Ethiopian Journal of Biological Sciences, vol. 7, no. 1, pp. 69–84, 2008.

[74] Y. Gebremariam and D. Assefa, "Effect of age and height on some selected physical properties of Ethiopian highland bamboo (Yushania alpina)," International Journal of Scientific Research and Management, vol. 6, no. 8, pp. 70–74, 2018.

[75] A. Tolessa, B. Woldeyes, and S. Feleke, "Chemical composition of lowland bamboo (Oxytenanthera abyssinica) grown around Asossa Town, Ethiopia," World Sci. News, vol. 74, pp. 141–151, 2017.

[76] G. Desalign, "Durability of Ethiopian bamboo culms and alternative damage control measures against biodeteriorating agents," Ethiopian Journal of Science and Technology, vol. 14, no. 2, pp. 93–127, 2015.

[77] G. Desalign and M. Abegaz, "Increasing the service life of bamboo culms as construction and furniture material by controlling biodeterioration and rational utilization," in Forestry and Forest Products in Ethiopia. Proceedings of the National Workshop on Forestry Research Technologies Dissemination 29–31 May 2012, Hiruy Hall, W. Tadesse, G. Desalign, and A. Yirgu, Eds., pp. 328–360, Ethiopian Institute of Agricultural Research (EIAR), Addis Ababa, Ethiopia, 2012.

[78] A. Andargachew, "Value chain analysis for bamboo originating from Shedem Kebele, Bale Zone," M.Sc. thesis, Addis Ababa University, Addis Ababa, Ethiopia, 2000.

[79] F. Bakala, T. Bekele, and T. Woldeamanuel, "Market supply determinants of lowland bamboo culms: the case of Homosha district, Northwestern Ethiopia," African Journal of Marketing Management, vol. 9, no. 4, pp. 46–58, 2017.

[80] S. Erifo, L. Zemedu, and T. Wamanuel, "Value chain analysis of bamboo production: the case of Bule Woreda, Gedeo Zone," Industrial Engineering Letters, vol. 6, no. 1, pp. 38–47, 2016.

[81] M. Fekadu, E. Csaplovics, and P. Degeen, "Household contribution of bamboo in Masha district, southern Ethiopia," in Forestry and Forest Products in Ethiopia. Proceedings of the National Workshop on Forestry Research Technologies Dissemination 29–31 May 2012, Hiruy Hall, W. Tadesse, G. Desalign, and A. Yirgu, Eds., pp. 263–273, Ethiopian Institute of Agricultural Research (EIAR), Addis Ababa, Ethiopia, 2012.

[82] G. D. Gebramnlak, N. Abadi, and E. B. Hizkiyas, "Socioeconomic contribution of Oxytenanthera abyssinica (A. Rich) Munro and determinants of growing in homestead agroforestry system in northern Ethiopia," Ethnobotany Research and Applications, vol. 14, pp. 479–490, 2016.

[83] Y. W. Guadie, D. H. Feyssa, and D. B. Jiru, "Socio-economic importance of highland bamboo (Yushania alpina K. Schum) and challenges for its expansion in Bilibu District, East Gojjam, Ethiopia," Journal of Horticulture and Forestry, vol. 11, no. 2, pp. 32–41, 2019.

[84] T. Kassahun, "Review of bamboo value chain in Ethiopia," Journal of Biology, Agriculture and Healthcare, vol. 4, no. 27, pp. 179–190, 2014.

[85] T. Kassahun, B. Emana, and A. Mitiku, "Determinants of highland bamboo (Yushania alpina) culm supply: the case of Loma and Tocha districts, Dawuro Zone of Southern Ethiopia," Journal of Biology, Agriculture and Healthcare, vol. 5, no. 21, pp. 49–60, 2015.

[86] A. A. Kebede, "Opportunities and challenges to highland bamboo-based traditional handicraft production, marketing and utilization in Awil Zone, Northwestern Ethiopia," International Journal of History and Cultural Studies, vol. 4, no. 4, pp. 57–67, 2018.

[87] E. Kelbessa, T. Bekele, A. Gebrehiwot, and G. Hadera, A Socio-Economic Case Study of the Bamboo Sector in Ethiopia: An Analysis of the Production-to-Consumption System, International Bamboo and Rattan Organisation, Addis Ababa, Ethiopia, 2000.

[88] Y. Mekuriaw, M. Urge, and G. Animit, "Role of indigenous bamboo species (Yushania alpina and Oxytenanthera abyssinica) as ruminant feed in northwestern Ethiopia," Livestock Research for Rural Development, vol. 23, no. 9, p. 2011, 2011.

[89] O. Obsa, M. Kassa, and L. Tajebu, "Income contribution of bamboo (Arundinaria alpina) based agroforestry practice in Dawuro Zone, South West Ethiopia," Journal of Economics and Sustainable Development, vol. 6, no. 9, pp. 155–161, 2015a.

[90] K. Onyicha, Afromontane Bamboo Arundinaria alpina in Sidama Highlands: Its Utilization and Propagation Capacity by Calm Cuttings, MSc. thesis, Swedish University of Agricultural Sciences, Skinnskatteberg, Sweden, 1997.

[91] B. L. Tinsley, "Bamboo harvesting for household income generation in the ethiopian highlands: current conditions and management challenges," M.Sc. thesis, The University of Montana, Missoula, MT, USA, 2014.

[92] H. Honfo, C. Gnaanglé, S. Mensah et al., "Traditional ecological knowledge and use value of bamboo in Southeastern Benin: implications for sustainable management," Ethnobotany Research and Applications, vol. 14, pp. 139–153, 2015.

[93] S. D. Akoto, R. Obour, M. A. Appiah, and A. P. Frimpong, "Bamboo use for the housing industry in Ghana: urban stakeholders' perception," JENRM, vol. 3, no. 3, pp. 85–91, 2017.
[94] B. D. Obiri and A. A. Oteng-Amoako, “Towards a sustainable development of the bamboo industry in Ghana,” Ghana Journal of Science, vol. 21-22, pp. 14–27, 2007.

[95] F. W. Owusu, E. Appiah-Kubi, S. L. Tekpetey, C. Essien, P. I. Arthur, and G. K. Zorve, “Products development of laminated panel doors from plantation grown bamboo species in Ghana,” Journal of Bamboo and Rattan, vol. 13, no. 3-4, pp. 91–105, 2014.

[96] S. Rudolf and T. Emmanuel, “Bamboo, hope for the wood industry in Ghana,” Journal of Natural Sciences Research, vol. 3, no. 12, pp. 1–5, 2013.

[97] D. Safro, Bamboo as a Source of Bioenergy Feedstock in Ghana, M.Sc. thesis, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, 2008.

[98] O. Abimbola, “Promoting green growth of forest products industry in Nigeria through bamboo development,” Developing Country Studies, vol. 2, no. 11, pp. 65–74, 2012.

[99] J. Atanda, “Environmental impacts of bamboo as a substitute constructional material in Nigeria,” Case Studies in Construction Materials, vol. 3, pp. 33–39, 2015.

[100] O. R. Ogbanje and C. M. Diko, “Nigeria and bamboo plants as a forest product,” Journal of Agriculture and Veterinary Science, vol. 3, no. 6, pp. 55–59, 2013.

[101] A. A. Ogunjinmi, H. M. Ijeomah, and A. A. Aiyeloja, “Socio-economic importance of bamboo (Bambusa vulgaris) in Borgu local government area of Niger State, Nigeria,” Journal of Sustainable Development in Africa, vol. 10, no. 4, pp. 284–298, 2009.

[102] A. A. Ogunwusi and A. P. Onwualu, “Prospects for multi-functional utilization of bamboo in Nigeria,” Chemistry and Materials Research, vol. 3, no. 8, pp. 58–70, 2013.

[103] INBAR, “Rural enterprise development for livelihood enhancement: creation of rural community micro and small enterprises in Tanzania. INBAR’s Livelihood Development Programme,” 2008, http://www.inbar.int/livelihood/ldmain.htm.

[104] R. Gléle Kakai and A. MacNeilage, “Population structure of montane bamboo and causes of its decline in echuya central forest reserve, south West Uganda,” African Journal of Ecology, vol. 46, pp. 325–332, 2007.

[105] J. Wong, “Recommendations for the inclusion of nationally important NTFPs in standard forest inventories (EI & ISSMI),” Report to the EDF/Uganda Forest Department: Forest Resources Management and Conservation Programme, Wild Resources Limited, Gwynedd, UK, 2003.