

Review Article

Review on Factors Affecting Regeneration of Indigenous Tree Species in Ethiopia

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Abstract: This paper is a review from various research articles and literatures on factors affecting regeneration of indigenous tree species in Ethiopia. A couple of decades ago, the regeneration status of indigenous tree species in the natural forest of the country were better as compared to the situation at the present. In addition, because of the various benefits they provide for farming community, farmers cultivate indigenous tree species on their farmlands as components of agroforestry systems. The regeneration status of these indigenous tree species can be determined by comparing the population of seedlings, saplings, and matured trees of each species. The successful regeneration of these indigenous woody species depends on several factors. The ability of these woody species to initiate new seedlings and their survival and also growth of seedlings and saplings of the species are among the major factors affecting their regeneration. In addition, knowledge gap on seed biology and germination physiology, which is the base for planning quality seed collection by understanding the maturity of seeds; climatic and environmental factors that affect the resistance of a tree species and seedling survival; expansion of invasive alien species that affect the stage of either fruiting, germination or growth of tree species; anthropogenic activities such as deforestation and forest fragmentation; as well as expansion of exotic tree species are also some of the factors that affect the regeneration of these native tree species. Therefore, management and conservation strategies and interventions that are well aligned with addressing these factors should be designed and implemented for enhancing the regeneration of indigenous tree species of the country.

Keywords: Indigenous Tree Species, Regeneration Status, Tree Species, Diameter at Breast Height (DBH)

1. Introduction

Ethiopia is a country known for its diversity of landscapes including deep gorges, river valleys, huge altitude and latitude ranges as well as vivid geological history. These might be the reason for the country to be the biodiversity hotspot and the center for the origin and diversity of many flora and fauna [1-2].

Accordingly, about 6500-7000 species of higher plants are estimated to exist in the country and from these about 12% plants species are endemic [3].

Tree species diversity is a fundamental to overall forest biodiversity as it provides various resources and special environment for living for almost all other forest dwelling

species. [4]. Forests with indigenous trees are critical in providing clean water, fresh air, fertile soil, food, fiber, fuel, and drugs [5]. Before their degradation due to selective harvesting, deforestation and forest fragmentation, prominent indigenous tree species, such as *Cordia africana*, *Podocarpus falcatus*, *Millettia ferruginea*, *Juniperus procera*, *Prunus africana* and *Croton macrostachyus* had been easily regenerating naturally in natural forests of Ethiopia [6]. But currently most of them are used in the agricultural landscapes as components of agroforestry systems serving the farming community by providing multipurpose functions (timber products, non-timber products and non-market benefits) and livelihood support functions [7].

The information regarding the regeneration and viability

status of these indigenous tree species can be derived from the population structure of the species which is used for designing their management and conservation strategies [8]. This can be achieved by comparing populations of seedlings, saplings and adults dynamics of the tree species that can manifest the regeneration profile and determine regeneration status of the respective tree species [9].

The regeneration status of species can be analyzed by comparing seedling (young trees of < 1.3m height) with sapling (trees of ≥ 1.3 m height and ≤ 5 cm DBH) and sapling with matured trees [10-11]. Accordingly, regeneration can be categorized as: good regeneration (if present seedlings > saplings > mature trees); fair regeneration (if present seedlings > saplings < mature trees); poor regeneration (presence of species only in the sapling stage); none (presence of species only as mature trees) and new (species presence only in sapling and/or seedling stages).

However, different patterns of seedling, sapling and mature tree/shrub distribution could be exhibited by different

species depending on several factors. Among these factors, the major one is the capacity of a species to reproduce and extent of pressure on that particular species that could threaten it [12]. Therefore, this review paper is aimed to identify the factors affecting the regeneration of indigenous tree species in Ethiopia, which could be the basis for designing sound management and conservation strategies for improving the regeneration status of the native tree species of the country.

2. Uses of Indigenous Tree Species in Ethiopia

Indigenous trees in Ethiopia provide different benefits to farming communities that can be classified as timber, non-timber and non-market benefits. These benefits are summarized below (Table 1).

Table 1. Uses of some indigenous tree species in Ethiopia.

No	Name of the tree		Uses			References
	Scientific	Local name	Timber products benefits*	Non-timber benefits**	Non market benefits***	
1	<i>Acacia albida</i>	Laaftoo (Or)	Fuel, furniture	Food, fodder, medicines	Shade, wind break, SWC	[13-14]
2	<i>Albizia gummifera</i>	Muka arbaa (Or)	Timber, fuel,	Food, fodder, medicines	Shade, ornamental, nitrogen fixation, soil conservation	[15, 13]
3	<i>Boswellia paprifera</i>	Yetigre etan zaf (Am)		gum and resin		[15, 13]
4	<i>Cordia africana</i>	Waddeessa (Or)	Timber, Internal construction (household furniture)	Food, fodder, medicine	SWC, soil fertility, biodiversity conservation, cultural, aesthetic, shade	[16, 15, 13]
5	<i>Croton macrostachyus</i>	Bakkanniisa (Or)		medicine, bee forage	SWC	[15, 13]
6	<i>Ekebergia capensis</i>	Somboo (Or)			SWC, Shade	[15, 13]
7	<i>Ficus sur</i>	Harbuu (Or)		Food, medicine	SWC	[5]
8	<i>Hagenia abyssinica</i>	Kosso (Am)	Timber	Medicine	SWC, aesthetic	[15, 13]
9	<i>Juniperus procera</i>	Gaattiraa (Or)			Aesthetic, biodiversity conservation	[15, 13]
10	<i>Millettia ferruginea</i>	Birbira (Am)	Timber, construction (tools)	Fodder (for ruminants), Medicine	Coffee shade, SWC	[15, 13]
11	<i>Podocarpus falcatus</i>	Birbirsa (Or)	Timber, poles,	Medicine	SWC, cultural, aesthetic, shade, nourishment for birds and small mammals	[15, 13]
12	<i>Prunus africana</i>	Hoomii (Or)	Timber, fuel, poles,	Medicine, bee forage	SWC, shade, wind break	[15, 13]
13	<i>Tamarindus indica</i>	Roka (Am)	Timber, charcoal, Firewood, pole,	Food, Fodder, medicine	SWC, soil fertility, biodiversity conservation, shade, wind break, aesthetic	[15, 13]
14	<i>Bersama abyssinica</i>	Lolchiisaa (Or)	Firewood,	Medicine, bee forage	Live fence	[13]

NB: Am-Amharic language; Or-Afaan Oromoo language; SWC-soil and water conservation

3. Discussion

The reproduction and/or recruitment potential of tree species with in the forest stand can determine the future forest composition. Moreover, understanding the regeneration status of the tree species is important to determine the floristic composition of the remnant forest [17].

In addition, having the knowledge of regeneration and plant population structure can help to understand the function and structure of an ecosystem [18]. The proper management of forest ecosystems including remnant forests is applied by having understanding of tree species diversity and

socio-economic factors causing destruction of the forests [19].

Factors that affect the regeneration of the native tree species of the country are discussed as outlined below.

3.1. Knowledge Gap on Seed Biology

Many indigenous tree species have developed survival strategies through evolutionary process; due to this there is a gap to understand their seed biology that hinders their propagation [20]. To get the required amount of seedlings for mass propagation/planting from the tree species, the tree seeds must attain their maturity stage for the successful germination.

Seed physiological maturities are also important for the

planning of collection, since mature seeds have a higher germination rate [21]; however, the ability of old trees to produce mature seed in which its maturity can't be identified easily can be considered as the causes of less regeneration of the respective trees [22]. For instance, to get matured, high quality and viable seeds from *Podocarpus falcatus* fruit, the seed should change its color to yellow [20]. Additionally, changing the colour of fruits from green to bright, red, orange, yellow and becomes soft; and at the same time the pulp usually loosens easily from the seed, fruits develop a strong odor of fragrance that attracts seed dispersals are the signs that show seed maturation [23]. On the other hand, lack of awareness on the seed maturity identification for conservation of tree species might be the cause for low germination of some indigenous tree species [22].

3.2. Climatic and Environmental Factors

The patterns of tree species distribution in the forest can be affected by various climatic and environmental factors [24]. In addition to pathogens and insects; climate variability, disturbances from fire have significant impacts on woody plants species in the forest. The rate of tree seedling survival can be determined based on the resistance of a tree species to these destructive environmental elements as well as climatic shocks and events [25]. The drought occurrence due to climate change also has an impact on the natural regeneration of trees in the forest, especially on indigenous trees [13, 22].

Seed germination of certain indigenous tree species can also be affected by their ability to adapt to the local environmental conditions. For instance, *Croton macrostachyus* and *Cordia africana* are pioneer species whose seeds germinate and establish under canopy gaps soon after disturbance [26]; whereas *Podocarpus falcatus*, *Prunus africana*, *Pouteria adolfi-friederici* and *Syzygium guineense* are shade tolerant species whose seeds germinate and establish in shades under story of forests.

The crowd availability of seedlings and saplings of the trees species in the forest can be considered as an indicator of their regeneration potential [27]. This implies, when there is suitability of the environment there is the presence of good regeneration. The successful natural regeneration of tree species in the forest are the base for management of natural forests in which the trees establish and develop as part of the stand by themselves [28].

3.3. Biotic Interference Factors

Biotic interferences during fruiting or seed germination or successful conversion of seedling to sapling stage of tree species are the major factors that affect the regeneration of indigenous tree species [8].

Among biotic interferences Invasive Alien Species (IAS) are the major that affects the regeneration of tree species. IASs are living organisms which are exotic that occur outside their adaptive and dispersal ranges. These include plants, mammals and insects that have the ability to establish themselves, invade, compete native species directly (competing resources such as food and breeding sites) and indirectly (by altering habitat and modify hydrology, nutrient cycling and other ecosystem processes and take over the new environment) [29].

Some characteristics of invasive species that makes them unique are their ability to germinate without special environment, having fast seedling growth, producing seeds for longer period of time, tolerant to edaphic and climatic variations. They have also the ability to reproduce sexually and asexually as well as ability to compete other indigenous species on their natural habitat. These unique characteristics of the invasive species constrain the use and conservation of an ecosystem by affecting the goods and services it provides [31].

Invasive alien species affect the regeneration of indigenous tree species by restricting their germination and growth, for instance, *Eucalyptus species* affect by its allelopathic property over other indigenous species [30].

On the other hand, these invasive species affects the regeneration of indigenous tree species by ignoring the interests of local communities to conserve indigenous tree species and dominating over the indigenous tree species. For instance, *P. juliflora* are threatening endemic plant species such as *A. prasinata*, *B. ogadensis*, *E. doeloensis*, *E. ogadensis* and *I. ferakelleri* in Afar Region [29].

Lantana camara is also one of the invasive alien species seriously affecting the regeneration of the indigenous tree species in Ethiopia. In addition to Ethiopia it is highly distributed and is becoming an aggressive environmental weed affecting vegetation biodiversity in many countries in the world [32].

Among 22 invasive alien species threatening the biodiversity in Ethiopia [40], the major ones affecting indigenous tree species are listed below (Table 2).

Table 2. Major invasive alien species (IAS) that affects native tree species.

No.	IAS	Origin	Impacts
1	<i>Parthenium hysterophorus</i>	Mexico	Allelopathic and rapid replacement of the habitat [34]
2	<i>Prosopis juliflora</i>	Mexico and Caribbean	Inhibiting the germination by its allelochemicals [35]
3	<i>Lantana camara</i>	South and Central America	1) Allelopathic [36] 2) Competing soil nutrients [37] 3) Altering micro environment [38]
4	<i>Senna didymobotrya</i>	Africa	Impede growth and regeneration of native plants by forming dense impenetrable thickets [39]

3.4. Anthropogenic Factors

The demography of many plants in tropical forests is

modified by human impacts in which they restrict the population and distribution of tree species [40].

Due to various human induced pressures such as, agricultural land expansion, overgrazing and forest trees

exploitation for fuel wood and construction materials the natural forest cover of Ethiopia has been diminishing over times [41, 31].

This results in depleting the genetic resources of most tree species and putting biodiversity under threat. As a result, the eastern African countries, including Ethiopia, need more efforts of conserving trees since most tree species are under human induced threats [42].

3.4.1. Deforestation and Forest Fragmentation

Increased dependency of the communities on forest resources due to poverty leads to forest clearing for expansion of agricultural land, for fuel and charcoal production [43].

Accordingly, in Ethiopia there is imbalance between deforestation rate which is increasing at alarming rate and afforestation rate which is very negligible [50]. On the other hand, the structure and composition of natural woody plant species in the forest is damaging due to intensive logging practice. This intensive logging declines the forest diversity and puts a serious threat to regeneration of tree species, especially for those selected and damaged by this activity [44].

Over-harvesting of matured indigenous trees by people for different purposes influenced the regeneration of these tree species and their capacity to sustain themselves through natural regeneration. [45].

Similarly, selective harvesting of some indigenous tree species for own consumption (e.g. for household furniture) and an increase in the market value of their products have resulted in increased pressure on these species [13]. For instance, high demand of *Cordia africana* for its better timber quality caused a rapid depletion of the species in Ethiopia [46] and also overexploitation of the male or seed bearing female of *Podocarpus falcatus* trees can reduce its abundance and genetic diversity, and finally resulting in local extinction.

3.4.2. Expansion of Planting Exotic Tree Species

In Ethiopia plantation of non-native species like *Eucalyptus species*, *Cupressus lusitanica* and *Pinus patula* are on expanding. In contrary, there is ongoing destruction of natural forest due to various purposes and there is still shortage of fuel wood and construction materials throughout the country. To alleviate shortage of fuel and construction materials the farming communities are expanding the exotic species and they become dominant over the indigenous ones [47, 31].

Even though, the expansion of exotic tree species may promote the regeneration of indigenous woody species to some extent [48] and satisfy demand of the communities for forest products (e.g. fuel wood, construction) and reduces pressure on native forest and woodland [26]; they change the composition and structure of tree species in the forest [49], and may contribute to the extinction of indigenous woody species [50]. On the other hand, expansions of exotic trees can replace the indigenous tree species and reduce their management attention by changing the interests of farming communities.

Some exotic tree species has the ability to reduce the diversity of indigenous tree species. For instance, *Cupressus lusitanica* has high shading impact and less litter

decomposition that reduces indigenous woody species diversity. Such situation might affect seed germination and creates unfavorable soil conditions for seed germination [23].

4. Summary and Conclusion

The people of Ethiopia, like other developing countries, depend on natural resources for their livelihood. Indigenous tree species are trees grown well in climatic condition of Ethiopia without any human interference. But, due to anthropogenic factors (agricultural expansion, production of charcoal, selective cutting for their better benefit, such as timber values), the regeneration status of these indigenous species in the forest ecosystems has not been promising. In addition, the tree planting activities undertaken by the government of Ethiopia through the national green legacy initiative over the last couple of years has given emphasis to the expansion of exotic tree species than focusing on indigenous tree species. These situations have generally led to undermining the emphasis given to enhancing the regeneration status and improved management of the country's indigenous tree species.

The important information about the regeneration status of indigenous species and viability status of their population, which can be obtained from understanding the patterns of species population are necessary for designing evidence based conservation and management strategies of the species. Based up on the seedlings, saplings and matured tree populations of certain tree species, it is possible to understand the status of that tree species regeneration and prioritize for conservation. Thus, the species with no seedlings and saplings (none regeneration) can be prioritized first, the species with seedling but not sapling are prioritized in second and the species with both seedling and sapling can be prioritized at the third for conservation class since they are on appropriate conservation status.

5. Future Prospects

To reduce the over exploitation of indigenous tree species that leads to decline in their productivity, regenerative capacity and finally local extinction of the species, the following points should be considered.

- 1) The concerning body over the harvesting of the forest tree throughout the country including government sectors should give due attention to indigenous tree species across different agro-ecology.
- 2) Understanding the natural regeneration potential of indigenous tree species and conservation priority setting should be applied for woody plants which are currently not regenerating (have no seedling or saplings) by themselves.
- 3) Conservation of remnant forests should design special strategies of enhancing the regeneration of indigenous tree species as an integral part of the overall forest management system

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