To Study the Aspects for Sustainable Management Perspectives for Climate Change in Tropical Dry Forest

DR. PANKAJ MISHRA[1], PROF. R.M. MISHRA[2]
[1] *Faculty, School of Environmental Biology, A.P.S. University, Rewa (M.P.)*
[2] *Professor, School of Environmental Biology, A.P.S. University, Rewa (M.P.)*

Abstract*— Tropical dry forests (TDFs) occur in dryland environments, which are characterized by prolonged periodsof dry months. They experience distinct seasonality and high inter-annual variability in climatic variables, particularly rainfall. Despite the enormous ecological and livelihood importance of TDFs, these forests are highly threatened by global changes. Their significance is still overlooked in many countries' national policies. Current modeling frameworks show that drought, precipitation, and temperature are highlighted as strong drivers of tree growth and/or mortality in these forests. Well-valued and sustainably managed TDFs have the potential to contribute to climate change adaptation and mitigation, buffer against erosion and desertification, and contribute to economic development, food security, and poverty alleviation. TDFs suffer notable disregard from research and development strategies. So far, they have received far less attention from research and development interventions as compared to the humid tropical forests. Thus, greater awareness and appropriate policies and investments are needed at various levels to counteract the increasing vulnerability of people, forest ecosystems, and species living in these fragile ecosystems. Further research is also needed to generate knowledge on the status and significances of TDFs and their responses in the face of the changing climate so as to bring their sustainable management to the attention of policymakers and managers.

***Indexed Terms*— sustainable management, Dry forests, Forest management, Livelihood resilience, Threats.**

I. INTRODUCTION

In general, tropical forests are facing greater risks both from human-induced and natural factors. This is particularly true for tropical dry forests (TDFs), whichare under severe upheavals due to man-made and natural factors. Accounting for the largest proportion (about 40%) of all tropical forests (1), TDFs are reported to have substantial roles in climate mitigation and adaptation measures by significantly contributing to the global carbon stock, and supporting and regulating various ecosystem services (2). These ecosystems are known to harbor diverse and multifunctional landscapes and are inextricably linked to the lives of millions of people across the globe.

TDFs are particularly vital for supporting vulnerable households at times of hardships (including those increasingly affected by climate change and variability) (3). Despite their vast ecological and socio-economic significances (4), TDFs remain overlooked from research and development interventions as compared to their wet counterparts (5).

On the other hand, TDFs are disappearing at alarming rates; they are receiving severe threats from the exceptionally high rates of changes in land use and climate. Although there is lack of comprehensive and re- liable data on their rates of deforestation and dynamics in the context of climate change (6). On top of climate change, population explosion, food insecurity, and increasing demand for energy sources, and among others, are adding more pressures to these fragmented resources. This review is, thus, an attempt to provide further insights into the state of knowledge of tropical dry forests and their dynamics in the light of the changing climate and management activities.

II. RECENT STUDIES FOR DYNAMICS OF DRY FORESTS

Using systematic review methods, an attempt was made to synthesize a diverse range of evidence on a wide array of topics related to TDFs. The author also re- lied on own expert knowledge and experiences in identifying and synthesizing relevant articles. Based on a synthesis of the available empirical evidence, the conservation status and the main drivers and/or threats to these resources were evaluated, with particular focus to the climatic drivers which, directly or indirectly, might modulate the dynamics of these ecosystems.

Drylands are generally perceived as resource-poor areas and hence attracted fewer development endeavors (6). Earlier management plans were largely associated with management of the more bio-diverse tropical humid forests. Thus, dryland resources (including dry forests) are still poorly known and have not attracted the same level of interestand investment as that of the humid tropical forests despite the encouraging initiatives. As a consequence of this pervasive misconception, TDFs continued to degrade at higher rates. Theyare still among the least studied ecosystems and remain undervalued in many countries, and their importance is overlooked in many national policies and developmentprograms (10). Even though there are some attempts (Table 1) to define dry forests, there is still lack of agreement in developing common understanding. It has been noted that this is a complex issue and requires a further comprehensive understanding of the complexity, status, and roles of drylands in general and dry forests in particular, as well as context-specific approaches tailored to the unique conditions of the dryland ecoregions that are needed (11). In order to assess the conservation status of forests in drylands, information is required on their distribution pattern and rate of change in the forest extent in relationto global environmental changes.

As the climate becomes warmer and drier, the extent of dry forests may expand into areas currently occupied by humid tropical forests. On the other hand, areas considered as dry forests under current definitions may be changed into, for instance, savanna due to different disturbance factors. For instance, the Miombo woodlands in Africa and dry dipterocarp forests in Asia,which are currently classified as dry forests under the FAO definition, might be described as savanna ecosystems (12). Considerable variations in TDFs have also been observed in different localities and across continents in terms of floristic compositions (16) andin terms of strategies employed to cope with water def- icit conditions. Thus, there is still considerable work pending towards the development of global and ecologically cohesive characterization scheme for TDFs.

III. ALLOCATION OF FOREST LAND AREAS

Accounting for nearly half of the world's tropical and sub-tropical forests, dry forests are generally distributed over an extensive geographical range, spanning large areas of Africa, Latin America. They are known to occur in an environment with a seasonal climate characterized by a prolonged period of dry months and with an inadequate amount of rainfall for tree ecological function (17). Latin America hosts about 54% of the TDFs. Similarly, FAO's report confirms that the largest areas of dry forests are foundin South America, followed by Sub-Saharan Africa (SSA)and India. Although updated figures on the extent of dry forests across different areas and scales are lacking, considerable concentrations are also found in Southeast Asia, Northern Australia, andparts of the Pacific, Central America, and the Caribbean (18).These variations in the extent of TDF coverage world-wide may partly be attributed to the differences inmethods employed for the assessment and also variations in the definition of dry forests.

IV. FORESTS PLAY A PIVOTAL ROLE IN RURAL LIVELIHOODS

In addition to their roles in maintaining resilient and multifunctional landscapes, dry forests and woodlands also contribute inthe direct provision of various products, including timber and non-timber forest products (19). These products are known to supplement livelihoods and contribute to poverty alleviation; especially, they play vital roles as safety-net during hardships when other economic activities are constrained by the frequent drought events. A wide variety of these products is col- lected either for household consumption or sold to gen-erate a modest cash income. For instance, the African Miombo woodland was reported to support the lively hoods of about 100 million people (20). Income from the dry forest in the drylands of Southeastern Ethiopia constituted the second most important component of the total household income, next to the income from livestock. The same study revealed that income from the dry forest contributed up to 63% of the total income of the very poor households. They are also important sources of employment opportunities for local forest dependent people (21). Several other studies (also see Table 2) elsewhere reported that many households earn a significant amount of income for their livelihoods from the dry forests and woodlands (2).

This, in turn, supports agricultural systems upon which millions of subsistence farmers depend (22). In general, these myriad ES offered byTDFs can be categorized as provisioning (food, water, timber, biofuels, and fiber), regulating (air quality, water availability, carbon sequestration, nutrient cycling, and soil erosion regulation), supporting (maintenance of genetic diversity and habitat for species), and cultural (recreation, tourism) services. The economic importance of dry forests is, however, being recognized very recently, and their marketing system is not yet well developed (23). Given that the majority of forest users extract products mainly for subsistence and an important part of the trade happens the contribution of dry forests to the formal gross domestic product remains relatively low in many dry forest countries (24). Therefore, further research and development endeavors need to be undertaken in various drylands of the tropics to show their values and thereby call upon the promotion of sustainable management of dry forests for integrated livelihood adaptation, biodiversity conservation, and combating desertification.

V. THREATS AND CONSERVATION STATUS OF TDFS

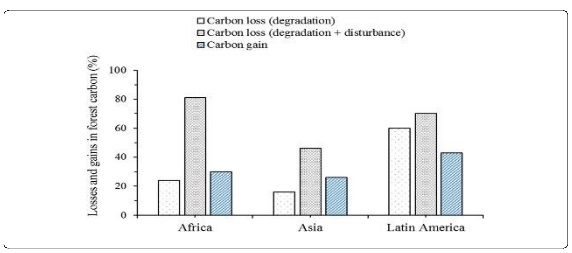
Despite their extensive coverage and manifold significances, TDFs are currently facing severe upheavals from global changes. The threats to dry forests and woodlands are multiple and complex, largely emanating from the interplay of anthropogenic and natural factors. These threats include pressures from agricultural encroachment, climate change, fire, overgrazing, and population explosion (25). It has been reported that about 95% of the TDFs are threatened by one or a combination of these factors. (MEA (Millennium Ecosystem Assessment), 2005). A greater density of human population was reported in these ecosystems due to a relatively suitable climate and soils thatcan support agriculture Consequently, the largest threats are still expected to emanate from anthropogenic fire, overgrazing, and ill-informed agricultural expansions. Billions of people farm for survival and de- grade these environments, and this is expected to get worsewith global climate change and population growth. In- creased fire risks are also expected with the increasing sce-nario of warming and drying due to higher degradation rates inthe dry tropical areas (26).

The climate-induced impacts are even worse in drylands of developing countries with a large number of forest- dependent populations, such as the SSA. Dryland resources(especially the dry forests) in these regions are among the most exploited systems and are being transformed to agricultural lands at an alarming rate. Inhabitants of these areas are generally poor; in theabsence of other livelihood options, they often overexploit the remnant resources. The decreased rainfall and recur- rent drought events are also expected to further exacerbate the current exploitation levels, thus resulting in more pressures on the remnant vegetation resources or total conversion to persistent agricultural lands(27). This would, in turn, impose additional stresses on the inhabitants whose livelihood is dependent on products (e.g., NTFPs) gatheredfrom the dry forests.

VI. REGULATING THE GLOBAL CLIMATE

In view of this, researchers recently revealed that deforestation is more responsible for the lossof dry forests than predicted impacts by climate change (28). Accordingly,the potential of tropical forests in sequestering carbon isbeing negated by forest degradation. This shows the attempts being made to account forthe possible forest losses emanating from both degradation and disturbances (human-induced and natural). The relative impact of climate change and deforestation on tropical dry forests and found out that the impact of deforestation is signifi- cantly higher than those attributed to climate change. These emerging results highlight the need to account forchanges in disturbance factors as well when dealing withthe interactions between these factors and climate change. Previously thought when the bio-mass and carbon losses due to degradation and deforestation that were accounted for. Even though the highrates of degradation and deforestation in these regions are significant contributors for the carbon losses, bio-mass gains were also reported due to re-growth of thewoodlands, offsetting the carbon losses from deforest- ation and degradation(29).

The following figure(Fig. 1) tries to demonstrate these variations on a continental basis. Even though the effects of anthropogenic disturbances seem to outweigh the climate-induced impacts, projec- tions into future scenario also show serious repercus- sions of climate change in the dry tropics. Therefore, climate, besides the human-induced land use changes, will continue to play an important role in the dynamics of dryland systems. The effects tropical regions in particular given their high sensitivity to the climate anomalies, such as frequent occurrences of extreme heat, increasing aridity, and erratic rainfall patterns. The variations in rainfall and temperature regimes are expected to influence treegrowth, leaf phenology, and survivorship through their impacts on photosynthesis, respiration, and nutrient dynamics from climate change are expected to be even pronounced in the SSA and related dry(30).



Under seasonal water deficit conditions, plants either tolerate drought or avoid drought by, for example, dropping leaves and thus limit transpiration during the dry season, to survive these dry environments. Such strong variability in rainfall and the existence of extended dry spells (water stress) have significant effects on the annual carbon gain and allocation patterns of plants challenging their survival in the dry- land systems. Thus, the future of these ecosystems remains uncertain in the backgrounds of the changing climate and its complex interactions with various disturbance factors. This will likely result in various drastictransformations, including losses of biodiversity compo- nents, species range shifts, altered tree productivity, and an overall extinction risks to the already endangered species living in the highly fragmented environments (31).

In general, the impacts from climate change may vary from positive to negative according to regions; climate change may increase tree productivity in some areas while decreasing it elsewhere also confirm that there is no concrete evidence for consistent long-term growth stimulation of tropical tree growth induced by CO_2 fertilization, but witnessed an increase in water-use efficiency. Predicting the consequences of climate changeon tropical dry forests has, thus, emerged as one of the grand challenges for global change scientists. In order to fully under- stand the impacts of climate change, we need to address the interactions and/or feedbacks from both climate- induced effects and other disturbance factors at different levels. Recent evidence shows that the inclusion of disturbance factors while modeling climate-induced effects may elevate estimates of productivity losses or cancelout productivity gains attributed to climate change (32).

VII. MANAGING DRY FORESTS UNDER A CHANGING CLIMATE

In addition tothe roles in sustaining the lives of millions of vulnerable households, TDFs have a huge potential in capturing largeamounts of carbon, maintaining diverse and resilient land-scapes, and water conservation (32). Therefore, their sustainable management wouldmean a lot for the local communities, national economies, and the environment at large. That is, if well-valued and sustainably managed, TDFs have the potential to contribute to climate change adaptation and mitigation, buffer against erosion, and desertification, and contribute to economic development, food security, and poverty alleviation. The sustainable utilization of forest products and services is closely attached to how successful a country man-ages its forest resources (dry forests in this particular case).

Nevertheless, in spite of significant contributions of the dry forests in the drier part of tropical regions, only a few countries, if any, are making adequate investment in their management. There is a general lack of laws and regulations and/or their enforcement, absence of programs, and political commitment to encourage the participation of stakeholders, especially the private sector and local communities, in the sustainable management of these re- sources (33).

This has often been attributed to the lack of appropriate institutional arrangements and policies that regulate the use and management of the resources To ensure SFM, there is an urgent need to address the agents re- sponsible for degradation with the corresponding undesir- able consequences. In general, SFM has been reported to be a viable framework for simultaneously reducing carbon emis- sions, sequestering carbon, and enhancing adaptation to climate change. In addition, it helps to supply various forestproducts, protect biodiversity, secure fresh water supplies, and provide other manifold ecosystem services.

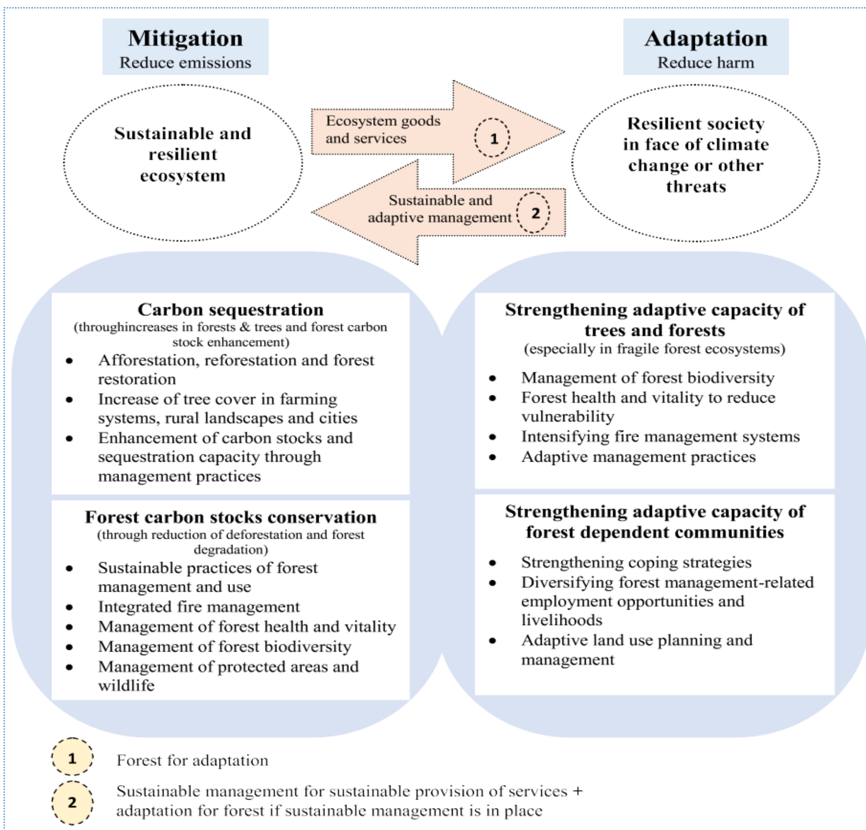


Fig. Mechanisms showing how forest management helps tackle climate change (Source: Adapted from FAO 2010)

Some of the potential major environmental changes in the region include changes in amount and seasonality of rainfall, rising concentrations of atmospheric CO_2, rising temperatures, and altered fire and other disturbance regimes. These changes will result in adverse impacts on TDF biodiversity, carbon sequestration and storage, and other ecosystem services, and thusthere is a dire need to understand how these changes will alter the ES that support the livelihoods of the poor (33). TDF ecosystems are characterized by extended water deficit conditions. Besides, the high variability of rainfall together with the increasing temperatures, evaporation, and evapotranspiration rates result in reduced ecosystem productivity in these regions.

Nevertheless, the management interventions should be carefully applied for different ecosystem types. There are always trade-offs among different management interven- tions and ecosystem services. For instance, in savanna eco- systems, given that water is seasonally scarce resource, an increase in tree biomass with woody encroachment or afforestation may threaten ecosystem services related to water resources, posing an indirect effect on ecosystem functioning and biodiversity. To address such conflicts, it is important to adopt specific management practices for specific ecosystem types. Nevertheless, this may not be the case in other for- ested ecosystems where there is a relatively conducive soil and climatic conditions. While fire is the most relevant disturbance conditioning the existence of savannas and grass- lands in most regions of the world (35). Thus, when recommending best management prac- tices for a particular biome, we should first carefully iden-tify and classify the type and unique attributes of the biome as conservation goals that differ significantly with biomes. In this regard, we need an improved under- standing of the savanna-forest dynamics and their re- sponses and feedback mechanisms to various disturbance regimes and environmental controls (36).

CONCLUSION

In conclusion, Studies warn that the future of dryland resourcesin general and that of TDFs, in particular, is uncertain as they are under mushrooming threats. The impacts from anthropogenic activities are being compounded by those impacts from global climate change. These valuable eco- systems remained overshadowed by the historical preoccupations of the more humid forest ecosystems. They provide essential ecosystem goods and services, livelihoods, and well-being of its residents. Despite these and other related significances, virtually all of theremnant TDFs are currently exposed to various threats, largely resulting from anthropogenic activities. Consequently, these ecosystems are caught in a spiral of deforestation, fragmentation, degradation, and desertification.It is also believed that the lack of education and trainingat university and technical and vocational level greatly contributed to these dismal pictures associated with TDFs. The scientific literature showed that there are many reasons that urge us to give due attention to these ecosys- tems, particularly in the face of the changing climate. Beyond supporting the livelihoods of millions of people worldwide, they are among the biodiversity hotspot cen- ters in the world and have pivotal roles in climate change mitigation and adaptation (37).

However, little focus has been given to these resources, and their long-term responses to climate change and the feedbacks thereof are poorly known. Thus, in our efforts to mitigate the impacts of climate change and to realize the sustainable development goals, we need to pay more attention to these most fragile and least understood ecosystems.

REFERENCES

[1] Allen CD, Macalady AK, Chenchouni H, Bacheletd D, McDowelle N, Vennetierf M,Kitzbergerg T, Riglingh A, Breshearsi DD, Hoggj EH, Gonzalezk P, Fenshaml R, Zhangm Z, Castron J, Demidovao N, Limp J-H, Allardq G, Runningr SW, Semercis A, Cobb N (2020) A global overview of drought and heatinduced tree mortality reveals emerging climate change risks for forests. For Ecol Manag 259:660–684

[2] Baccini A, Walker W, Carvalho L, Farina M, Sulla-Menashe D, Houghton RA (2017)Tropical forests are a net carbon source based on aboveground measurements of gain and loss. Science 358:230–234

[3] Banda-R K, Delgado-Salinas A, Dexter KG et al (2016) Plant diversity patterns inneotropical dry forests and their conservation implications. Science 353: 1383–1387

[4] Battles JJ, Robards T, Das A, Waring K, Gilless K, Biging G, Schurr F (2008) Climate change impacts

[5] on forest growth and tree mortality: a data-driven modeling study in the mixed conifer forest of the Sierra Nevada, California. Clim Chang87(1):193–213

[6] Bazzaz FA, Fajer ED (2008) Plant life in a CO_2 -rich world. Sci Am 266(1):68–74Bekele M, Girmay Z (2014) Reading through the charcoal industry in Ethiopia:

[7] Bhadouria R, Singh R, Srivastava P, Raghubanshi AS (2016) Understanding the ecology of tree-seedling growth in dry

tropical environment: a management perspective. Energ Ecol Environ 1(5):296–309

[8] Bogino S, Fernández Nieto MJ, Bravo F (2009) Climate effect on radial growth of Pinus sylvestris at its southern and western distribution limits. Silva Fennica 43(4):609–623

[9] Bonan GB (2008) Forests and climate change: forcings, feedbacks and the climate benefits of forests. Science 320:1444–1449

[10] Bongers F, Tennigkeit T (eds) (2010) Degraded forests in East Africa: management and restoration. Earthscan, UK

[11] Campbell B, Frost P, Kokwe G, Breton G, Shackleton S, Tiveau D (2014) Making dry forests work for the poor in Africa – building on success. Forest Livelihoods, Brief No 3. CIFOR, Bogor

[12] Campbell B, Jeffrey S, Kozanayi W, Luckert M, Mutamba M, Zindi C (2002) Household livelihoods in semi-arid regions: options and constraints. CIFOR, Bongor

[13] Cavendish W (2000) Empirical regularities in the poverty-environment relationship of rural households: evidence from Zimbabwe. World Dev 28(11):1979–2003

[14] Ceccon E, Huante P, Rincón E (2014) Abiotic factors influencing tropical dry forests regeneration abiotic factors regeneration influencing tropical dry forests regeneration. Braz Arch Biol Technol 49(2):305–312

[15] Charles-Dominique T, Staver AC, Midgley GF, Bond WJ (2015) Functional differentiation of biomes in an African savanna/forest mosaic. S Afr J Bot 101:82–90

[16] Chazdon RL, Brancalion PHS, Laestadius L, Bennett-Curry A, Buckingham K, Kumar C, Moll-Rocek J, Vieira ICG, Wilson SJ (2016) When is a forest a forest? Forest concepts and definitions in the era of forest and landscape restoration. Ambio 45:538–550

[17] Chidumayo EN, Gumbo DJ (eds) (2010) The dry forests and woodlands of Africa: managing for products and services. Earthscan Ltd., London

[18] Chipeta ME, Kowero G (2004) Valuation of indigenous forests and woodlands: an international perspective. In: Lawes MJ, HAC E, Shackleton CM, Djoudi H, Geach BGS et al (eds) Indigenous Forests and Woodlands in South Africa: Policy, People and Practice. University of KwaZulu-Natal Press, Pietermarizburg

[19] Clarke J, Cavendish W, Coote C (2006) Rural households and Miombo woodlands: use, value and management. In: Campbell B (ed) The Miombo in Transition: woodlands and Welfare in Africa. CIFOR, Bogor

[20] Corlett RT (2011) Impacts of warming on tropical lowland rainforests. Trends Ecol Evol 27:145–150

[21] Cunningham A, German L, Paumgarten F, Chikakula M, Barr C, Obidzinski K, van Nooordwijk M, de Koning R, Purnomo H, Yatich T, Svensson L, Gaafar A, Puntodewo A (2008) Sustainable trade and management of forest products and services in the COMESA region. An issue paper. CIFOR, Bogor

[22] Cunningham SC, Read J (2003) Do temperate rainforest trees have a greater ability to acclimate to changing temperatures than tropical rainforest trees? New Phytol 157:55–64

[23] Dexter KG, Pennington RT, Oliveira-Filho AT, Bueno ML, Silva de Miranda PL, Neves DM (2018) Inserting tropical dry forests into the discussion on biome transitions in the tropics. Front Ecol Evol 6:104 https://doi.org/10.3389/fevo. 2018.00104

[24] Diaz S, Grime JP, Harris J, McPherson E (1993) Evidence of a feed-back mechanism limiting plant response to elevated carbon dioxide. Nature 364:616–617

[25] Dovie DBK (2004) Economic value of secondary resources in the context of total livelihoods. In: Lawes MJ, Eeley HAC, Shackleton CM, Geach BGS (eds) Indigenous forests and woodlands in South Africa: policy, people and practice. University of KwaZulu-Natal Press, Pietermarizburg

[26] Enquist BJ, Leffler AJ (2011) Long-term tree ring chronologies from sympatric tropical dry-forest trees: individualistic responses to climatic variation. J Trop Ecol 17:41–60

[27] Ermias M, Zeleke E, Demel T (2014) Non-timber forest products and household incomes in Bonga forest area, southwestern Ethiopia. J For Res 25(1):215–223

[28] Eshete A, Teketay D, Hakan H (2015) The socio-economic importance and status of populations of Boswellia papyrifera (Del.) Hochst in Northern Ethiopia: the case of north Gondar Zone. For Trees Livelihoods 15:55–74

[29] Feeley KJ, Rehm EM, Machovina B (2012) The responses of tropical forest species to global climate change: acclimate, adapt, migrate or go extinct? Front Biogeogr 4(2):67–84

[30] Feeley KJ, Wright SJ, Supardi MNN, Kassim AR, Davies SJ (2007) Decelerating growth in tropical forest trees. Ecol Lett 10:461–469

[31] Fisher M (2004) Household welfare and forest dependence in Southern Malawi. Environ Dev Econ9(2):135–154

[32] Gebremeddhin T (1997) Boswelliapapyrifera from the Western Tigray: opportunities, constraints, and seed germination responses. MSc thesis.Swedish University of Agricultural Sciences, Skinnskatteberg

[33] Gillespie T, Lipkin B, Sullivan L, Benowitz D, Pau S, Keppel G (2012) The rarest and least protected forests in biodiversity hotspots. Biodivers Conserv 21:3597– 3611

[34] Godoy LR, Markandya A (1993) A method for the economic valuation of non-timber forest products. Econ Bot 47(3):220–223

[35] Golding N, Betts R (2008) Fire risk in Amazonia due to climate change in the HadCM3 climate model: potential interactions with deforestation. Glob Biogeochem Cycles 22(4):GB4007

[36] Good P, Jones C, Lowe J, Betts R, Booth B, Huntingford C (2011) Quantifying environmental drivers of future tropical forest extent. J Clim 24:1337–1349

[37] Jumbe CB, Bwalya SM, Husselman M (2008) Contribution of dry forests to rural livelihoods and the national economy in Zambia. World Bank and CIFOR

[38] Kalame FB, Nkem J, Idinoba M, Kanninen M (2009) Matching national forest policies and management practices for climate change adaptation in Burkina Faso and Ghana. Mitig Adapt Strat GL 14(2):135–151

[39] Lehikoinen A (2014) Bayesian network applications for environmental risk assessment. University of Helsinki, Finland, Dissertation

[40] Lemenih M, Teketay D (2003) Frankincense and Myrrh resources of Ethiopia II. Medical and industrial uses. Ethiop J Sci 26(2):16–72

[41] Lemenih M, Teketay D (2014) Natural gum and resin resources: opportunity to integrate production with conservation of biodiversity, control of desertification and adapt to climate change in the drylands of Ethiopia. In: Proceeding of a workshop on conservation of genetic resources of non- timber forest products (NTFPs) in Ethiopia, Addis Ababa, pp 37–49.