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The Impacts of Climate Change on Ecosystem Services in Tropical Areas

Adugna Babu [1]*and Kitessa Hunderra[2]
1. Department of Natural Resources Management, Jimma University College of Agriculture and Veterinary Medicine, P. O. BOX 307, Ethiopia
2. Department of Biology, Jimma University College of Natural and Computational Science, P. O. BOX 307, Ethiopia

Abstract
Ecosystems generate a range of goods and services that are important for human wellbeing. However, these goods and services are decreasing from time to time due to climate change impacts across the tropics. Tropical area is one of the most climate change prone areas of the world. The objective of this paper was, therefore, to review the impacts of climate change on the four ecosystem services in tropical areas. Due to increasing temperature, the geographical distribution of the biological diversity is changing. As the result, the four ecosystem services namely; provisioning services, the cultural services, the regulating services, and the supporting services are affected. In tropics, the provisioning services, like food production ,the crop failure, loss of animal forage and water supply, loss of wild fish due to ocean acidification, scarcity of forest and forest products ,and loss of medicinal plants are the critical challenges taking place due to change in climate. In addition, the tropical ecosystem's response to erosion, climate change, diseases and other ecological problems are declining. Some of the attractive resources such sacred lakes and other water resources and forest areas, which serve as centre for cultural services are being degraded due to climate change in tropical areas. The tropical soil resources are prone to moisture deficit and consequently the soil microorganism and the soil formation processes are disrupted. As conclusion, the ecosystem services of the tropical regions are under unprecedented pressure of climate change stresses. Therefore, any organization working on climate adaptation and mitigation project should play pivotal roles to reduce the impacts across the tropics.
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Introduction

Ecosystems generate a range of goods and services that are important for human wellbeing, collectively called ecosystem services (Millennium Ecosystem Assessment, 2005b). The production of food and raw materials, clean air and water, flood regulation, and recreation and ecotourism are all dependent on ecosystem services provided by soil, waters, and forests. The production of ecosystem services is based on ecological processes and biodiversity; therefore, it is crucial to understand how the state of ecosystems and the utilization of natural capital are linked (Bergstrom et al, 2011).

Ecosystem services are the many benefits—large and small, direct and indirect—that ecosystems provide to people. These consist of all the natural products and processes that contribute to human well-being, as well as the personal and social enjoyment derived from nature (Landsberg, et al, 2011). For example, forests provide wood products and a host of non-timber products and act as a venue for recreation and spiritual renewal; they also help to mitigate climate change by sequestering carbon. Wetlands absorb pollutants, purify water, and help reduce floods. Since different ecosystems provide different bundles of ecosystem services, there are tradeoffs and synergies amongst ecosystem services. For example, conversion of forest to agriculture lowers the wood supply and potentially the water flow regulation but it increases food production from crops. On the other hand, restoring a wetland may remove more pollutants from drinking water supplies and increase recreation benefits for bird watching.

According to Millennium Ecosystem Assessment, (2005b), ecosystem services are categorized into four major components, namely Provisioning services (the goods or products obtained from ecosystems, such as food, timber, medicines, fiber, and freshwater), Regulating services (the benefits obtained from an ecosystem's control of natural processes, such as climate, disease, erosion, water flows, and pollination, as well as protection from natural hazards), Cultural services (the nonmaterial benefits obtained from ecosystems, such as recreation, spiritual values, and aesthetic enjoyment), and Supporting services (the natural processes that maintain the other ecosystem services, such as nutrient cycling and primary production).

Climate change is believed to represent a serious challenge to the globe (Skoufias, 2011).There is wide recognition that human-induced climate change is a serious environmental and development issue. Earth is warming, with most of the warming of the last 50 years attributable to human activities (that is, emissions of greenhouse gases); precipitation patterns are changing, and sea level is rising (Mastrandrea et al, 2010). Human activities have significantly increased the atmospheric concentrations of numerous green- house gases since the pre-industrial era, with most gases projected to increase significantly over the next 100 years (for example, carbon dioxide has increased from about 280 to 370 parts per million, and is projected to increase to between 540 and 970 parts per million by 2100). The global mean surface temperature has increased by about 0.6 Celsius over the last 100 years, and is projected to increase by a further 1.4–5.8 Celsius by 2100. The spatial and temporal patterns of precipitation have already changed and are projected to change even more in the future, with an increasing incidence of floods and droughts. Sea levels have already risen 10–25 centimeters during the last 100 years and are projected to rise an additional 8–88 centimeters by 2100.

Climate change is both a cause and an effect of biodiversity and ecosystem change. Climate change is amongst the most important determinants of change in the distribution and abundance of species in both managed ecosystems such as agriculture, production forests, cities and many coastal zones, and natural terrestrial and marine ecosystems. Climate change is also an effect of land uses that generate greenhouse gases (CO_2, CH_4, and N_2O) and of alteration in biological stocks of carbon in terrestrial and marine system (Perrings, 2010). Land use change and the increasing Climate change from it, with the expectation of warmer temperatures, changes in precipitation, and increases in extreme weather events such as heat waves, floods, and droughts and associated fires and pest outbreaks are threatening our ecosystem services (Millenium Ecosystem Assessment, 2005b).

The role of living organisms in the production and sequestration of greenhouse gases is reasonably well understood. Ecologists also agree that climate change is already changing the world's biota (Perrings, 2010). It is affecting species distributions and abundance, the timing of reproduction in animals and plants, animal and bird migration patterns, and the frequency and severity of pest and disease outbreaks. Species are moving from lower to higher elevations and from lower to higher latitudes. Species that are unable to move are at risk. At the same time, changes in the world's biota from other causes are affecting the ability of ecosystems to adapt to climate change (Scholes, 2016). The simplification of many ecosystems to make them more 'useful' to people reduces their flexibility. By eliminating species that are 'redundant' given current climatic conditions and current uses, the capacity of many ecosystems is reduced due to change in climatic conditions (Irina et al, 2011).

FAO,(2008) indicated that for increases in global average temperature exceeding 1.5-2.5°C and in concomitant atmospheric carbon dioxide concentrations, there are projected to be major changes in ecosystem structure and function, species' ecological interactions, and species' geographical ranges, with predominantly negative consequences for biodiversity, and ecosystem goods and services e.g., water and food supply. By 2100, the resilience of many ecosystems (their ability to adapt naturally) is likely to be exceeded by an unprecedented combination of change in climate, associated disturbances such as flooding, drought, wildfire, insects, ocean acidification, and other global change drivers such as land-use change, pollution, over-exploitation of resources). Smallholder and subsistence farmers, pastoralists and fisher folk are likely to suffer complex, localized impacts of climate change (Irina et al, 2011).

Climate change poses a major challenge for mankind. As the climate changes, ecosystem services – that is, the important goods and services provided by nature – come under threat. For example, diversity of ecosystems or availability of sufficient clean and good-quality water resources may be endangered. In addition to the environment, climate change affects livelihoods, such as agriculture, forestry, fishing, and nature tourism, as well as land use in the urban environment (Bergstrom et al, 2011).

It is therefore very likely that climate change affects the ecosystem services provided by biodiversity. This impact is different for the different components of biodiversity. There are mismatches in response times to climate change between interacting species (plant and pest). Certain genotypes will be favored against others and communities within agro-ecosystems are reshuffling (Scholes, 2016). This means potentially that there is trophic decoupling of food webs and disruption of mutualism and evolutionary processes, leading to loss of functional biodiversity and to localized impacts in the delivery of ecosystem services such as lack of pollination, loss of soil biodiversity and capacity for nutrient cycling, or loss of natural biological control leading to potential new pest outbreaks (FAO, 2008).

The general objective of this paper is, therefore, to review the impacts of climate change on ecosystem services in tropical areas.

The Impacts of Climate Change on Ecosystem Services

Observed recent changes in climate, especially warmer regional temperatures, have already had significant impacts on biodiversity and ecosystems, including causing changes in species distributions, population sizes, the timing of reproduction or migration events, and an increase in the frequency of pest and disease outbreaks (Millennium Ecosystem Assessment, 2005a). Many coral reefs have undergone major, although often partially reversible, bleaching episodes when local sea surface temperatures have increased during one month by 0.5–1° Celsius above the average of the hottest months. By the end of the twenty-first century, climate change and its impacts may be the dominant direct driver of biodiversity loss and changes in ecosystem services globally (FAO, 2008).

The scenarios developed by the Intergovernmental Panel on Climate Change project indicate that an increase in global mean surface temperature of 2.0–6.4˚ Celsius above preindustrial levels by 2100, increases incidence of floods and droughts, and a rise in sea level of an additional 8–88 centimeters between 1990 and 2100. The impact on biodiversity will grow worldwide with both increasing rates of change in climate and increasing absolute change in climate. Although some ecosystem services in some regions may initially be enhanced by projected changes in climate (such as increases in temperature or precipitation), and thus these regions may experience net benefits at low levels of climate change, as climate change becomes more severe the harmful impacts on ecosystem services are likely to outweigh the benefits in most regions of the world (Millennium Ecosystem Assessment, 2005a). The balance of scientific evidence suggests that there will be a significant net harmful impact on ecosystem services worldwide if global mean surface temperature increases more than 2˚ Celsius above preindustrial levels or at rates greater than 0.2˚ Celsius per decade (medium certainty).

Future climates continue to allow ecosystem services to be delivered and consumed, in some cases at a level greater than in the past, and in others degraded relative to their historic supply. Across a wide range of ecosystem services, the losses exceed the gains for magnitudes and rates of climate change projected under low-mitigation scenarios (Scholes, 2016). On balance, global mean temperature (GMT) rises greater than 2 ^{0}c above preindustrial have a spatially patchy but net negative effect on many ecosystem services. The negative impacts occur in many places and affect most people (Fig.1).

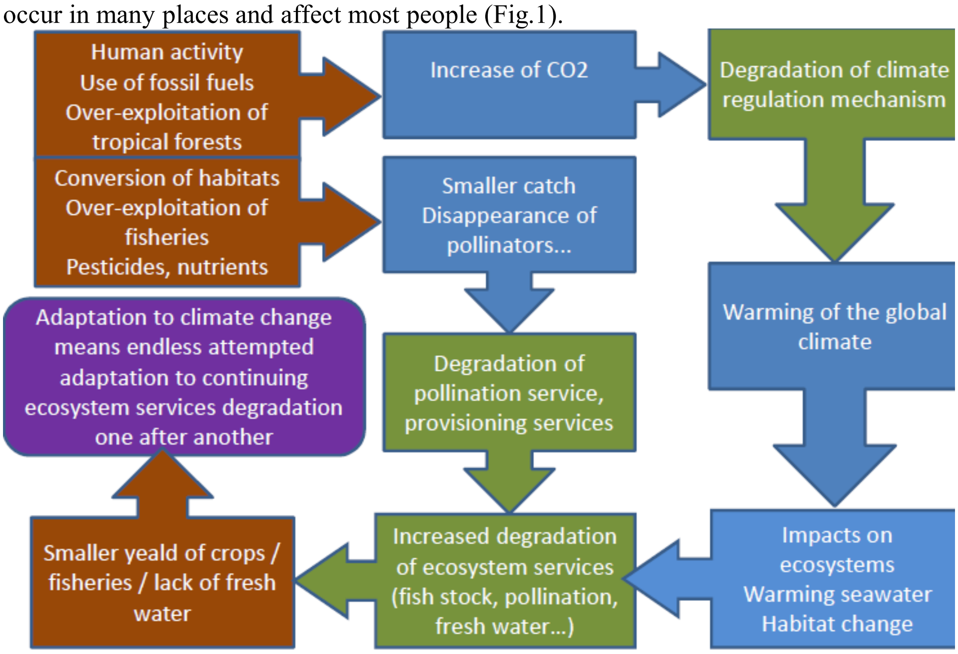

Fig .1; Impacts of climate change on Ecosystem Services
Sources: Suvantola, 2010

Impacts of Climate Change on Provisioning Services
Impacts on Food provision

Climate change has spatially and temporally patchy (erratic) effects on food provision, becoming generally negative for higher warming (Scholes, 2016). Thus, for modest climate change (1–2 ^{0}c rise in global mean temperature relative to preindustrial) global food provision is little affected, though food supply in many tropical regions is already negatively affected, at 1 ^{0}c. Above 2 ^{0}c, the net effect becomes increasingly negative; and taking into account the rising demand for food and competition with other land and water uses (specifically, bioenergy production as a climate mitigation strategy), the risks to global and local food security from this level of climate change are high (FAO,2008) .For global mean warming above 2 ^{0}c relative to 1960 –1990, most global studies indicate a net decrease in food production, because yield declines become apparent in tropical areas. The amount of yield loss rises in an accelerating fashion with further warming, even when reasonable adaptive actions are taken. As the global scope for crop land expansion is now quite limited, the key adaptation to satisfy the projected doubling of food demand to mid-21st century is likely to be increased production per unit cultivated land and improved food system efficiencies, in both cases while trying to minimize the emissions of greenhouse gases from agriculture (Scholes, 2016).

Crop Production

The unimpeded growth of greenhouse gas emissions is raising the earth's temperature in tropics (Irina et al, 2011). The consequences include melting glaciers, more precipitation, more and more extreme weather events, and shifting seasons. The accelerating pace of climate change, combined with global population and income growth, threatens food security everywhere. Agriculture is extremely vulnerable to climate change. Higher temperatures eventually reduce yields of desirable crops while encouraging weed and pest proliferation. Changes in precipitation patterns increase the likelihood of short-run crop failures and long-run production declines (Suvantola, 2010). Although there will be gains in some crops in some regions of the world, the overall impacts of climate change on agriculture are expected to be negative, threatening global food security (Nelson et al,2009). Populations in the tropical areas, which are already vulnerable and food insecure, are likely to be the most seriously affected.

The increasing climatic variability brought about by the increase in the extreme whether events, global warming, sea water rise and deficit in rainfall would obviously have serious implications for food production and availability in the tropics (Parry et al, 2004). Thus, climate change has threatened the food security. Climatic change would significantly affect the livelihoods patterns, the ability to access food and the socio economic lives of the majority of the people in many tropical areas (Chijioke et al, 2011).Climate change is becoming more frequent and intense in arid and semiarid as temperatures have been rising, advancing the timing and magnitude of spring snow melt floods and reducing river flow volume in summer. Direct effects of climate change include increased heat and water stress, altered crop phenology, and disrupted symbiotic interactions (Parry et al, 2004). These effects may be exacerbated by climate changes in river flow, and the combined effects are likely to reduce the abundance of native trees in favor of non-native herbaceous and drought-tolerant competitors, reduce the habitat quality for many native species, and slow litter decomposition and nutrient cycling. Climate change effects on human water demand and irrigation may intensify these effects (Suvantola, 2010).

The impacts of climate change are occurring more rapidly than previously anticipated .Crop production is directly affected by many aspects of climate change stemming from average temperature increase, change in rainfall amounts and patterns, raising atmospheric concentration of CO_2,change in climatic variability and extreme events, and sea water rise (Chijioke et al,2011). Countries in the tropical areas (lower latitude), where water availability is low would generally be at risk of decreased crop yield due to warming. This is consequence of increased evapo-transpiration and lower soil moisture content (Nelson et al, 2009). Due to these factors tropical areas are becoming unsuitable for agricultural production. As the results of climate change, the tropical area is becoming drier. The intensity of rainstorms could increase and precipitation could become more variable and unpredictable. The change in rainfall can affect the soil erosion rates and soil moisture, both of which are important for crop yield. Thus, increase in temperature along with decreased precipitation would likely result in loss of cropland and arable land due to decreased soil moisture, increased aridity, increased salinity and ground water depletion (Chijioke et al, 2011).

Livestock Production

Currently climate change is a great challenge in tropical areas. Intergovernmental panel meeting on climate change underlined that the poorest vulnerable groups are the worst and affected groups. Indirectly climate change has significant impact on feed resources on livestock productivity, carrying capacity of rangelands, and feeds, feeding options and grazing managements. Changed temperature increases the lignifications of plant tissues and reduces the digestibility and rates of degradations (Getu, 2014). Livestock is also directly exposed to stresses of the mortality, growth, reproduction and maintenances. Climatic change aggravates the water scarcity and accelerates the poverty level. Climate change impacts, particularly shifting precipitation regimes, are expected to affect the long-term trends in forage production, and plant community composition (Ackerly et al., 2012).According to Yilma et al., (2009), for instance, livestock production in Borena pastoralists is affected by climate change through feed shortage, shortage of water, reduced productivity, and decreased mature weight and/or longer time to reach mature weight in their order of importance and livestock death is also the common phenomena in Somali region of Ethiopia (Somali Region Program of Plan to Adapt to Climate Change,2011).

Fig 2; Death of livestock due to drought in Ethiopia Somali

Source: Somali Region Program of Plan to Adapt to Climate Change, 2011

Climate change has significant impact on animal feed resources. Shifting precipitation regimes, are expected to affect; the long-term trends in forage production, and plant community composition (Ackerly et al., 2012).

Fig.3: Encroachment of unpalatable plant species in Borena Rangelands
Source: Yilma et al., (2009)

Wild Fisheries

Overall, ocean primary production is projected to increase modestly under a $+2^0$C GMT increase, but the response of fish production is complicated by marine biome shifts, changes in body size, and the as-yet poorly understood effects of ocean acidification on fish production (Parry et al, 2004). Projections of ocean temperature changes in tropics suggest substantial geographical shifts in the locations of the broad types of marine fisheries during the 21^{st} century as a result of climate change, but not necessarily a decrease in their total productivity (bearing in mind that the productivity of ocean fisheries is already under severe threat due to overfishing) (Scholes, 2016). Broadly, fisheries in tropical waters are projected to decline 40–60%, due to climate change impacts (IPCC, 2002).

Ocean acidification is the ongoing decrease in the pH of the Earth's oceans, caused by the uptake of carbon dioxide (CO_2) from the atmosphere. Seawater is slightly basic (meaning pH > 7), and ocean acidification involves a shift towards pH-neutral conditions rather than a transition to acidic conditions (pH < 7). An estimated 30–40% of the carbon dioxide from human activity released into the atmosphere dissolves into oceans, rivers and lakes (Irina et al, 2012). To achieve chemical equilibrium, some of it reacts with the water to form carbonic acid. Some of the resulting carbonic acid molecules dissociate into a bicarbonate ion and a hydrogen ion, thus increasing ocean acidity (H^+ ion concentration) (Scholes, 2016). Between 1751 and 1996, surface ocean pH is estimated to have decreased from approximately 8.25 to 8.14, representing an increase of almost 30% in H+ ion concentration in the world's oceans. Earth System Models project that, within the last decade, ocean acidity exceeded historical analogues and, in combination with other ocean biogeochemical changes, could undermine the functioning of marine ecosystems (Suvantola, 2010) and disrupt the provision of many goods and services associated with the ocean beginning as early as 2100.

Ocean acidification is an unavoidable consequence of rising CO2 levels with many direct and indirect impacts on wild-caught fisheries, predominantly negative (Leisz and Burnett, 2008). Marine organisms which build their shells from calcium carbonate (in particular, the aragonite form of CaCO3) are severely negatively affected as the ocean pH falls toward and below 7.8 (a level which will be reached by end 21st century under 'business-as-usual' emission scenarios such as RCP 8.5). Affected organisms include wild-harvested and farmed molluscs and crustaceae, but also the many planktonic organisms on which the oceanic food web is based. Even marine organisms with an internal skeleton (such as fish) are susceptible (Scholes, 2016).Coral reefs are highly vulnerable to the combination of warming waters, eutrophication resulting from runoff from the land, and ocean acidification.The many species directly dependent on the coral reef habitat are threatened, along with the fisheries and tourism services it supports (Suvantola, 2010).

The Products of Trees and Forests

According to Leisz and Burnett, (2008), the species distribution of tropical forests is determined by the regional and continental distribution of rainfall and soil water availability. Seasonality and physiognomy (leaf flush and flower production) of tropical forests are mainly determined by the amount of annual rainfall and its seasonal distribution (IPCC, 2002). Changes in soil moisture availability caused by global climatic change and forest fragmentation are likely to alter tropical species distributions, community composition, and diversity. Conversely, predicted climate change may be unlikely to affect the physiognomy of rainforests with high annual rainfall and low seasonality (Esio Unanaonwi, 2014). Phenological events, such as flowering and fruiting, are often highly determined by climatic conditions. Because there are often strong co-evolutionary interactions between plants and their pollinators and seed dispersers, small changes in climate may decouple these highly specialized associations that may lead to failure of reproduction and reduction of forest resources (FAO, 2008).Climate change may be viewed as a progressive anthropogenic cause of change in vegetation composition. When atmospheric temperature and precipitation regimes is altered, coupled with elevated CO2, it brings a direct impact on vegetation composition through their effects on the physiology and population ecology of plant species as well as other processes. Increase forest fires and extreme weather due to climate change will exert a stronger effect on forest vegetation composition (Esio Unanaonwi, 2014).

Many aspects related to climate change are likely to affect forest growth and productivity. Increases in temperature, changes in precipitation, and increases in carbon dioxide (CO2) have influences on trees resources (Brodie et al ,2012). Warming temperatures generally increase the length of the growing season. It also shifts the geographic ranges of some tree species. Habitats of some types of trees are likely to move north or to higher altitudes. Other species will be at risk locally or regionally if conditions in their current geographic ranges are no longer suitable. Climate change will likely increase the risk of drought in some areas and the risk of extreme precipitation and flooding in others (IPCC, 2002). Increased temperatures alter the timing of snowmelt, affecting the seasonal availability of water (Suvantola, 2010). Although many trees are resilient to some degree of drought, increases in temperature could make future droughts more damaging than those experienced in the past. In addition, drought increases wildfire risk, since dry trees and shrubs provide fuel to fires (Esio Unanaonwi, 2014). Drought also reduces trees' ability to produce sap, which protects them from destructive insects such as pine beetles.

Forest resources play key roles in satisfying the growing human needs for timber as a construction material, industrial feedstock, and source of paper .However, these products of forest resources have been declining due to climate change across tropical areas particularly through wildfire, disease outbreaks and change in pheneology (Somorin, 2010).

As it was reported by Somorin, (2010) impacts are the negative or positive consequences that result from an event. In the case of climate change, the increased concentration of GHGs in the atmosphere causes disruptions in the climate system such as changes in precipitation regime and the frequency and severity of extreme events (typhoons, hurricanes, flooding, etc.) or changes in the rhythm and intensity of such phenomena as El Nino .While these impacts will vary in degree, magnitude, probability, frequency and duration, across different regions of the tropics, modifications in the structure and functioning of the ecosystems are expected to be produced by these impacts. Since the natural range of most types of ecosystem is primarily determined by a combination of temperature and rainfall patterns, a change in these climate variables therefore implies a change in the structure and functioning of the forest ecosystems (Khanum et al, 2013). A large fraction of the developing world still depends on wood or charcoal as a primary energy supply, and the fraction of biomass energy in the supply mix of both developing and developed countries is increasing due to its climate benefits. Energy from biomass is reduced due to change in climate across tropical areas.

Climate change is one of the greatest challenges to biodiversity, and affects all organisms. Species with known medicinal value experience pressure due to loss of habitat from rapid climate change and changes in land use and land cover. Threats are serious if not managed properly. Changes have already been observed in different tropical regions, including impacts to change threats to plant diversity resulting in drastic effects on plant life cycles and distributions due to increased global temperatures (Khanum et al, 2013).Habitat, fragmentation, shifting range of distribution, change in phenology pattern and invasion of new species due to climate change and global warming are currently threatening valuable medicinal plants (Kumar et al, 2012, Tangjitman et al, 2015).

Water supply

Climate change is expected to make water supplies more variable, both spatially and temporally in tropics. Given that evaporation and evapotranspiration rates across the country are also expected to change, water scarcity and water-quality issues will be exacerbated in many parts of the tropical areas (Nelson et al, 2013). Because water is essential to so many facets of human life, the impacts of these changes could be profound. Ecosystem services provided by water bodies include clear water, fish stocks, and recreational accessibility. As climate change advances, the greatest threat to the ecosystem services provided by water bodies is eutrophication of those water bodies (Bergstrom et al, 2011). If the annual cycle of hydrology changes, with spring arriving earlier and autumn being delayed, the nutrient retention capacity of water bodies may decline. This intensifies eutrophication of water bodies (Suvantola, 2010). With eutrophication and overgrowth of vegetation, the water quality, recreational accessibility, and aesthetic values of aquatic nature in water bodies decline. With global warming, the ice-cover period in lakes shortens. Climate change is expected to make water supplies more variable, both spatially and temporally. Given that evaporation and evapotranspiration rates are also expected to change, water scarcity and water-quality issues will be exacerbated. Because water is essential to so many facets of human life, the impacts of these changes could be profound (Nelson et al, 2013).

The hydrologic cycle is a multifaceted ecosystem service that plays critical roles in the physical, chemical, and biological processes of the Earth. Ecosystems control the characteristics of freshwater resources by regulating the partitioning of precipitation into evaporative, recharge, and runoff processes. The capacity of ecosystems to sustain an adequate quantity and quality of freshwater service is declined in tropics due to climate change imposed loss of vegetation through forest fire, warming temperature and insect pests and disease outbreaks associated with climate changes (Ackerly et al., 2012).

Impacts of Climate Change on Regulating Services

Regulating services are the category believed to be most dependent on biological diversity and ecosystem integrity, and therefore most vulnerable to loss of diversity as a result of climate change.

Climate Regulation

If ecosystems are relied on for future assistance on moderating climate change, then the climate sensitivity of the mechanisms of carbon storage in ecosystems is of crucial importance. Currently, land and marine ecosystems are together absorbing about half of the anthropogenic CO2 emissions, helping to moderate the rate of climate change (Scholes, 2016). In the oceans, the equivalent service comes with considerable risk to fisheries and biodiversity-related services, as a result of the accompanying ocean acidification.

On land, the capacity to absorb CO2 is limited and time bound because respiration or combustion of the stored carbon eventually balances or exceeds the uptake and the respiration rate increases with temperature, while the uptake rate saturates with rising CO2 and peaks and then declines with temperature. Furthermore, the incidence of wildfires has been observed to increase in some tropics in recent decades, and the fire risk is increased under climate change. The fraction of anthropogenically emitted CO2 remaining in the atmosphere is rising and is projected to continue to do so (Scholes, 2016). Thus, although the absolute magnitude of the oceanic carbon sink and the terrestrial carbon sink continues to increase, their proportional contribution to the carbon budget is declining at a global scale.

Soils and vegetation are important global reservoirs of carbon. Locally, these reservoirs are an important component for achieving the statewide goal of reducing greenhouse gas emissions through C sequestration. As the result of change in climate, vegetation and soils are declining from time to time across the tropical areas leading to the disruption of the ecosystem's response to climate change (Ackerly et al., 2012).

Storm and Flood protection

Intact riparian and coastal vegetation have been widely shown to attenuate flooding and reduce bank and coast erosion (Ackerly et al., 2012). This service is generally in decline in tropics due to more extreme storms and sea level rise. Many of the initial set of Ecosystem-based Adaptation (EbA) projects are founded on the principle of enhancing this service. Protected or restored natural communities are suggested to be a more cost-effective and resilient defense against rising sea levels and increasing storm severity resulting from climate change than the 'hard engineered' responses that dominated in the 20th century, though the evidence base in support of this claim remains sparse. Hence, the coastal vegetations which play key contributions in protection of coastal erosion are under threat due to climate change across different tropical regions (Scholes, 2016).

Pests and Diseases Control

According to some inferential evidences the high climate change accompanies further weakening of the ecosystem service of pest and disease suppression, which could then undermine the provision of other services (Scholes, 2016). Over the past centuries, there has been a proliferation in the extent, frequency, and severity of outbreaks of diseases of humans, their plant and animal domesticates, and wild organisms due to climate change (Ackerly et al., 2012). At the same time, there has been an increase in the spread of 'alien invasive species,' that is, species that become very successful outside of their historical area of distribution. Many factors are involved in these changes: increased movement of people and goods, increased opportunity for trans-species disease transmission, larger and more densely packed human and livestock populations are among the explanations. In addition, there are plausible arguments that ecosystems are more vulnerable to the outbreak of single species populations, when they have reduced landscape and species diversity and are experiencing climate-induced stress (Mastrandrea et al, 2011).

Pollination

Pollination is a biological mutualism essential for many specific instances of the food production in ecosystem service. Pollination is also crucial to the integrity of natural ecosystems (Scholes, 2016). There are global concerns regarding the widespread observation of declines in pollinator populations and diversity, for which several causes have been mooted, including the use of insecticides, the proliferation of bee diseases due to the movement of hives by the beekeeping industry, and loss and fragmentation of pollinator habitat due to the increase in scale of modern agriculture (Perrings, 2010). As the pollinator and its target flower have the potential to respond differently to climatic cues and thus become decoupled, climate change is high among the concerns (Suvantola, 2010).

Observed changes in flowering phenology have been among the first biological markers unequivocally attributed to climate change (Ackerly et al, 2012). There are further potential negative impacts on the capacity to deliver pollination services (and the pest regulation services discussed above) resulting from changes in the structure (physical layout) and composition of the landscape, both of which are sensitive to climate change, among other drivers, especially if the change is rapid. Thus, the projections of the impact of climate change on the pollination service are generally pessimistic, though some commentators point to a high capacity for genetic adaptation in some pollinator species as a reason to be somewhat less pessimistic in the longer term.

Impacts of Climate Change on Cultural Services

The highly valued, but hard to quantify cultural services—variously described as ‘heritage,’ ‘sense of place,’ ’identity,’ and ‘spiritual’ services—are often based on patterns of landscape structure and composition, including the presence of particular species or features, which have co-developed with particular societies (IPCC, 1997).In tropical regions, many water bodies and other vegetation species serving as cultural centers are declining due to climate change (FAO, 2008). Many of these are climate-sensitive, but there is not an extensive formal (‘scientific’) literature dealing with climate risks to these cultural services (Scholes, 2016). The possible vulnerability of these services is a concern more frequently raised by indigenous, traditional or local knowledge systems. Conversely, harnessing the power of cultural values has been invoked as an important strategy in adapting to climate (Brodie et al, 2012).

Tourism and Recreation

In contrast, the cultural services of recreation and tourism support a large market. Some recreational services are highly vulnerable to global warming in their current locations: notably and possibly in tropical areas which could become dangerously warm, stormy, or more prone to disease (IPCC, 2002). Those which are carbon energy intensive (such as requiring travel to distant locations) are vulnerable to increases in the price of carbon-based energy. Cultural landscapes are under threat everywhere from many stressors, including climate change (FAO, 2008; Perrings, 2010).

According to Anderson et al, (2011) the ability of ecosystems to provide cultural services in tropical areas is compromised by climate change. The cultural history and natural history of the tropical are interwoven. Human cultures, knowledge systems, religions, and social interactions peoples all reflect a strong connection to the landscape and the importance of a sense of place. High mountains, lakes, certain trees and animals, and many other geographic and biological entities have sacred status. These sacred sites and beliefs influence landscape management strategies. Tropical ecosystems in good ecological condition also provide recreation areas and a basis for environment-based tourism, an important source of revenue for tropical countries (Scholes, 2016). However, climate-related changes could influence ecosystems’ ability to provide cultural services, and may degrade the identity of natural areas (e.g, visual, iconic biodiversity elements). Industries like wildlife, nature reserves, coastal resorts and an abundant water supply for recreation decline due to droughts and/or reduction in precipitation that would devastate wildlife and reduce the attractiveness of some nature reserves, thereby reducing income from current vast investments in tourism in tropics (IPCC, 2002).

Impacts of Climate Change on Supporting Services

Supporting services comprise the main ecosystem processes that underpin all other services such as soil formation, photosynthesis, primary production, nutrient, and water cycling (Millenium Ecosystem Assessmen, 2005b). The concern over climate change is primarily a concern over the atmospheric consequences of changes in the carbon cycle (Scholes, 2016) .These services play out at very different spatial and temporal scales, extending from the local to the global, and over time periods that range from seconds to hundreds of years (Perrings, 2010).However, the supporting services like nutrient and water cycling, soil formation and fertility in tropical areas are now under disruption as a result of climate change (FAO, 2008).

As the result of climate change across the tropical areas, the supporting services, one of the major four ecosystem services, are declined. The cycling of water and nutrients are disrupted due to climate change impact which eventually leads to the loss of tropical vegetation which play critical roles in nutrients and hydrological recycling (IPCC,2002). As hydrological recycling are disrupted, no nutrients can be recycled among different ecosystems and no soil formation process takes place. As the water recycling is lost, the soil moisture content is reduced which collapses the soil formation process which is the basic for the production food and other ecosystem services (Ackerly et al, 2012). To sum up, some soil microorganisms which have major contributions in decomposition of organic matter to increase the fertility of soils are also disappeared. As the green plants are lost due to climate change, photosynthesis process cannot take place (IPCC, 1997).

Conclusion

Tropical area is one of the most climate change prone areas of the world. Due to increasing temperature, the geographical distribution of the biological diversity is changing. As the result of climate change, the four ecosystem services provisioning services, the cultural services, the regulating services, and the supporting services are affected. In tropics the provisioning services, like food production ,the crop failure, loss of animal forage and water supply, loss of wild fish due to ocean acidification, scarcity of forest and forest products ,and loss of medicinal plants are the critical challenges taking place due to change in climate. In addition, the tropical ecosystem's response to erosion, climate change, diseases and other ecological problems are declining. Some of the attractive resources such sacred lakes and other water resources and forest areas, which serve as centre for cultural services are degrading due to climate change in tropical areas. As the result of rising temperature, the tropical soil resources are prone to moisture deficit and consequently the soil microorganism and the soil formation processes are disrupted across the tropics. As conclusion, the ecosystem services of the tropical regions are under unprecedented pressure of climate change stresses.

The Way Forward

In this paper, the impacts of climate change on ecosystem services, namely provisioning services, supporting services, regulating services and cultural services have been considered. To minimize the impacts of climate change on the ecosystem services, the following points are to be considered. To reduce the impacts, the drought resistant crops should be produced and the animals which have the ability to withstand the effects of climate change should be reared at large scale. Diversification of agricultural crops in the most climate impact prone areas should be taken in to account. This is because; different agricultural crops have different capacity to survive as the drought episodes progresses. There is a need to give consecutive training for farmers and pastoralists to increase the vegetation cover in order to adapt to the impacts of climate change. The governments across the tropical areas should motivate the communities through distribution of different technological energy sources so as to reduce the human dependency on natural resources of the environment. As alternative energy sources are created, the pressure on the natural environment is minimized. There is a need to give effective training for farmers and pastoralists about the climate change adaptation and mitigation strategies .The indigenous knowledge which concentrates on climate change impacts reduction through early warning system should be motivated and incorporated in the modern science. Large scale water harvesting techniques should be done during wet season to store enough water for human, livestock and wild animals. This is because, as the dry season progresses the water deficiency increases. There is a need to do research in climate change prone areas so as to put critical points regarding causes of climate change, mitigation and adaptation techniques, and which type of economic activities are relevant to the area.

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