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# Tropical Grassland Ecosystems and Climate Change

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Grasses are unique group of flowering plants that form the foundation for the trophic structure in terrestrial communities. The grasses are found in every conceivable habitat where plants can thrive – from sea to deserts and from wetlands to peaks of highest mountains. The grasses form a distinct biome – a major ecological formation in the global classification of vegetation. The grassland biomes are most widely spread worldwide and occupy 20% of the global land surface. The grassland biomes are different in structure and composition across the continents. The tropical grassy biomes composed of a wide range of grassland communities depending upon topographic, edaphic, moisture, biotic and climatic gradients. Areas where grasses are predominant without scattered woody plant species are known as open grasslands (natural grasslands). All those grasslands with scattered woody plants (upto 80% of tree cover) are knows as savannas or mosaic grasslands. Similarly the Cerrados of Brazil are climax moist savannas and are maintained by grazing and burning. African savannas are very extensive and represent the climax vegetation type with rich wildlife particularly mammalian megafauna. These savannas are short, medium and tall grasslands and are sustained by herbivore grazing and burning and composed C4 grass species. These may be natural, mosaic and derived. Derived grasslands are those grasslands are transformed tropical forest through Savannization (cleared or repeatedly burned) and these are found in Amazonia and Asia. Alpine and subalpine meadows in tropical and subtropical climates and grasslands of Sholas in India are also climax type. The alpine and subalpine meadows are found in Himalaya and are sustained by snow and grazing and burning, whereas the grassland of Sholas in Western Ghats are also unique and sustained by grazing or burning. The grassy biomes mentioned above are all on the upland.

Some of the tropical grasslands are located on the: (i) flood plains of river systems (flood plain grasslands) and or the landslips, hilltops and forest margins. These are seral communities and sustained by flooding and grazing in case of flood plain grasslands and grazing and burning in other grassland types. The grasslands in areas (where the rivers shifted their courses) and the grasslands (which are never subjected to flooding) are sustained by grazing and or burning. In other words in the absence of regulatory ecological processes (flooding and grazing) burning of grasslands is the key for sustaining the grasslands. Grass-fire cycle is unique for tropical grassy biomes and is critical in promoting grasses and suppresses the woody growth. In India there are three types of grasslands – short, intermediate and tall grasslands. All the three seral stages of ecological succession can be sustained by flooding, grazing and or burning. The annual cycle of flooding and herbivore migration sustains network of the complex grassland ecosystem of the Corbett Tiger Reserve of India that support rich wildlife.

The grassland biomes render a wide range of ecosystem services. For example, 15% of the carbon on earth is stored in grasslands which account 30% of total terrestrial net primary productivity; grasslands represent 85% of the global land area burnt annually and contribute to global carbon and energy cycles; 3 grasses alone provide 90% of world food and livelihoods of 1/5 of global human population depends directly on grasslands. Most of the mammalian megafauna of the earth are found in grassland ecosystems. The environmental drivers for structuring the woody vegetation and community assembly in savannas are climate, atmospheric chemistry, fire, herbivory (particularly by large mammals) soil fertility and the amount and seasonality of rainfall.

Grassland ecosystems are most threatened ecosystems across the world due to anthropogenic mediated factors. For example: (i) damming of rivers and rivulets changed flooding patterns, (ii) the luxuriant grasslands are converted into woodlands or agricultural fields, (iii) intensive grazing led to desertification, and (iv) the indiscriminate burning result in depauperization of most of the grasslands in terms of species composition. In most of the areas no new grasslands are being established due to prevention of natural ecological processes that promote development of grassland ecosystems.

Based on studies carried out by different workers, using pot experiments, field plot studies and simulation models, the following likely impacts of climate change are predicted. Climate change – an increase in temperature of 1 to 4 ÚC, changes in precipitation patterns, elevated $CO_2$ levels (400 ppm currently) and extreme events such as droughts and floods – will have the following impacts on the tropical grassland ecosystems. An increase of 1 to 4 ÚC in temperature will: (i) increase the aridity and hence reduce the productivity and the soil organic carbon, (ii) enhance the water stress, (iii) alter the distribution pattern of grassland communities, (iv) decrease the palatability of the herbage, (iv) enhance inflammability, (v) promote dominance of drought tolerant species, (vi) lead to extinction of moist loving species, and (vii) become source for $CO_2$ rather than C sink.

Elevated $CO_2$ will render the grassy biomes vulnerable, and $C_3$ grasses could replace $C_4$ grasses with cascading effects on herbivores and fire regime.

Elevated $CO_2$ will enhance the productivity by 15 – 20% and also enhance soil carbon storage. The effect of elevated $CO_2$ on grassland ecosystem evapo-transportation and therefore on water stress will be rather small. However that in $C_4$ dominated grasslands where the elevated $CO_2$ will enhance the biomass production of $C_4$ grasses because of increase in soil moisture but the $C_3$ grass species will be unaffected. It has been shown that the community composition of grassland changes rapidly in response to elevated $CO_2$ in warm season and if water stress occurs at the same time $C_4$ grasses will take over $C_3$ grasses. Under low nitrogen availability, the response to elevated $CO_2$ will be suppressed due to nitrogen limitation. In the short term, the impact of elevated $CO_2$ may be reduced by increased nutrient use efficiency and increased nutrient uptake due to higher root biomass at elevated $CO_2$. In the long-term less nitrogen will be available due to slower decomposition of litter because of reduced litter availability.

Responses of grassland ecosystem to climate change is critical in grazing animal production efficiency as climate change will have impact on forage quality (nutritive value). Forage quality depends on digestibility, protein and energy content, palatability, concentrations of minerals and anti-nutritional factors, all of which are sensitivity to growing conditions of grassland and elevated $CO_2$. Foliage quality decreases at elevated $CO_2$ because of higher C:N ratios, higher concentrations of unpalatable/toxic compound and also reduced mineral concentrations (except phosphorous).

Herbivory will also be affected due to feedback to carbon acquisition and nutrient cycling at elevated $CO_2$. Forage consumption may increase as the quality declines; ruminants and functional caecum animals will have reduced consumption and reduced productivity. Herbivory in turn will also affect the nutrient cycling by changing the rate of decomposition and mineralization. The reduced nitrogen content of plant tissues at elevated $CO_2$ will reduced the rate of decomposition and hence slowing nutrient cycling and energy flow.

Elevated $CO_2$ enhances net primary production everywhere except in cold steppe regimes but decreases soil carbon by 4 PG from global grasslands after 50 years. Combined climate change and elevated $CO_2$ will increase production and reduce grassland C losses to 2 PG with tropical soils as small sinks for C. Biogeographic models suggest significant changes in the distribution of grasslands worldwide in response to climate change. Semi-arid grasslands will be severely affected through changes in grassland – woody species boundaries as $C_4$ grasslands are increasingly populated by $C_3$ woody plants which are favoured by elevated $CO_2$. Further, with doubling of $CO_2$ climate change a 40% increase in warm grasslands and a 50% decrease in cool grasslands are predicted.

To sum up, on a large scale extensive species rich stable tropical grasslands are resilient to climate change, as the grasses have wide ecological amplitude. In such cases no action is the best action in tropical grassland ecosystems. Grassland can also mitigate the climate change by enhancing the soil organic carbon pool and preventing desertification and hence form climate resilient ecosystem. In fact grass species can be used in greening deserts and thereby combating desertification. There are flood-, snow- and fire- tolerant species, all of which can contribute to the development of climate resilient grassland ecosystems.