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Droughts and indices to improve water productivity

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Abstract
Drought is natural hazard occurred due to involvement of biotic and abiotic factors. It's impacts can be observed through the world. Immediate drought impacts can include visibly dry vegetation and lower water levels in lakes and reservoirs. Longer-term impacts, such as land subsidence, seawater intrusion, and damage to ecosystems, can be harder to see, but more costly to manage in the future. Health problems related to low water flows and poor water quality along with lower agricultural production system. Thus, in order to manage drought and lowering its impacts on living organism can be successfully be diagnosed, planed and accordingly acts with the helps of different agricultural techniques to coop up our demands under changing scenario.

Keywords: Drought, types of drought, Selection and management crop, INM and water productivity

Introduction
The natural history of the earth has witnessed many changes in the atmosphere and biosphere over last millions of years. These changes were slow in the past but now the pace of change is quite rapid and remarkably influenced by human activities. The climate change is one of them, which is influenced by natural factors such as continental drift, volcanoes, and earth's tilt and ocean currents. Concern about climate change has been growing for the last two decades. Climate variability and change are not new phenomena, but the scale of climate change in recent decades is unprecedented. This accelerated climate change is driven largely by emission of greenhouse gases mostly resulting from use of fossil fuels (IPCC, 2007). Weather and climate are the key factors that affect the life of flora and fauna on the earth. Agriculture, animal husbandry and fisheries are highly dependent on weather and climate change for producing food and by-products necessary to sustain human life and therefore changing climate could have a significant role for maintaining food security. Human factor in climate change is the industrial activities. Droughts, floods, tornadoes, hurricanes, temperature peaks and heat waves have caused material losses and human suffering.

The growing population of human as well as animals will result in considerable additional demand for food, fiber, fuel and fodder. Huge livestock population of Indian subcontinent is not only a source of livelihood for poor but also a source for human and crop nutrition. India supports nearly 20% of the world livestock and 16.8% human population on only 2.3% land with less than one fourth irrigation facilities. Our country is leader in cattle (16%) and buffalo (55%) population and has world's second largest goat (20%) and fourth largest sheep (5%) population (Anonymous, 2009) [1]. The livestock sector adds almost 32% of Agriculture output in India, but the area under fodder cultivation is only 8.3 m ha which about 4% of total cropped area. At present, the country faces a net deficit of 61.1% green fodder and also recent population trends of India is not matching with the required trend of livestock growth rate (Datta, 2013) [3].

Simultaneously, water demand from non-agricultural sectors will keep growing in both developed and developing countries. About 40% of the land in the world is under arid and semi-arid climatic conditions (Gamo, 1999) [4]. Abiotic stresses are the primary cause of crop loss in these areas for most crops. Droughts, floods, acidity and salinity are becoming particularly widespread in many regions, and may cause serious Stalinization of more than 50% of all arable lands by the year 2050" (Wang *et al*. 2003) [6] Environmental stresses such as erratic and insufficient rainfall, extreme temperatures, salinity, alkalinity, aluminum toxicity, acidity, stoniness and others limit yield and productivity of many cultivated crop plants. Not only are such problems serious today, it seems they are inevitably worsening. Future estimates of climate change, including temperature increases and unreliable rainfall patterns for the region, may add stress to crop production.

In this article my aim is to summarize some important aspects on how to counteract with erratic behaviour of monsoon due to climate change. Among the different production factor role of water, temperature, Sun shine hour as well as selection of crops are more important. All the biotic and abiotic factors can be managed with application and adaptation of resources and technology.-Some major threat and their remedies are mentioned here under-

Drought: Types and strategies for it's management

Although water is most important inputs in Agricultural production system. Its role from soil tillage formation to harvesting further more up-to value addition. As it is natural phenomenon which results from natural balance due to human and other living organism intervention. Time of occurrence and Intensity of rainfall, created different types of situation. Although total amount of precipitation had more or less same as the earlier. Besides it's we are experiencing drought, heavy rain, thunder, storm flood due to excessive rainfall.

Drought is a natural hazard, it has a slow onset, and it evolves over months or even years. It may affect a large region and causes little structural damage. The United Nations Convention to Combat Desertification or UNCCD, defines drought as "the naturally occurring phenomenon that exists when precipitation has been significantly below normal recorded levels, causing serious hydrological imbalances that adversely affect land resource production systems."

The impacts of drought can be reduced through preparedness and mitigation. Mitigation means actions that we can take before, or at the beginning of, drought to help reduce the impacts of drought. Mitigating drought involves a wide range of agricultural practices including finding additional water supplies and conserving water that is already available. However, it is not enough to make drought plans based only on agricultural practices. There are many other strategies at government level that are just as important. Thus the components of a drought preparedness and mitigation plan are the following:

1. **Prediction:** Prediction can benefit from climate studies which use coupled ocean/atmosphere models, survey of snow packs, anomalous circulation patterns in the ocean and atmosphere, soil moisture, assimilation of remotely sensed data into numerical prediction models, and knowledge of stored water available for domestic, stock, and irrigation uses.
2. **Monitoring:** Monitoring exists in countries which use ground-based information such as rainfall, weather, crop conditions and water availability. Satellite observations complement data collected by ground systems. Satellites are necessary for the provision of synoptic, wide-area coverage.
3. **Impact assessment:** Impact assessment is carried out on the basis of land-use type, persistence of stressed conditions, demographics and existing infrastructure, intensity and areal extent, and its effect on agricultural yield, public health, water quantity and quality, and building subsidence.
4. **Response:** Response includes improved drought monitoring, better water and crop management, augmentation of water supplies with groundwater, increased public awareness and education, intensified watershed and local planning, reduction in water demand, and water conservation.

Our country had recognised seven types of drought viz

a. **Meteorological Drought:** Due to less rainfall. A meteorological drought occurs when rainfall is less than average over a significant period, often a month.
b. **Hydrological Drought:** A marked depletion of surface water causing very low stream flow and drying of lakes, rivers and reservoirs
c. **Agricultural Drought:** Shortages of soil moisture in the root zone during the cropping season because of a lack of precipitation. The water stress due to moisture deficit can cause significant yield losses, especially for crops in sensitive growth stages. An agricultural drought is considered to be taking place when a lack of rainfall leads to a decline in soil moisture affecting pastures and rain-fed crops.
d. **Soil Moisture Drought:** It is due to lack of available soil moisture to the plant.
e. **Socio-Economic Drought:** It occurs when the demand for an economic good exceeds supply as a result of a weather-related deficit in water supply.
f. **Famine:** Due to shortage of food/feed due to less production or market chain related issue.
g. **Ecological Drought:** Episodic deficit in water availability that drives ecosystems beyond thresholds of vulnerability,

Table 1: Drought types and major tips for its management

Drought	Remedies/key points to manage it
Meteorological Drought	1. Water harvesting, protecting water sources against contamination, developing water sources – such as micro dams, ponds and wells, use of reserve sources of groundwater and water rationing/allocation.
	1. Restoring pastures and balancing land and water resources.
Hydrological Drought	Increasing rain water conditions (more plantations, protection of watersheds and others) and water conservation. Recharge ground water by increasing rainwater harvesting and infiltration capacity.
Agricultural Drought	Irrigation management, soil moisture conservation practices, to check evaporation and deep percolation loss
Soil Moisture Drought	Practice of soil moisture conservation technique. Selection of crops and variety
Socio-Economic Drought	Charitable donations, as these droughts hinge on organizing water systems, and on the financial capability for constructing more efficient water delivery systems.
Famine:	Humanitarian aid. To address the immediate crisis, begin with general food distributions, followed by targeted food aid, along with the provision of heath care, clean drinking water, and sanitation.
Ecological Drought	Nature-based solutions like forest restoration to reduce urban flood impacts and provide for recreation). Similarly, water management approaches that integrate environmental flows into planning seek to address ecological water demands in addition to agricultural, industrial, and other water demands.

Land planning system

Some lands can only sustain limited cultivation because they are prone to drought. These are best used for alternate uses rather than normal food grain crops. Growing of short

duration legume crops, like Guar, Rice-bean, mung-bean (green gram), cowpea etc.

Land-use systems give stability to dry land production systems and also make good use of the land and rainfall during the off-season.

- Establishing perennial grasses for livestock farming
- Alley-cropping, and Silvipasture practices.

Soil management techniques

Tillage during the off-season or in pre-rainy season helps with rain water intake by breaking the hard soil and making the soil surface more permeable.

1. This allows water to seep to the deeper soil layers and keeps the soil wet for longer time.
2. The result is the soil will have more moisture during sowing the crop.
3. Tillage also controls weeds which depletes the soil moisture.
4. Off-season tillage also destroys the eggs, cocoons and larvae of some pests by exposing them to the sun which otherwise affect the already stressed crop plants.

Crop management techniques

a) Selection of crops

1. Avoid growing of drought prone crops like maize, cotton etc.
2. Growing drought resistant grain crops like sorghum, pearl millet, finger millet, fox tail millet etc.
3. Growing drought resistant legume crops like pigeonpea, green gram, horse gram etc.
4. Growing of oil seed crops like castor, sunflower, niger, sesame, safflower etc.
5. Intercropping practices
6. Intercropping refers to growing more than one crop in the same land area in rows of definite proportion and pattern.
7. Intercropping system provides insurance against total crop failure in drought prone areas.

A few examples of suitable intercropping systems under drought are

- Sorghum + Pigeonpea, Sorghum + Cluster Bean, Sorghum + ricebean
- Pearl millet + Pigeonpea
- Pearl millet + Cowpea
- Fodder maize + Horsegram, Baby corn + Horsegram

Sequence cropping on heavy soils with normal rainfall

- Sorghum/ maize – mustard
- Blackgram/ greengram/ cowpea/ sorghum fodder - mustard
- Sorghum (fodder) – mustard
- Sorghum – safflower Intercropping
- Maize + blackgram (2:2 row ratio

Plant Density

1. It is important to keep optimum plant population and row spacing. Generally wider plant spacing is preferred in drought prone areas.
2. You must careful not to space the plants too widely. This will not use the available soil moisture to the capacity.
3. Remember that more plants do not necessarily means more yield. In dry lands more healthy plants needed for better yield.

Weed management

1. Weeds compete with crops for soil moisture and nutrients.
2. Weeds also host some pests and diseases and these will migrate and affect the crops which are already under stress under drought conditions.
3. So, good weed control from the early stages of crops is essential in drought areas.

Surface mulching

1. Surface mulching either by timely inter cultivation or
2. by covering the soil surface with plant residues
3. benefits the crops
4. Reduce water evaporation from soil.
5. Reduces water runoffs from the cropped fields.
6. Help control weeds.
7. Adds organic matter to the soil and improves soil quality.

Integrated Nutrient management (INM)

INM takes care of physical, chemical and biological needs of the soil. It meets the nutrient needs of the soil from the use of organic and inorganic fertilizers.

Benefits of INM

1. Increases water holding capacity of the soil.
2. Increases the amount of nutrients in the soil.
3. The soil will be free from disease causing organisms.

Integrated watershed management (IWM)

IWM is an efficient way to continually manage land and water resources in the drought prone areas. The focus of IWM is conservation and efficient way of using rain water. IWM combines several approaches to minimize the risk of drought. These approaches are:

1. Soil and water conservation
2. Rain water harvesting
3. Efficient land and crop management

Other practices

Use of transgenic and PGPR

Transgenic can be very helpful in reducing the effect of drought. In rice cultivar, Nipponbare was used for transformation with the barley HVA1gene (Chandrababu *et. al* 2004) [5]. Investigations into how drought stress affects plant hormone balance revealed an increase in abscisic acid (ABA) content in the leaves, indicating that the reduction of endogenous cytokinin levels magnifies ABA content, eliciting stomata closure (Cowan, *et al*. 1999) [2]. The cytokinin– ABA antagonism might be the result of metabolites interactions because they share a common biosynthetic origin.

Strategies for improving fodder as well as livestock water productivity

The brief outlines four strategies for improving fodder livestock water productivity, to reduce the amount of water used in livestock production and to increase the benefits from livestock per unit of water used.

Strategic sourcing of animal feeds

Reducing the amount of water depleted to produce animal feed may be one of the most effective ways to improve water productivity globally. Three basic ways of accomplishing this are

- Promoting non-grain food sources with high water

productivity
- Adaptation of drought tolerant annual as well as perennial fodder suited to locality.
- Use of crop residues and by-products as feed
- Practices that encourage more efficient grazing
- Use of non-traditional animal feed and others

Enhancing animal productivity and reducing herd sizes
In much of the developing world livestock productivity is less than 50% of genetic potential. Milk production is low-often less than two liters per cow per day- as opposed to 15 liters or more. Promoting better health, genetics, nutrition and animal husbandry practices would enable livestock keepers to get more form fewer animals.

Reducing negative environmental impacts
Loss of vegetation due to overgrazing results in increased soil erosion, down slope sedimentation and reduced water infiltration. Research indicates that low to moderate grazing pressure has little negative impact on hydrology. Managing animals in ways that reduce land and water degradation, for example, by restricting animal access to certain areas and more integrated management of grazing land will help to reduce negative environmental effects.

Strategic provision of drinking water
The amount, quality and location of livestock drinking water can have a big impact on livestock water productivity. Water deprivation reduces feed intake and can greatly lower milk production. Providing adequate quality drinking water- strategically placed- enables animals to reach otherwise inaccessible grazing areas, keeps them from contaminating domestic water sources, and enhances production of meat and milk. Given the high value of animals, particularly to poor households, and the relatively small amount of water animals drink, strategic provision of drinking water is a good investment.

Conclusion
Major boost in water productivity in drought situation comes from non water management options. Among the different abiotic stress Salinity is widespread, floods and droughts are inevitable but considering them as natural calamity will not serve the purpose. Droughts, salinity and Flash floods are most harmful for the agriculture based farming. Selection of suitable crops with special aim to quality fodder; the types / nature of fodder and its variety is most important management option available in agriculture. There is availability of stress tolerant crops and varieties in the country Transgenics with LEA genes, Sub-1 gene has given a whole new avenue to agronomy in mitigating droughts, floods salinity and host of other abiotic stresses Use of mycorrhiza and PGPR in saline and drought affected areas need to be promoted. Already proven technologies for droughts have not penetrated in the rainfed/dry areas. However, Promotion of non grain fodder crops like roughes, use of nontraditional feed, development and management of grazing land, keeping ideal size of herds, proper care on levels of nutrient supply to animal and health, hazards and proper housekeeping are some important aspects that certainly will improve the management levels of animal domestication.

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