Drought

Drought is a protracted period of deficient precipitation resulting in extensive damage to crops and hydrological imbalance. It is a period of abnormally dry weather sufficiently prolonged for the lack of precipitation to cause a moisture deficiency with respect to man's usage of water. Based on impacts of deficit precipitation on different components of hydrology and biosphere, drought may be classified into four categories viz., meteorological drought, agricultural drought, hydrological drought and socio-economic drought which occurs in the following sequence:

Meteorological drought > Agricultural drought > Hydrological drought > Socio-economic drought

WATER TECHNOLOGY CENTRE FOR EASTERN REGION
(Indian Council of Agricultural Research)
Bhubaneswar - 751 023, India
January, 2006
In eastern India, agriculture during kharif (rainy) season depends on performance of southwest monsoon. Though the region receives 700-1200 mm rainfall within rainy season (June to September), but sometimes due to occurrence of agricultural drought in that season, rainfall and soil moisture are not sufficient to meet the water requirements of main crop rice, as a result, crop growth and development suffer. At early rainy season deficit soil moisture creates 'sprouting drought' in rice and results very low yield. On the other hand, dry spells or breaks in southwest monsoon at mid season affect tilling of rice. Sometimes crop also encounters moisture stress during the reproductive stage because of early withdrawal of southwest monsoon. To overcome these problems and encounter with the drought conditions in the region, contingencies crop planning on watershed basis is needed, which will mitigate drought as well as ensure stable productivity of the region.

The basic principles to be followed for contingency crop planning are:

(i) Crop management plan according to behaviour of south west monsoon.
   - Normal monsoon
   - Early break in monsoon
   - Timely onset but early withdrawal
   - Delay in onset of monsoon

The crop management plan with different south west monsoon scenario is given in Table-1.

(ii) Crop replacement: The high water requiring crops/variety should be replaced with low water requiring crops which are efficient to utilize soil moisture and more responsive to production input. In delayed monsoon condition, crops should be of short duration and drought resistant.

(iii) Better cropping system: By adopting intercropping (growing of subsidiary crops between two widely spaced rows of main crops) and multiple cropping, natural resources can be utilized in better way for maximum crop production during low rainfall period.

(iv) Integrated nutrient management: Under drought condition combination of organic and inorganic fertilizers improves moisture retention capacity of soils. Due to limited soil moisture application of the fertilizer in furrows below the seed is recommended. Application of compost, farm yard manure and raising legumes add the organic matter to the soils as well as increase the water holding capacity of soils.

(v) Effective rainwater management: Rainwater harvesting during excess rainfall period and its multiple use through farm enterprise diversification (aquaculture, rice-fish, fish-duck, livestock) is another best option for increasing production, productivity and sustainability of rainfed system.

(vi) Indigenous rainwater management for drought mitigation: Indigenous drought management practices refer to proven farmers practices developed over long period of time from the experiences of farmers themselves which can be effectively implemented to overcome drought. Some of the indigenous agronomic measures for rainwater management are contour farming, conservation tillage, mulch tillage, off-season tillage, dead furrow/shallow trenching.

(vii) Alternative land use system: Dry land horticultural crops, agro-forestry are one of the alternatives of drought mitigation which can be adopted in watershed. In addition to drought mitigation these will help to generate off-season employment, utilizes off-season rains, prevents degradation of soils and restores ecological balance.

**Agro-forestry:** The field crops like maize, cowpea can be compatible grown with tree species like Albizzia lebbek (Sirishl) and Gmelina arborea (Gambhari). Crops like sesameum, blackgram, groundnut, ragi can be profitably intercropped with Australian teak (Acacia mangium).

**Agro-horti system:** Dry land horticultural crops like guava, custard apple, mango, jackfruit, pomegranate, aonla, karonda, tamarind, ber and cashewnut are suitable in the rainfed unbunded upland areas. The crops like maize, arhar, cowpea, niger are suitable to grow within these crops.

Some of the suitable varieties of dry land fruits, are:

**Fruits:**

- Mango: Amrapalli, Mallika, Banganpalle, Suvarnarekha, Lengda, Sindhu
- Papaya: Honey Dew, Co-1, Co-2, Pusa Delicious
- Pineapple: Kew, Queen
- Guava: Allahabad Safed, Chitidhar
- Pomegranate: Paper Shell, Ganesh Gol
- Sapota: Cricket Ball, Kalipati
- Cashewnut: Bhubaneswar-1, Vengrula 1,4, NRCS 1
**Table -1: Contingency crop planning for drought mitigation**

<table>
<thead>
<tr>
<th>Situation</th>
<th><strong>Crop and water management options</strong></th>
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| Normal onset of southwest monsoon (10th June) | To increase the water productivity of rainfed area, rice in upland can be substituted with vegetable crops like brinjal, cowpea, bean, pumpkin, bitter gourd, ladies finger, cucumber during rainy (kharij) season. Intercropping through maize + cowpea, groundnut + pigeonpea can also be adopted by substituting rainfed upland rice. Some of the suitable varieties of vegetables in rainfed conditions:  
  - Brinjal: Utkal Tarini, BB 49, BB 44, Pusa Kranti, Penth  
  - Okra: Utkal Gaurav, Baisali Vandhu, Arka Anamika  
  - Sweet Potato: Samrat, Gouri, Sankar  
  - Pumpkin: Guamal, Arka Suryamani, Arka Chandan  
  - Chilli: Agnirekha, Sinduri, NP46A, G-3  
  - Bitter gourd: Pusa Domausumi, Arka Harit  
  - Cowpea: Pusa Kamal, Pusa Dophasali  
  - For very traditional rice farmers those who cannot afford to leave rice even in upland, partial substitution of rice through rice based intercropping like rice + pigeonpea, rice + blackgram, rice + groundnut (4:1) is recommended.  
  - Based on rainfall analysis, 24th standard weeks (14th to 20th June) was found feasible for sowing of direct seeded upland crops of eastern India under normal monsoon.  
  - Off-season tillage (summer tillage) with pre-monsoon shower can be done in 19th-20th standard weeks for raising rice nurseries as well as to reduce the effects of pest, disease and weeds. Off-season tillage will recharge the soil profile and land can be prepared immediately on that land after onset of monsoon.  
  - Since during the south-west monsoon months (June-September), 80% of rainfall occurs under normal condition, which may be harvested and recycled for raising second crops after rice specially in medium and lowland rice ecologies.  
  - Under normal monsoon condition, some of the suitable rice varieties for up, medium and lowlands are:  
    - Upland: Kalinga-II, Kalinga-III, Heera, Vandana, Anjali, Pathara  
    - Medium land: Lalat, Swarna, Mascori.  
  - Some of the suitable varieties of non-rice crop which can be adopted in rainfed upland by substituting rice are:  
    - Maize-Hybrids: Ganga-5, Daccan-103, KH 510, KH-101, MMH69  
    - Maize Composites: Shakti-1, Novjyot.  
    - Groundnut: TMV-2, Smruti, AK-12-24, JL 24, TAG 26, TAG 26, TAG 24, ICGA II  
    - Pigeonpea: UPAS-120, ICPL 151, T21, KPH-8  
  - Double cropping in upland can be done through maize-horsegram / sesame rotation. |
### Crop and water management options

**Situation**

- **Delay in onsets of monsoon (maximum 3-4 weeks from normal date)**

  - Shifting from traditional crops/varieties to short duration, low water requiring crops in upland, by substituting rice totally.
  - Some of the suitable varieties of low water requiring crops which can be adopted in rainfed upland are:
    - Blackgram - T-9, PU-30, Sarada, Ujala prasad
    - Greengram - K-851, Dhauti, PDM 54, PDM 11, ML5
    - Horsegram - Urmil, Madhupur
    - Sesame - Kanak, Kalika, Gujarati-1
  - The recommended dose of nitrogen application should be reduced by 40% and should be applied as basal and full-recommended doses of P and K should be placed as basal in delayed monsoon situation.
  - The field should be free of weeds for utilization of water and nutrients by the late sown crops. Furrow sowing of kharif crops at closure plant-to-plant distance with wider inter-row spacing is recommended.
  - Frequent intercultural operations should be practised to facilitate effect of loose soil as dust mulch.
  - Use of bulky organic manures and summer ploughing will facilitate to recharge the soil profile quickly.
  - Major emphasis should be given on in-situ rainwater conservation, harvesting excess runoff for its recycling to make provision for protective irrigation at later stage/crops.
  - Seed treatment and proper plant protection measures should be taken to avoid any germination failure because sowing has already been delayed because of late onset of monsoon.
  - In the event of late arrival of southwest monsoon the pulses like cowpea, blackgram, greengram can be grown up to last week of July in eastern India but pigeonpea, groundnut, maize are not recommended to be sown after 20th July. Castor can be successfully planted up to last week of August. Planting of maize, cowpea, greengram, blackgram after first week of August can be done only for the purpose of fodder.

**Normal onset but dry spell after sowing (Drought at early stage)**

  - When sowing of crops is completed with normal onset of monsoon but dry spell occurs after 1-2 weeks of sowing for 2-3 weeks consecutively, raising community nurseries of rice is recommended for transplanted rice. Direct seeded rice is also damaged because of incidence of 'sprouting drought'. Resowing of direct seeded rice should be avoided till sufficient rains have been received.
  - If sufficient good quality seed is not available, locally available seeds from adjoining areas should be used after proper germination check.
  - In upland, non-rice low water requiring crops may be gap filled and re-sowed with subsequent rain rather than allowing sub-optimal poor plant stand to persist.
  - Ridge and furrow land configuration technology may be adopted at 20 days after sowing as in-situ soil moisture conservation practices for non-rice upland crops.
  - By replacing upland rice the legume based intercropping systems like groundnut + pigeonpea, groundnut + blackgram, groundnut + greengram, groundnut + cowpea in the ratio of 4:1 were proved profitable and sustainable in rainfed upland based on findings in farmers' field when drought occurs at early stage.
Crop and water management options

- In this scenario, farmers will sow crops as per local recommended practices in different land ecologies due to normal onset of southwest monsoon. But early withdrawal of monsoon will affect the crop at reproductive stage.

- Development of ridge and furrow across the slope will be effective for soil moisture and rainwater conservation for direct seeded crops like maize, groundnut, pigeonpea, upland rice, blackgram, greengram etc. to overcome late season drought.

- Use of locally available organic mulch material to conserve soil moisture is recommended. The practices of intercropping and multiple cropping minimize the risks of aberrant weather in upland. If fertilizers are to be applied, foliar application is recommended.

- Harvesting of crops like cowpea, maize, greengram, etc. for fodder purpose and harvesting of upland rice at physiological maturity when late season drought is anticipating.

- Fields should be leveled for uniform water distribution within the sub-plot. Cover cropping like greengram, cowpea can be adopted to restrict the soil moisture loss from the field.

- Repeated intercultural operations and integrated weed management to make the land weed free is advised to farmers. Lowland rice will be at tilling to dough stage at the time of withdrawal of monsoon, so harvesting of excess runoff water during early monsoon period and utilizing it for protective irrigation will be effective.

Success story - I

In-situ soil moisture conservation with crop diversification for drought management

Due to occurrence of dry spells in mid kharif (rainy) season in 2000 and 2002 and late arrival of southwest monsoon in 2003, the upland rice was damaged, net return was nil to negative from the upland rice but alternative low water requiring crops (maize, groundnut blackgram, green gram, pigeonpea) produced at least Rs.10,000/ha net return per annum.

Mr. Iswar Samal, a farmer of Arnapurnapur, Dhenkanal, Orissa started contingency crop planning through crop diversification technology in 1999 and be found that the ridge and furrow method of sowing promotes in-situ conservation of moisture during dry spells, drainage of excess water during heavy downfall, encourages ground water recharge and reduces runoff and soil loss. This technology of drought mitigation was also influenced farmers of his village and neighbouring areas to adopt this. Mr. Samal also observed that fastest return (Rs.23391/ha in 70 days), was obtained from maize (Cob) that too in lean period (August-September), and he is getting 5-6 times more net return than that of earlier from the same land.

Presently, all the thirtyfive farm families of his village replaced upland rice with low water requiring crops and their income was stabilised. The farmers of nearby villages like Bijadi, Alnabereni, Parjang, Jirai, Kingol, Noagao of Dhenkanal district have started to adopt this technology in large scale. The recommended contingency crops and management plan were found effective by farmers for drought mitigation in the region.
Success story - II

Replacement of upland rice with vegetables by tribal farmers

Mr. Dularam Baske, an unemployed tribal youth from Majhisahi village of Bahausi watershed of Dhenkanal, Orissa having 2.0 ha of upland where he was getting low and unstable return from upland rice due to occurrence of drought in kharif/rainy season. He approached WTCER for getting necessary technical support to stabilise his yield from the upland. As per the technical guidance of WTCER, he opted for vegetables like bean, cowpea, bitter gourd, cucumber, okra, (elephant's fruit) during rainy (kharif) season by replacing upland rice to achieve ‘more crop per drop’ and to make his landuse system sustainable. After adopting this system, now annually, Mr. Baske is earning a net profit of acres Rs. 10,000/ha from field crops and 20,000/ha from kharif (rainy season) vegetables. This success story was quickly spread to other tribal farmers of his village and neighbouring areas.

The crop diversification plan has not only benefited to him in terms of his livelihood but it has also influenced other tribal farmers of his village and neighbouring areas to adopt this profitable proposition. Presently (2005 kharif), all the 30 tribal families of Majhisahi village of Bahausi watershed have adopted the technology.

Photographs from the top:
- Maize + Cowpea intercropping (4:1)
- Growing of cucumber fetching high return in upland
- Okra is another best option in upland
- Bean gives fastest return in upland


Farm revolution through WTCER

The green revolution has helped increase food production especially in the assured water supply regions. Studies reveal that raised agriculture supports 60% of the India's 1033 million population and contributes 26% to the national food basket. Keeping the importance of scientific crop and water management in mind, the National Agricultural Technology Project (NAP) at Dhenkanal, NATP has put major thrust for refinement of technologies at the district through on-farm trials for better productivity of different rice ecosystems. It started in the year 1999 and several trials conducted on ‘effective rainwater utilization and crop diversification’ on site situations. "Arahal papadum", "milk replacment", "conservation basin" etc. Successful trial conducted under farmers management convinced local farmers to grow successively, groundnut, pigeon pea, black gram, pigeon pea inter-cropping in high terrains traditional paddies yielded less and unstable. Several cash crops like winter maize, pea, sunflower, winter, saltflower, gram, mustard have been introduced in different villages of the district through research trials.

The projects are undergoing at......

The Indian Express (3.4.2004)

They no longer migrate for livelihood

After success of the experiment, many farmers of the villages started growing each crops. Now the success stories have spread to neighbouring villages.

The cultivation of cash crops have made the farmers self reliant. And instead of going to other places in search for work, they provide work to labourers of neighbouring villages.

Suvaki Subh, a farmer, said many farmers who used to go to districts like Cuttack, Jajpur and Angul in search of work after the harvest suddenly after success in inter-cropping methods and crop diversification, they get work throughout the year.

Another farmer Kailash Patra said he invested only Rs. 1500 in male and groundnut cultivation and received yield worth Rs. 5,000.

Farmers Bimalkumar Niyak who invested Rs. 1000 in male cultivation, has received returns worth Rs. 15,000.

Farmers do not face marketing problems. As soon as the harvest is over, they are picked up by local businesses and poultry owners.

When asked about the success, WTCER senior scientist Dr. Gourie Ram said crop diversification is the need of hour in rainfed us
Success story - III

Agricultural diversification through harvested rainwater and participatory watershed management

The harvesting of water in the existing pond has facilitated for introduction of double cropping and also sometimes triple cropping, utilization of pond for fish culture and additional crops on pond bund in a tribal dominated watershed, Bahasuni watershed (Majhisabi and Banasahi), Dhenkanal, Orissa. Instead of only one crop in a year from their low-lying land, 2-3 crops are now possible and an amount of Rs. 50,000/- annually can be earned from double crops, fish inside the pond and vegetables on pond bund. This shows the increase of annual income of 7-8 times of their earlier income. Before our interventions only 4 ha area was under double cropping, now after developing water resources, 34 ha area of the watershed has been brought under double cropping. Several farmers' participatory, demand driven, on-farm agricultural diversification trials were conducted in the watershed.

The tribal farmers of Majhisabi village (Mr. Rupei Baske, Mr. Chaitanya Baske, Durga Hembram) felt that the rainfall and runoff water received in the rainy season could effectively be used for mitigating drought/dry spell during Muraj and also the harvested water can be used for agricultural diversification (field crops, flowers, fruit, fish, vegetables). The success story was widely reported by different national and regional news papers and electronic media.

Clockwise from top left:
- Harvested water is watered
- Agricultural diversification with Marigold in Majhisabi
- Harvested fish from the pond of watershed
- High prospects for watermelons during pre-monsoon season with harvested water
- Farmer's satisfaction with pumpkin crop with harvested water

Crop management holds key to rural incomes

As per the report published in the Hindustan Times on 5th September 2001, farmers in the area have successfully marketed their produce and have increased their income. The report highlights the success of the project in Dhenkanal district.

The Indian Express (27.9.2004)

Majhi Sahi tomatoes find takers

WTCE scientists take up village for research programme

One of the scientists, G. Krishnakumar, discussed the success of the project. He said that if the project is successful, it would benefit the local farmers and help them in improving their livelihood.

Farmers of the village cultivate tomatoes for eight months in a year.

The Indian Express (22.9.2004)

Cash crops bring bonanza to them

The success of the project has been attributed to the efforts of the farmers and the support from the government agencies. The farmers have been able to diversify their crops and have increased their income.

The Hindustan Times (5.9.2001)

The project has been initiated successfully in 240 districts of the country.

Delivering the introductory speech on the occasion, scientist Dr. O. K. Sahi said that the project has been initiated successfully in 240 districts of the country.

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Success story - IU

Adoption of low water requiring contingent crops

Alternative cropping system was popularized and horsegram, bean, sesame, sweet potato were found suitable as contingent crops during pre-winter period. This study of WTCER prompted many farmers of Dhenkanal district to adopt low water requiring horsegram or sweet potato, bean as contingent crop after kharif maize or rice. The horsegram crop gives not only a net return of Rs. 4500/ha/annum but also beneficial to maintain the sustainable soil fertility. The short duration crops like lathyrus, pea were also found profitable after kharif rice in lowland as relay/autera crops.

From top:
- Low water requiring contingent crops, horsegram
- Two cultivars of sweet potato were tested which requires less water

To achieve sustainable livelihood quickly from large agricultural area, alternative land and water resources plan were developed throughout the whole watershed using modern tools like GIS, GPS and remote sensing technology. A national level one week training programme was organised at WTCER centre, Bhubaneswar to disseminate the technology. The dissemination was widely covered by print and electronic media.

The Indian Express (6.9.2005)

Changing crops answer to dry spells

Express News Service

Bhubaneswar, Sept 5: A blend of traditional and modern watered technologies along with crop diversification can be the answer to the problem caused by scarce weather conditions for farmers, water technology experts feel.

With the threat of a drought looming large over 16 districts in the State, the suggestions seem to have come at an appropriate time.

Though major portions of Eastern India receive an average rainfall ranging from 1,000 mm to 2,000 mm, the region has one of the lowest farm productivity, say experts here on Monday.

At a meeting organised by Water Technology Centre Eastern Region (WTCER), a body under Indian Council of Agricultural Research (ICAR), the experts deliberated on “Blending modern and traditional technologies for watered management” to tackle dry spell conditions.

Of the 21.1 million hectares rain-fed rice area in eastern region, according to WTCER, about 20 percent is rain-fed upland rice land. Productivity is very low and unstable due to erratic rainfall and dry spells during the farming season. But farmers traditionally grow rice on such land.

The experts felt that crop diversification with low-water requiring and high value crops such as oil-seeds, pulses and cereals can be some of the solutions for the farmers.

The water technology experts also felt that low-water requiring dry land fruit crops can also play a major role in mitigating drought in rainfed areas.

Besides mitigating drought, the crops can also serve the nutritional needs.

East India receives good rainfall but farm productivity is the lowest

- Crop diversification with low-water requiring plants can boost productivity
- Fruit, high value oil-seed crops and cereals can be better options

Harvesting More

Principal Investigator of the project: Dr. Gouranga Kar, Scientist (S.S.) Agro meteorology
Published by: Dr. Ashwani Kumar, Director, WTCER, Bhubaneswar

The WTCER has come out with a training course on watered management for the farmers.

Besides mitigating drought, the crops can also serve the nutritional needs. The experts felt that low-water requiring dry land fruit crops can also play a major role in mitigating drought in rainfed areas.

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