Research Article

Causes of Agro-Ecological Crises Related to Rainfall and Groundwater Faced by Farmers of Dryland Agro-Ecosystem: A Critical Analysis

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Abstract

Ground water crisis accounts for 60 percent of the irrigated areas in the country and critical to food security. It is estimated that over 70 percent of India's food grain production now comes from irrigated agriculture, in which groundwater plays a dominant role. Ground water crisis is a great problem in arid and semi-arid regions of the country. Farmers in dryland regions were facing severe water crisis and losing crops. While rainfall-amount, timeliness and pattern have all become quite erratic, on one hand, even ground water resources got depleted due to competitive digging of bore wells, Droughts and long dry spells, untimely rains have also been regularly causing stress to farmers. Climate change aberrations have further worsened the already grave situation. As these conditions continued to prevail, at regular intervals, over the years a critical analysis of causes of agro-ecological crisis related to water was delineated through focused group discussion, personal interview and factor analysis. An attempt has been made in eight villages of three Mandals in Ananthapur district of Andhra Pradesh to analyse the cause behind the agro-ecological crisis with a sample of 120 farmers selected randomly. The major findings were: Among the causes related to erratic rainfall, early withdrawal of monsoons, lack of contingency crop-water planning, and long dry spells leading to drought were most important. Among the causes related to depleting ground water resources, neglect of pro-active intervention, over exploitation of ground water resources without any replenishment were most important.

Keywords: Agro-ecological crises, Dryland agro-ecosystem, Critical analysis, Rainfall and Groundwater

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Introduction

Water is the most important input in agriculture [1]. A farmer cannot think of cultivating any crops without water to irrigate the crops. From ages, agriculture has been dependent on water from rainfall. Rainwater gets soaked into soil, percolates and gets collected in ground water reservoirs, which are another source of irrigation [2]. Water has a vital role to play in securing the prosperity of an agriculture based nation such as India. Among the states of India, about 100 districts are drought prone and face acute water scarcity during crop growth periods. The most number of drought affected districts are in Karnataka (14), Rajasthan (13), Gujarat (12), Madhya Pradesh (11), and Maharashtra (9), Andhra Pradesh (8), Tamil Nadu (8), Bihar (7), Uttar Pradesh (6) and other states (11) [3]. But among the arid districts of India with around 500 mm of annual rainfall, Rajasthan, Gujarat, Maharashtra, Karnataka and Andhra Pradesh stand apart. Water crisis looms large in these five states. One of the most drought prone districts of Andhra Pradesh, Ananthapur receives very scanty rainfall with a mean of 568.5 mm that is way below the average for the State [4]. Agriculture is primarily rain-fed but fluctuating monsoons and near-perennial drought had forced the villagers to rely on groundwater for their agricultural and personal needs [5]. Bore wells had been drilled in large numbers to extract groundwater, as a result of which the water table had gone down to below 400 feet [6].This, in turn, had led to drying up of bore wells, open wells and other sources of water. Though they were aware of the gravity of the situation, farmers continued to drill bore wells in the absence of any alternatives, aggravating the state of affairs. The potential for expanding irrigated agriculture is decreasing as it becomes more expensive or risky to further exploit water resources [7].It has been realized that even if the full irrigation potential of the country were to become operative, 50% of the net sown area would continue to be rain-fed. Hence, rain-fed agriculture is still high on India's development agenda. Its contribution is vital to the food security and livelihoods of the poorest farming families and communities, who have no access to irrigated land [8]. Moreover, dryland agriculture holds the key for future food security because the green revolution has reached its saturation point in enhancing land productivity. It has also been shown that returns on investment in rainfed agriculture are greater than those in irrigated agriculture. Decline in water table has encouraged farmers to explore deeper aquifers through digging deeper tube wells. The decline in water table

was attributed to inadequate rainfall and excessive water use in intensive paddy cultivation. New methods of irrigation like drip and sprinklers should be used wherever suitable, which would save water greatly [9].

Material and methods

The study was conducted in dryland agro-ecosystem of Andhra Pradesh. District Ananthapur (Rayalaseema region) is purposively selected as large number of farmers are facing very grave situation in Ananthapur due to agro-ecological crises [10].A pilot study was conducted before the actual start of research work to check the availability and time taken by the farmers in this areas [11]. To study the determinants and generalize the findings in this study a critical analysis of causes of agro-ecological crisis was delineated through focused group discussion, personal interview and factor analysis [12].The causes of agro-ecological crisis as perceived by farmers was drawn from them through focused group discussion. Then a list is formed and categorized into sets like causes related to erratic rainfall and depleting ground water. Since the pilot study revealed the availability of farmers from the identified list of water sharing groups with the purpose of validating and checking reliability of the schedule developed with the perceived causes and respondent's perception of degree of severity of these listed causes was measured on three-point continuum *viz., 'most severe', 'severe'* and *'less severe'* and given scores of 3, 2, and 1. Farmer respondents were asked to respond to each cause and state their perceived level of severity. Data collected were from 120 farmers analysed with the help of SPSS 20.0 and Excel Stat software to draw valid conclusion. To achieve this, a two-step process was adopted. First the respondents of the study were asked to respond on the perceived severity of the causes agro-ecological crisis, then select the top most important causes (based on the mean values arranged in a descending order) only those were taken which had a mean score of more than 2.5 (out of a maximum score of 3) for factor analysis, which is a data reduction statistical procedure through correlations of correlations. Factor analysis used here to further reduce the number of causes of agro-ecological crisis as a confirmatory approach.

Result and Discussion

Causes of agro-ecological crisis related to rainfall

Erratic rainfall is the major cause of agro-ecological crisis in dryland agro-ecosystems. Out of the 14 causes related to rainfall, only seven were found to be perceived as more important based on the mean scores of severities of causes. Only those were taken which had a mean score of more than 2.5 (out of a maximum score of 3) for factor analysis, which is a data reduction statistical procedure through correlations of correlations.

Table 1 Mean scores of severities of rainfall related causes of agro-ecological crisis as perceived by farmer respondents n=120

S. No.	Rainfall related causes	Mean	SD	More severe	Severe	Less severe
1	Uneven distribution of rainfall with no rain during the most important crop growth stages	2.95	0.201	115 (95.8)	5 (4.2)	0 (0.00)
2	No rain in the mid-crop season leading to water shortages	2.89	0.312	107 (89.2)	13 (10.8)	0 (0.00)
3	Weak monsoon winds in the beginning of the season resulting in very little rain	2.87	0.341	104 (86.7)	16 (13.3)	0 (0.00)
4	Early withdrawal of monsoons a few days after start of rainfall	2.82	0.403	100 (83.3)	19 (15.8)	1 (.8)
5	Lack of facilities for rain water harvesting and storage	2.77	0.419	93 (77.5)	27 (22.5)	0 (0.00)
6	Early withdrawal of winter rains affecting rabi crops	2.60	0.509	73 (60.8)	46 (38.3)	1 (.8)
7	Late onset of monsoons	2.58	0.629	79 (65.8)	32 (26.7)	9 (7.5)

For factor analysis, only those were taken which had a mean score of more than 2.5 (out of a maximum score of 3). Factor analysis is a data reduction statistical procedure through correlations of correlations. The purpose of this analysis was to arrive at few factors that may be meaningful and relevant.

Before proceeding with factor analysis, 7 variables were finally selected from the 14 causes after deleting those causes which had the mean values less than mean score 2.5. It is evident from the data that 7 rainfall related agro-ecological causes were judged as relatively more important by the farmers. These seven variables were inter-correlated and the variables matrix of correlation coefficients was subjected to principal component factor analysis

with *varimax* rotation. The total variance explained, eigen values, number of factors extracted and the factor loadings are presented in tables and discussed here. Only the results of factor loadings are presented here.

Table 2 Factor loadings of causes related to rainfall n=120

Causes of agro-ecological crisis related to Rainfall	Factors		
	1	2	3
Early withdrawal of monsoons a few days after start of rainfall	0.955	0.001	-0.06
Weak monsoon winds in the beginning of the season resulting in very little rain	0.957	0.062	-0.01
Lack of facilities for rain water harvesting and storage	-0.18	0.801	0.31
Early withdrawal of winter rains affecting rabi crops	0.086	0.813	0.23
Not being able to choose appropriate crops when rainfall is very low.	-0.2	-0.72	0.405
Late onset of monsoons	-0.16	0.147	0.621
No rain in the mid-crop season leading to water shortages	-0.13	-0.05	-0.84

The results in the table above indicate the factor loadings on each of the seven causes related to rainfall. These seven were grouped through factor analysis in three factors. Based on the causes (variables) loaded on the factor, a new name is given to the factor. Here for all the three factors the following names are given.

Factor 1: Early withdrawal of monsoon
Factor 2: Lack of contingency crop-water planning
Factor 3: Long dry spells leading to drought

Each of these factors, the major causes of agro-ecological crisis related to rainfall are discussed here.

Early withdrawal of monsoon

Under this factor two cause-variables were listed: first, early withdrawal of monsoons a few days after start of rainfall, and second, weak monsoon winds in the beginning of the season resulting in very little rain.

This factor is named *'early withdrawal of monsoon'* because both causes deal with very little rainfall in the early days of monsoons and sooner withdrawal. This may happen when monsoon winds are very weak, without surviving for long, and result in early withdrawal. This can be compared to infant mortality when the infant is under weight and very weak to survive.

Chronic shortage of water may result, if the rains fail early in the monsoon season, jeopardizing the future of crop fields and lives of the dryland farmers.

Lack of contingency crop-water planning

Under this factor three cause-variables were listed: first, *lack of facilities for rain water harvesting and storage*, second, early withdrawal of winter rains affecting Rabi crops', and third, *'not being able to choose appropriate crops when rainfall is very low'*.

This factor is named *'Lack of contingency planning'* as the major cause of agro-ecological crisis. A dryland farmer lives with uncertainties of rainfall every season and so needs to have a plan for every contingency that may happen. If proper water harvesting structures are arranged far earlier to onset of monsoon, enough rain water gets stored and can be used for irrigating crops.

If such rainwater is harvested and stored properly during monsoon months, then this water may be used in Rabi season even if winter rains withdraw early. If these are not planned for, agro-ecological crisis may set in because water harvesting is not done to meet any future irrigation needs in next crop (*Rabi*) season.

Similarly, if rains fail or if rainfall is scanty, farmers do not have any seeds to sow or choose an appropriate crop that survives and gives a yield.

Long dry spells leading to drought

Under this factor two cause-variables were listed: first, 'late onset of monsoon', and 'no rain in mid-crop season leading to water shortage'.

These two causes have come into one factor and this factor is named *'long dry spells leading to drought'*. When the monsoon arrives late, sometimes delaying the rainy season, farmers face acute shortage of water. In dryland areas,

sowing starts immediately after onset of monsoon. If the monsoon is delayed, the farmers face acute crisis of adverse agro-ecological conditions.

Next, if the rains do not fall during the essential crop growth stages, acute water shortage occurs leading to moisture stress in crop fields and psychological distress among farmers.

This factor essentially focuses on the water shortage, soil moisture stress and distress among farmers. Chronic shortage of water will adversely affect productivity of crop plants.

Results of Factor analysis of causes of agro-ecological crisis related to Ground water resources

Among the causes related to depleting ground water resources, only seven were perceived as more important based on the mean scores of severities of causes, as given in Table 4.1.3. Only those were taken which had a mean score of more than 2.5 (out of a maximum score of 3) for factor analysis.

In similar manner as has been done in case of causes related to rainfall, the set of causes related to ground water resources were factor analysed and the final factor loadings are given in **Table 3**.

Table 3 Mean ranks of severity perceived by farmer respondents on the ground water related causes of agro-ecological crisis n=120

S. No.	Ground water related causes	Mean	SD	More severe	Severe	Less Severe
	Farmers have pumped out all ground water by competitive digging of bore wells. They have wasted ground water resources. They have also wasted lot of money in digging up bore wells.	2.84	0.518	109 (90.8)	3 (2.5)	8 (6.7)
	Life-saving irrigation is not available when necessary during a critical crop growth stage.	2.80	0.507	102 (85.0)	14 (11.7)	4 (3.3)
	Ground water reserves have depleted and aquifers got dried due to excessive pumping out of ground water.	2.89	0.312	107 (89.2)	13 (10.8)	0 (0.00)
	Early withdrawal of monsoons leading to lower quantities of ground water reserves.	2.95	3.00	115 (95.8)	5 (4.2)	0 (0.00)
	Lack of facilities (Water tanks) for storing rain water and allowing for recharging of aquifers under the bore wells.	2.86	0.373	104 (86.7)	15 (12.5)	1 (.8)
	Rain water not being able to reach deep ground water reserves	2.71	0.452	86 (71.7)	34 (28.3)	0 (0.00)
	Leaving away damaged check dams and other water conservation structures without regular maintenance timely repairs.	2.75	0.429	91 (75.8)	29 (24.2)	0 (0.00)

Table 4 Factor loadings of causes related to ground water resources n=120

causes related to ground water resources	Factors	
	1	2
Life-saving irrigation is not available when necessary during a critical crop growth stage.	0.707	0.499
Lack of facilities (Water tanks) for storing rain water and allowing for recharging of aquifers under the bore wells.	0.803	0.096
Leaving away damaged check dams and other water conservation structures without regular maintenance timely repairs.	0.836	-0.188
Farmers have pumped out all ground water by competitive digging of bore wells. They have wasted ground water resources. They have also wasted lot of money in digging up bore wells	-0.123	0.886
Early withdrawal of monsoons leading to lower quantities of ground water reserves.	0.073	0.354

From among seven, only five have been taken for factor analysis, because these two factors had insignificant eigen values. The results in the table above indicate the high factor loadings on each of the five causes related to ground water resources. These five causes were grouped through factor analysis in three factors. Based on the causes (variables) loaded on the factor, a new name is given to each factor. Here for all the two factors the following names are given.

Factor 1: Neglect of pro-active interventions
Factor 2: Over exploitation of ground water resources without any replenishment

Under factor 1, three cause-variables have got high factor loadings and three were: first, 'life-saving irrigation is not available when necessary during critical crop growth stages', second,' lack of facilities (Water tanks) for storing rain water and allowing for recharging of aquifers under the bore wells', and third, 'leaving away damage check dams and other water conservation structures without regular maintenance timely repairs'. Keeping in mind the essence of these three causes, a new name is given to this factor as 'neglect of pro-active interventions'.

Lack of pro-active interventions has been another major cause of the agrarian crisis. While dealing with rainfall in dryland region, farmers need to be pro-active and take few actions for conserving rainfall water in water tanks so that the aquifer below bore wells get adequate supply and fill up ground water resources. Any neglect of maintenance and timely repair of soil conservation structures like check dams, ponds will lead to shortages in storage of rainfall water. Old farmers who have witnessed the construction of water conservation structures and water being stored and used, have also seen these structures being neglected and in repair and maintenance. They have particularly highlighted this as the major cause of agro-ecological crisis.

Under factor 2, two cause-variables have got high factor loadings and these were: first, 'farmers have pumped out all ground water by competitive digging of bore wells. They have wasted ground water resources. They have also wasted lot of money in digging up bore wells' and second, 'early withdrawal of monsoons leading to lower quantities of ground water reserves'. This factor has been given a new name: Over exploitation of ground water resources without any replenishment.

The fact that ground water is limited and needs to be replenished every monsoon. Farmers, through their competitive digging of bore wells have over exploited ground water resources without saving rainfall water.

This is a major cause of agro-ecological crisis. On one hand, the ground water is over exploited. On the other hand, the ground water is not getting returned to full capacity due to inadequate rainfall, early withdrawal of monsoon.

These two causes relate to depleting ground water reserves caused by over drawing out and not depositing the ground water reserves. Both relate to unsustainable ways of dealing with ground water resources.

Discussion on the results of analysis of causes of agro-ecological crisis

A list of causes was prepared through focused group discussion, categorized into different sets of causes related to erratic rainfall and causes related to depleting ground water. Then farmers' perception of severity of these causes was sought on a three-point continuum of more severe, severe and less severe were analysed.

First the causes were screened by deleting the causes which had mean scores less than 2.5 from this most important causes, two to three factors were derived from each set of causes through factor analysis. These factors were given a new name as the major cause being represented by the causes.

Finally, the major *cause-factors* that emerged were five reduced through factor analysis of 14 causes perceived as *most important* from the initial list of 22 causes collected from focused group discussion. They are:

Factor 1: Early withdrawal of monsoons
Factor 2: Lack of contingency crop-water planning
Factor 3: Long dry spells leading to drought
Factor 4: Neglect of pro-active intervention
Factor 5: Over exploitation of ground water resources without any replenishment

A cursory look into the causes of agro-ecological crisis listed above would reveal that these causes were essentially due to *'man-made errors'* to *Mother Nature* and complete neglect of any pro-active ameliorative measures for recuperative and regenerative farming systems.

Conclusion

All the causes of agro-ecological crisis faced by farmers were analysed and the results have succinctly brought the major causes of the agro-ecological crisis. In fact, agro-ecology, if not taken care of at every step may become vulnerable and gradually may get destroyed. The agro-ecological conditions prevailing in crop fields with open well, field ponds, water tanks, large water reservoirs have gradually been neglected and allowed to die slowly, with silting up of open wells, ponds, tanks resulting poor water storage capacity. Hence over flowing got resulted in leakages and wastages. Hence, the corrective measures started with understanding the hydrological cycle, ways of water harvesting, saving and water sharing.

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