GROUNDWATER MARKETS A PANACIA FOR MANAGING CLIMATIC VARIATION-AN ECONOMIC STUDY IN CUDDALORE DISTRICT

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Abstract: Climate change is one of the most important global environmental challenges, with implications for food production, water supply, health, energy, etc. India is bestowed with two distinct phases of monsoon. About eighty per cent of national average rainfall is received from southwest monsoon phase and the rest twenty per cent showers from the northeast phase of monsoon. The regions mainly benefited from northeast monsoon are coastal Tamil Nadu. About fifty per cent of rainfall of Tamil Nadu and forty eight per cent of rainfall of southeast coast of India is obtained from northeast monsoon. Northeast monsoon is one of the important components of Indian climate system and Tamil Nadu receive significant amount of rainfall during the northeast monsoon. In the present study, an analysis of performance of monsoons using time series rainfall data was carried out in Cuddalore district which mainly depends on the northeast monsoon. This study has shown that high co efficient of variation in rainfall was noticed during northeast monsoon. It has been found that in all the years northeast monsoon rainfall was below the normal, due to frequent failures and erratic distribution of northeast monsoon. This northeast monsoon precipitation is a major source of groundwater recharge which replenishes the declining water table levels. This short supply of surface water and high variation of rainfall resulted in declining groundwater levels which escalated the cost on groundwater investment. In this condition the famers are to depend on the emerging of groundwater markets which, has helped in increasing agricultural output by way of improving water use efficiency. The suggestion of the study states that emergence of water market is the best tool of groundwater management. The government may form cooperative water market system to streamline and develop the performance of existing water markets so, as to serve as an effective institutional tool in groundwater management.

Key words: Rainfall, climatic Risk, Groundwater, groundwater market, Groundwater Management

I. INTRODUCTION

Climate change is one of the most important global environmental challenges, with implications for food production, water supply, health, energy, etc. Rainfall is an important part of the global freshwater supply. The overall contribution of rainfall to the country's annual groundwater resource is 68 per cent and the share of other resources, such as canal seepage, return flow from irrigation, recharge from tanks, ponds and water conservation structures taken together is only 32 per cent. Due to the increasing population in the country, the national per capita annual availability of water has reduced from 1,816 cubic meters in 2001 to 1,544 cubic meter in 2011 (15 per cent reduction) (RoopaSuhag 2016). Globally, about 40% of irrigation water is supplied from groundwater, and India is the world's largest user (Aeschbach-Hertig and Gleeson 2012), which is among the greatest consumer of groundwater in the world with an estimated annual withdrawal exceeding over 230 km^3. Thus the increasing population and their dependence on groundwater for irrigation are further inducing heavy stress on groundwater resources, leading to the decline of groundwater levels in this region. Groundwater irrigation is the most predominant method used India, Wherein agriculture sector consumes over 60 per cent of the groundwater (Hoekstra 2013). In India, the distribution of rainfall which is a major recharging factor however, varies from place to place owing to different physiographic and climatic setting. With the resultant depletion of groundwater aquifers has some analysts predicting that 25 percent of India's harvest may be at risk in the coming years.

In India ground water is being non-sustainably exploited, particularly in Andra Pradesh, Gujarat, Haryana, Karnataka, Punjab, Rajasthan, Tamil Nadu and Uttar Pradesh. Among the Indian states, Tamil Nadu has seen tremendous increase in groundwater use for agriculture in the past decade. The south Indian state of Tamil Nadu is one of the largest producers of agricultural products, and is largely dependent on groundwater for irrigation. The lowering of groundwater levels has resulted in reduction in individual well yield, growth in well population, failure of bore wells, drying up of dug wells and increase in power consumption (Imtiyaz & Rao 2008). More than 60% of the groundwater is already exploited and in recent decades, the exploitation of groundwater has increased greatly particularly for agricultural purpose, because large parts of the country have little access to rainfall due to frequent failures of monsoon (Ramesh 2012). India is bestowed with two distinct phases of monsoon. About eighty percent of our national average rainfall is received from southwest monsoon phase and the rest twenty percent showers from the northeast phase of monsoon. The regions mainly benefited from northeast monsoon are coastal Tamil Nadu. About fifty per cent of rainfall of Tamil Nadu and forty eight per cent of rainfall of southeast coast of India is

obtained from northeast monsoon. Northeast monsoon is one of the important components of Indian climate system and Tamil Nadu receive significant amount of rainfall during the northeast monsoon. The rainfall increases from July onwards, attains a peak value in October and decreases to a low in January. When there is short supply of canal water, farmers depend on groundwater which is available for his use in the piece of land he owns. But all the farmers need not have access to the groundwater since installing pump sets require huge investments owing to its scarcity due to declining water table. Even though Tamil Nadu government provides electricity at free of cost, all the farmers are not able to install pump sets because of huge investments. The high investment costs of electric tube-wells encouraged their owners to operate their pumps at a higher level of capacity utilization by supplying irrigation service to other farmers.

To aid formulation of better groundwater management plans, an interdisciplinary approach is urgently needed to quantify sustainable agricultural practices and water storage in Tamil Nadu state of India. The emergence of water markets, both ground and surface water, has not only helped in increasing agricultural output but ensures its efficient use and restricts over exploitation. It has also widened the equalities in the rural areas and protected the interests of the small and marginal farmers and other weaker sections of the society.

Cuddalore district is purposively selected for this study wherein groundwater is the main source of irrigation. Most of the people in this area mainly depend on this resource that is available for their use in the piece of land owned by them. In this improper property rights lead to the violation of spacing norms between the wells. This context all the farmers need not have their own groundwater structures, since this resource is limited scarce and costly. At time of good rainfall this makes the supply of groundwater sustainable and gives the opportunity for the farmer to use the groundwater in the days of short supply of canal water. But in major duration of the season, canal water supply is not assured and farmers intend to cultivate crops almost depend on bore well water. Studies show that marginal and small farmers because of the cost involved in owning a bore well and pump set prefer to buy water from their neighbours. Farmer's who own bore well and pump set offer to sell water since there is scope to sell water from their high capacity bore well. For the above said reasons water marketing is in the practice of farmers of Cuddalore district. With the above focused background the present study was undertaken with the following objectives.1.To analyse the variation of rainfall in Cuddalore district.2. To study compound growth rate of ground water level in Cuddalore district.

II. RESEARCH METHODOLOGY

The study was attempted in Cuddalore district of Tamil Nadu. The present study used the secondary data collected from secondary sources. The time series data on pre and post monsoon ground water level and rainfall of Cuddalore district were collected from Department of Statistics in Cuddalore district and analysed using the following tools.

2.1 Growth rate:

Growth rate calculated for pre and post monsoon ground water level in Cuddalore district. Growth rate is measure of performance of groundwater level variation. They are not predicting; but describe the trend in variables over a period of years. Hence, compound growth rate was estimated with the help of following exponential model:

$Y = ab^te$

Where,

Y= Dependent variable for which growth data is estimated.

A = Intercept.

b = Regression co-efficient.

t = Time variable.

e = Error term.

The logarithmic from of the above equation estimated the compound growth rate

$\text{Logy} = a + t \log b + e$

The compound growth rate (g) was estimated by using

$g = [\text{Anti log of (b)} - 1] * 100$

2.2 Variability analysis

The first step in working out the Coefficient of Variation (CV) is to find out the standard deviation of the particular time series using the following formula. From the Standard Deviation (SD) and mean rainfall of the particular time series, the Coefficient of Variation is calculated.

Based on the magnitude of the Coefficient of Variation (CV), the dependability of rainfall is normally ascertained. The following percentage of Coefficient of Variation given in Table 2 is dependable for various time series of rainfall based on IMD. Lower values of CV indicate better reliability (Ramana Rao, 1988). To analyse the trend over the study area linear regression model has been used.

2.3 Percentage analysis

It was used for making simple comparison, for calculating percentage the frequency of the particular cell was multiplied by 100 and divide by the total number of respondents pertaining to particular cell.

III. RESULTS AND DISCUSSION

3.1 Trends in rainfall pattern:

Table: 1 Season wise distribution of rainfall in cuddalore district (in mm)

S.No	Year	Southwest monsoon (June –Sep)	Northeast monsoon (Oct-Nov)	Winter (Dec-Feb)	Summer (Mar-May)	Total
1.	2000-01	382.9	733.9	175.4	53.1	1345.3
2.	2001-02	424.1	581.8	3.6	178.7	1188.2
3.	2002-03	298.7	572.7	245.6	25.8	1142.8
4.	2003-04	488.4	725.6	0.6	87.9	1302.5
5.	2004-05	375	828	5.1	413.9	1622
5.	2005-06	370.3	138.5	13.2	234.8	756.8
6.	2006-07	424.4	960.4	22.8	103.55	1511.15
7	2007-08	449.5	892.9	21.4	58.4	1422.2
8	2008-09	297.5	1079.23	103.5	317.9	1798.13
9	2009-10	291.02	900.5	12.8	127.83	1322.15
10	2010-11	337.9	1022.6	30.7	62.3	1453.5
11	2011-12	359.6	797.6	49.8	130.9	1337.9
12	2012-13	208.9	468.6	3.8	31.9	713.2
13.	2013-14	454	494.8	14.1	55.6	1018.5
14.	2014-15	348.1	135.0	0.0	0.0	483.1
15.	2015-16	290.3	590.3	0.8	97.3	978.1
	Mean	362.53 (29.89)	682.65 (56.28)	43.95 (3.62)	123.74 (10.20)	1212.87 (100.00)
	SD	74.42	281.48	71.12	112.75	
	CV	20.52	41.23	161.82	91.12	

The season wise average annual rainfall of selected study district of Cuddalore presented in the table 1 the Cuddalore district has a hot tropical climate. The summer season, which is very oppressive, is from March to May. The southwest monsoon, which follows, lasts till September. October to December constitutes northeast monsoon season. January to February is the comparatively cooler period. The annual normal rainfall for the period (1901-2000) ranges from 1050 – 1400 mm. The normal annual rainfall over the district varies from about 1050 mm to about 1400mm and it is heavy in coastal area. The Cuddalore district received an average rainfall of 1300 mm. The rainfall in southwest monsoon period has the minimum coefficient of variation (20.52) followed by the northeast monsoon (41.23), summer (91.12) and winter season (161.82) rains. The rainfall was not well distributed in all the seasons. The district is more benefitted by northeast monsoon seasons followed by southeast monsoon. The surface flow in the rivers can be observed only during monsoon periods. The deficient monsoon rainfall has affected the flow of surface water into reservoirs, anicuts, lakes etc. Hence under these circumstances the agriculturists have to totally depend upon an alternative source i.e., Ground Water to meet their irrigation requirement.

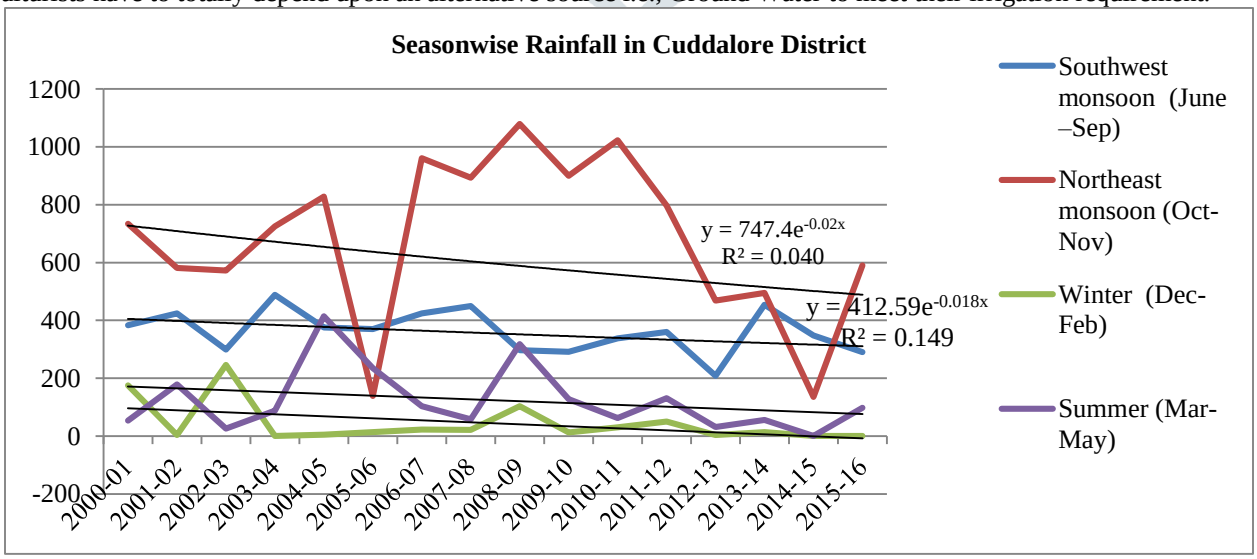

chart: 1 season wise rainfall in cuddalore district

The season wise average rainfall of the selected study district of Cuddalore presented in the figure 1, it was observed from the fig that the major monsoon period northeast was not behaving consistently and exhibited an erratic behaviour and a cyclical exhibited is observed obtained in the case of southwest monsoon, another important observation was that both the monsoons have registered a declining head.

3.2 Trends in groundwater levels:

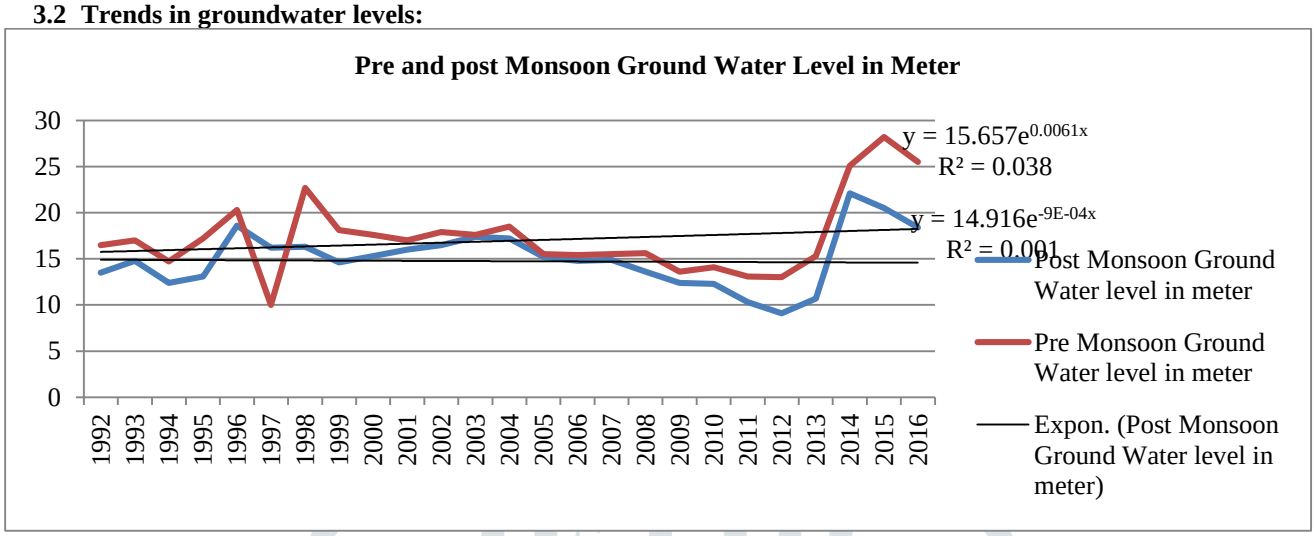

Chart: 2 Pre and Post Monsoon Ground Water Level in Cuddalore (Meters) (1992-2016)

The trend line was drawn for post and pre monsoon period water levels and it is given in figure 2. The trend line for the post monsoon period indicated that the water level was maintained constantly and the deviation from trend line was very small in post monsoon period. But the trend line for pre monsoon period indicated that the depth to water levels increasing year after year and the deviation was also very high. From the year 2012-13 the water table has declined at alarming rate with increasing depths which had a high negative correlation with the rainfall performance.

3.3 GROUNDWATER MARKET PARTICIPATION STATUS OF THE SAMPLE FARMERS

Due to the rainfall induced climatic rise the ground water levels exploited an erratic and declining behaviour. Hence the farmers who heavily depend on groundwater opted for groundwater market participation as an adaptation strategy. To analyse and understand the existing ground water market conditions a study was carried out in Keerapalayam and Melbhuvanagiri blocks in Cuddalore district were selected. The selected blocks represent varying groundwater scarcity conditions viz safe(S) (< 60 per cent) and semi critical (SC) (60-80 per cent).

Table 2 Ground Water Market Distribution of Sample Farmers in the Study Areas

S. No	Particulars	Keerapalayam (Safe block)	Melbhuvanagiri (Semi Critical block)
1.	Water market participating	34(56.66)	38 (63.33)
2.	Water market non participating	26 (43.33)	22 (36.66)
	Total	60 (100.00)	60 (100.00)

It was observed from the table 2 that the percent of farmer involved in water market (both water buyer and water seller) was in higher proportion compared to the non participatory farmers in both the blocks. However in semi critical block (Melbhuvanagiri block) the share of water market participatory farmers was more where compared to the safe block (Keerapalayam block). This indicates the fact scarcity growing more farms are participating in water market activities.

Groundwater Market Details of the Sample Farms:

Table 3 Distribution of Farm Size Categories among the Sample Farm

Block 1: Keerapalayam (S)					Block 2 : Melbhuvanagiri (SC)			
Farmer	**Control Group**	**Water Buyer**	**Water Seller**	**Total**	**Control Group**	**Water Buyer**	**Water Seller**	**Total**
Marginal below 1 ha	17 (65.38)	15 (75.00)	1 (7.14)	33 (55.00)	14 (63.64)	18 (66.67)	2 (18.18)	34 (56.67)
Small 1-2ha	6 (23.07)	3 (15.00)	5 (35.71)	13 (21.67)	7 (31.82)	8 (29.63)	3 (27.28)	18 (30.00)
Big farmer Above 4ha	3 (11.53)	2 (10.00)	8 (57.15)	14 (23.33)	1 (4.54)	1 (3.70)	6 (54.54)	8 (13.33)
Total	26 (100)	20 (100)	14 (100)	60 (100.00)	22 (100)	27 (100)	11 (100)	60 (100.00)

It could be observed the table 3 farm size distribution in which the category of marginal farmers was the highest with more than 50% share followed by small farmers in both the blocks. The group of marginal farmer and small farmer accounted for around 75 per cent share in both of the blocks. Most of the water buyers belong to the category of marginal farmers and in the case of water sellers a large proportion of them are medium and big farm categories (more than 50%). Between the blocks the water buyers belonging to small farmers and marginal farmers were category in higher participation in semi critical block compared to safe block. This corroborates the interesting finding that the marginal categories were lacking the physical access to their own groundwater resource due to their deficiency in getting the economic access.

Table 4 Intersectoral Water use in Groundwater Markets

Block 1: Keerapalayam						Block 2: Melbhuvanagiri			
S. No	**Purpose**	**Control Group**	**Water Buyers**	**Water Sellers**	**Total**	**Control Group**	**Water Buyers**	**Water Sellers**	**Total**
1	Irrigation	26 (100)	15 (75.00)	11 (78.57)	52 (85.00)	15 (68.18)	20 (74.07)	6 (54.54)	41 (68.33)
2	Drinking and domestic use	0	3 (15.00)	2 (14.28)	6 (10.00)	4 (18.18)	4 (14.81)	3 (27.27)	11 (18.35)
3	Industry and construction	0	2 (10.00)	1 (7.15)	3 (5.00)	3 (13.64)	3 (11.11)	2 (18.18)	8 (13.33)
	Total	26 (100)	20 (100)	14 (100)	60 (100)	22 (100)	27 (100)	11 (100)	60 (100)

The table 4 showed the intersectoral water use in water and non water market participating farms. In the case of control group all the farmers use the groundwater only for irrigation purpose in both the blocks. Among the water buyers of selected two blocks the buying of water was mainly intended for irrigation purpose (around 85 per cent). In case of water selling the purpose was though mainly for irrigation the purpose for others utilities namely viz drinking, constructions were substantially higher 40-45 per cent. Between the blocks the purpose of selling water for other than irrigation was marginally higher in Bhuvanagiri block (semi critical) 45 per cent compared to Keerapalayam block (safe) 40 per cent.

CONCLUSION:

India is bestowed with two distinct phases of monsoon. The regions mainly benefited from northeast monsoon are coastal Tamil Nadu. About fifty per cent of rainfall of Tamil Nadu and forty eight per cent of rainfall of southeast coast of India is obtained from northeast monsoon, which is one of the important components of Indian climate system, in Tamil Nadu. The present study revealed an inconsistent and ill distributed nature of the northeast monsoon which is a major recharging factor of groundwater. The groundwater levels revealed a negative correlation with the rainfall. In this context the institutional role of groundwater markets was considered as an efficient groundwater management tool which ensures its efficient case in the context of its scarce supply. The study also revealed that as scarcity increases to critical levels the emergence of water market is also flourishing particularly when the small farmer and marginal farmer category was diver more towards this option. Hence the study suggests the government to may form cooperative water markets system to streamline and develop the performance of existing water market system.

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