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Agriculture Drought Management in Ramanathapuram District of Tamil Nadu, India

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Abstract: Drought is one of the recurring features of Indian agriculture, especially in the rain fed areas. It affects not only the national food security but also causes miseries to human life and live stock. The study area, i.e., Ramanathapuram district of Tamilnadu, India (Latitude 9º40'and Longitude 78º70') has been affected consecutively for the last three years from 2015 to 2018 by drought, due to the failure of rainfall of northeast and southwest monsoons. So, the economic status of the area has declined due to the drought and the people from this district have migrated to other districts to improve their socio-economic status. This district has seven taluks, eleven blocks and four hundred villages. Major physiography units of the district are vast coastal plain, adjacent alluvial plain and a small area of buried pediments. The predominant geological formations are recent alluvium, and laterite followed by mio-pliocene Cuddalore Sandstone, upper cretaceous calcareous sandstone and proterozoic basement rocks. The total thickness of sedimentary rocks may be upto 3000 metre. The shallow aquifer in the district is severely affected by sea water intrusion and the inland salinity of marine sedimentary formations. Since the shallow aquifer is saline, paddy cultivation practices are generally being done through rain fed lake irrigation. According to the Central Ground Water Board report, the deeper groundwater aquifer in this district would give a continuous supply of freshwater. In order to develop agriculture activities and avoid drought management, the following steps are to be undertaken immediately.

1. River linking scheme of westerly debouching, i.e., Western Ghat Rivers in the Arabian Sea with the ephemeral rivers of the study area such as Vaigai, Gundar and Kottakkarai Rivers to improve the recharge of groundwater and prevent sea water intrusion.
2. Delineation of the depth of deeper fresh water in Tertiary and Cretaceous aquifer by sub-surface mapping study through 2D resistivity imaging depth profile study and borehole data.
3. Augmentation of engineering structures in the coastal area will prevent sea water intrusion in the shallow aquifer.
4. To improve the socio-economic status of the farmer and for drought management, a crop insurance scheme should be implemented for farmers.
5. Providing long term loans with subsidy facilities should be implemented for the construction of bore holes to improve crop production by getting fresh water from a deeper aquifer.

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6. The study area is located nearer to the sea, so the large scale desalination plant system should be implemented by government organisation to get fresh water for improving agriculture practices.

Keywords: Lake irrigation; River linking scheme; 2D-resistivity imaging; Desalination plant; Geology and drought.

Introduction

At present day, drought is one of the periodically happening features, which affects the Indian agriculture system, which not only makes the national food security vulnerable but also causes discomfort to human life and livestock. Drought is an insidious natural hazard that results from a deficiency of precipitation from expected (or) normal such that when it is extended over a season or longer period of time, the amount of precipitation is insufficient to meet the demands of human activities and the environment (Wilhite, 2005). In Bangladesh, agricultural and meteorological drought risks through the applications of remote sensing and GIS database were interpreted (Murad and Saiful, 2011). A qualitative and quantitative appraisal about droughts in Tamil Nadu were analysed and identified in ten drought-prone districts such as Coimbatore, Pudukottai, Thirunelveli, Ramanathapuram, Madras, Madurai, Salem, Dharmapuri, North Arcot, Thiruchirapalli (Nathan, 1998). The drought management plan report was published by the Ministry of Agriculture and Farmer's Welfare department of agriculture co-operation and farmers (2017). Numerous researchers not only in India but also in various parts of the world have discussed drought management (Chopra, 2006; TDEC report of Tennessee, 2010; Belal et al., 2012; Gedif et al., 2014).

The Ramanathapuram region in Tamilnadu, India has been consecutively affected since the last three years from 2015 to 2018 by drought, due to the non-appearance of the northeast and south west monsoon. The groundwater level and rainfall as shown in Figure 1 indicate a decreasing trend from the year 2004 to 2018. This has led to the decline of the economic status of the area. Due to this effect, the people of the district have migrated to other districts to improve their socio-economic status. There are seven taluks, eleven blocks and four hundred villages in the district. Keeping with this aim, a scientific attempt has been made to analyse the agriculture drought of the region.

In order to develop agriculture activities and avoid drought management based on the terrain characteristics, such as physiography, geology and other feasibility features, some important steps are recommended to be

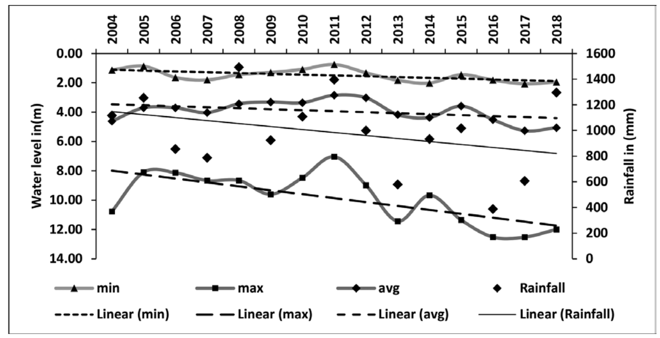

Figure 1: Graph shows the decreasing trend of groundwater level (Source: CGWB) and rainfall (Source: IMD) for Ramanathapuram District.

undertaken immediately. No such scientific thought of research work has been evaluated previously by any researchers in the study area. This is the first proposed scientific research work in the study area.

Study Area

Ramanathapuram district has an area of 4089.57 sq.km. It lies between the latitudes N 9.05° and N 9.50° and Longitudes E 78.10° and E 79.27° and is bordered with the areas of Tuticorin, Sivagangai, and Viruthunagar districts and Palk Straits and Gulf of Mannar region of Bay of Bengal. Ramanathapuram is the capital town of this district. The district has a longest length of 236.8 km coast line. The study area has been connected with national and state highway road networks. Ramanathapuram and Rameshwaram are two important railway stations. The pilgrimage centre Rameshwaram is connected with the land part by Pamban-Indira Gandhi Bridge.

Physiography

The major physiographic units of the district lies in a vast area of coastal plain bordered by the Bay of Bengal, adjacent alluvial plain and a small area of buried pediments. In the alluvial plains and buried pediment area, paddy, green chilies, millets, groundnut, and sugar cane are cultivated. But, paddy cultivation practices are predominantly being done through rain fed lake irrigation. The rivers of the district are only jungle streams that remain dry for the greatest portion of the year. However, Vaigai and Gundar are the two important ephemeral rivers that connect the many lakes of the districts. There are other seasonal small rivers like Malataru river, Kotttakarai river and Sarugani river. The main source of irrigation is a tank fed by monsoonal precipitation. There are 61382 tanks that are available in this district. The important land use and land cover part of the district are forests, barren land, uncultivable land, agricultural land, cultivable waste land and villages. The total cropped area is 191823 hectares. The entire area of the district consists of red loamy soil, lateritic soil, black soil, and sandy soil.

Climate and Rainfall

It is a dry and backward area. The hottest months of the area are May and June. Rainy seasons begin from the month of August. The SW and NE monsoons are responsible for contributing rainfall in this area. The annual rainfall of this district from southwest monsoon is 136.1 mm and Northeast monsoon is 507.4 mm, respectively. The district gets considerable rainfall received from the NE monsoon.

Geology and Geomorphology

The majority of the older rocks occur as a subsurface outcrop. The proterozoic basement rocks such as charnockite, gneiss, granite occur at 3000 meters depth in the coastal region and shallowly buried pediment occurs in the Kumuthi taluk area. Proterozoic basement is overlain by Cretaceous sandstone and limestone beds, followed by Tertiary Cuddalore sandstone bed. It is overlain by Quaternary and Recent alluvium, laterite, calcrete and beach sediments. The entire stratigraphical succession of the Ramanathapuram district is shown in Table 1. Despite the shallow aquifer that may be affected by sea water intrusion and inland salinity of the subsurface Quaternary marine formation, the deeper aquifer of Tertiary and Cretaceous formation would tend to give a continuous supply of freshwater (CGWB, 2014).

Table 1: Stratigraphical succession of the study area

Age		*Formation*
Quaternary	Recent	Alluvium – Sand, Clay Silt Laterite – Calcrete
	Mio-Pliocene	Cuddalore Sandstone and Clay Lignite
Tertiary (Eocene-Paleocene)		Clay and Shale, Sandstone
Upper Cretaceous		Calcareous Sandstone, Arenaceous Limestone, Calcareous Grey Shale
Proterozoic		Basement rocks Charockites, Gneiss, Granite and Pegmatite

Result and Discussion

The agriculture activities have been practiced for a long term in the study area through rain-fed lake irrigation process. If the lake is filled with rainfall, one-time agriculture activity would be fulfilled. But due to the lapse of monsoonal failure from 2015 to 2018 consecutively, there is a need for some permanent drought management ideas that have to be done in the study area. In order to develop agriculture activities and avoid drought, due to the lapse of rainfall, the following theme of steps for agriculture drought management is discussed. They are 1. River linking scheme with the Western Ghat rivers, 2. Delineation of freshwater aquifer and seawater intruded areas through 2D resistivity imaging depth profile studies, 3. Augmentation of engineering structures for recharge the shallow aquifer by preventing seawater intrusion, 4. Implementation of crop insurance schemes for the farmers and 5. Long term loan with subsidy facilities to farmers for making bore holes to get deep aquifer water.

River Linking Scheme

To expand agriculture productivity and address water scarcity, National River Linking Projects (NRLP) have been implemented in India (Mehta and Naveen, 2013). Sir Arthur Cotton thought about a plan to link rivers in south India for inland navigation in the 19th century. The river interlinking scheme has several benefits, such as irrigation, food production, generation of electricity, navigation, higher GDP growth, business opportunities, and drinking water and revenue aspects. The issues related to interlinking of rivers in India are ecological imbalance in aqua life, deforestation, area getting submerged and displacement of people. The total costs for rivers linking scheme in India have been estimated as Rs. 560,000 crores (Mehta and Naveen, 2013).

In the study area, there are two ephemeral rivers such as Vaigai and Gundar which are originated from the western ghat regions. Many of the rivers that originate from the Western Ghat of the Kerala region, which is adjacent to the Ramanathapuram district, are debouching the water into the Arabian sea. They travel a very short distance and it also not possible to construct a dam in Kerala, due to the steep slope of the terrain. If it is diverted to the east and interlinked with the rivers of Gundar and Vaigai, the entire district of Ramanathapuram would become fertile and prevent sea water intrusion, due to the upliftment of the groundwater recharge in the alluvial plain of the district. Inter-linking possibilities of Western ghat Rivers with Gundar and Vaigai are shown in Figure 2.

2D Resistivity Imaging

The 2D resistivity image meter survey systems are widely applied in groundwater investigation, for hydrology, mineral exploration, cavity mapping and geotechnical survey. Groundwater potential zones and sea water intrusion areas are delineated through Earth Resistivity Image (ERT) (Prabakaran et al., 2020). Numerous researchers have identified the groundwater potential zone through ERT images in different terrain (Naudet et al., 2003; Ratnakumar et al., 2012; Tsiboah, 2002; Ehirim and Ebeniro, 2010; Kumar et al., 2010; Sathish et al., 2011; Levi, 2011; Shamaun et al., 2011; Kumar et al., 2014; Rai et al., 2013; Jayeoba and Oladunjoye, 2015; Gopinath et al., 2016; Hussain and Javadi, 2016). The integrated study of the GIS data base, 2D resistivity imaging and geochemical study of existing ground water wells of the study area would delineate such sub-surface details of groundwater zone and sea water intrusion part of the study area (Agastheeswaran et al., 2021; Selvam et al., 2021). So, the above scientific survey is required in the study area for drought management purposes.

Augmentation of Engineering Structures

Augmentation of engineering structure is required in the study area to prevent seawater intrusion in the shallow aquifer. The shallow aquifer of the Thiruvadanai taluk of Ramanathapuram is highly affected by sea water intrusion (Vaithyanathan, 2003). Series of construction of check dam within the gap of 1km in the jungle streams of the study area would increase infiltration of groundwater and avoid more run off. Due to the construction of a check dam, the rate of sedimentation increases and the accumulation of sand will also be increase and turn into a good aquifer zone (Bagyaraj et al., 2021). The construction of the concrete wall along the coast in the erosional areas and construction of dykes in the river creeks would prevent the sea water intrusion in the alluvial plain of the study area (Shanmugam et al., 2014; Kongeswaran and Sivakumar, 2021). Due to the improvement of aquifer recharge, agricultural drought will be managed through the groundwater recharge of the study area. The model check dam in the river and coastal wall diagram is shown in the Figure 3 (Raju et al., 2013).

Crop Insurance

Paddy cultivation practices are generally being done through rain fed lake irrigation in the study area. But in the last three years from 2015 to 2018, the entire district is consecutively affected by drought, due to the failure of rainfall of north east and south west monsoon. So the socio-economic status of the area is declined due to drought and people of the district have migrated to other districts, like Coimbatore and Tirupur for jobs to improve their socio-economy and some of the farmers were pushed to the condition of suicide status. There are some crop insurance schemes, like Pradhan Mantri Fasal Bima Yojana (PMFBY), National Crop Insurance (NCI), and Agriculture Insurance Company of India (AICI) (Vikas pedia, 2019).

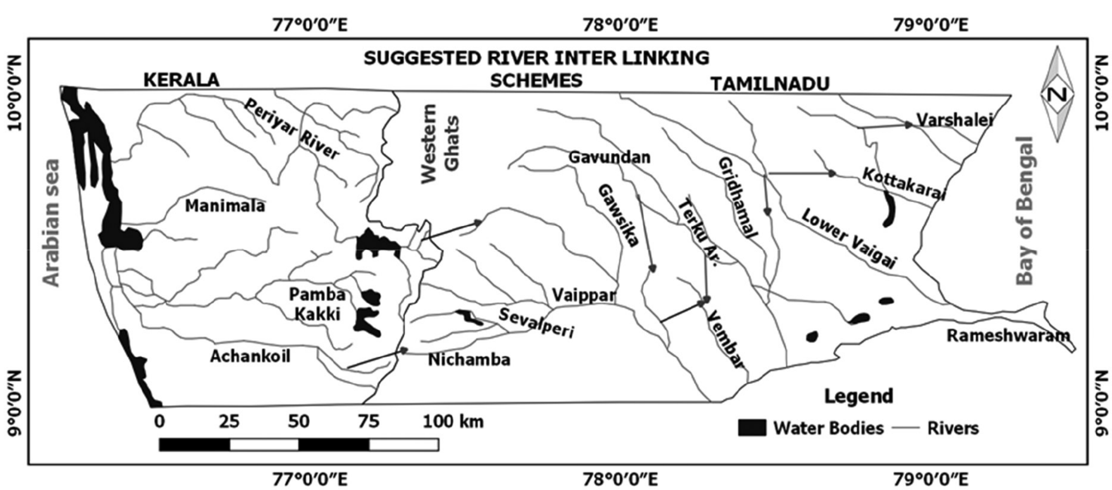

Figure 2: A view of the River linking possibilities of Kerala rivers with the study area rivers Vaigai and Gundar.

The people of this district have received only the insurance amount for the period of 2015-2016. The remaining periods insurance amount have not been received to date. So, the people of the district are undergoing agitation for crop insurance for the remaining period. So, in drought management the distribution of crop insurance amount without delay, would promote and safeguard the socio-economic status of the farmers.

Long Term Loan with Subsidy Facilities

The deep aquifer from the Tertiary and Cretaceous provides a continuous supply of ground water (CGWB, 2014). This aquifer is located at 115-375 m depth with an average thickness of 68 m to 136 m at Andavurani, Suryankudia and Thiruvadanai villages of the Ramanathapuram region (Vaithyanathan, 2003). So, the farmers of this district should be given long term loan facilities with a subsidy for agriculture development in this district. By giving such facilities, agriculture drought would be manageable in this district. The cross section of the deep aquifer in the Thiruvadanai taluk of the Ramanathapuram region is shown in Figure 4 (after Vaithyanathan, 2003).

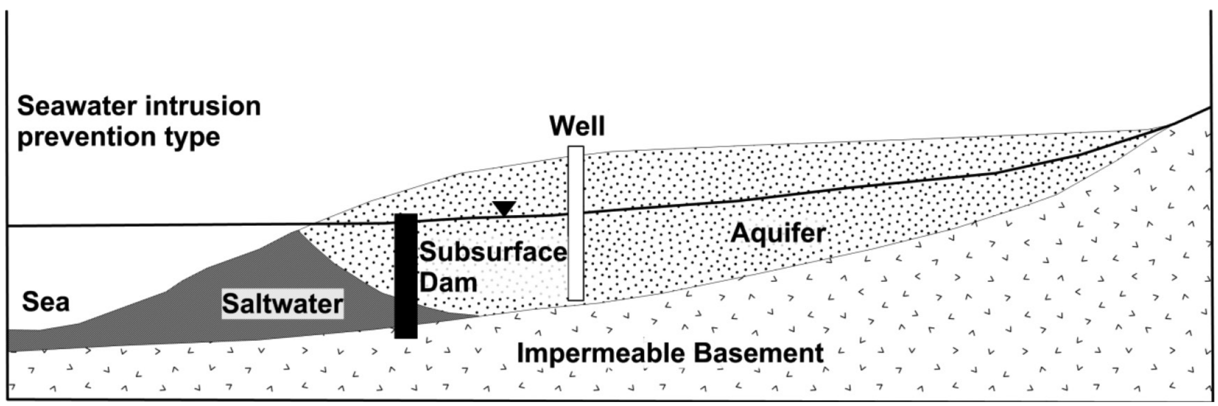

Figure 3: A model view of the Check dam to prevent sea water intrusion (Raju N. et al., 2013).

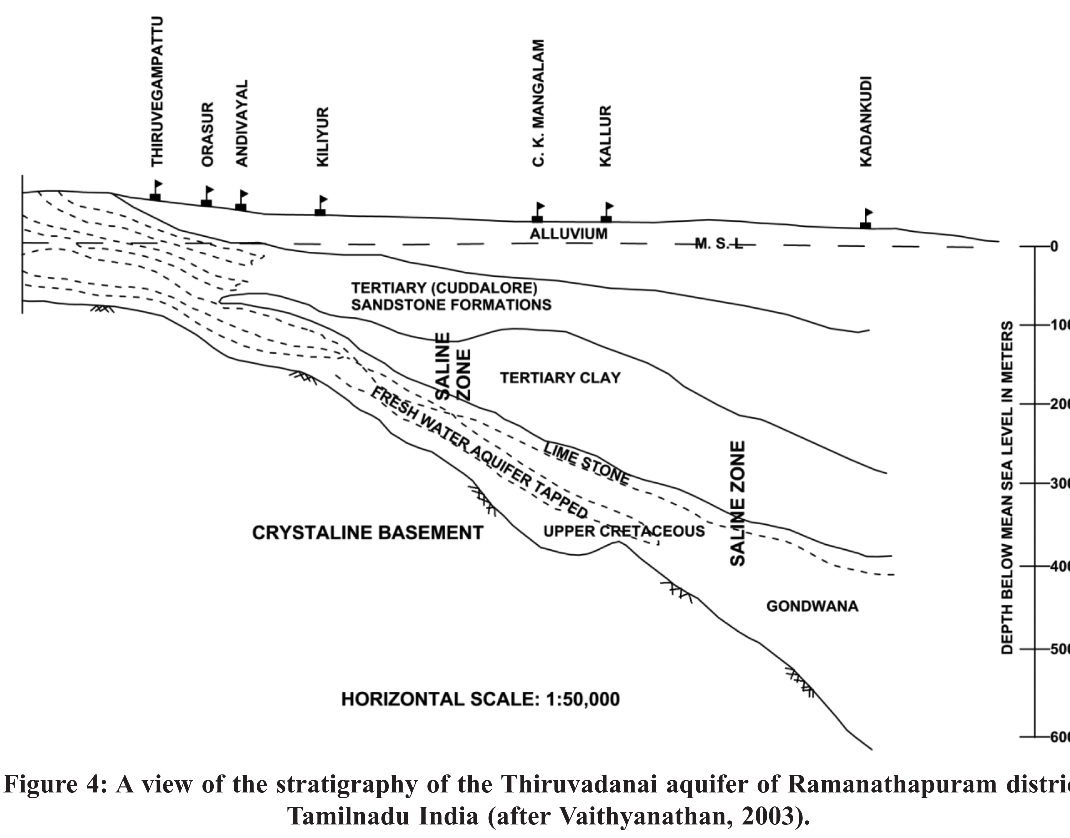

Figure 4: A view of the stratigraphy of the Thiruvadanai aquifer of Ramanathapuram district, Tamilnadu India (after Vaithyanathan, 2003).

Large Scale Desalination Plant System

Ramanathapuram district has a vast area of coastal line with a length of 236.8 km. The coastal plain of this study area also generally has saline groundwater (Ramachandran et al., 2021). So, the installation of large scale desalination plants can be possible, not only to provide domestic water but also to supply a large scale of fresh water for agriculture development. The installation of large scale desalination plant for the coastal wells such as Jaldoot scale remover and sea water desalination plant would definitely promote the agriculture development in the study area. Israel and Middle East countries are obtaining freshwater for domestic and agriculture development by the installation of large-scale desalination plants in their country. Such type of installations of large scale desalination in the Ramanadhapuram district would definitely promote agriculture development and satisfy the domestic need of freshwater of the district.

Conclusion

The following scientific conclusions have been made to develop agricultural management in the study area. Implementing river linking schemes to connect the Arabian Sea's westerly debouching western ghat rivers with the study area's ephemeral rivers, such as Vaigai and Gundar, will prevent the study area's agriculture drought. Intrusion area through the study of 2D resistivity imaging would scientifically provide information about the groundwater occurrences in the study area. This research study would not only help in giving scientific information to the source but also provide more support to the administrator for the agricultural development. Augmentation engineering structures like check dam and the coastal wall will prevent sea water intrusion in the shallow freshwater aquifer zone and increase the recharge in the study area. The implementation of crop insurance and rectifying the drawback of clearances in the distribution of crop insurance systems would promote the socio-economy status of the farmers. Long term loan facility with subsidies given by the government to farmers, for making boreholes to receive water from deeper aquifer groundwater, would promote agriculture development during the monsoon failure. Large scale desalination plants from the sea and saline wells of the land would give freshwater and from which agriculture, can be developed in the study area.

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