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# Integrated water resource management for sustainable development-a case study of Kottakarai Aru water shed of lower Vaikai river basin in Ramanathapuram district using geo-spatial technology

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**ABSTRACT**

Digital elevation model (DEM) is used to determine the drainage networks involving the size, length, slope and similar features of the basin and sub basin features related to the water resource. Most importantly the hydrological analysis to be effective if the slope, area, direction, flow length, runoff length could be better reached through DEM. Scattered hydrological models clearly suggest the spatial variability of the physical properties of the basins. In this study, the characteristics of the Kottakarai Aru water shed located in Ramanathapuram district nearer to the Bay of Bengal are explained through the digital elevation model (DEM)for a detailed study of the drainage networks.



## Introduction

Water is one of the most important renewable natural resources. By the term “exploitation of a region’s water resources” we refer to the activities that aim in rational exploitation of these resources within the quantity limits of the annual fluctuation of water resources and in combination with works and activities with the lowest cost possible, not only financially but also environmentally (5,11). Since the past few decades, increasing of drought conditions especially in Ramanathapuram district area affect the ground water level. This is a global issue which happens throughout the world when there is below average rainfall.

Recent approaches for sustainable water management at the basin scale involve the using up of a framework of an integrated water resources management (IWRM) by combining surface, groundwater, and unsaturated flow modelling as tools for the decision making, the development of decision support systems, e.g., to improve planning and management in large irrigation schemes, the involvement of multiple decision tools to find conflict resolutions, or the integration of multi-discipline aspects into a web-enabled spatial Decision Support System (DSS).

The researchers also focused on the analysis of irrigation and environmental quality impact at the basin level, and adopted multi scale modelling tools for solving conflicts in rural basins with irrigation water uses. Therefore sustainable water resources management for irrigation is not only an objective on the farm level but also an overall goal at the district level, which means in general at the basin scale. Due to the competition of all water users of a river basin, especially in water scarce regions, a comprehensive approach is needed regarding not only agricultural purposes but also domestic, industrial, and ecological aspects. The GIS applications for hydrological analyses in accordance with the principles of sustainable development, will contribute to the development of infrastructural objects of water resources.

The objective of the present study is to reveal the physical characteristics of the basin and allow positional assessment of hydrological variables besides determining the sub-basin borders by digital elevation models (DEM). This study also aims to calculate water flow directions and flow accumulation grids.

The implementation of the European Union’s WFD through a National Irrigation Plan in Spain, especially the sustainable and integrated use of water resources. The results of a questionnaire were used as the basis for a water management model and for analysing the ongoing monitoring of irrigation use in this region. A management model is developed as an interdisciplinary approach, namely to promote long-term social and economic development and at the same time ensure long-term environmental protection(1).

An irrigation district was used as a study case for the application of a Decision Support System (DSS) called FACILITADOR(6). It is a software tool to support decision making processes with the use of decision alternatives, helping to the solution of the overall problem of irrigation water productivity. First water needs to be priced and to train water users and delivering by volume. It is also presented a watershed management methodology based on land-use planning model, whereby sustainability criteria were introduced according to the capacity of the environment to support intervention in the watershed(13).

The study focussed on the identification of appropriate strategies to improve water management and productivity in the Sirsa district, India. The field scale eco-hydrological model SWAP, in combination with field experiments, remote sensing and GIS, has been applied in a distributed manner generating the required hydrological and biophysical variables to evaluate alternative water management scenarios at different spatial and

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temporal scales. Improved crop husbandry in terms of improved crop varieties, timely sowing, better nutrient supply and more effective weed, pest and disease control, will increase crop yields and water productivity in this district. The scenario results further showed that reduction of seepage losses will improve significantly the long term water productivity, halt the rising and declining groundwater levels, and decrease the salinisation in Sirsa district(10).

The contribution of workshop(3) applied the IWRM concept to develop an integrated water resources river basin plan for the São Francisco river basin in Brazil. The paper breaks down the concept to consider the multiple objectives and uses of water, the incorporation of other sectors in the planning process and the involvement of stakeholders in the decision-making process. The preparation of the plan involved a large number of stakeholders. As a result, besides significant progress in some aspects, the lack of definition concerning water allocation affects the performance of the whole set of IWRM instruments. They evaluated their plan actually as an initial landmark: seeking basin sustainable development is principally seen as a process of activation and channelling of the social forces, an exercise of initiative and creativity, and an improvement of the cooperation and interaction skills of the different players who live in the basin.

The dilemma of water management development is described(7) in Mexico, analyzing the current decentralization process. Although important advances have been made with irrigation management transfer, river basin councils, nascent user participation in groundwater management, and water and energy legislation, IWRM remains an elusive goal, principally due to inherent institutional and procedural contradictions in water resource allocation.

The contributions of the workshop on IWRM application in Latin America for case studies in Mexico (8) and Colombia (2) underline the actual problems of implementation in practicing integrated water resources management. The fundamental demand of IWRM in hydrological basins is the creation of a participative work frame for decision making, where all the water-using sectors, including the environment, are represented. A recent publication on a case study in Mexico (9) analyze the basic characteristics that mathematical basin models must have in order to satisfy the requirements of IWRM. The results of the analysis indicate that models for IWRM must be accessible to non expert users, integrate different viewpoints, representing adequately the problem to be solved, in addition be flexible and have a structure focused on practical solutions.

The problems of analyzed the Mexican Rio Conchos Basin, the largest tributary to the lower part of the Rio Grande/Rio Bravo Basin(4). They developed a decision support system as a semi-distributed model, based on System Dynamics, to evaluate several allocation alternatives for the main basin´s users: Irrigation District and Water Treaty. The DSS application showed that understanding the effects of multiple interacting variables is necessary to develop good natural resource management policies.

An integrated approach is presented (12) to study the impacts of external forcing on irrigated agricultural systems in the semi-arid grasslands of the Central Plains of the United States of America. Individually, models are presented that simulate groundwater hydrogeology and econometric farm level crop choices and irrigated water use. The natural association between groundwater wells and agricultural parcels is employed to couple these models using GIS and open modelling interface protocols. This approach represent the first time that groundwater and econometric models of irrigated agriculture have been integrated and provides useful methods for decision making.

**Study area:**

Ramanathapuram is located between 9° 05' and 9° 50' North of Latitude and between 78° 10' and 79° 27' East of Longitude. It covers the geographical area of 4123 km².and has the total population of 11, 87,604 including 5, 83,376 males and 6, 04,228 females. Ramanathapuram District is an administrative district of Tamil Nadu state in southern India. The city of Ramanathapuram is the district headquarters. It is bounded on the north by Sivaganga District, on the northeast by Pudukkottai District, on the east by the Palk Strait, on the south by the Gulf of Mannar, on the west by Thoothukudi District, and on the northwest by Virudhunagar District(Fig .1&2).

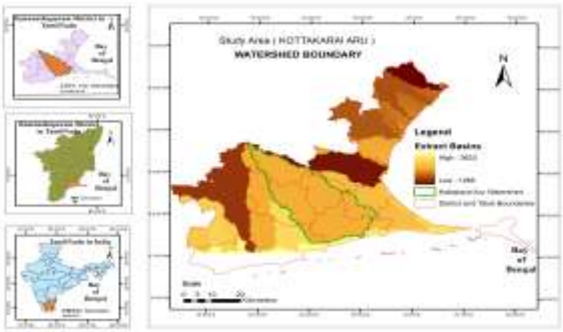


**Fig .1 Study area**

The district contains the Pamban Bridge, an east-west chain of low islands and shallow reefs that extend between India and the island nation of Sri Lanka, and separate the Palk Strait from the Gulf of Mannar. The Palk Strait is presently navigable only by shallow-draft vessels. It is one of the drought prone areas in the country. Dry tropical climate, an average annual rainfall of 94 cm that hails from mostly northeast monsoon from October to January are typical of this region. Temperature is around 30°C to 35°C and the highest ever recorded at Pamban station is 37°C and lowest is 17°C. All major economic activities including tourism are based on the Rameswaram islands and its temples. In contrast, the outer islands vary considerably in both geology and topography, ranging from smaller coralline islands to larger coralline that support to produce fishing zone. Groundwater is the main source for irrigation and for drinking purpose.

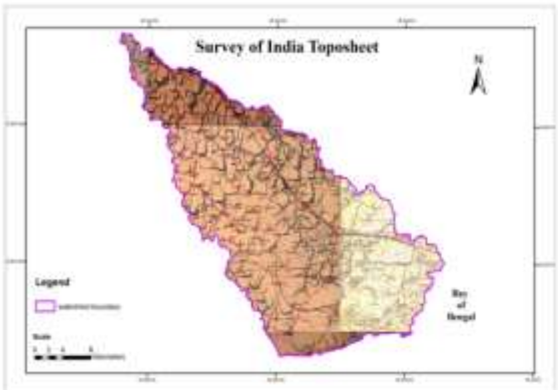


**Fig.2 Study area-Tposheet**

**Methodology:**

SRTM-WRS-2 Tiles image having, path 142 and row 53, GLCF acquired in 2000. Geo-referenced to UTM map projection

(Zone 43, North) and WGS84 ellipsoid, was used for the image analysis(Fig.3). Digital elevation models (DEM) are efficient and effective methods used to determine the features of drainage networks and like size, length, and slope of drainage network(Fig.6) and to determine characteristics of basin and sub-basin.

Moreover, the DEM many significant values like area, slope, direction, flow length, surface flow lengths etc can be obtained. Dispersed hydrological models clearly reveal positional changeability of physical characteristics of basins and allow positional assessment of hydrological variables. Besides determination of sub-basin borders by digital elevation models (DEM), this study aims to calculate water flow directions and flow accumulation grids and to determine drainage networks. DEM models were prepared using ERDAS imagine 9.1, Arc Hydrology model of Arc GIS is been used to identify the basin, flow direction, stream order and water shed.

**Analysis**

In this study, 1/50.000(1972,58 –K/3,O/ 2)scaled topographic maps containing water accumulation basin were used. First of all, 1/50.000 typographic map of the basin was digitized and transferred to computer (Fig.2). Elevation information of each contour was defined in geographic information system and according to these values, three-dimensional modelling of the field was gained (Figure 3). As it can be seen in the figure, study field was not very much rugged and has altitudes between 0 and 60 m.

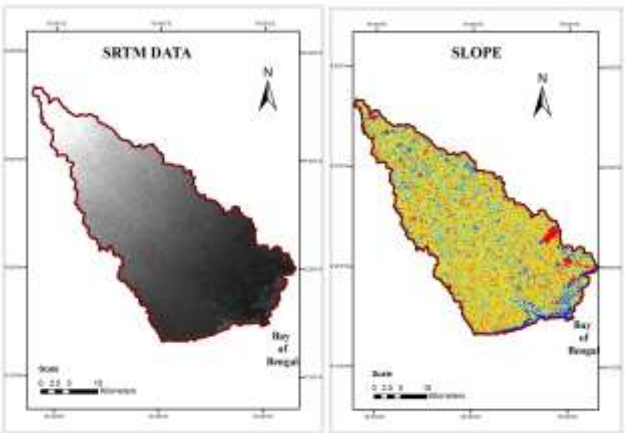


**Fig 3. Shuttle Radar Topography Mission - SRTM data and slope of the study area**

**Determination of drainage networks**

Drainage networks are made from flow accumulation model. A lower limit value is determined considering the precision and size of the study on this model and according to the highest cell value obtained from flow accumulation model. All cells above this lower limit value are defined as a part of drainage network.

When defining these drainage networks, all cells except for cells with zero value represent a part of the drainage network .By considering the water flow directions and flow accumulation model in the drainage network, main stream and side-branches are created.

Water flow direction in flow accumulation model is from cell with lower values to those with higher values. Drainage network map of the study area was drawn on this flow accumulation model (Fig. 5). This map shows existent stream paths and possible drainage network paths.

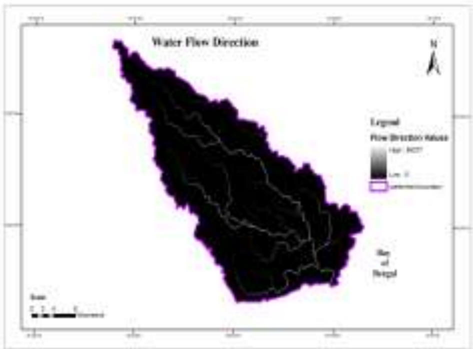


**Fig 4. Water flow of the study area**


**Fig 5. Stream orders of the study area**

**Digital elevation model (DEM)**

Satellite remote sensing can provide operationally digital elevation models (DEM) through radar interferometry or stereoscopic optical satellite images. DEMs form the basis for contour line-, slope- and aspect maps and can be further analysed through Geographical Information System (GIS) technology to define watersheds, stream-networks and order.

Digital elevation models (DEM) are efficient and effective methods used to determine the features of drainage networks and like size, length, and slope of drainage network and to determine characteristics of basin and sub-basin. Moreover, the DEM many significant values like area, slope, direction, flow length; surface flow lengths can be obtained. Dispersed hydrological models clearly reveal positional changeability of physical characteristics of basins and allow positional assessment of hydrological variables. Besides determination of sub-basin borders by digital elevation models (DEM), this study aims to calculate water flow directions and flow accumulation grids and to determine drainage networks. Elevation information of each contour was defined in geographic information system and according to these values, three-dimensional modelling of the field was gained.

The following shows the stream order found in the study are calculated based on the Strahler method (Fig.6.)

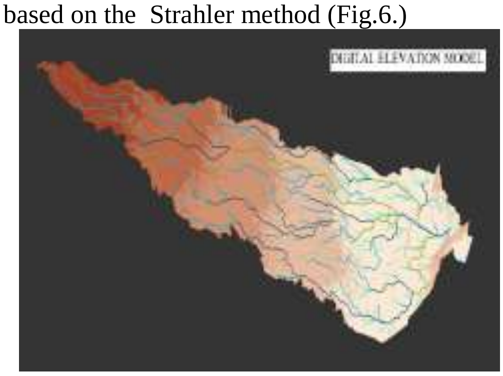


**Fig 6. Digital Elevation Model of the study area**

The following shows the stream order found in the study are calculated based on the Strahler method (table 1).

**Table 1.shows the stream order**

| Stream Order | Length ( Mts) |
|---|---|
| I st order | 378994 |
| II nd order | 221651 |
| III rd order | 139287 |
| IV th order | 71641 |
| V th order | 11647 |
| **Total Length** | **813220** |

If the streams are idealized as single lines containing no lakes, islands, nor junctions of more than two streams at the same point, the resulting diagram is known in the geomorphic literature as a trivalent planted tree, or dendritic stream network. The sources are the points farthest upstream in a stream network, and the outlet is the point farthest downstream. The point at which two streams join is called a junction. An exterior link is a segment of stream network between a source and the first junction downstream. An interior link is a segment of stream network between first two successive junctions or between the outlet and the first junction upstream.

## Conclusion

The digital elevation model of study area was developed in this study. The region's water flow directions were determined from this model and drainage map. Flow directions in the study area were determined and accordingly flows were generally in east- southeast direction. According to the Strahler method there were five stream orders were found with the total length of 813220 mts. It is also found that study field was not very much rugged and has altitudes between 0 and 60 m.

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