APPLICATION OF GIS ININTEGRATED WATER RESOURCES MANAGEMENT (IWRM) FOR EFFECTIVE SERVICE DELIVERY

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ABSTRACT:

IWRM is defined as "a process which promotes the coordinated development and management of water, land and other resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems." IWRM should integrate the exiting scenario of the water resources and others resources which will help to improve the management and implementation for its sustainability in various sectors like water management, social, cultural, and economic. IWRM with multi sectoral convergence is a very big challenge. It is a long process for organizing various process in a single domain, but with the application of Geographical Information System (GIS) in this concept it is possible because it is a decision support system, which involves the integration of spatially referenced data in a problem-solving environment. For this Upper vellar sub basin which is located in the Vellar river basin between the latitudes 11° 13'N - 12 00' N and longitude 78° 13'E - 79° 47 E is taken for model study.

Keywords: GIS, IWRM, Effective Service Delivery

1. INTRODUCTION:

Population growth, increased economic activity and improved standards of living are placing tremendous pressures both on water resource supply and service delivery systems and the water crisis has reached critical levels. Growing demands on water resources from industrial, domestic, and environmental sources, along with increasing quality and quantity issues as a result of rapid urbanization, have made water resource management imperative in India. As the opportunity costs of water increase, and management of water resources and their allocation among competing demands assumes vital importance, and demand management must undoubtedly receive preference over traditional supply management. Integrated water resource management (IWRM) is a holistic approach that promotes coordinated development and management of water, land, and related servicesto maximize economic and social welfare equitably, without compromising the sustainability of vital ecosystems. The river basin is taken as a logical hydrological unit of management, and institutional support usually comes in the form of a river basin organization (RBO) or a similar organizational structure. Successful implementation of IWRM envisages a vital role for the state, with its associated infrastructure as the chief regulator in the water sector. Involvement of active stakeholders is, likewise, essential for prioritizing water resources issues and improving the present water resources management system (Rajagopal, 2007).

2. CONCEPT OF INTEGRATED WATER RESOURCES MANAGEMENT (IWRM) :

IWRM emerged around the 1980’s inresponse to increasing pressures on limited waterresources from competition amongstvarious users for a limited resource, therecognition of ecosystem requirements,pollution and the risk of declining wateravailability due to climate change. A centralgoal of IWRM at the river basin level is toachieve water security (WWF, 2006).

The path towardswater security requires proper balance betweenmeeting multisectoral,multistakeholderneeds, and establishingadaptable governance mechanismsto cope with evolving environmental,economicaland social circumstances. IWRMstrives for effective and reliable delivery ofwater services by coordinating and balancingthe various water-using sectors – thisis an important part of sustainable watermanagement. As water is mainly managedlocally, the river basin approach is recognizedas a comprehensive process for managingwater resources in a more sustainablemanner. However, well-developed, welltested,scientifically robust, socially acceptable and economically viable approaches toimplement IWRM at the river basin levelare still not widely available (AFDB, 2008).

3. NEED FOR GIS IN IWRM:

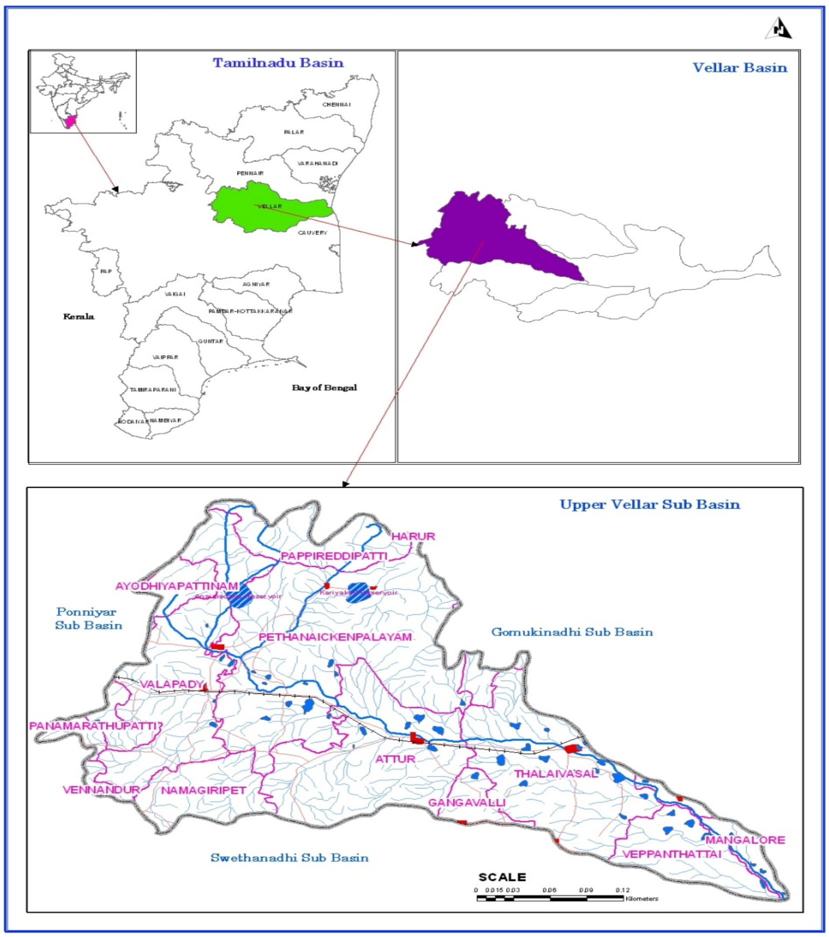
IWRM is the process of planning and implementing strategies for sustainable water resources development and utilization with a Multisectoral convergence and Multi state holder focus due consideration of all spatial and temporal interdependencies among natural process, human and ecological water uses (Castelletti, 2007). Effectiveness of GIS is dependent on how well it is integrated as a whole. For the optimum use of the GIS technology it should be integrated to attain strategic benefits.This is a very good platform for good and effective communication which mainly focuses on creating anwater based environment-conscious about the society. It also gives a thorough understanding of hydro (geo) logicalcharacteristics and socio-economic conditionsat the sub basin level.

4. OBJECTIVE:

The following are the major objectives of the study

1. To obtain the existing scenario in sub basin level using remote sensing and GIStechnologies
2. Identification of the water related challenges and proposing suitable multisectoral interventions with convergence to have synergy and ensure effective service delivery
3. To demonstrate the use of GIS as a powerful planning, implementation, evaluation and monitoring tool for IWRM and enhance the transparency and accountability of the water Governance.

4. STUDY AREA:



Government of Tamil Nadudecided to renovate the Irrigation systems in Tamil Nadu by rehabilitating and modernizing the irrigation systems. This is to restore the age old storage systems back to their capacity and bridge the gap area.In order to achieve that, the Government decided to take up this project with World Bank assistance as an integrated program with the active involvement of 8 professional agencies that provide water and food services under the co-ordination of Water Resources Organization (WRO). This World Bank assisted program is named as Integrated\AgriculturalModernisation and Water Resources Management (IAMWARM) project. TheIAMWARM project covers all the river basins in the state except Cauvery basin. Among the 61sub basins, 9 basins wereselected for implementation of this project in the first year of the project period which includes the upper vellar sub basins.The Vellar river basin is located in the Northern part of Tamil Nadu State in South India, between the latitudes 11° 13'N - 12 00' N and longitude 78° 13'E - 79° 47 E. This basin is in between Ponnaiar, Paravanar and Cauvery river basins. The total area of the basin is 10187 ha (Figure-1). The terrain lying in the Kalrayan hills, AtturTaluk of Salem District is drained by river upper velar, VasistaNadhi known as Upper Vellar joined with to form the Vellar in the PerambalurTaluk of Perambalur District.

5. METHODOLOGY:

Figure-2 represents the overall structure and methodology adopted for this study

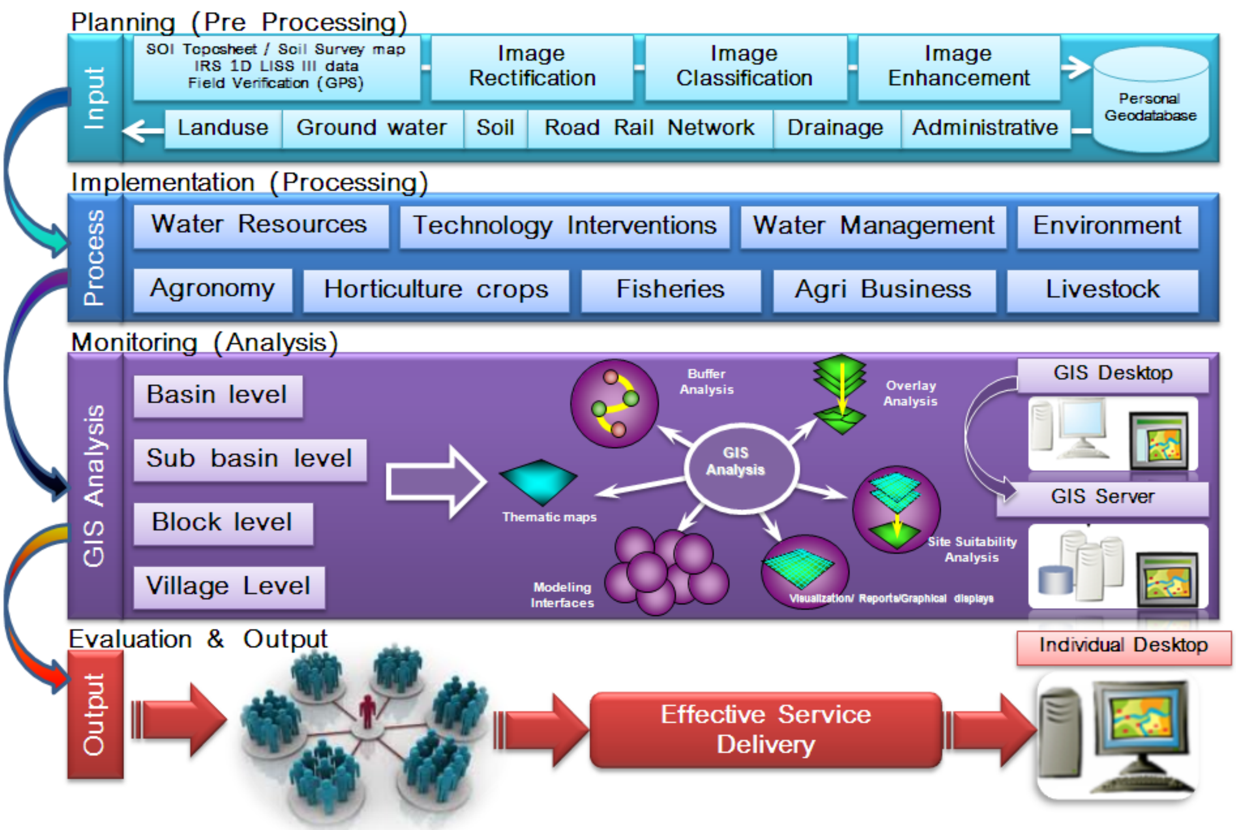


Figure-2 Methodology of the study

6. PLANNING(INPUT/PRE PROCESSING):

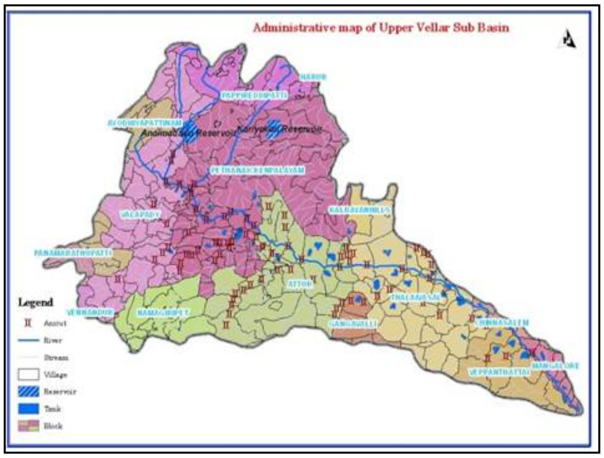
Geographical Information System (GIS) is a powerful tool for collecting, storing, organizing, retrieving, transforming and displaying data from the real world for a set of particular purpose (Burrough, 1986). It is a decision support system, which involves the integration of spatially referenced data in a problem-solving environment (Cowen, 1988). Function of an Information system is to improve one's ability to make decisions and for effective service delivery.

Digital layers of SOI (Survey of India) toposheet, Soil texture (Soil survey of India) maps and IRS LISS III data were used to map the existing scenario of the upper vellar sub basin. Maps were prepared in 1:50,000 scale and the doubtful areas were verified in the field using GPS. Using the ArcGIS software the thematic layers like hydrological boundaries (Basin, and Sub basin), administrative boundaries (District, Block and Village), Drainage boundaries(River, Streams, Tanks, Dam and Reservoir), Transport maps (Road and Rail Network), landuse maps, Groundwater maps and DEM maps were prepared for the planning level (base data). Based on that detailed project report (DPR) was prepared by the individual departments for proposing the suitable activities in a convergence manner. DPR contains the following details also for the study area, hydrological characters (rainfall, temperature, water resources availability, surface water potential, water demand, scope for the project and etc.,).
The weighted annual average rainfall of the upper vellar sub basin `is about 847.5mm and average monthly temperature max./min.in 32.30/ 23.80º Celsius. Monthly Runoff Simulation (MRS) Model assesses the surface water potential for 75% dependable yield for southwest, northeast and non monsoon periods.

The versatility of the GIS tool is demonstrated by the decision support to the project management like, clustering the tanks for a procurement package, contracting and demarcating the boundaries for water users association. This enabled better monitoring and organizing support services for served and unserved area by avoiding crisis cross movements and facilitating earth moving equipment for field work.

6.1 Administration:

The Upper Vellar Sub Basins has 4 Districts (Salem Villupuram, DharmapuriCuddalore, Namakkal and Perambalur), 13 Blocks (Attur, Ayodhiyapattinam, Gangavalli, Harur, Mangalore, Namagiripet, Panamarathupatti, Pappireddipatti, Pethanaickenpalayam, Thalaivasal, Valapady,VennandurVeppanthattai) and 251 Villages (Figure-3). The tank Memoirs available with water resource department provide historical information of the irrigation infrastructure.



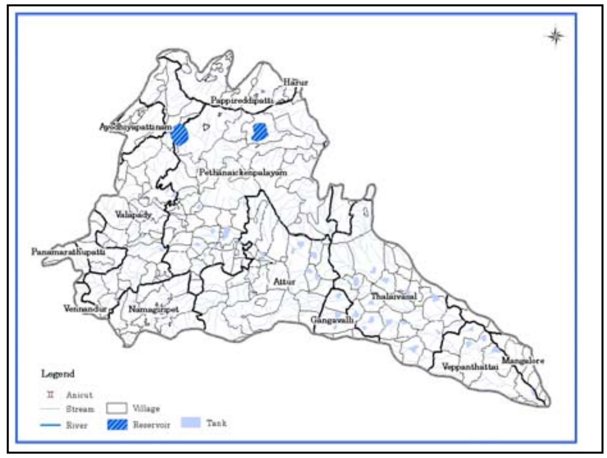
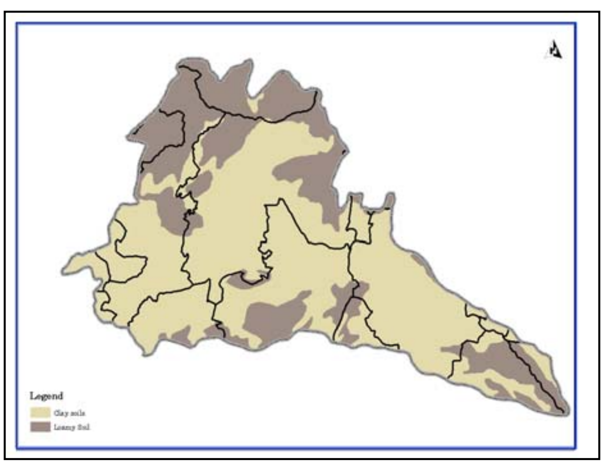


Figure-3 Figure-4

6.2 Drainage:

Upper vellar known as vasista river originates from Kalrayan hills and confluence with Swetha river near Tholudur in Perambalur and becomes Vellar river. Chittar river, Manjini river and Ammampalayam river are major tributaries to Vasista river. Chittar river and Manjini river are originates from paithur reserve forest and Ammampalayam river originates from Kalrayan Hills. Length of the Vasista river is 107kms. Drainage area is 412.80 km^2.Vasista river sub basin covers Valapadi, Pethanaickenpalayam , Attur and Thalaivasal blocks of Salem District. Major reservoir in this area is Kariyakovil and Anaimadu reservoir with an ayacut area of 1456.90 and 2028 ha (Figure-4).



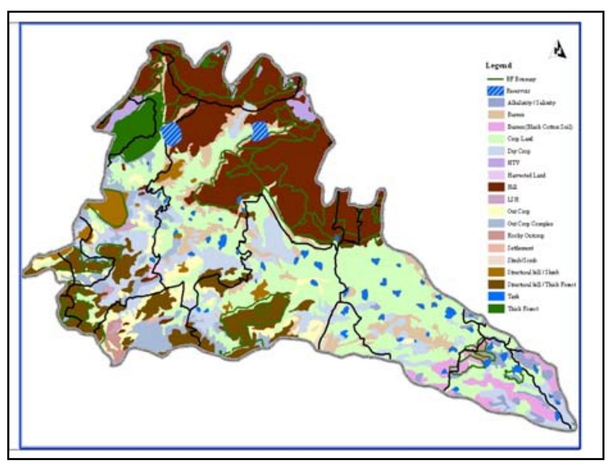


Figure-5 Figure-6

6.3 Soil:

Clay and Loamy are the major soil types with an area of 120117.55 and 61417.06 ha (Figure-5). PH value of soil has the range from 7.2 to 8.5 and problem soils like saline, alkaline and acidity are not predominantly present in upper vellarsub basin area

6.4 Landuse:

Figure-6&7 and table - 1 explain the landuse classes and its spatial extent in the upper vellar sub basin. Out of the total area of 181534.61 ha the following classes occupies Alkalinity / Salinity (1531.51 ha), Barren (12986.32 ha), Crop land (50755.89 ha), Dry crop (19557.70 ha), Harvested land (329.49 ha), Hill (42992.43 ha), Hill top valley (6424.03 ha),LSH (689.49 ha),Out crop (8042.32 ha), Out crop complex (9515.59 ha), Rocky outcrop (1362.67 ha), Settlement (201.96ha), Shrub/Scrub (589.40 ha),Structural hill / Shrub (4267.56 ha), Structural hill / Thick Forest (16493.40 ha), Tank (1209.11 ha), and Reserve forest (4585.74 ha).

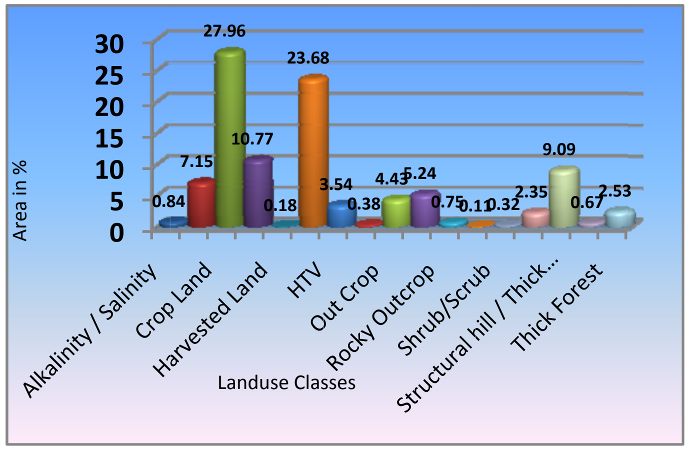


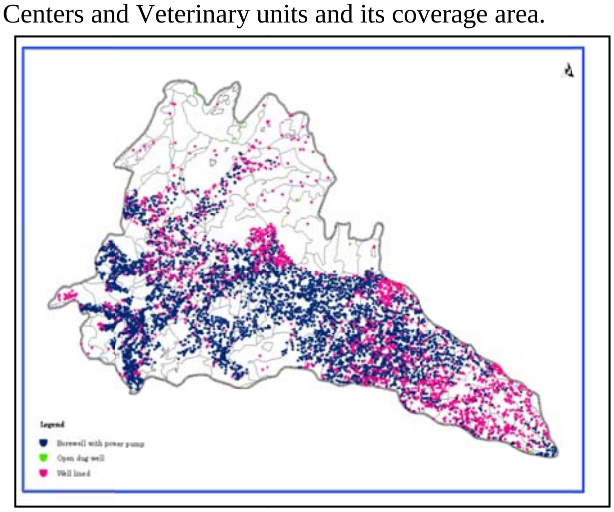
Figure-7

6.4 Surface and Groundwater potential:

Surface run off is the response of a catchments to precipitation reflecting the integrated effects of a wide range of parameters like catchments, climate and precipitation, intensity, duration, size and shape of the catchments the direction of storm, orientation of the catchments, slope, soil, land use, climate etc. Monthly Runoff Simulation (MRS) Model assesses the surface water potential for 75% dependable yield for southwest, northeast and non monsoon periods. The upper reaches are influenced by southwest monsoon and lower reaches are influenced by northeast monsoon. Available surface water potential in this sub basin is about 136.03 mm^3, Present storage in (70 Nos)tanksis about 59.66 $mm^3$and diversion to direct ayacut under (79Nos)Anicutsis about 111.45 $mm^3$and ground water available in the command area under consideration is 73.82 mm^3 and total Surface water & Ground Water Potential is 185.270 mm^3.There are 4,443 numbers of bore well with power pumps, 7 open dug well and 1784 well lined are available in the study area (Figure-8). Attur and Pethanaickenpalayam blocks are over ground water exploited blocks in this sub basin.

6.5 Road and Rail Network:

This sub basin is well connected with road ways and railways. Types of Road in this sub basin are National Highway, District road, Village road, car tract in hills, Car tract in plains, Footpath in hills, Footpath in plains, Pack tract in hills, Pack tract in plains and Tract follows stream (Figure-9). While implementing the marketing infrastructure in the sub basin level, this information played an important role for the location of Agri Business Centers and Veterinary units and its coverage area.



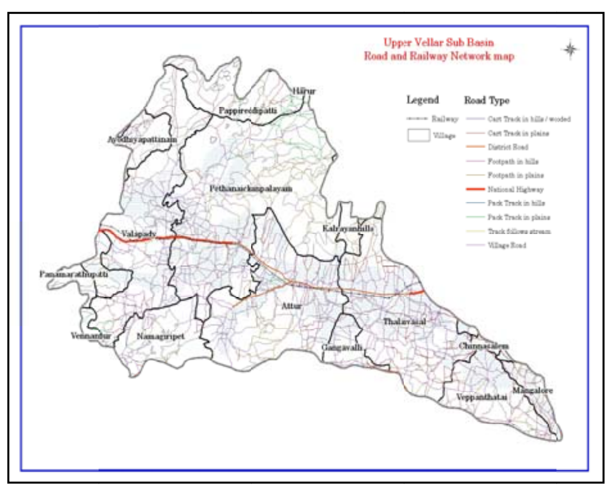


Figure-8

Figure-9

7. IMPLEMENTATION (PROCESSING)):

The project interventions were strategized to achieve

- ✓ More crop/Drop of Water
- ✓ Convergence for Effective Service Delivery
- ✓ Increased Income/Farm

This was enabled by

i. The rehabitation and modernization of irrigation infrastructure was aimed to increase the storage capacity and increase convergence efficiency

ii. A two pronged Agricultural Intensification and Diversification strategy to
   a) Introduce improved crop production technologies that maximize water productivity (SRI).
   b) Crop Diversification to low water consuming crops such as Maize, and
   c) High value, High tech Horticultural crops like tissue culture banana, Hybrid vegetables et.c,
   d) Precision farming and
   e) Introduction of Water conserving improved irrigation methods like Drip/Sprinkler

iii. Promoting labour saving improved farm machinery and implements

iv. Agri-Business support like Post harvest, processing and Market infrastructure, Supply chain management like farming commodity groups, establishing Agri Business Centers , Market Information Systems (MIS).

v. Livelihood support through Improving livestock health milk yields, fodder production, modern farm land/Inland fisheries production systems

vi. Institutional Modernisation of Irrigated Agriculture by establishing water users Association and their Capacity Building.

The major highlight of this project is convergence of various departments. Major departments involved in this project are Water resources organisation (Water resources), Agricultural Engineering (Water Management), Agriculture(Improved cropping techniques), TNAU (Technology interventions lab to land), Horticulture (Alternate high value crops in place of Paddy & Sugarcane), Agri-Marketing (Agri Business), Fisheries and Animal Husbandary Department (Livestock& Livelihood support) and Environment. Table-1 explains about the convergence matrix of the concept. Thus, integrated development approach is essential to attain the desired results. All the Departmental wise activity maps were prepared in GIS format based on the tank wise, village wise data and updated through field verification using GPS.

8. EVALUVATION (ANALYSIS):

For the preparation of thematic maps for each department, a separate format which includes the particulars of the name of the crop, variety, survey number, farmer name, village, block, district, area, crop condition, and yield details. This format will vary for each department according to its activity which was validated by the individual departmental experts. Based on that Information's of each departmental activity were collected and further analyzed. All the collected data was converted in to spatial data base format by matching the village name using Arc GIS software and also field verification was carried out using GPS and imported using Arc pad software into the GIS format year wise. And also the field photographs were hyperlinked with the spatial database. All the specialists in the department were trained to use the GPS in the field that data also updated in the GIS environment for each department periodically.

8.1 Irrigation systems Modernization(Water Resources):

8.1.1Base line approach: Application of GIS in Water resources management plays an important role in the formation of the Cluster, Package and WUA (Drainage, road and rail network and other administrative themes). The Upper Vellar Sub-basinhas 11000 ha of registered ayacut area. The existing GIS database

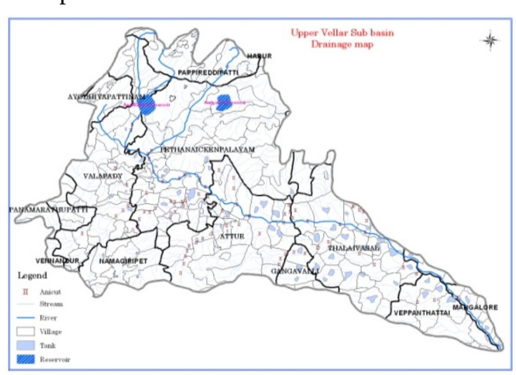


Figure-10

system gives the exact location (Lat& Long) of the tanks, its water spread area, existing condition of the tank its ayacut area and so on. There are 79 anicuts 70 tanks and 2 Reservoir in this sub basin, of this, 16 Anicuts are located in the main river and 63 anicuts located are in tributaries. This spatial database helped to identify the project planning by overlaying various drainage and administrative layers. Out of 70 tanks, 49 tanks are WRD fed by anicuts and 21 Panchayat Union tanks are self catchment tanks serving the needs of irrigation in the sub basin (Figure-10).

8.1.2Package:

After the identification of the tanks, for the implementation the packages were formed based on the road network accessibility by incorporating other features. It was grouped based on the chain of tanks database. Periodically the progress of the work was reviewed for contract management and updated. The total number of the package forms in this sub basin is 3(Figure-11).

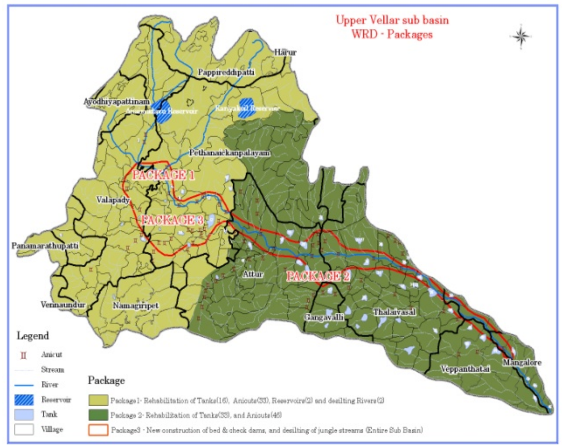


Figure-11

8.1.3 Cluster:

Convergences activitiesof the other departments were organised based on the Cluster approach. For thisthe above spatial data was overlaid with the other thematic layers (Soil texture, water availability, road network accessibility etc.,) and clusters were formed. Totally 29 clusters were formed in this sub basin (Figure-12). These activities were periodically monitored for further improvement.

8.1.4Water Users Association (WUA):

By interpolating all the spatial water resources data and road network data WUA's were formed. WUA was formed based on the TNFMIS Act with principal of tank area not more than 500 ha. The GIS output helped to precisely demarcate the jurisdictions of WUA and later hold elections. There are 67WUA's in this Sub basin (Figure-13). These WUA's were periodically monitored and updated.

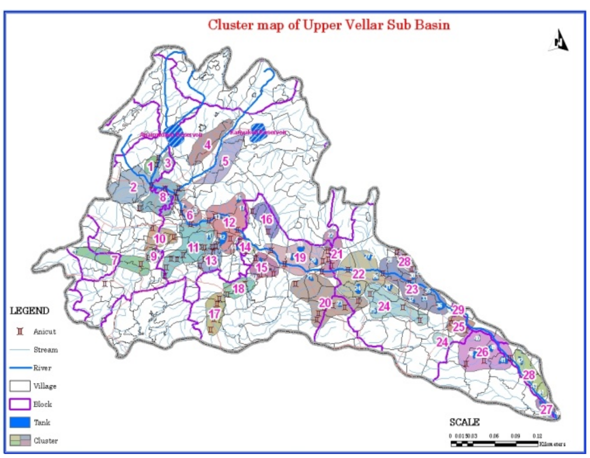


Figure-12

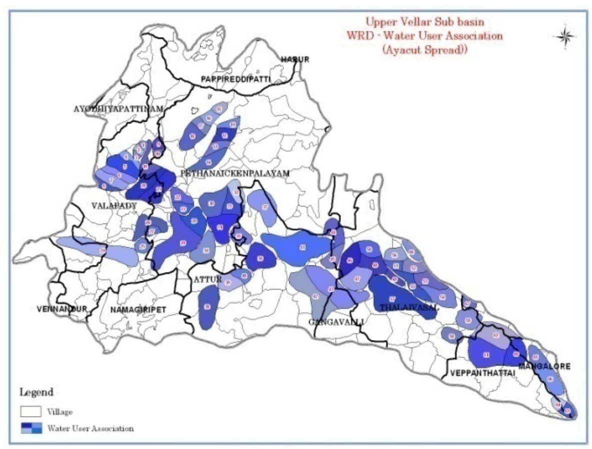


Figure-13

8.2 Lab to Land:

The lab to land land interventions by the scientists among others included SRI demonstrations, Rice fallow pulses, Castor as a border crop in Turmeric fields, IPT for Groundnut.The GIS tool served as a major guide to judiciously promote the above activities in a focused manner according to the field properties of various theme layers (drainage, soil, slope and soil and water quality) which otherwise is attempted in a

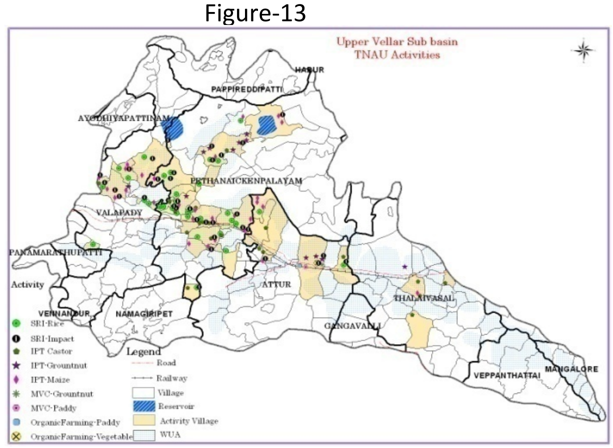


Figure-14

generic method. Successful SRI demonstrations were conducted in 250 ha which had a spreading effect in 525 ha. Demonstrations on IPT for rice fallow pulses were organized in 350 ha which had ripple effect aimed at covering 490 ha. Hence, in the TN-IAMWARM project, demonstrations on improved castorproduction technologies were organized in 75 ha with Castor hybrid TMVCH.The crop establishment was so convincing that led to self perpetuating effect which had ripple effect aimed at covering an impact area of 205 ha. Marketing tie-up with private sector pharmaceuticals was felicitated through TN-IAMWARM project by TNAU. The sub-basin was noted for groundnut production and it was considered as focus crop under IAMWARM project and IPT were demonstrated in 70 ha which had a spreading effect in 230 ha. Similarly, Maize was another focus crop in the sub-basin for which demonstrations were organized in 110 ha (Figure-14)with an impact area of 630 ha.Figure-15 explains about the attributes of the spatial data department wise.This spatial activity data was monitored for every 6 months and the yield details were updated regularly, based on this yield analysis were done. The GIS database helped to identify the gap area for further implementation of the project for the next year and also it is very well helpful to focus the activities within the selected sub basin which avoids the areal extent of the activities out of the sub basins.

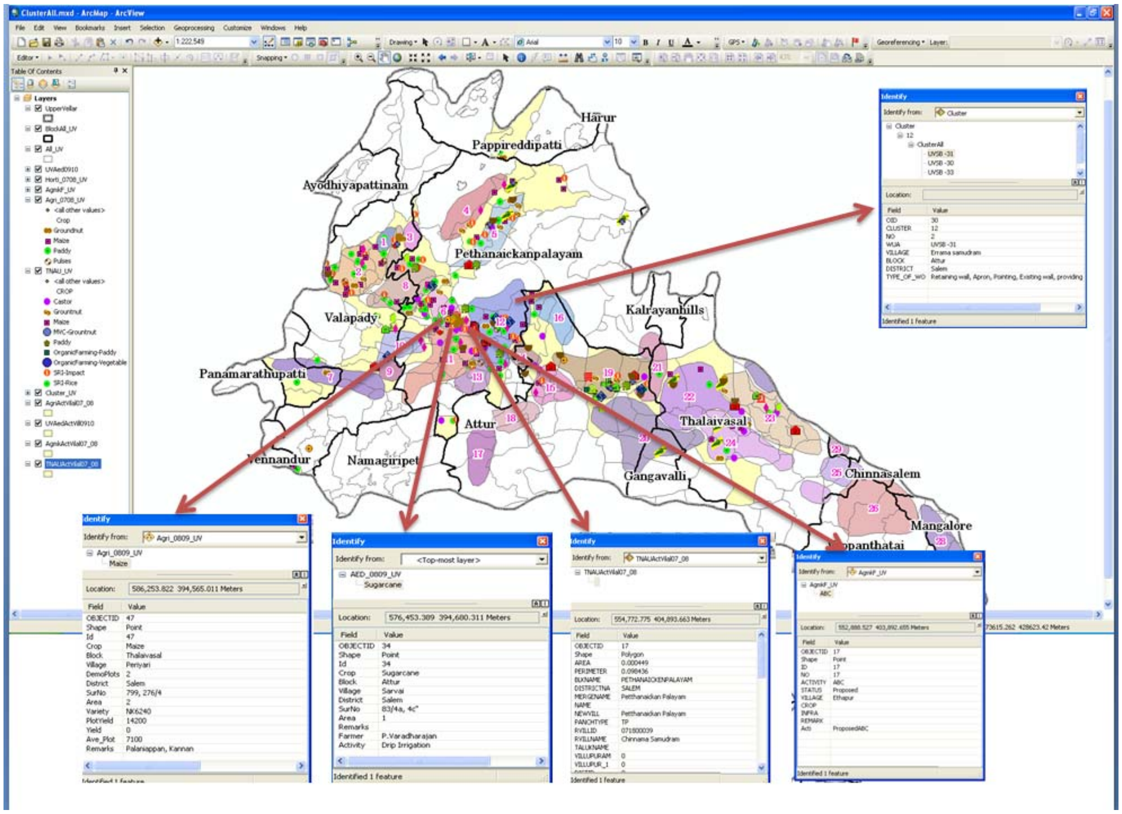


Figure-15

Table- 1Convergence Matrix

Sector / Intervention	Water Resources Management	Water Conservation & Management	Agricultural Intensification&Diversification			Integrated farming Practices	Environmental Services
			Lab to Land	Improved Cropping Technologies, Practices	High Value Cropping Systems		
Irrigation System Modernization	Rehabilitation, Modernization of irrigation tanks						Environmental&Social monitoring
Water /Food Productivity			SRI & Site specific INM in Drip/fustigation Increase CP& D.I	INM / IPM techniques & Adoption of IPT CD from paddy to Maize Irrigation WST & Agro climatic suitable crops with CD Improving crop economics & Laying trials &demons.	Promoting WST in horticulture crops Introduction of TC Banana & NAC in horticulture crops.	Aquaculture in irrigation tanks, Aquaculture in Farm ponds Fish seed Rearing in cages Augmenting fodder availability	Soil & water quality testing
Water Conservation	Construction, reconstruction of anicuts& sluice, Bed & check dams	Water harvesting through farm ponds, Check Dams	IIPT for groundnut by INM & IPT for maize Castor IAT	Soil health sustainability			
Improving Water Use Efficiency	Lining the Channels	Installation of DIS & SIS Demos	Precision Farming with MIS				
Farm Mechanization		Farm Mechanisation Support					
Post harvest&Supply Chain Management				Construction of thrashing floor, Storage, Godown, Collection centre, Pack House &ABC			
Livelihood Support						Establishing FSB Supplying mineral mixture, VHC camps	
Institutional Modernization, Multi Stakeholder Participation, PIM & Capacity Building	Formation of WUA, Vision Building, Water Budgeting and SWIC's	Trainings on MIS,O&M of Farm Machinery Exposure Visit	Trainings on SRI, INM & IPT	Trainings on SRI, INM, IPT & WST	Trainings on INM & IPT	Conduct night meetings & trainings,	Creating Awareness to WUA&Multi Stake holders

WST	Water Saving Technologies	INM	Improved Nutrient Management	WUA	Water Users Association	TC	Tissue Culture
Demos	Demonstrations	MIS	Micro Irrigation System	GWR	Ground Water Recharge	NAC	New Area coverage
VHC	Veterinary Health Camps	IMT	Improved Production Technologies	WST	Water Saving Technology	ABC	Agri Business Centre
MVU	Mobile Veterinary Unit	IAT	Improved Agro Technologies	WHT	Water harvesting Technologies	FM	Farm Mechanisation
CD	Crop Diversification	SC	Supply Channels	CB	Capacity Building	FSB	Fish Seed Bank
CP	Crop production	D.I	Diversification & Intensification	SWIC	Single Window Information System	GW	Ground Water
DIS	Drip Irrigation System	PIM	Participatory Irrigation management	SIS	Sprinkler Irrigation System	O&M	Operation &Maintainace
SRI	System of Rice Intensification						

8.3 Agriculture

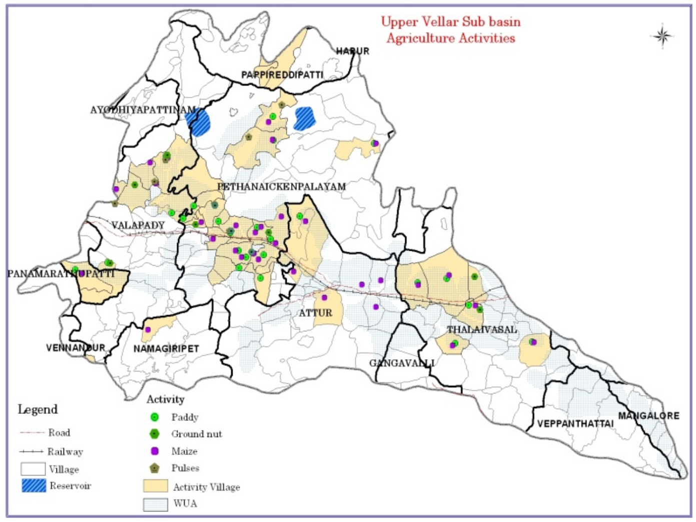


Figure-16

The interventions include large scale farm based demonstrations comprising sustainable agricultural practices, Crop diversifications high value cropping systems, IPM/INM, etc.,. The spatial data developed in GIS format was a good guide to field operations unit to identify the suitable locations for various crops based on the availability of assured irrigation facilities and soil types. 1157 ha were covered under demonstration programs in the sub-basin. Demonstrations of different kind, including 400 ha of paddy, 100 ha of pulses, 85 ha of groundnut, 71 ha of coconut INM and 40 Nos. of vermicompost were organized in clusters in the farmers holdings. In total 1157 ha of demonstrations were laid in the sub-basin. 9,660 ha of impact area around the demonstration plots had also been identified (Figure-16). This developed GIS database was updated regularly and yield details were analysed further. Based on this gap area, very poor performance etc., were identified which was taken up for focused improvement.

8.4 Water Saving through Crop husbandry:

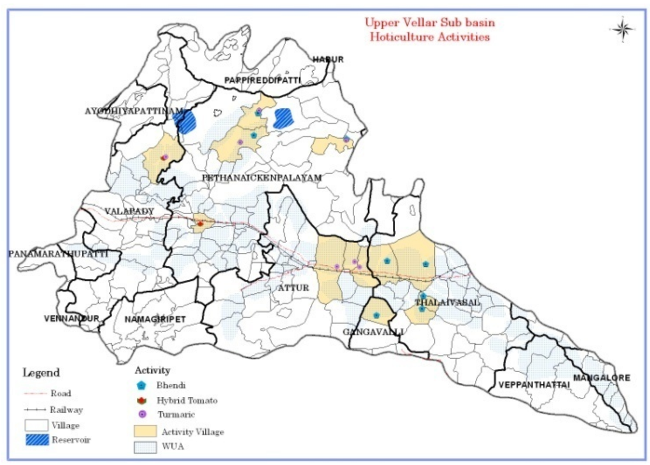


Figure-17

The developed GIS database like water resources, soil and other infrastructure details were overlaid and based on this horticulture crops locations were identified for the projects. High value high tech Horticultural interventions werecovered 509 ha additionally under area expansion with Horticultural crops (Figure-17). High density Mangografts were planted in 19 ha. An extent of 370 ha covered with hybrid vegetable crops like Tomato, Brinjal, Bhendi and others. Improved Turmeric variety was promoted in 100 ha, replacing the traditional varieties. Cocoa plantation crop was planted in 20 ha with marketing buy back tie-ups with Cadburys. Kuruchi is one of the villages in the sub-basin, where one could find many number of progressive farmers. This developed GIS database was updated regularly and yield details were analysed further. Based on this gap area were identified which was covered later. Links were developed with Agri-Business GIS themes to set up ABC's and collection centers.

8.5 Water Conservation and Management:

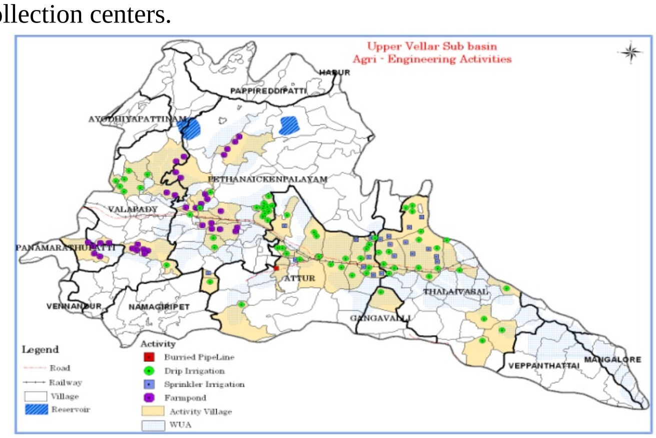


Figure-18

Adortancy improved irrigation methods like Drip/Sprinkler essentially required data lead on existing wells /tube wells within and outside the command area of the project. By overlaying the spatial data of water resources, ground water, soil texture and other administrative layers potential area of the Drip/Sprinkler areas were identified and promoted in the field.Agri Engineering interventionsin the Upper vellar sub basin covered 75ha of area by drip irrigation with the major crops are Turmeric, Groundnut, Maize, Coconut, Mango, Sugarcane, Tomato and Vegetables, 20 ha by sprinkler Irrigation with the major crops are Turmeric, Groundnut, Maize and Vegetables through buried pipeline for the first year (Figure-18).AgriculturalEngineering Department, in convergence with Fisheries Department, had completed the formation of farm ponds benefitting 34 farmers in the sub-basin. Introduction of Micro Irrigation System to major crops such as Sugarcane, Coconut, Arecanut, and Tapioca was one of the major inventions in the sub-basin. MIS such as drip and sprinkler had covered an area of 95 ha benefitting 77 numbers of farmers. This spatial data layer was regularly monitored and updated for further analysis and to identify the gap areas.

8.6 Agri-Business:

Agricultural Marketing Department had several challenges in Upper Vellar sub-basin. Using the GIS, the site selection of ABC and other centers were identified using site selection parameters and the overall coverage of the area was identified using multiple buffer analysis(Figure-19). Hence the technology like GIS helped to monitor the crop growing, quick transport, storage and market information was assumed greater importance which was also brought out during the consultative process with primary stake holders. With around 24,000 MT of marketable surplus, there existed an infrastructural gap which was identified using GIS techniques and to bridge the infrastructural gap, construction of 5 Storage godwns, 8 Drying yards, ABC and Collection centers were proposed using GIS. This was monitored regularly and updated. With the identification of the gap area using GIS 1 Pack house, 2 Collection centers and 1 ABC (Ethapur) were proposed using GIS. This would gave agri-business perspective to farming in this sub-basin (Figure-20). The other areas were covered by existing infrastructure facilities. Besides the above, 11 Nos. of Commodity Groups for different agricultural and commercial crops were formed along with capacity building measures. Due to high labour charges, transport, perishable nature of produce and fluctuation in market prices etc. farmers preferred farm gate sales of produces. Few agreements, with corporate sectors such as Reliance Fresh, were arrived for produces like tomato. 20 banana farmers, who reside in Abhinav Village, joined and formed a Commodity Group.

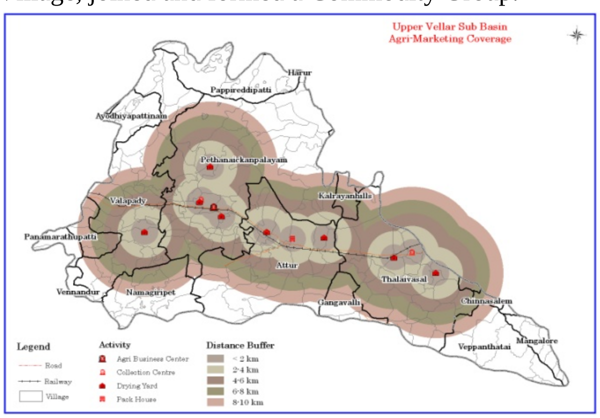


Figure-19

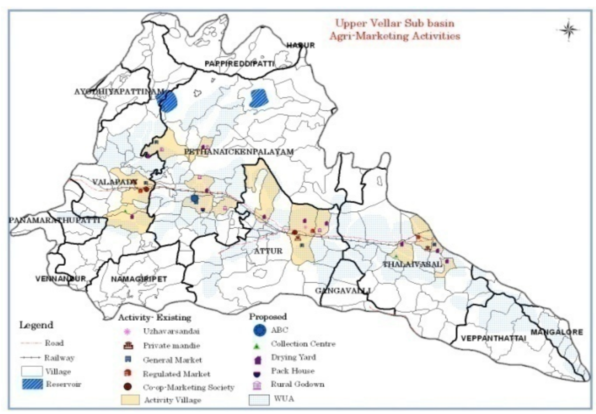


Figure-20

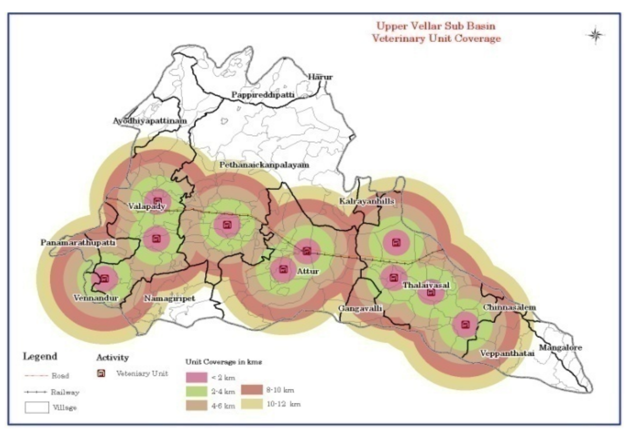


Figure-21

8.7 Livestock:

This was developed through Animal Husbandry and fisheries department.Animal Husbandaryestablished 10 Cluster level Veterinary Units. These locations were identified based on the site suitability criteria using various thematic layers in the GIS environment. And further using the Buffering Analysis, overall coverage area was mapped (Figure-21). It indicates that the uncovered area was mainly found in the hilly and reserved forest area. The area coverage Veterinary dispensaries and 17 sub centers in the sub-basin were provided with necessary equipments. According to the base data developed in the water resources and other landuse maps the suitable area for fodder Cultivation was identified and promoted in 135 ha. 759 beneficiaries were provided fodder inputs covering 75 ha (Fodder cholam), 10 ha (Kollukattai seeds) and 50 ha (Co3 fodder slips) at their door steps ((Figure-22). GIS inputs on the spread of the cattle population greatly helped to choose the locations for the Infertility cum total health care camps, farmers trainings and artificial inseminations, The voluminous spatial information on the benefited farm families and animals is a strog basic data for future animal husbandry development. The uncovered area was identified based on the GIS mapping and it was covered by the next year. 120 Infertility cum Total Health Care Camps were conducted benefiting 1,13,341 animals and 18.975 farmers. 5,137 calves were facilitated to participate in calf rally. 4,631 farmers, including 3,337 males and 1,294 females, participated in the 104 meetings conducted. In addition, Posters on project activities were displayed at prominent places in the sub-basin.

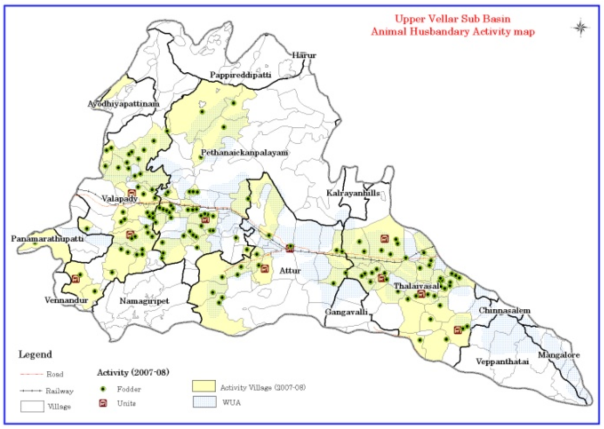


Figure -22

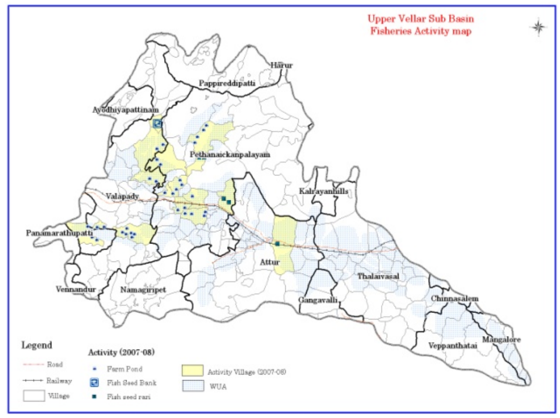


Figure-23

The Fisheries helped 51 farmers in the sub-basinto take up the aquaculture in farm pond. Using GIS site suitability analysisthese farm ponds were identified by various thematic layers (Administrative, drainage, and slope). According to their importance values (scores) were assigned for the site suitability index and sites were identified in the GIS environment. 12 farm ponds (Figure-23) were stocked with carp seeds and the culture was in progress. The growth assessment trials showed good growth of fishes in the farm ponds. Two farm ponds were stocked with fresh water prawns (scampi) as a trial experiment to further enhance the net revenue per pond. Five units of cages were supplied to the progressive farmers and fishermen. Rearing of fish seeds would be taken up during the ensuing season.This spatial data layer was regularly updated for further analysis and to identify the gap area.

8.8 Convergence:

At every stage of the intervention the service area characteristics developed were useful for planning and to demonstrate water and food productivity gains. The convergence of various water and crop production services organised by the project were overlaid using overlay analysis (Figure-24). This clearly illustrates that the demand based services were spread in the zone of the major drainage lines indicating the importance of the availability of water source. The Sub basin characterized (Figure-25) by the reserve forests and hills, hill tops, ass evident from the Digital Elevation Model (DEM) have no interventions This output validates the geo physical characteristics of the sub basin and the potential water productivity zones which clearly demonstrate, the utility of the GIS tools for monitoring effective service delivery.

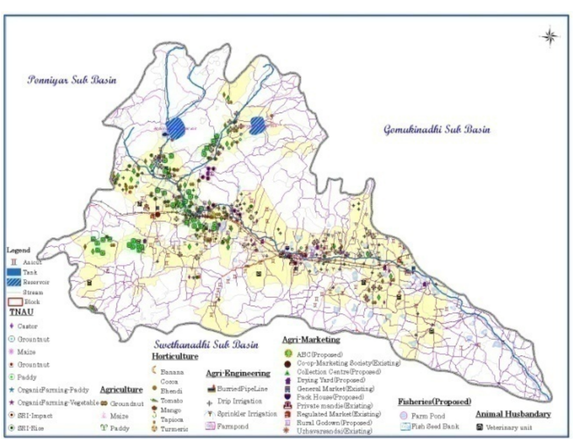


Figure-24

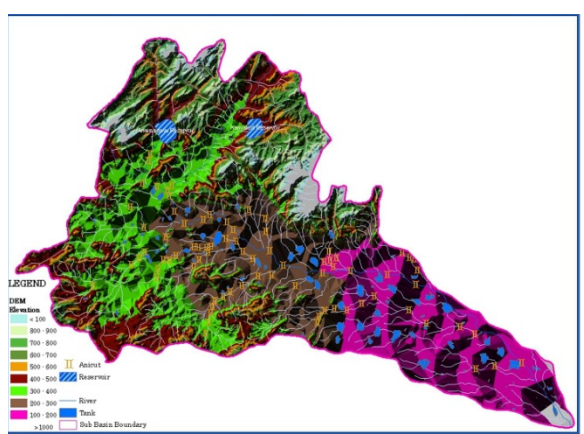
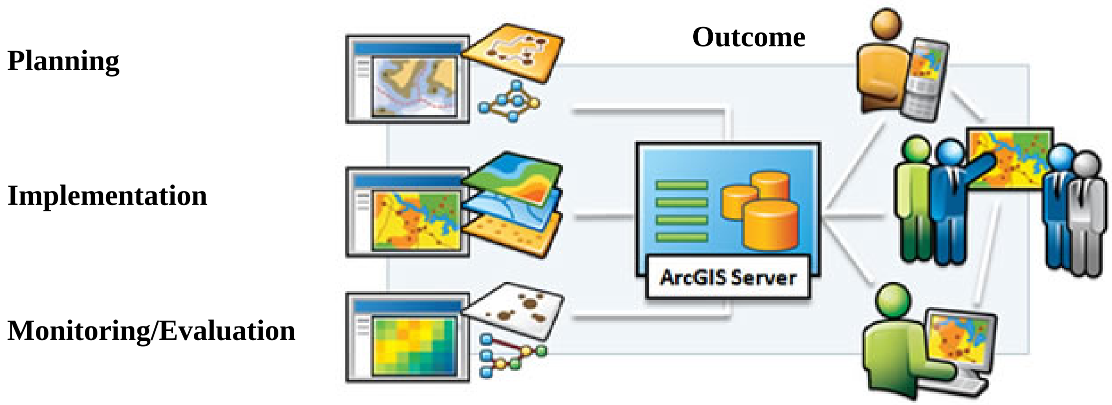


Figure-25

9. OUTCOMES:

Through the Convergence activity with the involvement of 8 departments projectirrigation efficiency improved which resulted in enhanced farm productivity per unit of irrigation water, the gap area is bridged, sustained farm income to the farming community, the farm productivity per unit area is increased, Increase in cropping intensity and improvement in socio-economic status of the farmers.
ArcGIS Server works with ArcGIS Desktop, ArcSDE, ArcIMS, and ArcGIS Engine. In ArcGIS Desktop,
spatial data is created and edited and ArcGIS Server services are managed. ArcSDE manages multiple users editing the same spatial database and supports long transactions, alternate versions, and history.ArcGIS for Server implifies access to GIS services for GIS professionals, mobile workers, as well as knowledge workers without any GIS experience. With ArcGIS for Server, you stay in control of your content through centralized management of spatial data, including imagery.In addition, ArcGIS for Server provides you with a scalable GIS server platform that can be deployed on a single machine to support small workgroups, or it can distributed across multiple servers for supporting enterprise applications. You can also deploy ArcGIS for Server on Cloud infrastructure.
All the thematic maps developed for IAMWARM project were published through web service using Arc GIS Server within the intranet and planned to publish internet using web service for the sub basin level Multi departmental officers for its effectiveness.



10. ADVANTAGE OF WEB PUBLISHING:

The advantages of Web Publishing areUser friendly, Flexibility and Scalability. It has the ability to Publish; manage the data base according to user applications, Simple and easy to provide public access to the GIS information. An Effective IAMWARM GIS spatial database. This database has editing functionality such as add, change, remove where ever needed. This baseline could be used for further development and as a Web interface Framework which supplies intuitive user interface objects (map, table of contents, scale bar, etc.). Further this has the Ability to integrate content from tabular databases and data from the file system as needed. Additional advantages are, it enablesGeoprocessing, Geocoding, Spatial, 3D and Network Analysis. This GIS Web based platform can be potentially used to dynamically update the information's for Effective service delivery

11. LIMITATIONS OF THE STUDY:

- Scale is a critical issue in the application of GIS in IWRM concept for effective service delivery. Generally spatial component is a scale-dependent behaviors. The data which comes from the combination of scales either in a macro level or micro level for various kinds of applications can be displayed and analyzed in the same spatial environment for IWRM concept, While using this mixture of the various spatial data from differing scales will lead to wrong or inaccurate results. Using data from many different scales introduces these types of problems where the service delivery is not in a effective way.
- The combination of the spatial and attribute data will make the Central GIS Server data center. There is lots of commercial software's and formats like Arc GIS (gdb/cov/shp), Map Info (mif/mid), Micro station (dgn) etc., and open source software available in the market like Quantam GIS (shp). Organizing these data in a single format will be a big deal because of the different user interfaces.

12. CONCLUSION:

Integrated Water Resources Management poses a complex challenge. The Demand side management requires a robust decision support system. The GIS based tool for planning, monitoring and Evaluation of the Multi sectoral project interventions has proved stable for analysis and Decision making. The multiplicity of data of a river basin both spatial and non spatial otherwise would have posed a serious challenge. The spatial database of 25 layers on 8 major themes covering 10187 ha comprising 150 villages and 500 individual farmers is a proof by itself for ensuring smooth implementation and accountability in every single case. The project could create a structures database (spatial and non spatial) for 61 sub basins covering 669062 hectares. It is possible that the GIS database in future could be shared with individual departments, civil society and other Government Institutions in the public domain for ensuring transparency and future service delivery for an effective way. The technology enables linking the spatial data with Aadhaar card or Kissan card etc., which is a futuristic thought and that might become a reality.

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BRIEF PROFILE OF THE AUTHORS

A. VibhuNayar is a Senior Water Sector Policy Maker and Utility Head of India. At present, He is the Project Director of a World Bank assisted TN-IAMWARM Project in the Water Sector. He is also a member of the UN-International Steering Committee on Global Water Operators Partnerships (GWOPA) and founder Member Secretary of the Indian National Change Management Forum on Governance and Service Delivery.

He has been nominated as the Anchor Technical Adviser to assist Department of Drinking Water Supply, Government of India on service delivery and establishing Water Operators Partnerships in India. He has worked on various national and international groups on a very wide gamut of issues in the Water sector over more than two decades. He is credited with initiating Change in many Water Utilities in India culminating in the establishment of Centre of Excellence for Change of which he is the founder mentor. He has many policy papers to his credit and has worked with Governments at both Policy and Implementation levels.

N.Kavitha completed doctoral degree in the field of Remote Sensing and GIS Techniques with ICAR Fellowship in CIBA (Awaiting for results) and working as a GIS Specialist in TN-IAMWARM Project from 2008 to Till date. Specialized in the field of Remote Sensing and GIS in Land Resources Assessment, ICZM, Land Suitability Analysis, Aquaculture Development and Watershed Analysis and Management.