Water Resource Planning of Patan branch canal command area through RS & GIS

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Introduction

Water is an important natural resource on the earth and plays a vital role in every aspect of life. The sources of consumable water are mainly ground water, rain and surface water bodies like river, ponds and lakes etc. but the competitors are too many like domestic sector, agricultural sector, infrastructure sector and industrial sector etc. The agricultural sector is the major consumer of water and land resources. Ever increasing pressure of population coupled with poor management of land and water resources are putting tremendous stress on our fragile environment. With the limited availability of natural resource made it mandatory to use them optimally, so that the need of each sector will be fulfilled with justification. The scenario of fast growing world compelled the human civilization to make efforts that maintains the developments with the sustained utilization of natural resources. With increasing demand of water by growing world population, it has become necessary for mankind to look for additional sources, as well as to conserve the available resources.

There are many approaches that are made to conserve soil and water, but they are not the only complete way to get sustainable growth. There is further need for a comprehensive strategy for utilizing the natural resources in such a way that they can be used forever with minimum degradation when exploited in their optimal capacity. Thus, for sustainable development it is the initial phase to work out the land and water resource action plan, which takes the capability into prime account for utilization of the available natural resource in the concern area. RS and GIS approach is an advanced tool for such analysis. Bargi irrigation project is new major irrigation project commenced in the year 1989 and still the targeted irrigation potential could not be achieved. Further land use planning considering land and water resources is a necessary step in order to utilize the natural resources optimally and in sustained manner.

Study area

The Bargi dam, which is a major dam in M.P., is built across the river Narmada and situated near the village Bijora that is about 43 km from the Jabalpur city. Rani Avanti bai Sagar Project (RABSP) is associated with 20 lakh farmers of Mahakaushal and Vindhayachal region. The Left Bank Canal (L.B.C.) of Bargi dam covers Jabalpur and Narsinghpur district. Total length of L.B.C. is 137.2 km, out of which 65 km passes through Jabalpur district. Patan Branch Canal (PBC) is a part of this network. The network of the PBC was selected for the present study. Patan

Branch Canal Command Area (PBC) was considered for the present study. Command area lies between 23˚05′00″ to 23˚ 30′00″ N latitudes and 79˚20′00″ to 80˚00′00″ E longitudes.

PBC is originate at about 31.58 Km from LBC of Bargi reservoir. It crosses the river Narmada through an aquaduct to irrigate Jabalpur, Patan and Shahpura blocks of Jabalpur district. The total length is 9.74 Km. It cover's an area of about 54,200 ha as Culturable Command in Patan and Shahpura blocks of Jabalpur district. Index map of study area is shown in Fig.1.

The climate of the area is classified as sub tropical, semi arid. The annual average rainfall in the Command area is 1159 mm. Wheat, Paddy, Gram and Maize are the principal crops. The Different water resources, canal, tube well, pond, wells etc are available in command area which meets water requirement of terrains for domestic, agriculture, infrastructure and industrial uses.

Methodology:

Necessary Data and Equipment Used:

Following data was procured and used to get the different thematic maps of Bargi command area.

Topographical and Satellite Data: To collect the information regarding topographical details and other land characteristic, toposheet at the scale of 1:50000, which were prepared by Survey of India (SOI), in 1976, were consulted. Satellite data for Rabi and Kharif seasons of the year 2000 were obtained from National Data Centre, National Remote Sensing Agency, Hyderabad.

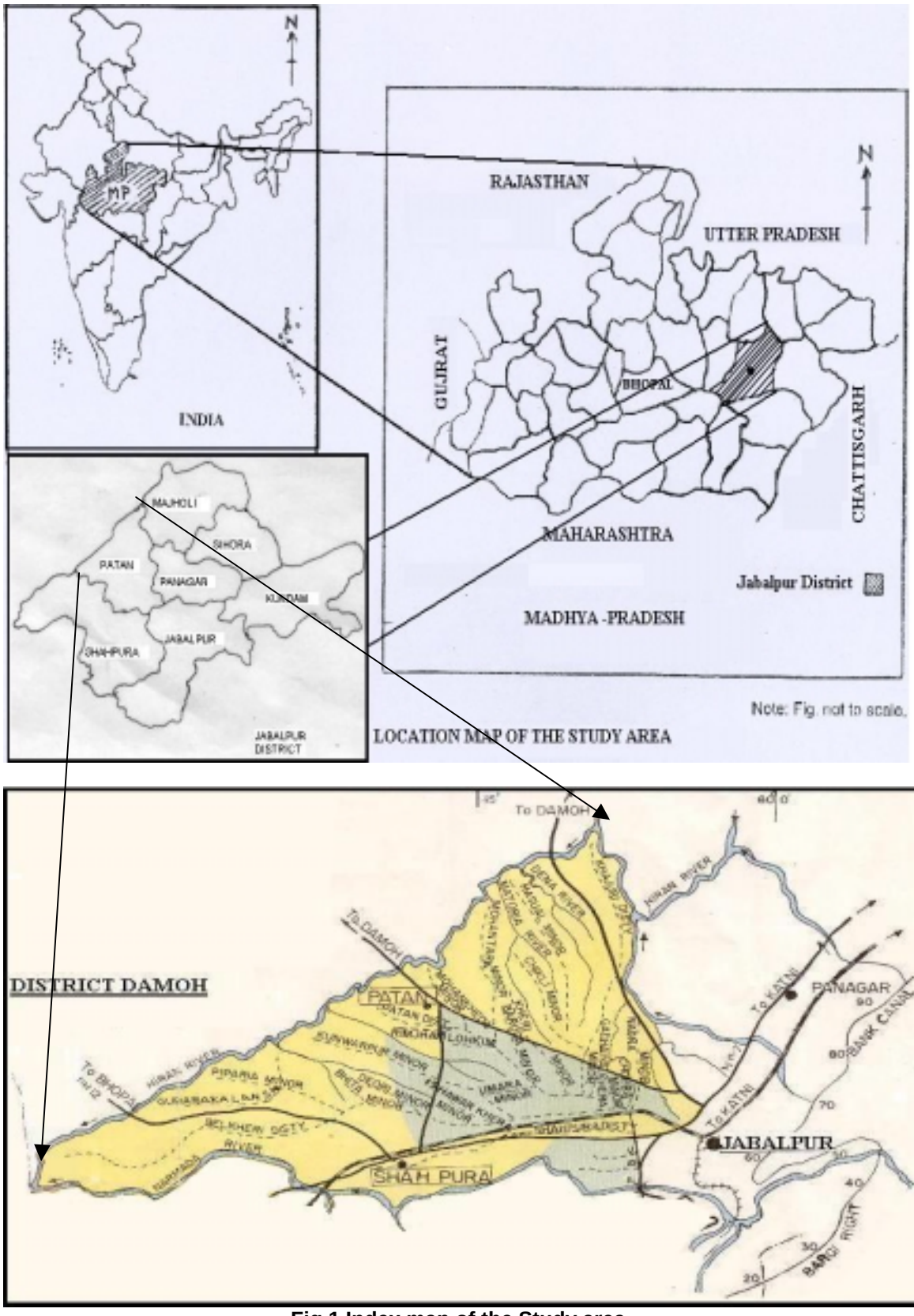

Fig 1 Index map of the Study area

Remote Sensing Data Used:

Toposheet No.	Satellite and Sensor	Date of pass	Source
55M/8, 55M/11, 55M/12, 55M/15 55M/16	IRS – 1C, LISS-III	18th Jan, 2000 and 23rd Oct, 2000	NDC, NRSA, Hyderabad

Hardware and Software:

The hardware used are namely Personal computer, H.P. scanner, Color scanner, Plotter (HP 5400 C), DeskJet printer (HP 840 C), CD Writer and ILWIS 2.2 (Integrated Land and Water Information system version 2.0), Microsoft Office, Microsoft Word 6.0, Microsoft Excel, Adobe Photoshop software's which were used for the preparation of thematic maps of the command area.

Generation of Thematic map:

Initially base maps were prepared from SOI toposheets at 1:50000 scales. Command area boundaries, slope map, settlements/transport network, soil map, hydrogeomorphological map, drainage network, land use/land cover, ground water potential, canal water availability are the theme maps prepared for study. Features on a paper map or other analog documents were scanned. They were imported and, georeferenced then digitized by 'on screen digitization' in ILWIS. Command area boundaries, Contour, Soil, Drainage, hydrogeomorphological, canal water availability and ground water potential maps were prepared by digitization. Digital elevation model (DEM) was generated through contour interpolation. The output of the contour interpolation was a raster map, using shortest distance towards the two nearest isoclines. The DEM was converted into slope percentage map. The digitized thematic maps are the vector map, which were also converted in the raster form for further interpretation.

The land use / land cover map of the command area was prepared through the data obtained from NDC, NRSA, Hyderabad. IRS – IC LISS III data of 18th Jan. 2000 was used for this purpose. The false colour composite (FCC) of 4 band data in the ratio of 3,2,1 i.e. red, green & blue colour assigned to infrared band, red visible band and green visible band prepared from the satellite imagery. To differentiate different land covers, Normalized Difference Vegetation Index (NDVI) was calculated. In NDVI map Values are ranging from – 0.5 to + 1.0. They are classified by slicing operation for three basic land uses, as per the requirement of study, namely water bodies, wasteland & cultivated area.

Integration of Maps through GIS:

Intersections of various thematic maps were performed by overlaying one theme map over the other, through cross operation of raster maps in ILWIS software. The cross operation performs an overlay of two raster maps by comparing pixels at the same position in both maps and keeping track of all the combinations that occurred between the values or classes in both maps. The georeference of input raster maps was kept the same. During the cross operation, combinations of class names, identifiers or values of pixels in both maps were listed and the number of pixels occurring in this combination was computed through histogram. The results were stored in an output cross map and in a cross table. The output cross table obtains an identifier domain, with the same name as the output map. This domain contains items, which were combinations of the class names, IDs, groups, name or values of the first input map.

Water Resource Action Plan:

Preparation of water resource planning involves study of different thematic maps and quick visit to the study area for verification. A number of spot observations were made by covering almost all types of landforms, soil, slope, ground water potential and quality, rainfall and climate, present land use etc. The land characteristics as mapped in the respective theme maps were recorded along with the present land use. The existing irrigation practices and cropping pattern were also noted. Few possible options were discussed with an aim to achieve, optimally within the overall framework of sustainability of production. Unless and otherwise the present land use was found beyond the threshold limit of some land parameters, a drastically different option was not recommended since such a change would not meet the high level of acceptability. The threshold limit of a parameter vis-à-vis its consideration for a particular recommended land use practice varies from area to area.

While making alternate recommendations for land use practice, futuristic consideration such as exploitation of ground water, if presently not exploited, possibility of adopting more efficient system of irrigation and water management and other site improvements through soil and water conservation were also kept in view.

Availability of improved varieties of crops, trees, shrubs and grasses and advantages of interdependency of agriculture, livestock, and other practices as in case of integrated farming system that had been made available through contemporary research were also taken into consideration. Current trends on land use management and sustainable farming systems were adopted from Guidelines of IMSD (IMSD, 1996). Thus, with these considerations, finally land use practice is recommended for the site as per its recorded parameters.

For a particular recommendation or combinations of recommended land use practices various types of combinations of land parameters were developed which serve as the decision rules for integration of thematic maps and preparation of action plan. On preparation of the decision rules, the same was discussed with experts / specialists in land management and

farming system research. Views of the selected farmers and local line departmental officials of the study area were suitably considered to finalize the decision rules. The decision rules for water resource planning were finalized and presented in Table 1.

The final composite units were enumerated as various types of homogeneous units of polygons. These would fit into one or the other combinations of the decision rules as explained in table 1. Recommendation was than made on the decision rules. Similarly recommendations were made for all other homogeneous polygons. The Recommendation made was again discussed among experts and finalized plans were prepared.

Table-1 Decision Rules for Water Resource Planning:

S.No.	Geo.	Litho.	Slope (%)	Soil	G.W.	Canal W.	Land Use/ Land Cover	Action
1.	APY Or APO	ALLUVIUM	0-1	CWL Or Deep Clay	V.G To Good	Available	Agriculture	Double Crop
2.	APY Or APO	ALLUVIUM	1-3	CWL Or Deep Clay	Moderate	NA	Agriculture	Agri-Horti
3.	APY Or APO	ALLUVIUM	1-3	CWL Or Deep Clay	Good	Available	Agriculture	Agri-Horti
5.	St. Plain	Arc.Rocks	3-10	CWL Or Cal. Clay	Poor	NA	Stony or Bare Rock	Silvipasture
6.	St. Plain	Arc.Rocks	3-10	CWL Or Cal. Clay	Poor	NA	Gullied Or Ravine land	Silvipasture
7.	St. Plain	Arc.Rocks	0-1	CWL Or Cal.	Vary good To good	Available	LWWS	Agriculture

				Clay	or moderate			

Result & Discussions:

The value of contours is ranging from 360 meters to 420 meters. The 0 to 1% slope class is maximum 79263 ha followed by 1 to 3% slope class 4019 ha; other slope classes were in patches. The area under settlement is around 1491 ha. It was found that the NH-12, Patan road and central railway are the major network of transport. Part of drain lines heading towards north oriented joins the river Pariyat and Hiran whereas the southern drain lines joins Narmada river. Soils were broadly classified as calcareous clay near the river Narmada, clay with loam in central part, deep clay near the Pariyat and Hiran and in the south west corner of command. The dominating categories in the field were older alluvium plain in 69891 ha and younger alluvium plain in 13102 ha. Few patches of structural plain and structural hill were also found. Land use classes in PBC Command was shown in following table, which were generated from NDVI map.

S.No.	Land use/Land cover	Area (ha)
1.	Cultivated area	63773.12
2.	Waste land	20761.39
3.	Water Bodies	878.72

Water tables fluctuate from pre monsoon to post monsoon season. Water table fluctuation was found ranging from 2 meter to 4 meter in different parts of command. Higher fluctuation shows more recharge during the rainy season. These fluctuations when combined with the aquifer properties resulted in to ground water availability for the post monsoon period. The discharge of ground water available from 75 to 150 m^3/day. This was also taken into consideration for assessing the ground water potential. Data of depth to water table in open wells was collected in command area. These depths vary from 1 meter to 10 meter.

Integration of Theme Map:

For generation of water resource action planning integration of different themes i.e. soil, geomorphology, slope, land use / land cover, canal water availability and ground water potential was accomplished. The resulting map has identifier domain. The large numbers of polygons occurred in this map. Combinations of smaller areas are merged. Area that is, more than 100 hectare belonging to different combination of these six themes were selected for water resource planning. Fig 2 presents the cross map of all six themes.

Water Resource Planning:

The cross map, of all six themes shows all combinations, which were possible through integration procedure. Each combination was studied and compared with the decision rules already discussed methodology. Action is

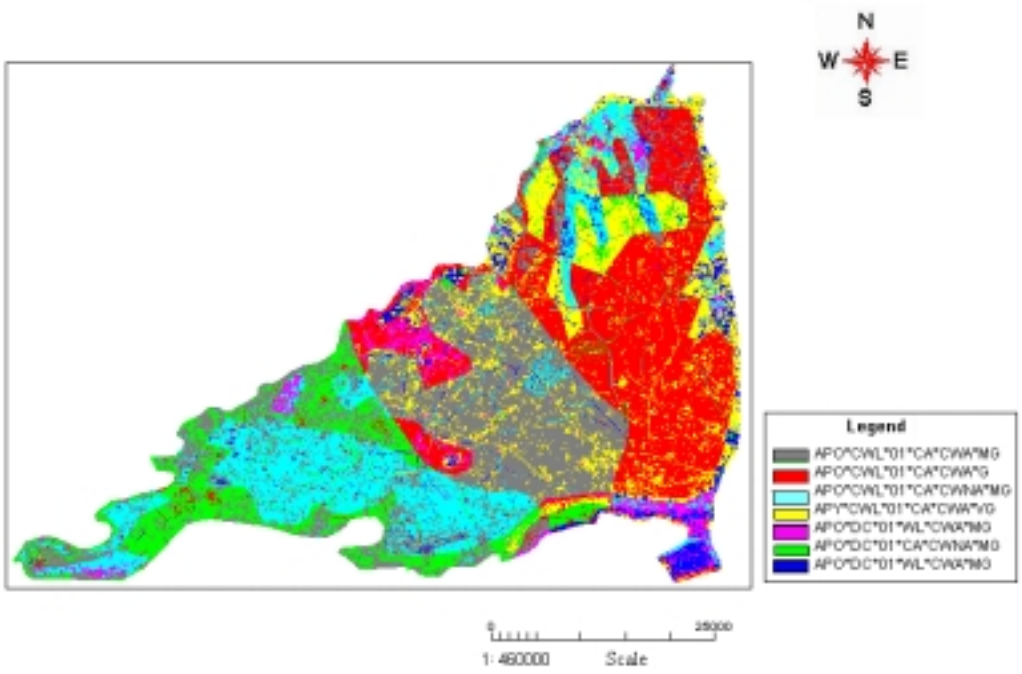

Fig 2 Integrating Map for prepairing Water resource Action Plan

proposed for land use were done by matching a particular combination with decision rules of land and water resource action plan.

In all 248 numbers of combinations are observed, in the command area based on different themes. Combinations, which are having small areas, were merged in mixed one. Other combinations were assigned particular action to optimize the resource utilization as per decision rules. These combinations were formed by assigning class to each and every pixel. Categories assigned were; single crop, double crop, agro-horticulture, silvipasture, water resources, water harvesting and mixed actions. Fig 3 shows the water resource planning in PBC command area. Maximum area of 54490 ha is falling under slope of 0-1% and water is available through canal/ground water, soils are also good for cultivation and hence it is proposed for double cropping. The area proposed for agro-horticulture is 2811ha where as an area of 13612 ha is proposed to be kept for single crop. Locations proposed for water harvesting may be used to collect water and store it for future use. Area under the category water resource is belonging to water bodies, wastelands are kept under silvipasture.

Table 2 Water Resource Action Planning of PBC Command

S. No.	No. Of pixel	Area (m^2)	Area (ha)	Action Plan
1.	99371	28115060	2811.51	Agro-Horti
2.	1925898	54489480	54489.48	Double Cropped
3.	44049	12462794	1246.28	Mixed
4.	481113	136121400	13612.14	Single Crop
5.	147087	41615359	4161.54	Silvipasture
6.	51351	14528750	1452.88	Settlement
7.	182016	51497829	5149.78	Water Harvesting
8.	12229	3459954	346.00	Water Resource

Summary:

Predecided decision rules were applied to decide actions to be taken on 248 classifications observed in integrated map. Smaller areas were merged into a mixed category. Following conclusions were obtained looking to the action suggested:

1. An area of 54490 ha is proposed to be double cropped. This area has sufficient water for the both the crops.
2. An area of 13612 ha is proposed to be single cropped area. Its main feature is lesser availability of water.
3. Around 2812 ha area is either at a higher slope or a piece of wasteland. This area is proposed for agri-horticulture.

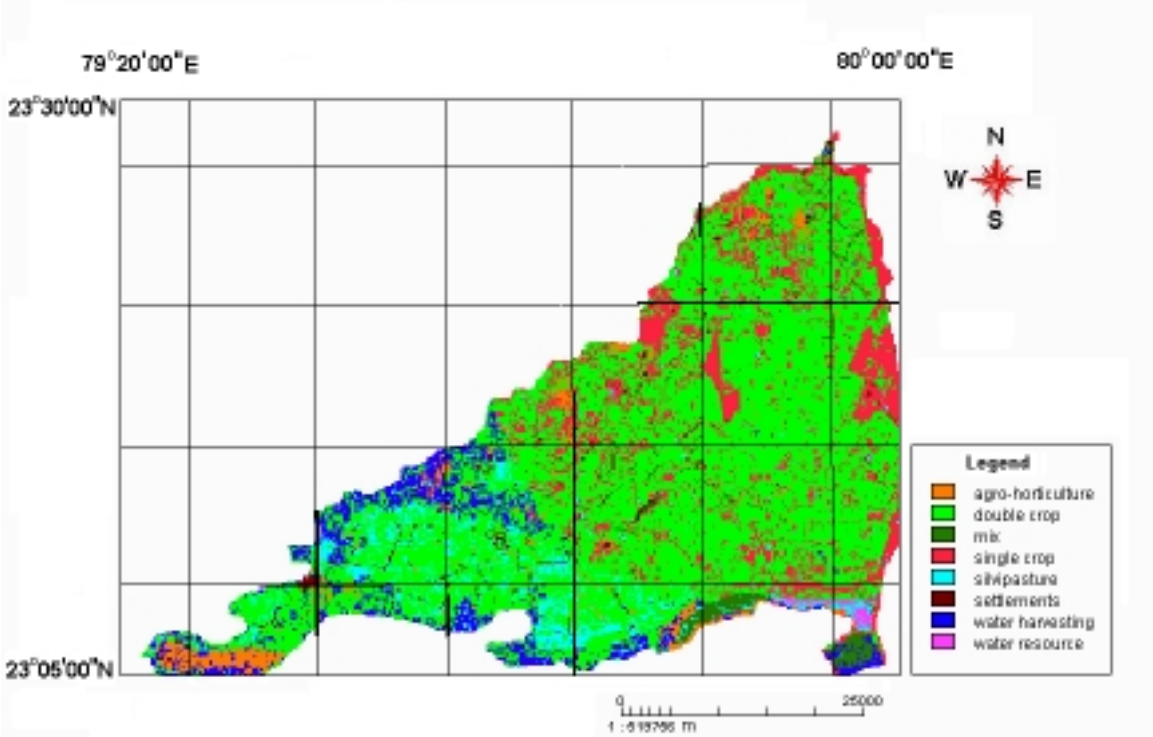

Fig 3 Water Resource Action Plan of PBC Command Area

4. A part of the area is at a slope of 3 to 10% or more comprising 4126 ha. It should be kept under silvipasture.
5. The areas having wasteland and the water availability for irrigation was very poor; were reserved for future extension of settlement areas.
6. The water bodies in the area of 346 ha are proposed to be used as water resources. Also around 5150 ha area belonging to wasteland on structural hills and structural plain is proposed to be utilized for harvesting rainwater in Kharif season, which can be utilized for surrounding areas.

The study reveals the fact that remote sensing data along with field data when combined on GIS platform results into useful informative map for planning land and water resource actions, keeping in mind the resource availability and utilizability. The spatial distribution of resources availability, utilization and its quantification in very short time with least affords makes this information widely acceptable to variety of fields specially where time factor is a constraint.

Concluding remote sensing and GIS technology seems to be very very useful for planning command area activities where the potential gap is still to be filled up.