Remote Sensing Study on Interlinking of rivers from Pennar to Cauvery

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Abstract - Water scarcity is becoming a grave problem in India due to monsoon effect and increasing population. More over the rainfall in the country is also unevenly distributed. As a result the regions receiving heavy precipitation are facing floods resulting in huge amount of water runs into the sea at the same time lack of rain fall regions are suffering with droughts and famines. To overcome the problems in the distribution of water, National Water Development Agency (NWDA) put a proposal of water transfer from surplus region to deficit regions. The total length of the present study is 483km. between Pennar (somasila) and Cauvery (Grand Anicut) and it consists of 10 km. buffer on both sides of the canal and it covers 17,215.68 sq. km. out of which area of 10,105.96 sq.km.is the proposed command area falling in Chittoor, Chengalpattu, North Arcott and South Arcott districts. The characteristics of the rocks, lineaments, drainage, settlements and land use/land cover are demarcated using IRS-P6, LISS-III data for better analysis. The study reveals that Current fallow land of 5340.14 km^2 and 6307.98 km^2 of cropland will be benefited for cultivation which is more than what NWDA estimated. The canal will provide water for irrigation and drinking to 4597 villages and 244 villages to be reclocated. 119 culverts and 24 aqueducts have to be constructed across the canal.

Key *Words*: Land use/ Land cover, Remote Sensing, rehabilitation, Lineaments.

Nomenclature :
NWDA- National Water Development Agency
IRS - Indian Remote Sensing
LISS-Linear Imaging Self Scanning
GIS - Geo Information System
SOI – Survey of India
ERDAS - Earth Resources Data Analysis System

1. Introduction

India has large amount of water resources, but their distribution is uneven due to the temperature differences and geological settings. Due to that some of the areas are blessed with good resources of water where as the remaining is deprived of water resources. This also occurs due to uneven rain fall both in space and time. Water scarcity impacts not only the plant and animal life but also it may lead to conflicts between states and countries. Since the population is increasing, the pressure on land for food is also increasing. This resulted in a sizeable area of erstwhile barren, fallow and marginal lands and forests in the country have been brought under cultivation. [1]

To overcome the water scarcity there is a need of harvesting the same. Increasing Population alongside river basins causes a greater increase in the demand for water for agriculture,

industrial and basic needs. The surplus water areas suffer with floods and deficit areas face droughts and famines. To avoid all these problems it was conceived that if water could be transferred from surplus region to the demanding one, it may prove to be of greater use to meet the demand for water, particularly in urban areas. That is why river channeling with the help of canals has been proposed so as to provide water to the population this most important source of life. Inter basin transfer of water is not a new concept. The concept of river channeling in India was brought forward in 1973 for the first time stating that the Perennial rivers of the Himalayas could be linked with the Peninsular rivers on the Southern part of India so that every part of the country is provided with water not only for human needs but also for agriculture and industrial needs.

Number of researchers discussed harvesting surplus water in a basin and its pros and cons at length .[2-10] However National Water Development Agency (NWDA) foresees that interlinking of river basins must be carried out not just to meet all the water demands but also for sustaining sub-surface water reserves in a healthy condition.

The Pennar (Somasila) – Cauvery (Grand Anicut) link Canal study area passes through Nellore and Chittoor districts of Andhra Pradesh, Tiruvallur, Kancheepuram, Vellore, Tiruvannamalai, Villupuram and Cuddalore districts of Tamil Nadu and Pondicherry. The existing sources of irrigation are mainly seasonal tanks and wells/dugwells in the study area. Experts argued over the issue both in favor and against the concept. Intellectuals who supported the linking of rivers stated it is unavoidable whereas those who opposed the concept quoted "it is not much useful considering the This information is also vital to oversee, design the Land use and for detecting the changes in the environment as well. Remote sensing and GIS are effective's tools for land cover and vegetation mapping. Various techniques of remote sensing, digital image processing are discussed in.The observation of the physical cover that includes vegetation both natural and planted is defined as Land cover.

 An attempt is made in this study so as to map out the Land use/Land cover in order to obtain comprehensive information about the potentials and limitations of the uses of the present study area. The attempt is also towards understanding the environmental impact of the project on the present study area. Assessment of environmental impact is considered very crucial at the early stages of planning of irrigation projects to identify expected negative impact and ways to subdue the problem. Many river channeling projects which have the bases and measures adopted correspondingly in order to conserve the ecosystem and human rehabilitation. With the rapid growth in population, such projects and inter linking of rivers are essential for domestic and development of food grains. [**16 -18**]

expenditure that is to be incurred on such projects". Information on land use/land cover offers a better understanding of the cropping pattern and spatial distribution of fallow lands, forests, grazing lands, wastelands and surface water bodies, which is vital for developmental planning. [**11**] In view of the pressure put by increasing population, need for mitigating increasing demand of land resources, appropriate scientific land-use planning and land management strategies could provide the alternative for the sustainable development of any region.

It is suitable to use powerful methodology such as GIS combined with Remote Sensing to make the planning of use task of river channeling easier and effective. [**20**] Many investigations were done with Remote Sensing & GIS inputs for studying various land features and the changes. [**12- 15**]

The total diverted water of 8565 Mm3 from the Somasila dam is proposed through the link to meet command area enrooted (3048 Mm3). Other than this the total domestic and industrial water requirement of the area (1105Mm3), transmission losses (557 Mm3) and Transfer to Cauvery (3855 Mm3). The areas under each of the branches so measured were adjusted to match with the gross command area of 840,218 ha., after deducting the forestland.

2. Study area
The study area of the Pennar (Somasila) – Cauvery (Grand Anicut) link canal occupied 17,215.68sq.km.including command area. It occupied by 53 SOI sheets of 1:50,000 scales. The canal is bounded between 10°43'57"N - 14°36'52"N latitude and 78°44'2"E - 80°18'12"E longitude. Figure-1shows the link canal (Center line), study area buffer of 20km. on both sides and the proposed command area.The annual rainfall in the command area varies from 635 to 1019 mm. The Pennar - Palar - Cauvery Link Project lies in Andhra Pradesh and Tamil Nadu states. The existing Somasila dam is located just downstream of the confluence of Cheyyeru River and Kallettivagu River with Pennar River. Grand Anicut is located on the border of Tiruchchirappalli and Thanjavur districts of Tamil Nadu.
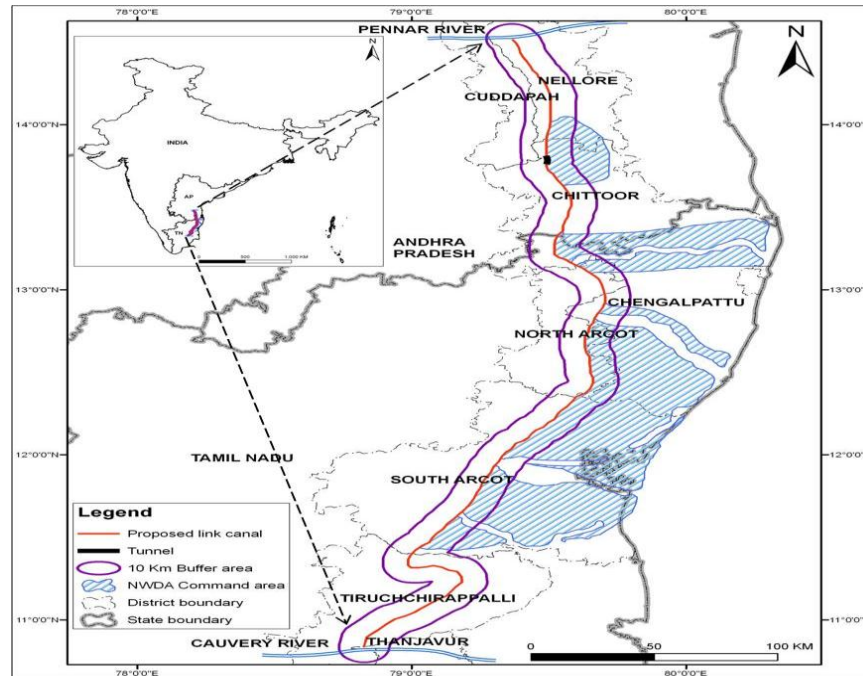
Fig.1.Location map of the study area

Registered to real world co-ordinates using ERDAS IMAGINE 9.1software.

Total 53 topo-sheets are rectified and prepared a subset as per the study area polygon. A topo-sheet mosaic is prepared for all the maps which fall in the study area. From this mosaic image, study area is extracted using shape file in the software. LISS-III images of IRS-P6

satellite data are Geo-registered utilizing SOI data base. The study includes geology, rocky out crops, drainage, road network, settlements, Land use Land cover and lineaments with remote sensing data update in detail for the link canal. The mosaic of LISS III data information is given in the table-1. The remaining images are projected based on the rectified image.

Table.1 IRS-P6, LISS III – Data

Satellite	Sensor	Path	Row	Date	Resolution
IRSP6	LISS-III	101	063	12-MAR-2010	23.5m
IRSP6	LISS-III	102	063	17-MAR-2010	23.5m
IRSP6	LISS-III	102	064	17-MAR-2010	23.5m
IRSP6	LISS-III	102	065	15-JUL-2010	23.5m

4. Settlements

An attempt is made to demarcate all the villages in the study area along with attribute data in Arc GIS. While studying villages in the area with reference to administrative boundaries, the command area polygon data is overlay on the topo-sheet mosaic. From the topo-sheet mosaic settlements are extracted in Arc GIS environment. All the villages are marked as point data which come into the corridor of the link and the command area.

The link canal starts near Yenkatareddipalli village in Kaluvoya mandal of Nellore district in Andhra Pradesh. From this point it passes through five mandals in Nellore district touching number of villages in these mandals. Then it arrives the district of Chittoor where it goes through a good number of mandals and villages, before entering Tamilnadu. It enters Tamilnadu at kottainadu village in Palipattu mandal of Chengalpattu district. Only a part of Chengalpattu district falls directly under the canal area, whereas a number of villages fall under the study area.

After thatThe canal enters the village of Ramasamudram in Palipattu taluk of Chengalpattu district and passes through number of villages. The density of villages is so great in this section. Then it goes to the North Arcot district entering at Bodinayakankandigai village in Arakkonam taluk. The density of villages in this region also is very high but slightly less when compared to that of Chengalpattu. The canal once again passes through the districts of Chengalpattu and North Arcot respectively and then penetrates South Arcot district at Singanikuppam village of Tindivanam taluk.

The canal enters at Pudur village in Tirukkovilur taluk in the district of South Arcot. The number and the density of the villages is very high in this phase also covering large amount of the study area. The canal then enters the district of Tiruchirapalli and Perambalur taluks. The density of villages here is moderate and as the canal progesses in to the district of Thanjavur that the density of villages is very less.

Buffer area if 1km is created in Arc GIS around the positioning of the link canal to assimilate the villages falling within the buffer area. All the villages covered within the buffer area are deemed to be affected villages during the construction. There are 244 villages coming under the buffer area which have got to be saved either fully are partially. There are four villages in Nellore district, 34 villages in chittoor district, 45 in Chengalpattu, 53 in North Arcot, 63 in South Arcot and 45 villages in Tiruchhirapalli falling under the buffer area.

4.1 Road Network

The roads in the study area of the canal are mapped through onscreen digitization from the topo-sheet mosaic. The study includes highways, metal roads, unmetal roads and foot paths. The road network is shown in figure 3. Topo-sheet mosaic is taken in Arc-GIS and canal alignment and buffer of the study area boundaries are overlay on it to digitize the roads and intersection points with alignment. The interesting points of canal alignment with all type of roads are marked and tabulated with the distance parameter.

The canal starts from Pennar near Baddevalu and passes through 10 km in Kaluvoya and enters Rapur mandal where it crosses 6 major roads and a few minor roads. After Rapur canal covers a few kilometers in Renigunta and Yerpadu mandals and 20 km in Puttur mandal. The canal crosses 7 major roads and railway line at 100 km point. After Puttur canal enters Pallur and Tiruttani mandals and crosses 7 major roads and number of minor roads for a length of 22 km. After Tiruttani the canal enters Arakkonam and Kancipuram taluks for a distance of 36 km where it crosses 11 major roads before it enters Cheyyar at 213 km. The canal crosses railway line at 195 km and 6 major roads in Cheyyar. After Cheyyar, canal passes through Vandavasi and crosses 8 major roads before it enters Tindivanam. At 274 km canal passes through Gingee and Viluppuram taluks where it crosses 11 major roads number of minor roads. After Viluppuram canal passes through 40 km distance in Tirukkovilur taluk and crosses 10 major roads and a number of minor roads. After Tirukkovilur link canal passes through Kallakkurichchi and Vriddhachlam taluks where it crosses 10 major roads and a number of minor roads. At 384 km canal enters Peramballur taluk where it crosses 6 major roads before it enters Ariyalur.

In Ariyalur canal cut across many major roads (22) with in a distance of 37 km. After Ariyalur it enters Lalgudi taluk and crosses 10 major roads before joins Cauvery River. The canal cut crosses a railway line at 455 Km and another railway line at 476 Km. The metal/unmetal roads crossing points of the river shown in the table -2.

Table 2: Metal roads for cross bridge locations

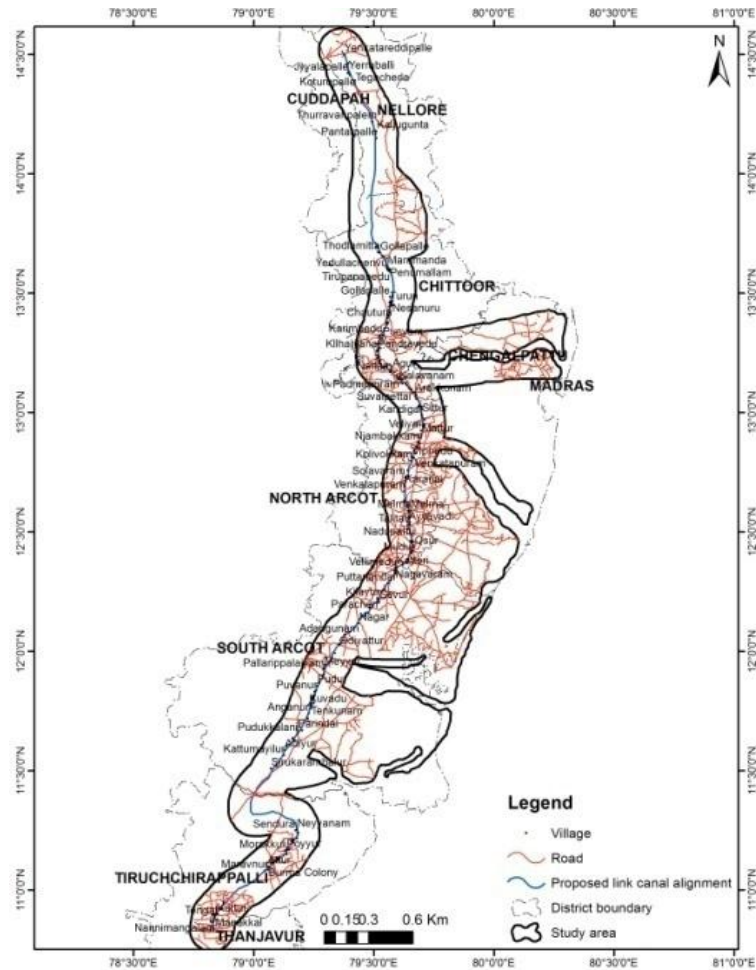| District	Metal roads
Nellore	6
Chittoor	9
Chengalpattu	5
North Arcot	26
South Arcot	35
Tiruchhirapalli	38
Total	119

Figure-2 Villages and Road network of the Study area
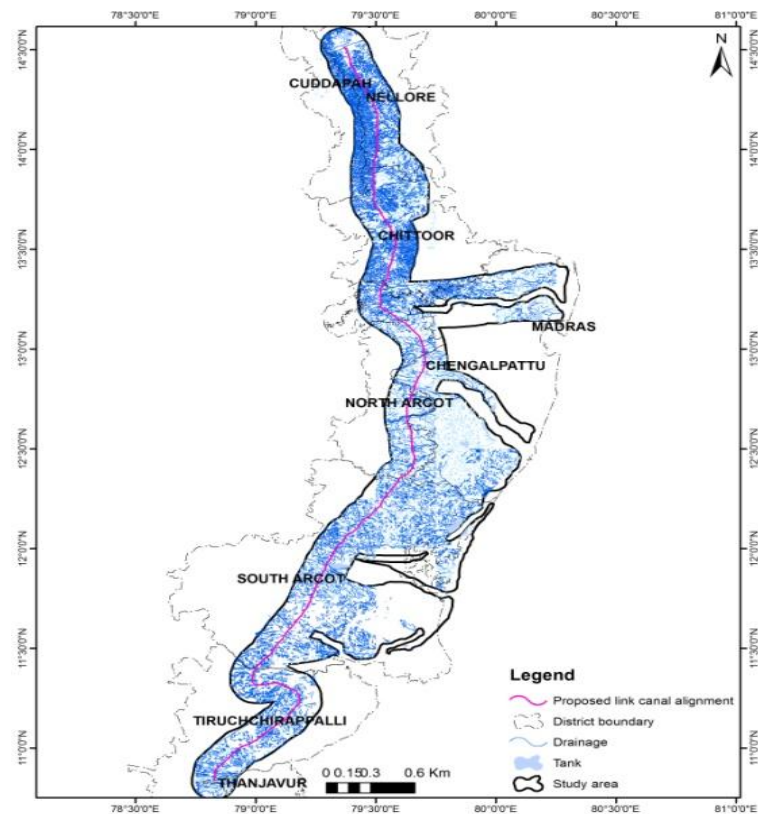
5. Drainage

The drainage of the study area is extracted through onscreen digitization from the toposheet mosaic. The drainage includes streams, canals, tanks and reservoirs which are covered in the study area of the link canal (figure 3).

Besides the drainage study along the alignment, major Nala, Canal and River crossing are noted and described, with reference to their location. Alignment starts near Nellore and passes through a major tank before it enters Rapur mandal. In Rapur, the alignment crosses vagu systems at 10 locations before it enters Dakkali mandal. In Dakkali,the canal crosses Pedda kona vagu, Chinna kona river besides Alapaleru river at 52 km. In Venkatagiri also it crosses Biragundlu kaluva and Devara kona. In Srikalahasti alignment crosses Marrimanu kona, Repalli kaluva, Varlapudi kaluva and Uppu Kona. Beyond this point, it enters Renigunta where it crosses Tummuru kona, Ralla kaluva and Swarnmukhi river

in Yerpedu. In Pallippattu canal crosses Nagari river at 139 km. Nandi river is crossed by the canal at 156 km in Tiruttani taluk. In Arakkonam, Kallar river is crossed by the canal at 178 km. Vegavati river and Palar rivers are cut across by the canal in Kanchipuram taluk. At 222 km alignment crosses Cheyyar river in Cheyyar and Suka nadi in Vandavasi taluks. In Gingee alignment crosses Varaha nadi at 276 km, Ponnaiyar river, Gadilam river and Sesha nadi and a few major tanks are crossed by the alignment in Tiruekkovilur taluk. Manimukha nadi in Kallakkurichchi taluk and Gomukha nadi and Velar river in Vriddhachalam taluk are cut across by the canal. Chinnar river is crossed by the alignment at 390 km. Anaivari oda in Perambalur, Anaivari river, Kallar river in Ariyalur and Marudaiyar, Nandiyar and Kulaiyar rivers in Lalgudi are traversed by the canal before joining Cauvery river at Lalgudi village. The river crossing points of the link canal data given in the table-3.

Table.2.Pennar – Cauvery link canal alignment and river crossing locations

District	Rivers
Nellore	3
Chittoor	3
Chengalpattu	4
North Arcot	4
South Arcot	5
Tiruchhirapalli	5
Total	24

Figure-3 Drainage of the study area

6. Remote sensing

Remote sensing has been very useful for land use/land cover mapping in different parts of India.[19-21] LISS-III Sensor data of IRS-P6 can be used to carry out the detailed Land use Land cover information. [22]

6.1 Visual land use classification for LULC

The visual interpretation has been carried out based on the data acquired from standard FCC (False color composite) imagery of IRS-P6, LISS-III for land use and land cover.

The land use and land cover are interpreted separately putting into use the interpretation keys. Then the ground truth information is obtained considering the scheme drawn previously and traverse plan. The ground data has been collected as per the stipulated Performa so that a minimum of 10% of the specified area is covered. The areas which were doubtfully interpreted at the preliminary stages have been verified specifically. Basing on the data of ground truth, the changes have been effected and classes along with the boundaries have been refined after which the estimation of areas falling under different classes (figure-4) has been

carried out using planimatric measurements so has to fulfill the statistics of stipulated land use.

Crop Land is indicated in bright red to red in colour, although the shape and size vary from place to place. The total crop land is 6307 km^2 in the study area whereas the command area comprises of 4336 km^2 of the total area of cropland. Current Fallow is an agricultural land where cultivation does not follow any uniformity. These lands appear in light red to cyan in colour with varying shape size in the study area. An area of 5340.14sq.km is occupied by these lands throughout the study area out of which 2907 sq.km. falls in the command area of the canal. Forest areas appear in dark red to red of different sizes. The area of forests in the study area is precisely 2965sq.km. Approximately 895sq.km.of forest land falls in the command area. Water bodies include Reservoirs, lakes, tanks, canals besides natural lakes, rivers and streams and creeks. These are indicated in blue to dark blue color basing on the depth of the water body and turbidity. They occupied an area of 1322.35sq.km in the study area wherein about 1048 sq.km. of water bodies come under the command area. Most of the water bodies are irrigated tanks. The Scrubland is described as a forest where the vegetative density is less than 20% of the canopy cover. Scrub lands, basing on the moisture cover on the surface, appear in light yellow to brown and greenish blue. Scrub lands occupy an extent of 400sq.km approximately in the study area.

Built-up land is an area where human residences exist due to non-agricultural use and that has a cover of buildings, transport and communication, utilities in association with water, vegetation and vacant lands. They appeared in light brown to cyan colour. An area of 457sq.km approximately is occupied by built up land in the study area. Sandy areas are those where large deposits of sand are found. They appear in white colour. The total area of sand in the study area is 29.75sq.km. Plantations are under agricultural tree crops, planted adopting certain agricultural management techniques. It includes tea, coffee, rubber, coconut, areca nut, citrus fruits, orchards other horticultural nurseries. They appear in dark red to red of different sizes. They also be identified based on association property. The remaining land use categories are treated as miscellaneous because their physical appearance and other characteristics are not worthy to be mentioned. It also includes linear features, rail and roads in the study area. The study area comprises to an extent of 338.82sq.km under this class.
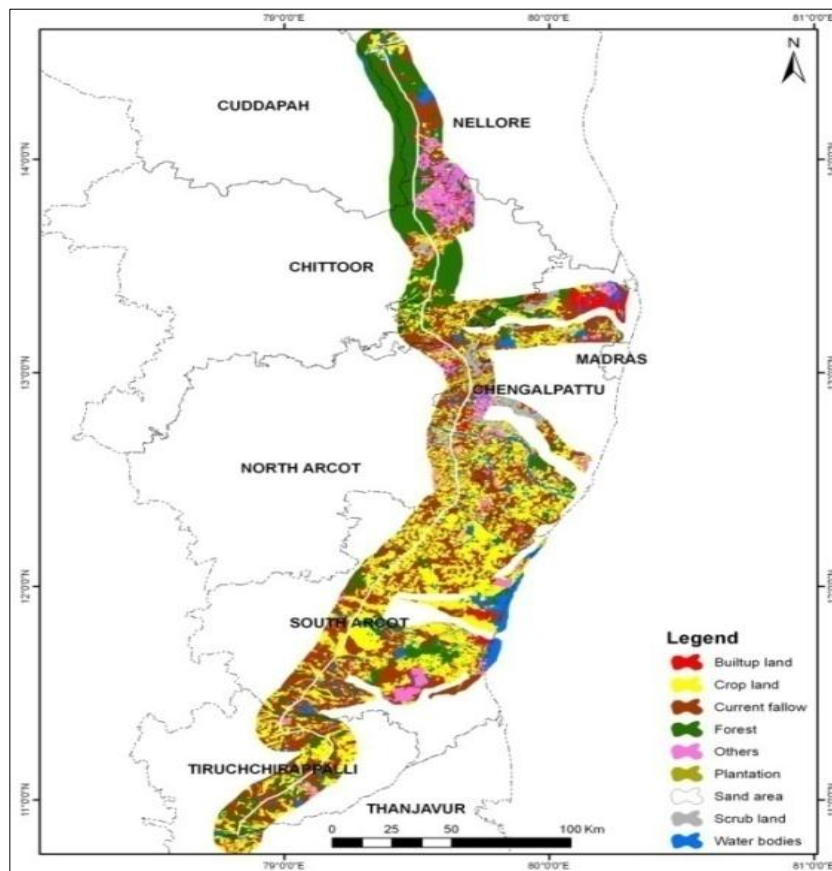

Figure-4 Land use land cover of the Study area

7. Geology and Lineaments

LISS-III image mosaic is taken in Arc GIS and study area buffer is overlaid on the image. Geological lineaments/fault zones are identified and mapped through on screen digitization. This study is limited to the link canal study area.

The canal alignment in Nellore district passes through hilly terrain where regional strike is mostly parallel to the alignment. In Nellore 9 lineaments are demarcated and all of

them are intersecting the alignment in perpendicular direction. Chittoor district is also covered by hilly terrain and the strike of the formation is parallel to the alignment. Here 10 lineaments are identified and all of them are intersecting perpendicular to the alignment. There are 2 lineaments each from Chengalpattu and North Arcot districts of the study area and one from South Arcot district. The study area of Tiruchcharapalli indicated 5 lineaments and all of them are intersecting with the alignment. 8 more lineaments are taken from the map which is prepared by Ganapathy (2010) (Figure-5).
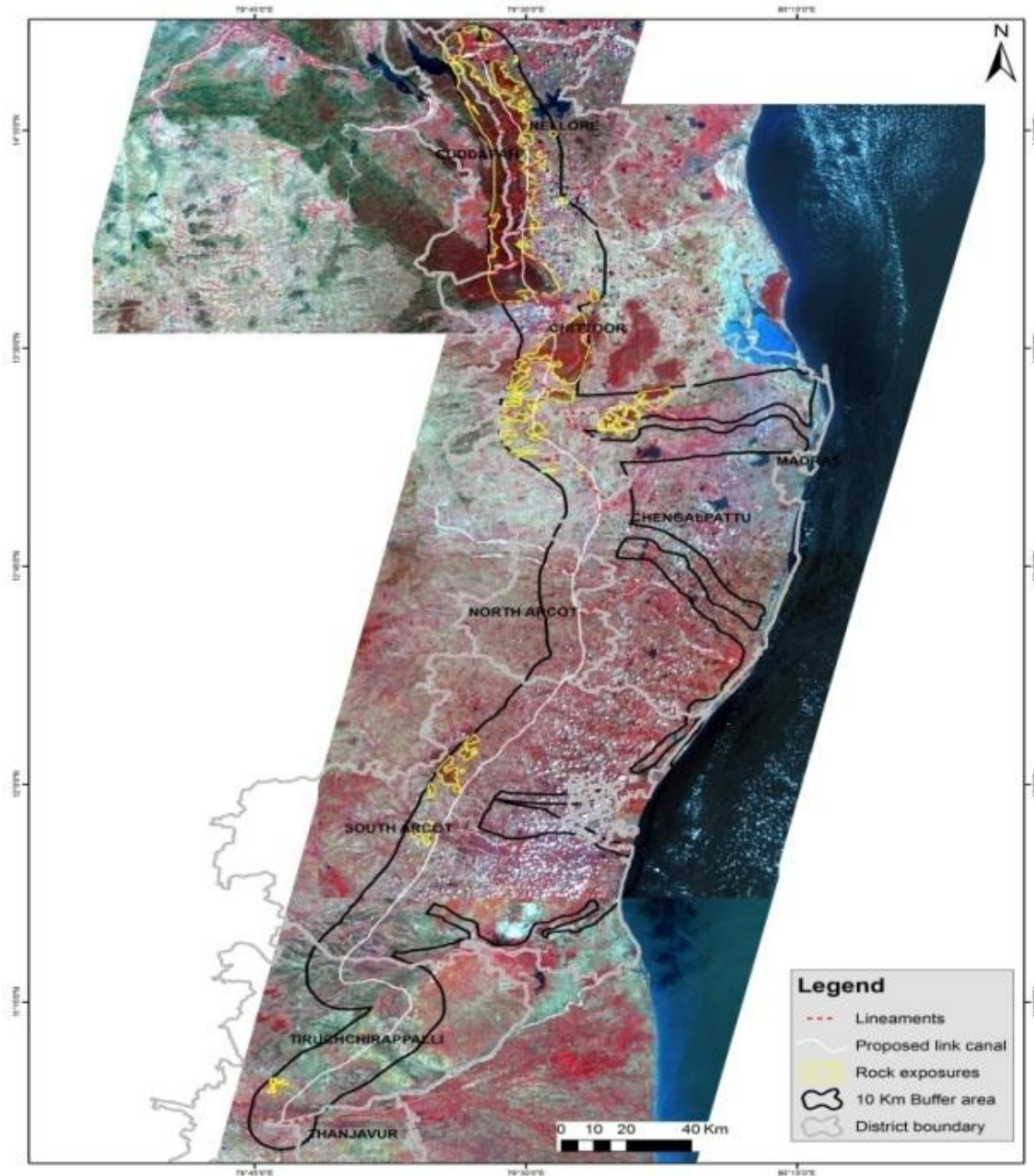

Figure-5 Study area and proposed alignment draped on satellite image mosaic

8. Alignment modification

The canal alignment is over laid on the toposheet mosaic of the study area and the image. The alignment direction is examined closely with topographic features, hilly terrain, croplands, settlements and reserved forest. Accordingly changes in the alignment are suggested at 10 locations. These locations are shown in the Figure 6. in two parts for clarity of display. A change in the direction of the canal is suggested near Kothurupalle village in Koluvoya mandal to bypass forest area which crossed by the original alignment (26.3km). Another change in the alignment is

suggested from Alturupadu village to Palerukota (7.3km.) in Venkatagiri mandal. A similar diversion is suggested at Devaru kona to Kuntakalva (9.11k.m.).
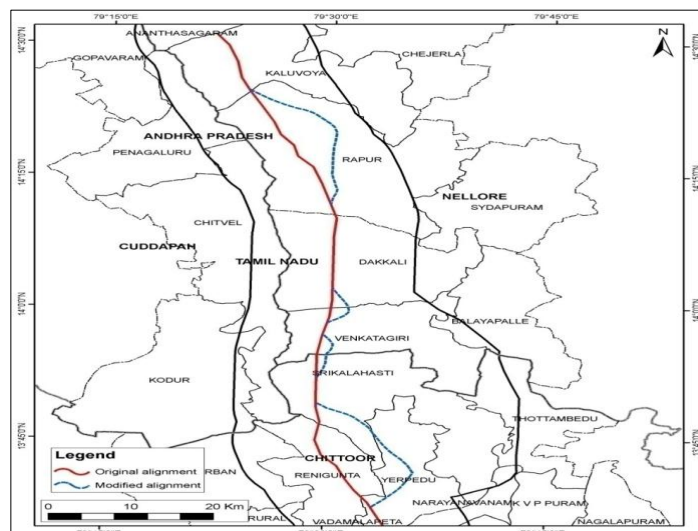
The original alignment is cutting across Velikonda hill and Krishnapuram protected forest, hence a diversion is suggested from uppukonda near Gollapalle village in Srikalahasti mandal and at 140m contour to join at Vikrutamala village in Yeripedu mandal (28.88k.m.). In Narayanavanam mandal the original alignment is through Narayanavanam reserved forest, hence a change in the direction of the alignment is indicated from Suddakaka village to Ramakrishnapuram (12.73k.m.). The alignment again cut across hilly terrain (400 m elevation) near Krishna Samudram and hence a change in the alignment direction is put forth from Krishna Samudram to Pentakandigai (12.75k.m.) in Chengalpattu taluk. The original alignment passes through Arakkonam town hence a small change in the direction is suggested from Kaimur village to Perumuchchi (5.88k.m.). Another small diversion is taken to bypass 3 villages and joins original alignment at Pullalur (3.3k.m.) village. A similar change in the alignment is shown to bypass 3 more villages from Katteri village to

Kalpakkam village. Finally by modifying the alignment it is noted that 21 villages are being bypassed. The modification effects save approximately 39sq.km. area of reserved forest which was to be lost with the prior alignment. Hilly terrain of 58sq.km.area remains intact due to the modification and the burden of cutting and flattening of this terrain can be saved which proves to be cost effective for that reason.

9. Environmental Impact

The environmental impact due to the canal alignment is both advantageous as well as disadvantageous. The canal will be beneficial to about 4597 villages to supply drinking water alongside recharging the ground water levels and providing an additional source of irrigation. Large amount of area of about 5340 sq.km falls under Current fallow land class. With the proposal of the canal the above Current fallow land can be irrigated and additional water can be supplied to those lands in which single crop are formed due to inadequacy of water for double crop. It is 1,164,812 ha derived from the real time data as against the NWDA projections of 840,218 ha. In the path of the canal 217 km is through unclassified crystalline rocks out of 483km. It will be useful to avoid the seepage zones while constructing the canal.

244 villages have to be rehabilitated during the canal construction more over 5 tribal villages also impact on its course. For a length of 81 km, the canal runs through hilly area. Due to canal construction 112 sq.km. of the forest canopy will be disappears. About 149 sq.km area of crop land will be affected in the plains due to alignment of the canal and its water longing.
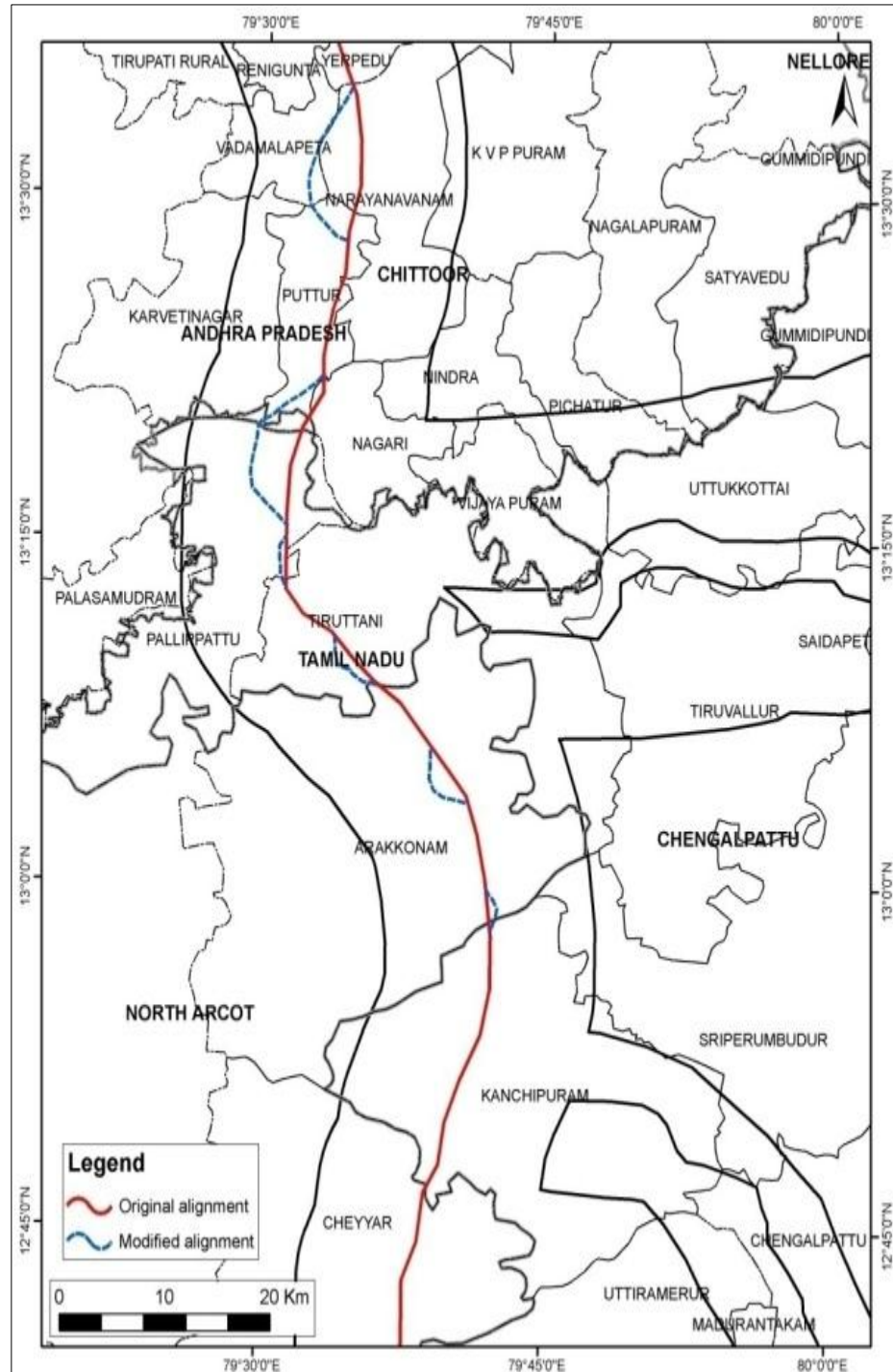
Figure-6 Alignment modification of the Pennar Cauvery link canal

10. Conclusion

The present study describes the Pennar to Cauvery link canal, which is proposed by National Water Development Agency (NWDA). The total study area is occupied by 17,215.68sq.km. The study reveals that 4597villages will be benefitted with drinking water and facilitated with irrigation source. IRS-P6, LISS-III data disclosed that current fallow land of 5340sq.km can be transformed into productive land. The demarcation of the drainage revealed that the total length of the canal cuts across 24 river basins, comes into touch with 10 tanks where as it traverses 25 streams and

streamlets. The alignment crosses 119 major roads and number of minor roads. There 32 lineaments that are being crossed by the proposed link canal. By modifying the alignment it is noted that 21 villages are being saved. The modification effects save approximately 39sq.km.area of reserved forest which was to be lost before the alignment was modified. Hilly terrain of 58sq.km.area remains intact due to the modification and the burden of cutting and flattening of this terrain can be saved which proves to be cost effective for that reason.

Acknowledgements

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Author's Profile

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Prof. K.NIRANJAN is presently working as Professor, In the Department of Physics, Andhra University College ofScience & Technology, Visakhaptanam. He obtained M.Sc. degree in physics from Andhra University. He obtained Ph.D.in physics from Andhra University. Twenty three students got PhD degrees and 15 students got M. Phil. under his guidance. He published 113 research papers in international journals and 15 in national journals. He got State Meritorious Teacher Award 2013 from Govt. of Andhra Pradesh. He got UGC- BSR Award from the University Grants Commission, New Delhi one of the 33 awards given in the country from all science faculties and the only teacher from the state of Andhra Pradesh.BOYSCAST Fellowship award by the Department of Science & Technology, Govt. of India, 1990.Best Research paper award at the National Space Science Symposium 1996,Awarded by Chairman, Indian Space Research Organisation. He got Best Researcher Award, Andhra University, 2003. He also gotBest paper award at the National Space Science Symposium (awarded by Chairman, Indian Space Research Organization) 2004.