LAND USE AND LAND COVER MAPPING

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Vegetation Indices

- A “Vegetation index” is mathematical transformation of spectral bands that enhances the spectral properties of green plants so that they appear distinct from other image features.
- Indicates the AMOUNT of vegetation (e.g., %cover, LAI, biomass, etc.)
- Distinguish between soil and vegetation
- Reduce atmospheric and topographic effects to some extent

Reflectance properties of soil

- Soil reflectance can be bright in NIR (like vegetation)
- Especially bright in dry soil and much darker in wet soil
- Has low red reflectance (like vegetation)
- Difference between NIR reflectance and Red reflectance for soil is much less than for live vegetation! (shape of curve)

Types of Vegetation index

Difference Vegetation Index (DVI)

- Probably the simplest vegetation index
- DVI = NIR – Red
- Sensitive to amount of vegetation
- Distinguishes between soil and vegetation
- Does NOT deal with the difference between reflectance and radiance caused by the atmosphere or shadows

Ratio-based Vegetation Indices

- Simplest ratio-based index is called the Simple Ratio (SR)
- or Ratio Vegetation Index (RVI)
- SR = NIR/Red
- High for vegetation
- Low for soil, ice, water, etc.
- Indicates amount of vegetation
- Reduces the effects of atmosphere and topography

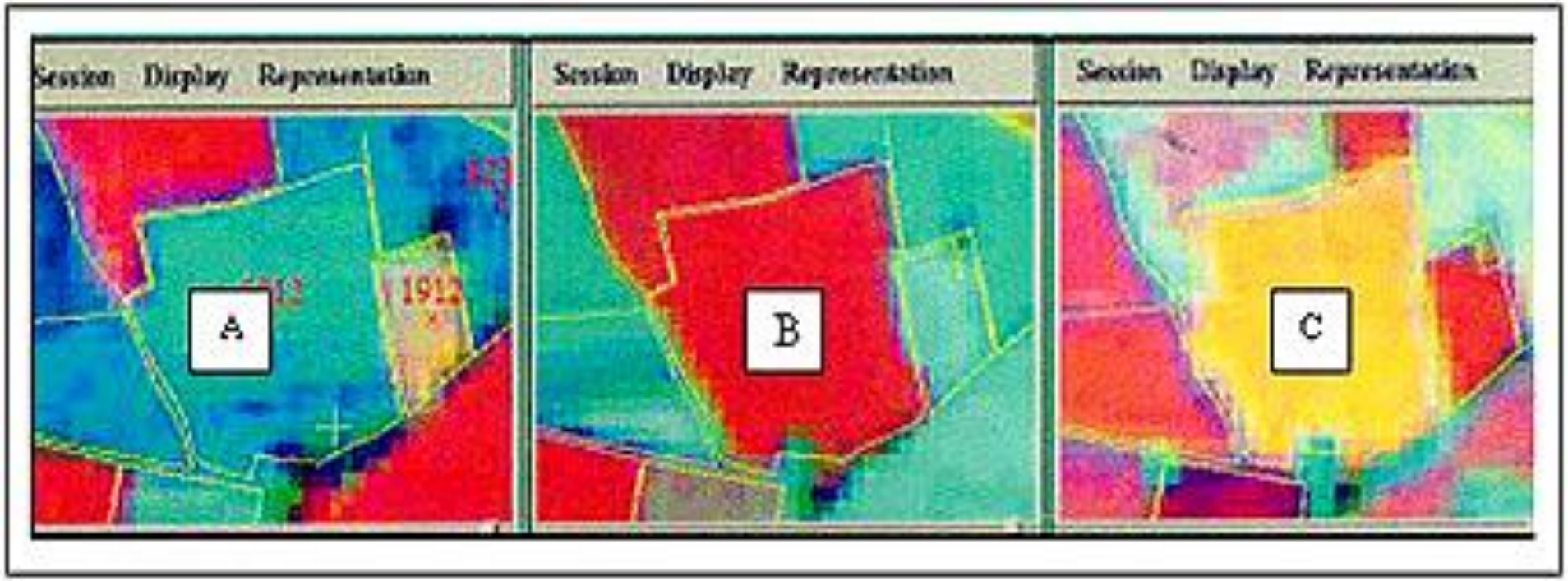
Normalized Difference Vegetation Index

- Normalized Difference Vegetation Index (NDVI) is an index of plant “greenness” or photosynthetic activity, and is one of the most commonly used vegetation indices
- NDVI = (NIR – Red)/(NIR + Red)
- Ranges from -1 to 1
- Indicates amount of vegetation,
- Distinguishes vegetation from soil,
- Minimizes topographic effects, etc.
- A good index! – Does not eliminate atmospheric effects!

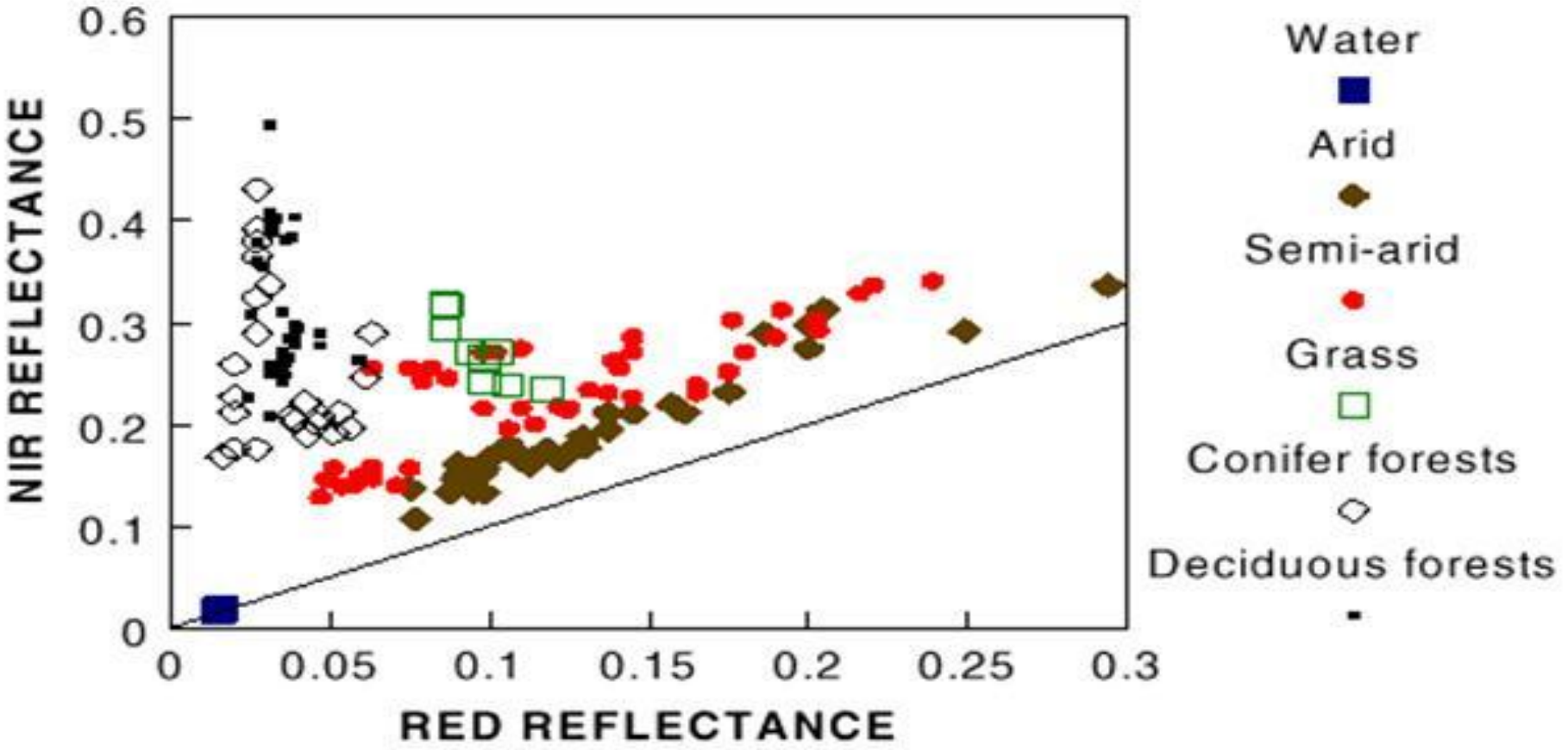
Factors influencing NDVI mesurements

- Atmospheric, cloud, soil, Anisotropic effects
- Spectral effects.
- To address limitations, number of derivatives proposed
- Perpendicular Vegetation Index,
- Soil adjusted vegetation index
- Atmospherically Resistant Vegetation Index
- Global Environment Monitoring Index

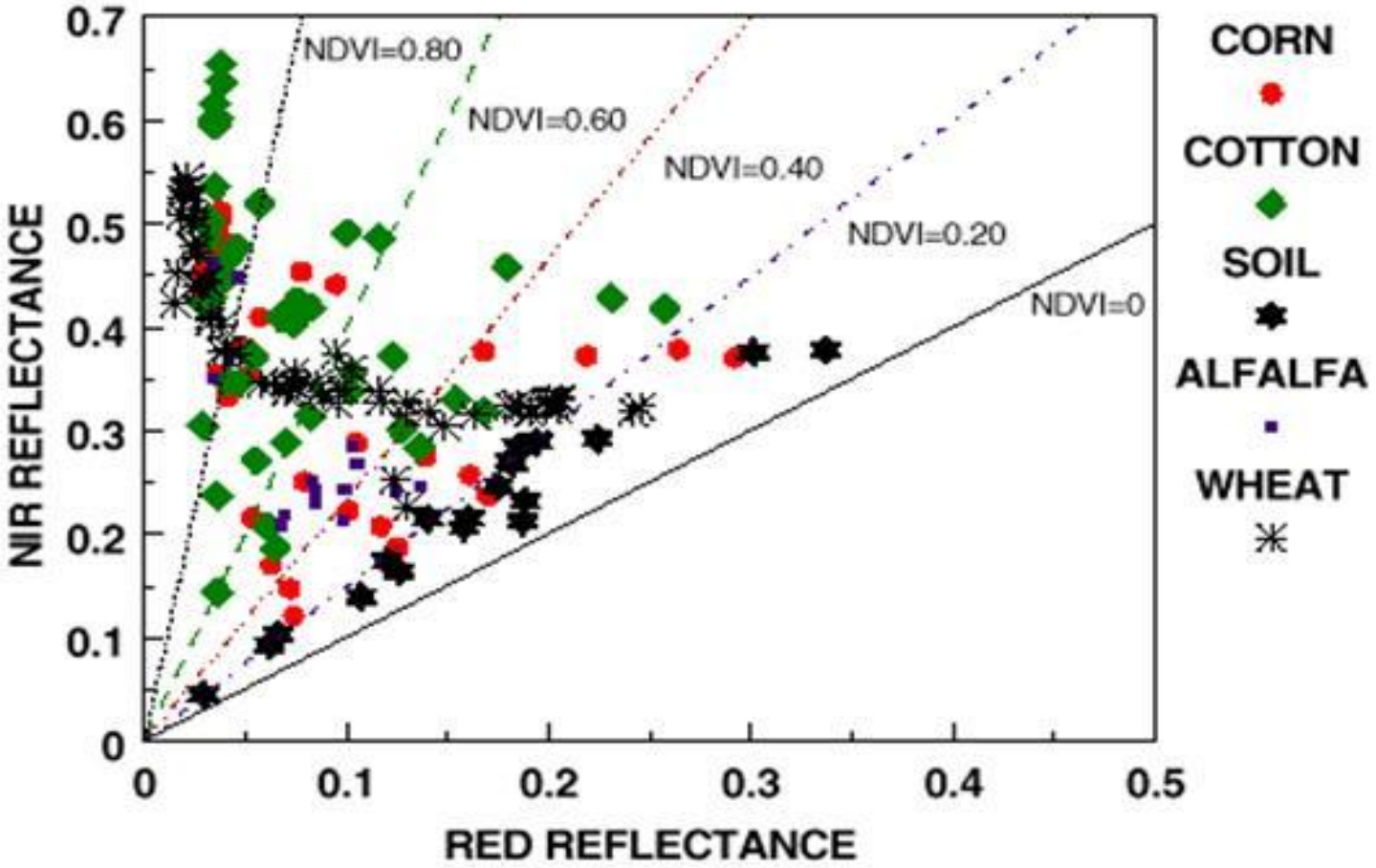
Enhanced performance of modern sensors take into account all external factors



A=Bare soil B=Full cover C = Senescence



Reflectance spectra from Landsat TM 5 plotted in red-NIR space for a wide range of land surface cover types.



Cloud of reflectance points in NIR-red waveband space for agricultural crops observed throughout the growing season.

Land cover definition –

- Refers to the natural sketch on physical surface of the earth that includes various combinations of vegetation types, soils, exposed rocks and water bodies as well as anthropogenic elements, such as agriculture and built environments.
- Land cover classes can usually be discriminated by characteristic patterns using remote sensing.

Land use

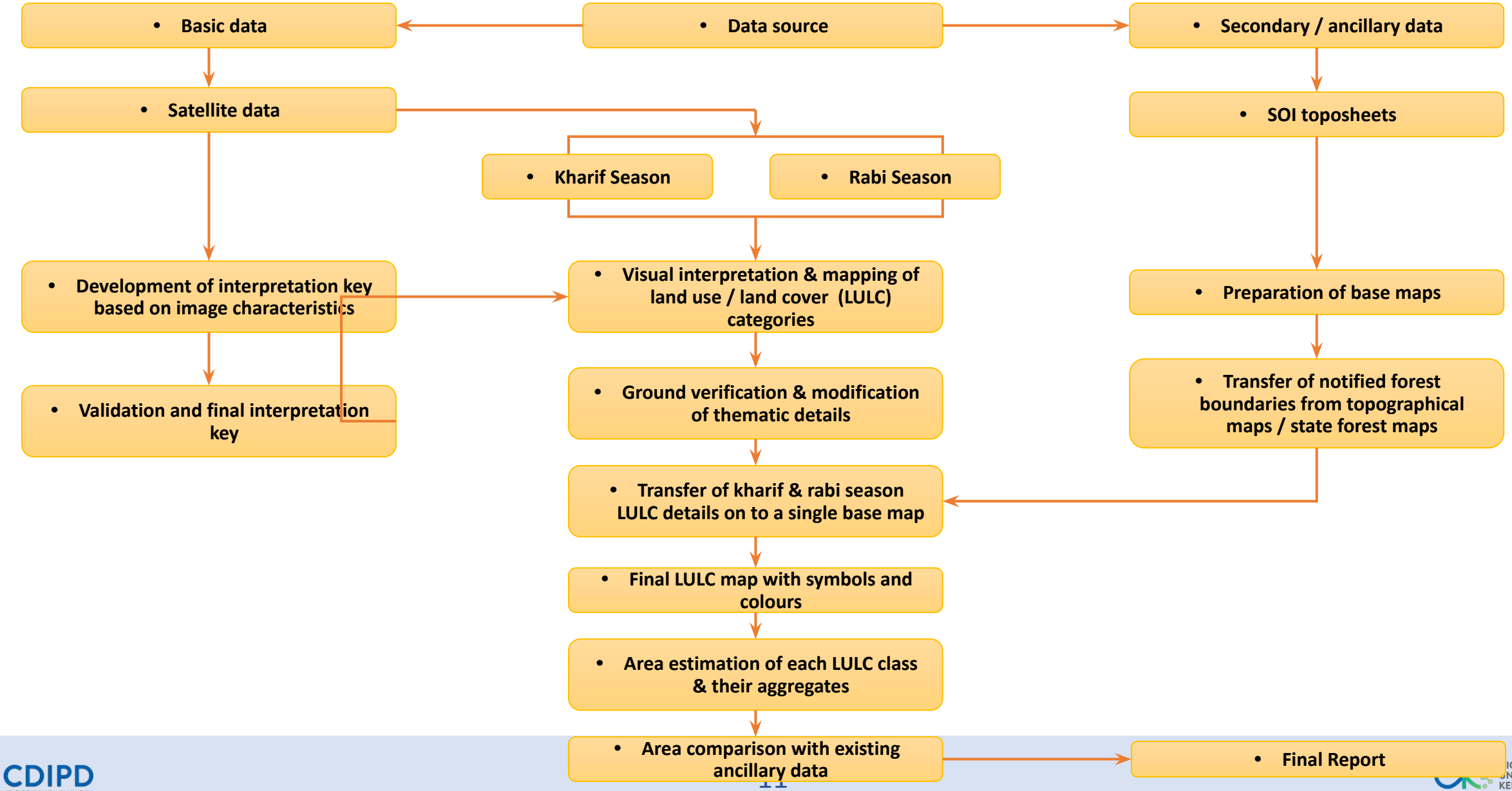
- Is the human use of land.
- It involves the use and benefits obtained from use of land
- Land management activities carried out by man to produce products and benefits such as settlements
- Semi natural habitat such as arable fields, pastures and managed forests.

Land Use / Cover Information Extraction

Visual interpretation

- Computer assisted digitization and digital cartography is playing a major role in land use/cover mapping
- Detection of various classes is based on the characteristics like tone,shape,size,pattern,texture, shadow and the association with surroundings
- Main disadvantage with this approach is that it is highly subjective and results vary from interpreter to interpreter.
- Knowledge of the interpreter in understanding and analyzing the image is crucial in deciding on the results
- Distinct advantage is that this approach can consider all the image elements that are not amenable to computer at present.
- Complex image element interactions could be captured in visual interpretation approach.

Methodology for LULC by visual interpretation technique



Digital Classification Techniques

- **Numerical techniques for satellite image classification have been used in the early 70's**
- **There are two basic techniques–Unsupervised and supervised classification techniques.**

Unsupervised classification,

- **No prior information about the land cover types or their distribution is required**
- **In this method the scene is divided into more or less pure spectral clusters, typically constrained by pre-defined parameters characterizing the statistical properties of these clusters and the relationships among adjacent clusters**

- **The assignment of land cover labels to individual spectral clusters is made subsequently on the basis of ground information, obtained in the locations indicated by the resulting clusters**
- **When mapping a large area previously not well known, unsupervised classification is a better strategy**
- **One approach that is generally adopted to reduce the errors due to various interferences is to increase number of clusters and then progressively merging into target classes.**
- **One important limitation of unsupervised classification is the potential mismatch between spectral clusters and thematic classes due to spectral overlap and seasonality in image acquisition.**

Supervised Classification- preparing training datasets

- **Classification refers to the task of extracting information from an image by identifying information classes- land cover types, called as training sites .**
- **Soft ware is used for statistical characterisation using algorithms like K- Nearest Neighbour, Fuzzy C- Means, Maximum Likelihood method**
- **Main objective is to detect, identify and classify features occurring in the image in terms of types of classes seen in the field.**
- **Land use classes in the field identified by assigning minimum number of pixels to a respective class.**
- **The file providing this information is called a training data set**
- **Preparation of training data sets is time consuming and tedious process involving field surveys and collation of reference data.**
- **Size of the data set has to be kept small**

Supervised classification- For Land cover mapping

- Supervised classification employing maximum likelihood algorithm has been the most commonly used digital classification technique on remotely sensed data
- When the spatial resolution becomes finer and finer, around 5 to 10 m the image texture works as a better discriminator in separating most land covers
- When the spatial resolution is at sub-meter level, then object-based classification becomes a more suitable approach.
- In this classification technique, initially the pixels are grouped into objects and then these objects are classified

Land use cover detection

Land cover and use changes are bound to happen.

Satellite based sensing is one of the proven methods for capturing these changes in a cost-effective way

Aspects of change detection to be described are

- **Detecting that changes have occurred**
- **Identifying the nature of the change**
- **Measuring the area/ extent of the change**
- **Assessing the spatial pattern of the change**

Methodology for LULC by Digital techniques

- Satellite data
- Preprocessing of satellite data
- Unsupervised classification (isocluster)
- Ground truth verification for sample clusters
- Merging and labeling clusters based on GT
- Map composition of LULC classes

- *Unsupervised classification procedure*

- Satellite data
- Preprocessing of satellite data
- Knowledge on LULC of the study area or ground truth data
- Development of Training sites
- Supervised classification (maximum likelihood, parellepiped etc)
- Merging and labeling clusters based on GT
- Map composition of LULC classes

- *Supervised classification procedure*

Digital techniques for land use / cover change detection include:

- **Post-classification comparison**
- **Principal component analysis**
- **Image difference**
- **Image ratio**
- **Temporal Image transformations – linear, wavelet,**
- **Temporal feature space analysis**
- **Change vector analysis**
- **Image regression**
- **Composite analysis**

Thematic Accuracy Assessment

- Important aspect of any mapping output is to validate and find out its accuracy and confidence with which the map can be used
- Accuracy essentially deals with how correct the map with respect actual conditions on the ground

Errors in classification of data

- Data acquisition and sensor related problems,
- Data processing,
- Data interpretation / analysis,
- Truth data sampling,
- Error assessment methodology per se.

Theme accuracy assessment ------

- **Out of these, first four have influence on classification / thematic output while subsequent item has influence on error estimation and representation of output.**
- **To estimate the accuracy, truth information required.**

  Generally obtained
- **Through field visits and collecting the information along with GPS coordinates from high resolution satellite data / aerial photographs**

Classification of Land Use Cover

Built up land

Defined as an area of human habitation developed due to non-agricultural use and that which has a cover of buildings, transport, communication utilities in association with water vegetation and vacant lands.

Agricultural lands

Land primarily used for farming and for production of food, fibre, and other commercial and horticultural crops.

Includes land under crops (irrigated and un-irrigated), fallow, plantation, etc.

Crop Land

It includes those lands with standing crop (*per se*) as on the date of the satellite imagery. The crops may be of either *Kharif* (June-September) or *Rabi* (October – March) or *Kharif Rabi* seasons.

Fallow land

It is described as agricultural land which is taken up for cultivation but is temporarily allowed to rest un-cropped for one or more seasons, but not less than one year. These lands are particularly those which are seen devoid of crops at the time when the imagery is taken in both seasons

Plantations

- It is described as an area under agricultural tree crops, planted adopting certain agricultural management techniques. It includes tea, coffee, rubber, coconut, arecanut, citrus, orchards and other horticultural nurseries.

Forests

It is an area (within the notified forest boundary) bearing an association predominantly of trees and other vegetation types capable of producing timber and other forest produce.

Evergreen/Semi-evergreen forest

- It is described as a forest, which comprises of thick and dense canopy of tall trees, which predominantly remain green throughout the year.
- Includes both coniferous and tropical broad-leaved evergreen trees. Semi-evergreen forest is a mixture of both deciduous and evergreen trees but the latter predominate]

Deciduous forest

- It is described as a forest which predominantly comprises of deciduous species and where the trees shed their leaves once in a year.

- **Degraded forest or Scrub**
- **It is described as a forest where the vegetative (crown) density is less than 20% of the canopy cover. It is the result of both biotic and abiotic influences. Scrub is a stunted tree or bush/shrub.**

Forest Blank

- **It is described as openings amidst forests without any tree cover. It includes openings of assorted size and shapes as seen on the imagery.**

Forest Plantations

- **It is described as an area of trees of species of forestry importance and raised on notified forest lands. It includes, eucalyptus, casuarina, bamboo, etc.**

Mangrove

- **It is described as a dense thicker or woody aquatic vegetation or forest cover occurring in tidal waters near estuaries and along the confluence of delta in coastal areas. It includes species of the general Rhizophora and Aviccunia.**

Wastelands

- It is described as degraded land, which can be brought under vegetative cover with reasonable water and soil management or on account of natural causes.
- Wastelands can result from internal/imposed constraints such as, by location, environment, chemical and physical prosperities of the soil or financial or management constraints (NWDB, 1987).

Salt-affected land

- Land that has adverse effects on the growth of most plants due to the action or presence of excess soluble or high exchangeable sodium. Alkaline land has an exchangeable sodium percentage (ESP) of about 15, which is generally considered as the limit between normal and alkali soils.
- Predominant salts are carbonates and bicarbonates of sodium. Coastal saline soils may be with or without ingress or inundation by seawater.

Waterlogged land

- Land where the water is at/or near the surface and water stands for most of the year. Such lands usually occupy topographically low-lying areas. It excludes lakes, ponds and tanks.

Marshy/Swampy land

- Permanently or periodically inundated by water and is characterised by vegetation, which includes grasses and weeds. Marshes are classified into salt/brackish or fresh water depending on the salinity of water. These exclude Mangroves.
-

Sandy area (coastal and desertic)

- Have stabilised accumulations of sand in-site or transported in coastal riverine or inland (desert) areas.
- Occur either in the form of sand dunes, beaches, channel (river/stream) islands, etc.

Gullied/Ravinous land

- Formed as a result of localised surface runoff affecting the friable unconsolidated material in the formation of perceptible channels resulting in undulating terrain.
- The gullies are the first stage of excessive land dissection followed by their networking which leads to the development of ravenous land.
- 'Ravine' is usually associated not with an isolated gully but a network of deep gullies formed generally in thick alluvium and entering a nearby river, flowing much lower than the surrounding high grounds. The ravines, are extensive systems of gullies developed along river courses.

Land with or without scrub

- They occupy (relatively) higher topography like uplands or high grounds with or without scrub. These lands are generally prone to degradation or erosion. These exclude hilly and mountainous terrain.

- **Barren rocky/Stony waste/Sheet rock area**
- **It is defined as the rock exposures of varying lithology often barren and devoid of soil cover and vegetation and not suitable for cultivation. They occur amidst hill forests as openings or scattered as isolated exposures or loose fragments of boulders or as sheet rocks on plateau and plains. It includes quarry or gravel pit or brick kilns.**
- **Water bodies**
- **It is an area of impounded water, areal in extent and often with a regulated flow of water. It includes man-made reservoirs/lakes/tank/canals, besides natural lakes, rivers/streams and creeks.**
- **River/Stream**
- **It is a course of flowing water on the land along definite channels. It includes from a small stream to a big river and its branches. It may be perennial or non-perennial.**

Reservoir/Lakes/Tanks/Canal

- **Natural or man-made enclosed water body with a regulated flow of water**
- **Reservoirs are larger than tanks/lakes and are used for generating electricity, irrigation and for flood control.**
- **Tanks are smaller in areal extent with limited use than the former.**
- **Canals are inland waterways used for irrigation and sometimes for navigation.**

Others

- **It includes all those, which can be treated as miscellaneous because of their nature of occurrence, physical appearance and other characteristics.**

Shifting Cultivation

- **It is the result of cyclic land use practice of felling of trees and burning of forest areas for growing crops. Such lands are also known as *Jhum* lands.**

Grassland/Grazing land

- **It is an area of land covered with natural grass along with other vegetation, often grown for fodder to feed cattle and other animals. Such lands are found in river beds, on uplands, hill slopes, etc. Such lands can also be called as permanent pastures or meadows. Grazing lands are those where certain pockets of land are fenced for allowing cattle to graze.**

Snow-covered /Glacial area

- **It is snow-covered areas defined as a solid form of water consisting of minute particles of ice. It includes permanently as on the Himalayas. Glacier is a mass of accumulated ice occurring amidst permanently snow-covered areas.**

Changes in land use/cover using geospatial techniques:A case study of Ramnagar town area, Nainital,Uttarakhand,

- Land use/cover change has become a central and important component in current strategies for managing natural resources and monitoring environmental changes.

Methodology

- **Land use/cover detection and analysis**

  Supervised classification method with maximum likelihood algorithm was applied in the ERDAS Imagine 9.3 Software.

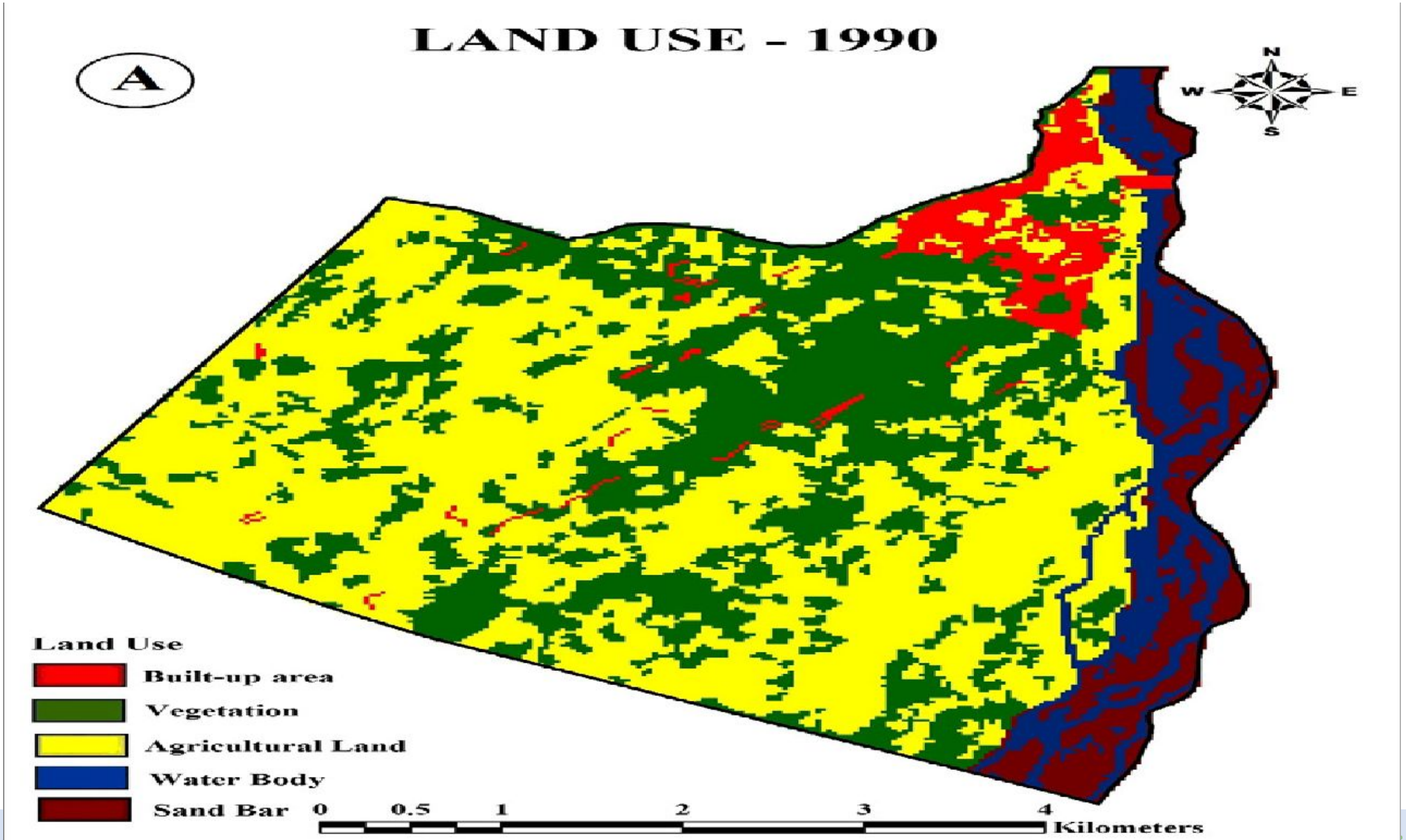
- **Normalized difference vegetation index (NDVI), normalized difference water index (NDWI) and normalized difference built-up index (NDBI) were also applied to classify the Landsat TM images at a resolution of 30 m**

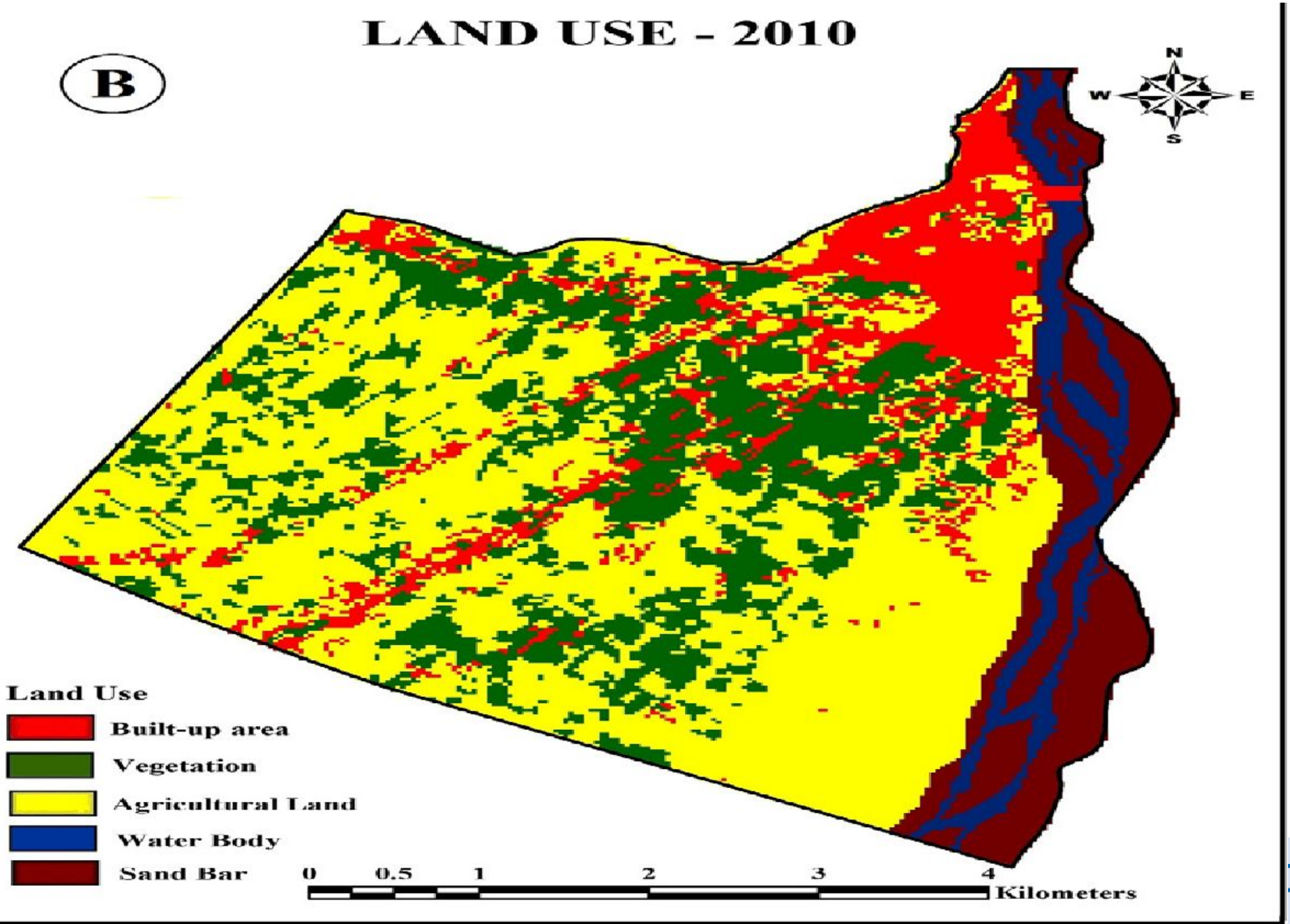
- **Ground verification was done using in doubtful areas.**

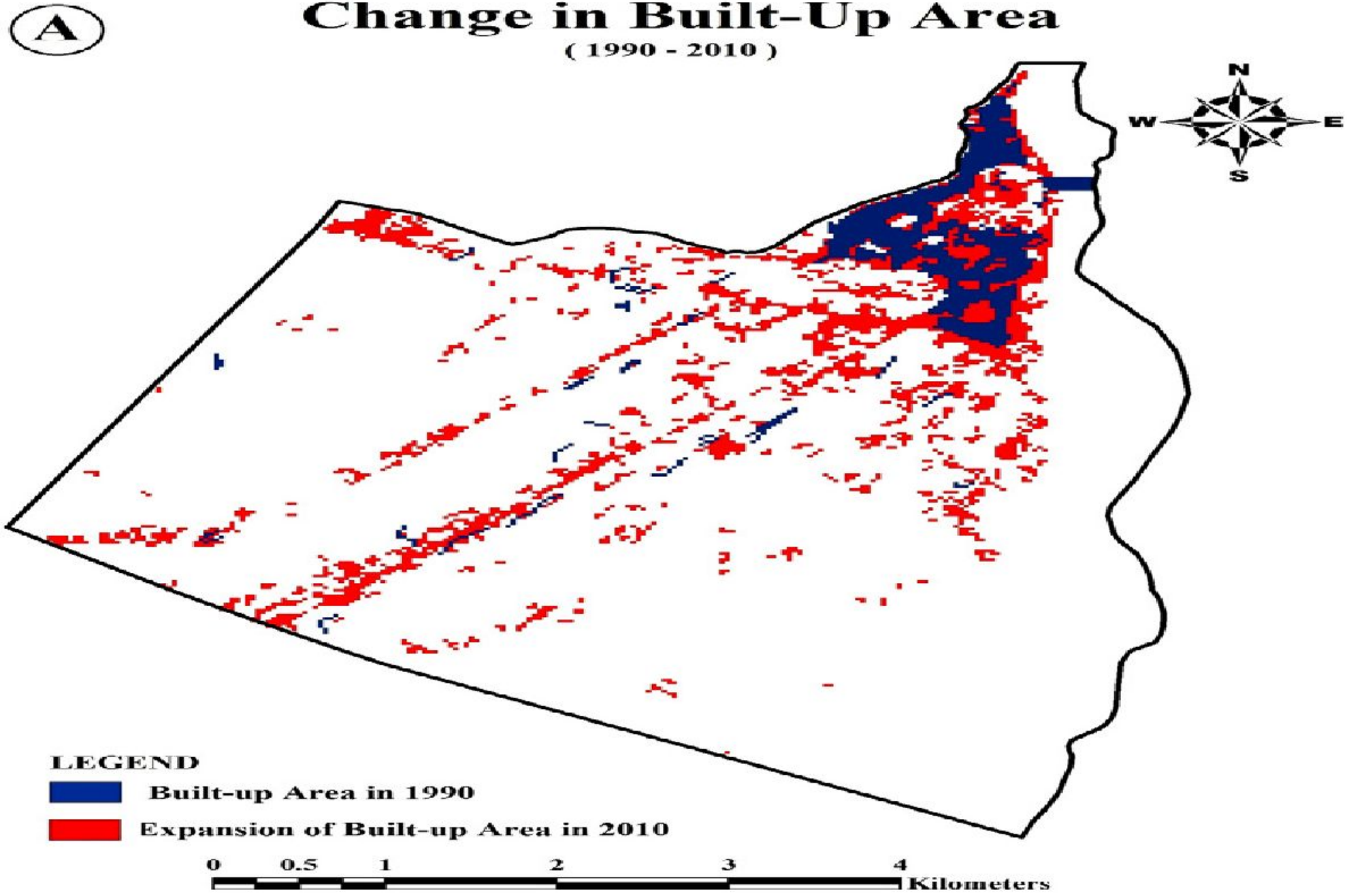
- **Based on the ground truth, the misclassified areas were corrected using recode option in ERDAS Imagine 9.3.**

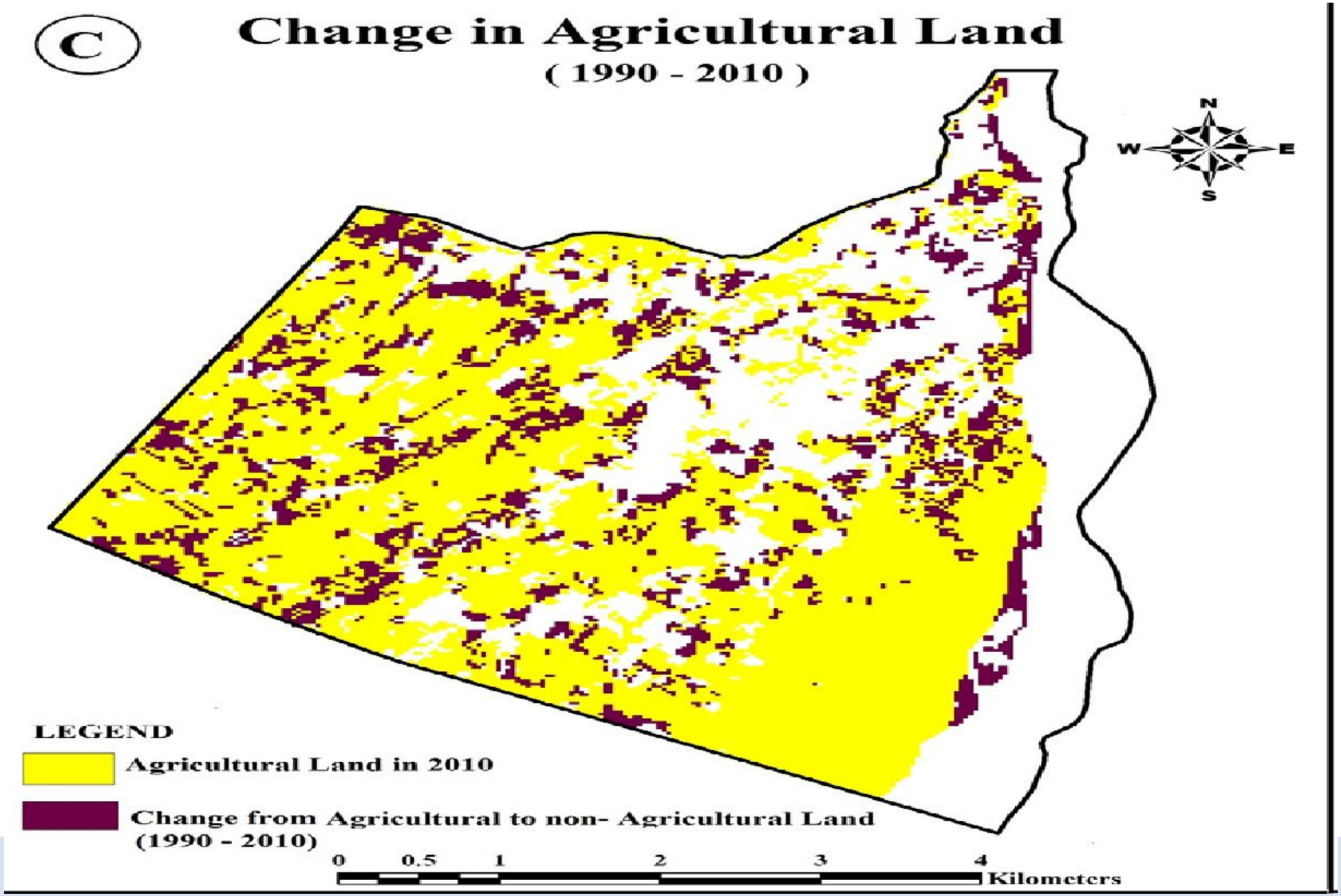
Land use/cover change detection and analysis

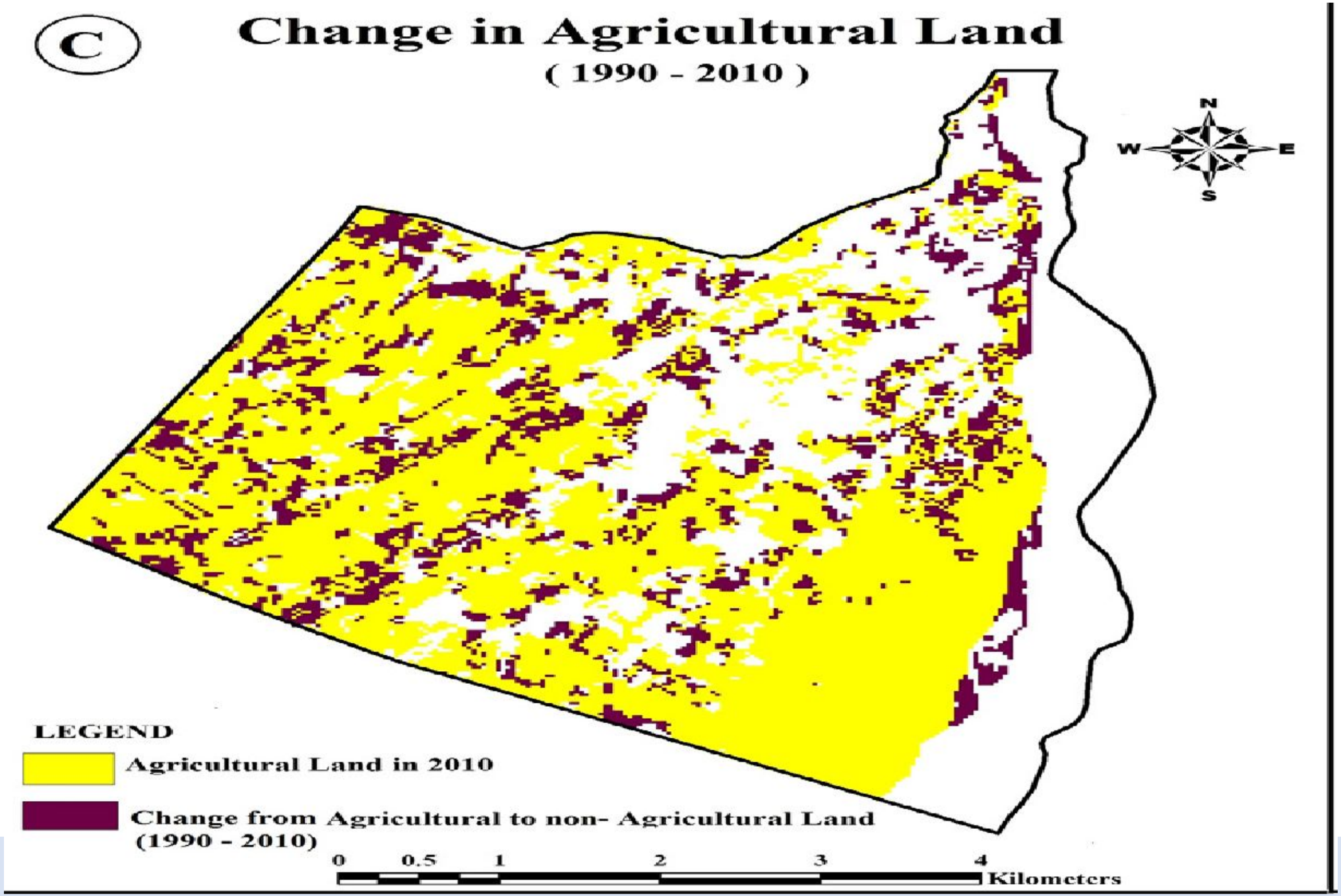
- For performing land use/cover change detection, a post-classification detection method was employed
- A change matrix was produced with the help of ERDAS Imagine 9.3 software.
- Quantitative areal data of the overall land use/cover changes as well as gains and losses in each category between 1990 and 2010 were then compiled.

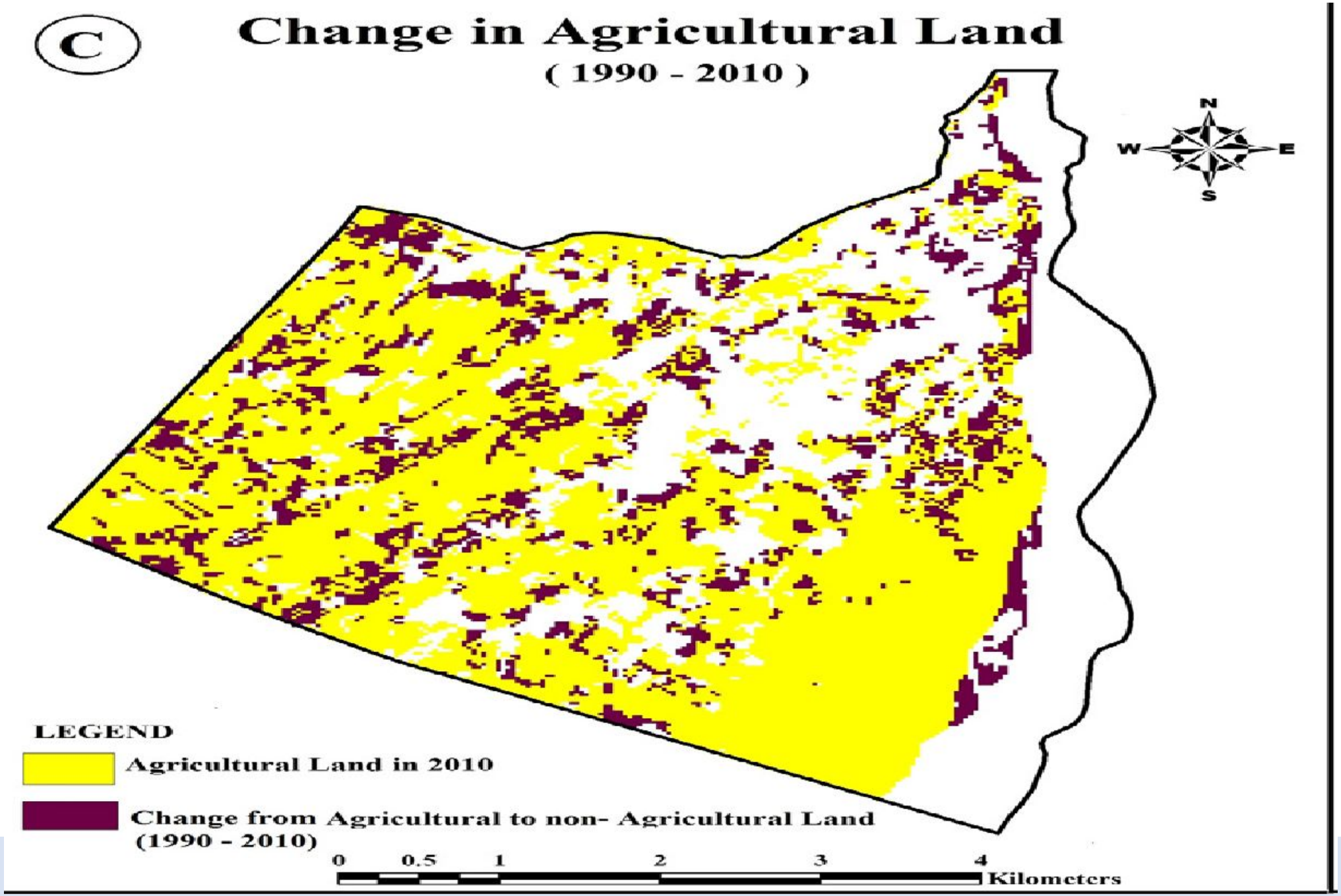

LAND USE - 1990
A
N
W
E
S
Land Use
Built-up area
Vegetation
Agricultural Land
Water Body
Sand Bar
0
0.5
1
2
3
4
Kilometers

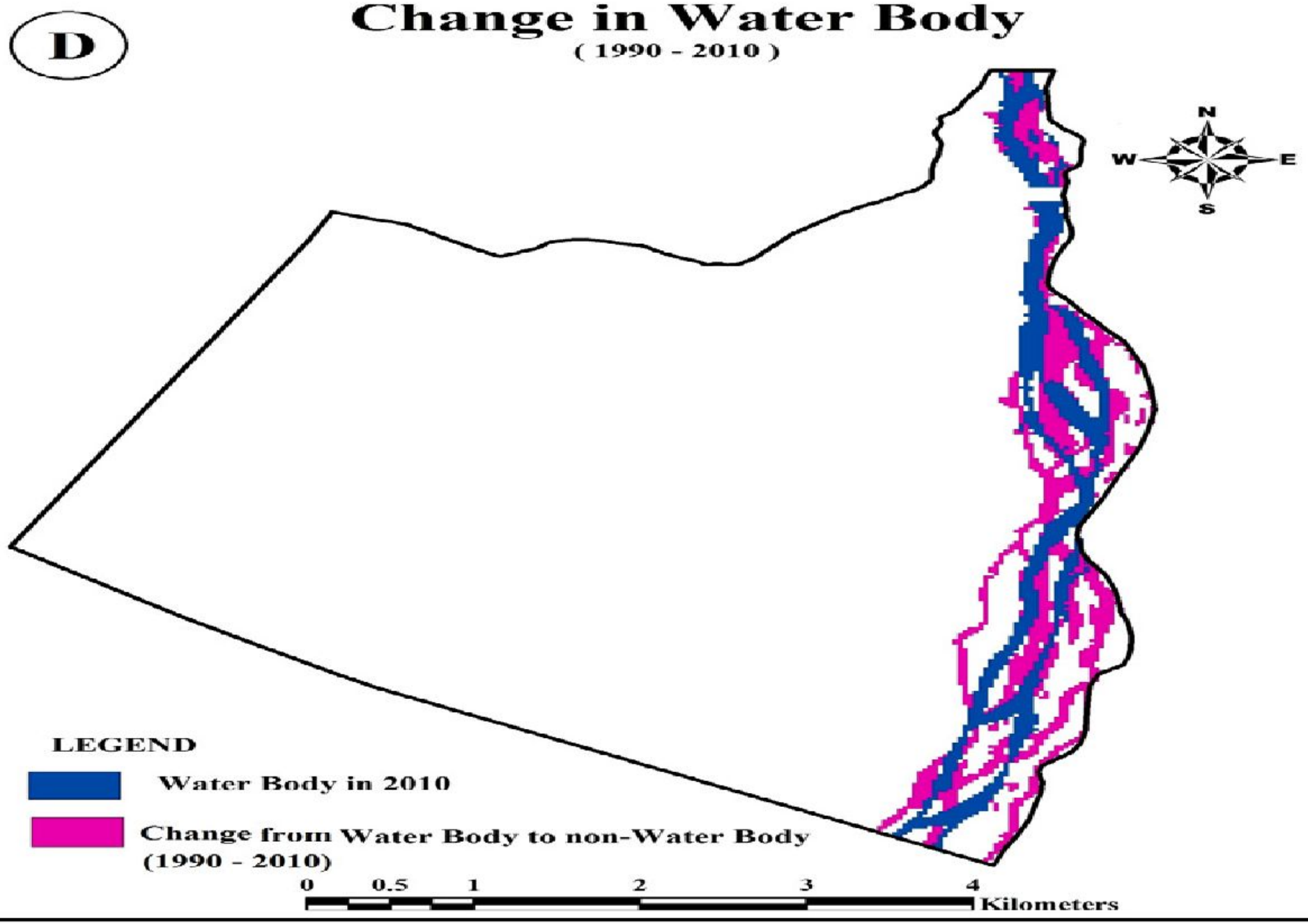

LAND USE - 2010
B
N
W
E
S
Land Use
Built-up area
Vegetation
Agricultural Land
Water Body
Sand Bar
0
0.5
1
2
3
4
Kilometers


A
Change in Built-Up Area
(1990 - 2010)
N
W
E
S
LEGEND
Built-up Area in 1990
Expansion of Built-up Area in 2010
0
0.5
1
2
3
4
Kilometers


C
Change in Agricultural Land
(1990 - 2010)
N
W
E
S
LEGEND
Agricultural Land in 2010
Change from Agricultural to non- Agricultural Land
(1990 - 2010)
0
0.5
1
2
3
4
Kilometers

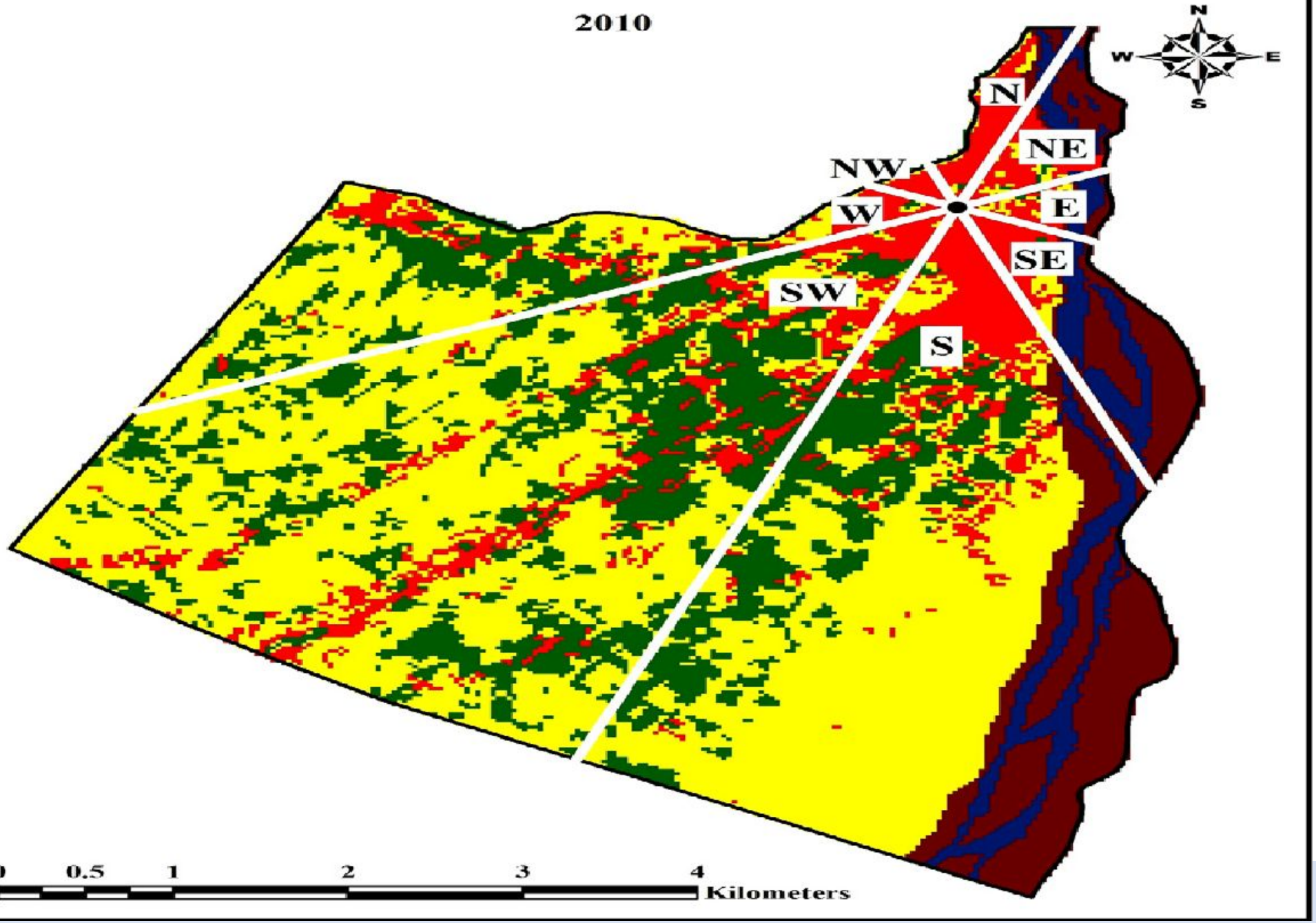

C
Change in Agricultural Land
(1990 - 2010)
N
W
E
S
LEGEND
Agricultural Land in 2010
Change from Agricultural to non- Agricultural Land
(1990 - 2010)
0
0.5
1
2
3
4
Kilometers

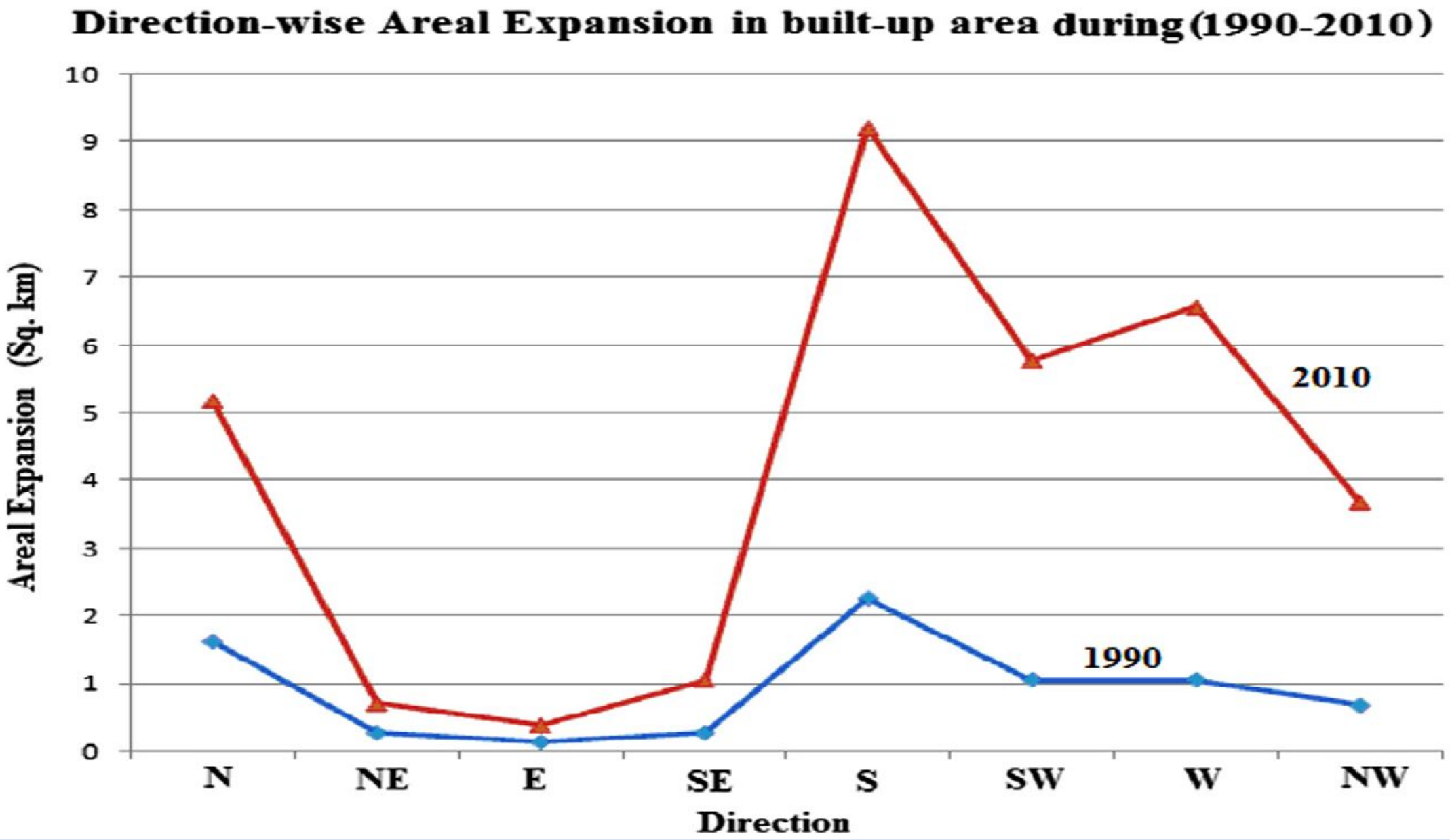

C
Change in Agricultural Land
(1990 - 2010)
N
W
E
S
LEGEND
Agricultural Land in 2010
Change from Agricultural to non- Agricultural Land
(1990 - 2010)
0
0.5
1
2
3
4
Kilometers


D
Change in Water Body
(1990 - 2010)
N
W
E
S
LEGEND
Water Body in 2010
Change from Water Body to non-Water Body
(1990 - 2010)
0
0.5
1
2
3
4
Kilometers

DIRECTIONAL MAP OF RAMNAGAR TOWN AREA

2010




Direction-wise Areal Expansion in built-up area during (1990-2010)
Areal Expansion (Sq. km)
10
9
8
7
6
5
4
3
2
1
0
2010
1990
N
NE
E
SE
S
SW
W
NW
Direction

Conclusions

- **Multi-temporal satellite data are very useful to detect the changes in land use quickly and accurately.**
- **During the last two decades the area under built-up land has been increased by 8.88% (2.83 km2) due to construction of new buildings on agricultural and vegetation lands**
- **Area under vegetation land is decreased by 9.41% (3 km2) due to deforestation activities by which the vegetation land is converted into agricultural and built-up land.**
- **The agricultural land has also decreased by 0.69% (0.22 km2)**

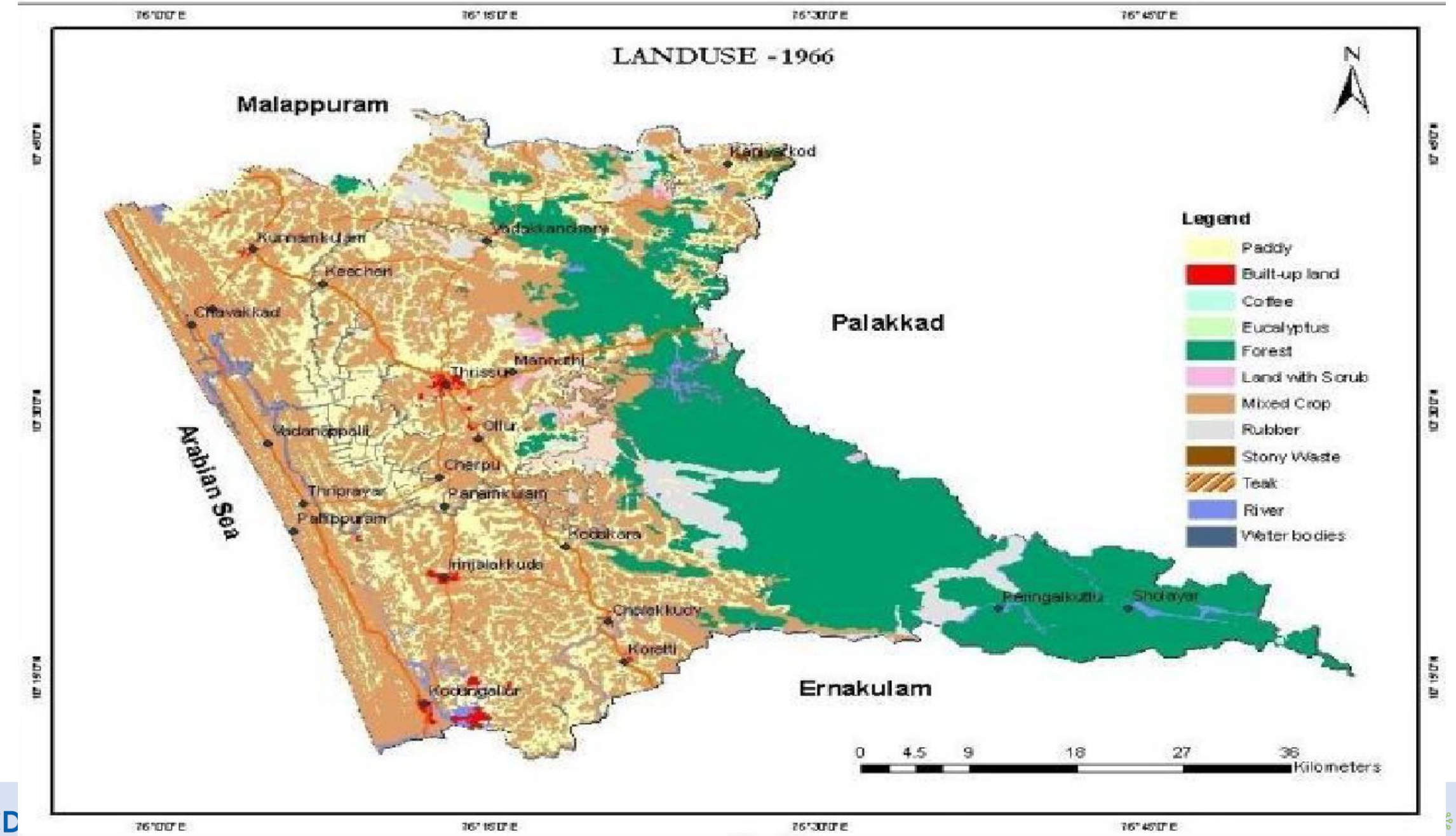
Conclusions

Land under agriculture is cleared and sold out for the development of commercial and infrastructural activities

- **The built-up area is expanding maximum towards southern direction along the National Highway 121 while it expanded minimum towards the north eastern direction.**
- **The approach adopted in this study clearly demonstrated the potential of GIS and remote sensing techniques in measuring the change pattern of land use/cover in town area.**
- **Diagrammatic illustration of directional change in the built-up area in 2010 in the Ramnagar town area.**

DETECTION OF LAND USE PATTERN CHANGES AND MANAGEMENT PRIORITIES FOR THRISSUR

- Land use/ land cover pattern was interpreted from the topographic data for the year 1966 and converted as digital databases in GIS environment.
- High resolution Cartosat-1 satellite data for the year 2010 was used for interpretation of current land use land cover pattern of the study area and generated GIS data bases.
- The classes were derived based on LULC classification standards of NRSC during 2011
- GPS is used to distinguish waterlogged area from natural water bodies.
- Change detection was made using GIS overlay techniques.
- Derived themes were analyzed and suggested the management plans for degraded and non reclaimable zones


LANDUSE - 1966
N
Malappuram
Palakkad
Ernakulam
Arabian Sea
Kanjikkod
Vadakkanchery
Kunnamkulam
Kecheri
Chavakkad
Thrissur
Mannuthi
Ollur
Vadanappalli
Cherpu
Thriprayar
Panamkulam
Pattippuram
Kodakara
Irinjalakkuda
Chalakkudy
Koratti
Kodungallur
Peringalkuthu
Sholayar
Legend
Paddy
Built-up land
Coffee
Eucalyptus
Forest
Land with Scrub
Mixed Crop
Rubber
Stony Waste
Teak
River
Water bodies
0 4.5 9 18 27 36
Kilometers

Sl. No.	Landuse Classes	Area (Km^2)	% of Total Area
1	Paddy	636.60	21.00
2	Mixed crop	1266.22	41.80
3	Built-up land	18.90	0.62
4	Coffee	0.36	0.01
5	Eucalyptus	3.03	0.10
6	Forest	873.04	28.79
7	Rubber	147.44	4.86
8	Teak	0.55	0.02
9	Land with scrub	8.89	0.29
10	Stoney waste	3.17	0.10
11	River	70.66	2.345
12	Water bodies	0.15	0.005

Sl. No.	Landuse Classes	Area (Km^2)	% of Total Area
1	Waterlogged due to clay mining	14	0.46
2	Fallow due to clay mining	1.26	0.04
3	Virippu and Puncha (Double crop)	398.52	13.15
4	Current fallow	7.95	0.26
5	Fallow land	4.06	0.13
6	Arecanut(Converted from paddy)	0.02	0
7	Coconut (Converted from paddy)	26.31	0.86
8	Banana (Converted from paddy)	0.05	0
9	Mixed(Converted from paddy)	23.87	0.79
10	Rubber(Converted from paddy)	0.71	0.02

11	Commercial(Converted from paddy)	1.69	0.06
12	Residential(Converted from paddy)	12.48	0.41
13	Coconut dominant mixed crop	1146.01	37.81
14	Built-up land	95.49	3.15
15	Rubber	170.14	5.61
16	Coconut	20.66	0.68
17	Pine apple	0.15	0
18	Forest (R.F.)	856.94	28.27
19	Open forest	3.84	0.13
20	Rubber (R.F.)	27.46	0.91
21	Cashew (R.F.)	8.38	0.28
22	Eucalyptus	2.34	0.07
23	Eucalyptus (R.F.)	59.17	1.95

24	Eucalyptus & Soft wood (R.F.)	7.23	0.24
25	Teak (R.F.)	34.17	1.13
26	Land with scrub	14.59	0.48
27	Barren rocky/stoney waste	5.55	0.18
28	Rock quarry	1.03	0.03
29	Beach	4.51	0.15
30	Marshy	0.72	0.02
31	River	47.17	1.56
32	River island	0.1	0
33	Reservoir	28.89	0.95
34	Reservoir bed	4.66	0.15
35	Water bodies	1.89	0.06
Total		**3032**	**100%**

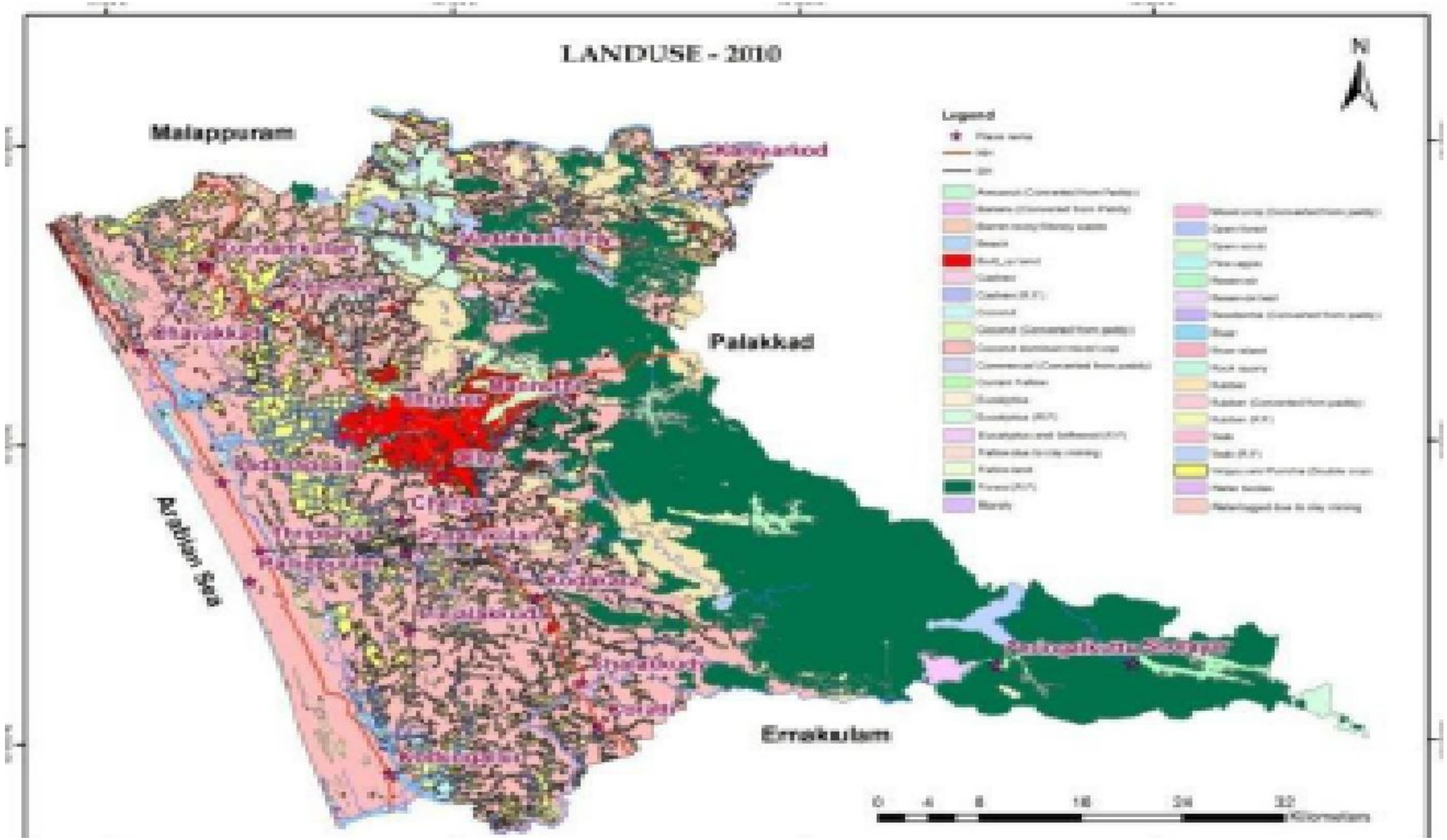

LANDUSE - 2010
N
Malappuram
Palakkad
Ernakulam
Arabian Sea
Legend
0 4 8 16 24 32
Kilometers

Fig. 4. Waterlogged mining pits in Kadalassery (Nenmanikkara Panchayath)

Fig. 5. Brick kilns in Chathanchal (Kadukutty Panchayath)

- **Conclusion**

- **The land use pattern changes were analyzed in GIS platform during 1966 – 2010 and found that large areas of agricultural land are being lost continuously to this irreversible developmental process**
- **Eight five clay mining locations were identified in 23 panchayaths**
- **Agricultural land become converted through clay mining creates environmental problems like water scarcity during summer months due the over exploitation of water from the mining pit.**
- **Mining also triggered soil erosion and deterioration of soil fertility due to the removal of top soil.**

- The paddy cultivation is found decreasing in the district due to socio-economic problems like shortage of labors and low price for produce.
- Management plan was suggested to curtail further degradation of the agricultural land and already degraded zones
- Refilling of mining pits with top soil for regaining the equilibrium of the ecosystem,
- Waterlogged mining pits to be utilized for pisiculture and floriculture.
- Cultivation of vegetables and seasonal crops can be taken up in fallow lands where paddy is not cost effective.


Thank You