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Two advance tools viz., Satellite Remote Sensing and Geographic Information System (GIS) were used in the present study, i.e., Sustainable Utilization of Land Resources using GIS and Remote Sensing in Central Upper Sind Catchment. Five Years (1989-2005) IRS data along with support information and sample survey (140 respondents from 7 villages) were collected analyzed and mapped using ArcGIS and ERDAS software. The results were based on the 47 Maps and 66 Tables. The objectives of the study were study of landform & landuse/landcover, landform – landcover relationship, change detection and to provide landuse plan. The entire work elements were presented in to six chapters viz., geographical and conceptual background, landform analysis and classification, landuse / landcover analysis and mapping, change detection, results & discussion and plan of sustainable utilization of land resources.

The western parts of the study region exhibit hilly tracts, high uplands and covered by dense forests. Deforestation in the western part and unscientific land resource utilization in the eastern parts resulted into deterioration of land resources and environmental degradation. The main river of the region is Sind. It enters in the region near Binega village and flowing towards north. Amar nala, tributary of river
Sind, join the river near Pachpedia village. Finally, Sind river left the study region after khapoli village. About 59.22% area of the study region was covered with forest. The topography of the region exerted powerful influence on the utilization of land and water resources. The study revealed that high population density (480) was found in 9 villages, medium density (150-480) was in 19 villages and low density (1-150) was found in 44 villages. The relative height or relief exert powerful influence on the land cover / land resources utilization pattern. The highest elevation (430m) was recorded in the north-eastern part of the Balarpur village. In the northern part of the study area, especially in the south and eastern part of the Fotka village, the height recorded above 400m. The major landform types found in the region were low lying basins, gentle slopping plain, undulating plain, upland dissected plateau, and isolated hillocks &ridges.

The study of LU/LC (1989) revealed that the area under crops, forest, fallow land, prosopis, grasslands, barren lands and wetlands were 16.00, 62.84, 11.38, 0.44, 4.48, 2.08, 0.33 and 0.05 percent respectively. The maximum area (91.09%) under cultivation was recorded in Imaliya village where as negligible land was used for crop production in Jhiri, Dongri, Jhonpdi, Teela, Balarpur and Parasari villages. The special distribution of cropped area was found highly uneven as area under cultivation was 80-100% in five villages, 60-80% in 4 villages, 40-60% in 9 villages, 20-40% in 15 villages and upto 20% in 33 villages. The area under forest cover was 62.84 percent in 1989. The forest was concentrated in hilly areas. About 22 villages
had 80-100% forest cover where as there were no forest records in 10 villages. The region is rich in forest resources as more than 60% villages having forest cover above the 33 percent. Fallow lands cover 11.38% of the total area of the region. It was found maximum (53.62%) in Jarawani village where as nothing is recorded in 13 villages. About 4.48% land was infested by shrubs. During the field survey it was noticed that these lands were initially highly degraded forest lands. Shrubs cover maximum area (61.13%) of Khapoli village. There were no grasslands / grazinglands in 40 villages where as in 28 villages it was recorded up to 20 percent. About 30% lands were classified as grasslands in Nijampur village.

The study of Landuse/ land cover was based on IRS data of February 1992. After the primary interpretation the classification key was decided and the region was broadly grouped under 7 heads viz., cropped area, forest cover, barren lands, fallow lands, shrubs, wetlands, and grasslands. The area under the crop lands, forest cover, barrenlands, fallowlands, shrubs, wetlands and grasslands/ grazinglands were 19.14, 61.14, 0.02, 9.02, 4.48, 0.09 and 3.28 percent respectively. There were no cultivations in 5 villages viz., Jhiri, Dongri, Sausa, Balarpur, and Parasari. Very little portion of land (up to 20%) were used for cultivation in 31 villages and in 14 villages the cropped area ranges between 40 – 80 percent. The region was rich in forest resources as about 61.14 percent land of the study area was covered with forest. There was no forest cover in 10 villages. The study also revealed that very little portion of land covered with forest in 12 villages, 20 – 40% forest cover was found in 6 villages, 40 – 60% forest cover in 12 villages and 60 – 80% forest cover was recorded in 15
villages. The forest were concentrated mostly on upland dissected plateau and hills in western part of the study region. About 9.02% lands were classed as fallow lands. It is clarified that 20 – 40% land left as fallow lands in 10 villages whereas as up to 20% land grouped as fallow land in 39 villages. Fallow lands found maximum in Nayagaon(84.27%) and Jujhai Narwar (40.71%) villages. The land infested with shrubs was about 4.48 percent in the region. It was recorded maximum in Amolpatha village (41.36%) and minimum (nil) in 52 villages. Shrubs covered up to 20% of 17 villages like Nayagaon I (19.64%), Madari (18.03%), Karai Ahmedpur (12.87%) and Theh Dongar (12.15%) villages etc. About 3.28% land of the study region was covered with grasses / grazing resources.

The study region was broadly grouped under 7 heads viz; cropped area, forest cover, barren lands, fallow lands, shrubs, wetlands, and grasslands on the basis of IRS 1B data of 1995. The area under crops, forest cover, barren lands, fallow lands, shrubs, wetlands and grasslands/grazing lands was 25.78, 59.53, 0.31, 4.92, 2.06, 0.31 and 4.22 percent respectively. There were no records of cultivations in 2 villages viz., Jhiri and Balarpur. Very little portion of land (up to 20%) were used for cultivation in 19 villages and in 20 villages it was found between 40 – 80% . Though, about 59.53% land of the total area of the study region was covered with forest but the past study shows that the area under forest cover has reduced. The number of villages with more than 80% forest cover was 18 where as no forest cover was found in 15 villages. The study also revealed that 2 villages viz., Jhiri and Balarpur were fully covered with
forest. The high forest cover (>40% area) was recorded in 39 villages. The study revealed that about 4.92% lands were classed as fallow lands. About 20 – 40 % land has left as fallow land in 3 villages viz., Jaitpur (34.46%), Sarkhadpur(33.26%) and Thar Khera(25.62%) where as it was ranges up to 20 percent in 30 villages and nil in 37 villages. The land infested with shrubs was about 2.06 percent in the region. It was recorded maximum in Narayanpur(26.57%) and Nanakpur(21.42%) villages and minimum (nil) in 39 villages. Shrubs covered up to 20% of lands in 31 villages like Jaitpur (17.16%), Amarpura (12.11%) Dhingwas (11.54%), Berkheda(9.32%), Jarawani (8.83%) and Nijampur (8.14%)villages etc. About 4.22% lands of the study region was covered with grasses / grazing resources. The grasslands / grazinglands were found maximum in Amolpatha village(27.65%) followed by Nijampur village (23.24%) where as it was found nil in 32 villages. The degraded forest area and fallow land and cropped area (after harvesting) were used by grazing animal in the study region.

The area under cropped land, forest, fallowlands, shrubs and grasslands / grazinglands in year 2000 was 27.07, 59.20, 3.91, 1.84, 0.63 and 4.27 percent respectively. The study reveals that the area under crops has increased to 27.07% by the year 2000. Very little portion of land (up to 20%) was used for cultivation in 24 villages and in 21 villages it was found between 20 – 40 percent. Forest area with 40% canopy cover was estimated as 59.20% of the total geographical area of the study region. The number of villages with more than 80% forest cover was 15. The highest
forest cover was found in Jhiri (93.35%), Patha (89.15%), Saunsa (89.05%) villages where as only 4 villages grouped as without forest. The forest cover ranges between 40 – 80% in 32 villages viz., Berkhadi (79.61%), Karai Kerau (76.24%), Janjadehi(68.37%), Madari(65.75%), Subhaspura(64.97%), Dongar(58.48%) and Meri Narwar(42.75%) etc. About 3.91% lands were classed as fallow lands where as about 1.84 percent land was affected with shrubs in the region. It was recorded maximum (9.70%) in Narayanpur village and minimum (nil) in 20 villages. Shrubs infested lands were ranged up to 20% in 52 villages like Shergarh(8.42%), Amarpura(7.99%), Jarawani(7.50%), Madola(7.12%), Nayagaon Dhol.(6.01%) and Paghata (5.52%) and minimum in Karai Kerau (0.35%) villages etc. About 4.27% land of the study region was covered with grasses / grazing resources.

The area under cropped land, forest, fallowlands, shrubs, wetlands and grasslands / grazinglands were 27.04, 59.22, 3.70, 1.76, 0.76 and 4.24 percent respectively in 2005 (IRS P6). The area under crop lands was 27.04 percent in 2005. It was noticed maximum (84.51%) in Theh Dongar village. Where as 60 – 80% lands were used for cultivation in 15 villages as Gadoli (79.74%), Pananer (79.54%), Deori Khurd(79.52%), Magroni (76.19%), Shorhadrup (74.00%), Kheriya (73.69%),Mahal (71.59%), Dongarpur Fakeer (71.13%), Nayagaon-2(67.32%) and Pipra (62.00%) etc. villages. Very little portion of land (up to 20%) were used for cultivation in 24 villages and in 32 villages it was found between 20 – 60 percent. The land covered with forest was calculated as 59.22 percent. The number of villages with 40-100% forest cover
was 43, out of which 16 villages were fully covered (80-100%) with forest. The villages with more than 90 percent forest cover were Parasari (96.75%), Khajuri (96.16%) After the analysis and interpretation of satellite data (IRSP6) about 3.70% lands of the region were classed as fallowlands. The infestation of land with shrubs was about 1.76 percent in the region. It was recorded maximum in Dhigwas village (9.86%) and minimum (nil) in 37 villages. Shrubs was found up to 20% in 35 villages like Khiria, Pananer, Sultanpur, Meri Narwar, Amol patha and Jarawani villages etc. The shrubs infested lands were closely situated with degraded forest lands, wasteland and grazinglands. About 4.24% land of the study region was covered with grasses / grazing resources. It was found maximum (22.24%) in Amol patha village where as it was found nil in only 3 villages namely Balarpur Parasari and Siroha village.

Land cover is susceptible to change by natural processes. The present study of landuse / land cover was based on the periodical data of IRS 1A (1989), IRS1B (1992 and 1995), IRS 1D (2000) and IRSP6 (2005). The landuse / landcover of the study area have changed significantly from 1989 to 2005. The land used for cultivation by the farmers in the region under study was 16.00, 19.14, 25.78, 27.07, and 27.04 percent in the years 1989, 1992, 1995, 2000 and 2005 respectively. The relative Change Percent (RCP) was calculated as 31.37, 97.81, 110.67 and 110.41 percent for the period 1989-1992, 1989-1995, 1989-2000 and 1989-2005 respectively. The study reveals that maximum change (110.67%) was noticed in the period 1989-2000. Based on the village level data of Relative Change Percent (RCP) of cropped
area, the region was grouped under positive (high, medium & low) and negative (high, medium & low) changes and the same information was presented for the period 1989-1992, 1989-1995, 1989-2000 and 1989-2005. The Positive Change (PC) was recorded in 53, 64, 61 and 58 villages for the same period and the Negative Change (NC) in 19, 8, 11 and 14 villages for the respective years.

The study revealed that overall Negative Change (NC) in forest cover was found as 16.92, 33.05, 36.37 and 36.15 percent during the periods of 1989-1992, 1989-1995, 1989-2000 and 1989-2005 respectively. HNC was recorded in Siroha (-425.56), Akahi (-807.83), Akahi (-731.31) and Meri narwar (544.23) villages respectively during the same periods. Earlier, these villages were densely packed with forest cover. The land under dense forest, moderately degraded forest and heavily degraded forest were 17.30, 33.17 and 12.38 percent in 1989; 19.59, 29.66 and 11.88 percent in 1992; 14.08, 37.06 and 8.35 percent in 1995; 15.46, 35.74 and 7.99 percent in 2000 and 14.73, 32.91 and 11.56 percent in year 2005. The study provides detailed information on changing pattern of fallow lands during the past 17 years. The area under fallow lands was 11.38, 9.02, 4.92, 3.91 and 3.70 percent in the years 1989, 1992, 1995, 2000 and 2005 respectively (Table 4.7). Shrub infested lands was generally associated with marginal and sub-marginal lands on undulating plains and along the degraded forest in the study region. The Relative Change Percent (RCP) was calculated for each village for the periods of 1989-1992, 1989-1995, 1989-2000 and 1989-2005. The area under shrubs infested lands for the years 1989 – 2005 was
calculated at village level. The field study revealed that after the construction of irrigation channels the current landuse as well as cropping system of central eastern part of the region have changed.

In general, forest cover were found on hilly and plateau region; crops on plains; shrubs, grasses and wastelands etc. on undulating areas. The Landform-landcover / landuse Relationship and Changing Pattern (1989-2005) was studied. About 7.55% of land under gentle sloping plain was covered with forest in 1989. About 27.18 and 4.41 percent land of gentle sloping plain was occupied by fallow lands and shrubs respectively in 1989. Undulating plain covers about 22.28% (16238.47 ha) of the total area of the region under study. Forest cover occupied more than fifty percent land of the undulating plain as it was recorded 65.85, 60.67, 57.49, 56.98 and 56.85 percent for the years of 1989, 1992, 1995, 2000 and 2005 respectively. Fallow lands occupied 12.49 percent area in 1989 and was reduced to 8.25 percent in 2005. The study shows that cropped area has increased by nearly 3 times during the said period (1989-2005). Major portion (43.81%) of land of the study area was classed as upland dissected plateau. It was predominantly covered (>93%) with forest. Isolated hillocks and ridges cover hardly 3.86 percent land of the total geographic area of the study region. The additional land brought under cultivation during the said years was mainly from forest, fallow lands and shrubs infested land.
Seven villages viz; Pananer, Imaliya, Madari, Jujhai Narwar, Tuki and Parasari were selected for the sample study from the different part of the study region. The total number of selected respondents was 140. The percent of respondents having <2ha, 2-5ha, 5-10ha and > 10ha was 36.43, 37.14, 18.57 and 6.43 percent respectively. Maximum number of old farmers (22%) were observed in large land holding category and young farmers (below 40 years) were maximum in medium land holding category. The literacy status of the farmers increased upward with increase in land holdings. The maximum number of illiterate farmers was from small and medium land holders. Fallowlands including grazing lands (FL &G) was maximum (69.28%) in upland dissected plateau and lowest in gentle slopping plan. The maximum area under NCA was recorded in Pananer village (90.65%) and lowest (41.57%) in Parasari village. During the said period about 31.86 percent land under NCA has increased. The total area of the selected villages was 5229.92ha. It was recorded maximum in Imaliya (77.21ha) and Pananer (72.52ha) and lowest in Parasari village (6.72ha). The study revealed that wheat, groundnut and mustard were increased by 81.10, 195.83 and 36.69 percent in Imaliya village during the past 16 years. The cultivated lands used under different crops have changed during past 16 years. The study of perception survey revealed that during the said period about 57.21% land have increased in TCA of selected respondents. Though, the area under Wheat crops has increased by 36.86% but it was recorded highest in gentle sloping plain (Imaliya village, 81.10%) and lowest in upland dissected plateau, (Parasari village, 13.48%). The result of sample survey can be projected for the entire study region. It was found maximum (60%) in
Parasari and Madari villages. Both the villages were situated within the proximity of forest cover and the land was classed as upland dissected plateau. Villages of gentle slopping plain viz.; Pananer and Imaliya shared the highest percent (20.00%). The study of seed quality and their availability were assessed and found highest in Pananer(35.00%) village and lowest (nil) in Madari, Tuki and Parasari villages. After the construction of dam on Sind river near Siroha village, cannal and tank irrigation have increased in the study area. Farmers of north-eastern and central-eastern part of the study area were able to provide optimum irrigation to their crops. The study revealed that 15-60% farmers of different villages were unable to fulfill the food requirements of their family with own produce. Keeping in view of land holdings of farmers it was clear that land productivity was not good. The study revealed that only 12.14% farmer were getting actual market price. The sample study also revealed that maximum numbers of cattle were reared by small and medium farmers. Large farmers were not rearing the sheep and goat in the selected villages.

An integrated approach, using Satellite Remote Sensing and Geographic Information System (GIS), offers technologically the appropriate method of studying the land and water resources, characterizing the coherent agricultural zones and identifying the constraints for land resource management. The ultimate aim of the present study was to provide a plan of sustainable utilization of land resources. Valuable information like landuse/landcover types and changing pattern (both landuse and cropping system), landform types and relationship with LU/LC and farmers perception about the farming system etc can be used for the planning of land
resources. A systematic flow chart has been developed for the sustainable utilization of land resources. The model (flow chart) of land use plan can be used for similar region.