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Land Use and Land Cover Change Detection through Remote Sensing and Gis: Bist Doab, Punjab (India)

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Abstract

Land is germane to all forms of life. Land provided the stage on which the human drama was played out as well as the tools with which this drama was enacted. Incremental human activity on land however did not leave land itself untouched. Land has been subjected to varied land uses and landscapes have been variedly modified. Bist Doab is not an exception to this scenario. There have been some notable changes in land use in the Bist Doab during the last fifty years. Human activities also have profoundly changed the land use and land cover in Bist Doab and it can be shown as uncontrolled development that can be analysed through land use and land cover change detection in Bist Doab. Land use and land cover change detection resulted out through the analysis of land use and land cover change over the two time period vis-a vis 1975 and 2015. This study provides a base to understand, how man modified the land according to his needs from past to the present time. Landsat 1975 and 2015 images were used to detect land use and land cover change. The whole study area is classified into 9 categories as followed respectively rivers, reservoirs, dense scrub, open scrub, agricultural area, current fallow, barren area, built-up area and sandy area. The study concludes that agricultural area and built-up area has been increased at a fast rate while rivers, reservoirs and current fallow have a marginal increase in their total area. Whereas barren area, dense scrub and open scrub has shown a decrease. Thus, satellite images and use of GIS provides efficient tools to analyse land use and land cover change detection in Bist Doab.

Keywords: Land Use and Land Cover Change Detection, Remote Sensing and GIS.

Introduction

Land and water are the most important components of life supporting system and they are under intense pressure due to human activities. Land is finite while the human population and greed is increasing that pushing consequences against the environment e.g. soil erosion, pollution, forest degradation and loss of agricultural land for settlements. Endless human needs are modifying the land according to their needs, that is called as land use and land cover change. Land use and land cover change is observed in various ways like conversion of forest into agricultural land, the shifting of agricultural land into urbanisation, recreational areas and industrial developments. Various natural areas like wetlands, sandunes, flood plains, scrub land have been converted to human use.An important factor to understand role of human interaction with the environment is demonstrated via land use and land cover change. This issue was highlighted with the support of several studies with respect to land use and land cover change (Meyer and Turner II, 1992; Turner II et al., 1994; Chowdhary, 2006; Tiwari and Saxena, 2011; Dewan et al., 2012; Iqbal et al., 2018; Liping et al. 2018; Akyürek et al. 2018).

Human activities also have profoundly changed the land cover in Bist Doab and it can be shown as uncontrolled development resulted as environment degradation. Uncontrolled urban expansion was noticed all over Bist Doab, mainly in Jalandhar periphery (Rani, 2014), water depletion has found in Kandi area with north-east portions of Hoshiarpur and Nawashaher have deeper groundwater level (Lapworth et al. 2014). Decreasing soil fertility has been noticed by overuse of chemicals and fertilizers after the introduction of Green Revolution in Punjab(Foley et al., 2005; Blanco-Canqui and Lal, 2010). In the past three to four decades,

intensive agricultural practices have put a tremendous pressure on the soils and resulted as steady decline in soil fertility with respect to availability of macro and micronutrients (Sharda et al. 2015; Kaur, 2014 and Benbi et al. 2006). Land use changes have also been observed in Bist Doab e.g salt affected soils and levelling/ clearing of sand dunes had been taken up by the farmers with or without the help of State Department of Soil Conservation and Engineering, Punjab (Sharma et al. 1989).

Objectives of the Study

The aim of the study is to project major changes from 1975 to 2015 in Bist Doab, Punjab (India). Scenario of Bist Doab shows a drastic increase in Built-up area and augmented expansion of the agricultural area.

Review of Literature

Liping et al. (2018) evaluated the results of the classification, the water area decreased first and then increased. In 1992–2003, a large amount of sand mining equipment was built in the Jinxi River, and a large amount of sediment was deposited on the river bank, so that the water area was drastically reduced. In 2003–2014, river sand mining equipment had reduced significantly, and the river was cleared, which led to the gradual restoration of the water area.The forest areas in 1992, 2003 and 2014 were 2012.78, 2020.76 and 1997.88 km^2, respectively. Construction land increased from 1992 to 2014 year by year. Water, bare land, and farmland area changes were closely related to human activities.

Rawat et al. (2015) studied the spatial temporal dynamics of land use and land cover of Hawalbagh Block of district Almora, Uttrakhand, India. Landsat images of two different time periods i.e. 1990 and 2010 were acquired and supervised classification methodology was adopted. The study reveals that the area under vegetation has increased by 3.51% due to afforestation work during 1990-2010. The second major category of land classification in the study area is agriculture which decreased by 1.52%. The third major category of the land in the study area is barren, which has also decreased by 5.46%. The area under forth category is built-up land which has increased by 3.55% due to mainly expansion of the Almora town area during the last two decades. This paper highlighted the importance of digital change detection techniques for nature and location of change of the Hawalbagh block.

Rimal (2005) carried out a study on application of remote sensing and GIS , land use and land cover change in Kathmandu metropolitan city, Nepal. The study reveals that th urban/ built-up areas in Kathmandu had a noticeable increase from 16.85% of the total area in 1976 to 66.61% in 2009 due to population migration. The forest area has decreased by 13.90% in 1976, 8.80% in 1989, 2.93% in 2001 and 2.32 % in 2009 respectively. Analysis showed the water area has fluctuated over time. It was 2.90%, 1.10%, 4.33% and 3.71% in 1976, 1989, 2001 and 2009 respectively. Cultivated land has increased by 1% from 59.35% to 60.43% in 1976 to 1989 due to rapid decline in forest area. He discussed, open fields have largely decreased between the years of 1976 to 2009. This has been changed for urban and agricultural purposes.

Assessment of changes in land use/land cover in Tamilnadu state in India using GIS was focused by Mani et al. (2013). They compared three satellite images of different time periods: Landsat 1973, 1990 and IRS-P6 of 2008. They classified the whole images in 7 categories and then change detection technique has been used to get results. The study concluded that the area under built-up and agriculture has increased while the area under forest, grazing, wasteland, wetlands and water bodies has decreased in the study area.

Hussain et al. (2013) focused on change detection from remotely sensed images: from pixel based to object based approaches. They analysed traditionally pixel based and statistics- oriented change detection technique which focus mainly on spectral values and mostly ignore the spatial context. A comparative study has been done between merit and issues of different techniques. Hybrid change detection technique has been adopted and data mining technique and change detection also used to future remote sensing change detection.

Gutman et al. (2004) discussed NASA land use and land cover change program. The objectives of land use and land cover program are to develop the capability to perform repeated global inventories of land use and land cover from space; to improve the scientific understanding of land use and land cover processes and models necessary to simulate the processes taking place from local to global scale; to model and forecast land use and land cover change and their direct and indirect impacts and to evaluate the societal consequences of the observed and predicted changes.

Jaganathan et al. (2010) discussed Geomatics based assessment on land use change and its impact over ground water conditions in the newly developing sub urban area in southern Chennai. This technology has been found to be very effective in identification of land use changes occurred over a period of time with temporal data. They concluded that explosive growth of urbanisation, increasing demand of water for industries and IT parks have resulted in reduction of water bodies and land use in southern urban area of Chennai city.

Reddy et al. (2013) focused on land use and land cover change in the urban area, Tirupati, India, using remote sensing data and GIS technology. They stated that the study area Tirupati is a rapid developing town During the past few decades, the study area has witnessed substantial increase in population, economic growth, industrialization, and transportation activities that have negative impact on the environmental health of the region. They noticed that built up area has been expanded and on the other hand, decreased have been noticed in agricultural area, water spread area and forest area. The agricultural lands which are used for paddy and production of food, vegetables, and other mixed varieties of trees are largely decreased.

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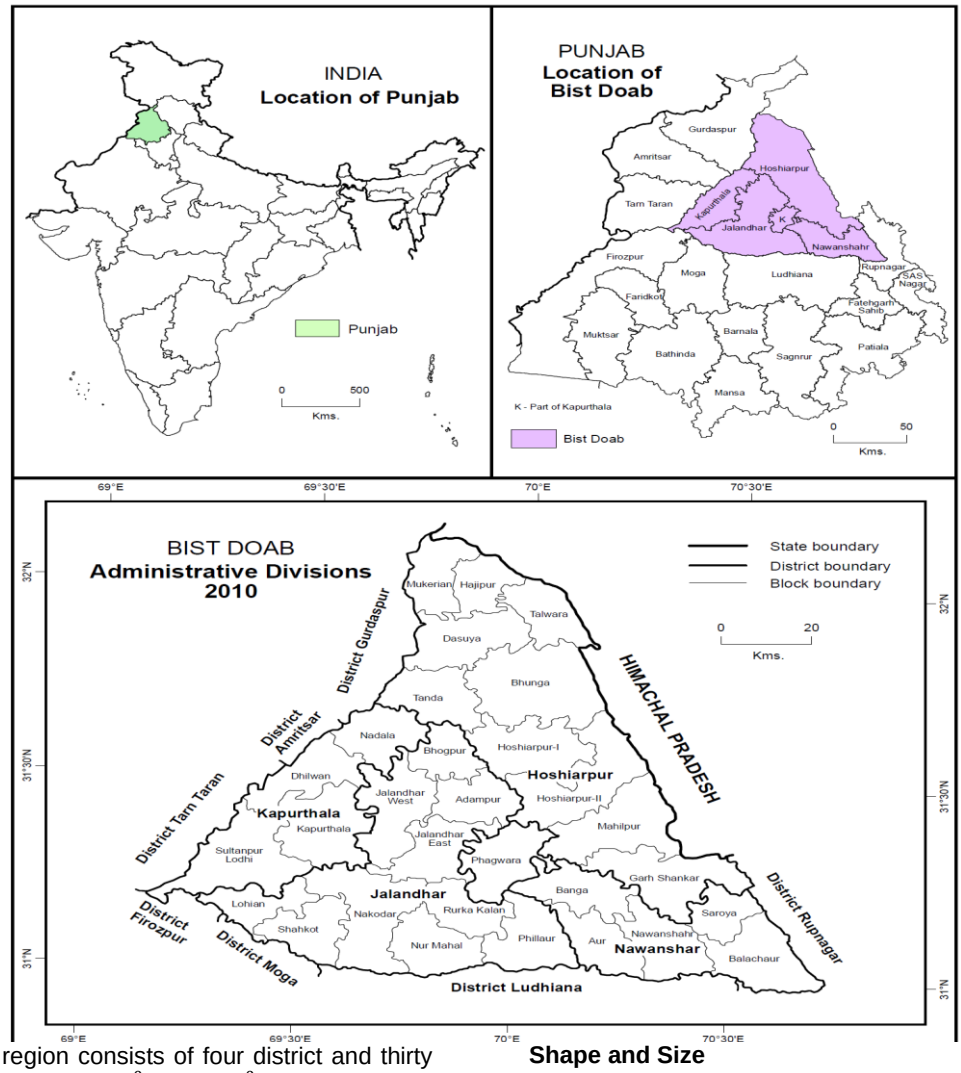
Study Area

Bist Doab is a triangular shaped region of Punjab. The area bounded by Sutlej on the south, Beas on the North West and Siwalik ranges running in the NE-SE. The area received itsname at the time of Emperor Akbar by combining the first letters of the name of the rivers Beas and Sutlej. Doab is a Persian term meaning a landmass lying between two rivers. The study area covers an area of 8915 sq, km, 37 towns and has 5580 villages.

Map 1.1



The region consists of four district and thirty blocks. It extends from 30^0 57' to 32^0 7' North latitude and from 75^0 4' to 76^0 30' East longitude. It is surrounded by Malwa in South after SutlejRiver and Majha region in the NW after Beas. Himachal Pradesh lies to its eastern side behind the Siwalik ranges. Bist Doab looks like a triangle with its base in south formed by course of river Sutlej. Its apex lies in North in Mukerian block that merge in to Hoshiarpur district. It constitutes 17.8 percent of the total area of Punjab.

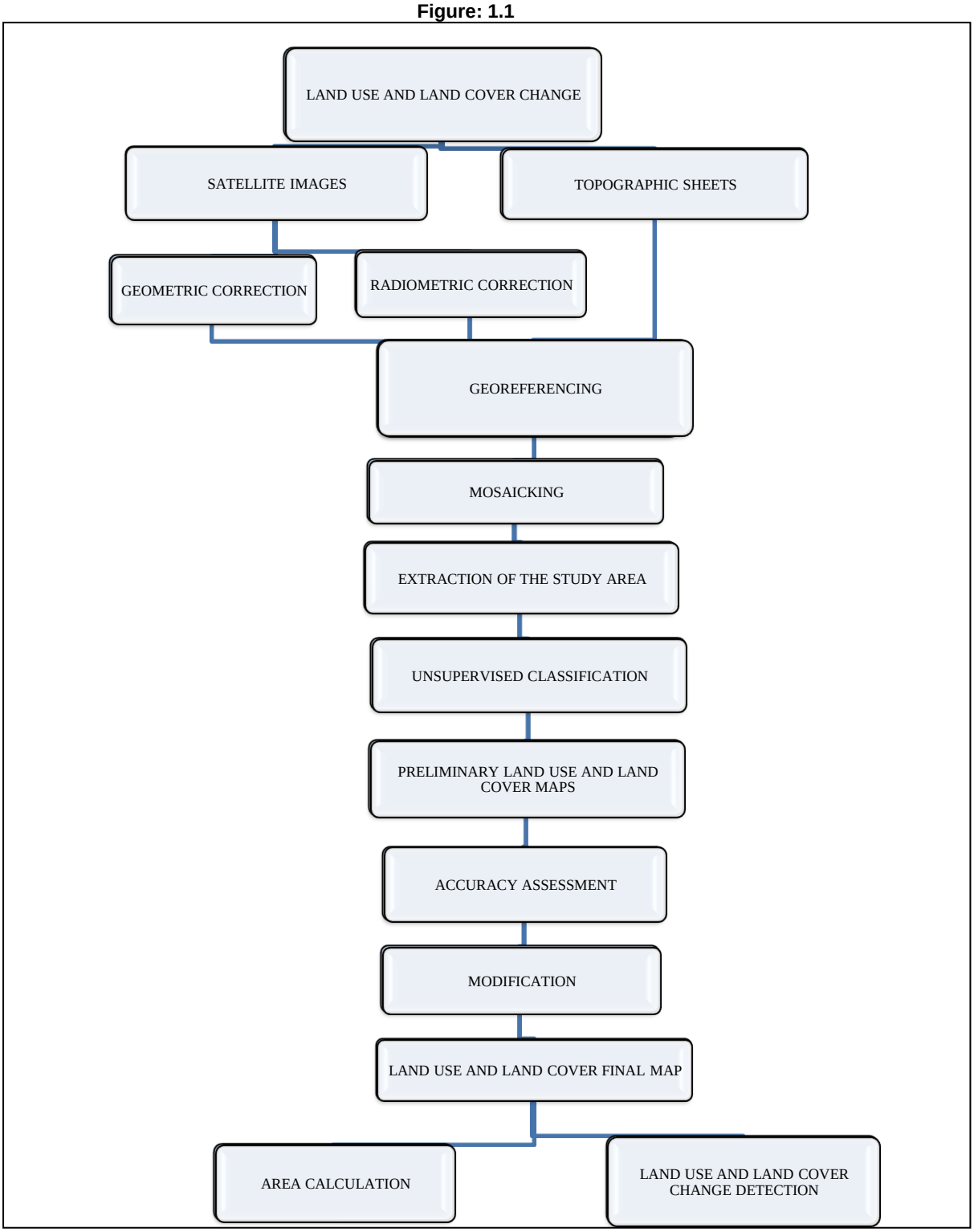
Shape and Size

Bist Doab looks like a triangle with its base in south formed by course of river Sutlej. Its apex lies in Mukerian block in Hoshiarpurdistrict. Bist Doab is in the middle of the three folk regions of Punjab. It has an area of 8915 sq. km which constitute 17.8 percent of the total area of Punjab. Bist Doab is smaller than Malwa region and bigger than Majha region. It includes the districts of Hoshiarpur, Kapurthala, Nawashaher and Jalandhar.

Data Sources and Methodology

Figure 1.1 explains the methodology adopted for land use and land cover change pattern from 1975's to 2015.

Methodology: Land Use and Land Cover Change Detection
Figure: 1.1



Three scenes have been mosaicked and clipped to introduce the study area therefore total two and half pairs of cloud free Landsat Images have been used to classify: Landsat 2, Multispectral Scanner satellite image (hereafter MSS image with path/row 159/38) November 10, 1975, Landsat 5, Thematic Mapper satellite image (hereafter TM image with path/ row 147/38, 147/39 and 148/38) November 17, 1989 & October 20, 1999 and Landsat 7 Enhanced Thematic Mapper (hereafter ETM+OLI with path/row 147/38, 147/39 and 148/38) October 20, 2005 and Landsat 8 Operational Land Imager &

Thermal InfraRed Sensor (hereafter OLI+TIRS with path/row 147/38, 147/39 and 148/38)October 17,2015.All the images were taken from Glovis USGS and were brought to UTM Projection in Zone 43N, World Geodetic System 84. Topographic maps from 1956/2005 at the scale of 1: 50,000 prepared by Survey of India, have been used to prepare land use and land cover classification. Here table shows the list of data acquired along with their date of production, resolution and sources. Classification and post classification overlay was carried out and thematic land cover maps for the year 1975 and 2015 were produced for the study area by unsupervised classification. Nine major land use and land cover classes were mapped e.g river, reservoirs, dense scrub, open scrub, agricultural land, barren land, current fallow built up land, sandy area.

Accuracy Assessment

Remote sensing technique is becoming a more powerful source of information. During the procedure of classification, remote sensing thematic maps contains lots of errors due to geometric errors, incorrectly labelled clusters after unsupervised, training sites have incorrectly labelled before supervised classification and unidentified classes. Accuracy assessment has been done to reduce all the above said errors. For this purpose, total 241 samples have been collected randomly to cover the study area. After that, overall accuracy, commission error, omission errors and finally kappa coefficient have been calculated using the appropriate techniques. Ground points have been tested through field visit, Google images and Topographical sheets. Overall accuracy of the classification is 88.7% with 0.84% Kappa coefficient for 2015 classified satellite image (Table 1.1).

Table: 1.1

	Error Matrix									
	Ground Points									
Map Points	**Classes**	**River**	**Reservoir**	**Dense Scrub**	**Open scrub**	**Current Fallow**	**Barren Area**	**Agriculture Area**	**Built -Up Area**	**Sandy Area**	**Total**
	River	4	0	0	0	0	0	0	0	0	4
	Reservoir	0	0	0	0	0	0	0	0	0	0
	Dense Scrub	0	0	7	2	0	1	0	0	0	10
	Open scrub	0	0	3	13	0	0	1	3	1	21
	Current Fallow	0	0	0	0	7	1	3	0	0	11
	Barren Area	0	0	0	0	1	3	0	0	0	4
	Agriculture Area	0	0	1	0	3	3	77	0	1	85
	Built- Up Area	0	0	0	0	1	0	0	93	0	94
	Sandy Area	1	0	0	0	0	0	0	1	10	12
	Total	5	0	11	15	12	8	81	97	12	241

Computation of K_{hat} Coefficient of Agreement

$$\hat{K} = \frac{N\sum_{i=1}^{k} x_{ii} - \sum_{i=1}^{k} (x_{i+} \times x_{+i})}{N^2 - \sum_{i=1}^{k} (x_{i+} \times x_{+i})}$$

N= 241

$$\sum_{i=1}^{k} x_{ii} = (4+7+13+7+3+77+93+10) = 214$$

$$\sum_{i=1}^{k} (x_{i+} \times x_{+i}) = (4*5)+(10*11)+(21*15)+(11*12)+(4*8)+(85*81)+(94*97)+(12*12)$$

$$=20+110+315+132+32+6885+9118+144=16756$$

$$\text{So } \hat{K} = \frac{241(214)-16756}{(241)^2-16756} = \frac{51574-16756}{58081-16756} = \frac{34818}{41325} = 0.84\%$$

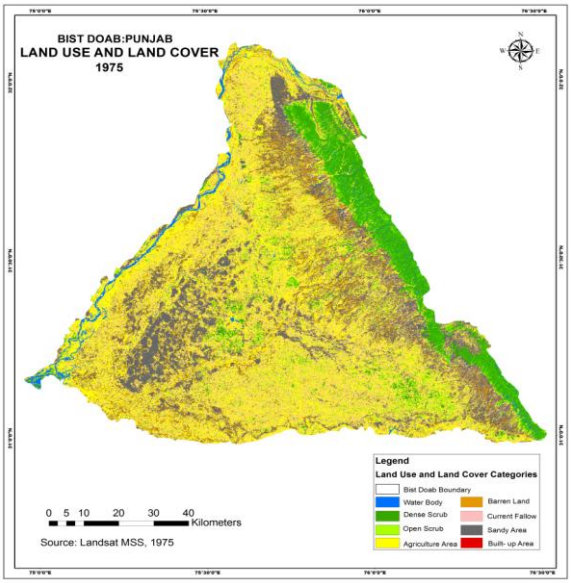
$$\hat{K} = 0.84\%$$

Bist Doab: Land Use and Land Cover- 1975

Water body covered an area of 2.33 % of the total area of Bist Doab.It has been located in the western direction of the Bist Doab, known to be River Beas. Few pockets of River Sutlej have been seen in southern direction of the Bist Doab.

The area under forest was well distributed in the Siwalik Hills. In 1975 total forest area was covered by 12.60% of the total area, in which dense scrub were 7.70 % whereas open scrub has been 4.90%. Area under forest was also found in some pockets of the inland area e.g a circular shape around Jalandhar city, partially in Adampur, Bogpur, Dasuya, and Hoshiarpur-II and in pockets of Nawashaher, Banga and Southern Balachaur. A big patch was also noticed to the north of the Beas River in Talwara block. Barren area was observed by 3.10% in few pockets of the study area. In this year, it was prominent in the parts of Bhunga, Hoshiarpur-I, Hoshiarpur-II and Balachaur, especially along the Siwalik Hills.The built-up covered an area of 1.36 % of the total area of Bist Doab. Agricultural area was located all over the Bist Doab, partially central blocks e.g. Jalandhar East, Jalandhar West and Kapurthala blocks, it was also located along the rivers: Beas and Sutlej mainly due to availability of irrigation facilities. The area along Siwalik Hills was not much suitable for agriculture at that time.

Map 1.2



The main concentration of agricultural area was seen in Dhilwan, Nadala, Tanda, Bhogpur, Adampur, Bhunga, Mukerian, Dasuya, Aur, Nawashaher, Phillaur, Banga, Rurka Kalan, Nurmahal, Nakodar, Shahkot, Eastern part of Mehatpur, South-western of Lohian and SultanpurLodhi accept eastern part. It was covered an area of 58.87 % of the total area. Current fallow was distributed in the small pockets spread all over the Bist Doab. The area covered by current fallow was 1.59 % of the total area of Bist Doab.

The sandy area was observed by 20.15 %.. A general view of the map indicates that the sandy area was spread in the choes along the Siwalik Hills and in the south-western part of the Bist Doab. It was highly distributed in Kapurthala, Jalandhar East and Jalandhar West blocks. Otherwise, it was seen in small pockets of blocks e.g. North-Eastern part of Lohian, North part of Shahkot, North-Western part of Nakodar, North-Eastern part of SultanpurLodhi, South part of Bhogpur and Eastern part of Dhilwan (Map 1.2).

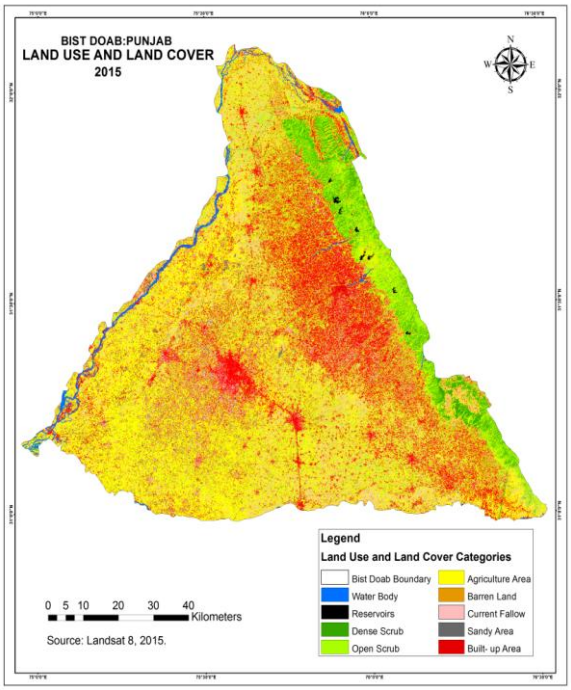
Bist Doab: Land Use and Land Cover- 2015

The map (1.3) depicted the spatial distribution of land use and land cover change in 2015. River area has been increased by 2.52 % of the total area from 2.33 % in the year of 1975. Reservoirs have marginally increased by 0.22 % in this year from 1975. Because in1975, reservoirs were not introduced and in 2015, there were total eight dams in Bist Doab e.gChohal dam, Dhamsal, Dholbaha, Janauri, Mailli, Patiari, Saleran and Thana dam. Thana dam was constructed in the year of 2008 in Hoshiarpur district. Dense scrub has been decreased by 6.32 % from7.70 % in 1975. Open scrubs have been decreased by 4.60 % while it was 4.90 % in 1975. The major change has been noticed in Saroya, Garhshankar, Balachaur, Bhunga, Hoshiarpur-I and Hoshiarpur-II blocks along Siwalik Hills. This change has been the result of clearance of open scrub for agricultural uses.

Barren land has been decreased by 0.98 % from 3.10 % in 1975. Barren land has shown a great fall between these two periods. Maps have shown barren land in previous images has turned into agricultural land. The main change has been seen in Balachaur, Nawashaher, Aur, Phillaur, Nurmahal, Nakodar, Shahkot, Lohian, Banga, Phagwara, Rurka Kalan, Kapurthala, SultanpurLodhi, Dhilwan,Nadala and Tanda. These blocks are located in south and western Bist Doab, extended from River Beas to River Sutlej, whereas Eastern belt has shown a few small patches of barren land in blocks: North- Western Balachaur, South Saroya, Hazipur and Talwara blocks along Siwalik Hills (Map 1.3).

The built-up area has grown by 163.6 times. This is mainly due to rise of population as well as due to rise in semi-urban centres in Jalandhar, Hoshiarpur, Kapurthala and Nawashaher district which are the results of industrial development in these four districts. The built-up area was 1.36 % in 1975which increased to 16.32 % of the total area in the year of 2015. The major change was noticed in Jalandhar East, influence was seen in hinterland of Jalandhar East, Jalandhar West, Kapurthala, Nakodar and Bhogpur blocks. The another eye catching change was seen in the hinterland of Hoshiarpur-I, Hoshiarpur-II, Bhunga and Mahilpur blocks lying along Siwalik Hills and these blocks belongs to Hoshiarpur district of Punjab. Out of 80% of its population is still rural and 70 % population is dependent upon sustenance agriculture and livestock rearing due to its physical terrain (census, 2011). Even Hoshiarpur city has been growing at snail pace since last three decades. Nawashaher block also registered growth in built-up area. It has been increased due to the decreased agricultural area over this time period.

Map 1.3



Agricultural area has increased by 64.70 % of the total area from 58.87 % in 1975. Agricultural area was seen in Balachaur, Nawashaher, Aur, Phillaur, Nurmahal, Nakodar lying between Chitti (White) Bein and River Sutlej, Shahkot, Lohian, Banga, Rurka Kalan, Western Kapurthala, SultanpurLodhi, Dhilwan, Nadala and Tanda blocks extended from river Beas to river Sutlej. The concentration was seen in blocks lying between river Beas and Kalli (Black) Bein. Area along Siwalik Hills was not appropriate for agricultural activities due to its physical terrain, scarcity of water and erratic fall in rainfall. Though many small dams have come up in the region, but still agriculture is badly affected by flash floods in the choes. In comparison of the maps of 1975 and 2015, the area lying under river has been encroached by agricultural activities, in Harike wetland of SultanpurLodhi.

Current fallow has been witnessed a marginal fall in 2015 by 1.57 % of the total area from 1.59 % in 1975. The change in current fallow has been a result of increase in built-up area and open scrub. Whereas current fallow has been seen, in small parts of Phillaur,Aur, Banga, Phagwara and Garhshankar blocks. It has been also noticed in the pockets of Bhogpur, Nadala, Tanda, Dasuya and Jalandhar-West along Kalli(Black)Bein.

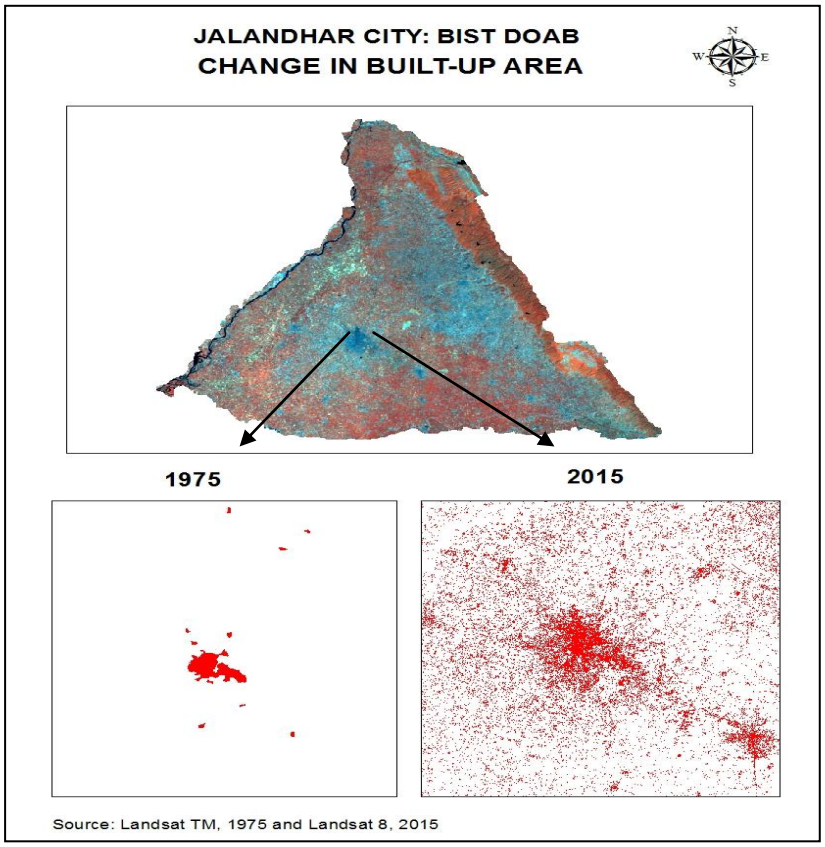
Sandy area has been reduced by 2.73 % in 2015 from 20.15 % in 1975. The great change has been the result of clearing and levelling of sand dunes in Kapurthala, Jalandhar and Hoshiarpur districts. All the area was covered by sand dunes in 1975, now have used for agricultural activities by the farmers and also used for built-up area. In 2015, Nadala, Shahkot and Lohian blocks have witnessed as the pockets of sandy area. Otherwise all the sandy area has been converted into agricultural area.

Bist Doab: Change Detection 1975- 2015

Map 1.4 depicts the land use and land cover change detection from 1975 to 2015. The area under river has slowly increased from 2.33 % in 1975 to 2.52 % in 2015. This category included 0.05 % from dense scrub, 0.23 % from agricultural area. 0.01 % from open scrub, 0.33 % from barren area, 0.06 % from current fallow, 0.23 % in sandy area and 0.00% in built-up area whereas 1.61 % remaining in rivers, Reservoirs/ ponds has been increased by 0.0 % in 1975 to 0.22 % in 2015. It included 0.01 % from rivers, 0.16% from dense scrub, 0.0 1% from open scrub, 0.01 % from barren area, 0.03 % in sandy area. Whereas agricultural area, current fallow and built-up area have not shown any change in reservoirs/ ponds.

Likewise, 7.70 % of dense scrub has decreased to 6.34 % in 2015. Of this, 5.27 % of dense scrub has not under gone by any change. Remaining dense scrub includes 0.30 % of barren area, 0.01 % of sandy area, 0.21 % of open scrub, 0.06 % of current fallow, 0.16 % of agricultural area followed by 0.33% of rivers. Open scrub has also decreased by 4.90 % in 1975 from 4.60 % in 2015. It has included 1.37 % of the barren area, 1.40 % of dense scrub, 0.66 % of sandy area, 0.47 % of current fallow, 0.29 % of agricultural land, 0.05 % of rivers followed by 0.01% of built-up area and 0.35 % of remained in open scrub. As for as barren area was concerned, it has been decreased in 2015.It was 3.10 % in 1975 and now it was only 0.98 % in 2015. Such an areal extend of barren area has decreased at a very high rate. It included 0.12 % in sandy area, 0.05 % in current fallow, 0.44 % in agricultural area, 0.16 % in dense scrub, 0.08 % of open scrub and 0.04 % of river, whereas 0.09 % remained in barren area. Table 1.2 shows that built- up area has increased by 16.32 % in 2015 from 1.36 % of the total area in 1975. It was mainly increased due to conversion of agricultural area by 10.81 %, current fallow by 0.19 %, sandy area by 2.87 %, barren area by 0.46 %, open scrub by 0.33 %, dense scrub by 0.32 % followed by rivers by 0.01 %. Whereas 0.08% remaining in built-up area (Map 1.4& 1.5).

Map 1.4


JALANDHAR CITY: BIST DOAB
CHANGE IN BUILT-UP AREA
N
W
E
S
1975
2015
Source: Landsat TM, 1975 and Landsat 8, 2015

Map 1.5

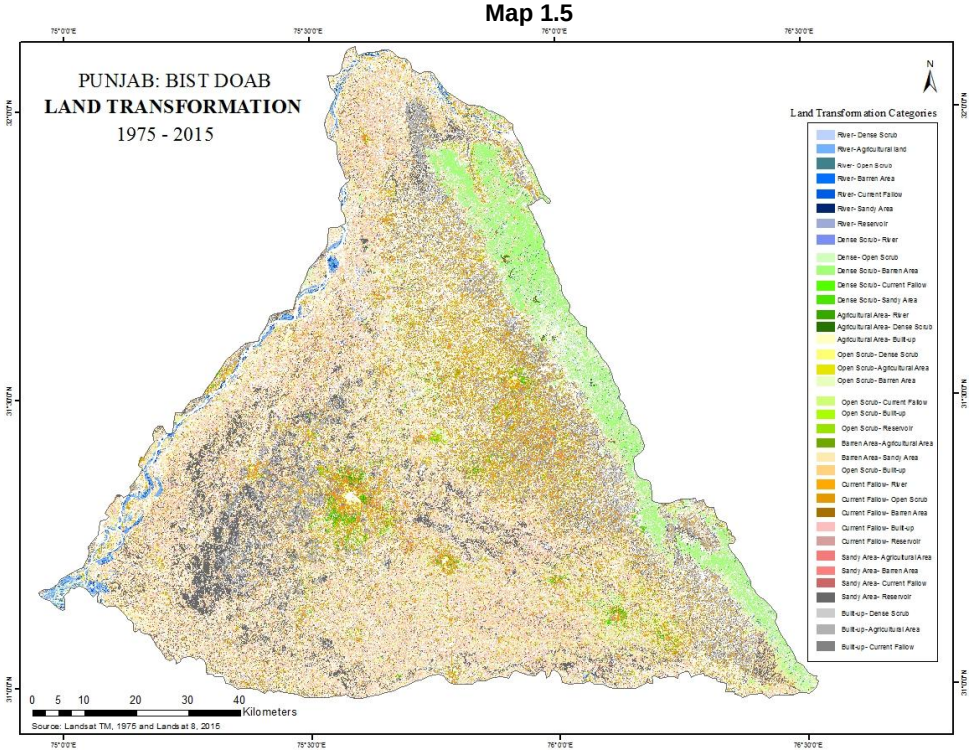

PUNJAB: BIST DOAB
LAND TRANSFORMATION
1975 - 2015
N
Land Transformation Categories
River- Dense Scrub
River- Agricultural land
River- Open Scrub
River- Barren Area
River- Current Fallow
River- Sandy Area
River- Reservoir
Dense Scrub- River
Dense- Open Scrub
Dense Scrub- Barren Area
Dense Scrub- Current Fallow
Dense Scrub- Sandy Area
Agricultural Area- River
Agricultural Area- Dense Scrub
Agricultural Area- Built-up
Open Scrub- Dense Scrub
Open Scrub- Agricultural Area
Open Scrub- Barren Area
Open Scrub- Current Fallow
Open Scrub- Built-up
Open Scrub- Reservoir
Barren Area- Agricultural Area
Barren Area- Sandy Area
Open Scrub- Built-up
Current Fallow- River
Current Fallow- Open Scrub
Current Fallow- Barren Area
Current Fallow- Built-up
Current Fallow- Reservoir
Sandy Area- Agricultural Area
Sandy Area- Barren Area
Sandy Area- Current Fallow
Sandy Area- Reservoir
Built-up- Dense Scrub
Built-up- Agricultural Area
Built-up- Current Fallow
0 5 10 20 30 40
Kilometers
Source: Landsat TM, 1975 and Landsat 8, 2015

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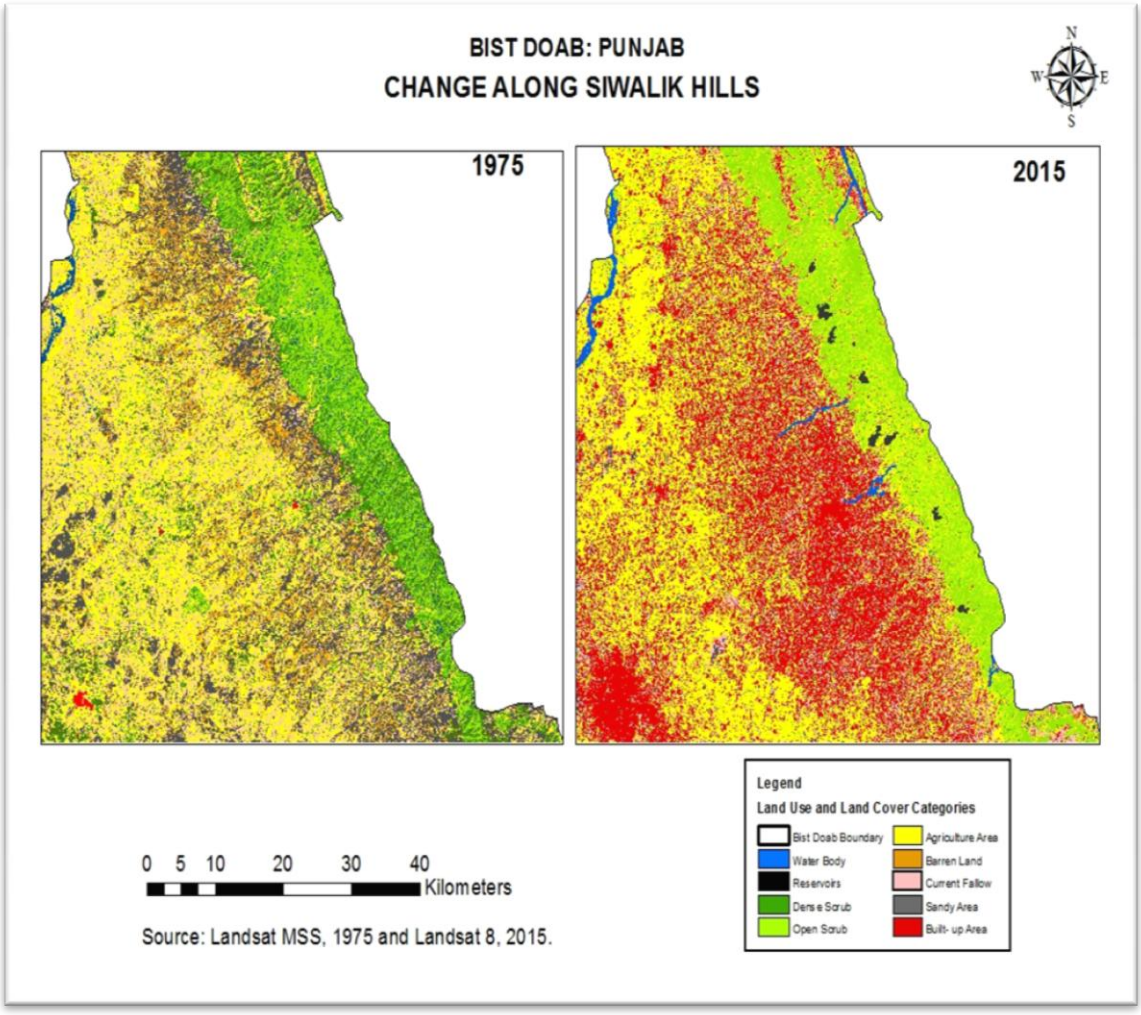
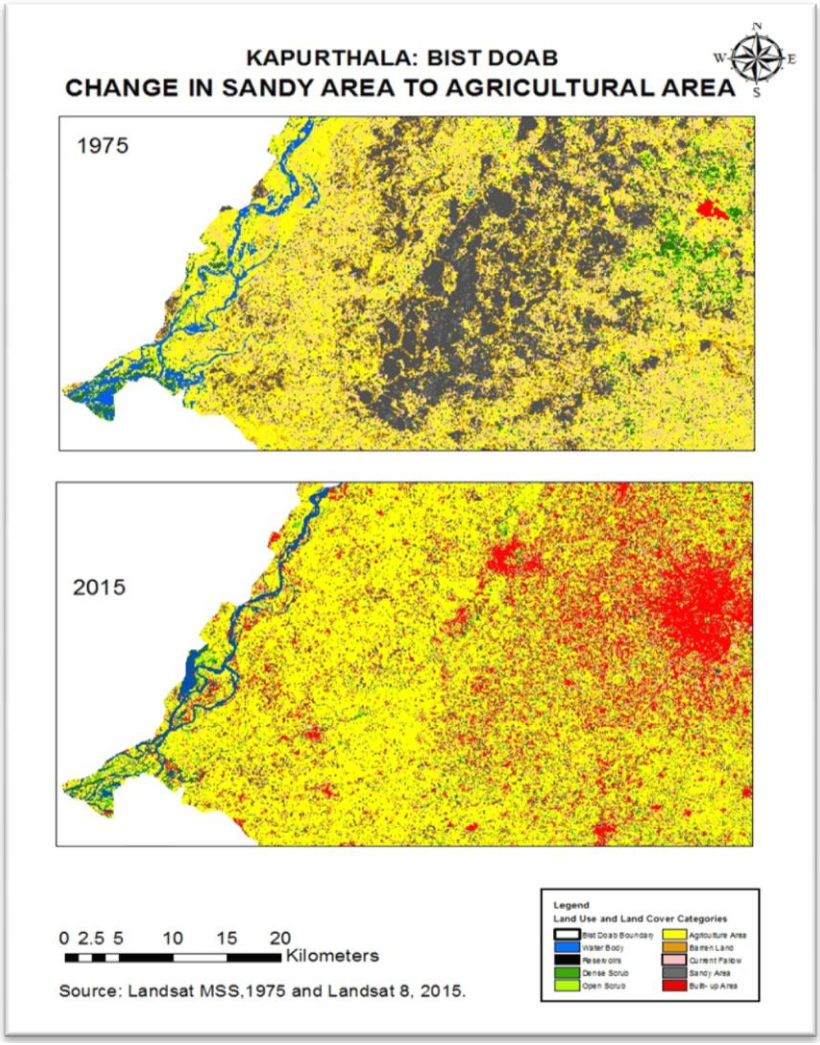
	Table 1.2 2015									
		River	Reservoirs / Ponds	Dense scrub	Open Scrub	Barren area	Built-up area	Agricultural Area	Current fallow	Sandy area	total
1975	River	1.61	0.01	0.33	0.05	0.04	0.01	0.09	0.15	0.04	2.33
	Reservoir/ Ponds	0	0	0	0	0	0	0	0	0	0
	Dense scrub	0.05	0.16	5.27	1.40	0.16	0.32	0.15	0.14	0.05	7.70
	Open Scrub	0.01	0.01	0.21	0.35	0.08	0.33	3.40	0.45	0.06	4.90
	Barren area	0.33	0.01	0.30	1.37	0.09	0.46	0.17	0.20	0.17	3.10
	Built-up area	0.00	0.00	0.00	0.01	0.00	1.33	0.01	0.01	0.00	1.36
	Agricultural Area	0.23	0.00	0.16	0.29	0.44	10.81	45.58	0.27	1.09	58.87
	Current fallow	0.06	0.00	0.06	0.47	0.05	0.19	0.10	0.11	0.55	1.59
	Sandy area	0.23	0.03	0.01	0.66	0.12	2.87	15.23	0.24	0.76	20.15
	Total	2.52	0.22	6.34	4.60	0.98	16.32	64.73	1.57	2.72	100.00

Map 1.6





Agricultural area has increased by 58.87 % in 1975 to 64.73 % in 2015. It overtake, 0.09 % from river, 0.15 % from dense scrub, 3.40 % from open scrub, 0.17 % from barren area,0.10 % from current fallow, 15.23 % from sandy area and followed by 0.01% from built-up area. 45.58 % remaining in the category of agricultural area in 2015.The area under current fallow has slowly decreased from 1.59 % in 1975 to 1.57 % in 2015. This included 0.01 % of barren area, 0.24 % of sandy area, 0.27 % of agriculturalarea, 0.45 % of open scrub, 0.15 % of river, 0.14 % of dense scrub and 0.01 % of built-up area and 0.11 % remaining in current fallow in 2015. The areal extent of sandy area has also decreased at a high rate by 20.15 % in 1975 to 2.72 % in 2015. In 2015, sandy area remained by , 0.04 % in river, 0.05 % in dense scrub, 1.09 % in agricultural area, 0.06 % in open scrub, 0.17 % in barren area, 0.55 % in current fallow, 0.0% in built-up area and 0.76 % in its own category of sandy area (Map 1.5 & 1.6).

Conclusion

Land use and land cover change mapping of Bist Doab shows that the agricultural area was prominent feature follow by sandy area. These two categories occupied an area of 79.02% of the total area till 1975. During the period of 2015, 15.23% of sandy area was converted into agricultural area. The agricultural area, which was 58.87% in 1975, has been increased to 64.73% in 2015. Here one another change has noticeable as built-up area that was increased to 16.32% in 2015 in comparison to 1.36% in 1975. In which 10.81% was increased due to the extended habitation over the agricultural area. Table shows that built-up area has grown fifteen times in 2015 than in 1975. Forests (both, open scrub and dense scrub) have decreased to 10.94% in 2015. While these were 12.60% in 1975. In forested area 3.40% of open scrub has been replaced by agricultural area in 2015.

Rivers have increased to 2.52% in 2015 from 2.33% in 1975. Areas under reservoirs have also increased to 0.22% in 2015 which were not present in 1975. Because in 1975, reservoirs were not introduced at that time and in 2015, there were total eight dams in Bist Doab e.g.Chohal dam, Dhamsal, Dholbaha, Janauri, Mailli, Patiari, Saleran and Thana dam.

While barren areas have been decreased to 2015, 1.37% of the total area was replaced by open

scrub. Current fallow has an ignorable decrease to 1.57% in 2015 as compare to 1.59% in 1975.

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