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Detection of land use changes in micro watersheds through RS & GIS

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Abstract
The present study showed that barren land has increased by 16.50% to 27.5% in last 15 years. Land use pattern includes cultivation of Horticulture crops like Mango, Sapota Coconut and Banana whereas Agriculture crops include paddy and sugarcane cultivation. As the micro watershed is adjacent to Navsari city, it has units of dairy farming. Agri – Horti – Forestry model is also observed in the area, the residents are among medium to low income group. There are few houses of NRI's in the micro watershed. It was also seen that existing ponds need to be cleaned and desilted at regular intervals otherwise; colonizers may occupy these water bodies and build concrete houses and roads thus preventing essentially ground water recharge.

Keywords: watershed, land, agriculture crops, water recharge

Introduction
The Global Environmental Outlook (GEO-6) Regional Assessment Report published ahead of UN Environment Assembly held at Nairobi in May 2016, states that the worst impacts of climate change are projected to occur in the Pacific and Southeast Asia. India tops the chart with nearly 40 million Indians will be at risk from rising sea levels by 2050, with Mumbai and Kolkata having maximum exposure to coastal flooding in future due to rapid urbanization and economic growth. Coastal areas are highly exposed to cyclones and typhoons which will affect the poor living in the hazardous lands along the coast. Gujarat has 1600 km of coast line which is the longest coastline among all states of India, accounting for 22% of the country. Increasing population pressure on main land mass, especially due to agriculture and industrial growth in the state is pushing the developmental activities on saline waste lands along the coasts, thus increasing the demand of potable water for domestic purposes, industrial use and agricultural consumption. Due to over exploitation of ground water resource, saline sea water has infiltrated deep within the aquifers of coastal districts making the water unsuitable for drinking and irrigating. Even after development of canal irrigation approximately 65 to 70% irrigation is still dependent on ground water resource; irrigation with poor quality water directly affects crop productivity. Perennial water demands coupled with erratic monsoon patterns and global warming is creating recurring water crisis in India which aggravates in coastal areas due to incoming coastal salinity through ground water. Ground water, which is the source of 85% rural domestic water requirement, 50% of urban water requirement and over 50% of irrigation water requirement of the country. Study by Central Ground Water Board (CGWB) warns reduction of ground water stock to 22% by 2050, going by present rate of ground water exploitation per person availability will dip below the actual use. Groundwater stock is expected to reduce to 3120 l/day/person by 2050. It was 14,180 in 1951, 6030 in 1991, 20120 in 2001and is projected to 3670 in 2025 and 3120 in 2050. Depleting water table is indication of vanishing rainwater harvesting with ponds, lakes and wells, poor awareness and reduced green cover. Whereas, as per Central Water Commission (CWC) estimates by 2050, an average annual water requirement will be 1180 BCM and the average annual water availability 1140 BCM (Anonymous, 2016) [1]. Land use plan of coastal areas is need of the day when we are planning for improvement of coastal regions as well as to sustain the quality of natural resources, when there are erratic climatic changes taking place due to global warming. Government investments in five year plans require precise data on demand and supply of natural resources, social, economic, and regional vulnerability to disasters. Monetary allocations are made to the districts by the center and state governments based on such information which percolates to taluka and village or watershed level. For effective execution of plan and money skills of watershed management play a significant role. Watershed management could be defined as a harmonious development and management of

land and water resources within the natural boundaries of watershed so as to promote or produce on a sustainable basic abundance of plant and animal and their product and still deliver clean and controlled flow of water to the downstream (Maitra 2001) [3]. The remote sensing and GIS techniques provide an excellent opportunity to create and manage database on spatial and non-spatial data for integrated watershed development. Thus, generated could be helpful to formulate site specific action plans for watershed management (Khanday, 2009) [2]. Geomorphology, soil and land use/ land cover through systematic analysis following the synoptic and multispectral coverage of a terrain and the information generated can be interpreted for various themes namely land capability, land irritability and crop suitability, etc. for better management and conservation of resources on watershed basis several studies have been initiated on potential use of remote sensing data for characterization and management of land resources at watershed level (Srivastava *et al.*, 2015) [4]. In the current study, micro watersheds near Dandi coast have been selected to monitor spatial and temporal changes during the year. Dandi village in the Jalalpore Taluka of Navsari district in Southern Gujarat. The study identified the problem of each micro watershed and attempts to give specific solutions to cope with the problems. The study of different micro watersheds will help us to prioritize the micro watersheds in which government investments could be made in the order of its importance and for adopting the focused energy for initiating the developmental work for the welfare of coastal communities. The study also intends to indicate and establish the systematic methodology to deal with multiple problems in any area for long term sustenance.

Materials and Methods

Study Area: Study area consisted of watersheds '5B2F1C' near Dandi coast, lies in the Jalalpore Taluka of Navsari District in Southern Gujarat (Fig. 1). which lies at the72.78 E to 72.96 E longitude, 20.86 N to 20.96 N latitude and 3 to 18 m Altitude, Navsari city is at around 13 Km from Dandi village located in Arabian Sea coast. There are 9 micro watersheds namely 1C1, 1C2, 1C3, 1C4, 1C5, 1C6, 1C7, 1C8 and 1C9 in the watershed '5B2F1C'. Spatial observations or primary data were collected from selected villages by spot sampling the soil and water samples. The temporal changes were observed through analysis of remotely sensed imageries as well as from secondary data collected from Government records. Each micro watershed was characterized using geo morphological analysis using RS & GIS. Ground truthing was done by collecting samples on monthly basis and later analyzing the same in the laboratory of Natural Resource Department for further calculations. Relevant parameters were graphically presented for interpretation and discussion. Problems of each micro water shed were identified with the help of laboratory analysis, field observations and personal conversation with residents as well as government records. The analysis done from ground truthing was later matched with the information obtained from satellite imageries to draw conclusive solutions of each identified problems for each micro watershed.

Characteristics of watershed: A watershed is the area of land that drains to a water body. A watershed characterization gives an overview of a watershed that includes a description of its geography and natural features, certain physical properties of watersheds that significantly affect the characteristics of runoff and as such are of great interest in hydrologic investigation. The principal watershed characteristics are:

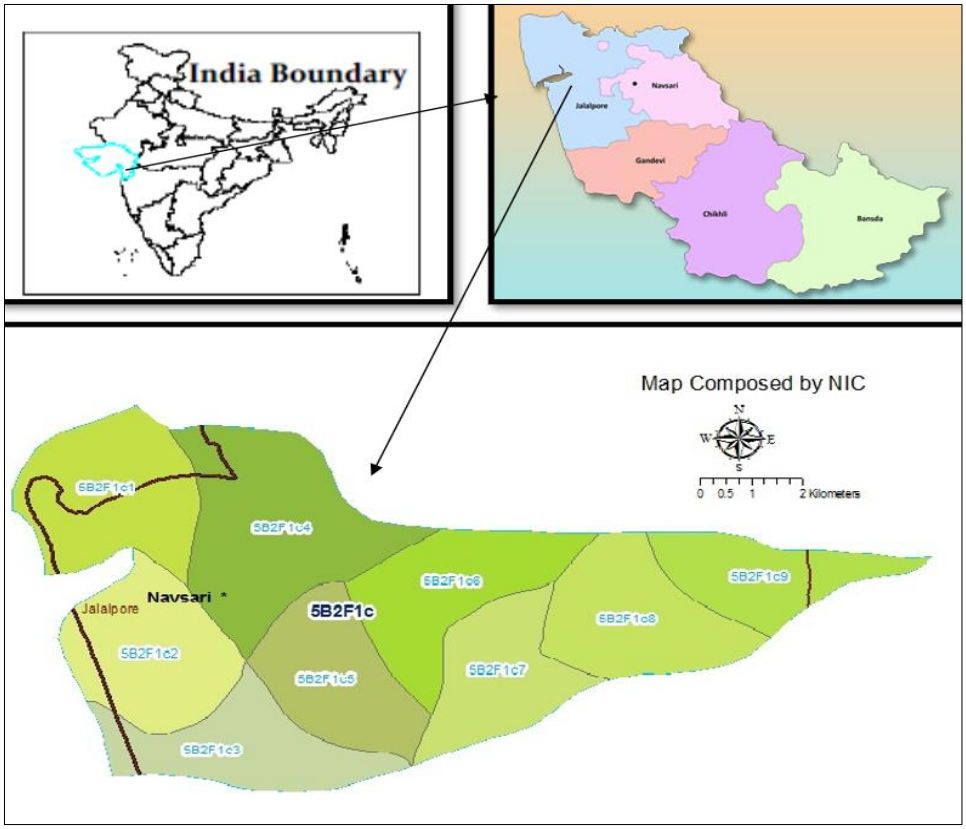

Fig 1: Location of watershed "5B2F1C" under study

Results and Discussion

The results obtained through the analysis of multi-temporal satellite imageries are illustrated in table 00 to 00 with land use/cover status and change in different land use categories. These results are discussed in the following paragraphs.

Micro watershed 1C1

Table 01 depicts spatial distributional pattern of land use/cover of micro-watershed - 1C1 for the year 2001 and 2015. The analysis of imageries in ERDAS imagine software revealed that in 2001, about 49.02% (532.68 ha) area was under water bodies, 40.56% (440.76 ha) area was under vegetation, 6.94% (75.37 ha) area under built-up & sandy land and 3.49% (37.89 ha) area under barren land. The land use pattern of 2015 is different from that of 2001 period, *viz.* 35.92% (390.38 ha) under water body, vegetation has 35.92% (390.38 ha), 4.83% (52.47 ha) under built-up & sandy land and 16.50% (179.30ha) under barren land. The land use pattern that falls under water category has reduced by 13.09 per cent. Similarly, Built up area and sand class has reduced in 2.11 per cent, but all other classes has positively increased over 2001 land use patterns. It could be inferred that area under brackish water or sea water or the river joining the sea has decreased, whereas barren land has increased. It shows that during 15 year period silt has got deposited in this micro watershed and since the micro watershed is at the mouth of river or delta region making the soil saline which is not favorable for vegetative growth, thus increasing the area under barren land.

Table 1: Spatial and temporal land use patterns in MW – 1C1

SN	Land use Pattern	Area in 2001(ha)	% of area	Area in 2015(ha)	% of area	Changes (ha)	Change in%
1.	Water	532.68	49.02	390.38	35.92	-142.30	-13.09
2.	Vegetation	440.76	40.56	464.55	42.75	23.79	2.19
3.	Built up & sand	75.37	6.94	52.47	4.83	-22.90	-2.11
4.	Barren land	37.89	3.49	179.30	16.50	141.41	13.01
Total		1086.70	100	1086.70	100		

Micro watershed 1C2

In micro-watershed - 1C2, the Table 02 depicts spatial distributional pattern of land use/cover of for the year 2001 and 2015. The data analysis shows that in 2001, about 63.62% (635.65 ha) area was under water body, 19.97% (199.59 ha) area was under vegetation, 8.67% (86.66 ha) under built-up & sandy land and 7.74% (77.30 ha) under barren land. The land use pattern of 2015 is different from that of 2001 period, *viz*. 38.72% (386.87 ha) area was under water body, vegetation was in 18.28% (182.68 ha), 7.69% (76.79 ha) under built-up & sandy land and 35.32% (352.96 ha) under barren land. The land use pattern that falls under water category has reduced by 24.90 per cent. Similarly, vegetation & Built up area and sand class have reduced in 1.70 per cent & 0.99 per cent. It could be inferred that area under brackish water or sea water or the river joining the sea has decreased, whereas barren land has increased up to 27.59 per cent. This shows that in this micro watershed also silt has deposited and owing to nearness to sea it has become saline that could not hold any vegetation making the land barren.

Table 2: Spatial and temporal land use patterns in MW-1C2

Sr. no.	Land use Pattern	Area in 2001 (ha)	% of area	Area in 2015 (ha)	% of area	Changes (ha)	change in%
1.	Water	635.65	63.62	386.87	38.72	-248.78	-24.90
2.	Vegetation	199.59	19.97	182.62	18.28	-16.97	-1.70
3.	Built up & sand	86.66	8.67	76.79	7.69	-9.87	-0.99
4.	Barren land	77.30	7.74	352.96	35.32	275.66	27.59
	Total	999.20	100.00	999.20	100.00	-	-

Micro watershed 1C3

Land use/cover of micro-watershed - 1C3 for the year 2001 and 2015 are shown in Table 03 depicts. The spatial distributional pattern of data reveal that in 2001, about 24.94% (208.86 ha) under water body, 28.91% (242.08 ha) area was under vegetation, and 46.15% (386.41 ha) under barren land. The land use pattern of 2015 is different from that of 2001 period, *viz*. 59.54% (498.54 ha) under water body, vegetation has 28.23% (236.42 ha), 12.23% (102.43 ha) under barren land. The land use pattern that falls under vegetation category has reduced by 0.68 per cent. Similarly, barren class have reduced in 33.91 per cent, but water classes has positively increased over 2001 land use patterns up to 34.59 per cent in 2015. It could be inferred that area under develop water body with brackish water or sea water or the river joining the sea has increased.

Table 3: Spatial and temporal land use patterns in MW-1C3

S.N	Land use Pattern	Area in 2001 (ha)	% of area	Area in 2015 (ha)	% of area	Changes (ha)	change in%
1.	Water	206.86	24.94	498.54	59.54	289.68	34.59
2.	Vegetation	242.08	28.91	236.42	28.23	-5.66	-0.68
3.	Barren land	386.41	46.15	102.43	12.23	-283.98	-33.91
	Total	837.35	100.00	837.39	100.00		

Micro watershed 1C4

Table 04 depicts spatial distributional pattern of land use/cover of micro-watershed - 1C4 for the year 2001 and 2015. These data show that in 2001, about 46.95% (673.10 ha) under water body, 28.45% (407.89 ha) area was under vegetation, 10.73% (153.83 ha) under built-up & sandy land and 13.87% (198.77 ha) under agriculture land. Whereas, the land use observed in 2015 was 35.92% (713.88 ha) under water body, 16.68% (239.16 ha) under vegetation 9.22% (132.23 ha) under built-up land and 28.30% (348.30 ha) under

agriculture land. The land use pattern that falls under vegetation category has reduced by 11.77 per cent. Similarly, Built up area and sand category reduced by 1.51 per cent over 2001 land use patterns. In this water ponds (brackish) and agriculture respectively increased by 2.84 per cent and 10.43 per cent in 2015 land use pattern.

Table 4: Spatial and temporal land use patterns in MW-1C4

SN	Land use Pattern	Area in 2001(ha)	% of area	Area in 2015(ha)	% of area	Changes (ha)	change in%
1.	Water	673.10	46.95	713.88	49.80	40.79	2.84
2.	Vegetation	407.89	28.45	239.16	16.68	-168.73	-11.77
3.	Built up & sand	153.83	10.73	132.23	9.22	-21.60	-1.51
4.	Agriculture	198.77	13.87	348.30	24.30	149.53	10.43
	Total	1433.59	100	1433.59	100		

Micro watershed 1C5

Spatial distributional pattern of land use/cover of micro-watershed - 1C5 for the year 2001 and 2015 is given in Table 5. These data reveal that in 2001, about 23.77% (204.46 ha) area was under water bodies, 12. 65% (108.79 ha) area was under vegetation, 10.75% (92.52 ha) under built-up & sandy land 30.29% (260.58 ha) under agriculture land and 22.55% (193.97 ha) under the barren land. The land use pattern of 2015 was 26.97% (232.00 ha) area under water body, 17.69% (152.21 ha) under vegetation 32.08% (275.99 ha) under built-up land, 14.21% (122.22 ha) under agriculture land and 9.05% (77.87 ha) was barren land. The land use pattern that falls under agriculture category has reduced by 16.08 per cent. Similarly, barren land reduced by 13.49 per cent. In this water, vegetation and agriculture respectively increased by 3.20 per cent, 5.05 per cent and 21.33 per cent in 2015 land use pattern. Thus it could be inferred that in this micro watershed construction of houses, roads and buildings has significant increased at the cost of agriculture and barren waste land. Also, there is increase in water bodies and vegetation which could be around the residential areas or along the roads during the past 15 years.

Table 5: Spatial and temporal land use patterns in MW-1C5

Sr. no.	Land use Pattern	Area in 2001(ha)	% of area	Area in 2015(ha)	% of area	Changes (ha)	change in%
1.	Water	204.46	23.77	232.00	26.97	27.54	3.20
2.	Vegetation	108.79	12.65	152.21	17.69	43.42	5.05
3.	Built up	92.52	10.75	275.99	32.08	183.47	21.33
4.	Agriculture	260.58	30.29	122.22	14.21	-138.36	-16.08
5.	Barren Land	193.97	22.55	77.87	9.05	-116.10	-13.49
	Total	860.32	100	860.32	100		

Micro watershed 1C6

Spatial distributional pattern Land use/cover of micro-watershed - 1C6 for the year 2001 and 2015 is shown in Table 6 These data reveal that in 2001, about 3.87% (36.22 ha) under water body, 42.22% (395.36 ha) area was under vegetation, 10.15% (95.01 ha) under built-up land 19.65% (184.04 ha) under agriculture land and 24.12% (225.85 ha) under the barren land. The land use pattern of 2015 shows that 19.05% (178.44 ha), 33.26% (311.45 ha), 1.86% (17.44 ha) 32.29% (302.35 ha) and 13.54% (126.80 ha) was under water body, vegetation built-up land, agriculture land and barren land respectively. The land use pattern that falls under vegetation category has reduced by 8.96 per cent. Similarly, built up and barren land reduced by 8.28 per cent and 10.58 per cent, In this water and agriculture respectively increased by 15.19 per cent and 12.63 per cent in 2015 land use pattern. These changes in this micro watershed could be attributed to conversion of barren land and vegetative land to aquaculture farming as well as raising agriculture crops, which could be due to the availability of good quality ground water or canal water for irrigation. Decline in buildup area may be because of migration of inhabitants to foreign countries and their kachha houses may have been demolished and used as agriculture land.

Table 6: Spatial and temporal land use patterns in MW-1C6

S. N	Land use Pattern	Area in 2001(ha)	% of area	Area in 2015(ha)	% of area	Changes (ha)	Change in%
1.	Water	36.22	3.87	178.44	19.05	142.22	15.19
2.	Vegetation	395.36	42.22	311.45	33.26	-83.91	-8.96
3.	Built up	95.01	10.15	17.44	1.86	-77.57	-8.28
4.	Agriculture	184.04	19.65	302.35	32.29	118.31	12.63
5.	Barren Land	225.85	24.12	126.80	13.54	-99.05	-10.58
	Total	936.48	100.00	936.48	100.00		

Micro watershed 1C7

The table 7 shows spatial distributional pattern of land use/cover of micro-watershed - 1C7 for the year 2001 and 2015. These data reveal that in 2001, about 2.92% (22.88 ha) under water body, 33.74% (264.77 ha) area was under vegetation, 9.43% (74.02 ha) under built-up land 42.57% (333.98 ha) under agriculture land and 11.34% (88.97 ha) under the barren land. The land use pattern of 2015 was 7.89% (61.90 ha), 48.54% (380.83 ha), 4.60% (36.06 ha), 32.16% (252.33 ha) and 6.82% (53.50 ha) under water body, vegetation, built-up land, agriculture land and barren land respectively. The land use pattern that falls under agriculture category has reduced by 10.41 per cent. Similarly, built up and barren land reduced by 4.84 per cent and 4.52 per cent, whereas, water and vegetation respectively increased by 4.97 per cent and 14.79 per cent in 2015 land use pattern. Increase in water bodies and vegetation shows increase of aquaculture activities or land mass getting eroded and getting converted into water swamps. Due to plantation there is increase in vegetative land, it may be at the cost of agriculture land.

Table 7: Spatial and temporal land use patterns in MW-1C7

Sr. no.	Land use Pattern	Area in 2001(ha)	% of area	Area in 2015 (ha)	% of area	Changes (ha)	change in%
1.	Water	22.88	2.92	61.90	7.89	39.02	4.97
2.	Vegetation	264.77	33.74	380.83	48.54	116.06	14.79
3.	Built up	74.02	9.43	36.06	4.60	-37.96	-4.84
4.	Agriculture	333.98	42.57	252.33	32.16	-81.65	-10.41
5.	Barren Land	88.97	11.34	53.50	6.82	-35.47	-4.52
	Total	784.62	100.00	784.62	100.00		

Micro watershed 1C8

Table 8 gives the description of spatial distributional pattern of land use/cover of micro-watershed - 1C8 for the year 2001 and 2015. These data shows that in 2001, about 3.76% (35.73 ha), 34.02% (323.01 ha), 9.03% (85.77 ha), 42.70% (405.45 ha) 10.48% (99.54 ha) area under water body, vegetation, built-up land, agriculture land and barren land respectively. The land use pattern of 2015 was 2.19% (20.76 ha), 51.64% (490.35 ha), 3.60% (34.18 ha), 35.09% (333.18 ha) and 7.48% (71.03 ha) under water body, vegetation built-up land, agriculture land and barren land respectively. The land use pattern that falls under agriculture category has reduced by 18.09 per cent. Similarly, water, built up and barren land has reduced by 1.58 per cent, 5.43 per cent and 3.00 per cent, respectively. In this vegetation respectively increased by 17.62 per cent in 2015 land use pattern, it indicates plantation of orchards or trees in agricultural lands and their canopy covering the built up land area.

Table 8: Spatial and temporal land use patterns in MW-1C68

Sr. no.	Land use Pattern	Area in 2001(ha)	% of area	Area in 2015(ha)	% of area	Changes (ha)	change in%
1.	Water	35.73	3.76	20.76	2.19	-14.97	-1.58
2.	Vegetation	323.01	34.02	490.35	51.64	167.34	17.62
3.	Built up	85.77	9.03	34.18	3.60	-51.59	-5.43
4.	Agriculture	405.45	42.70	333.18	35.09	-72.27	-7.61
5.	Barren Land	99.54	10.48	71.03	7.48	-28.51	-3.00
	Total	949.50	100.00	949.50	100.00		

Micro watershed 1C9

Spatial distributional pattern of land use/cover of micro-watershed - 1C9 for the year 2001 and 2015 is given in Table 9 These data reveal that in 2001, about 3.59% (24.57 ha), 25.29% (173.07 ha), 15.78% (108.00 ha), 48.25% (330.20 ha), and 7.09% (48.52 ha) area was under water body, vegetation, built-up land, agriculture land and barren land. The land use pattern of 2015 was 1.56% (10.70 ha), 23.92% (163.67 ha), 28.80% (197.07 ha), 40.23% (275.33 ha) and 5.49% (37.59 ha) area under water body, vegetation, built-up land, agriculture land and barren land respectively. The land use pattern that falls under agriculture category has reduced by 8.02 per cent. Similarly, water, vegetation and barren land has reduced by 2.03 per cent, 1.37 per cent and 1.60 per cent respectively. But, built up area recorded an increase of 13.02 per cent in 2015 from 2001. Thus, in this micro watershed, population pressure could be seen by the construction activity at the cost of all the other land use patterns.

Table 9: Spatial and temporal land use patterns in MW-1C9

Sr. no.	Land use Pattern	Area in 2001(ha)	% of area	Area in 2015 (ha)	% of area	Changes (ha)	Change in%
1.	Water	24.57	3.59	10.70	1.56	-13.87	-2.03
2.	Vegetation	173.07	25.29	163.67	23.92	-9.40	-1.37
3.	Built up	108.00	15.78	197.07	28.80	89.07	13.02
4.	Agriculture	330.20	48.25	275.33	40.23	-54.87	-8.02
5.	Barren Land	48.52	7.09	37.59	5.49	-10.93	-1.60
	Total	684.36	100.00	684.36	100.00		

Conclusion

The present study showed that barren land has increased by 16.50% to 27.5% in last 15 years. Drinking water is supplied from Navsari for the study region. Vast stretches of land lies as barren and scrub lands. There are few lakes which are filled by pumping ground water for raising saline/sweet water fish production for livelihood security. The existing models were listed as Agri–Horti, Horti–Forestry, Dairy and Aqua model. Limited Agriculture land with short duration less water requiring crops such as sorghum, pigeon pea and wal were growing. Sweet water and saline water were using for aquaculture. Conversion of barren land and vegetative land to sweet water aquaculture farming were also reported during the study. Construction activity at the cost of all the other land use patterns were also observed.

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