

# IMPLEMENTATION OF LCCS LEGEND AND TEMPORAL LAND COVER ANALYSIS OF KEENJHAR FRESHWATER LAKE

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## Abstract

Land Cover change analysis of the Keenjhar Lake was performed by using temporal satellite images (1989, 2000, 2006 and 2007). This is ever first study in Pakistan which deals with Land cover legend definition through Land Cover Classification System (LCCS) designed by Food and Agriculture Organization (FAO) and United Nations Environment Programme (UNEP).

Study reveals a decrease of 439% in area coverage of *Tamarix* spp. from 1989 to 2006. The main reason appears to be the cutting pressure and conversion of land into agricultural fields. Spread of exotic vegetation i.e. *Prosopis* spp. 345ha (65%) might be the catalyst agent for the decrease in *Tamarix* spp.

**Keywords:** Land cover, LCCS and FAO, remote sensing.

## INTRODUCTION

Keenjhar Lake is one of the largest fresh water lakes of Pakistan (Fig. 1). It plays a significant role in the Indus River Basin Ecological System. On the basis of its ecological importance, Keenjhar Lake was designated as a Ramsar site under the Ramsar Convention dated 23<sup>rd</sup> July 1976 [Michael 1990].

Keenjhar Lake lies in dry subtropical monsoon climatic zone. Temperature of the summer and winter season varies from maximum 49°C and minimum 2.2°C respectively. Annual rain fall 178mm was recoded in the monsoon season [<http://www.foreverindus.org>]. The lake has a rich fauna and flora which portray the biodiversity. Flora of the lake provides both food and shelter to fauna species, submerged, floating and terrestrial vegetation survive in and outer periphery of the lake.

The tomb of famous lovers “Noori-Jam Tamachi” is in the centre of the Keenjhar Lake. It is an eco-tourist spot. The lake is surrounded by approximately 62 large and small villages. The occupations of people are mainly fishing, crop cultivation and livelihood.

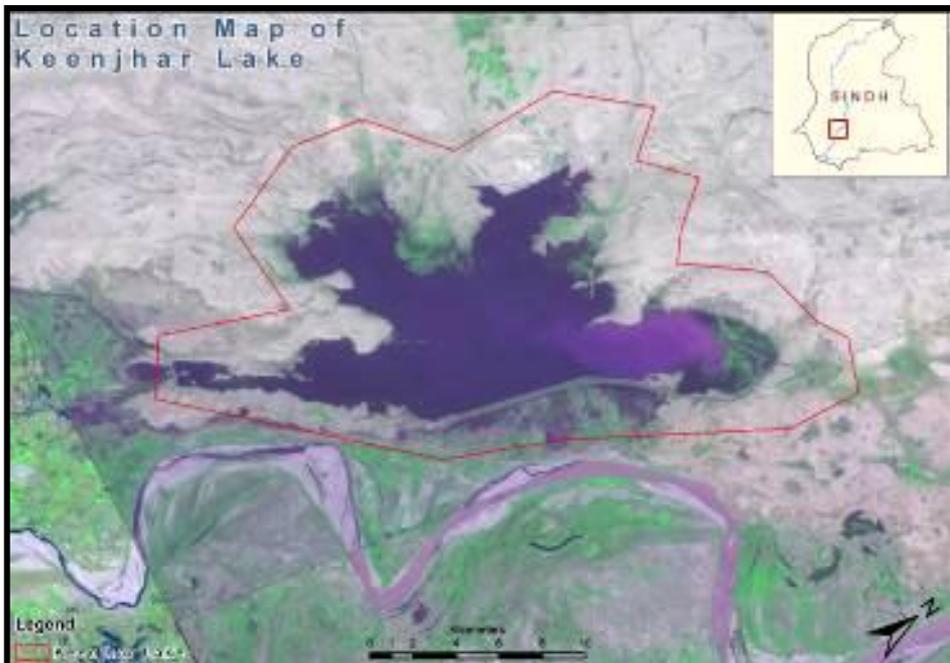
The purpose of present study is:

- To develop a legend using Land Cover Classification System (LCCS)
- To develop historic and current Land Cover maps of Keenjhar Lake

## EXPERIMENTAL

### STUDY AREA

Keenjhar Lake is situated in district Thatha of Sindh province at a distance of 122km from the east of Karachi city. It occupies approximately an area of 14,000ha with 24km length [<http://www.foreverindus.org>]. Historically it was a combination of two separate lakes named as Sonehri and Keenjhar Lake [Muhammad 2005]. Central geographic coordinates of Keenjhar Lake are 68.06°E, 24.95°N with an average elevation of 70m. Location map of study area is shown in Fig. 1.



**Fig. 1:** Location map of the study area.

## METHODOLOGY

ASTER images were procured from USGS in Hierarchical Data Format (.hdf) whereas Landsat images were downloaded from GLCF web site in Tagged Image File Format (.tiff). For easy handling and processing, all satellite images were imported in ERDAS Imagine image format (.img).

All the satellite images were truncated at the desired AOI. Standard Deviation Stretch and Brightness Contrast Control utilities were applied to improve the satellite image contrast and brightness for better interpretation.

A field visit of Keenjhar Lake was arranged to collect ground truth data. A-2 paper size field maps of ASTER images (FCC of band 321) at 1:25,000 scale, with geographic grid of 30 seconds intervals were developed for field survey. GIS layers (settlements, drainages, spot heights etc) were also overlaid on the maps. Garmin 76CSX GPS receiver and digital camera were used to record the ground coordinates and respective field observations. Total 116 Ground Control Points (GCPs) were collected which were used as sample points for the Land Cover.

## SATELLITE DATA SOFTWARE USED

Landsat and Terra satellite images were used for the development of thematic layers. Images were converted into metric coordinates system (i.e. Universal Transverse Mercator – UTM, Zone 42) with WGS 84 Spheroid and Datum. The characteristic details of satellite images used in this study are given in Table 1.

**Table 1:** Characteristics of satellite data.

Satellite	Sensor	Acquisition Date	Spatial Resolution (m)	Source	Spectral Bands
Landsat	TM	28-10-1989	30	GLCF	7
Landsat	ETM+	03-11-2000	30	GLCF	7
Terra	ASTER	20-01-2006	15	USGS	3
Terra	ASTER	13-04-2007	15	USGS	3

For current Land Cover mapping, ASTER images acquired in two different dates were procured due to unavailability of same date data in USGS archive.

For satellite images interpretation and processing ERDAS Imagine 8.7<sup>®</sup> was used. All the maps were developed in Arc GIS 9.0<sup>®</sup>. Microsoft Word and Excel were used for the documentation and graphical analysis.

## **LCCS LEGEND DEFINITIONS**

Classification in a simplest way can be defined as an abstract representation of the ground situation. On the other hand legend can be defined as the translator of that abstract. It should be therefore scale and source independent which can lead integration of Land Cover of diverse areas in a same database [Antonio and Louisa 1998]. For land cover legend standardization, Food and Agriculture Organization (FAO) and United Nations Environment Programme (UNEP) introduced a Land Cover Classification System (LCCS) for legend definition. LCCS provides harmonized and standardized legend for the Land Cover. The classification legend follows the dichotomous structure which can be identified and recognized anywhere in the world. The classification system leads to mutually exclusive Land Cover classes, which comprise:

- (1) a unique Boolean formula (coded string of classifiers used),
- (2) a standard name and
- (3) a unique numerical code [[Antonio and Louisa 1998].

Land Cover legend of Keenjhar Lake is given in Table 2.

## **SUPERVISED CLASSIFICATION**

In this study, thematic layers of Keenjhar Lake were developed by using supervised classification technique. In supervised classification a small area, called training site or hot spot, which is representative of each terrain category or class in the image is defined by the analyst. Spectral values for each pixel in a training site are used to define decision space for each class [Swain 1973].

On the basis of satellite image interpretation elements (tone, texture, pattern, association etc) specific Land Cover classes were identified. Spectral signatures with defined Euclidian distance and feature space also helped to segregate different Land Cover classes [Lillesand and Kiefer 2003]. By using the band combinations (Landsat 3<sup>rd</sup> - 4<sup>th</sup>, ASTER 3<sup>rd</sup> - 2<sup>nd</sup>) feature plots were selected to analyze and differentiate mixed classes [Mausel *et al.* 1990].

Maximum Likelihood classification (MLC) algorithm was performed to develop thematic layers from Landsat (TM & ETM+) and ASTER images. For continuity and analysis, thematic layers developed by using ASTER images were mosaicked. Output thematic layers were recoded into eight classes which were developed by using LCCS.

**Table 2:** LCCS legend for Keenjhar Lake

No	LCC Code	LCC Level*	LCC Own Label	LCC Label
1	40050	A4A12B3C2	<i>Typha</i> spp.	Closed Shrubs on the Temporarily Flooded land
2	40304	A6A16B4C1E5	<i>Sacchrum</i> spp.	Mixed Sparse Grassland on permanently Flooded land
3	20602-13314	A3A10B2XXD1E2F1-B7	<i>Prosopis</i> spp.	Broadleaved Deciduous Low Trees, Single Layer
4	40703-4777	A4A12B3C2D1E2F1-B8	<i>Tamarix</i> spp.	Broadleaved Deciduous Closed High Shrubs On Temporarily Flooded Land
5	21348-325	A6A11B4XXE5F2F6F10G3-A12B13G9	Grasses/ Shrubs	Open ((70-60) - 40%) Short Grassland with Medium High Shrubs
6	8013-5	A1B1C1D2-A5	Water	Turbid Deep To Medium Deep Perennial Natural Water bodies (Standing)
7	11239-11376	A3B1XXC2D3D9-B3C3C7C19D4	Agriculture Land	Permanently Cropped Area With Surface Irrigated Herbaceous Crop(s) (One Additional Crop) (Herbaceous Terrestrial Crop Sequentially)
8	6020-6	A5B13-A12	Land Soil	Stony Bare Soil And/Or Unconsolidated Material(s) With Salt Flats

\* LCC level is the code generated by the software for data retrieving as and when required.

## RESULTS AND DISCUSSION

Land Cover maps defining temporal variations from 1989 to 2007 are shown in Fig. 2. Five vegetation (aquatic and terrestrial) classes and three other Land Cover classes were mapped.

### TEMPORAL CHANGE ANALYSIS

Area covered by each class derived from three thematic layers is shown in Tables 2 and 3. According to the statistics, from year 1989 to 2006 the area coverage of *Tamarix* spp. has been reduced by 912 ha (439%). The main reasons appear to be cutting pressure and conversion of land into agricultural fields.

According to International Union for Conservation of Nature (IUCN), the human-assisted arrival of exotic species is now about a million times greater the natural rate in some instances [<http://edu.iucnp.org/rptee.htm>]. Dominating exotic vegetation i.e. *Prosopis* spp. 345ha (65%) might be the catalyst agent the decrease in *Tamarix* spp. Spectral analysis show decrease of *Typha* spp. and *Saccharum* spp. classes the over-cutting by locals, seasonal variation and changes in water level.

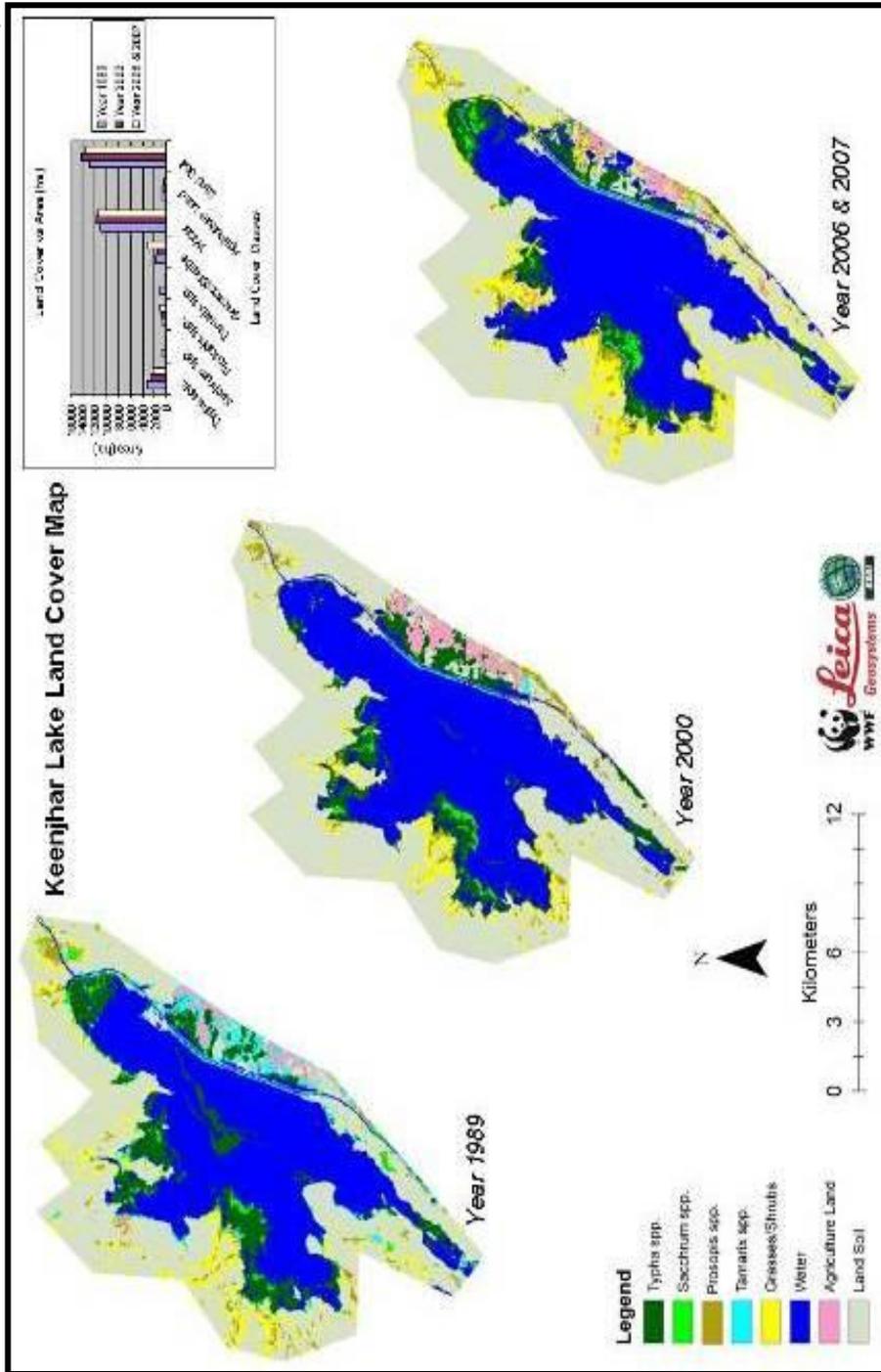


Fig. 2: Land Cover maps developed using Temporal satellite Images.

**Table 3:** Tabular representation of change in Land Cover area.

Land Cover Classes	Area (ha)			Difference (ha)	
	Year 1989	Year 2000	Year 2006	Year 2000-1989	Year 2006 & 2007-2000
<i>Typha</i> spp.	3317	2693	2422	-624	-270
<i>Saccharum</i> spp.	669	225	220	-444	-5
<i>Prosopis</i> spp	645	820	990	175	170
<i>Tamarix</i> spp.	1181	213	269	-968	56
Grasses/Shrubs	1932	1390	3122	-542	1732
Water	11090	11944	11420	854	-524
Agriculture Land	711	712	349	1	-363
Land Soil	12748	14296	13499	1548	-796

## CONCLUSIONS AND RECOMMENDATIONS

Decrease of 439% *Tamarix* spp. in 18 year period is an alarming fact. Measures should be taken to protect the remaining timber within the area.

LCCS proved to be an efficient tool for local level Land Cover mapping. It helped to develop legend with defined track back mechanism. This will be very useful in Land Cover standardization and integration at national/regional level. It is recommended to follow LCCS in Land Cover mapping for future research projects.

It is recommended to use developed Land Cover as an input in Universal Soil Loss Equation (USLE) soil extraction rate per year. The extraction rate will help to make decisions for the management of Protected Area.

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