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GIS in Demarcation, Management and Planning of Sand Mining Zone

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Abstract: ***The accelerated development activities in recent time have imposed immense pressure on rivers which acts as a treasure for the building sector. The main aim of the study was to prepare the block wise map demarcating legal sand mining zones according to the records of Mines and Geology Department of the State Government. The maps were generated with the aim of identifying illegal mining, overexploitation and to plan for further prospecting zones by the Mining Department. Sand mining zones have changed with the changing river course. Updated records were not being incorporated for long as a result of unawareness of proper technique. This has resulted in dispute areas especially along state boundary along Yamuna river, illegal mining, over exploitation and degradation of riverine ecosystem. Haryana government is fighting for long to solve this miss management. The study was performed along the Yamuna River flowing through the state of Haryana, India and is a small step taken to resolve the problem with accuracy using GIS technique.***

Keywords: Sand mining, GIS, Cadastral data, Encroachment

1. Introduction

There has been a distinct progress in built up area and infrastructure development worldwide. Advancement of information technology are contributing to lop sided increase in demand for resources such as sand in river streams, which has no substitute for use as building material in reinforced concrete cement [1] Recently the demand for construction material has increased in many parts of the world due to build complexes, private townships, flyovers, airports, metro railways, increase in highway lanes and other subsequent growth in infrastructure projects [2][3].To meet the growing demand on the way of modernization, construction materials such as sand, stone and clay are needed in large quantities [4][5][6][7]. Thus there is a need of regulated law bound mining activity at places where there is scope and source of this economic commodity. Or it may result in changes in the main channel cross-section like increase in the width-to-depth ratio [8]. Removal of commercially desirable grades of gravel can cause channel instability due to the role of gravel as armor for the channel bed [9]. Local reductions in bed level are also caused due to removal of sand from river bed. One such case occurred in the Tujunga Wash in California [10]. Mining pits, creating steeper temporary gradients, are associated with increased scour force [11] which can lead to migration of the pit [12] and in turn can produce scour several kilometers upstream and downstream in the area of the mining disturbance [13][14]. This activity seriously damage engineering structures such as bridges [15] causing heavy monitory loss. In-stream gravel mining has also been shown to have a variety of other effects, such as local water table changes [16] and decreases in sinuosity through meander cut-offs [17]. Yet little statistical work has been done to quantify relationships between mining and channel change. Removal of commercially desirable grades of gravel causes channel instability as gravel acts like armor for the channel bed [18]. Mining activities lead to changes in forms of channels, physical habitats and food webs [19][20][21][22][23], agricultural lands [24][25] and social conditions [26]. Mining pits, creating steeper temporary gradients, are associated with increased scour force [27] which can lead to migration of the pit [28] and in turn can produce scour several kilometers upstream and downstream of the mining disturbance [29][30]. This widespread scour activity can have serious monetary repercussions in the form of damaged engineering structures such as bridges [31][32][33][34]. In-stream gravel mining has also been shown to have a variety of other effects, such as local water table changes [35] and decreases in sinuosity through meander cut-offs [36], Mining of sand and gravels cause alteration in fluvial characteristics of river channels [37].

Geographic information systems (GIS) have gained increasingly widespread use in the past decade and have potential applicability to studies relating mining and floodplain land cover to channel changes. GIS have been referred to as 'an integrated package for the input, storage, analysis, and output of spatial information' [38]. Recently, GIS have been used in research areas where more manual techniques have traditionally dominated, from environmental modeling to land use assessment [39]. GIS now a days are used in geomorphology for mapping and modeling [40][41][42] and has the potential for assessing channel plan form change, as demonstrated by [43] whose study incorporated GIS to map plan form change in the relatively stable River Dee near the England/Wales border.GIS is considered as 'an integrated package for the input, storage, analysis, and output of spatial information' [44] Recently, GIS have been used in research areas where more manual techniques have traditionally dominated, from environmental modeling to land use assessment [45] Floodplain mining and river channel changes [46]identified, isolated and examined individually and in combination to explore relationships between them. This study can potentially be used in the decision-making process for managing river systems with the goal of minimizing illegal and environmental friendly mining activities and a better administration.

The construction boom in Delhi and surrounding National Capital Region (NCR) in Haryana has generated huge demand of concrete [47]. This triggered the quarrying of construction materials directly from the beds of the surrounding rivers and adjoining terraces in Haryana. The state has experienced large scale legal as well as illegal mining of construction material heeding to increasing demand of construction resources but not caring for the provisions made in several central legislations for conservation of environment and mineral resources. The illegal extraction of these resources, with generous help of political and bureaucratic big wigs, is so unbridle that not only are the region's precious natural resources being pilfered in a big way, its forests are being clean-felled, land degraded and its rivers threatened with extinction [48]. People dependent upon such activities seem to be least concerned about its environmental impacts, illegal quarrying was a common practice and rampant till the Supreme Court order that banned it in October, 2009. The lack of sufficient information regarding the negative effects of extraction activities has also been an important factor for laying strategies for the conservation and management of the small catchment rivers in the region. Therefore, the present study is a modest attempt to evaluate the impacts of mining of sand and gravels on land use/ land cover, vegetation and groundwater resources around the channel of river Dohan in Narnaul Block of district Mahendergarh in Haryana.

The present study was carried out in the state of Haryana, along the course of Yamuna River. The main aim of the study was to show how fruitfully sand mining survey can be done by using Remote sensing GIS techniques. This research used Cartosat and WorldView- II imagery to assess and monitor mining areas, which were then compared with data obtained from mining department. Considerable changes were noticed in mining areas. These changes were demarcated and new mining maps were proposed to the mining department of Haryana for up gradation of their data and auctioning of new mining areas.

2. Objectives

1. Preparation of GIS dataset for micro level planning
2. Demarcate the area of legal/illegal mining.
3. Identify the sand parcel that have encroached the river territory according to cadastral map.
4. To provide a set of guidelines and some strategic measures of conservation and monitoring to tackle the problem of illegal sand mining faced by Haryana Government.

3. Study Area

River Yamuna is the largest tributary of the Ganga River in North India. Its total length is around 1370 kilometers. Yamuna originates from the Yamunotri Glacier of Uttar Kashi in Uttar Pradesh. River Tons and Giri are the important tributaries of Yamuna and principle source of water in mountainous ranges. Yamuna flows through the states of Delhi, Haryana and Uttar Pradesh, before merging with the Ganges at Allahabad. World famous cities like Delhi, Mathura and Agra lie on its banks. After origin Yamuna river flows through several valleys for about 200 km in lower Himalayas and emerges into Indo-Gangetic Plains. In the Himalayan Segment (from Yamunotri Glacier to Tajewala Barrage) the river water quality is good and it meets all the standards also. Within this segment in Hathnikund / Tajewala in Yamuna Nagar district of Haryana state, river water is diverted into Eastern Ya-muna Canal (EYC) and Western Yamuna Canal (WYC). Generally no water is allowed to flow in the down-stream of the Taje-wala Barrage especially during summers and winters to fulfill the water demand of the surrounding districts. Due to this the river remains dry in many areas between Tajewala and Delhi. After crossing a route of 224 km Yamuna enters Delhi. The Yamuna water is again trapped by Wazirabad barrage. Usually no water or extremely little water is allowed to flow downstream of this barrage during lean seasons. There is another barrage Okhla barrage 22 km downstream of Wazirabad. From here Yamuna water is diverted into Agra canal. River water is not allowed to flow downstream during summers; beyond the Okhla barrage. Yamuna River after receiving water through other important tributaries joins the river Ganga and the underground Saraswati at Prayag (Allahabad) after traversing about 950 km.

Sand brought down by a river in its channel is deposited on its banks over a period of time. A boulder from the mountain falls into the river, get churned along the way to form fine particles of sand by the time it reaches the plains. "The river is like a factory that converts boulders into sand. It takes thousands of years for a rock near Goumukh, the source of the Ganga, to become sand at the Sangam in Allahabad," says Anupam Mishra, environmentalist at the Gandhi Peace Foundation. This sand deposits on the sides of the river, forming a strong bank over the years that absorbs the force of the water and does not let it go out of its channel. For ages, people have used sand from the river banks for construction. They would dig out just enough for their requirement and let it replenish. But with the construction boom in the country, the builders do not think twice about extracting the freely available material. It takes minutes to remove a few trucks of sand with an excavator and weaken the bank. The new soil that fills up the banks as a result is not so strong to absorb a gush of water, forcing a river to leave its channel.

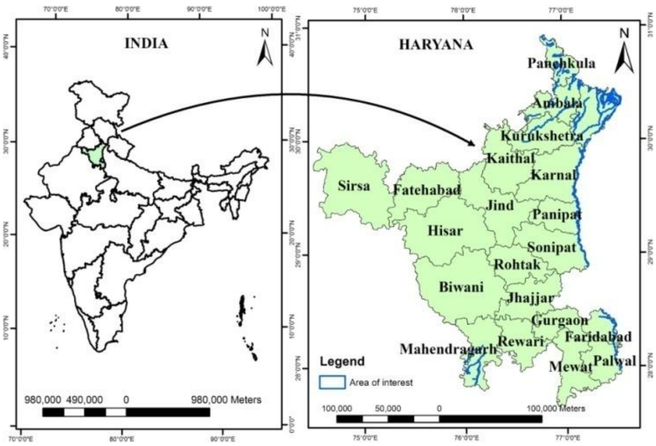

Figure1- Study area

Study area as shown in figure 1, consist of 10 districts of Haryana through which the river Yamuna passes, namely Ambala, Panchkula, Faridabad, Mahendergar, Palwal, Kurukshetra, Karnal, Yamunanagar, Sonipath and Panipath. Further these districts consist of a total of 64 blocks and 293 villages.

4. Geospatial Technique in Mining Activity

In the era of information technology with rapid advancement in computing, decision making has become more informed and scientific [49]. In this situation geospatial technology has strongly developed with diverse application. It has been identified as one of the most emerging field because of providing unbiased, repetitive and synoptic nature of data as well as tool for integration of information for analysis, which is very useful in management and monitoring natural resources [50][51][52][53][54][55][56]. The satellite data provides a permanent and authentic record of the land-use patterns of a particular area at any given time, which can be re-used for verification and re-assessment. Geospatial technology is a multidisciplinary field that includes discipline such as Geographic Information System (GIS), Global Positioning System (GPS), Remote sensing, photogrammetry and mapping. According to the U.S. Department of Labour 2005, now a days, Geospatial techniques are considered as an information technology field of practice that acquires, manages, interprets, integrates, displays and analyses data focusing on geographical, temporal and spatial context [57]. This paper discuss the application of GIS and GPS tools in managing and monitoring sand mining zone on a river basin. Hence, a geospatial technique based visualization and analysis of mining zone marking has been attempted all along Yamuna River flowing through Haryana state.

5. Data Used

5.1 Satellite data –Cartosat, Wordview-II

5.2 Software used – Arc GIS 9, Microsoft Office 2007

5.3 Other data used –Toposheet maps of survey of India with 1: 50,000 scale were used to locate and identify villages. Attribute information of mining areas consists of village names, there areas and Khasra Numbers of the year 2012.

6. Methodology

Step by step methods of block wise map generation are as follows:

1) Attribute information about the mining area was provided by Mines and Geology department of Haryana which consist of village names, their areas and Khasra Nos.
2) The mussavies (village base map) of the mining area concerned were collected from Revenue department
3) The mussavies were then scanned.
4) Cadastral layer were then prepared by digitization on these scanned mussavies
5) Cadastral layers thus obtained were then rectified based on the satellite data.
6) After that Block wise mozaicking of digitized cadastral layers of concerned villages were carried out.
7) Latest River course was digitized from the satellite image.
8) Change detection of the data provided by the mining department for the study area is carried out with the latest satellite imagery.
9) Composition of Block wise Maps were done.

7. Description of Output

Observing the pattern of mining along the Yamuna River we can broadly divide it in to two types. Firstly inside River bed which was further subdivided into in stream mining and out stream mining, and secondly outside river bed.

7.1 Inside River Bed - Inside river bed mining refers to the mining that takes place within the river channel. Since the river channel has two parts active and passive so the mining types are also divided into two parts.

In stream mining which takes place in the active channel part, it is an underwater mining process. In this heavy machinery technology like stone crusher, cranes are used for sand extraction from the river basin.

The out stream mining process. This takes place in the sediment bars i.e. the channel bars and point bars where there is considerable sand deposit. As these are the main points on a river channel where deposition takes place and they can be easily identified from satellite images in dry season data as white patches due to high reflectance.

7.2 Outside River Bed - Outside river bed mining refers to the mining that takes place along the abandoned channels, younger flood plains or older flood plains. That is it lies away from the active channel and no water is present. These places also have high reflectance due to presence of sand and can be easily identified from the satellite image.

The block wise map of study area was prepared on high resolution satellite data (world view). In these maps the villages and its khasra numbers are being highlighted which fall on sand deposition area and mining activity is taking place or can take place in future. Sand deposition area are easily interpreted from satellite imagery because of it high reflection and lighter color tone from the surrounding areas which do not have any sand reserve. As mentioned earlier two different types of maps were composed, namely Inside river bed maps and Outer river bed maps. In inside river bed maps the khasra numbers were calculated after extracting the intersected area of village and river course area and then the data base is generated. In outer river bed maps deep deposit area information provided my Mines & Geology department are being highlighted and there areas are being calculated in ArcMap software.

Apart from this Block wise maps were prepared and each block was scrutinized carefully for illegal mining as shown in figure-2 and figure-3. A total of 9 districts, consisting of 293 villages were composed and each block was suggested with required corrections.

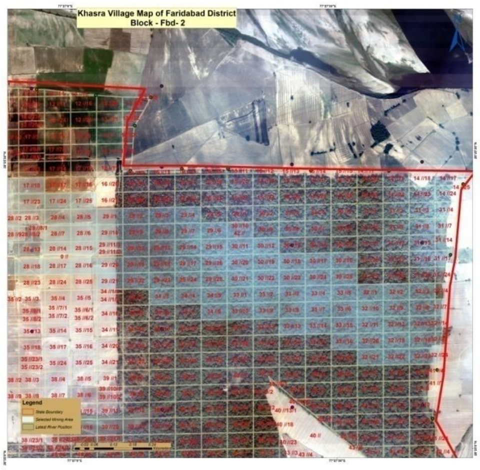

Figure 2: Showing mining area (as on auction list 14th August 2012) encroachment over forest.

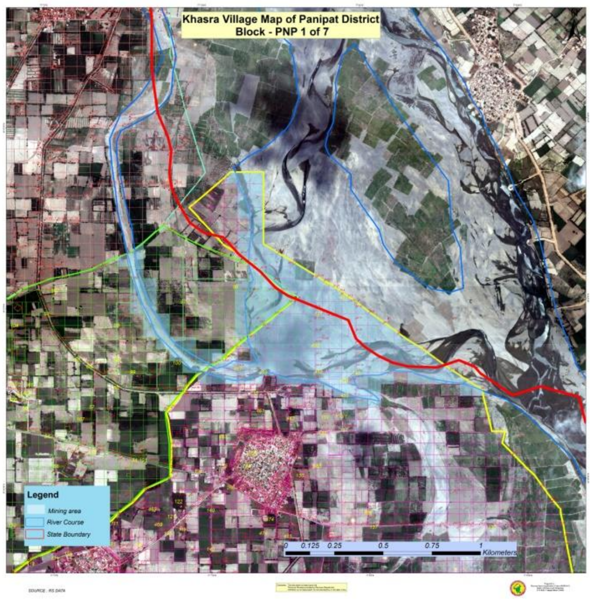

Figure 3: Showing mining area away from state boundary.

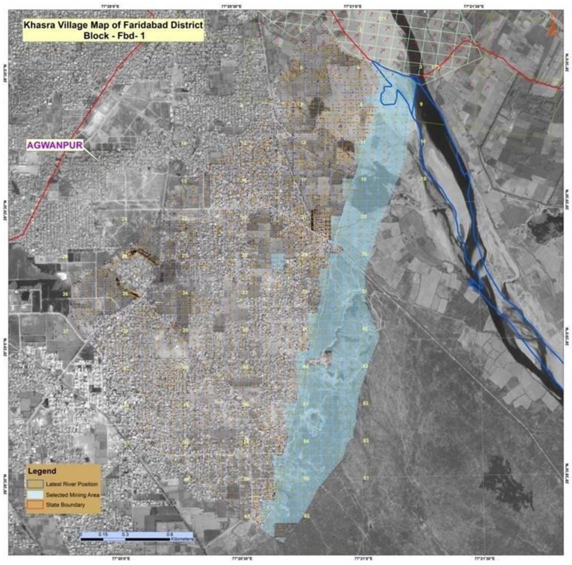

Figure 4(a): Showing mining area (as on auction list 14th August 2012) on built up land.

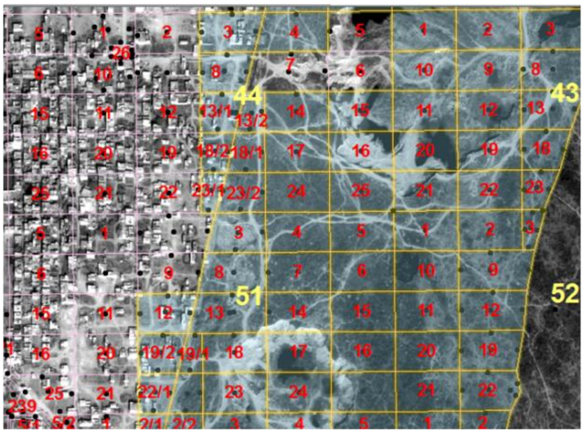

Figure 4(b): Zoomed map of Faridabad block 1, mining area (as on auction list 14th August 2012) on built up land

8. Conclusion

Sand is required but at what cost needs to be answered – a sound basin wide assessment of resource replenishment rates to be monitored and revised with the rapid changing climate and hydrological cycle. Alternative to sand for use in coal mines, rationalization of construction activity with optimal usage of alternative but equivalent sturdy materials. Material research should be given emphasis to test in different uses and environments. Demarcations of quarry lease boundaries are to be brought up in public domain to strengthen monitoring and checking violations. Rivers being common property have several tangible and non-tangible benefits to different stakeholders, monitoring thus cannot happen without taking into account these stakeholders. This could become part of the environment management plan itself. State Empowered and Coordination committees exist and formed in several states, emphasis to bring implementable options at the forefront. Primary joint analysis of ecological regime of different river zones if made mandatory will enrich understanding from the existing level and also make states more accountable to resource protection. State's auction rates thus could be rationally increased and dedicated to such conservation efforts and implementation with a dedicated team. Enabling provisions in the cooperative legislations to enable mining of minor minerals wherever feasible by local cooperatives and reviving the traditional cooperative societies at state level and working with such cooperatives on systematic mining practices to draw out a mining framework through understanding local's perceptions on various facets of extraction and damages.

From the study we see that:

1) Satellite imagery can provide a cost effective method of monitoring of mining areas.
2) Satellite images can be used to provide a quantifiable monitoring of mining sites.
3) Modeling of medium spatial resolution imagery can assist in maximizing the use of such images in monitoring progress of mining area.
4) Satellite derived assessment can be more cost effective compared to intensive field-based surveys.

9. Limitations

The present project work is my humble amateur effort to know the utility of remote sensing and GIS software tools in the field of mining. There are some known limitations while there may be numerous others that are yet unknown. Today sand mining is a national phenomenon because of excessive exploitation of sand from Indian rivers.

1. The primary limitation in study is difficulty in field visit for observation of sand mining because of sand mafia.
2. Secondly data provide by Mines& Geology department and other departments are old and are not updated with later date and changes.
3. Other limitation is that Dixit Award.

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