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Kharlands-An Agrarian Disaster in Coastal Areas of Southern Ratnagiri, Maharashtra: A Study Using Remote Sensing and GIS

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Abstract :- In recent years the study of coastal resource is very essential that provides information to enable its bearable use. Coastal zone is involving various resources, naturally complex interface between the ocean and land and providing useful products for economic development of the region. The term coastal zone is a spatial zone where interaction of the sea and land processes also occurs, both the terms coast and coastal area habitually used to describe a geographic location or region. The coastal resource includes differential ecosystems like swamps, mangroves, sea grass, salt marshes, mud flats, estuaries etc. Agricultural land is significant natural resource in the area; provide food products to the locals. In the coastal zone of Ratnagiri, most of the agricultural lands along the banks of the estuaries or near the sea are converted to saline land also called as kharlands. Such expansion of the kharlands in the study region shows rapid land degradation in the area. The application of Remote Sensing and GIS is most suitable technique for coastal resource management. GIS based analysis gives better results and effective strategies for the mitigation of such affected coastal zones. Thus coastal kharland areas in southern part of Ratnagiri have been mapped and analyzed using Landsat TM, google earth images and SRTM data.

Keywords: - Saline land, Land degradation, Agricultural disaster - Crisis, Reclamation, Sea grasses.

I. INTRODUCTION

Rural and urban population of India directly or indirectly depends on agriculture. Agriculture typically depends on the climatic condition and soil type of the region. Moreover, agriculture relies on monsoon, if rainfall exceeds it causes flooding and destroys crops and if rainfall decreases, gives rise to drought conditions. In both ways, agriculture is affected and provides inadequate food grains. Coupled with the natural calamities and human activities, land is degraded rapidly. Now days, over exploitation of agricultural lands with uncontrolled irrigation water, excess use of fertilizers resulting land degradation. In coastal areas, agricultural lands become kharlands due to intrusion of sea water. Such type of land degradation and salinization are the major threats to agriculture system and come to be agrarian disaster. The dynamic processes that occur within the coastal zone produced diverse and productive ecosystem which have been of great importance, historically for human population. Available resources are considered to be a common property and are in high demand for coastal product for subsistence use and for economic development. The coastal area of Ratnagiri is having very limited agricultural lands that has also affected by salinity problem. Therefore management of agriculture in coastal zones is significantly necessary with scientific study. In view this; an attempt has been made to study the kharland areas in southern coastal part of Ratnagiri.

In the study sites mudflat, salt marshes, coastal rice farms, kharland etc. are protected by sand spits, sand dunes and sand bars. Mudflats are the temporary accumulations of thick fine-sediment with organic matter, clay and silt that form sub-circular depositional areas along the estuaries and at the mouth of the estuaries extended up to the offshore zone [1, 2]. Most of the kharland areas are developed in the vicinity of such landforms. In India, the saline soils are identified and recognized by different local terms, such as Khar or Kshar in Gujrat and Maharashtra; Usar or Reh in Uttar Pradesh; Luni in Rajasthan; Chouddu or Uppu in Andhra Pradesh; Chopan, Choulu, in Karnataka and Kari, Papali, Kaipad or Khar in Kerala [3, 4, 5,]. Surplus salinity affects soils in various methods. It reduces water availability to plants, because the osmotic pressure of the soil solution increases with the increase in salt concentration and the plants are unable to extract water easily from soil. Another effect is that, the higher amount of salt concentration and absorption is much toxic to some crops

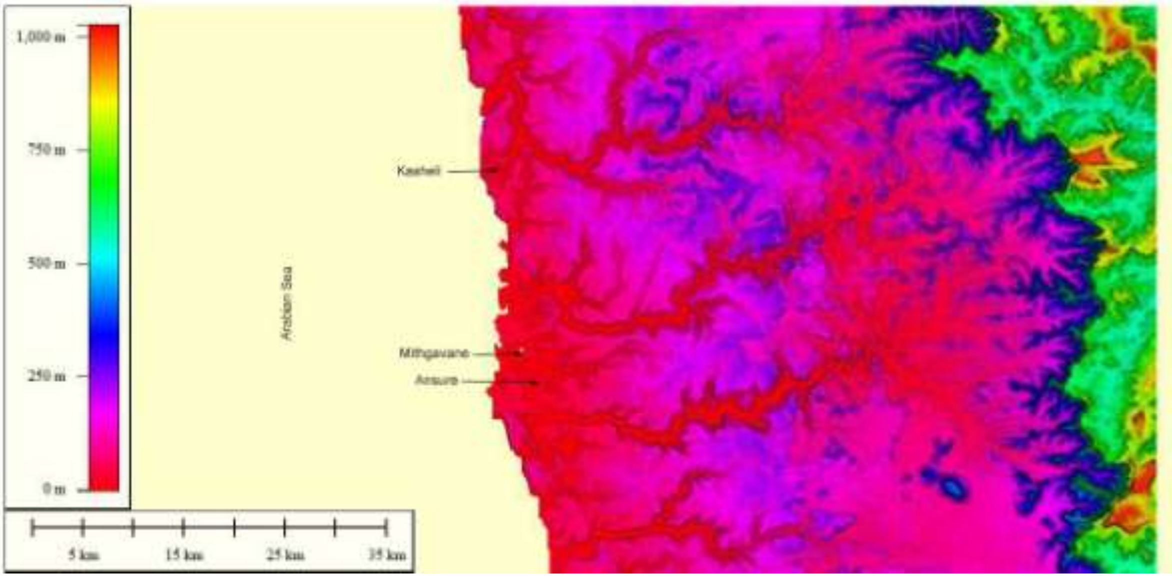
[6]. Therefore, agriculture is a complex and critical sector of the Indian economy. Its involvement to the overall Gross Domestic Product (GDP) of the country has fallen from about 30 percent in 1990-91 to less than 15 percent in 2011-12, a trend that is expected in the development process of any economy, agriculture yet forms the backbone of development. An average Indian still spends almost half of his/her total expenditure on food, while roughly half of India's work force is still engaged in agriculture for its livelihood [7]. With an increasing pressure of population and a decreasing per capita availability of cultivable land, there is a need to improve cropping pattern [7]. Hence, coastal resource management with considering rehabilitation of degraded lands due to salinity requires accurate, up-to-date and comprehensive scientific data on the basis of remote sensing techniques. Land Sat TM, IRS-I B and LISS – I has been used by Dwivedi et.al in 1999 for detecting water logging areas in their research studies [8]. Periodically, changes occurs in agricultural crops , their diseases, crop damages , increase in soil salinity and many other degradational processes can be access using remotely sense data and images. Long-term monitoring of changes in land degradation is usually accomplished by spatially comparing multi-temporal satellite images, a technique known as change detection. A number of change detection techniques have been devised for this purpose, such as transparency compositing, image differencing, post classification comparison, band and principal components analysis [9]. Gao in 2008 used two types of medium-resolution satellite data i.e. Landsat TM and ASTER for assessing rigorous degraded land in the forms of salinization, alkanization, waterlogging and desertification in his study area [10].

According to Panjab Singh, GIS can be used as decision support system to identify, monitoring and predicting hydrological hazards, which are the major environment risks for Indian agriculture. It is emerging as pioneering technology of great significance and may serve as a powerful tool for planning and governance, together with disaster management education [11].

The quality of soils in study area is under the process of degradation. The foremost fear to agricultural soil quality arises from salinization, water-logging and intrusion of saline water from adjacent sea. There is an adverse effect of such processes on crop productivity of the region. The major crop in this region is rice, but the annual yield of rice is decreasing day by day. In view of the serious problem that occurs in the region, there may be an alternative option to change the cropping pattern in the salinity affected areas. The traditional crops must be replaced by the new varieties with salinity tolerant plants/crops. Central Soil Salinity Research Institute (CSSRI) is a research institute that carries interdisciplinary research on basic, strategic and applied researches on the reclamation and management of salt affected soils and poor quality water in agriculture. According to report of CSSRI, approximately 6.73 million hectare area in India is salt affected. For coastal areas where water congestion is often a problem, shallow, medium deep and deep water depth tolerant rice varieties have been introduced [12]. At present many authors and research scholars have suggested to adopt salt-resistant varieties of rice in the regions of salinity affected lands [13]. According to CSSRI, the recent improved rice varieties in coastal saline soils are SR 26 B, CSR 1, CSR 2, CSR 3, CSR 27, CSR 13, Panvel 1, Panvel 2, Panvel 3, Pokkali (in Kerala only), Vytilla 1 and Vytilla 2. CSR 22, CSR 23, CSR 26, CSR 27 and CSR 30 have been identified to suit sodic soils. Salt tolerant rice varieties like Pokkali, Vytilla 1, Vytilla 2, Vytilla 3, Vytilla 4 and Vytilla 5 have been developed by the Kerala Agricultural University to solve the coastal salinity problems of the state. SR 26 B from Orissa, Kalarata, Bhurarata, Panvel 1, Panvel 2, Panvel 3 from Maharashtra are also improved varieties [12, 14]. Beside this; several halophytes have potential agricultural value and can be grown in the degraded saline areas. These plants may produce considerable biomass. Many of the salt-tolerant species are of industrial application and may be grown as commercial crops [15].

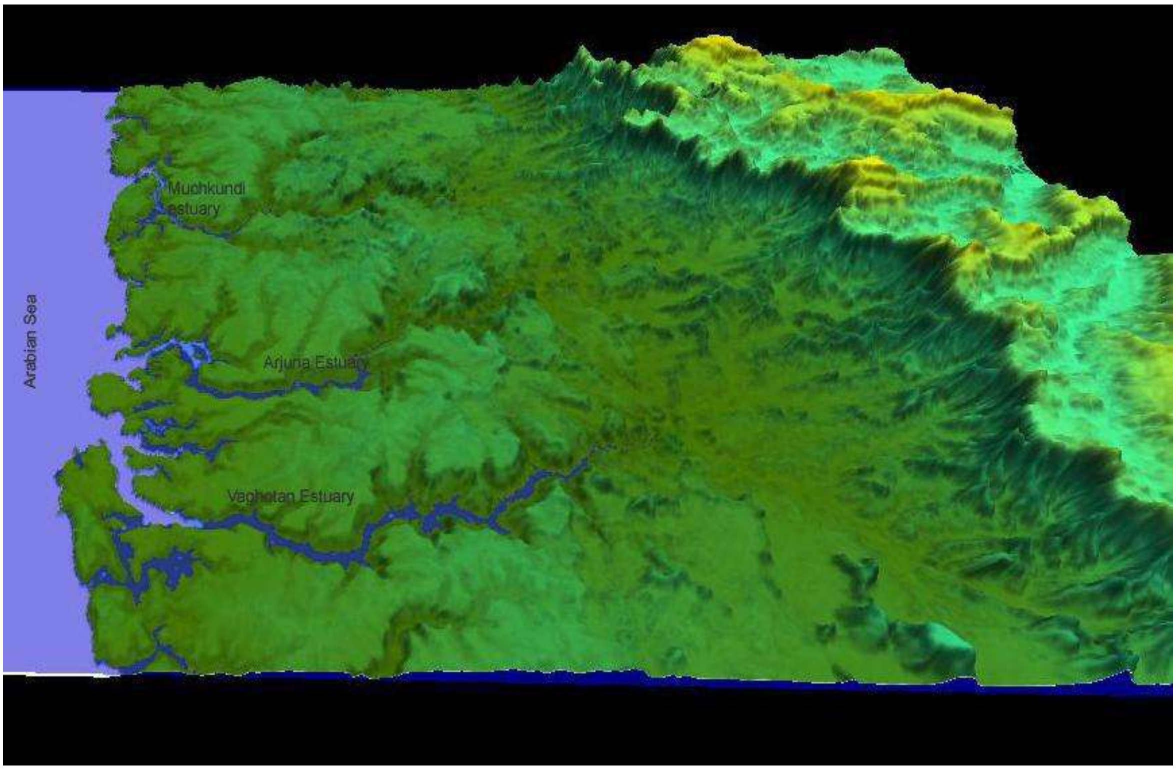
In Ratnagiri district, on an average total 72.45 % of land is considered and suitable for agricultural activities but, only 45.95% land is used for agricultural purpose and crop cultivation [16]. According to the statistical report and Agricultural department of Ratnagiri district in the year 2011-12, near about 0.72% land is covered by forest. Report also indicates that, 27 percent land is not used for agriculture, 40% land is barren and waste land that is not used for cultivation, only 32% land was under cultivation. That means near about 271804 hectares of land was under cultivation. Pulses and cereals accounts for 37%, rice cultivation accounts for 28% and remaining are accounts for vegetables and fruits [16].

In view of the agricultural crisis occurs in study region, Remote Sensing images are significantly useful to identify the sites of interest and identify its problem. Such images are also useful for regional and resource



Source: ***Based on SRTM data.***

Fig. 1 : Location map and DEM of Study area



Source: ***Based on SRTM data.***

Fig. 2: Three –D view of Study area

mapping, environmental assessment and natural hazard management. Land degradation in terms of soil erosion, water logging, excess use of water through irrigation , use of fertilizers , salinization, coastal salinity, etc are the major threats to agricultural production. This minimizes food supply to the growing population, makes a serious agricultural catastrophe. Hence, the study is essential to monitor the degradation of land i.e. increasing salinity so that conservative measures can be undertaken to minimize the problem.

Table No. 1 : Details of villages

Name of village	Total population	House hold	Village Area in hectare
Kasheli	2003	467	545.26
Mithgavane	1735	369	1087.88
Janshi	403	96	227.03
Ansure	2113	536	813.56

II. STUDY AREA

Ratnagiri district is located in the Southwestern part of Maharashtra state along the Arabian Sea. It is a part of a greater tract known as Konkan. It lies between 16˚ 30' and 18˚ 04' North latitude and 73˚02' and 73˚ 52' East longitude with a coastline of 167 km. The Savitri River in the North separates Ratnagiri from Raigad district also forms the Northern boundary of the district; on another hand Satara, Sangali and Kolhapur districts forms Eastern boundary; on the western sides there is an Arabian sea, and Sindudurg district comes in the south, separated by Waghotan River. Administratively Ratnagiri district is divided into 09 tehsils as Mandangad, Dapoli, Khed, Chiplun, Guhagar, Ratnagiri, Sangmeshwar, Lanja and Rajapur. Ratnagiri District can be physiologically divided into 3 zones, includes the coastal zone, the middle zone and the zone of hilly area. The coastal zone extends about 10-15 km from sea coast towards the eastern side and generally has low altitude. The average rainfall is about 3188 mm. Most of the activities in this area are connected with sea. Most of the land is covered by lateritic soil [17]. The study region has a limited agricultural land in low levelled areas, mostly used for rice cultivation and seasonal cereals. The undulating land with lateritic surface is mostly covered with mixed wild vegetation and trees.

The average depth of the soil is 1 to 1½ metres only; therefore moisture holding capacity of the soil is very less. In the area most of the agricultural land is not suitable for major crops. The study region for kharlands has considered the Kasheli, Mithgavane and Ansure-Janshi villages (Fig. 1) of southern Ratnagiri that comes under the basin area of Muchkundi, Arjuna and Waghotan estuaries (Fig. 2). The details of the villages are given in table no. 01. The actual area of Saline land in the above villages has estimated with the help of Remote Sensing and GIS techniques.

III. DATA BASE AND METHODOLOGY

There is a great challenge to provide sufficient food grain from the available agricultural fields in this area. Agricultural crisis occurs due to such saline lands and there is an urgent need to access the land degradation processes and salinization. Therefore, identification of kharland areas is essential to study sustainable land use and its management. The field investigation consisting of observation and interviews for collecting information/identification of kharland area have carried out in the study area. Data regarding salinity affected sites in the area have generated by using SRTM data and Remote Sensing images i.e. Landsat TM and Google earth images. The collected data and information has analyzed with statistical and GIS software's like Global mapper. Some locational data collected using GPS with Ground Control Points (GCP) used for Georeferencing of map. The estimated area of kharland in the village Kasheli, Mithgavane, Ansure-Janshi have calculated and delineated from the images using GIS softwares. Contours for the study area were generated using SRTM data and Global Mapper software (Fig.3, 4, 5). For the different sites, inundated saline land has projected at various water levels and depths from mean sea level (Fig.6). In the kharland of Kasheli (Fig. 6-1), Mithgavane (Fig. 6-2) and Ansure-Janshi (Fig. 6-3) the saline water from sea enters through estuaries and small tidal inlets, therefore inundated area with various water levels and heights were predicted. In figure 6, 'a' part indicates water level with 0 metre and 'b' part indicated inundation (dark blue colour) with a height of 8 metres, which submerge most of the agricultural lands in the villages. The coastal zone are now highly disturbed and threatened due to rapid increase of population and development activities along the coast. Remote

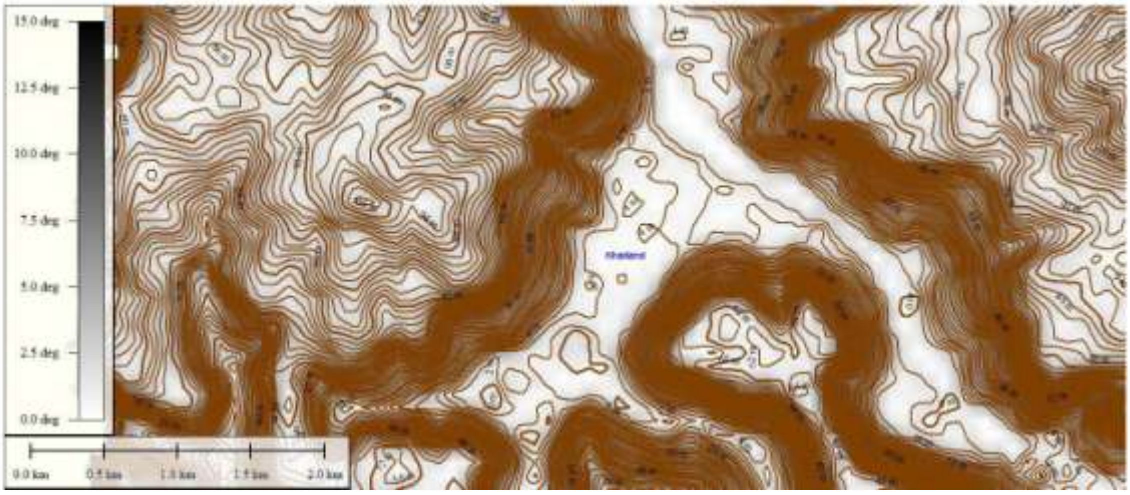


Fig. 3 : Contour map generated for Kasheli site using SRTM data.

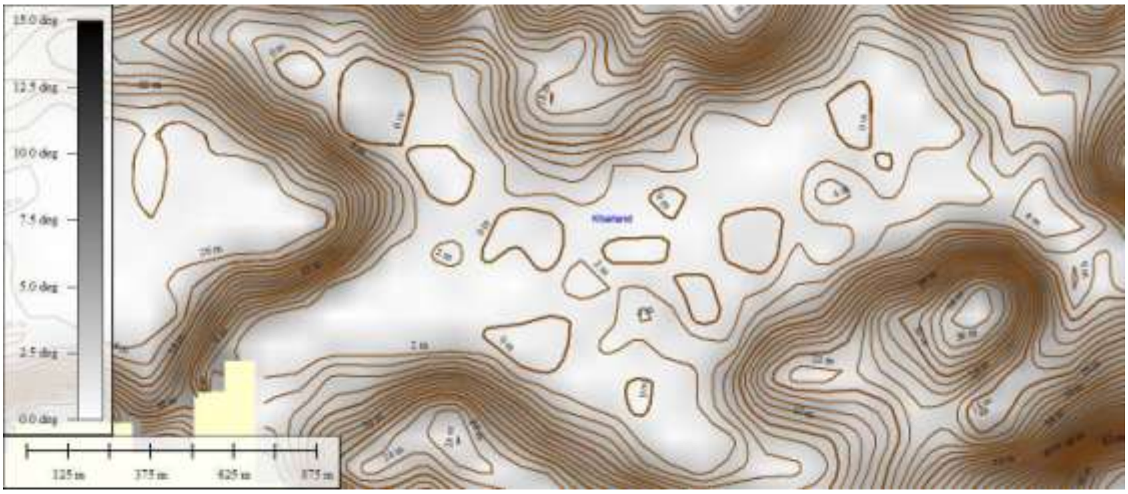


Fig. 4 : Contour map generated for Mithgavane site using SRTM data.

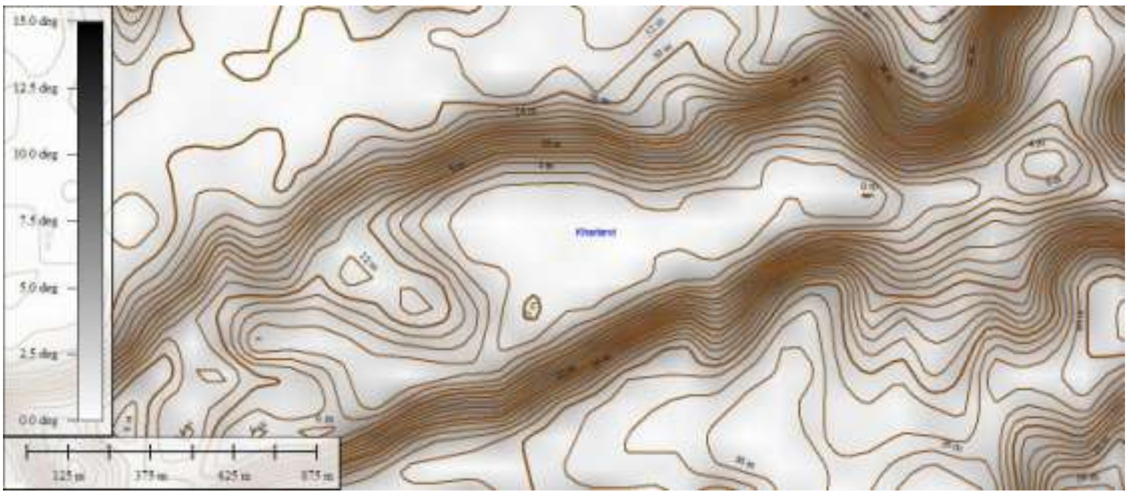


Fig. 5 : Contour map generated for Ansure site using SRTM data.

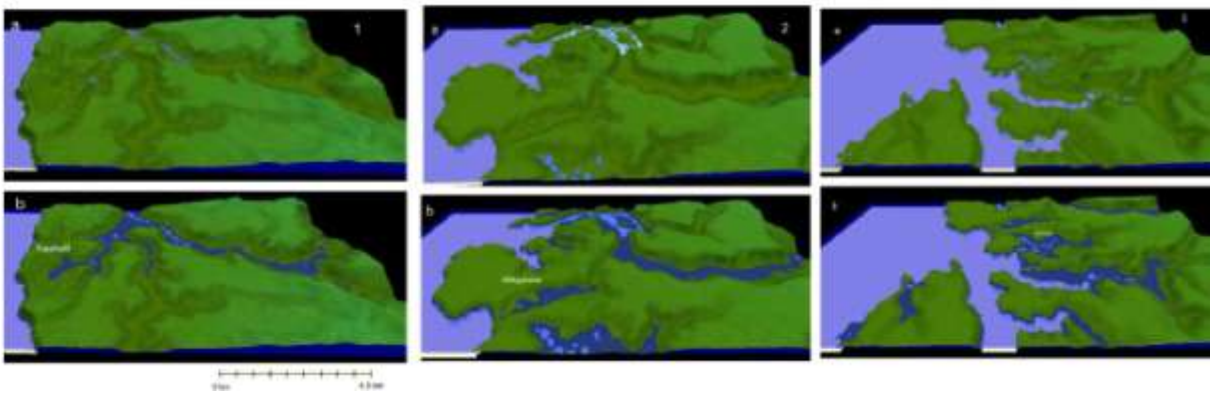


Fig. 6 Khar land inundated area of Kasheli (1-a, b); Mithgavane (2-a, b); Ansure-Janshi (3-a, b) at 0 metre and 8 metre depth from msl.

Sensing data have been found to be extremely useful to provide information on this aspects and major problem. Hence an attempt has been made to use such type of advanced tools and techniques for the present research work.

Table No. 2 : Estimated Area of Kharland

Name of village	Area in Square metres
Kasheli	5,23,535
Mithgavane	3,88,118
Ansure - Janshi	6,36,439

IV. RESULTS AND DISCUSSIONS

As above, kharland means the land which is submerged under the sea water during high tide. Mostly the salt contained sea water enters agricultural low lands through estuary and tidal inlets. Such low levelled agricultural land inundated with this saline sea water for few hours and evacuated during low tide. This process have a tendency to increase the quantity of salinity in the upper most layers of soil and fertile lands become unfertile and called to be kharland. Degradation of agricultural land in terms of salinity affected lands was studied in three major sites of Kasheli, Mithgavane and Ansure-Janshi villages. TM images, google images and SRTM data have used to identify the saline area with long grasses in the study region of southern Ratnagiri. The appearance of salt affected areas was confirmed with ground reality and delineated the kharland areas using remote sensing images and GIS softwares. The delineated estimated area of kharland and interpretation results from remote sensing images and ground truth field observations gives the appropriate information about the salinity affected agricultural lands. Table no. 2 shows the estimated areas of kharland (excluding the area of mangroves) and reveals that 5,23,535 square metres area has affected by salinization in Kasheli (Fig. 7). Land degradation is continuously increased in this area. Near about 3,88,118 square metres and 6,36,439 square metres of saline land has estimated in Mithgavane (Fig. 8) and Ansure-Janshi (Fig 9) villages respectively. These kharland/saline lands are not suitable for the cultivation of major crops even rice, but can be suitable for coconut plantation. In the kharland of Ansure –Janshi approx. 41,797 square metres have reclaimed for the coconut plantation (Fig.10). At the same site more or less 3,16,192 square metres have been reclaimed for shrimp/prawns farming and also used as a salt pans. Major part of Janshi and Ansure is inundated with saline water (Fig. 11, 12). It has also observed that, nearby kasheli site approximately area of 11, 92, 385 square metres is covered by mangroves along the Muchkundi estuary between Gaonkhadi to Kondsar village. Study also reveals that, at this site north eastern side of mangroves are protected, but degradation of mangroves have seen at the western side towards village. In the area of Kasheli and Janshi, villagers are approaching to use their rice fields and saline lands for aquaculture or prawns farming. This gives more profits and benefits to farmers. In

Fig. 7 : Kharland of Kasheli village

Fig. 8 : Degraded Rice farms of Mithgavane

Fig. 9 : Janshi village-Kharland with Sea grass .

Fig. 10 : Janshi village -saline land.

Fig. 11 : Mangrove degradation near Janshi.

Fig. 12 : Inundated saline water at Ansure

Kasheli and Janshi the kharland that has used for prawns farming will also influenced on the adjoining rice fields. Some farmers had converted the traditional rice fields into prawns' farm; there is a high risk of agricultural degradation/crisis. Continuous stagnant saline water throughout the year infiltrates into the ground and also increases the salinity of fresh ground water table. This salt contained water effects on the surface soils when used through wells and tube wells. Thus coastal agricultural tracts of the study area are more vulnerable to salinity. New varieties of salinity tolerant crops should be introduced for cultivation in these areas. There is a need to change the cropping pattern scientifically. After harvesting of kharif crops, rabbi crops should be introduced with some vegetables that favours climate and soil type. In some part of the study area, coconut plantation is the appropriate option, also gives its byproduct as coir. Cashew nut, Betel nut and Casuarina are another horticulture plant that can grow in this area.

V. CONCLUSION

Among the three major sites considered for study, Ansure-Janshi villages having large area of degraded- kharland with a size of 6,36,439 square metres. The saline water from sea enters through estuaries and small tidal inlets at the time of high tide and inundated most of the agricultural land. There should be control over the direct entrance of saline water into the agricultural land. To mitigate from this salinity problem earthen bund should construct across the entrance according to the rules of coastal regulation zone. But in view of the mangrove conservation practices, construction of bunds under the scheme of kharland development may not be suggested at the opening of the estuaries, wherever sea water enters into estuary or tidal inlets. There may be a threat to mangrove destruction due to such activities. Therefore, best option is to grow salt tolerant plants and crops that may survive in such conditions in kharland area. Justifiable policies and schemes must be developed to improve agricultural yields in the salinity affected agricultural lands.

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