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Wastelands Management for Sustainable Development: A study of lower Jia Bharali basin in Sonitpur district, Assam, India

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Abstract: In the present study, an attempt has been made to evaluate the status of wastelands for its management through optimum utilization of existing natural resources. With this objective, a detail study of the major terrain and morphometric parameters that influence land management is made through preparation of thematic maps using satellite imageries and toposheets in GIS environment. A multi criteria evaluation of the study area is carried out adopting GIS tool to obtain a land suitability model for cropland, grazing land, forestry and woodland forestry land-use options.
Keyword: Sustainable , Management , geographical , ecological.

INTRODUCTION

India occupies approximately 2.4 percent geographical area of the world, while it supports fifteen percent of the world population. Unprecedented population pressure on land, water and biological resources and resultant degradation of these resources are adversely affecting the stability and resilience of our ecosystems and the environment leading to creation of wastelands.

Wasteland may be defined as the land with ecological constraint and economic potentiality which are not being used to their optimum potential. However, keeping geo-environmental conditions of Northeastern region of India including Assam, a working definition has been applied in the present study. As per the definition "Wastelands are those miscellaneous land types which are not presently suitable for, or capable of, producing materials or services of value due to some constraints ranging from geo-environmental to socio-economic causes" (Deka and Bora, 2002). Based on this definition existing wastelands of the study area can be classified into two main categories such as culturable and unculturable wastelands.

The massive land degradation, which has been accelerating the process of wastelands development in this part of the world, is not only posing threat to environment by causing ecological insecurity, but also to the socio-economic development. Wasteland evaluation is, therefore, of great significance to realize the full potential of the available land resource and to prevent its further degradation. Hence it is very much momentous to plan for management of wastelands in order to protect its prospective values.

The objective of this paper is to identify the cultural wastelands for sustainable use of natural resources, through bringing the wastelands under suitable land-use to ensure a harmonic socio-economic growth and ecological development within the carrying capacity of the local ecosystems. In an ecosystem, terrain characteristics have their enduring impact on wasteland development and genesis (Deka, 2008). As such evaluation of terrain characteristics is indispensable for wasteland management and to determine the suitability of the existing wasteland.

In this study, considering the wastelands resources four types of land-use options such as crop land, grazing land, forestry and woodland forestry have been taken based on physical and morphometric variables to find out their suitability levels and to identify the wasteland resource for effective planning to accomplish sustainable development of the study area.

The Study Area

The lower Jia Bharali river basin covers an area of 890.84 km2 that lies between the 26036'45"N and 27002'18"N latitudes and 92036'07"E and 92059'58" E longitudes. The basin extends from Bhalukpong in the north to Rajbharal where it meets the mighty Brahmaputra. The river originated at an elevation of 4520 m of the Himalayan range and traverses a distance of 247 km to its confluence to meet the mighty Brahmaputra. The river enters the state of Assam near Bhalukpong (27001'04"N and 92039'05"E) through the Siwalik ranges in a south and south-easterly direction. After entering into the state of Assam the river flows downstream amidst of plain lands for a distance of 72.40 kms to debouch into the Brahmaputra river.

Based on the geological accounts of Survey of India and the works of Verma and Tandon (1976) and Balasundram (1956) the geology of the basin could be characterized as Quaternary sediments that occurs extending from the foothills in the north to the Brahmaputra river in the south. The lithology and fossil assemblage found in this location indicates fluvial environment of deposition.

The study area being located in the humid sub-tropical monsoon region of South-East Asia is characterized by two seasons, the summer and winter. This region receives an average annual rainfall of 130 cm to 170 cm in the month of April-May. The average maximum and minimum temperature recorded are 32º C and 10º C respectively with a relative humidity of more than 86 percent.

METHODOLOGY

Primary Data

The Indian Remote Sensing (IRS)-P6 Satellite Linear Image Self Scanning (LISS) - 3 sensor data of 29th February, 2008 were collected and registered to Survey of India (SOI) topographical sheets at 1:50,000 scale in the Super Map Express version 10 and Spatial Analysis GIS system (ArcGIS version 9.3).

Secondary Data

The weather data of Bhalukpong are taken from Meteorological Centre, Barjhar, Guwahati, Assam. Survey of India toposheets of 1:50,000 scale of 1971 publication are procured from Survey of India, Shillong. Information on administrative boundaries like villages is collected from the Chariduar Circle Office and Ghuramari BDO's office that comes under the study area. Forest boundaries (Range, Division) are obtained from the DFO office, Sonitpur Division.

REMOTE SENSING DATA

Digital image analysis techniques are used to retrieve thematic information such as wastelands distribution, morphometric analysis, geomorphology, Soil, land-use, ground water, etc. applying over the IRS data. The software in this connection has been used Supper Map Express / Arc GIS software. The data of IRS 1C/P6 LISS III in digital format were used for further analysis.

Digital Elevation Model (DEM)

Using contours and spot heights a DEM is created. Based on the DEM a detailed slope map is retrieved.

By using ArcGIS 9.3 software a number of thematic maps has been overlaid on each other and viewed. The land suitability is derived by overlaying thematic layers such as soil, land use, slope, geomorphology and different morphometric parameters. The overlay helps to combine the spatial data with the corresponding attribute files.

Distribution of wastelands

The distribution of the wastelands in the villages of the study area reveals the resource base of the locality which is still untapped for their development. In the study area there are eighty-seven villages. From the wasteland distribution map (figure 1) it is found that the undulating upland with or without scrub land occupying 5.95 km2 area (table 1) and are distributed in Maranakuri, Tangni Jhar, Mahana Pathar villages, Naduar and Chariduar Reserve Forest.

Table 1: Category wise distribution of wastelands in lower Jia Bharali basin in Sonitpur District, Assam, India

Wasteland Category	Area (in km^2)	Wasteland area to study area (%)
Upland with or without Scrub	5.95	00.67
Marshy land	1.18	00.13
Degraded grazing land/pasture	2.55	00.29
Sandbar	44.3	04.97
Degraded notified forest	173.83	19.51
Total	**227.80**	**25.57**

Area of lower Jia Bharali basin = $890.84 km^2$

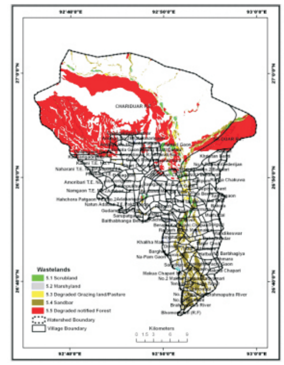

Figure 1

The marshy land category of wastelands shares 1.18 km2 area and are found distributed in Samdhara, Khalihamari, Barghat, Maranakuri, Tangni Jhar, Berajan, Kachubil, Roumari Gaon, Pat Gaon, Chillali Bengali, Mora Bharali, Bhalukmari Gaon, Bhobola Gaon and Chariduar Reserved Forest.

Degraded grazing land or pasture land type of wastelands cover an area of 2.55 km2 that are located in the Kekokali, Pat Gaon, Bardikarai Miri villages and in Naduar and Chariduar Reserve Forest.

Sand bars category of wastelands forms 44.3 km2 of the study area. This type of wasteland exists extensively and is distributed along the banks and bed of the Jia Bharali river.

The most widely covered degraded notified forest category of wastelands has occupied 173.83 km2 area of the study area constituting the highest share.

WASTELAND MANAGEMENT

Land is not only a basic resource but also a cherished asset. It has to be utilized in accordance with its ecological capacity and suitability. The misuse and mismanagement of the land result some miserable and irreversible situation. Its calls for appropriate land-use planning based on optimal use of land in accordance with its potentiality and suitability.

Land management is a process to put the land to proper use. The lower Jia Bharali basin that accounts 25.57 percent area under wastelands can be utilized to draw on sustainable development through its management. The major terrain and morphometric variables that influence land management are studied and classified for further analysis.

RESULT AND DISCUSSION

Drainage Density

Drainage density is derived following the definition and formula given by Horton, 1945. The drainage density of the study area varies from 0 to 4 km/km2. The drainage density map (figure 2) displays five density classes of which values range from low to high, such as 0-0.5, 0.51-1, 1.01-2, 2.01-3, 3.01-4 km/ km2 covering 33.42, 16.85, 27.17, 17.66 and 4.9 per cent of the area respectively (table 2).

Table 2: Drainage density of lower Jia Bharali river basin in Sonitpur district of Assam, India

Drainage density (km/km^2)	Area in km^2	Drainage density area to study area (%)
0 - 0.5	297.72	33.42
0.51 - 1	150.12	16.85
1.01 - 2	242.04	27.17
2.01 - 3	157.32	17.66
3.01 - 4	43.64	4.9
Total	890.84	100

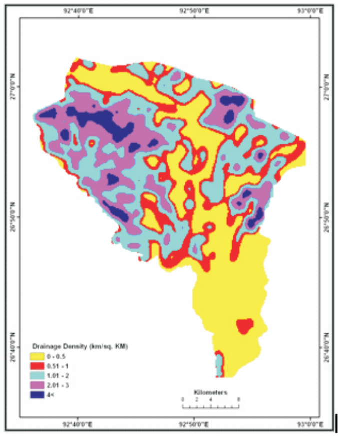

Figure 2

Drainage density indicates that the low drainage density (0-2 km/km2) exists along the confluences and valley side of the lower Jia Bharali basin, having high permeable sub surface material and is under vegetation cover and low relief. In contrast, moderate drainage density values (2-4 km/km2) are pragmatic in the denudational/foot hills and piedmont plains of the study area.

Relative Relief

The relative relief of the study area is delineated after preparing a contour map and later digitizing it for GIS application (figure 3). The relief of the study area has been classified into six categories such as less than 100m, 100-150m, 151-200m, 201-250m, 251-300m, 301-350m and has constituted an area of 59.05%, 20.63%, 15.87%, 3.18%, 0.95% and 0.32% of the basin area respectively (table 3).

Table 3: Relative Relief of lower Jia bharali basin in Sonitpur district of Assam, India

Relative Relief (meter)	Area (km^2)	Relative Relief area to study area (%)
<100	526.04	59.05
100-150	183.78	20.63
151-200	141.38	15.87
201-250	28.33	3.18
251-300	8.46	0.95
300<	2.85	0.32
Total	890.84	100

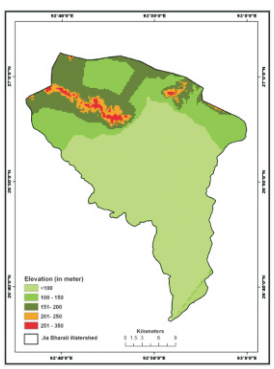

Figure 3

In the study area high relative relief are represented by the foot hills zones followed by the piedmont plains. On the other hand, the plains of the lower Jia Bharali basin in its downstream are characterized by low relative relief.

Slope

The slope of our study area is retrieved based on Digital Elevation Model which is created using contour and spot heights. The slope values are found varying between 0 and 9º which has been categorized into five groups namely less than 10, 1.10-30, 3.10-50, 5.10-70, 7.10-90 and above 9º (figure 4). Nearly level slopes (0-1º) are observed in the downstream and valley fill zones covering 82.33% of the total area (table 4). These slopes are found to be extended over the plains of the river basin. The very gentle sloping (1.10-30) constitutes 78.66 km2 areas succeeding the nearly level slope category and are mostly found to occur along the southern hills margins of the study area. Gently sloping (3.10-50) category represents 44.99 km2 areas and is observed to be succeeded by very gentle sloping.

The moderately sloping (5.10-70) category constitutes 16.93 km2 areas which is scattered in some pockets following the gentle slope category. The highest slope being above 90 (gently steep sloping) is in association with hill top and structural hills with an area of 5.61 km2 of the study area. These slopes are characterized by high drainage density and high stream frequency.

Table 4 : Slope of lower Jia bharali basin in Sonitpur District of Assam, India

Slope in Degree	Area (Km^2)	Slope area to study area (%)
1>	733.43	82.33
1.1 - 3	78.66	8.83
3.1 - 5	44.99	5.05
5.1 - 7	16.93	1.9
7.1 - 9	11.22	1.26
9<	5.61	0.63
Total	890.84	100

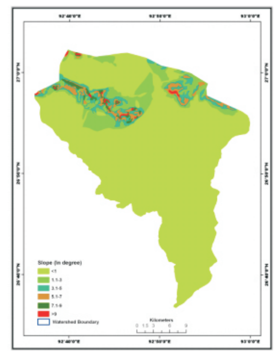

Figure 4

Strongly sloping is found to exist mainly in the north-western, central and north-eastern parts of the ridge of the Balipara and Naduar Reserve Forest. Gently sloping (3.10-50) category represents 44.99 km2 areas and is observed to be succeeded by very gentle sloping. The moderately sloping (5.10-70) categories which constitute 16.93 km2 areas are scattered in some pockets around the gentle slope.

The highest slope being above 90 (gently steep sloping) are in association with hill top and structural hills with an area of 5.61 km2 of the study area. These slopes are characterized by high drainage density and high stream frequency.

Ground water

The water that flows beneath the earth's surface, filling the porous spaces in soil, sediment, and rocks are called groundwater. The depth of water table from the surface of the study area has been prepared based on well observation of water in different coordinates of the study area. The coordinates are taken using Global Positioning System (GPS) to identify location of wells over the image.

Table 5: Depth of water table from surface in the lower Jia Bharali basin in Sonitpur district of Assam, India

Depth of water table (meter)	Area (km²)	Area under depth of water table to study area(%)
<3	242.76	27.25
3.0-5.0	276.79	31.08
5.1-7.0	151.85	17.05
7.1-9.0	208.95	23.46
9.0-11.0	10.39	1.17
>11	0.10	0.01
Total	**890.84**	**100**

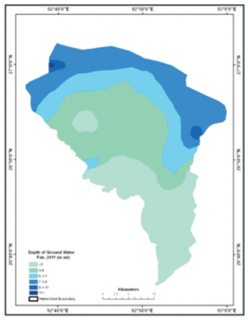

Figure 5

Considering the well depths in different point of locations some isoneph lines are drawn to represent the status of depth of water table in the study area (figure 5). The table 5 indicates the area under water table at different depths from the surface.

Geomorphology

On the basis of the study and analysis of relief, slope, drainage and geological formations, the study area can be divided into three main geomorphological divisions, viz. (a) Structural landforms, (b) Denudational landforms and (c) Depositional landforms (figure 6).

In lower Jia bharali basin structural landforms are found to be extended over the north eastern and north western periphery of the study area. Under this unit, the high mountains and hills of elevation between 200 m and 350 m cover up an area of 110.44 km² (table 6). The area is characterized by gently steep sloping (above 90) and high drainage density (2.1 km/km2 to 4 km/km2). The hills slopes of red, coarse, gritty to sandy soils get eroded due to excessive run-off during summer.

Just above the margin of the alluvial plains, the lower piedmont plain is found to be developed. This zone develops on the foothills of the Eastern Himalayas having altitudes between 151m and 200m with broad crest and conical summits. It contains coalescence of several alluvial fans comprising boulders, pebbles, cobbles, gravels, sands, silts and clays of unconsolidated nature stretching over an area of 379.55 km².

Table 6: Distribution of Geomorphic landforms in lower Jia Bharali basin of Sonitpur district of Assam, India

Geomorphic units	Area (km²)	Area under geomorphic units to study area (%)
Alluvial Plains and Flood Plains	400.85	44.99
Piedmont Plains	379.55	42.61
Denuational Hills and Foot Hills	110.44	12.40
Total	890.84	100

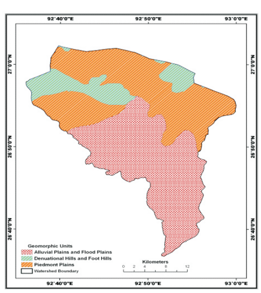

Figure 6

The depositional landforms develop on the floodplains, younger alluvial plains, older alluvial plains and upper piedmont plains of the study area. In this zone of low relative relief (less than 100 m) and low slope (less than 10), the features like old meanders, palaeochannels, natural levees, back swamps are found to develop on the floodplains. This floodplain zone is characterized by recharge zone with shallow depth of ground water.

Soils

The major soil groups identified in lower Jia Bharali river basin in Sonitpur district of Assam includes a. Course-loamy , Typic Fluvaquents, b. Fine-loamy, Typic palevdalfs, c. Fine-silty, Typic Haplaquepts, d. Fine-loamy, Typic Haplaquents, e. Coarse-loamy (figure 7).

Table 7: Soil types of lower Jia Bharali basin in Sonitpur district of Assam, India

Soil types	Area (km²)	Soil type area to study area (%)
Course-loamy , Typic Fluvaquerts	373.63	41.94
Fine-loamy, Typic Palevdalfs	18.53	2.08
Fine-silty, Typic Haplaquepts	361.60	40.59
Fine-loamy, Typic Haplaquerts	3.75	0.42
Coarse-loamy, Aeric Fluva quents	133.33	14.97
Total	**890.84**	**100**

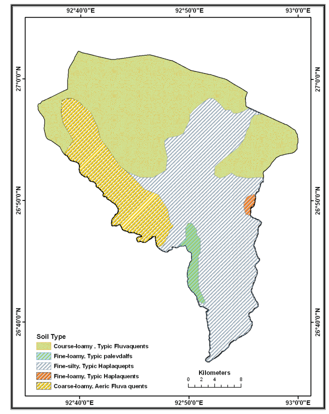

Figure 7

The foothill region of Eastern Himalaya which is built up with coarse-loamy, typic 41.94 percent area of the study area. Fine-loamy, typic palevdalfs and fine-loamy, typic haplaquents are distributed in a very smaller quantity in the watershed area constituting 2.08 and 0.42 percent respectively (table 7).

The floodplain of the Jia Bharali watershed is built up of fine-silty, typic haplaquents which are light textured in nature. The old riverine alluvial soils which are not subjected to flood are found in the valley portion and their texture ranges from sandy loom to clay.

Land-use pattern

Land-use pattern is a complex phenomenon developed as a result of the interaction of physical, historical, social and economic factors. It is determined by the relief features, climate, soil, vegetation and nature of use made by occupants. Demographic and socio-economic conditions, institutional framework and technological levels of people also determine land use pattern.

The idea of land-use hierarchy varies with the production and consumption factors. The production factors are land, transformational facilities and the stage of technological advancement. The consumption factor includes the number of people, consumption of goods per person and gross export.

In order to study the land-use pattern of the study area a land-use map of 1:50,000 scales are prepared from the Survey of India toposheet of 1962/1971 and the geocoded IRS 1C LISS-3 data of 29th February, 2008. After identification and classification, the concerned areas are delineated to prepare land-use map of the study area (figure 8).

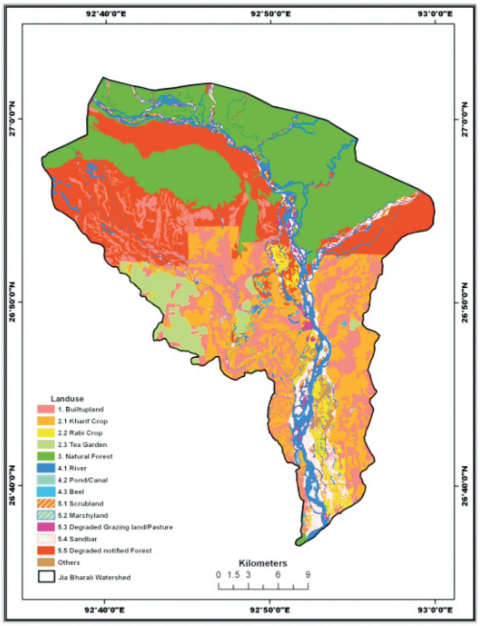

Figure 8

From land-use data (table 8) it is observed that in the study area wastelands occupy 25.57% of which cropland covers 21.47%, built up land 16.81%, water bodies 6.3% and other types 1.55%.

Table 8: Land-use data of lower Jia Bharali basin in Sonitpur district, Assam, India

Class	Area (km^2)	Land-use area to study area (%)	Sub class	Area (km^2)	Land-use area to study area (%)
1. Built-up land	149.84	16.81	Built-up land	149.84	16.81
2. Cropland	191.15	21.47	2.1 Kharif	135.56	15.23
			2.2 Rabi	20.26	02.27
			2.3 Tea Garden	35.33	03.97
3. Natural Forest	252.19	28.30	Natural Forest	252.19	28.30
4. Water bodies	56.14	06.30	4.1 River	54.92	06.16
			4.2 Pond/Canal	0.24	00.03
			4.3 Beel	0.98	00.11
5. Wasteland	227.80	25.57	5.1 Scrubland	5.95	00.67
			5.2 Marshy land	1.18	00.13
			5.3 Degraded grazing land/ pasture	2.55	00.29
			5.4 Sandbar	44.3	04.97
			5.5 Degraded notified forest	173.83	19.51
6. Others	13.81	01.55	6. Others	13.81	01.55
Total	890.84	100.00		90.84	100.00

Land Suitability Analysis

The findings of terrain analysis are supposed to be the most convenient basis of study of physiographic and morphometric variables for land suitability analysis of the study area. The suitability is a function of crop requirements and land characteristics and is a measure of how well the qualities of land unit match the requirements of a particular form of land-use (FAO, 1976). The suitability of the study area is assessed considering rational cropping system for optimizing use of a piece of land for a specific use (FAO, 1996).

For determination of suitability of land of lower Jia bharali basin in Sunitpur district of Assam, terrain analysis of the study area is carried out after analyzing major terrain and morphometric variables like drainage density, relative relief, slope, ground water, geomorphology, soil and land-use.

Suitability Analysis in GIS context

Suitability analysis in a GIS context is a geographic or GIS-based process used to determine the appropriateness of a given area for a particular use. To develop a suitability map of land for a specific practice, GIS based Multi Criteria Evaluation is used for improve decision making (Malczewski, 1999).

The basic principle of GIS suitability analysis in Geography is to consider each feature of landscape that has fundamental characteristics which are either suitable or unsuitable for certain activity. Thus in order to determine suitability of the study area some elements of terrain are taken as input for modal formulation. The results are displayed on maps which highlight the areas from high to low suitability.

RESULT AND DISCUSSION

Crop production

The crop production land suitability map (figure 9) of the study area reveals that the highly suitable (HS) land for crop production are mostly concentrated in 9.93 % area of the plains of the study area (table 9).

Table 9: Priority area under different land-use options in lower Jia Bharali basin

Land-use	Marginally suitable (MS)	Moderately suitable(MoS)	Highly suitable(HS)
Crop production	303.59 (34.08%)	498.86 (55.99%)	88.39 (9.93%)
Grazing land	467.16 (52.44%)	386.49 (43.38%)	37.19 (4.17%)
Forestry	630.38 (70.76%)	236.07 (26.5%)	24.39 (2.74%)
Woodland Forestry	367.66 (41.27%)	273.28 (30.67%)	249.89 (28.05%)

Area in km²; Figure in brackets indicates percentage of area to study area

The wasteland categories and their suitability level for cropland (table 10) reveals that the wastelands those are lying in areas under HS for crop occupies 3.87 % area of the total wastelands of the study area. In the areas under moderately (MoS) and marginally suitable (MS) for crop, wastelands cover 36.93 % and 59.20 % area of it total.

Table 10: Wasteland category and their suitability levels for cropland

Wasteland category	Area under wastelands (km²)	Wastelands area highly suitable for crop (km²)	Wastelands area moderately suitable for crop (km²)	Wastelands area marginally suitable for crop (km²)
1. Scrubland	5.95	0.41	4.48	1.06
2. Marshy land	1.18	0.15	0.82	0.21
3. Degraded grazing land/ pasture	2.55	0.11	1.96	0.48
4. Sandbar	44.3	8.14	32.19	3.97
5. Degraded notified forest	173.83	00	44.68	129.14
Total area	**227.80**	**8.81 (3.87%)**	**84.13 (36.93%)**	**134.86 (59.20%)**

Figure in brackets indicates percentage of wastelands area in different suitability levels

Grazing land

Grazing or pasture land is an important land use for the study area, as it comes under rural inhabitants. The suitability map reveals that the land having relatively moderate relief and low slope are highly suitable for grazing. Whereas, the hill tops and plain lands are found to be moderate and marginally suitable for grazing land land-use option (figure 10). The priority area for grazing land that comes under HS, MoS and MS occupies 4.17%, 43.38% and 52.44% of the study area respectively (table 9).

The wasteland which could be utilized to promote grazing is found to expand in different proportions, in HS (8.56%), MoS (47.98%) and MS (43.46%) land of the study area (table 11).

Table 11: Wasteland category and their suitability levels for grazing land

Wasteland Category	Area under wasteland (km²)	Wastelands area highly suitable for grazing land (km²)	Wastelands area moderately suitable for grazing land (km²)	Wastelands area marginally suitable for grazing land (km²)
1 Scrubland	5.95	0.84	1.02	4.09
2 Marshyland	1.18	0.00	0.19	0.99
3 Degraded grazing land/ pasture	2.55	0.14	0.78	1.63
4 Sandbar	44.3	4.13	11.09	29.07
5 Degraded notified forest	173.83	14.38	96.24	63.21
Total area	**227.80**	**19.49 (8.56%)**	**109.32 (47.98%)**	**98.99 (43.46%)**

Figure in brackets indicates percentage of wastelands area in different suitability levels

Forestry

The suitability map for forestry (figure 11) shows that the hill tops with relatively high drainage density, high slope, high relief along with high stream frequency and low ground water level are taken as the highly suitable land for forestry that comprise 2.74% of the study area. Similarly the comparatively low lands and plains are considered as MoS and MS which constitutes 26.5% and 70.76% of the study area respectively (table 9).

Wastelands categories those are located under HS, MoS and MS land for forestry comprises 13.43%, 51.89% and 34.68% area of the total wasteland in the study area (table 12). The sand bar and degraded notified forest which has constituted highest wasteland area could be treated effectively for plantation to restore ecological balance of the study area.

Table 12: Wasteland category and their suitability levels for forestry

Wasteland Category	Area under wastelands (km²)	Wastelands area highly suitable for forestry (km²)	Wastelands area moderately suitable for forestry (km²)	Wastelands area marginally suitable for forestry (km²)
1 Scrubland	5.95	0.00	0.69	5.26
2 Marshyland	1.18	0.00	0.03	1.15
3 Degraded grazing land/ pasture	2.55	0.00	0.66	1.89
4 Sandbar	44.3	1.03	7.09	36.18
5 Degraded notified forest	173.83	29.56	109.75	34.51
Total area	**227.80**	**30.59 (13.43%)**	**118.22 (51.89%)**	**78.99 (34.68%)**

Figure in brackets indicates percentage of wastelands area in different suitability levels

Woodland forestry

In rural areas people mostly use woods for household cooking. Normally people use to collect their woods from their nearby forest. Thus to prevent forest from over exploitation in the study area it becomes essential to plan for woodland forestry. With this purpose a suitability map (figure 12) for woodland forestry has been designed. The map divulges that woodland forestry land-use is highly suitable in the highland territories. It has been observed that the low relief hills and plains are found moderately and marginally suitable land of the study area (table 9).

The HS, MoS and MS land under woodland forestry land-use, the wastelands categories occupy 31.86%, 40.28% and 27.86% of the total wastelands of the study area respectively (table 13).

Table|13: Wasteland category and their suitability levels for woodland forestry

Wasteland Category	Area under wastelands (km²)	Wastelands area highly suitable for woodland forestry (km²)	Wastelands area moderately suitable for woodland forestry (km²)	Wastelands area marginally suitable for woodland forestry (km²)
1 Scrubland	5.95	0.31	1.09	4.55
2 Marshyland	1.18	0.00	0.12	1.03
3 Degraded grazing land/ pasture	2.55	0.48	0.89	1.18
4 Sandbar	44.3	1.14	10.09	33.09
5 Degraded notified forest	173.83	70.65	79.56	23.62
Total area	227.80	72.58 (31.86%)	91.75 (40.28%)	63.47 (27.86%)

Figure in brackets indicates percentage of wastelands area in different suitability levels

On the basis of the above surveillance, the study area could be brought under proper land-use planning following the potentiality analysis of the wastelands for its optimal utilization with an aim to increase the productivity of land on sustainable basis.

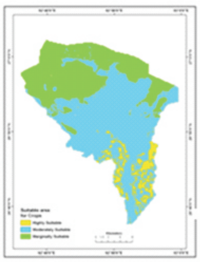

Figure 9 : Suitability map or crop production

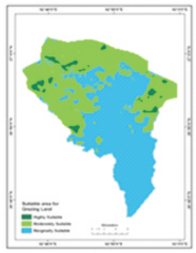

Figure10 : Suitability map for grazing land

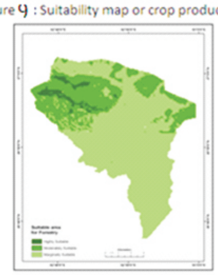

Figure11 : Suitability map for forestry

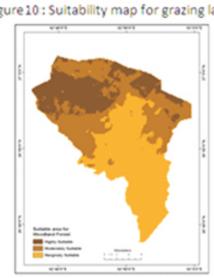

Figure12: Suitability map for woodland forest

CONCLUSION

Development of wastelands is an undeniable necessity in the present context of increasing population and deteriorating environment of the Northeastern region of India in general and the study area in particular. Lesser the wastelands better the environment and consequently better the economy of the region. The menace of recurring degradation due to natural and other human activities can be controlled efficiently by reclaiming the wastelands appropriately through proper management. The study area, which posses 25.57 percent of wastelands has been classified into highly suitable, moderately suitable and marginally suitable land as an outcome of the modal formulated on the basis of major terrain and morphometric variables for four land-use options. Further, the wastelands (227.80km²) in each suitability levels of crop land (i,e. HS,3.84%; MoS, 36.93% and MS, 59.20%), grazing land (i.e., HS,8.56%; MoS, 47.98% and MS, 43.46%), forestry (i,e. HS,13.43%; MoS, 51.89% and MS, 34.68%) and woodland forestry (i,e. HS,31.86%; MoS, 40.28% and MS, 27.86%) land-use options are identified for its proficient planning and management to obtain sustainable development of the study area.

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