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RESEARCH ARTICLE

DETERMINANTS OF WASTELAND FORMATION: A CASE STUDY OF KHOYRASOLE BLOCK IN BIRBHUM DISTRICT, WEST BENGAL

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ABSTRACT

The term 'wasteland' is essentially understood as degraded land which is currently under-utilized and or land which is deteriorating for lack of appropriate water and soil management or on account of natural causes. Wasteland can be the resulted form of inherent or imposed disabilities such as by location, environment, chemical and physical properties of the soil or financial or management constraints (Wastelands Atlas, 2010). Thus, it is a humble effort to identify the principal factors responsible for the formation of wastelands over the 10 Gram Panchayats of Khoyrasole Block in Birbhum District, West Bengal.

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INTRODUCTION

The unhealthy interaction of man, nature and technology is responsible for wasteland formation. The genesis of wasteland and their spatial distribution are the result of various interacting factors. They not only determine the nature of wasteland and but also their magnitude in spatial context. Though the concentration of wasteland is primarily governed by the physical parameters of any region, varying level of technological uses for high degree of land utilization also accelerate the wasteland formation

Objectives of the Study

The present paper deals with the analysis of determinants responsible for wasteland formation and their spatial occurrence over 10 *Gram Panchayats* of Khoyrasole Block in Birbhum District, West Bengal.

Database and Methodology

In the present study, the data pertaining to land use and dominant attributes responsible for wasteland formation has been collected from different sources (Table 1).

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Other statistical and illustrative information have been assembled from the District Gazetteer by O' Malley and some relevant books and journals. To identify the relationship of wastelands with these selected variables, a co-relation matrix has been prepared. To determine the principal factors Categorical Principal Component has been calculated with SPSS (Version 14) software.

Table 1. Sources of Database of Selected Parameters

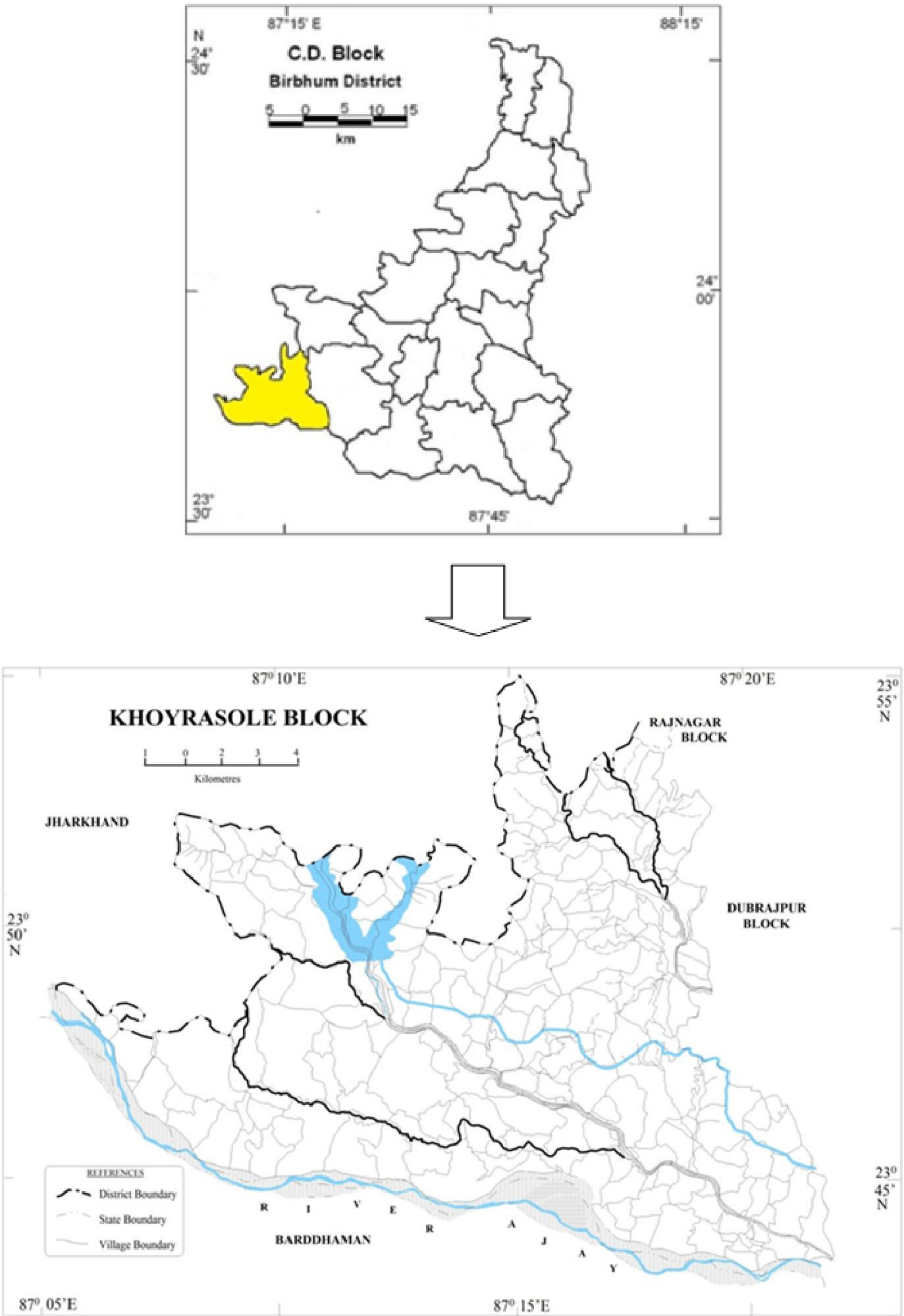
Database Theme	Sources
Slope	Topographical Maps 73M/1, 73M/2, 73M/5, 73M/6 Survey of India
Ruggedness Index	Topographical Maps 73M/1, 73M/2, 73M/5, 73M/6 Survey of India
Dissection Index	Topographical Maps 73M/1, 73M/2, 73M/5, 73M/6 Survey of India
Drainage Density	Topographical Maps 73M/1, 73M/2, 73M/5, 73M/6 Survey of India
Water Table	Field Survey April, 2014 and September, 2014
Water pH	Public Health Engineering Office, Suri
Soil Organic carbon, Nitrogen, Phosphorus, Potassium, Soil pH	Office of Assistant Directorate of Agriculture, Khoyrasole
Irrigated Area	District Census Handbook, Birbhum District, 2001
Wasteland Area	Focus on Birbhum District, published by Land and Land Reform Dept. Govt. of West Bengal

Study Area- A Brief Profile

The study area is located in the western part of Birbhum District in West Bengal with latitudinal and longitudinal extension of 23°44'N to 23°55'N and 87°5'E to 87°22'E. The area is agriculturally backward as vast tracts of land are left uncultivated and abandoned for year after year. Net cultivable wasteland occupies 2683.2 hectares out of total geographical area (27219 hectares) (District Census Handbook, 2001). The area under investigation suffers from inadequate irrigation facilities and depends upon the erratic seasonal rainfall. More than 53% of the selected lands are rain fed and practice mono-cultural cropping pattern.

Physical Set Up: The geological formation of Khoyrasole Block is comprised of *Archaean* Gneiss and Lower *Gondwana* System interspersed with lateritic formations. The granitic veins traverse the block in many parts with depth of various angles and strike from east to west, occasionally crop up at the surface. In the north-western part are formed of a few large boulders of granite deposits (O'Malley, 1996).

Topographically, the area is an extension of Chhotonagpur Plateau, rolling and infertile in nature with wedge shaped depressions receiving detritus from the adjacent highlands. In the region, the elevation of the ridges is ranging from 70 to 135 metres above the mean sea level.



Map 1. Study Area

The general direction of slope is towards south-east. The major rivers flowing over the area are Hingla and Sal, both of them have risen from the Chhotonagpur Plateau draining the middle and northern parts of the area accordingly and joined the Ajay River in the south-east. Though the rivers are non-perennial in nature, in rainy season the basin areas of Hingla River are severely affected by flood. The depth of pre-monsoon water table varies from 20 to 28 feet while in post-monsoon period it records from 5 to 11 feet with a wide range of spatial variation.

The climate of this area is normally hot and dry and is characterized by Humid Tropical Monsoon type. Summer temperature varies from 25.5^o to 39.4^o C and the temperature in winter season ranges from 12.7^o to 28.3^o C. Average annual rainfall is 1289 mm. But uncertainty of rain hampers the agricultural production frequently in the study area. The area is characterized by mainly sterile lateritic soil with frequent rock crops up in large masses. The pH ranges from 5 to 6.5 and poor in organic matter with availability of P_2O_5.

Natural vegetation of the area is composed of dense Sal with open scrub. The forest area covering only 1037.8 hectors is readily threatened by deforestation.

Socio-Economic Set up: In relation to the social characteristics, the demography of the study area is worthy to mention. Out of total 170 villages, 44 villages are completely depopulated. According to 2011 Census, the total population of Khoyrasole Block is 153248 persons, with 79118 males (51.63%) and 74130 females (48.37%) with density of 450persons/km^2. Among the total population, the proportion of Scheduled Caste is 35.55 %, Scheduled Tribe is 1.79% and the rest is General category. The study area experiences average literacy rate of 59.94% in which male literacy rate is 67.78% and female literacy is 51.56%.

The major economy of the area is based on agriculture with insignificant presence of small-scale industries, mining-quarrying and trade. Though agriculture is prime economic activity, it is not fully flourished here due to degraded infertile land and lack of irrigation facilities. The total cultivated land occupies 20543.87 hectors and the total irrigated area is 6351.70 hectors. Apart from agriculture, the livelihood of people depends on coal mines, stone quarries and sand lifting from the Ajay River.

The transport and communication system of the study area is inadequately developed as few metalled roads connect the surroundings suburbs with one major transport route from Suri to Rajnagar and again from Rajnagar to Dubrajpur via Khoyrasole total 31 miles. Andal-Sainthia Railway chord line touches the block in the south-eastern sides. Recently communication network of the area has been improved. The use of tele-communication and internet are increasing day by day.

Wasteland Distribution

Distribution of various types of wasteland in Khoyrasole block at village level, for the year 2005-06, have been studied on the basis of the data collected from the *Farm Information & Advisory Centre*, personal interaction with Block Development Officers and with the villagers. Wastelands constitutes as much as 8.86 per cent of its total geographical area, among which larger percentage share (3.18%) belongs to the first category viz. Barren and uncultivated land. The proportions of other categories are in the descending order as degraded pasture and grazing land (2.17%), culturable wasteland (2.12%), current fallow (1.18%) and fallow land (.09%). Occurrence of other types of wasteland such as abandoned mining area and sandy area are insignificant.

Determinants of Wasteland

The study area contains different types of wasteland. Thus it is very much essential to investigate the cause and effect relationship of their distribution. The numerous factors, which are directly or indirectly responsible for the formation of wastelands in the area under study, can be analyzed in detailed as given below.

Physical Determinants

A. Morphometric Determinants
   a. Slope
   b. Ruggedness Index
   c. Dissection Index
B. Hydrologic Determinants
   a. Drainage Density
   b. Water Table
   c. Water pH
C. Pedogenic Determinants
   a. Organic Carbon
   b. Nitrogen
   c. Phosphorous
   d. Potassium
   e. Soil pH

Anthropogenic Determinants

D. Technological Determinants
   a. Percentage of Irrigated Area to Total Area

Physical Determinants

A. Morphometric Determinants

Morphometry is the measurement and mathematical analysis of the configuration of earth's surface, shape and dimension of its landforms. Slope, Ruggedness Index and Dissection Index are the three important facets of morphometry, which are intricately related to the formation of various categories of wasteland in the area under study.

Slope: Slope is the most important and specific feature of earth surface form. It plays a significant role in the formation of wastelands. Generally in steep and moderate slope areas, the rate of soil erosion becomes high and as a result gullied and ravinous lands are commonly found. High rate of soil erosion also deteriorates the fertility status of soil and at later stage cultivators often leave the land as uncultivated and thus such land are converted to old fallow and culturable wastelands progressively (Yadav, 2011).

For slope analysis horizontal equivalent and vertical distances of different *Gram Panchayets* have been measured. Later on, C. K. Wentworth's method has also been followed to identify the average slope and cross verification of previous method. The general gradient in the study area, following the regional pattern, is from north-west to south-east but with a little variation. Maximum slope occurs in the Babuijore GP (1º46 '8"), located in the north-western corner of the block just at the fringe of Chottonagpur Plateau while the minimum slope calculated in Panchra GP (0º11'22"), situated at the south-eastern corner of the area where it gradually mix up with Alluvial plain.

Ruggedness Index: Ruggedness number is the product of relief and the drainage density and usefully combines slope steepness with its length. Naturally the low ruggedness value implies the area is less prone to soil erosion and have inherent structural complexity in association with relief and drainage density (Strahler, 1956). Ruggedness Number is positively correlated with wasteland that means high ruggedness value leads to higher amount of wasteland.

The maximum ruggedness number is observed in Panchra GP with the amount is 0.026 where as the lowest ruggedness value occurs in both Parsundi and Rupuspur GP with 0.003, situated in the south-western side, on the flank of the River Damodar and eastern side accordingly.

Dissection Index: Dissection index is the degree of dissection or vertical erosion and expounds the stages of terrain or landscape development in any physiographic unit. On an average, the values of Dissection Index vary between '0' (complete absence of vertical dissection/erosion and hence dominance of flat surface) and'1' (vertical cliffs, it may be at vertical escarpment of hill slope or at seashore). Low dissection index is proportionately associated with low amount of wasteland.

Dissection Index of the study area is extremely low in two GPs Rupuspur and Parsundi .05 and .06 accordingly. Surprisingly, the maximum value occurs in Panchra GP (.32). But in other GPs the value varies from .20 to .25 which indicates the area is less to moderately dissected.

B. Hydrologic Determinants

Wasteland formation and its gradual extension in any region are directly related to the hydrology of that specific part of earth surface. The basic hydrological parameters selected here are drainage density, behaviour of water table and water pH.

Drainage Density: Drainage density is generally calculated as the total length of all the streams and rivers in a drainage basin divided by the total area of the drainage basin. It is a measure of how well or how poorly a watershed is drained by stream channels. Generally rugged regions or those with high relief have a higher drainage density than other drainage basins if the other characteristics of the basin are the same. High drainage density dissects the upland areas frequently and also removes the top layer of soil through accelerated erosion and thus it has a positive relation with wasteland formation and its gradual development (Kalwar, 2008).

The drainage density is very low in the whole study area with a little bit variation from 0.81 per sq km (Panchra GP) to 0.35 per sq km (Brrah GP). In spite of comparatively higher drainage density in the northern part of the block, favourable land utilization for agricultural purposes is not possible here. This is mainly due to the prevailing first order streams which are mostly seasonal in nature. As a result heavy downpour in rainy season causes the removal of top soil and thus reduces the agricultural productivity.

Water Table: Behaviour of ground water table is one of the most important hydrologic parameters which intricately related to wasteland formation. Low water table reduces the opportunity of ground water utilization and enforces the area remained uncultivated year after year. Proportionately low water table in both pre-monsoon and post-monsoon period leads to higher amount of wastelands.

Depth of ground water in different parts of the block has been measured from dug wells in Pre-Monsoon (April, 2014) and Post-Monsoon (August, 2014) periods. Pre-Monsoon water table in the study area varies from 20 feet to 28 feet. The lowest value occurs in case of Parsundi GP, located on the flank of River Damodar whereas the highest value as measured in Lokepur GP located at the extreme north of the block. Low water table in the northern part not only act as hindrance to double-cropping but also creates water crisis in the summer months. However, the post-Monsoon data of water table represents quite satisfactory picture as it ranges from 5 feet (Khoyrasole GP) to 11 feet (Lokepur GP) from the ground surface.

Water pH: Water pH is also considered as an important parameter for wasteland formation. Generally both acidic and alkaline water hamper the agricultural production and successively low agricultural return creates lack of interest of small and marginal farmers to further investment in agriculture. As the water pH value in the study area is above the neutral level it is assumed that it is positively associated with wasteland formation.

The GP wise average water pH in the entire block varies from slightly alkaline to alkaline in nature as the lowest value is measured in Nakrakonda GP (7.03) whereas the highest value is in Kendgore GP (8.24).

C. Pedogenic Determinants

The distribution and extent of culturable wasteland, long fallow and fallow lands are predominantly governed by the soil fertility status of any region. A good fertile land enhances the agricultural productivity. But if the fertility status is low it demands a higher agricultural input and thus increases the expenditure of agricultural practices which again compels the small and marginalized farmers to leave their small patches of land uncultivated. Keeping in view the soil fertility, the pedogenic determinants considered here are Soil Organic

Carbon, Soil Nitrogen, Soil P_2O_5, Soil K_2O and Soil pH. All these parameters accelerate wasteland formation.

Soil Organic Carbon: Soil organic carbon (OC) has long been identified as key factor to soil fertility in both managed and natural ecosystems (Kucharik *et al.*, 2001). It affects nutrient cycling, soil structure and water availability in the soil (Rashidi and Seilsepour, 2009). So there is a negative relationship between OC and wasteland formation.

The agricultural productivity of the study area highly suffers from lack of OC in soil. The amount of OC varies in between 0.23% (Babuijore) to 0.55% (Barrah). As per critical limits of soil test values (Muhr *et al* 1965) organic carbon (0.5-0.75%) only the two GPs Barrah and Hazarathpur belong to standard group while the rest other GPs are suffering from low organic carbon as well as low organic matter.

Nitrogen: Nitrogen is an essential plant nutrient. The plants absorb nitrogen either as ammonium or as nitrate ions from the soil solution. The transformation of nitrogen compounds in the soils involves a corresponding process such as fixation of atmospheric nitrogen by free living and nodule forming bacteria, conversion of nitrogen containing compounds into humic acids, ammonification, nitrification, denitrification and then leaching loss of different nitrogen compounds by intra-soil and surface flows (Orlov, 1992). Nitrogen increases vegetative growth and produces good quality of foliage. It also assists in seed formation and enhances the food value of crops (Rai, 1998). Low nitrogen status reduces the soil fertility and low fertility increase the extent of wasteland.

Deficiency of nitrogen in soil is common not only in West Bengal but also all over India (Deshmukh, 2012). The study area is not an exception one. Almost all the GPs of Khoyrasole Block suffers from low nitrogen status. Lowest nitrogen status is recorded in Babuijore GP (.041%), whereas the highest value is recorded in Barrah GP (.063%), both are sub-standard (Standard value .068%). Low nitrogen inhibits the plant growth and lowers down the agricultural yield.

Phosphorus: One of the important macro nutrients of soil is phosphorus. Through bio-geo-chemical cycle phosphorus is deposited in soil and from where the plant tissues absorb it. Phosphorus exists in all the living cells and it helps in cell division of plants. It is also essential for root system and the formation of seeds and fruits. In case of cereals, it increases the ratio of grain to straw and thus increases the yield of grain (Rai, 1998). Phosphorus increases the resistance of plants against diseases. So its deficiency in soil significantly induces wasteland formation.

High grade of rock phosphate is available in limited amount in Chottanagpur Region (Rai, 1998). As the study area is located at the fringe of the plateau abundant phosphate is available in the soil. The amount of P_2O_5 varies from 123kg/ha in Nakrakonda to 250kg/ha in Panchra. So phosphorus level is high (>90kg/ha) in the entire block. But this is also to be mentioned that excess phosphorus hastens the maturity, reduces vegetative growth and thus depresses crop yields (Rai, 1998).

Potassium: Potash mica, biotite, muscovite are the important potash bearing minerals which are decomposed during chemical weathering and yield large amount of potash. Potassium plays a significant role in plant nourishment. It is essential for photosynthesis, protein synthesis and for starch formation in plants. Potassium increases crop resistance to certain diseases and helps to develop strong root and stem systems (Brady, 2001). Like all other macro nutrients it is also responsible for wasteland formation.

Potash deficiency is more commonly observed in India in acidic soils (Rai, 1998). But in the study area the amount of K_2O in the soil is quite satisfactory as it varies from 167 kg/ha (Barrah GP) to 306kg/ha (Nakrakonda GP). Almost all the areas of the block K_2O is available in medium range (150-340kg/ha) as per standard rate of Indian soil.

Soil pH: Soil pH is one of the most important physiological characteristics of soil. The presence and development of micro organisms and higher plants depend upon the soil reaction of any region. Differently, if the soil is remained uncultivated for a longer period such as cultivable wasteland or in case of long fallow, it encourages the loss of calcium, magnesium and other cations and thus it affects the base removal and lowers down the pH values in the soil (Rai, 1998). As the pH value in the soil is acidic in nature it is positively associated with wasteland formation up to the neutral level (7) is reached.

In the study region, the average pH ranges between 5 (Khoyrasole and Panchra GPs) to 6.5 (Rupuspur and Barrah GPs) which is slightly acidic in nature. Moderate to slightly acidic soil is good for average plant growth. The nutrient availability and the microbial activity in such a soil are quite satisfactory (Rai, 1998).

Anthropogenic Determinants

D. Technological Determinants

Irrigation: We have already analysed the physical determinants responsible for wasteland formation. Besides these, irrigation is one of the most important factors for the formation and extension of fallow land and culturable wasteland. It is assumed that there would be high percentage of wasteland where the percentage of irrigated land to the total cultivated land is less.

Irrigation is the artificial application of water to land and soil for the growing of crops, trees and grasses and it has greater importance for the disturbed, infertile soils and during the period of inadequate rainfall. Assured and controlled irrigation system can successfully change the landscape of any region. Though excessive irrigation and inadequate irrigation are both injurious for the growth of crops, but the appropriate timing and spacing of irrigation can raise the yield as much as 50 per cent even if the other inputs are not given (Husain, 1996). Irrigation is thus the single most important input on which success or failure of crops depends.

Porous soil and rapid drainage have necessitated the artificial irrigation in the study region. Irrigation is also necessary for double cropping area where rainfall is scanty throughout the year except rainy season (O'Malley, 1996). Major emphasis has been given for the development of irrigation potential in the district after independence (NBSS & LUP, 2007). The farmers gain access to irrigation from both the two sources here-

a. Surface water (from surface flows or water storage reservoirs) and
b. Subsurface water (water extracted from underground aquifers)

Tanks are the most useful sources of surface irrigation. There are several numbers of ponds of different sizes in the study area. Apart from this, River Ajay, Hinglo, Sal and Hinglo Canal also share a small percentage of surface irrigation in the study area. Groundwater or subsurface irrigation is accessed by dug wells, bore wells, tube wells and is powered by electric pumps and diesel engines. A small part of the study area is irrigated from artesian well. Table 2 shows the percent wise distribution of different sources of irrigation in the Khoyrasole Block. The net irrigated area in the block is 5.03 percentage (1363.60 ha) as calculated in respect of total area. GP wise irrigated area varies between 0 to 15.19 percentages of total area. The lowest value records in Babuijore GP located in the north western corner of the block. Though the area is located just beside the Hinglo Dam, comparatively high relative relief and eastward direction of slope impose limitations on the development of irrigation facilities here. Maximum irrigated area is recorded at Barrah GP which is located at the southern flank of Hinglo River. But 95 per cent of irrigation of this GP is contributed by tank water.

contribution in formation of wasteland. Prior to framing of correlation matrix original values of selected variables have been standardized with the 'Z-Score' values by calculating mean and standard deviation. Later on, correlation matrix has been prepared using contemporary statistical software, SPSS (Version 14.00).

It is clear from the data matrix that there is significant positive correlation with wasteland and slope (.41) at 5% level of significance. It clearly indicates that the areas having relatively higher amount of slope are more prone to wasteland formation. There is also significant positive correlation between wasteland and water pH (.411). High amount of water pH leads to low agricultural productivity and successively wasteland formation and its gradual extension.

Significant positive correlations also exist among wasteland and dissection index (.38); wasteland and K_2O (.39); wasteland and percentage of irrigated area (.39); which are significant at 10% level of significance. Relatively high dissected areas experience high rate of soil erosion and high rate of soil erosion is associated with wasteland formation. Though the amount of K_2O in soil is positively correlated with wasteland formation this is mainly due to its huge availability in almost all the areas under study. The irrigated area is also positively correlated with amount of wasteland. It indicates that the hypothesis stated previously regarding wasteland and irrigated area is not valid to some extent. Other variables ruggedness no, drainage density, water table at pre and post monsoon, organic carbon, nitrogen, phosphorous and soil pH are positively correlated with amount of wasteland.

Table 2. Distribution of Irrigated Area in Different Gram Panchayets of Khoyrasole Block

Name of GP	Total Geographical Area (ha)	Sources of Irrigation (%)								Total Irrigated area (ha)	Irrigated area to TGA (%)
		GC	PC	W	TW	TWE	TK	R	O		
Lokepur	2656.91	0	0	0	21.87	20.04	41.91	16.18	0	137.20	5.16
Rupuspur	2748.54	0	0	0	0	0	97.53	0	2.47	113.50	4.13
Nakrakonda	2406.42	40.42	0	6.78	0	0	40.42	12.40	0	42.80	1.78
Babuijore	3833.71	0.00	0	0	0	0	0	0	0	0	0
Barrah	1693.11	0.00	0	3.50	0	0	95.29	1.21	0	257.10	15.19
Hazrathpur	1667.46	100.00	0	0	0	0	0	0	0	26.30	1.58
Kendgore	2997.35	1.96	1.96	28.47	0	0	62.58	5.04	0	81.50	2.72
Khoyrasole	1910.29	15.99	0	12.96	0	0	54.54	12.96	3.54	115.70	6.06
Panchra	3936.08	65.05	0	7.26	12.09	0	14.52	0.84	0.24	333.30	8.47
Parsundi	3261.42	0.00	0	7.77	4.76	1.60	60.93	24.94	0	256.20	7.86
Total	27111.29	20.57	0.12	6.91	6.05	2.32	54.94	8.54	0.56	1363.60	5.03

Source: Calculated from District Census Handbook, 2001

N.B. GC-Governmental Canal, PC-Public Canal, TK-Tank, R-River Lift, TW- Tube well (without electricity), W- Well (without electricity), O- Others

Identification of Principal Factor

Analysis of Correlation Matrix

The summary statistics of these selected variables and their bivariate relationship with wastelands have been attempted. The correlation matrix will reveal the relative importance of these variables and their functional association in wasteland formation and their spatial distribution. Though there are numerous factors related to wasteland formation hence the following factors have been selected.

The correlation matrix has been prepared among all these selected 14 variables, in order to identify their actual

But their relationship is very much insignificant or in other words they fail to provide proper explanation for the formation of wasteland and its gradual extension in the study area.

From the above discussion, it is clear that the correlation matrix prepared for the identification of significant determinant for wasteland formation is not fully satisfactory. Though few of selected variables are explained properly but the other factors have negligible relationship with uneven distribution of wasteland in the study area.

For further explanation, Categorical Principal Component Analysis (CATPCA) has been attempted as the variables selected here are mostly categorical and belong to Morphometric, Hydrologic and Pedogenic categories accordingly. Hence the irrigation factor has been deliberately avoided from CATPCA as this is exclusively different in nature from other variables which are purely physical. With technological advancement the in future, irrigation facilities can be improved in problematic areas but the intrinsic characteristic can not be altered as these are pre determined by physical properties of that specific area. Prior to analysis, we have standardized a few values by deducting the actual values from standard value. The statistical technique has been followed here by using SPSS (Version 14.00) software.

Analysis of the Results of CATPCA

The model summary table 3 represents the internal consistency coefficient (Croanbach's Alpha) for each of two dimensions, we have specified here and the value of consistency coefficient is .974[a]. As C Alpha value is nearer to 1, it indicates that the set of variables selected here for wasteland formation is perfectly correlated with each other (Handbook on Constructing Composite Indicators, p 74). The second and third column represents the variance accounted for both two dimensions and their total. The *eigenvalues* we have calculated in first dimension is 5.334, in second dimension is 4.024 and the total is 9.357. Therefore the total model (both dimension) accounts for 77.98 % of the variance in the selected matrix of 12 items.

Table 3. Model Summary

Dimension	Cronbach's Alpha	Variance Accounted For	
		Total (Eigenvalue)	% of Variance
1	.886	5.334	44.447
2	.820	4.024	33.532
Total	.974(a)	9.357	77.978

a. Total Cronbach's Alpha is based on the total Eigen value

In table 4 Component Loadings, shows the coordinates for each item on each dimension; the highest factor loadings in each component are marked with red colour, representing diverse character and label to each of them (Research and Statistical Support). In first dimension the maximum loadings occur in case of Drainage Density (-.966), Dissection Index (-.928), Slope (.928), P_2O_5 (.917), and Ruggedness No (-.792). This is also to be mentioned that there are four components like slope, Water pH, Water Table in Post-Monsoon and P_2O_5 (kg/ha) have positive loadings in the first dimension while the rest other are negatively correlated in the whole system. Maximum variance of the data set is explained (44.48%) in first dimension. Factor Loadings in the first dimension explain that all the three selected Morphometric variables primarily determine the whole system along with one hydrologic (Drainage Density) and one pedogenic (P_2O_5) factors.

Variable Principal Normalization

In the next dimension highest factor loadings occurs in Organic Carbon (.949), Nitrogen (.949) and Post monsoon Water table (.871). Total variance explained in the second component is (33.53%). Hence the study reveals the fact that from subjective view point, the Post Monsoon Water table is not so much important as water crisis for agriculture in this period is not acute. So the Pedogenic factors are considered as most responsible in the second dimension.

Table 4. Component Loadings

Variables	Dimension	
	1	2
Slope (deg)	.928	.276
Dissection Index	-.928	-.276
Ruggedness No	-.792	.476
Drainage Density /km2	-.966	-.201
Water pH	.332	.014
Water Table(feet) (Pre-Monsoon)	-.625	.637
Water Table(feet) (Post-Monsoon)	.061	.871
OC(%)	-.204	.949
N(%)	-.204	.949
P2O5 (kg/ha)	.917	.372
K2O (kg/ha)	-.502	.496
Soil pH	-.608	-.503

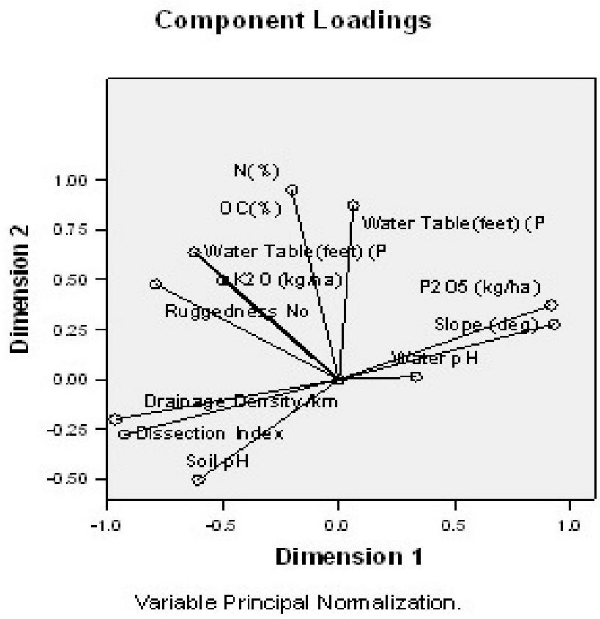


Fig. 2. Component Loading

In Figure 2 the component loadings have been displayed through scatter plotting. Hence we can see how the selected determinants interrelated to one another in two dimensions. There are two clusters. The first one (comprising east and south-west corner of the diagram) indicates the variables which have obtained highest scores in first dimension and very much nearer to 1 whereas the next cluster (north-west) indicates the other variables which have obtained the highest score in next dimension. There is only one variable which scores exceptionally low in both the two dimensions and does not appear to fit very well into the solution (Research and Statistical Support). So we can consider this item as less significant here but it may fit better in a higher dimensional solution.

Conclusion

From the ongoing discussion and analysis it may be concluded that though there are different factors of wasteland formation in the area under study, but their magnitude varies in wide range. The morphometric parameters with one pedogenic factor (phosphorus) show a higher response than other categories considered here. It means that the wasteland formation and its spatial occurrence is primarily guided by the morphometric determinants whereas the pedogenic factors especially organic carbon and nitrogen in soil are other important determinants which affect the endorsement of wasteland secondarily.

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