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RESEARCH ARTICLE

LAND RESOURCE EVALUATION FOR SUSTAINABLE LAND RESOURCE MANAGEMENT IN WESTERN PART OF WEST BENGAL, INDIA

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ABSTRACT

Land resources provide basic amenities to human society. Puruliya is the western most district of West Bengal falling plateau area and having undulating terrain. The main objective of the study is to integrate the functional attributes of land for land evaluation for sustainable land management. Functional attributes of land are integrated in GIS environment and generated three land management units: unit-I (good quality land), unit-II (moderate quality land), and unit-III (poor quality land). Management unit-II & unit-III cover almost equal area (about 45% area of the total geographical area) and unit-I cover nearly 10% area. Land management unit-I(good) & unit-II (moderate quality land) has highest priority for sustainable management as it has enough potentiality to develop the land for agriculture, agro-forestry and related activities through efficient use of water, use of bio-fertiliser and phosphorus rich fertiliser along with lime due to lack of phosphorus content in soil.

INTRODUCTION

Land is the basic but finite resource and is the most important component of this environment. Land, which provides the most benefits to mankind, is overall natural resource. Land means any portion of the earth over which rights of ownership, stewardship, or use may be exercised including: the earth's surface, water covered lands, water and mineral resources, as well as features and resources attached to the earth whether they are natural or artificial (Hoper et el 1994). According to UNCED (1992), land is normally defined as a physical entity in terms of its topography and spatial nature; a broader integrative view also includes natural resources: the soils, minerals, water and biota that the land comprises. Land evaluation is 'the process of collating and interpreting basic inventories of soil, vegetation, climate and other aspects of land in order to identify and make a first comparison of promising land use alternatives in simple socio-economic terms (Brinkman and Smyth 1973). Therefore, land evaluation has been defined as the process of assessing the potential production for various land uses (Beek 1978).The concept of environmental management is broadly related to the rational adjustment of man with nature. The physical, biological and cultural components form the interacting system, which is man's environment for his existence and survival. Environmental management involves management of all the components of biophysical environment comprising both living (biotic) and non-living (abiotic). Land is the most important abiotic component of the environment. Therefore, proper management of land is essential for increasing the productivity of the land for present generation and maintaining the quality of land for the future generation.

Puruliya ditrict is the western most district of West Bengal lying between latitude $22^0$42'35"N to $23^0$42'0" N and longitude $85^0$49'25" E to $86^0$54'37" E and part of Chotanagpur plateau having undulating terrainThis region falls under plateau region of West Bengal having undulating terrain of granitic-gneissic surface. There are three subdivision in Puruliya district such as Raghunathpur, Puruliya Sadar (West), Puruliya Sadar (East) and 20 Community Development Blocks. Puruliya municipal town is the headquarters of Puruliya district.

Objectives of the Study

The present study of the functional attributes of the land resources is aimed to explore the feasibility of the potential land for sustainable land resource management. The main objectives of the study are as follows:

- To study the functional attributes of the region
- To evaluate the land on the basis of the geomorphic parameters
- To evaluate the land on the basis of soil parameters
- To evaluate the land for sustainable land management through integration functional attributes particularly soil and geomorphic parameters
- To develop the policy for sustainable land management

MATERIALS AND METHODS

The functional characteristics of the land resources are determined from topographical maps of Survey of India

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having scale 1:50000, field survey, satellite imageries, published information. Rainfall forecasting based on 48 years rainfall data by ARMA model. Geomorphic parameters such as relief, slope, and drainage density are calculated in sq.km. grid. Soil chemical properties such as pH, phosphorous, organic matter and potassium are analysed in laboratory. All the functional attributes of land resources are interrelated to each other. Land management's units are determined by integrating geomorpological land evaluation map and land evaluation map based on soil fertility index in GIS environment using Map Info 7.5 and Adobe Illustrator 9. Geomorphological land evaluation map is prepared by integrating geomorphic parameters such as relative relief, slope and drainage density in GIS environment. Land evaluation map based on Soil fertility index is prepared from Proportionate Index Value (PIV) based on Azzi's method (1959) in GIS environment.

RESULTS AND DISCUSSION

Functional Aspects of Land Resource

The basic functions of land are agriculture, forestry and habitation of animals including man. These functions are developed with interaction of lithology, topography, hydrology, climate, soil, flora, and fauna and human beings. According to Vink(1975), land comprises the physical environment including climate, topography, soil, hydrology, flora, fauna and results of human activity. Land in this sense is considered the physical expression of ecosystem at earth surface. The functional aspects of land may be studied from litho function, top function, hydro function, climofunction, soilfunction, phytofunction and anthrofunction. These functions are analyzed to obtain the land resource management units of the study area.

Litho function

Lithofunction of the study area (Puruliya district) plays important role in the formation of topography, micro-relief, soil, ground water etc. The area is mainly covered by granite-gneiss rocks of Achaean- Proterozoic periods except north eastern and southern part. The oldest granite-gneiss rock is known as Chhotanagpur granite-gneiss. The rock has a tendency to produce such dome or ellipsoidal masses by exfoliation in regular circular scale. Such granite-gneiss are found in Jaychandi *Pahar*, ($23^0$31'40" N and $86^0$40'05"E near Raghunathpur), Tilaboni ($23^0$25'N and $86^0$33'15"E near the source of the Dwarakeshwar river) and Belami *Pahar* ($23^0$28'N, $86^0$03'E). The north eastern part is covered by sedimentary rocks of Gondwana age while the volcanic rocks of Dalma group cover southern part. Aluvium of quaternary periods covers mainly river valley region.

Topofunction

Topography helps in the choice of land utilisation types influencing management, accessibility of terrain and development of infra-structural works. Relief features are essentially controlled by geological formation including tectonic action and erosion processes. The study region consists of heterogeneous landform units. A classification is made based on lithoinformation and topoinformation. These information along with remote sensing data is utilised to obtain the following geomorphic units : i) western hilly upland zone, ii) north-western hilly zone, iii) rugged terrain, iv) undulating gneissic surface and v) valley fill zone and it is presented in Table - I

Table 1

Geomorphic units	Area in sq. km	% of area to total area
a) Western hilly upland	466.01	7.45
b) North-western hilly region	56.37	0.91
c) Rugged topography with lateritic capping	552.26	8.82
d) Undulating gneissic surface	3912.58	62.51
e) Valley fill zone	1169.47	18.68
f) Residual hill	102.31	1.63
Total	6259	100

Source: Data generated by author in GIS environment

Topofunction is interesting because the area has a hilly upland tract in western and north-western part and extensive undulating land with river valley in the middle and eastern part while southern part have rugged topography with lateritic capping **(Table 1&Fig 1)**. The western and north western part is mainly covered by forest due to hilly upland. This area has thin soil cover and rocky surface and lack of ground water. Forest cover is dispersed due to rugged topography. Remaining part, mainly middle and eastern part is agricultural field with small farms due to undulating nature of the field and cultivation is done in relatively undulating low land area.

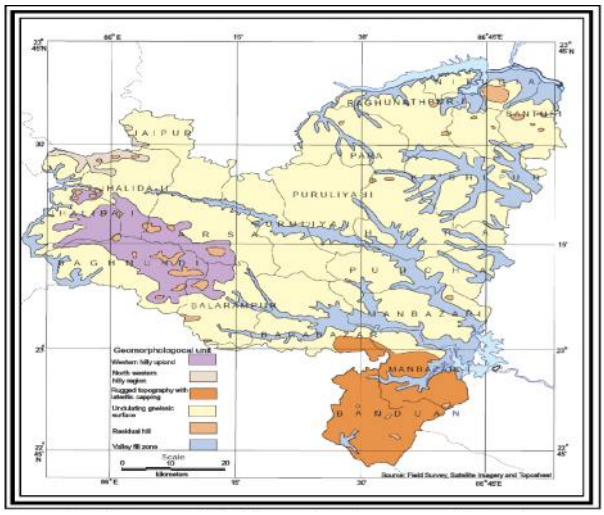

Fig 1 Geomorphologic map showing geomorphic units

Hydrofunction

Hydrofunction of the study area is particularly important because climate and topography is not favourable for agriculture and needs irrigation supply. The texture of drainage and availability of ground water are the products of their geological conditions, topography and rainfall. Hydrofunction are divided into two categories ii) surface water and ii) ground water.

i) Surface water: - The main source of surface water is rainfall. Surface water is mainly available through rivers, *jhors*, water reservoirs, tanks etc. The surface water regime of the areas is marked by extreme fluctuations in tune with the monsoon rainfall. The Kasai or the Kangsabati is the most important river of the region covering nearly one-third area; about 75% of the total river valley is non-perennial. Other important rivers are Kumari, Subarnarekha, damodar and Dwarakeswar etc.

The Panchat, Kangsabati and Turga reservoirs are the most important artificial lakes. The region has numerous tanks and

small storage pools called *bandhs.* The most notable example of such *bandh* is the Sahib *bandh* at Puruliya town covering over 24 ha during rainy season and 12 to 14 ha during lean season. Nearly 14% area of the district is irrigated by different sources. Among these, 13% area is irrigated by surface water. Among the surface water irrigation, maximum portion comes from tank (5.60% of the total geographical area) followed by canal irrigation (3.88%). Minor irrigation schemes (1.52%). *Jhore bandh* (0.77%) and river lift irrigation (0.75%).

ii) Ground water: - The area is very poor in ground water resources because of hard crystalline basement. Ground water is available in localized areas covered by cracks and crevices in the hard rocks and also from the upper weathered zone of the bed rock. Where the thickness of the soil mantle is considerable, the discharge from these wells is generally satisfactory. A majority of the shallow wells go dry or retain scanty water during the summer. Ground water is exploited through dug wells. Rainfall is the main source of groundwater recharge. There is more or less no function of ground water in agricultural development, about 1% area is irrigated from ground water.

Climofunction

Climofunction of the area is characterized by hot summer and monsoon condition. The climatic condition is extreme type due to its interior location i.e. approximately at a distance of 150 km from the sea, rocky outcrops, bare surface etc. The rainfall in the area is erratic with occasional drought in between two rainy periods, which may last for several days. The mean annual rainfall in the area for the last 48 years (1957-2004) is 1259.6 mm Temperature has important role in the crop growth. The summer season is excessively hot, average temperature is being 30^0C. Relative humidity is high during the monsoon season, being generally between 75% and 85%. After the withdrawal of southwest monsoon, relative humidity decreases gradually.

Statistical analysis of rainfall parameter is carried out by ARMA Method **(Fig 2)**. Rainfall is the most important environmental factor for determining of land use types. Though the area receives on an average more than 120 cm of rainfall annually, the prevailing climatic condition is moderate to extreme and belongs to agro- climatic zone VII having tropical monsoon climate. The actual rainfall data for the last 48 years (1957 – 2004) shows that average annual rainfall was 126 cm. The Arma analysis for the last 48 years indicates the increasing trend of rainfall pattern, rather than decreasing one. The ARMA model of rainfall for the coming 20 years indicates a promising feature in the area (Fig.2).

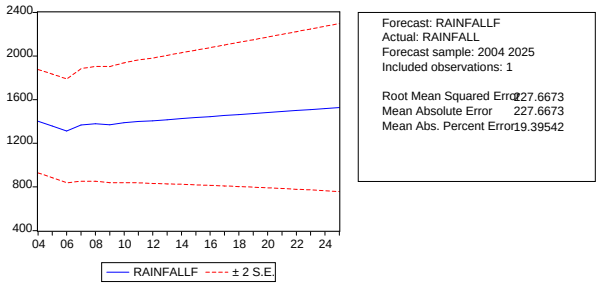

Fig 2 Forecast of average rainfall for the years 2004 to 2025 by ARMA model

This possibility suggests a promising feature for better land use option through water management in the area under study.

Soil function

Soil is the basic natural resource for land resource evaluation and land functions. The soil constitution may influence the land use pattern, water holding capacity, plant nutrients, and management option for sustainable crop growth. Soil function of the region is primarily controlled by parent materials mainly granite-gneiss rocks, undulating topography, climate and vegetation. The area is mostly covered by residual soil, which is formed due to disintegration and decomposition of rocks by weathering process. Geologically, these soils are older but immature. Most of the soil is lateritic, originated from granite-gneiss rocks. Soil of the district is mainly acidic in nature and low phosphorous content. Based on parent materials, soils are classified into three broad groups: -

a. Gneissic soils (laterite soils) cover major part of the region. These soils are formed from granite-gneiss rock. Gneissic soils are usually laterite, sandy loams of low fertility. These soils have low water holding capacity and mostly acidic in nature and these are mostly infertile. The colour of the lateritic soil varies from light red to brown depending on mineral matter. The undulating land with incompletely terraced fields is covered by these soils.
b. Gondwana soil (sandy soil) is originated from shale and sandstone of Gondwana age. It is found in the limited area of the northern part.
c. Transition soil (loamy soil) is originated from sub-metamorphic rocks. It is usually dark in colour, fine in texture and more fertile. Water holding capacity is more than the other two groups of residual soils. These soils occur in gently undulating topography.

Soil erosion is observed in the district 31.8% area of the district suffers from one or the other kind of land degradation. Water induced soil erosion is the major problem which accounts for 31.3% of the district. Land degradation due to water logging is limited to only 0.3% area whereas 0.2% area is degraded due to rock quarries, brick kiln and industrial effluents (Saini *et al* 1999).

Phytofuction

Phytofuction is the most important for development of soil, soil fertility and controlling the land degradation. The natural vegetation of the study area is characterized by deciduas forest. Dense forest occurs in limited area of inaccessible uplands of Ajadhya-Baghmundi region and southern part of the district. Other areas are patchy in occurrences. The most dominant species of the forest are *Sal*. However, other species are *palash, Kusum, Shisu, Arjun, Mahua, Khair, kend, Siris, Kadam* etc. Total forest land of the district is about 14% of the total geographical area. The green coverage of the district is increased from 17.80% (1988) to 20.95% (2000) which is far below of requirement i.e.33%. The major part of the forest region is degraded in nature. The forest territory has a crown density of less than 40%. Clear felling, uncontrolled grazing and poor forest management is the major causes of degradation. Nearly 7.40% of the total geographical area of the region is under degraded forest category and lies mostly in the eastern and northern part. Most of the forestland is under this category needs protection.

Anthrofunction

Anthrofunction is the most important factors for land resource management. Productive power of a man, in addition to physical ability, includes knowledge, skill, creative abilities, experiences and attitude, are the beneficiaries of land resource development. In 2011, population of the study region was 29, 27,965 with a density of 468 persons per sq. km. With the increase in the size of population and the density, the land use pattern has changed; more land area is converted into residential areas (particularly near urban areas). The quality of population also depends on the level of literacy. The literate persons are well aware about new technology, new crops, fertilizer use, crop management and land development. The literacy rate is 65.38% in 2011. The male literacy rate is 78.85% while female literacy is only 51.29%. So participation of women in economic activity is very poor. The district has 44.45% workers and 55.55% non-workers.

Land use is the most important human function over land. Land use pattern of the region is dominated by agricultural land (≈ 69%) and forest land (≈14%), followed by built up area (≈ 12%) and waste land (≈3%).There are three land classes of the study area mainly *baid* & *tard* (high land & ridge), *Kanali* (medium land) and *Bahal* (low land).

Land evaluation for land resource management

Land resource management implies management of land including soil and water resources for optimum and sustained production with minimum degradation of natural resources. The main concept of land management is sustainability, combination of production with conservation (Young 1998). For this purpose, different physical aspect of land is analyzed. Relief is one of the important topographic information for classification of land. Relief is analyzed in terms of both absolute and relative relief. Nearly 78% of the total geographical area has absolute relief below 300m which is demarcating line between dissected plateau and undulating erosion plain. Nearly 81% of the total geographical area has relative relief below 25m. About 70% of the total geographical area have lower slope (< 2°). The drainage density having very low (<1km/sq.km) to low (1-2 km/sq.km) cover ≈ 43% and 41% area of the study area respectively. High relief, slope and drainage density is only observed western, northwest and southern part of the district. Four geomorphologic land evaluation classes are generated by overlying relative relief, drainage density and slope in GIS environment. geomorphic features is not constraints for human intervention of land use.

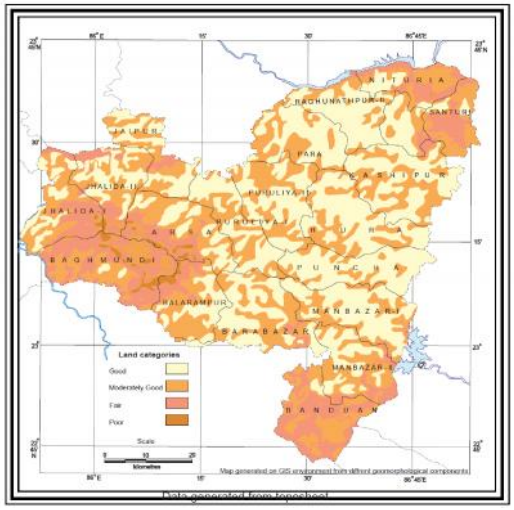

Fig 3 Geomorphic land evaluation map based on geomorphic parameters

Soil parameters are important factor for determining the quality of land. The chemical properties of soil samples are determined in laboratory and plotted on the map to obtain spatial variability of the various chemical properties. The soil of the study region is mainly acidic in nature. The most of the area in study region (≈ 56%) have medium organic content (0.85 – 1.35%). The phosphorus content of the soil represents a very gloomy picture. About78% area of the study regions has very low to low (<45 kg/ha) phosphorus content. About 74% of the total geographical area have moderate potassium content (150 -350 kg/ha).

Land classification based on soil of the study area is determined on the basis of generated chemical analysis of the soil data i.e. organic matter, available soil phosphorus, available soil potassium based on Azzi's method (1959). It is observed from the **Table 3 & Fig 4** that good quality land with index value 80 - 100 covers only 2.54% of the total geographical area while poor quality land with index value of 20-40 cover 30.15% of the total geographical area. Based on PIV, the study area is under the category of fair quality with fertility class – III covering more than 51% of the total geographical area. Good and moderately good quality land has patchy occurrences in the north eastern, south central and central part. So soil fertility status of the area is not satisfactory.

Table 2 Land classes based on geomorphic land evaluation

Categories of land	Area in sq. km	% of area to total district area	Land classes
Class – I	2665.70	42.59	Good
Class – II	2368.50	37.84	Moderately good
Class – III	1045.90	16.71	Fair
Class – IV	178.90	2.86	Poor

Source –Data generated on GIS environment by author

Table 2 & Fig 3 shows four land categories. Class-I category land (relative relief < 25m, drainage density < 1km/sq.km. and slope < 2 degree) covers mostly middle and eastern part of the region. Class –II land has patchy occurrence and distributed throughout the region. Class –III land is distributed in western, north-western, north-eastern and southern part of the district Class – IV land only concentrated in western part. Among this class - I and class – II land categories cover nearly 43% and 38%. It indicates that nearly 80% area of the study area, The land resources of the study area could be subdivided into three management units **(Fig 5)**. The management units are determined by overlying of soil fertility index map and geomorphological land quality map in GIS environment. It has been observed from **Table 4** that nearly 9% of the total land area of the study region belongs to management unit -I. The spatial distribution of unit-I i.e., good quality land covers a patchy occurrence and mostly concentrated in the north-eastern and central part of the region. Further analysis of the **Table 4& Fig 5** also reveals that land management unit – II

and unit – III have area more than 45% under these two categories. Unit – II land have moderate quality and unit – III is a poor quality land. The spatial distribution of unit – II land reveals that it has linear extension from west to east while unit – III land which is poor in quality is mostly concentrated in the hilly zones in the south western part of the region **(Fig 5).**

A combination of geomorphic land evaluation unit and fertility index unit with land management unit reveal that unit – I and unit – II types land i.e. the marginal land have the highest potentiality for agriculture and other related uses. Unit – III type of land management unit is suitable forestry and other related activities.

Table 3 Soil fertility index

Land category	Index limit	Land type	Area in sq. km	% of area to total area
Class – I	100-80	Good	159.03	2.54
Class – II	80-60	Moderately good	968.96	15.48
Class – III	60-40	Fair	3244.32	51.83
Class – IV	40-20	Poor	1886.77	30.15

Source: Data generated in GIS environment by author

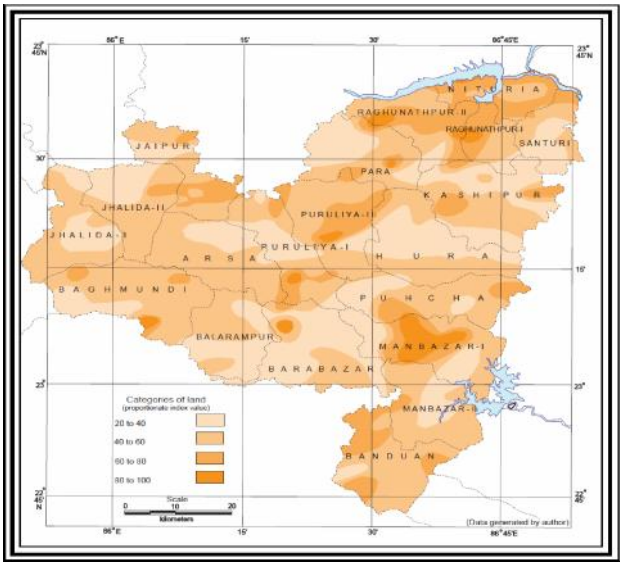

Fig 4 Land evaluation based on soil fertility index

CONCLUSION

From the above analysis the following conclusion may be drawn:

- Sustainable land management must be environment friendly, economically and socially acceptable. The land management unit- I & unit –II have highest priority of agricultural productivity. The productivity in these units will be increased through uses of phosphorous with lime, bio-fertilizer and crop rotation.
- The cultivation of the area is done by only surface water irrigation in lean period. But only 14% of the area is irrigated. Therefore, more area has brought under cultivation by digging new tanks, reservoirs at fallow land or suitable places where land is available. More *jhore bandh*, small reservoirs are constructed in the suitable places of tributaries and rivers. Run off would be reduced through water management. Water loss would be reduced through short distance transfer of water and terracing of the agricultural land. In this way irrigation facility must be increased.
- Short growing paddy will be cultivated in monsoon season. But in other seasons, oil seeds, vegetables, maize, pulses will be cultivated due to scarcity of water. It is also economically viable.
- Land degradation should be reduced by terracing of the land, contouring, criss cross ploughing, aforestation and applying other method of land conservation.
- Unit –III land categories is used for forestry, and related activities. Degraded, open forest land and scrub land have brought under aforestation forestry programme. In Puruliya district, Joint Forest Management (JFM) system has been undertaken to protect the forest and increasing the green coverage. Total number of Forest Protection Committee (FPC) in the district is about 721. But female member in this committee is not satisfactory (3%). Therefore, female participation must be increased to success the JFM.

Table 4 Land management units

Management unit	Quality of land	Area in sq. km	% of area to total district area
Unit – I	Good	544.56	8.70
Unit – II	Moderate	2845.32	45.46
Unit – III	Poor	2869.12	45.89

Source: Data generated in GIS environment

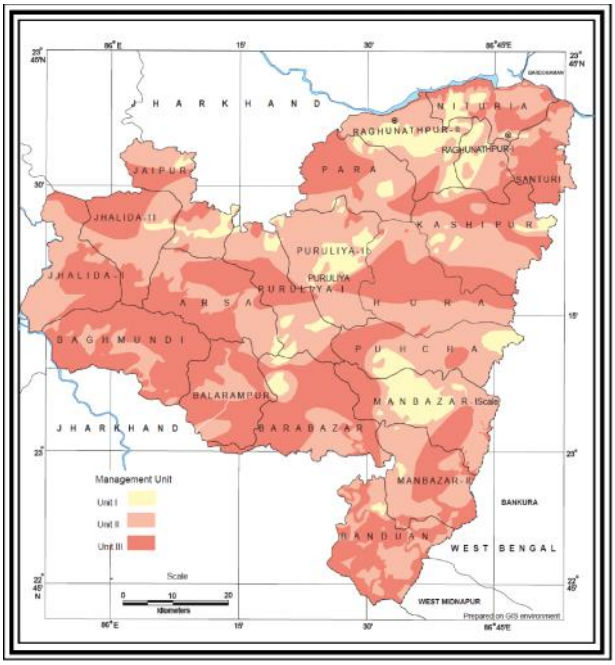

Fig 5 Land evaluation for land management units using geomorphic and soil parameters

Lastly, it may be concluded that literacy particularly female literacy must be increased for receiving the benefits of land management. It is also expected that awareness developed by the farmers about the use of modern scientific technology to

achieve sustained yield has penetrated deep inside the social milieu.

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