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Status of soil degradation in State of Uttar Pradesh

SANJAY ARORA[1] and B.P. SINGH[2]*

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ABSTRACT

Uttar Pradesh with a total area of 24.09 million ha is the India's fifth largest state in terms of land area with a population of about 200 million and population density of 830 people per km^2. Agriculture is the leading occupation in the state dependent on 16.8 million ha of cultivated land. Nearly 52.12 percent of the total geographical area in the state is affected by various soil degradation problems induced mainly by human-intervention. The most serious problem is of water erosion, causing loss of top soil and/or terrain deformation and has affected 11.39 m ha representing 38.69 percent area including ravenous lands along the rivers, wind erosion has been observed in 2.12 m ha, representing 0.72 percent of the total geographical area. About 4.65, 0.72 and 7.98% of the area of the state is affected by soil salinization or sodification, wind erosion and flooding, respectively.

Keywords: Soil degradation, Land, Erosion, Ravines, Waterlogging, Salt affected soil

INTRODUCTION

The state of Uttar Pradesh in north India is located between 23°52′ N and 31°28′N latitudes and 77°3′ and 84°28′ E longitudes covers an area of 24.09 million ha and has 16.81 million ha of cultivated area, constituting 70% of the total geographical area. The irrigated area is over 73% and the cropping intensity is 153 per cent.

The state is endowed with wide variations in climate, geology, landforms and vegetation which are reflected in the development of a large variety of soils. The soils belong to 5 Orders, 11 Suborders, 22 Greatgroups and 44 Subgroups (Singh *et al*., 2004; Bhattacharyya *et al*., 2013). Inceptisols being the dominant soils, occupy nearly 70.10% followed by Entisols, Alfisols, Vertisols and Mollisols, covering 18.96, 4.89, 1.57 and 0.22% of the total geographical area (TGA), respectively (Singh *et al*., 2004).

Physical Features

Being a border state of northern India, Uttar Pradesh's northern frontiers adjoin Nepal which earlier extended upto Tibet before the creation of Uttaranchal whose Shivalik ranges near Tibet Border. UP's boundaries touch Haryana, Delhi and Rajasthan in the west, Madhya Pradesh in the south and Bihar in the east. In geo-physical terms, the Shivalik range of the Himalayas in the north, the river Yamuna and the Vindhyas in the west, south-west and the south and the Gandak river in the east.

The state of Uttar Pradesh can be divided into two distinct hypsographical (altitude) regions. The larger Gangetic Plain region is in the north; it includes the Ganges-Yamuna Doab, the Ghaghra plains, the Ganges plains and the Tarai. It has fertile alluvial soil and has a flat topography broken by numerous ponds, lakes and rivers. The smaller Vindhya hills and plateau region is in the south. It is characterized by hard rock strata and a varied topography of hills, plains, valleys and plateaus; limited availability of water makes the region relatively arid.

Climate

The climate of Uttar Pradesh is predominantly subtropical; however, weather conditions change significantly with location and season. Depending on the elevation, the average temperatures vary from between 12.5-17.5 °C (55-64 °F) in January to 27.5-32.5 °C (82-91 °F) in May and June. Rainfall in the state ranges from between 1,000–2,000 mm (39–79 inch) in the east to 600–1,000 mm (24–39 inch) in the west. About 90 percent of the rainfall occurs during the southwest monsoon, lasting from approximately June to September.

Soils of Uttar Pradesh

Soil which is a finite valuable natural resource and on which depends the well being of mankind has to be used in complete harmony with its capabilities and long term sustainability. Over

[1]Principal Scientist (Soil Science), ICAR-CSSRI, Regional Research Station, Lucknow, Uttar Pradesh
[2]Director, Directorate of Agriculture, Krishi Bhawan, Lucknow, Uttar Pradesh
*Corresponding author Email id: drbpsingh_agri@yahoo.in

exploitation and imprudent use for immediate gains without due regard to its long term sustainability leads to various kinds of its degradation, at times resulting in an irreversible condition. The unending rapid rate of land degradation is not only hampering crop productivity and causing a lot of socio-economic as well as environmental problems but also has become a matter of serious concern.

In the western districts of Uttar Pradesh *viz*. Saharanpur, Meerut, Muzaffarnagar, Bijnor, Moradabad, Pilibhit and Bareilly, the soil is typically the same. It is, generally, deep brown and loamy in some places, also mixed with sand. The soil is shallow, gravely and full of stones – being generally acidic. In the western plains (Saharanpur, Meerut and Muzaffarnagar) the soil is deeper and fertile. Further east- wards (Bareilly, Moradabad, Bijnor and Pilibhit) the soil gets to be loamy, still further down the Pilibhit district, some of the soil become acidic while the rest shows some alkaline properties. The soil in the central regions comprising Lakhimpur Kheri, Sitapur, Lucknow, Barabanki, Hardoi, Kanpur and Azamgarh districts is loamy and sandy loams.

In the eastern part of the state, the districts of Gorakhpur, Basti, Mahrajganj, Siddarthnagar and Gonda contain two varieties of the soil, which are locally known as 'Bhat' and 'banjar'. The alluvial soil is called 'dhuh'. The one described as 'mant' is loamy sandy- calcareous, comparatively. The soil in the north western district of the state contains less of phosphate. The district of Jaunpur, Azamgarh and Mau are found to be lacking in potash and the drier areas are known as 'usar' and 'reh'. The soil of Aligarh, Mainpuri, Kanpur, Etah, Etawah, Sitapur, Unnao, Raebareli and Lucknow is salt affected and known as 'usar' and 'reh' soils (IWMP, 2009).

Mixed red and black soil is found in the Jhansi division of the state and the districts of Mirzapur and Sonebhadra as well as the Karchhana and Meja tehsils of Allahabad besides Chakia and Varanasi district. Black soil is sticky, calcareous and fertile as it expands to soak moisture and contracts on drying up. In the upper plateau of these districts the soil is red and is of two kinds *viz*. 'parwa' and 'rackar' where 'parwa' is light sandy or sandy-loam while 'rackar' is alkaline.

Classification of soils of Uttar Pradesh

Seven well defined and distinct soil groups differing from one another in their geological formations and pathogenic characters have been recognized in the state. The main zonal and azonal soil formations of the state have developed within these broad soil groups. Each of these soil groups have developed under the combined influence of a wide range of soil forming factors including climate, vegetation and parent material (Singh *et al*., 2004). They show characteristically different agricultural conditions with respect to crop adaptability, fertility and management practices. Variations in marco and micro-relief and the influence of pedogenic factors have contributed to the development of a number of soil associations in each of these tract. The total area occupied by each soil group is presented in Table 1.

Table 1. Land area occupied by broad soil groups in U.P.

Sr No	Broad soil group	Area (ha)	Percentage
1	Bhabar soils	810510	3.19
2	Tarai soils	1686740	6.63
3	Alluvial soils	18185300	71.48
4	Vindhyan soils	1501290	5.90
5	Bundelkhand soils	3192440	12.55
6	Aravalli soils	63290	0.25

Status of soil degradation

Land degradation in general implies regression from a higher to a lower status in soil productivity including present as well as potential capabilities through deterioration of physical, chemical bioIogical and socio-economic features.

In order to understand the extent and degree of changes occurring in soil and terrain characteristics which in turn influence the sustainability of the soils, an assessment of its degradation status is essential.

The status of soil degradation is elucidated in Table 2. The soil erosion is found to be the dominant degradation problem in the state followed by physical deterioration and chemical deterioration. The data revealed that 15.32 m ha land representing 52.12 per cent of the TGA is affected by various kinds of soil degradation. Besides lands unfit for agriculture, including rock outcrops, glaciers etc. that accounts for 0.84 m ha (2.86 per cent of the TGA) (Table 2).

Soil erosion

Soil erosion refers to the wearing away of soils by the forces of water and wind. It is both

Table 2. Status (area in million ha) of soil degradation in Uttar Pradesh compared to national status

Degradation	Area in U.P.	Total (in India)
Erosion (water and wind)	12.884	94.87
Waterlogging	0.176	0.91
Alkali/sodic soils	1.320	3.70
Acid soils	0.000	17.93
Saline soils	0.022	2.73
Mining/Industrial waste	0.003	0.26
Degraded area	14.405	120.40

constructive and destructive. Geologically, erosion is the chief agent responsible for the natural topographic cycles as it wears down the higher elevations and deposit the sediments in the plains. It is aggravated due to human interventions through indiscriminate felling of trees, excessive grazing, cultivation without adopting conservation measures etc. It is well known that exposed soils may erode very rapidly if it is not managed as per its limitations and requirements. Soil erosion not only retard soil development but also detrimental to the soil productivity and thereby reduces the land capabilities significantly.

Depending upon the intensity and severity of erosion, the soils of the state have been grouped under four classes. The extent of erosion in each class is presented in Fig. 1.

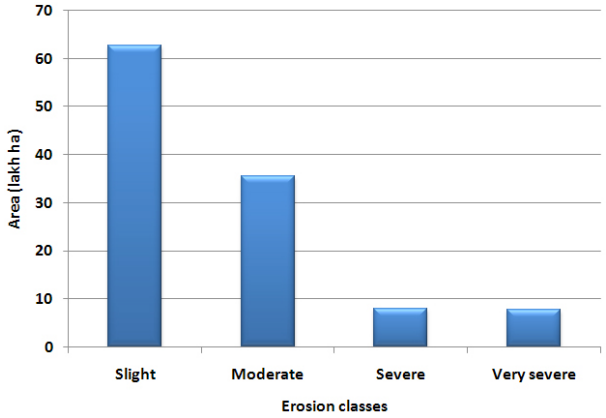

Fig. 1. Distribution of soil erosion classes

The 5.3 per cent area of the state is affected by severe to very severe erosion problem while 33.4 per cent are is under slight to moderate soil erosion. The problem of erosion and mass soil wasting such as landslides, rockfalls and soil creeps confront the hill tracks of Himalayan region. Ravine control and reclamation is a major problem along the banks of Yamuna, Chambal, Kuwari and Betwa rivers. About 0.69 m ha is affected by this menace. Wind erosion assumes major dimensions in the south western part of Agra and Mathura districts bordering Rajasthan. Nearly 0.21 m ha of the fertile lands is covered with sand decreasing their production potential to a great extent.

Water Erosion: A colossal loss of top fertile soils formed over a long span of hundreds and thousands of years takes place through water erosion. This is one of the dominant degradation type in the state covering about 11.39 m ha which is 38.69% of the TGA of the state. The loss of top soil and terrain deformation are the offsprings of erosional process. The severity of water erosion is found at the peak a long the banks of Yamuna, Chambal, Sengar, Kuwari rivers occurring in the parts of districts Agra, Etawah, Kanpur and Fatehpur etc. where terrain has completely deformed into ravines occupying 0.69 m ha which is 2.35% of the TGA. This type of degradation is due to deforestation coupled with sloppy landscape and over grazing. Water erosion is also due to unscientific management and non-adoption of conservation practices.

Wind Erosion: Wind erosion is most common in the hot dry region of the state occupying 0.21 m ha which is 0.72% of the TGA of the state. Wind erosion poses problems in the south-western parts of Agra and Mathura districts bordering Rajasthan. In these areas, sand blowing is common in the summer seasons due to which fertile lands are covered with sand decreasing their soil productivity.

Soil salinization and sodification

The problem of soil salinity and or sodicity is more prominent in the semi-arid tract of the Gangetic plain covering 1.37 m ha, reducing the productive capabilities of about 4.65% of the land surface in the state. The worst affected districts are Mainpuri, Etah, Etawah, Fatehpur, Aligarh, Farrukhabad, Kanpur, Unnao, Allahabad, Raebareli, Partapgarh, Sultanpur, Lucknow, Azamgarh, western parts of Ballia and Varanasi. Some saline patches in the districts of Mathura and Agra are also identified which are due to the high water table which is of mostly brackish in nature.

This degradation is mainly the manifestation of the human intervention with the nature. Many fertile productive lands mostly in command areas suffer from this problem chiefly because of sharp rise in water table resulting from marked disturbances in the hydrologic equilibrium under canal irrigation. As a result the crop yields have

decreased significantly and the cropping pattern has shown a shift towards the relatively more tolerant crops. Such negative trends question the sustainability of irrigated agriculture into long term perspective and this is a matter of concern.

Flooding

It covers an area of about 2.35 m ha which is about 7.98% of the TGA of the state. This menace is much evidenced in the eastern parts of the state. The worst affected districts are Allahabad, Mirzapur, Varanasi, Farrukhabad, Etah, Ghazipur and Ballia. It is mostly concentrated along the Ganga, Yamuna and Ghaghra rivers. The high water table and very slow surface drainage give rise to the hydromorphic condition in these areas resulting in uncertainity of kharif crops.

The information is quite indicative of the grave danger to the soil health and sustainable agriculture posed by such vast dimensions and severity of land degradation. It is therefore, imperative to restore the productivity of the affected areas adopting soil-site suitable strategies and preventing further deterioration/degradation of new lands through adopting eco-friendly resource planning.

Waterlogging

Waterlogging not only mean that the rise of water table above the surface areas but also it covers in the sub-surface areas. However, it is more problematic in the sub-surface areas. Groundwater Department, Government of UP has defined waterlogging in the state based on the soil conditions and water level, which is more relevant for measuring the extent of waterlogging in the state.

Waterlogging categories

There are four categories of waterlogging area in the state (Government of UP, 2003):

- Wet lands include marshy land and pond areas, where water level may be above the ground surface or perched waterlogging conditions prevails
- Critical waterlogged areas such areas in clay loam soils within 2.0 m of groundwater level in post-monsoon month and capillary rise of groundwater reaches the ground surface
- Semi critical areas fall between 2.0 to 3.0 mbgl level and groundwater capillary rise reaches the root zones of cereals crops in clay loam to sandy loam soils
- Potential for waterlogging covers between 3.0 to 5.0 mbgl, where excessive surface water irrigation and poor groundwater pumpage in such areas may create waterlogging problems

It is estimated that 45.84 lakh hectares of land coming under 0 to 2 meters below the groundwater, 38.09 lakh hectares are in the 2 to 3 meters range in the post monsoon of 1996. In other words, 83.93 lakh hectares, which is nearly 42% of the land of the state is waterlogged (Table 3). The level of waterlogging has declined marginally to 79.63 lakh hectares, which is nearly 40% of the reporting area during the post-monsoon of 2000 in the state. Waterlogging becomes a widespread problem especially in Eastern and Central region of the state not only due to recurrent floods but also rise of the water table above and very close to surface areas due to absence of well drainage system in the irrigated canal areas. It is estimated that just a little under one third of land area in the state is affected by surface and sub-surface waterlogging (Dhar, 2004).

The key requirement is to reduce the water table in the waterlogging areas. That would possible by reducing seepage of recharge and use of shallow tube wells for irrigation. However, reliable data on sub-surface and waterlogging and appropriate water management strategies are needed. The appropriate water management strategies such as conjunctive use of water (reducing canal irrigation in such areas on the one hand and increasing shallow acquifer groundwater pumping on the

Table 3. Region wise waterlogged Area in Uttar Pradesh (in lakh hectares)

Region	Reported area	Waterlogged area (0-2.0 mbgl)	Waterlogged area (2.0-3.0 mbgl)	Total
Eastern Plains	45.28	7.26	9.28	16.54 (36.53)
Central plains	75.02	15.70	25.42	41.12 (54.81)
Western plains	80.77	9.81	12.16	21.97 (27.20)
UP Plains	201.07	32.77 (16.30)	46.86 (23.31)	79.63 (39.60)

Source: Government of Uttar Pradesh (2004)

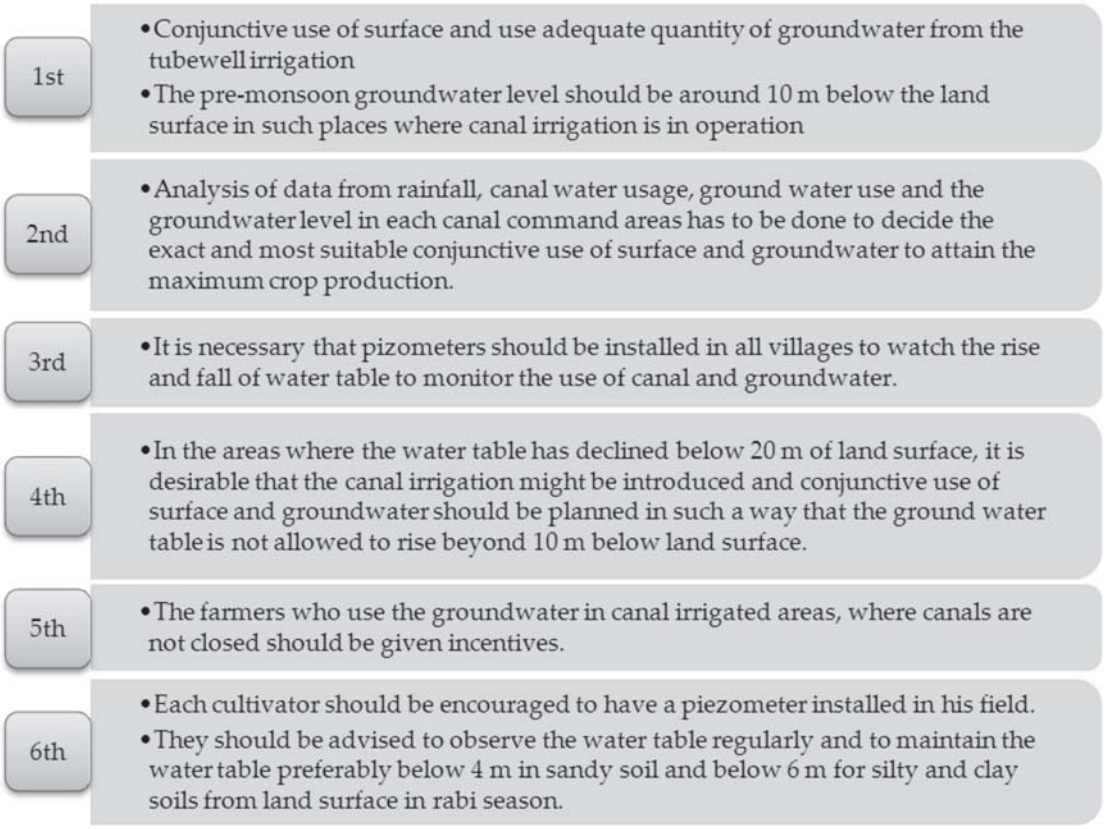

Fig. 2. Strategies for conjunctive use of irrigation in waterlogged areas

other for such areas), proper drainage, appropriate crop rotations, and even use of water absorbing hydropaths (tree species that absorb water, i.e., eucalyptus). Various strategies are suggested for better implementation of conjunctive use of irrigation in the waterlogged areas (Fig. 2).

Calcareousness or presence of hard pan

Calcareousness affects both the physical condition as also the nutrient availability of soils. A hard pan or layer of lime not only restrict water movement but also prevent root penetration. The high amount of lime when present in fine fraction may cause lime induced chlorosis in plants. Phosphorous and molybdenum availability restricted as a result of high level of magnesium associated with carbonates. In addition, micro-nutrient cation deficiencies are common in the soils having high calcium carbonates equivalent (Singh *et al*., 2008). The accumulation of calcium carbonate in the sub-surface layers is noted in the soils of Gangetic plain. Soils high in lime are productive for some crops like forage, maize, cotton and vegetables, while some of the other crops like sorghum, citrus suffers from lime induced chlorosis. The information regarding status of calcium carbonate in the soil would certainly help in sound fertilizer recommendations. Based on its content in the soil matrix four classes are identified (Fig. 3).

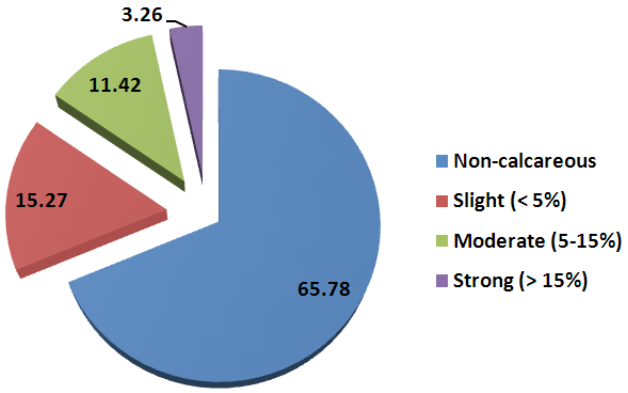

Fig. 3. Distribution of calcareousness classes in soils of U.P.

Soil salinity and sodicity

All soil contains some amount of salts but when this concentration increases beyond a specific limit plant growth is adversely affected. High concentration of neutral salts such as sodium chloride and sodium sulphate may interfere with the absorption of water by plants by developing high osmotic pressure in the soil solution. The presence of sodium carbonate results in high pH and a build up of sodium on the exchange complex.

Table 4. Distribution of salt affected soils of U.P.

Classes	Area	
	Lakh ha	(% TGA)
Saline soils	0.35	0.12
Saline-sodic soils	13.29	4.52
Sodic soils	0.06	0.02

Soils with high sodicity increase the dispersion of clay and organic matter leading to a general degradation of soil structure. Hence, the information on the degree of salinity and sodicity and their extent are imperative for any ameliorating plan and sound land use. The amount and extent of salinity and sodicity problem in the state is presented in Table 4.

Land capability classes

The land capability classification is an interpretative grouping of the soils made as per the suitability of the land for agricultural and non agricultural uses. The grouping of the soil into classes and subclasses is done on the basis of their capability to produce crops and pasture plants without deterioration over a long period of time. The criteria used in assessing a land unit are the physical land properties and the degree of limitations as a function of severity with which crop growth is inhibited. Since this system of classification is based on limitations, therefore, in case one of the parameters is limiting the soil is placed at a lower class which need careful management. Soils of the state are grouped into seven land capability classes. The extent of the area under each class is presented in Table 5.

The data reveals that majority of the soils (83.24 %) are under arable classes, i.e. suitable for cultivating all climatically adapted crops including agri-horticulture. Nearly 10.58 % area may be kept under permanent vegetation such as silvi-horticuture/silvi-pasture and silviculture whereas 1.9 % area should be utilized for recreation and wild life.

Table 5. Land capability classes

Classes	Area	
	Lakh ha	(% TGA)
I	44.23	15.02
II	71.35	24.23
III	96.51	32.78
IV	32.98	11.21
VI	23.90	8.11
VII	7.28	2.47
VIII	5.62	1.91

Ravine lands in Uttar Pradesh

In the state of U.P., 1.23 million ha area comprising over 25 districts is affected by ravines. Of the total ravine area, five districts viz. Agra, Banda, Etawah, Hamirpur and Jalaun contributes about 62% (Bhan and Arora, 2018). The ravine lands are distributed in the catchment of 14 rivers of which Yamuna and Betwa contributes about 60% of the total land. In these areas the people are very poor and have adapted to unsocial activities and end-up forming groups of dacoits. The natural physical inhospitable features of the area also support these activities. It is fact that 4 districts (Agra, Banda, Hamirpur, Jalaun) alone contributes about 0.70 million ha (62%) of the area (Fig. 4).

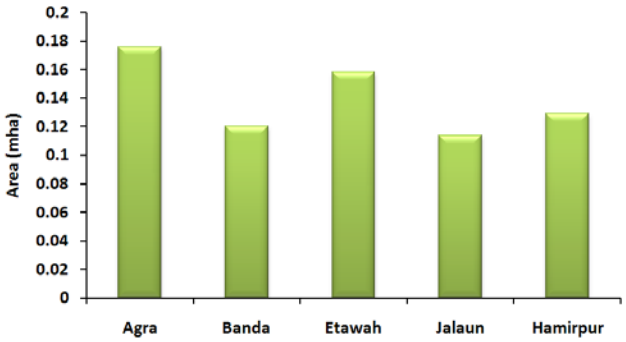

Fig. 4. Area under ravines in dominant districts of U.P.

Soil related constraints

Soil degradation is more precisely described as deterioration in physical, chemical and biological properties of the soils. It occurs through a combination of lowering of soil organic matter and loss of nutrients. The main processes involved are the following. 1. Lowering of soil organic matter with associated decline in soil biological activity. 2. Degradation of soil physical properties (structure, aeration, water holding capacity) as brought about by reduced organic matter. 3. Adverse changes in soil nutrient resources, including reduction in availability of the major nutrients, i.e., nitrogen, phosphorous, potassium. 4. Buildup of toxicities, primarily acidification through incorrect fertilizer use. Non scientific use of land creates numerous problems like land degradation, ravine and water logging. Poor soil health and low organic matter content in the soil is also a major cause for low productivity (Bhattacharyya, 2000). It has been reported that the soils of districts of west UP fall under low-to-medium category (< 0.75%) of organic

C content (Singh *et al*., 2012). Soils in most of the districts of Uttar Pradesh are low in available nitrogen, low to medium in available phosphorus and available potassium status. Soils are getting deficiency is some important nutrients like sulphur, iron, zinc, boron etc. which also results in low productivities of different crops and vegetables and low seed replacement rate particularly in case of pulses and oilseeds the main crops of the rainfed areas.

CONCLUSION

Degradation of soil becomes the important element of environmental degradation causes a serious threat for the economic development in the state. However, deforestation, salinity, waterlogging, decline of water table, improper use of fertilizer in both irrigated and non-irrigated area, are serious causes of land degradation in the state. Evaluating the precise magnitude of soil degradation and its impact on the environment and agriculture are major challenge. Urgent measures are taken to arrest the degradation process and to restore productivity of degraded soils. It is not possible to produce more food to fulfill the obligations to leave a better heritage for prosperity. A well-defined integrated land use policy at the implementable level should be developed.

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