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Assessment of Soil Degradation in Andhra Pradesh

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Abstract: In Andhra Pradesh a number of factors, both natural and human-induced activities have acted on the fragile ecosystems and agricultural lands to cause increasing problems with progressive degradation of soil productivity. The results of an assessment of soil degradation, three have been found to exert a greater influence, *viz.* accelerated water erosion, chemical and physical deterioration. Approximately 15 Mha (54.4%) of land area in the state is affected by various soil degradation problems. Water erosion is the major degradation problem causing loss of top soil and terrain deformation in about 45.5 per cent area. Chemical deterioration in the form of loss of nutrients and/ or organic matter and, soil salinization and sodification account for about 2.1 per cent area. Physical deterioration due to the formation of sealing crusts and compaction, and waterlogging and flooding have affected about 6.8 per cent land area in the state. An estimated area of 11 Mha (35.2%) has been considered to be a stable terrain where human-induced degradation problems are relatively insignificant. About 1.5 Mha (10.4%) was identified as miscellaneous land type (rock outcrops and salt flats) that is not fit for agriculture.
(*Key words: Soil degradation, water erosion, chemical and physical deterioration, stable terrain*)

Soil degradation can be defined as a decline in the soils' productive capacity through adverse changes in nutrient status, soil organic matter, soil structure, concentration of electrolytes and toxic chemicals (Lal & Stewart 1990). It is an important process not only in an arid environment but also in areas where the rainfall is substantially higher. Soil degradation processes usually develop in areas where the vegetation cover has been seriously damaged. Since the dry summer periods frequently coincide with or are followed by violent rainstorms, the unprotected top soil gets subjected to severe water erosion processes which cause average yearly soil losses exceeding 16 Mg ha^{-1} (Dhruvanarayana & Ram Babu 1983). This excessive loss of soil, nutrients, and seeds from the ecosystem restricts regeneration of vegetation by disrupting soil-plant-water relationships which sometimes may lead to irreversible environmental damage. In order to restrict soil and land degradation before the soils loose their resilience, it is of utmost importance to know the kind, degree and extent of degradation in an area. Andhra Pradesh being situated in a transition zone between semi arid/ arid and, dry and moist subhumid climates includes an enormous variety of physiographic, lithologic and edaphic conditions which are prone to degradation with slight mismanagement. Hence an attempt has been made to examine and assess the degradation processes

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affecting the soils of Andhra Pradesh and to establish the causes and factors involved for suggesting corrective measures.

Materials and Methods

Andhra Pradesh state situated on the east coast bordering the Bay of Bengal is between 12°37' and 19°54' north latitudes and 76°46' and 84°46' east longitudes covering an area of 27.5 million ha (Mha). Landforms in the state reflect the geology, the climate and the influence of geomorphological and soil forming processes and has been divided into 18 landforms reflecting their granitic, sedimentary, basaltic, lateritic and deltaic-alluvial origins (Reddy *et al.* 1996). Climate in the state is in a transitional zone from tropical to subtropical monsoonic with semiarid to arid in Telangana and Rayalseema regions, and subhumid to humid in the coastal region. The average rainfall for the state is 830 mm with the lowest of 545 mm in Rayalseema and a highest of about 1100 mm in northern Telangana and coastal regions. About 70 per cent of the rainfall is received during southwest monsoon (June to October) period with a high intensity, particularly during the localized early summer thunderstorms and also during the tropical cyclones which hit the east coast regularly.

The soil resource information generated on 1:250,000 scale at the level of association of soil families through image interpretation of Landsat imagery (1:250,000 scale) with adequate ground truth (Reddy *et al.* 1996) show the kinds of soils, their characteristics, soil-related constraints, geographic distribution and extent. The same was used for assessing the soil degradation in the state. From the soil resource map several thematic maps such as soil depth, erosion, slope, salinity/ sodicity, flooding and surface crusting were generated through Geographical Information System (GIS) on 1:1 M scale and were used for generating the soil degradation map on 1:1 M scale. For assessing soil degradation, the criteria and techniques as given in the guidelines on Global Assessment of Soil Degradation (GLASOD) (Oldeman 1988) was followed with slight modifications to suit the local conditions. Three major types of degradation processes were recognized. The first deals with degradation by displacement of soil-material by the forces of water (W) and the second deals with degradation *in situ* resulting from accumulation of chemical (C) substances such as salts and loss of nutrients, and the third deals with physical processes (P) such as flooding and crusting.

Soil degradation was assessed for each of the 238 soil map units (dominant, subdominant and inclusions of soils) mapped in the state to know the kind, degree, relative extent and severity of degradation. The kind of degradation refers to the processes that caused the degradation like water erosion, chemical or physical deterioration, the degree refers to the present state of degradation like slight, moderate, strong and extreme; the relative extent refers to the per cent area affected within the soil polygon like common, frequent and dominant. The severity of degradation is expressed as low, medium, high and very high by the combination of the degree and the relative extent of the type of degradation process.

Results and Discussion

The soil degradation map generated on 1:1 M scale was reduced to 1:4 M scale and is given in figure 1. The areal extent of different types of degradation in Andhra Pradesh is given in table 1.

Processes and Causes of Soil Degradation

Studies conducted in the field during soil resource mapping in the state indicated that the major types of degradation processes are accelerated soil erosion by water, chemical deterioration in the form of loss of nutrients and/ or organic matter, and accumulation of salts and soil pollutants, and physical deterioration in the form of degraded soil structure, formation of sealing crusts and compaction at the surface, increased runoff and waterlogging and flooding. The causative factors include deforestation, overgrazing, agricultural activities such as insufficient use of fertilizers, use of poor quality irrigation water, absence of proper soil conservation measures to prevent water erosion, over exploitation of the vegetation for domestic use and industrial activities leading to soil pollution.

Soil erosion by water (W): Approximately 45 per cent area of the state is affected by erosion

Table 1. Soil degradation status in Andhra Pradesh

Kind of degradation	Degree of degradation				Total
	Slight	Moderate	Strong	Extreme	
Water erosion (Wt)	2417.10* (8.8)**	5631.46 (20.8)	3772.77 (13.7)	602.37 (2.2)	12423.70 (45.5)
Water erosion (Wt) + physical deterioration (Pc) – crusting	–	670.47 (2.4)	–	–	670.47 (2.4)
Physical deterioration (Pc) – crusting + chemical deterioration (Cn) nutrient loss	–	–	333.99 (1.2)	–	333.99 (1.2)
Chemical deterioration (Cs) – salinity + sodicity	142.20 (0.5)	15.60 (0.06)	155.69 (0.5)	203.68 (0.7)	517.17 (1.8)
Chemical deterioration (Cs) – salinity + physical deterioration (Pw) – waterlogging	–	–	–	71.46 (0.3)	71.46 (0.3)
Physical deterioration (Pw) – waterlogging+ flooding	891.80 (3.2)	–	–	–	891.80 (3.2)
Total area	3451.10 (12.5)	6317.53 (23.3)	4262.45 (15.4)	960.96 (3.5)	14992.04 (54.4)
Miscellaneous lands not fit for agriculture					2873.84 (10.4)
Salt flats (z)	–	–	–	83.45 (0.3)	83.45 (0.3)
Rock land					2790.39 (10.1)

* Area, '000 ha

** Per cent of total geographical area

by the forces of water. The semi-arid and arid conditions have often led to the scant development of vegetation which offers negligible protection against erosion by the frequent short periods of torrential rainstorms (more than 80 mm within one minute duration of rainfall) specially during the hot summer premonsoon and tropical cyclonic periods. Nearly 75 to 100 million tonnes of soil is lost through water erosion annually in Andhra Pradesh.

The average total sediment load of Godavari river at various places in the state increased from 7.9 million tonnes at Mancherial in Adilabad district to 158.7 million tonnes at Polavaram in West Godavari district during June 1987 to May 1988 (Central Water Commission 1992). It signifies an enormous soil loss from the Godavari river basin in the state. Almost 100 per cent of this sediment load in Godavari river basin and more than 70 per cent in Krishna river basin occurred during the rainy season (June to November) alone signifying the impact of the forces of water on soil erosion.

Present farming practices have played an important role in the continued deterioration of soils by water erosion in Andhra Pradesh. Deforestation and subsequent cultivation without proper management, specially in red soils, has induced more runoff in Chinnatekur watershed in Kurnool district (Rama Mohan Rao *et al.* 1988). Runoff and soil loss were found to be highest in cultivated fallow Alfisols and minimum in grassed plots. Soil loss under castor-sorghum rotation was found to be 6.1 t ha^{-1} while it was 0.32 t ha^{-1} for *Cenchrus ciliaris*. Padma Raju *et al.* (1989) in their studies in Maheswaram watershed in Ranga Reddy district on Alfisols showed that sowing of crops along the slope induced more runoff as compared to planting crops with ridge and furrow system laid along contour lines which reduced the surface flow and allowed more time for water to infiltrate into the soil profile. Off-season shallow/ deep ploughing in Alfisols in Hyderabad followed by harrowing and deep ploughing in Vertisols was found to increase

yields of crops (Venkateswarlu 1981) specially in sub-normal rainfall years because this reduces run-off and allows more rainwater to infiltrate into the soil. These and other package of practices developed for dry land agriculture are to be scrupulously followed not only for sustained agricultural production but also for arresting further soil degradation.

Chemical Degradation (C)

Chemical deterioration in soils of Andhra Pradesh occurs through a number of processes like loss of nutrients and/ or organic matter and accumulation of salts or pollutants in the soil.

Loss of nutrients (Cn): The loss of nutrients results from excessive leaching of soils, soil erosion from water and intensive cropping without addition of adequate manures and fertilizers. The problem is more aggravated in the cultivated lands which are marginal or poor with steep slopes. The loss of organic matter after clearing forests or in areas where shifting (*Podu*) cultivation is practised, is almost irreversible which is evident in the tribal agency areas of Visakhapatnam, Vizianagaram and Srikakulam districts. Several studies have indicated that in most regions there is a net negative balance of nutrients and a gradual depletion of the organic matter content level (ICRISAT 1991). Andhra Pradesh over the past three decades has increased its annual food production from about 7.2 million tonnes in seventies to more than 12.3 m tonnes in nineties, which implies increased removal of nutrient elements from the soil. The future demand for food production will have to be met through increased intensity of cropping, the problems of maintaining nutrient balance and prevention of emerging nutrient deficiencies will be a major concern in most of the cultivated lands.

Soil salinization (Cs): The quantitative evaluation of the process of soil degradation due to soil salinization and sodification is generally a complicated issue given its spatial and temporal variability. Salinity in soils of Andhra Pradesh occurs as a result of capillary rise from subsoil containing salts due to semi-arid and arid conditions, indiscriminate use of canal water and poor quality water for irrigation, primary salinity due to weathering of parent materials rich in salts or sea water intrusion. Two types of salinity have been identified, *viz.*, natural salt affected soils in semi-arid and arid regions and soils with salinization induced by intensive agricultural use due to the indiscriminate use of water for irrigation. The physicochemical properties of these soils in Nagarjunsagar and Tungabhadra project areas, and Kurnool-Cudappah Canal area, *etc.* have been described by Krishnamoorthy (1980). The saline-alkali soils generally occur in coastal areas whereas alkali soils are more common in the interior plateau region which are irrigated by tanks, wells and minor and medium irrigation projects.

Physical Degradation (P)

Physical deterioration in soils of Andhra Pradesh has occurred because of decline in organic matter content in soils leading to the formation of sealing crusts and compaction at the surface, degraded structure and increased runoff, and waterlogging and flooding due to human intervention in natural drainage ways leading to flooding by rivers and submergence by rain water.

Crusting, sealing and compaction (Pc): Surface soil crusting and sealing is associated with red and lateritic soils and is promoted largely by the beating action of raindrops if the soil cover is not well protected. Soils low in organic matter and those with appreciable amount of silt and iron content are vulnerable. Compaction is generally caused by the use of heavy machinery. Adverse effects of sealing crusts and compaction can be abated mechanically and by amending the soil to conserve native soil aggregation.

Waterlogging and flooding (Pw): Flooding is a recurrent feature in Andhra Pradesh attributed largely to deforestation in catchments, sparse vegetation cover in the cultivated areas, increased industrialization and urbanisation, and cyclonic depressions in the sea. Flooding and waterlogging due to cyclonic depressions is causing a heavy damage to the soils of deltaic plains in the form of sand-overcast to a depth of 30-50 cm on the surface affecting crop yields significantly. These areas need to be protected by constructing a series of dykes all along the coast.

Yet another degradation process in the form of marine (prawn) farming in Andhra Pradesh is causing irreparable damage to the coastal ecosystem. Andhra Pradesh has a coastline of 974 km and an area of about 95,000 ha under swamps and marshes (Reddy *et al.* 1996). The prawn cultivation which was negligible in seventies has significantly increased by nineties (Venkataratnam & Thammappa 1993). Initially, the prawn cultivation was confined to low productive barren saline lands and the same is now spreading to the prime agricultural lands, and swamps and marshes in East and West Godavari, Krishna, Guntur, Prakasam and Nellore districts along the coast. Mangroves and swamps essential for ecological balance in the coastal ecosystems are being extensively cut and brought under prawn cultivation. This needs to be arrested for restoring the ecological balance in coastal ecosystems.

Soil Degradation Status

The soil degradation status in Andhra Pradesh was assessed from the soil resource map prepared on 1:250,000 scale with association of soil families qualified by dominant phases. Each of the 238 soil map units mapped in the state was assessed for the kind, degree and relative extent of degradation. The soil degradation map (Fig. 1) and the data showing the areal extent of different types of degradation in Andhra Pradesh is given in table 1.

It is seen that about 15 Mha representing 54.4 per cent of the total geographical area (TGA) of the state is affected by various soil degradation problems. Water erosion is the major degradation prob-

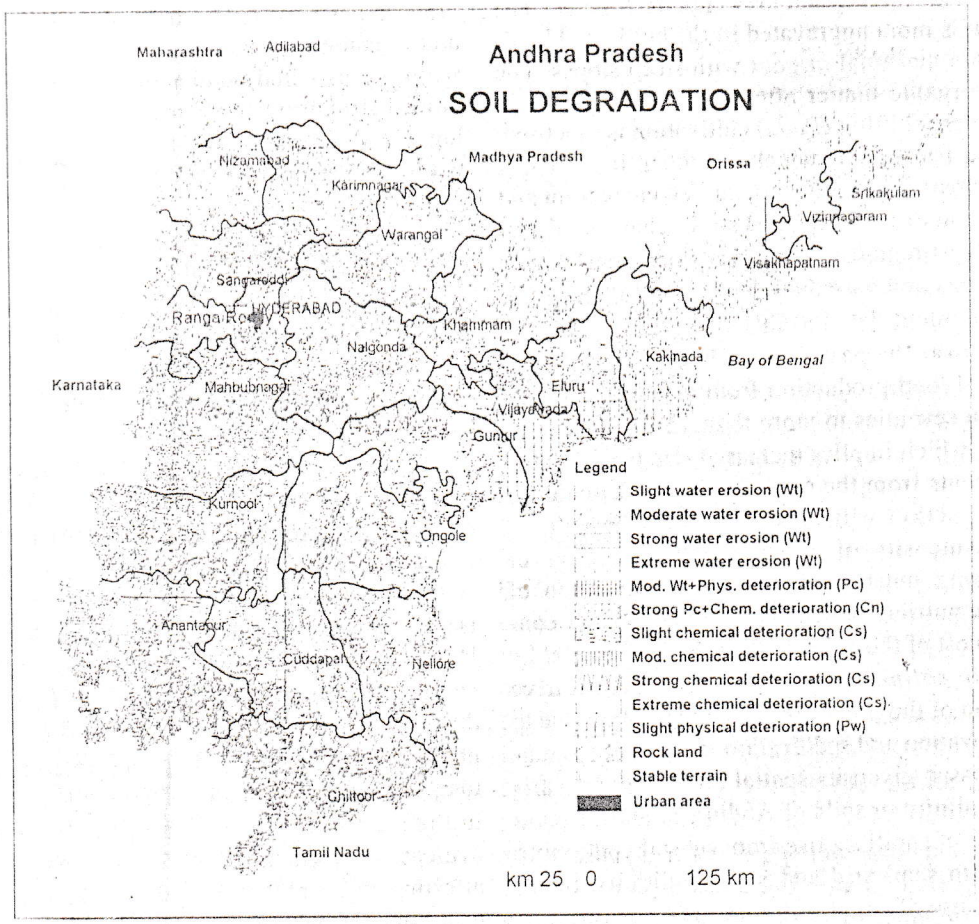

Fig. 1. Soil degradation - Andhra Pradesh

lem causing loss of top soil and terrain deformation in about 45.5 per cent area in the Deccan plateau, Eastern Ghats and Coastal plain areas. Of this an area of about 6 lakh ha (2.2%) suffers from extreme erosion mostly in the southern and south eastern parts of the state; about 37.7 lakh ha (13.7%) from strong erosion followed by 56.3 lakh ha (20.8%) under moderate erosion and 24.2 lakh ha (8.8%) under slight erosion. Almost all the districts in the state suffer from strong, moderate and slight erosion. Moderate water erosion associated with physical deterioration (crusting) accounts for about 6.7 lakh ha (2.4%) covering tribal agency areas of East Godavari, Visakhapatnam, Vizianagaram and Srikakulam districts. Physical and chemical deterioration (crusting and loss of nutrients) are prevalent in the lateritic areas of Ranga Reddy and Medak in Telangana and coastal districts of Nellore, Prakasam, East and West Godavari districts and cover about 3.3 lakh ha (1.2%). Chemical deterioration due to salinity/ sodicity covers about 5.2 lakh ha (1.8%) and is encountered mostly in the valleys, plains, command areas, coastal and delta regions. Physical deterioration due to waterlogging and flooding covers about 8.9 lakh ha (3.2%), mostly confined to the flood plains and delta plains of Godavari and Krishna rivers, and coastal region. The land not fit for agriculture accounts for 28.7 lakh ha which includes salt flats covering 0.8 lakh ha (0.3%) and rock outcrops 27.9 lakh ha (10.1%).

An estimated area of about 11 Mha (34.8%) is considered to be under the stable terrain where human-induced degradation problems are relatively insignificant. The areas grouped under the stable terrain include the valleys, lowlands and plains where agriculture is well managed and soil degradation problems are relatively insignificant and productivity levels will not decrease in the near future.

With nearly 55 per cent degraded lands in the state, there is an urgent need to take up soil and water conservation measures to regenerate and restore the present degraded forests and pastures, and undertake drainage and other reclamation measures before the soils lose their resilience.

The results obtained from this study using GLASOD approach had revealed that the methodology can be used wherever the soil resource information at soil map unit level is available. The results of this assessment can be used as a base line data for change detection and periodical monitoring of the status of degradation.

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