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Use of land use planning classification in soil resource inventory mechanism

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Soil, air and water are the basic natural resources that support all forms of life. Out of this, soil constitutes an important medium through which crops are grown, and food is produced. Aeration in sufficient quantity in proper proportion is a must to encourage metabolic processes. Water also please a significant role in soil plant growth relationship.

Present day soil studies have been generally a part of integrated land resource programme, the major aim of which is often to increase the crop production and also to improve proper land use. Soil surveys at one and locate the highly productive land with a description of the inherent soil properties and on the other they also define the so called unproductive lands and even indicate the appropriate technologies and cost for their reclamation. Many fold problems of the land have increased due to increasing industrialization which have resulted in polluting the natural resource i.e. air, water and soil by way of enriching with various harmful components.

Considering the food demand of the future, Planning Commission of India in the year 1989 gave a major priority to inventorization of soil and water and reclamation of problematic areas for intensive food production.

Various approaches for land use planning:

In order to develop a proper methodology a number of approaches have been made from time to time namely:

– Interpretational approach (through simple soil surveys),

– Complex agro-pedological approach

– Integrated land evaluation approach.

Interpretational approach:

In early sixties, interpretational approach was started through simple soil surveys considering soil mapping and interpretations. It was mainly based on a few individual profile characteristics like texture, drainage, soil depth and soil slope/erosion hazards and was called soil mapping unit (cl–d_5/A-e1). Soils were differentiated at high level between peodcals and pedalfers depending essentially on colour characteristics and on the eventual presence of free lime in the profile. Some times colour criteria was also linked with soil nutrient status. However, no systematic methodology with respect to any criteria was followed.

In cultivated areas, the soil appraisal was based on extrapolation and evaluation of crop yields obtained on similar well known soils. In virgin soils an expression of soil fertility status was based on the existence of native vegetation. Overall the relative approximations were mainly left to the personal interpretations of the soil scientist.

Complex agro-pedological approach:

After the world war 2nd, it was felt necessary to develop more systematic approach towards soil inventorization and their application to agriculture. It was thought to replace the personalized way of interpretations through range of parameters and their ratings. Klingebiel and Montgomery (1961) developed land capability classification (LCC) in USA. They in 1966 listed a number of criteria/limitations for judging the capability of soils to produce crops which included soil depth, erosion, drainage, workability, stoniness/ rockiness, WHC, nutrient availability, salinity/alkalinity/climate. Based on these parameters, 8 capability classes were introduced indicating the potential to produce crops and pasture over a long period of time. Risk of soil limitations were progressively greater from class I to class VIII.

This capability classification system served the purpose for a longer period. Wherever letter on some of the following inconveniences were felt by the researchers and end users.

Provided only general appraisal :

The system led to a general appraisal but did not deal with the growth and production of specific crops each having particular requirements. This was very useful for broad planning purposes at regional/national level but lacked to answer accurately regarding specific agricultural uses.

Based on soil characteristics :

Parameters considered for land capability groups, were based on soil properties and no attention was paid to climate growth requirements. Capability ratings did not provide productivity scale for crops.

Inaccurate criteria for grouping :

Accurate definitions of the criteria especially ratings for drainage, soil depth or MHC were provided however, no proper definitions of climate and soil fertility existed for the purpose of grouping the soils. This approach also did not show link with agro-climatic conditions of the region.

Integrated land evaluation approach:

Factors influencing crop growth have direct impact on the production. In this new approach, prime concern has been given to the plant and its specific growth requirements. The capability of a land to produce crops is determined by the combined effect of

– Physical (climate, land form pattern, soil and moisture conditions

– Human (availability of farmers and their ability and

– Capital resource availability of funds resources.

Basic principles of this new approach include 5 fundamental assumptions.

Specific kind of land use :

Land suitability can only be properly evaluated for specific kind of use *i.e.* a preliminary decision has to be taken with respect to the required land use before the evaluation procedure is initiated.

Comparison of benefits:

The evaluation requires a comparison of the benefits obtained and the inputs needed on different types of the land. Suitability for each use needs to be assessed by comparing the required inputs with the yields or other benefits. This indicates that highly productive land does not necessarily give highest benefits.

Physical, economical and social context of the area:

This refers to the specific crop growth requirements on one hand and their marketing values on the other. For

Table 1 : Three category system approach for land evaluation FAO (1976)

Order (kind of suitability)	Class (degree of suitability)
S-suitable land	S_1-Highly suitable (Optimum conditions for plant growth)
	S_2-Moderately suitable (Affecting productivity by 20% or less)
	S_3-Marginally suitable (Severe limitations but correctable)
N-Non suitable land	N_1-Non suitable but potentially suitable (slightly correctable)
	N_2- Non suitable because potentially unsuitable (non correctable)

Table 2 : Kind of limitations

Limitations	Symbol	Factors
Climate	C	RF (cr), Temp.(ct), Growing season (cg)
Topography	T	Slope (ts), Relief (tr), Erosion (te)
Wetness	W	Drainage (wd), Flooding (wf)
Physical soil properties	S	Depth (sd), Stoniness (ss), testure (st), lime (sl), gypsum (sg)
Natural fertility	F	OM (fo), CEC (fc), Base status (fb)
Salinity / alkalinity	A	EC (ac), GW (ag), ESP (ae)

Table 3 : Rating for various soil properties

Symbol	Rating for	Basis for calculation
A	Texture	Taken as 100 for loam and $\leq$ 50 for clay and sand
B	Soil depth	Taken as fraction of 1
C	$CaCO_3$ status	Taken as fraction of 1
D	Gypsum status	Taken as fraction of 1
E	Salinity / alkalinity	Taken as fraction of 1
F	Drainage condition	Taken as fraction of 1
G	Topography (slope)	Taken as fraction of 1

Hence, Ci of soil = 100 x 1.0 x 0.9 x 0.8 x 0.9 x 1.0 x 1.0 = 64.8 or 65 % *i.e.* suitability

Table 4 : Parametric approach using capability index (Ci) Sys *et al*. 1981

Capability index (Ci)*	Suitability	Limitations	Evaluation	Symbols used
$\geq$ 80	Excellent	No	Optimal for plant growth	0
60-80	Suitable	Slight	Nearly optimal (Productivity is affected by only 20%	1
45-60	Slightly suitable	Moderate	Decline of crop yield	2
30-45	Almost unsuitable	Severe	Use of soil not economical	3
< 30	Unsuitable	Very severe	Decrease of yield below profitable level	4

*Ci = ABCDEFG, A – Rating of soil texture, B–Soil depth, C –Calcium content status, D – Gypsum status, E–Salinity alkalinity status, F–Drainage condition, G –Topography example higher produce achieved may not be economical due to main markets located for away from the place of produce. In other words, the evaluation of the land must be done considering these parameters.

Suitability assessment:

The use of land must be assessed on a sustained basis. One should not think for short term profitability but on the contrary long term productivity should be maintained. Land degradation on the cost of getting high produce must not be appreciated.

Comparison of more than one single kind of use :

Evaluation is only reliable if the benefits and inputs from any given kind of use are comparable with one or several different alternatives for example comparison of different crops within one management type and *vice-versa*.

Phases for establishing soil site suitability:

The integrated land evaluation system is basically based on the crop growth requirements expressed in terms of climatic, soil and physiographic criteria followed by matching of those with the corresponding environmental parameters.

The step by step methodology as suggested by FAO (1976, 1984) Sys *et al*. (1981) and Verheye (1991). Is schematically represented in Fig. 1. It has 5 phases :

Phase 1. Identification of land use type: Type of crop or crop variety as well as the management type under which production will take place.

Phase 2. Definition of crop growth and production conditions: Plant growth requires a reasonable moisture and nutrient supply linked to a sufficient rooting depth. The nature of constraints can broadly be defined as :

– No limitation - optimal characteristics with no constraints.

– Slight limitation - Nearly optimal for given land and affects productivity by 20% only.

– Moderate limitation- Moderate influence on yield decrease which reaches upto 50%. Benefits however, can still be expected.

– Severe limitation - Marginal influence of productivity of the land where yield decrease reaches below to the profitability level.

Phase 3. Collection of environmental data which directly affect the crop production.

Phase 4. Key operation of the evaluation procedure : It deals with the matching of the environmental condition of the area with the specific crop and production criteria. This exercise leads to the evaluation for each individual soil and climatic unit of the nature and degree of limitations.

Phase 5. Criteria of suitability classification: based on the number and degree of limitations, a scale then be established and suitable and unsuitable lands can be demarcated.

Soil site suitability criteria:

FAO (1976) three category system approach of the resent evaluation procedure was introduced since the mid of seventies. The order (kind of suitability) and class (degree of suitability) are given in Table 1. Further the subclass that reflect the kinds of limitation are presented in Table 2.

The recent evaluation procedure was introduced since the mid seventies by FAO (1976) and lateron the same was modified by Sys *et al*. (1981). The classes and degree of limitations are presented in Table 1 and 2, respectively.

Parametric approach of Sys (1976):

He proposed a parametric approach for evaluating soil suitability using capability index. Ci = ABCDEFG

Conclusion:

India, followed the USDA system of land capability classification till 1980 (Vadivelu, 1997) but lateron started adopting FAO guidelines (FAO, 1976) and their derivatives for assessing the suitability of land for growing various crops.

Further the country, developed the modified version of land evaluation guideline (Sehgal *et al*. 1989) of FAO (1976) and Sys's (1981) by refining the soil site suitability criteria for different crops. However, still the improvements in the land evaluation approach are being made NBSS & LUP, in India.

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