From Soil Survey to Land Use Planning and National Soils Policies

New Developments in Soil Science

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Summary

The emphasis of soil studies has shifted over the past decades from descriptive inventories towards a more specific, pragmatic and problem solving approach related to land use and soil conservation.

Under conditions of growing population density, land may become a source of conflict between various users: settled farmers, miners, stock breeders, foresters, urban planners, ecologists,... In such cases, a national soils policy becomes imperative, as it provides a useful planning framework for evaluation of alternative land use scenarios and for the selection of the best options. It supports land use decisions for the future and helps in setting rules to meet the socio-political objectives, whilst preserving the delicate balance between economic and ecological aspects of land and land use.

A policy is an act of intention which lays down the principles for achieving long-term objectives. The details of the policy are left to implementing strategies and programmes; the former cover technical tools and steps for achieving the policy goals, whilst the latter are directly related to means of implementation. An example is given showing how a policy of food self-sufficiency has been realized in India.

Samenvatting

In de voorbije decennia heeft het zwaartepunt van het bodemonderzoek zich geleidelijk verplaatst van een grotendeels beschrijvende en inventariserende studie naar een meer pragmatisch zoeken van oplossingen voor specifieke problemen van bodemgebruik en -conservatie.

Onder toenemende bevolkingsdruk wordt "land" snel een bron van conflicten tussen potentiële gebruikers, zoals landbouwers, veetelers, bosbouwers, mijnbouwondernemingen, stadsplanalogen, milieu-activisten. In zo'n gevallen is een nationale bodempolitiek op haar plaats, omdat op die manier een blauwdruk kan opgesteld worden voor een vergelijkende evaluatie van de diverse bodemgebruiksvormen, en tevens een selectie gemaakt van de beste opties in het kader van te verwezenlijken objectieven. Dit laat toe op een wetenschappelijke basis beslissingen voor te bereiden met het oog op een toekomstig bodembeleid, en regels vast te leggen die niet alleen rekening houden met de geplande sociaal-politieke doelstellingen, maar ook met het delicaat evenwicht tussen economische en ecologische belangen van het bodemgebruik.

Een politiek is per definitie een intentieverklaring over de principes nodig om een vooropgezet doel te bereiken. De details in dit verband worden structureel vastgelegd in strategieën en programma's. Een strategie bepaalt de methodologie en de aan te wenden technische middelen, terwijl programma's rechtstreeks betrekking hebben op de uitvoeringsmodaliteiten zelf. Aan de hand van een voorbeeld wordt aangetoond hoe in India de politiek van de eigen nationale voedselvoorziening via het bodembeleid werd gerealiseerd.

Introduction

The number of soil studies carried out in recent decades is impressive. Realizing that soils have a major impact on crop production and on land use in general, many development projects have been based on more or less comprehensive soil investigations. In situations where this was not the case the East African groundnut scheme is "the" classic example crop failures and/or inconsistent crop outputs were not uncommon. Hence, many national and international donors are still insisting that a soil study be incorporated in (pre)feasibility project phases.

At present, most countries have a national soil service, with a professional expertise and laboratory facilities to provide soil information to agronomists, crop specialists, rural planners,.... It is, therefore,surprising that nowadays many of those institutes are hardly operational or are even out of work, and that there is

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an obvious lack of interest among planners and land use experts to call upon specific soil information. Amongst the various reasons for this are:

- From the point of view of land users or policy makers,the study of the soil is not a goal on itself but forms an integral part of a larger development project. Soil survey is a time-consuming activity and if its direct relevance to the overall project goals is not clear, there is a risk that the programme is cancelled or replaced by a rapid and less costly remote sensing study without appropriate field control.
- Soil surveys are too often carried out using standard procedures which are not cost-effective and often not properly oriented towards specific project goals; hence, soil mapping and related analytical characterizations should be more flexible in their approach, be more user-oriented and be primarily conceived to address the problems of the land users.
- Many soil investigations remain too descriptive and academic, whilst end users require that salient soil features be identified and reasonable recommendations be formulated;
- Soil science in the past decennia has put too much emphasis on research aspects without direct relevance to practical problems in the field; hence, a serious gap has been created between the academic approach to soil science and the urgent soils-related problems of modern societies in terms of crop production, land use planning, and soil conservation, viz. nature protection.

D.S.Dalal-Clayton and D.Dent (1) have produced a detailed critique of the failings of natural resources surveys in general, and of soil surveys in particular. It is obvious that soil science has to some extent developed along its own academic lines and has not been sufficiently flexible in addressing the problems of land use in a constantly changing society. In brief, there is no need to set up a comprehensive study with ample considerations on pedogenesis, classification, clay mineralogy, etc... if the objective is to know whether a crop can be grown, at what cost and under what management system !

Being aware of this situation international groups of soil specialists got together in the 1970s and developed the Framework for Land Evaluation (2). This new approach realized that soils should not be studied in isolation and as a separate discipline, but be seen as part of the environment for which various uses can be considered. This concept was at the origin of a completely new development in soil science.

Soil and land use

Soil is a part of the social and physical environment. Its properties, behaviour and potential are invariably associated with the surrounding climate, landform, vegetation, cropping pattern or other land use practices. Hence, soil is a focal point for an increasing number of competing and even conflicting land uses. In this respect, there is still a high demand for proper soil and land use information in the following context:

- Soils have a specific suitability for crop production, and they will react differently to various farming practices. Soil investigations are therefore needed to identify various land use scenarios and to select land use types that are optimal, both in terms of crop diversity and anticipated yields.
- Land which is actually less suitable for a particular use may be reclaimed with modern technologies. Proper soil studies can identify production constraints and, wherever possible, recommend reclamation measures to improve soil quality and outputs.
- Soil and land are not only linked to agricultural uses. Under conditions of rural migration and the development of urban and industrial centres, part of the former agricultural and forestry land has to be re-allocated to other uses. Soil information may support the decision-making processes related to the re-allocation of land for urban and infrastructural developments or for any other uses within the rapidly changing modern society.
- Finally, within the present-day concepts of sustainable development, land use options and aspects of soil quality cannot be dissociated from environmental considerations. Well selected soil data can provide a major input in nature protection and in the development of effective soil conservation techniques.

Competition for land

The available arable land at world, regional and national levels is well investigated. On the basis of the World Soil Resources Map (4), there exist about 3 million ha of suitable arable land of which some - 1.4 million ha is actually under arable and permanent cropping - out of a world total of 13 million.The available suitable land is hardly varying over time, but what is, however, consistently changing is the population, especially in the developing countries, where growth rates of 2-3% are not uncommon (Figure 1). Hence, under conditions of a growing population the competition for land is rapidly increasing.

Worldwide, the population has grown from 3.3 billion in 1961-65 to almost 5.3 billion people in 1991, with perspectives up to 7.5 billion in 2010 (5). However, these global figures mask high disparities between regions and nations, and in many developing countries the available cropland per head of the population has seriously dropped. Although this decrease is at present most severe in Africa, e.g. from 0.62 to 0.27 ha per person over the past 30 years (Table 1), these ratios have become most critical in Asia. With the exception of Ruanda, Burundi and Tanzania, there exist still vast reserves of land in Africa (and to some extent in South America), where only 36% of the arable acreage is used. In Asia this figure reaches 92% (4).

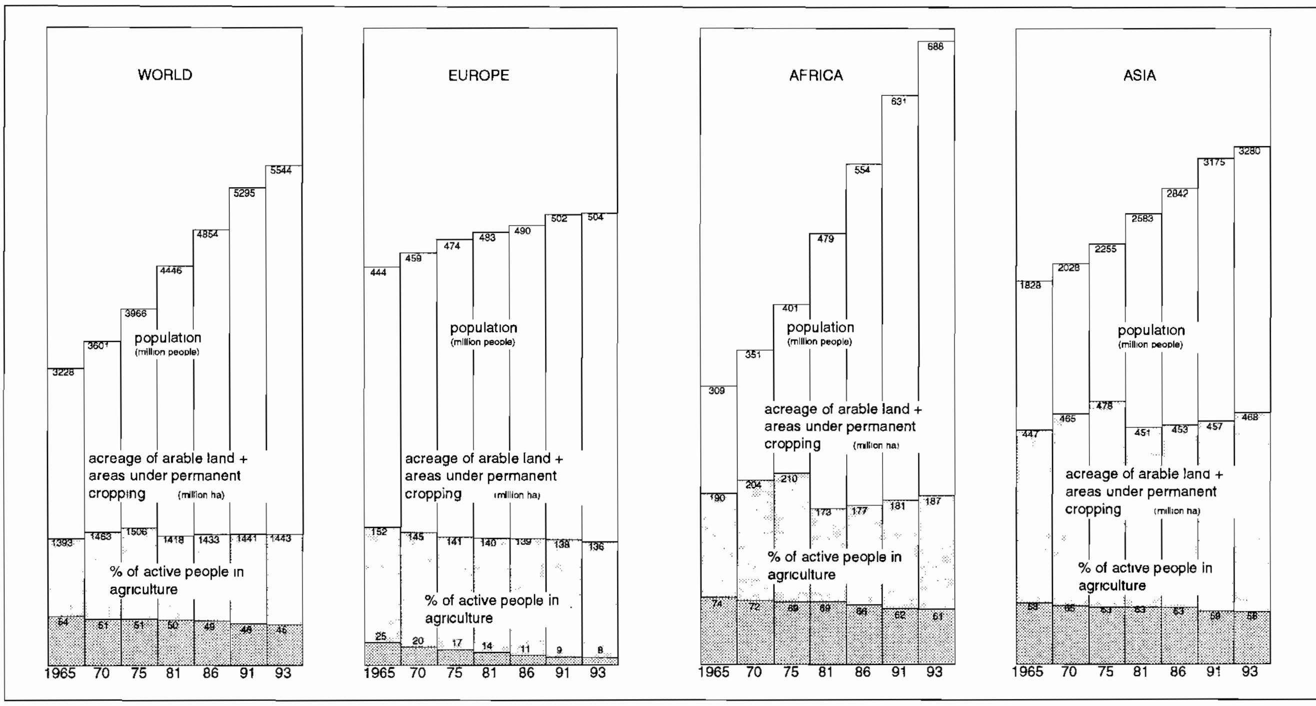

Figure 1. Trends in population growth, acreage of arabe land + land under permanent cropping, and number of people active in agriculture between 1965 and 1993 at world level, and in Europe, Africa and Asia (5).

Table 1 Population growth and changes in cultivable land/man ratios between 1961-65 and 1991 (5).

Country	Population (in millions)		Cultivable land/man ratio	
	1961-65	1991	1961-65	1991
WORLD	3,288,510	5,295,176	0.39	0.27
EUROPE	444,801	502,714	0.34	0.27
AFRICA	309,382	661,849	0.62	0.27
Angola	5,101	9,524	0.31	0.36
Benin	2,365	4,767	1.24	0.39
Burkina Faso	4,958	9,248	1.00	0.38
Cameroon	5,356	11,857	1.33	0.59
Malawi	3,932	9,986	0.40	0.17
Mozambique	7,449	14,495	0.36	0.22
Ruanda	3,199	7,271	0.20	0.16
Tanzania	11,616	26,898	0.29	0.13
ASIA	1,824,530	3,175,529	0.24	0.14
China	710,324	1,170,893	0.17	0.08
India	482,365	862,745	0.33	0.20
Indonesia	105,070	187,724	0.16	0.12
Malaysia	9,000	18,342	0.27	0.27
Nepal	10,100	20,072	0.18	0.13
Pakistan	52,415	121,485	0.34	0.27
Sri Lanka	11,164	17,440	0.15	0.10
SOUTH AMERICA				
Brazil	82,541	151,623	0.40	0.37
Guatemala	4,583	9,497	0.31	0.15
Nicaragua	1,701	3,807	0.51	0.37

The very low arable land/man ratios in Asia in general, and in a number of countries like China, Indonesia, Nepal and Sri Lanka in particular (Table 1), not only illustrate the enormous pressure on available agricultural land but, also, points to the risks of soil degradation due to soil nutrient depletion. Under those conditions, people in need for additional food production will encroach on non-cultivable and often erosion-prone areas. Because of the increasing land pressure in Java, it has been estimated that some 100.000 ha per year turn into critical erodible land (6). The following conflicts may occur in relation to land:

- Competition among settled farmers due to land shortage and to a reduction in length of the fallow period in traditional shifting cultivation systems. Over a period of 20 years (1956-76) the average length of the fallow period in Sierra Leone dropped from 15-18 years to less than 5 years (13), and this situation has accelerated migration movements from rural to urban areas.
- Competition for land between nomadic herders and sedentary farmers leads, under adverse climatic conditions, to an obvious shortage of grazing lands and water.
- Competition between various land users with different traditional land management practices. Hence, savanna fires initiated by herdsmen affect neighbouring croplands and forests, and constitute a main reason for forest degradation in the tropics.
- Side-effects of mining operations result in the pollution of neighbouring lands and waters, and affecting the quality of soils and fishing grounds.
- Urban development, often associated with the encroachment of valuable croplands and/or forest areas. The area of first-class rice land annually lost due to city encroachment in Java (Indonesia) is estimated at 50,000 ha, with a production potential of approximately 350,000 tons of paddy/year. In order to compensate for these losses some 200,000 ha of new, mainly forested lands have to be cleared every year (6).

- Forest degradation due to fuelwood exploitation and charcoal burning is a common phenomenon around rapidly developing cities in Africa. Almost 90 % of the present-day domestic energy needs of Freetown in Sierra Leone are provided by fuelwood, requiring approximately 350,000 to 500,000 cubic meters woody biomass per year. Charcoal production around the city increased from 10,000 tons in 1978 to 55,000 tons in 1987 and over 80,000 tons at the present moment, and former farmers around the town and feeder roads have now become full-time fuelwood/charcoal producers.
- ...

A number of land use activities referred to above cannot go on indefinitely without damaging the environment or creating social unrest. Conflicts over land and land use require that rapid decisions be taken with respect to land use in the future. Those decisions should be based primarily on objective criteria related to land suitability potential and carrying capacity, socio-economic and ecological considerations. In this way, various scenarios should be developed and a proper national land use planning and soil policy be established. Up to date and problem-oriented soil investigations have a role to play in this process, and should provide the scientific basis for such a policy.

Concept and objectives of a national soils policy

Under conditions of a steadily increasing population, people's lifestyle changes from dominantly rural to a mixed or even urban society. The number of people engaged in agriculture is decreasing (Figure 1), and economic progress is often based on the "mining" of natural resources without due attention being paid to biological equilibria or to rules of sustainability. Realizing that a broadbased sustainable development is not feasible without sound environmental assessment at the inception stage, and learning from adverse experiences, international organizations have expressed growing concern over a number of critical issues, related to growing world food demands, increasing risks of soil degradation and nature protection. Hence, the United Nations Environment Programme (UNEP), in collaboration with FAO and UNESCO, has emphasized the importance of a coordinated World Soil Policy, and has urged the need for national soils policies to conserve those natural resources. In this context, UNEP issued its World Conservation Strategy in 1981, and in the following year the World Soil Charter (3) was drafted.The "Bruntland" report of the World Commission on Environment and Development (15) and the UNCED resolutions of Agenda 21 (10) are a logical follow-up of those earlier expressed concerns.

All these documents draw attention to the importance of soils as a basic natural and almost non-renewable resource for agriculture, forestry and other land uses. They stress two major principles : one, of avoiding soil losses and degradation; and two, of utilizing soil to its maximal potential but within the context of sustainability. These principles thus promote the best use of soils and other land resources to meet present needs whilst, at the same time conserving resources for populations of the future.

A national soils policy is a set of guidelines, aiming at ensuring and stimulating maximal utilization of soils on a sustained basis without lowering productivity, and limiting direct or indirect damage to the environment. Emphasis is placed upon knowledge of the varied nature and properties of soils and, as a consequence thereof, upon the needs for appropriate management (12).

A policy, as defined above, has to take into consideration the nation's diversity and particular problems. Therefore, it should not focus only on soil production and conservation problems but should, also, cover other development aspects related to the management of forests, pasture and grazing lands, mining areas, city expansion, etc.

A national soils policy deals with four aspects, addressing technical, socio-economic, institutional and legal elements, at least to the extent that those contribute to the implementation of strategies and programmes. In broad terms, a national soil policy should aim to bring about activities which will :

- Assess available land resources and improve soil productivity by applying better management techniques and developing and/or promoting more productive agricultural systems.
- Enlarge cropping areas and improve the quality of the available agricultural land wherever feasible.
- Slow down losses of croplands and forests, monitor changes in soil quality and quantity, and evaluate the way land is used.
- Bring to the attention of all concerned the dangers and adverse consequences of soil degradation and the need for conservation and appropriate legislation.
- And create or improve the capabilities of national institutions to carry out those aims.

Modalities for implementation

A policy is an act of intention, which lays down basic principles for achieving long-term objectives. The details of the policy are left to implementing strategies and programmes (or modalities in general). The strategies cover technical tools and the steps for achieving the policy goals, whilst programme elements are specifically related to means of implementation. In contrast to the policy itself, the implementing strategies and programmes may vary with changing circumstances and, hence, should be able to adapt to new conditions without having to resort to the cumbersome process of revising technical parameters and legislation.

The *long-term development objectives* which govern a national soils policy vary widely from one country to another and, therefore, it is not useful to define standard modalities for its implementation. A common target for many developing countries is, however, related to food security, and the way this problem has been tackled in India may serve an example.

The basic elements which influence food production and food self-sufficiency in the world, and in India in particular, refer to (1) population perspectives, and (2) the national land use potential. Current projections for India indicate that, with an assumed average growth rate of 1.9 %, the national population will exceed 1 billion by the year 2000. In the past decades, the national production of food grains has increased from hardly 50 million tons in 1950 to 150 million in 1985 (Table 2), whilst the overall potential is estimated at 450-500 million tons/year (8,14). Hence, there is scope to achieve national food self-sufficiency and to improve the average food availability per head (Table 2) for another 30 years at least if population growth can be controlled, and if the natural soil potential is used adequately.

Table 2. Trends in foodgrain production and per caput food production index in India between 1950 and 2000 (5,8,9,14).

Year	Population (millions)	Total foodgrain production (million tons) *		Total per caput food production index (1985=100)
		Target	Achieved	
1950	359,000	-	50.9	-
1970	543,132	-	99.0	-
1980	688,856	-	129.6	100
1985	768,185	135.2	150.4	111
1986	785,933	142.0	144.1	110
1987	802,698	149.1	138.4	106
1988	819,482	156.6	169.9	117
1989	836,339	164.4	179.1	122
1990	850,638	172.6	175.2	121
1991	870,968	178.6	177.1	122
1992	884,425	184.9	180.3	125
1993	901,459	191.4	187.2	125
1994	-	198.1	192.4	-
1995	-	205.0	-	-
2000	(1,000,000)	239.0	-	-

* Foodgrains = rice, wheat, coarse cereals and pulses.
Food index refers to all food products.

During the Seventh Development Plan (1985-90) the target was to achieve an average yearly increase in food production of 5 %, slowing down to 3.5% after 1990. This should lead to a total foodgrain production of 172 million tons in 1990, 205 million tons in 1995 and 239 million tons in 2000. Presently available data show that those targets can reasonably be met (Table 2).

Strategies to implement these objectives included : (1) the extension of irrigable and dryland areas up to their potential of 110 and 150 million ha respectively, (2) an overall yield increase to 2.5 tons/ha in irrigated and 1.5 ton/ha in rainfed croplands, and (3) an average of 75% of all cultivable land as being used for foodgrain production (9).

Irrigated cropping. Crop yields in India are affected at least once every 3 years by adverse weather, especially rainfall conditions (see table 2, yields for 1987 and 1990-91). Therefore, the primary target is to increase water availability to crops, either through an improvement of the existing irrigation systems or through the extension of irrigated areas, and to achieve a maximal utilization of the total irrigation potential. Specific programmes to implement this strategy rely in particular on:

- Improvement of existing irrigation systems by a more efficient, viz. crop- and soil-specific water use, better maintenance of canals, water quality control and improved soil drainage.
- Reclamation and improvement of marginal, mainly saline-alkaline lands in the Indo-Gangetic plain, through chemical amendments (gypsum application) and leaching of excess salts.
- Development of small-scale irrigation projects in areas with good-quality groundwaters and aquifers by means of shallow tube and dugwells, mainly in smallholders fields.

Dryland crop production. Most of the potential rainfed croplands in the country are already under cultivation and, therefore, consistent production improvements can on be expected from yield increases. This can be realized by the introduction of soil conservation and water harvesting programmes on a communal watershed basis, or through the construction of checkdams and field tanks on a more individual basis, with the main objective to overcome short dry spells within the cropping season. Programme elements with direct relevance for a successful implementation of this strategy include:

- Confirmation of the legal status of land ownership and land tenure for small farmers with less than 2 ha of land.
- Creation of financial and other incentives to allow for initial investment costs for soil reclamation and water supply.
- Seed selection and the development of high-yielding varieties, and making these available both timely and at reasonable costs to farmers.
- Increased emphasis on pest control to combat crop losses.
- Promotion of the use of mineral fertilizers through a policy of subsidies to farmers. In this context the fertilizer consumption in the country has jumped from 65.000 tons in 1951 to almost 9 million tons in 1990, and whilst in the early 1960s mineral fertilizers accounted for hardly 2 % of the foodgrains output, this figure rose to 35 % in the 1980s (7)
- Re-adjustment of agricultural research, referring in particular "to the re-orientation of the former concept that physial input /output relationships rather than financial costs and returns consisted the primary area of concern of agricultural scientists, resulting in a large corpus of research findings with little or fortuitous relevance for the farming community" (8).

From the foregoing example it can be concluded that rural development planning still relies heavily on soil information, mainly in terms of land use optimization and of land conservation and reclamation. In the particular case of India, the whole land use programme has been supported by the nationwide Lab to Land Programme, bringing scientists and extension workers more closely to the real problems of the farmers in the field.

Conclusions

Modern soil science has still a major role to play in development programmes and in various land use planning exercises, where physical criteria are required to assess the potential of the land. In this respect, soil scientists should not work in isolation, but be part of multidisciplinary teams, where their expertise will be integrated into natural resource evaluations. The time that soil investigations were almost exclusively devoted to mapping and/or pedogenetic or classification work, without relevant outputs for land use and other social activities, has definitely passed.

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Résumé

Au cours des dernières décennies l'accent dans l'étude des sols s'est graduellement déplacé d'un travail plutôt descriptif et d'inventaire vers une approche plus pragmatique, attaquant davantage les problèmes d'utilisation et de conservation des sols.

Sous une pression démographique de plus en plus importante, la terre devient une source de conflit entre bon nombre d'utilisateurs potentiels, tels qu'agriculteurs, éleveurs, forestiers, compagnies minières, urbanistes, écologistes,.... Dans ces cas une politique nationale des sols s'impose, car ceci permet d'avoir d'un seul coup un aperçu sur la nature et les potentialités des terres, leur risque de dégradation, etc. De plus, ce document permet de sélectionner de manière plus scientique l'option la plus intéressante. Ultérieurement, cette approche peut enfin amener à des décisions pertinentes quant à l'organisation et l'utilisation de l'espace, et à la mise en place du cadre pour atteindre les objectifs socio-politiques de la région ou du pays, tout en préservant la balance délicate entre les aspects économiques et écologiques du territoire.

Une politique est par définition un acte d'intention arrêtant les principes pour atteindre le but voulu. Le détail de la politique est explicité dans les stratégies et programmes. La première définit la méthodologie, les moyens techniques à mettre en œuvre et les étapes à suivre pour atteindre l'objectif; les dernières concernent plutot l'exécution effective de la stratégie. Un exemple est donné, démontrant comment en Inde la politique d'auto-suffisance nutritive a été réalisée.

Literature

1. Dalal-Clayton D.S. & Dent D., 1993 - Surveys, plans and people : a review of land resource information and its use in developing countries. Environment planning Issues n° 2, IIED London, 148p.
2. FAO, 1976 - A framework for land evaluation.FAO Soils Bull.32, Rome, 72p.
3. FAO, 1982 - World Soil Charter. FAO, Rome, 7p.
4. FAO, 1989 - FAO World Soil Resources Map at scale 1:25,000,000 with explanatory note. FAO World Soil Res.Rep.66, Rome, 58p.
5. FAO, 1970-1994 - Statistical Yearbooks. FAO, Rome.
6. FAO-UNEP. 1994 - Advisory services to Indonesia on the Formulation of National Soils Policies. FAO. Rome, 71p.
7. Khanna S.S. & Gupta M.P., 1989 - Fertilizer strategy for the raising of agricultural production. Yojana, Delhi, India, **33**(5): 10-15.
8. Khanna S.S. & Pavate M.V., 1989 - Agricultural development: Challenges ahead. Yojana, Delhi,India, **33**(7): 13-18.
9. Khanna S.S., Pavate M.V. & Brij Bushan, 1989 - Recent trends in agricultural growth. Yojana. Delhi,India, **33**(12): 19-23.
10. UNCED, 1992 - United Nations Conference on Environment and Development. Agenda 21, Ch.II,2 : Conservation and Management of Resources for Development. Proceed. UNCED Conf. Rio de Janeiro, June 1992, pp.1-121.
11. UNEP, 1981 - World soil conservation strategy. UN Environment Programme, Nairobi, 70p.
12. UNEP, 1983 - Environmental guidelines for the formulation of National Soils Policies. UNEP Environm. Manag.Series 7,UN Envir Progr., Nairobi, 32p.
13. Verheye W., 1978 - The evolution of the land use pattern in the past 20 years (1956-1976) in a tropical woodland area. A case study of the Moyamba District, Sierra Leone. Ts. Belg. Veren. Aardrijksk. Studies, 1978(2): 241-256.
14. Verheye W., 1989 - Appraisal mission for the PPCL proposal to improve alkaline and acid soils in India. 1 : Physical aspects. (draft edition). Lab. General Pedology, State Univ. Gent, 35p.
15. WCED, 1989 - Our common future. World Commission on Environment and Development, Oxford Univ.Press, Oxford, UK.

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