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4th Dr. S.V. Govindarajan Memorial Lecture

National Soil Information System (NASIS) and Land Resource Mapping for Perspective Land Use Planning and Pragmatic Farm level Planning

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I thank the President and the Executive Committee of the Indian Society of Soil Survey and Land Use Planning, Nagpur for having given me this privilege and honour of delivering the 4th Dr. S.V. Govindarajan Memorial Lecture.

Dr. S.V. Govindarajan (1913-1991) was the Founder President of the Indian Society of Soil Survey and Land Use Planning, established in 1986. In 1956, he joined as Soil Correlator of the Southern Region and became the Chief Soil Survey Officer of the All India Soil and Land Use Survey Organisation of the Ministry of Agriculture, Govt. of India in 1961. He served as an Advisory Board member of FAO-UNESCO project on Soil Map of the World and compiled the soil map of India (1:3 million scale) with 23 soil groups as mapping units for the World Soil Resources Report No.26, FAO-UNESCO (1965). He also compiled the Soil Map of India in the scale of 1: 7 million in 1971 on the occasion of the International Symposium on Soil Fertility Evaluation held at New Delhi authored a Technical Bulletin on Soils of India by Raychaudhuri and Govindarajan (1971). This was his significant contribution in the year of his superannuation. That his approach was always to relate Soil Survey information with crop and land productivity reflected in the title of the book, he authored with H.G. Gopala Rao, *viz*., "Soil and Crop Productivity" (1971&1978).

Abstract: The complexity of soil variability, the purpose and use of soil survey information, soil classification and mapping at different scales are discussed. The need for a simplified National Soil Classification System based soil mapping for farm level land use planning at village / watershed scale is illustrated and reiterated. The paradigm shift from Soil Mapping to Land resource mapping at village level by detailed soil survey and socio-economic survey is emphasised for embarking upon a National Mission Mode Project, which will help in the development of Soil productivity indices and Rating, Land Capability Classification system and a National Portal on soils of India making Agro-Technology transfer both seed centric and soil driven.

Key words: Detailed soil survey and farm level land use planning, soil classification, soil productivity indices and land capability classification.

Soil Variability and Soil Survey

The immense variability and complexity of soil is not only revealed by soil survey investigation but also perceived by practicing farmers in terms of the response of the land to soil management and application of production inputs.

In his opening address at the meeting of the Consultative Group for International Agricultural Research (CGIAR) held at New Delhi in 1994, the late Prime Minister Shri. P.V. Narasimha Rao stated: "Each plot of land is like a human being. It has to be tended like a child. There is a need to find differentiated and properly considered prescription for each of these varieties rather than tarring with one kind of brush, which is not going to work in agriculture. I can tell you the characteristics of each and every survey number which I own in my village because I have seen it yield, failing to yield and under some conditions it refuses to yield. So far we have only been working in agriculture on general prescriptions. From the general to specific technologies is a long journey to be undertaken. So far we have tried to produce what we need by hook and crook, by getting hold of the best land, best

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inputs and best of everything. The Green Revolution methods are going to be found inadequate hereafter. "**There is a need to diagnose the nature, properties, potential and problems of each parcel of land"**.

In his inaugural address delivered at the 65th Annual Convention of the Indian Society of Soil Science held at Nagpur, on 27th December, 2000, Dr. J.S. Kanwar stated: **"I may be wrong but, I feel that we have to go back to the villages, *panchayats* and individual farmer or group of farmers or users"**. The plans must be responsive to their perceptions, aspirations and needs. The plans should relate to soil resources, water resources, biological resources and be relevant to the cultivated lands, uncultivated lands, forest lands and even the so-called waste and barren lands and responsive to irrigated and rainfed farming technologies. The need is for breaking away from the traditional mind set of only crop-based planning to integrated farming system planning.

The applicability and suitability of land capability classification system of USA to Indian situation should be critically re-examined.

The Krishi Vigyan Kendras (KVK) of ICAR and all the State Agricultural Universities (SAUs) could mount a National programme for training voluntary land resource planners' army from the rural areas. **India needs a movement of mobilisation of voluntary and public rural manpower and mount a mission-oriented programme of ICAR to provide the lead**.

The necessity of Detailed Soil Survey and Soil Mapping at large scales at village / watershed level for holistic farm planning taking into account climate-landscape-soil characteristics (Soil Health Card) and Socio-economic conditions of the farm holdings linked to Kisan card credit support is therefore obvious, urgent and cannot brook any further delay.

Soil Based Agro-Technology Transfer

I have highlighted as given below, the differential responses of soil units in a mapped area, for technology transfer at the 24th R.V. Tamhane Memorial Lecture delivered by me (Velayutham, 1997).

The use of Benchmark soil concept is the most effective way of combining soil research and soil survey to provide interpretations for planners' and farmers' use. A Benchmark soil has large area extent in a region or Nation or occupies a key interpretative position in a soil classification frame work. Research undertaken on Benchmark soils (on station and on farm) can be used to transfer these results with confidence to similar soil units and to estimate probable results / responses for soils not otherwise investigated (Swindale, 1977). The estimated suitabilities of Benchmark soils of nine soil series in the semi-arid environment of India were assessed for improved intercropping and sequential cropping under rainfed conditions. The differential response and suitability of different soil series was brought out in this study as given in Table 1 (Swindale, 1991).

Table 1. Estimated suitabilities of Benchmark soils for improved intercropping and sequential cropping systems

Suitabilities	Cropping System	Rating of Benchmark Soils								
		Marha	Kheri	Linga	Aroli	Sarol	Kamlia-kheri	Kasi-reddi-palli	Nimone	Sawar-gaon
Suitabilities to the improved technologies (Management Level C)	Intercropping	S2	S2	S2	S2	S1	S2	S1	S3	S3
	Sequential -rainfed	S3	S3	S3	S3	S1	S3	S2	S3	S3
	Sequential-irrigated	S2	S2	S2	S2	S1	S3	S1	S1	S3
Best of suitabilities	Intercropping	S3	S2	S3	S2	S2	S2	S2	S3	S3
	Sequential-rainfed	S3	S3	S3	S3	S3	S3	S3	S3	S3

Nanda *et al*. (1997) have brought out how soil survey and soil classification can help in better delineation of soil and land suitability for irrigation in Kuanria Irrigation Project in Odisha. In the Culturable Command Area (CCA) of 200 ha in the head reach of the main canal, Daspall, in the district of Nayaragh, Odisha, four soil series *viz*., Sariganda 1 loam (Udic Ustochrepts), Sariganda 2 clay loam (Udic Ustochrepts), Neliguda sandy loam (Typic haplustalf) and Patharpunja loamy sand (Aquic Ustifluvents) were identified. Based on fifteen characteristics pertaining to soil, topography and drainage conditions under sub-humid climate, the above soils were classified into four soil and land irrigability sub-classes.

Baskar and Gajbhiye (1997) in a detailed study of the soils of Jayakwadi Irrigation project – Minor 4 covering a command area of 460 ha delineated nine soil mapping units in terms of irrigation scheduling in relation to soil properties and water management. It was shown that the extreme values for frequency of irrigation for wheat was found to be 9 and 17 days in two mapping units and 7 and 14 days for cotton, using appropriate irrigation methods.

Velayutham *et al*. (2005) assessed the land quality as a tool for decisions on multiple uses of land in Nalatwad watershed (560 ha) in Bijapur district, Karnataka. In the watershed with sorghum as the predominant rainfed crop, six series and 19 phases were mapped on the basis of variation in slope and erosion status. The results are elaborated in NBSS&LUP Tech. Report No.582, by Ramesh Kumar *et al*. (2002 and 2005).

The six components of sustainable land management indicators namely, nutrient management, land productivity, input self-sufficiency, input productivity, crop yield security and family food sufficiency were calculated for each farm household. Principal component analysis was further utilized to group these six components into some well-defined dimensions (groups of variables). The groupings supported by the latent vectors of the first three principal components denote variables that go together.

Economic indicators like input productivity, crop yield security and land productivity dominated the first principal component and it is grouped as economic security index. The second principal component was characterized by ecological safety index represented by nutrient management by the farmers. The other two components, input sufficiency index and family food sufficiency index were grouped under the social stability index. Finally the ecological safety, economic security and social stability index were combined and final composite index of sustainability was worked out for each farm household in the watershed. Ten farm-level sustainability indicators were computed for sorghum production system in Nalatwad watershed. Individual maps of the ten sustainability indicators for the watershed were put in a Geographic Information System.

The soils of the watershed were classified into three land capability classes. Class II land covered nearly 387 ha, class III land 43.51 ha and class IV land 122 ha. All the four criteria revealed the economic feasibility and commercial viability of the investment of about Rs. 20 lakhs in the watershed for various soil and water conservation measures including land development activity.

Ramamurthy and Sarkar, in the ICAR News (Jan-March 2009) have illustrated the value of “participatory land use planning” for improved employment and livelihood opportunity in Kokarda and Kaniyadol villages of Kalmeshwar teshil of Nagpur district.

Perspective land use planning at macro level

The FAO (1997) Land and Water Bulletin No.5 elaborates the land quality indicators and their use in sustainable agriculture and rural development. Two categories of land namely 1) Degraded lands and Wastelands and 2) Agricultural lands and Forest lands can be taken as major entities for perspective land use planning at macro level.

Degraded and Wastelands

The latest harmonized estimate of the Degraded and Wastelands in the country is 120 million hectare (NAAS&ICAR, 2010). Suitable ameliorative technolo gies have been developed by the National Agricultural Research System, which need to be adopted through programmes supported by Government initiatives, Public - Private Partnership programmes, NGOs executed programmes and Panchayat Raj Institutions of local self-Government. There is ample scope to dovetail the National Rural Employment Guarantee Act provisions as Project components in all community based and community executed programmes in the country.

Arable Lands

The approaches for macro level perspective Land use Planning based on small scale maps have been documented for smaller states such as for Haryana by Aggarwal *et al*. (2001) and for Puducherry by NBSS&LUP (2008). Such approaches provide a broad basis for land use planning and allocating areas for different purposes including alternate land uses and developing a decision support system as illustrated by chatta (1999 & 2009), Ramachandra (2009), Sankar et al. (1999) and Ramamurthy and Sankar (2009).

Detailed Soil Survey for Farm Level Land use Planning

Based on the project proposal entitled, “Establishing Land Resource Database for Farm planning in Tamil Nadu”, submitted by the State level Task Force under my chairmanship in 2003, the pilot project for detailed soil survey was jointly undertaken in 17 blocks by the Government of Tamil Nadu, Tamil Nadu Agricultural University and the Bengaluru Regional Centre of the National Bureau of Soil survey and Land Use Planning. This experience has provided the methodological basis for detailed soil survey and land resource mapping for farm level and village level land use planning as detailed by Velayutham and Natarajan (2003), Natarajan *et al*. (2006a & b) and Natarajan *et al*. (2010). The experience gained under this project has helped to expand and develop a framework for a Nationwide Consortium Project entitled, “Soil resource mapping for Farm planning in India and development of National Portal on soils of India”, with NBSS&LUP as Mission Leader, (NBSS & LUP., 2009 and Velayutham, 2011).

Development of Soil Productivity Indices and Rating

The earliest approach for such an exercise was initiated by Shome and Raychaudhuri (1960). Unfortunately this area of research has not been pursued vigorously and continuously. A few case studies of application of Land Resource Database for Land Use Planning and Technology transfer were undertaken by Naidu *et al*. (1986, 1989 and 2010), Natarajan *et al*. (2002, 2003a & b) and Rajeswari *et al*. (2004). Huddleston (1984) has reviewed the development and use of soil productivity ratings in the USA. Olson and Lang (2002) have elaborated the methodology for calculating the soil productivity ratings for 786 soil types in the state of Illinois. Raymond Sinchair Jr. *et al*. (2006) have detailed the most recent approach being developed and validated by the National Cooperative Soil Survey (NCSS) of USA for development of soil productivity indices.

Soil Rating for Plant Growth (SRPG) version 4 model uses the soil interpretation modules of the US National Soil Information System (NASIS) of the Soil Survey Staff (2006 a & b) to assess the impact of numerous soil constraints or qualities on plant growth and thus compute a soil productivity or inherent soil quality index for components of soil map units. It provides a reasonable semi-quantitative index (from 1 to 100%) of soil productivity applicable to map unit components of the soil survey database. An example of this approach is given in Table 2.

Table 2. Numerical values generated for sub rule level 1, base rule level 2, and rule by SRPG model

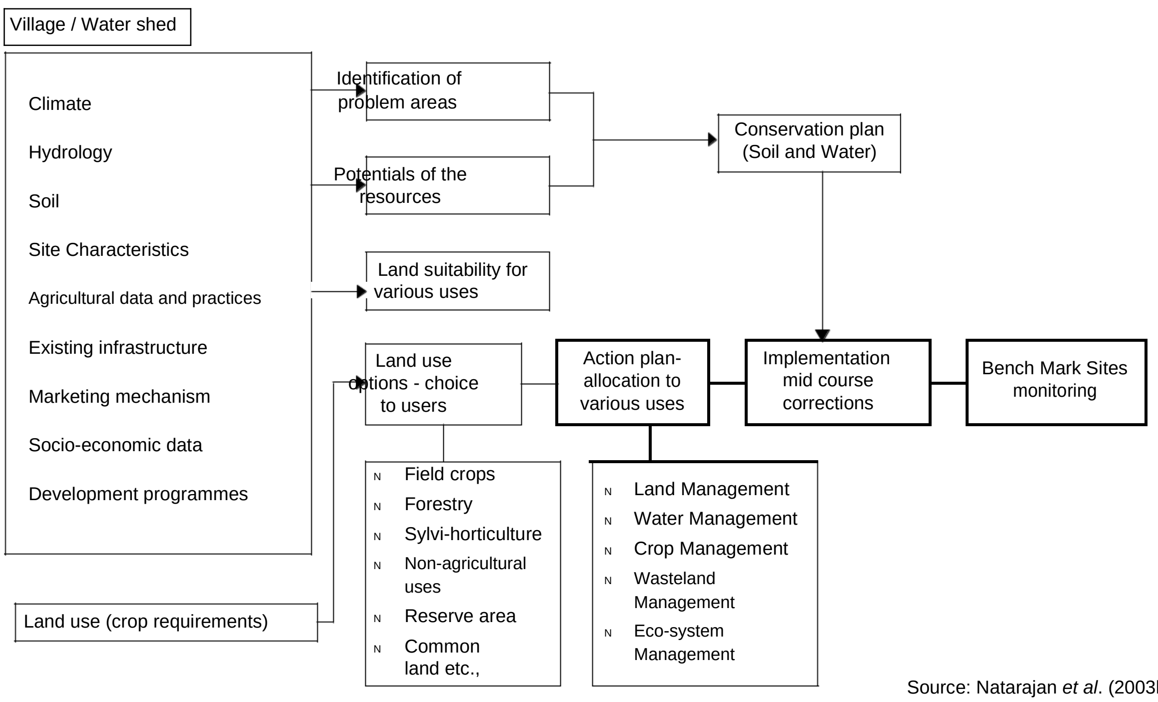
Chemical 0.971	Cation exchange capacity 1	pH 0.971	Sodium Adsorption Ratio 1	Gypsum 1	Electrical Conductivity 1	Calcium carbonate 1	
Landscape 0.947	Slope 0.947	Water table 1	Surface Rock Fragments 1	Flooding 1	Ponding 1	Accelerated erosion 1	
Physical 0.901	Content of organic matter 0.842	Ksat 1	Bulk Density 1	Linear extensibility Percent 1	Available water capacity 0.951	Rock fragment content 1	Root zone depth 1
Climate 0.845	Mean annual air temperature 0.9	Frost-free days 1	Mean Annual precipitation 0.939	Soil rating for plant growth (SRPG) 0.91			
Classification Fine-silty, superactive, mesic Typic Argiudolls				Family texture Class Fine-silty		Suborder Udolls	

Sub rule Level 1 ratings are weighted and used to calculate SRPG of 0.91 as given in this example. Source: NCSS Newsletter, Nov 2006 (37)

Land Resource Mapping for Land use planning and Management

Based on the detailed soil survey and socio-economic survey information the Land use Planning in a participatory mode at the village level can be implemented in a GIS framework and query based interactive Decision Support System (DSS) as given in the flow chart below.

The Land Resource Mapping arising out of the proposed National Project with delineated Soil Maps at Family level and development of soil productivity indices, using the approaches mentioned above, collated and calibrated from Crop and Agronomic field experiments (Benchmark soil sites) of all the Agricultural Research Stations (NARS) in the country (of 265) will provide the basis for Farm level Land use planning and soil specific transfer of appropriate



Source: Natarajan *et al*. (2003b)

recommendations for inputs, farm operations and Best Management Practices of Crop and Land Husbandry. In the process, in view of Climate Change scenario, the boundaries of Agro-ecological sub-regions delineated (Velayutham *et al*.,1999) can be revisited as illustrated by Pal *et al*. (2009).

A National Soil Classification System for Land Resource Mapping

The FAO-UNESCO system of soil classification based World Soil Map, published in 1974 has 28 major Soil Groups subdivided into 153 soil units. The advantage in this system is that each soil unit is a separate class by itself and may be taken as both a taxonomic unit and a mapping unit. Bhumbla (1981), in the 8th R.V. Tamhane Memorial lecture has broadly identified the occurrence of the soils of India into the equivalent soil units under FAO-UNESCO system, as given in Table 3. Velayutham and Pal (2003), tracing the Indian Soil Classification system have given the equivalents of the 23 major soil groups in India in the USDA system of soil classification.

Table 3. Extent of different soil units in India

Soil Unit	Extent (m. ha)	States/ Regions
Luvisols / Nitosols	94	Orissa, Eastern MP, part of WB, Bihar Plateau, Bundelkhand, region, Andhra Pradesh, Karnataka, Tamil Nadu, Kerala and Western Ghats, parts of Punjab and Haryana
Vertisols	73	Maharashtra, Madhya Pradesh, Gujarat, North Karnataka, and North Andhra Pradesh
Cambisols	56	Jammu and Kashmir, Himachal Pradesh, Bihar, Tripura, Eastern and Southern Rajasthan
Yermosols/Xerosols/Arenosols	33	Rajasthan, Punjab, Haryana and Gujarat
Acrisols	16	Assam and North Eastern States
Fluvisols	16	West Bengal, Bihar, Uttar Pradesh, Assam, Deltaic area of West Bengal, Orissa, Andhra Pradesh and Tamil Nadu.
Lithosols	41	Different Areas
Total	329	

Source: Bhumbla (1981)

Soil-Climatic Zonation provides the best basic matrix on which a soil classification system can be built (Mandal *et al*.,1999). Subramaniam (1983) delineated 29 Agro-ecological Zones of India with 36 combinations of “Moisture Adequacy Index” (IMA), (AE/PETx100) and dominant soil groups of FAO-UNESCO Soil Map.

Krishnan (1988) proposed a 40 fold soil-climatic Zones of the country. With 23 major soil groups already recognized in the country (Raychaudhuri and Govindarajan, 1971), it is suggested that this **may form the highest category of the National Soil classification system as proposed by Velayutham (2000), with soil family-soil series-soil type at lower category levels super imposed on the above mentioned Climatic Zones map of the country**. The Family and Series criteria may be selected based on the characteristic soil properties (Qualifiers) and their relative impact on Land productivity from an array of soil properties, such as, mineralogy, calcareous nature, texture, soil reaction, salinity, sodicity, available water capacity, saturated hydraulic conductivity, cation exchange capacity, soil depth *etc*. The classification at the Family level should be as **homogeneous** in aerial extent and as **homologous** in soil properties as possible, so as to include those important soil properties which influence response to management, farm operations and soil conservation measures so that soil family level-specific Agro-Technology Transfer can be advocated.

With the large volume of soil data that is now available from the Soil Resource Mapping Project, the time is now ripe for developing as suggested above, a **National Soil Classification System,** which will be not only **systematic in hierarchy but also systemic in** its character**,** for field level understanding by users (Mosi *et al.,*1991), who can relate soils to the landscapes and potential land uses in the Soil-Land Resource Maps as is being promoted by the Australian Government in the Internet, “Soil Health Knowledge Bank”(2009) and http://soilhealthknowledge.com.au. Such a classification system and mapping will permit accommodating both the available and future spatial soil information that will be generated and convey in an easily understandable manner the strength and weakness of the soils and their response to land management and farming systems.

Such a National Soil Classification can also be consistent enough to relate our soils to other schemes of soil classification for International correlation, reference and comprehension, (Dudal, 1964). The soil scientists particularly in the area of soil survey and mapping in the country may embark upon this stimulating and challenging exercise and put in practice such a classification system accommodating **the various soil units into soil management mapping units so that Agro-Technology Transfer can be both seed centric and soil driven.**

A similar simplified soil classification system has been proposed through World Reference Base (WRB) for soil resources by the International Union for Soil Science (IUSS), working Group on WRB(FAO, 2007). Peter Schod and Erika Mitchali (2010) have elaborated the usefulness of the simplified WRB system of Soil Classification and Mapping at different scales.

The Way Forward

The two pronged approaches for Land Resource Mapping for Farm level Planning to be operationalised in a consortium and Mission Mode programme, as a fitting tribute to the honour and memory of Dr. Govindarajan will encompass:

The pilot project being carried out by the NBSS&LUP, TNAU and the State Department of Agriculture, Tamil Nadu (2003) and the experience gained and the **theme of this National Seminar augurs well for the launch of the National Land Resource Mapping for Farm planning and a National Portal on soils of India, with NBSS&LUP as the Mission Leader**. The information from Remote sensing satellites including cartosat I and II can be dovetailed in the soil survey and mapping process. The suggested soil classification system and mapping will lead to Land resource mapping at cadastral level and help in formulating sound Land use policy on the one hand and Participatory Land use planning and management on the other (Velayutham *et al*., 2002 and Ramamurthy and Dipak Sarkar, 2009), eventually blossoming into **Peoples'** Land Care Movement in the country as is being exhorted by Bhoovigyan Vikas Foundation (2000), Nagpur (www.bhoovikas.org) and Land care groups in Australia, (www.landcareonline.com.au.) to ensure Food and Nutrition Security, now and in the future.

The above mentioned programme will also encompass characterizing the dominant soils in all the Agricultural Research Stations classified as Benchmark soils and identified as taxonomic and mapping units. In collaboration with the Project Directorate of Farming System Research (PDCSR), the Central Research Institute for Dry land Agriculture (CRIDA) and other soil based All India Coordinated Projects and Institutes and SAUs, soil productivity indices and crop production potentials for irrigated and rainfed areas in different Agro-ecological Zones may be developed. **This will help in evolving a Land Capability Classification System (LCC) coupled with Fertility Capability Classification (FCC) system of farm lands (Buol et al., 1975) suited to the Agro-ecological regions, Farming scenarios and production potentials of different kinds of lands (Bhattacharyya *et al.*, 2007&2011).** By grouping mapping units into 'Family level soil management units" at state level, adoption of appropriate land use practices and associated best management husbandry practices can be promoted in different zones including **Special Agricultural Zones (SAZ) and Peri-Urban Agricultural areas.**

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References

Aggarwal, P.K., Roetter, R.P., Kalra, N., Van Keulen, H., Hoanh, C.T. and Van Larr,H.H. (EDS). 2001. Land use analysis and planning for sustainable Food security: with an illustration for the state of Haryana,India. Joint Pubn. of IARI,IRRI and WURC, 167 p.

Baskar, B.P. and Gajbhiye, K.S. 1997. Soils of Jayakwadi irrigation project Minor 4 in Parbhani district. NBSS&LUP report.

Bhattacharyya,T., Ram Babu Sarkar,D., Mandal, C., Dhyani, D. H. and Nagar, A.P. 2007. Soil loss and crop Productivity model in humid sub-tropical India. *Curr. Sci.,* **10**: 1397-1403.

Bhattacharyya *et al*.2011.Soil resource information of different Agro-Eco subregions of India for crop and soil modelling. National Project on climate change. National Bureau of Soil Survey and Land Use Planning, (ICAR), Nagpur.p.302 with annexures 188 p.

Bhumbla, D.R. 1981. Land and Water Management and Agricultural Production in India. *J.Indian Soc.Soil Sci*. **29**: 403-418.

Buel, S.W., Sanchez, P.A., Jr. Cate, R.B. and Granger, M.A. 1975. Soil fertility capability classification - a technical soil classification system for fertility management. In : Soil Management in Tropical America, NC State Univ., Raleigh NC, 126-141pp.

Challa, O. 1999. Land resource evaluation for district level planning - An approach J. *Indian Soc. Soil. Sc*i., **47**: 298-304.

Challa, O. 2009. Land resource based planning at district level - A case study. p. 122-130. In: Planning and management of land resources (Eds.) Ramamurthy, V and Dipak sarkar. NBSS Report No. 1033, NBSS + LUP, Nagpur 217 p.

Dudal, R. 1964. Correlation of Soil Classification units used in different continents.In : *Proc. 8th Int. Cong. Soil Sci.,* **1**: 253-260.

FAO, 1997. Land Quality Indicators and their use in Sustainable Agriculture and Rural Development. FAO Land and Water Bulletin No.5.

FAO, 2007. World Soil Resources Report. 103, FAO, Rome.

FAO-UNESCO,1965. World Soil Resources Report No.26, Soil Map of the World.

Govindarajan,S.V. and Gopala Rao.,H.G. 1971. Soil and Crop Productivity. Asia Publishing House, New Delhi.

Govindarajan, S.V. and Gopala Rao., H.G. 1978. Soil and Crop Productivity. 2nd Edtion. Vikas Publishing House pvt. Ltd,New Delhi.

Huddleston, J.H. 1984. Development and use of soil productivity ratings in the United States. *Geoderma* **32**: 297-317.

Kanwar, J.S. 2000. Perspectives and Policies for Land Use Planning. *J. Indian Soc. Soil Sci*. **48**: 636-639.

Krishnan, A. 1988. Delineation of Soil Climate Zone of India and its Practical Application in Agriculture. *Fert. News*, **33** :11-19.

Mandal, C. Mandal, D.K., Srinivas, C.V., Sehgal, J. and Velayutham, M. 1999. Soil -Climatic Database for crop planning in India. NBSS&LUP (ICAR), Nagpur. **53**: 1014

Mosi, Dhanapalan, Janakiraman, M. and Eswaran, H. 1991. Communicating soil survey information to traditional farmers. Soil Survey Horizons, USDA. 31-33 pp.

NAAS and ICAR,2010. Degraded and Wastelands of India, Status and Spatial Distribution. DIPA, ICAR, 158 p.

Naidu, L.G.K., Verma, K.S., Jain, S.P., Rana, K.P.C. and Sidhu, G.S. 1986. An appraisal of the Productivity and Potential of dominant soils of Delhi. *J. Indian Soc. Soil* Sci. **34**: 558-67.

Naidu, L.G.K., Verma, K.S., Rana, K.P.S. and Sidhu, G.S. 1989. Parallel soil families behaviour to different Management levels. *J. Indian Soc. Soil Sci*. **37**: 205-207.

Naidu, L.G.K., Srinivas, S. and Ramamurthy, V. 2010. Land resource Information for prioritizing Agricultural development, Research and Technology Transfer. In: Proc. Sixteenth National Symposium on "Resource management Approaches towards Livelihood security, Bengaluru, 315-321pp.

Nanda, S.S.K., Mishra, B.K. and Bhatta, A.K. 1997. Soil Classification and Soil and Land suitability for irrigation in Kuanria Irrigation project. *J. Indian Soc. Soil Sci*. **45**: 333-338.

Natarajan, A., Krishnan, P., Velayutham, M. and Gajbhiye, K.S. 2002. Land Resources of Kudangulam, Vijayapatti and Erukkandurai Villages, Radhapuram Taluk, Tirunelveli District, Tamil Nadu. 2002. NBSS&LUP Publication, 277p.

Natarajan, A., Ramesh, M., Srinivas, S., Reddy, R.S. and Velayutham, M. 2003a. Resource Appraisal for alter native land use planning in Salem District, Tamil Nadu. *Madras Agric. J.* **90**: 197-206.

Natarajan, A., Reddy, R.S., Ramesh, M., Krishnan, P., Gajbhiye, K.S. Velayutham, M., Murugappan,V., Natarajan,S., Shanmugasndaram,V. and Farooque Ahmed, N. 2003b. Land Resource Data Base for Land Use planning: Status and Options in Tamil Nadu. *J. Agric. Res., Manage*., **2**: 50-58.

Natarajan, A. *et al.* 2006a. Land resources of Sivagangai Block, Sivagangai District, Tamil Nadu. A Joint pubn. of Tamil Nadu State Dept. of Agriculture (Soil Survey wing), TNAU and NBSS&LUP Regional centre, Bengaluru. 265 p.

Natarajan, A. *et al.* 2006b. The declining state of land resources in Sivagangai block, Sivagangai district, Tamil Nadu. Can we restore the old glory? A Joint pubn. of Tamil Nadu State Dept. of Agriculture (Soil Survey wing), TNAU and NBSS&LUP Regional Centre, Bengaluru, 17 p.

Natarajan, A. *et al.* 2010. Desertification: Assessment of land degradation and its impact on land resources of Sivagangai Block, Sivagangai district, Tamil Nadu, India. In: Land degradation and Desertification: Assessment, Mitigation and Remediation. (EDS)-Pandi Z Druli, Springer, Germany, 235-252 pp.

NBSS&LUP, 2008. Perspective Land Use Plan of U. T. of Puducherry. Tech. Bull. No.142, National Bureau of Soil Survey and Land Use Planning (ICAR), Nagpur 196 p.

NBSS&LUP, 2009. Project proposal on Soil resource Mapping for Farm Planning in India and Development of National Portal on Soils for the National Mission on Sustainable Agriculture. National Bureau of Soil Survey and Land Use Planning (ICAR), Nagpur.

Olson, K.R. and Lang, J.M. 2002. Average crop productivity Ratings for Illinois soils. *Soil Survey Horizons*.**43**:22-30 pp.

Pal, D.K., Mandal, D.K., Bhattacharyya, T., Mandal, C. and Dipak Sarkar. 2009. Revisiting the Agro-ecological Zones for crop evaluation. *Indian J. Genet.* **69**: (SPL.ISSUE): 315-318.

Peter Schad and Erika Mitcheli. 2010. The next step in soil classification or How to kill 3 birds with 1 stone: pedons, landscapes, functions. 19th World Congress of Soil Science, 1-6thAugust, Brisbane, Australia.

Rajeswari, R., Sivasamy, R. and Natarajan, S. 2004. Remote sensing for soil productivity assessment in Sengathurai village, Coimbatore District of Tamil Nadu. *J. Agric. Res. Manage.,* **3**: 16-19.

Ramachandra, T.V. 2009. Spatial decision support system for land use planning. In: Planning and management of land resources (Eds.) Ramamurthy, V and Dipak sarkar. NBSS Report No. 1033, NBSS + LUP, Nagpur 217 p.

Ramamurthy,V and Dipak Sarkar. 2009. Participatory Land Use Planning improved Employment opportunity, ICAR News. Jan - March, 4-5 pp.

Ramesh Kumar, S.C. Krishnan, P. Velayutham, M. and Gajbhiye, K.S. 2002. Economic Land evaluation for sustainable land management of watersheds in different Agro-Climatic Zones of Karnataka. Tech Report. No.581, Vol.1 Summary report, National Bureau of Soil Survey and Land Use Planning (ICAR), Nagpur.

Ramesh Kumar, S.C. Reddy, R.S. Naidu, L.G.K. Srinivas, S. Krishnan, P. Gajbhiye, K.S. and Velayutham, M. 2005. Characterization and Mapping of Farm level Sustainable Land Management Indicators - A case study of Nalatwad watershed, Karnataka. Paper presented at the National Seminar organised by the Indian Society of Soil Survey and Land Use Planning at Nagpur, April 2005.

Raychaudhuri, S.P. and Govindarajan, S.V. 1971. Soils of India, ICAR Tech. Bull. (AGR) No.**25**: 45.

Raymond Sinclair, H. Jr., Dobos, R.R. and Watman, S.W. 2006. An approach to the development of inherent soil productivity indices. National Soil Survey Cooperative Newsletter, USDA, Nov. Issue 37, 1-5 pp.

Sarkar, D., Velayutham, M. and Bhatta Charyya, T. 1999. Soils of Madhubani district for optimizing land use. NBSS Publication No. 76 177 p.

Shome, K.B. and Raychaudhuri, S.P. 1960. Rating of Soils of India. Proc. National Institute of Sciences of India. 26 part (A) Physical Sciences. 260-289 pp.

Soil Health Knowledge Bank, 2009. http://soilhealth knowledge.com.all.

Soil Survey Staff 2006a.Digital soil survey attribute tables (electronic media), USDA, NRCS, NASIS.

Soil Survey Staff 2006b.Soil survey interpretations model (electronic media),USDA,NRCS, NASIS.

Subramaniam, A.R. 1983. Agro-Ecological Zones of India. Arch. Met. Geoph. Biocl. Ser. Bull. **32**: 329-333 pp.

Swindale, L.D. 1977. The Role of Soil Science in Planning Agricultural Development. *J. Indian Soc. Soil Sci.* **25** : 201-206 pp.

Swindale, L.D. 1991. Research for the implementation of a land use policy in India. *J. Indian Soc. Soil Sci.* **39**: 14-31 pp.

Velayutham, M. 1997. Rural communities and sustainable land management and soil survey information dissemination-A common ground to forage. 24^{th} Dr.R.Tamhane Memorial lecture. *J. Indian. Soc. Soil Sci.,* **45** : 626-636.

Velayutham, M., Mandal, D.K., Mandal, C. and Sehgal, J. 1999. Agro-ecological sub-regions of India for Development Planning. NBSS & LUP, Nagpur, Pubn.No.**35**: 452.

Velayutham, M. 2000. Available soil information and the need for a Systematic classification of soils of India. *J. Indian Soc. Soil Sci*. **48**: 683-689.

Velayutham, M., Ramamurthy, V. and Venugopalan, M.V. 2002. Agricultural Land Use Planning: From theoretical perspectives to participatory action in the Indian Context. *The Land*, **2**: 45-60.

Velayutham, M. and Natarajan, A. 2003. Task Force Report: Project proposal for establishing Land resource Database for Farm Planning in Tamil Nadu. Dept.of Agriculture, Govt.of Tamil Nadu. 17 p.

Velayutham, M. and Pal, D.K. 2003. Indian Soil Classification System. In: Soil Science Encyclopedia (Ed.) Rattan Lal, Ohio State University, USA. 1-9 pp.

Velayutham, M. Ramesh Kumar, S.C. Reddy, R.S. Naidu, L.G.K. Krishnan, P. and Gajbhiye, K.S. 2005. Land qualities as a tool for decision on Multiple use of Land. In: Proc. National Workshop on Land Qualities for Sustainable Agriculture, Soil Survey Organization, Dept. of Agriculture, Govt. of Kerala, 39-55 pp.

Velayutham, M. 2011. A Framework for 10 years Mission Work for NBSS & LUP. Note presented at the combined meeting of the Directors and Research Advisory committee Chairmen of Natural Resources Management Division, presided by Dr.S.Ayyappan, Director-General, ICAR, 10.3.2011.

www.bhoovikas.org.Bhooovigyan.Vikas Foundation, 2000. Founder Chairman Dr.K.V.Sundaram, A regd.NGO.

www.landcareonline.com.au

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