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Geo-spatial Data Base for Conservation of Natural Resources by the People

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Abstract : India is endowed with bountiful natural resources for sustenance of mankind. However, the continuous population growth and increasing demand for food, fibre, fodder and fuel caused tremendous pressure on natural resources such as soil, water and forest resulting depletion of soil fertility, water stress and degradation of green cover. The scenario of Punjab state, one of the major contributors of food grain production in the country is critical due to over exploitation of ground water resources. The impact of degradation of natural resources is visible in the form of climate change that calls for scientific endeavour to mitigate the adverse effect of climate change on food production.

Basic information on soil and land parameters on hydrologic unit forms the prime base to adopt scientific measures as mitigation plan. The geospatial data base on hydrologic units, soil and land attributes are vital for evolving mitigation plan to conserve soil, water and vegetation resources.

Soil and Land Use Survey of India (SLUSI) has contemplated to disseminate the geospatial data base to the local people by creating platform free data base that would be provided through DVD to the users who could take print out of any microwatershed with drainage on A4 size paper and devise working plan on their own for conservation of natural resources.

The paper deals with generation and creation of digital spatial data base for web services for natural resource management by the people taking an example of Gurudaspur district, Punjab.

Gurudaspur district, Punjab an integral part of Thein catchment has been taken to demonstrate the use of geospatial data base for conservation of precious natural resources following watershed approach. Out 17 microwatersheds covering an area of 8,326 ha 16 have been identified as very high and 1 medium priority category on the basis of sediment yield index (SYI) values. The data reveals that about 94 % of the total area of the study area is falling under very high category and needs immediate attention for soil and water conservation measures.

It has been estimated that 180810 man days employment could be generated under watershed development programme for treating 7954 ha very high priority area out of total surveyed area of 8326 ha in Gurudaspur district, Punjab.

The modern tools for soil and land resource mapping such as remote sensing, creation of digital spatial data base using geographic information system, dissemination of geospatial data base to the user communities through Web with creation of ICT (Information Communication Technology) open a new vista for management of natural resources.

The accessibility of geospatial data base is limited to the executives for GIS based planning under G2G domain. Such data base is inaccessible to the local or common people as it requires adequate hardware and software which is rarely available at district or village level.

Soil and Land Use Survey of India (SLUSI) has contemplated to disseminate the geospatial data base to the local people by creating platform free data base that would be provided through DVD to the users who could take print out of any microwatershed with drainage on A4 size paper and devise working plan on their own for conservation of natural resources.

INTRODUCTION

Soil, water and forest vegetation are the three most precious natural resources for mankind for survival on earth. However, increasing biotic pressure and over-exploitation of natural resources for agricultural and non agricultural items production lead to accelerated soil erosion and destabilizing the natural eco-system as well.

India's food production depends mostly on ground water potential (Nath 2010). The states like Punjab, Haryana and Rajasthan develop more than 100% ground water and contribute major share in the country's total food production (Table 1 & 2).

The over exploitation of ground water for irrigation purposes in northern India may lead to serious water crisis. It is reported that more than 26 cubic miles of groundwater disappeared from aquifers in areas of Haryana, Punjab, Rajasthan and the nation's capitol territory of Delhi, between 2002 and 2008. These states withdraw more than 100% ground water (Fig.1) over natural replenishment (NASA 2009). The development of vital natural resources on a sustained manner without impairing its productivity for future generation is the need of the hour.

Watershed development has been a proven tool for natural resources management in the country. Various schemes are in operation under different ministries and departments for development of soil, water and forest resources considering watershed as hydrological unit.

Sustainability of watershed development programme depends with the use of scientific data base for planning purposes. It should provide basic information comprising various categories of hydrologic units, their prioritization with respect to the objective of the programme and terrain characteristics for evolving strategy by policy makers. Subsequently, the detailed data base on soil and land characteristics are required for preparation of working plan at micro level.

Table 1: Status of Ground Water Development

Group	G W D (%)	State
I	> 100	Haryana, Punjab, Rajasthan
II	45-80	Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Tamil Nadu, Uttar Pradesh, Uttrakhand
III	18-42	Assam, Bihar, Chattisgarh, Jharkhand, Orissa, West Bengal

Table 2: Ground Water and Food Production Scenario

State	Area		Food grain Production		Productivity	% coverage G W irrigation
	mha	% to all India	mt	% to all India	t/ha	
Group I + Uttar Pradesh	42.5	35	90	43	2.50	69
Group II – Uttar Pradesh	47.5	39	70	33	1.59	37
Group III	28.1	23	43	21	1.44	30

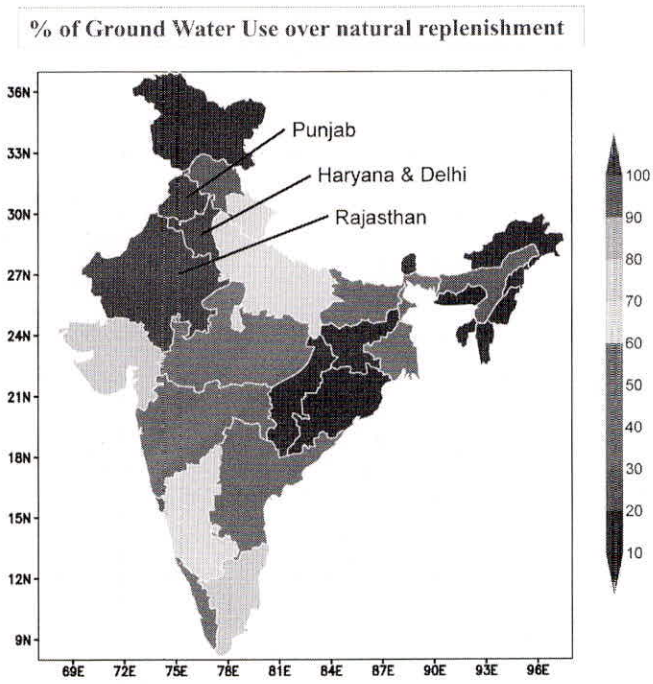

Fig. 1: Scenario of Recharge and use of Ground Water

The importance of scientific data base for natural resources management is an established fact but the affinity to use the same is limited that caused all developmental activities short-lived. The advent of modern tools in acquisition of real time data on soil and land attributes, storage and creation of digital spatial data base and their dissemination to the user communities have facilitated the problems related to inadequacy of optimal data base for natural resource management.

Gurudaspur district, Punjab an integral part of Thein catchment has been taken to demonstrate the use of geospatial data base for conservation of precious natural resources following watershed approach.

MATERIALS AND METHODS

Materials

The study has been carried out using the following base materials.

1. Watershed Atlas of India
2. IRS LISS III Remote Sensing Data (1:50K)
3. SOI Topographical Map (1:50K)
4. HP Mid End Workstation
5. HP Inkjet Colour Plotter
6. ARC INFO GIS Software
7. MS ACCESS

Methodology

The district microwatershed framework has been developed from data base generated by the organization out of Rapid Reconnaissance Survey on 1:50K scale. The steps involved in preparation of district microwatershed map for watershed development planning are outlined below.

- ❖ Preparation of drainage map, delineation and codification of micro- watershed.

- Development of Erosion Intensity Mapping Units (EIMU) from visual interpretation of satellite data followed by ground survey and preparation of EIMU map.
- Development of digital layers of micro watershed, EIMU and Administrative boundary and their integration using GIS and RDBMS.
- Computation of Sediment Yield Index (SYI), priority categorization

DEVELOPMENT OF DIGITAL DATABASE

SLUSI is developing digital data base on watersheds with priority categorization besides soil and land information for all the watersheds in the country.

Digital Watershed Atlas of India developed by the organization on 1:1000 K forms the base of digital spatial data base where the whole country has been divided into various hydrological units such as Water Resource Region, Basin, Catchment, Sub-catchment and Watershed with unique delineation and codification system. The watershed boundary taken from Watershed Atlas of India is subsequently transferred on 1:50 K topographical sheet for further delineation and codification from watershed to microwatershed with an extent ranging from 1000-2000 ha. Such base is used for priority categorization through conducting Rapid Reconnaissance Survey. It forms first stage of linkage.

The Digital Spatial Database is created from the maps which have been generated through various types of soil surveys and mapping. The steps involved have been explained in the flow diagram (Fig.2).

WATERSHED DEVELOPMENT – A TOOL FOR NATURAL RESOURCE DEVELOPMENT

Watershed development provides the way for regeneration, conservation and optimal use of all the natural resources which is in harmony with natural eco-system. It involves enhancement and stabilization of production, maintaining ecological balance, creating employment opportunities for rural poor in the rainfed areas. Thus, watershed development has increasingly chosen as the viable mechanism for rural development to provide sustainable means of livelihoods to the rural poor in the country.

The data base generated on the important catchment characteristics of the study area provides strong foundation for the sustainable agricultural production through watershed development programmes. The data base on priority (very high and high) microwatersheds may be utilized by the policy maker to plan various workschedule using scientific base under NREGS.

The database on priority microwatersheds is a vital base for strategic watershed development planning. Besides, it provides spatial distribution of various soil and land attributes that will help to know terrain condition in terms of slope, soil depth, soil erosion, land use and land cover condition. These attributes would serve as a special aid for planners dealing with soil and water conservation, aforestation, agriculture, horticulture and eco-development.

All the 17 microwatersheds of Gurudaspur district falling in the Thein catchment have been identified as very high and medium priority category on the basis of sediment yield index (SYI) values which have been summarized in Table 3.

The data reveals that about 94 % of the total area of the study area is falling under very high category and needs immediate attention for soil and water conservation measures. The spatial distribution of different priority categories of microwatersheds is shown in Fig. 3.

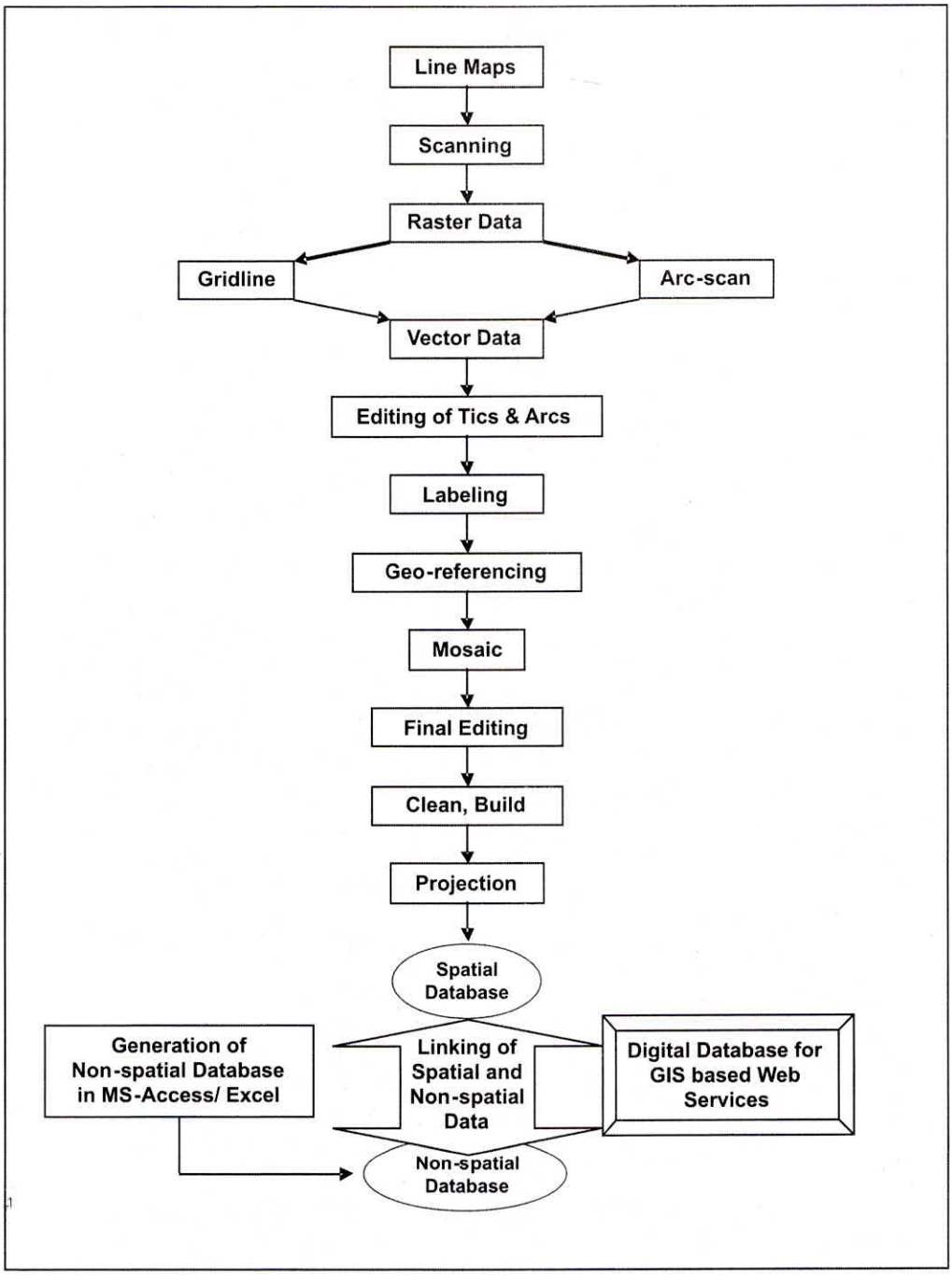

Fig.2: Development of Digital Spatial & Non-spatial Database for GIS based Web Services

Table 3. Priority Categorization of Microwatersheds

S. No.	Priority Categories	No. of Microwatersheds	Area (ha)
1.	Very High	16	7954
2.	Medium	1	372
Total		**17**	**8326**

Considering Rs.5000.00 per ha as cost of treatment under watershed development programme of which Rs. 3000.00 is assumed for wages requirement and rate of unskilled wages being Rs. 100/- per day, 30 mandays could be generated for each ha of vulnerable treatment area.

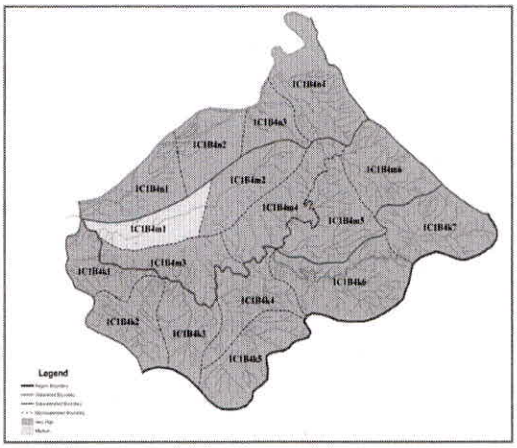

Fig. 3: Spatial Distribution of Priority Microwatersheds of the Study Area

Thus, the present study reveals that 180810 personsdays could be generated under watershed development programme for treating 6027 ha area out of 7954 ha of very high priority category areas in Gurudaspur district, Punjab.

SUGGESTIVE ACTION PLAN FOR SOIL AND WATER CONSERVATION MEASURES

The suggestive action plan for soil and water conservation measures has been formulated primarily based on LCC and presented in Table4. The spatial distribution of various kinds of measures has been shown in Fig. 4. The measures suggested are tentative as it is based on reconnaissance level of information. However, it may be a very useful for the planner while preparing the working plan.

Soil Erosion Control through NREGS: Soil and water conservation practices should receive top priority in watershed development planning as they

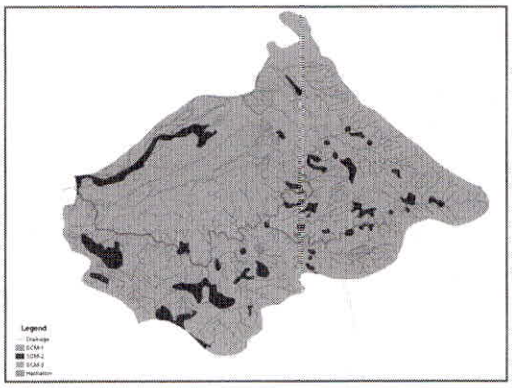

Fig. 4: Spatial Distribution of different SCM Classes of the Study Area

form the foundation of the sustainable agriculture production. Attempts need to be made for storage of rain and run-off water by raising structures such as bunding, check dams, water storage ponds / tanks for effective uses. The first step to check soil erosion is the in-situ method, especially contour farming. It is estimated that 184950 mandays may be generated for treatment of 6165

Table 4. Suggestive Action Plan for Soil and Water Conservation Measures

S. No.	Suggested Conservation Measures	Area (ha)
1.	**SCM-01:** Strip cropping, Crop rotation, Stubble mulching	704
2.	**SCM-02:** Bench terracing, Contour farming, Gully Plugging, Agro-forestry	616
3.	**SCM-03:** Gully Plugging, , Contour trenching, Contour vegetative hedges, Intermittent orchard terracing, Hillside ditches, Lock and spill drain, Aforestation/ Reforestation	6,941
4.	Miscellaneous	65
Total		**8,326**

ha of severe to very severely eroded areas of the study area through various engineering and vegetative measures assuming Rs. 3000.00/ ha as cost of labour charge and Rs.100.00 as daily wage per labour. The spatial data on soil erosion will be helpful for strategic planning of conservation of soil erosion in the district which are given in Table 5 while Fig.5

Employment generation through Eco Development:

The eco-hazard zonation map of a district may attract the environmentalist or forest department of the district (Fig. 6). The spatial distribution of eco-hazard zonation class has been derived by appreciating important soil land

Table 5. Spatial Extent of Soil Erosion Classes

S. No.	Erosion Classes	Area (ha)
1.	None to Slight	704
2.	Moderate	483
3.	Moderate to Severe	909
4.	Severe to Very severe	133
5.	Very severe	6032
6.	Miscellaneous	65
Total		**8326**

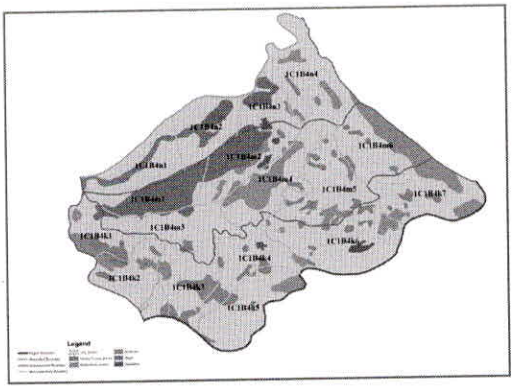

Fig.5: Spatial Distribution of Erosion Classes Microwatersheds of the Study Area

attributes that has been summarized in Table 6. The objective behind such thematic map is to identify the hazardous zone in relative term so that upper reaches could be rehabilitated with forest vegetation and other vegetative measures. It may serve as an additional input for planners.

It is worth mentioning that there is an increasing awareness about the interaction between rural, urban and industrial development and ecological balance of the area. Eco development refers to the process of regeneration, protection and conservation of natural resources through active participation of local people to

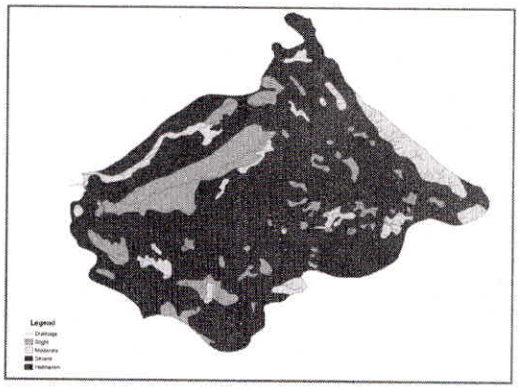

Fig.6: Spatial Extent Eco-hazard Zonation Classes of the Study Area

Table 6. Spatial Extent Eco-hazard Zonation Classes

S. No.	Eco-hazard Classes	Area (ha)
1.	Slight	1186
2.	Moderate	769
3.	Severe	6306
5.	Miscellaneous	65
	Total	**8326**

maintain and restore ecosystem. It involves checking of land degradation, deforestation and loss of biodiversity, augmentation of the availability of fuelwood, fodder and grasses from the regenerated areas, improvement of quality of life and self-sustenance aspect of people living in and around forest areas. The present study reflects that about 189180 mandays may be generated for treatment of 6306 ha of severe eco- hazard zonation class of the district assuming the aforesaid criteria.

Soil Information System for micro-level planning

The priority watersheds are generally taken up for acquisition of detailed database on soil and land characteristics that are essential for preparation of land capability map to guide the users for undertaking soil and water conservation measures as per land capability. The data base is generated through conducting detailed soil survey using 1:4K/1.8K/1:15K as base map. It establishes the linkages of microwatersheds with detailed soil information and completes the database for watershed development programme.

Soil information in consultation with drainage, slope, erosion, hydrologic soil grouping, land capability class etc., could be used for scientific land use planning, water resource development at village level, soil reclamation, crop diversification and other non-arable practices. Various themes could be derived out of soil information system to visualize the terrain characteristics for planning purposes. Some examples are given below (Fig. 7a –7c).

GIS Based Web Services

Natural resources is a subject matter that runs through international, national, regional to the local level to plan and implement soil, water and forest resource development programmes. It requires various kinds and levels of information for numerous users to address social, economic, environmental and political issues. The data base generation should be oriented in such a manner to meet the growing demand in the society with sound scientific platform and with the following objectives in mind.

The management of natural resources with scientific soil and land information is thus the need of the hour to mitigate the impact of climate change through appropriate adaptive measures to reduce hunger and restoration of fragile eco-system.

The various digital Spatial database generated by SLUSI are interlinked and data structure has been designed in user friendly manner to browse the data either on watershed basis or location specific i.e. State/ District/ Village/ Farm. For extracting the information about a particular microwatershed the user may come down from Water Resource Region to Microwatershed in hierarchical order.

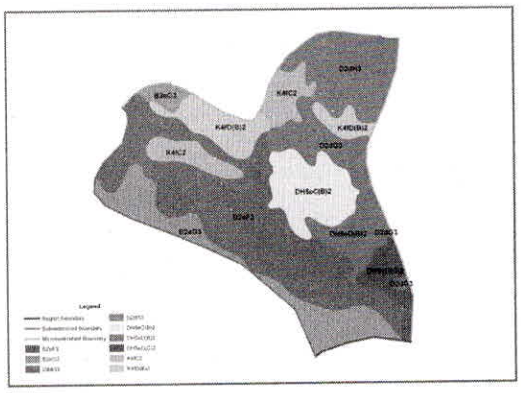

Fig. 7a: Spatial Distribution of soils of a Micro-watershed (1C1B4k2)

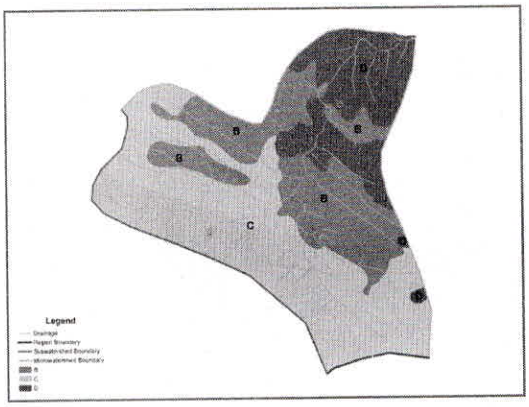

Fig. 7b: Spatial Distribution of HSG of the Micro-watershed (1C1B4k2)

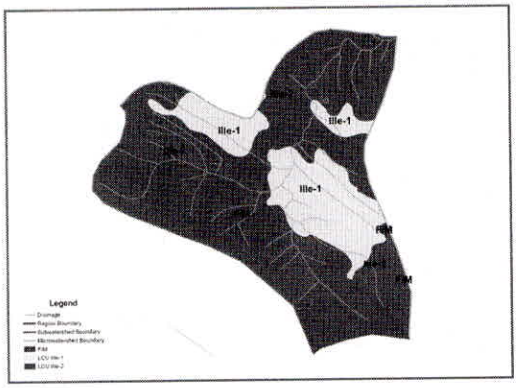

Fig. 7c: Spatial Distribution of LCC of the Micro-watershed (1C1B4k2)

Depending upon the need of the user agency different level of information about the soil and land characteristics may be browsed on different scale. For example, for detailed information about soil one can link the data with Detailed Soil Survey on 1:4K/ 1:8K scale. For generalized and reconnaissance level information on soil and land one can browse the data base acquired through various kinds of soil survey and land resource mapping respectively. The data structure for both spatial and non-spatial digital data base have been designed accordingly for networking to navigate the data base either administrative or hydrologic pathways.

The technological innovations in IT sector open new vista in GIS applications such as Internet GIS, Online GIS, Web GIS, and Participatory GIS. The explosion in growth of digital spatial data with these technologies will rapidly alter the traditional mode of human interaction everywhere in the world (Dragecivic, 2004; Kyem and Saku, 2009). These emerging trends widen the domain of GIS applications from spatial data management to participatory base in resource management timely with awesome cost effectiveness.

This new GIS initiative aims to develop a system that is "adaptable to inputs from ordinary citizens" and other non-official sources. In several communities around the world, PGIS applications complement grassroots efforts that advocates make to empower less privileged groups who are struggling to make an impact on local politics in order to effect a meaningful change in their lives (Kyem and Saku, 2009).

Initiatives by SLUSI

Web Services are programs that run on a web server, but their results are fed back to a calling program elsewhere on the Internet. Basically, GIS Web Services are self-contained, modular components and applications that can be published and accessed over the Web. They typically perform

a specific GIS function that can be integrated as part of a larger application. Provision of such GIS Web Services in GIS Technology should let developers quickly integrate functionality into their applications without having to build or host the functionality locally, often resulting in significant savings of time money and disk space (Anon 2004). The conceptual framework of GIS based Web infrastructure of SLUSI is shown below (Fig.8).

Approach and Methodology

The web-based services in INTERNET GIS environment is protected through password and other network security mechanism such as firewall in NICNET domain for G2G users. The various components of Web-based GIS Services are shown in Fig.9.

These web-based GIS services will be hosted at NIC on appropriate Enterprise GIS server with a Staging Server at SLUSI. The role of Staging Server is to provide Spatial Data update services (which is the responsibility of SLUSI) and facilitate disaster recovery in case of emergency situation. There will be no on-line update facility on Central Enterprise GIS Server.

GIS Services on the Internet

GIS Web services can be accessed from any Web-enabled application. This includes desktop applications, such as those built with Map Objects or ArcGIS components, as well as Web applications, commonly built with Java or ASP or ASP.NET. If the application can connect to the Web, a developer can integrate GIS Web Services from ESRI.

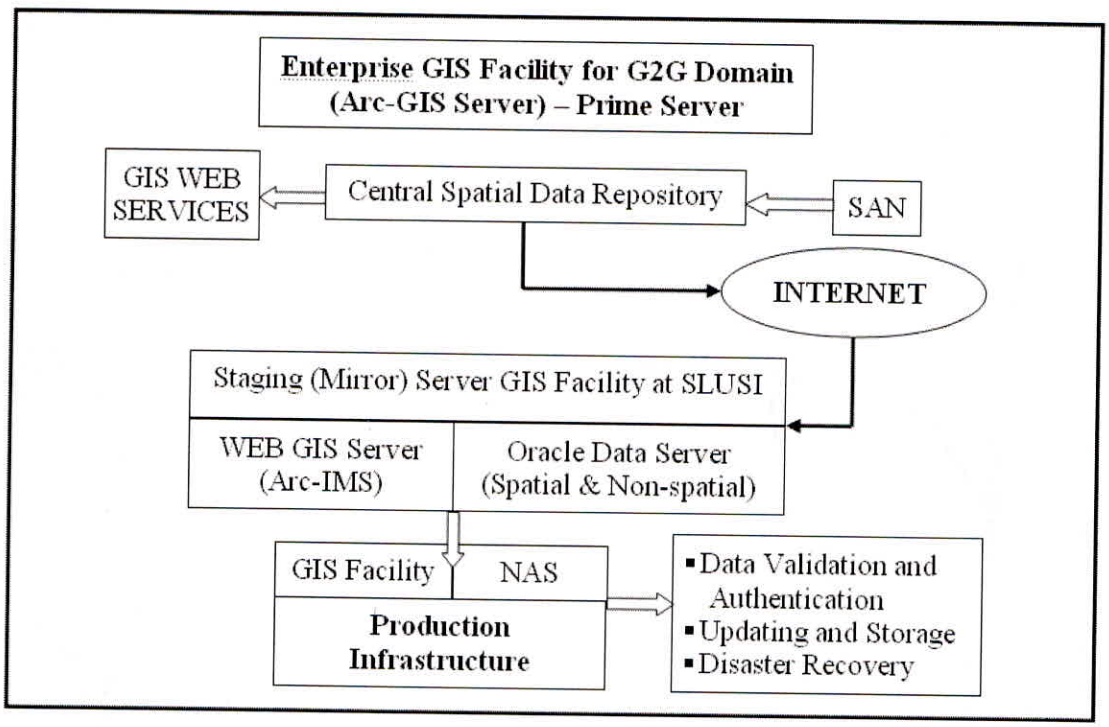

Fig. 8: Spatial Data Infrastructure – Prime Vs Staging Server for SLUSI

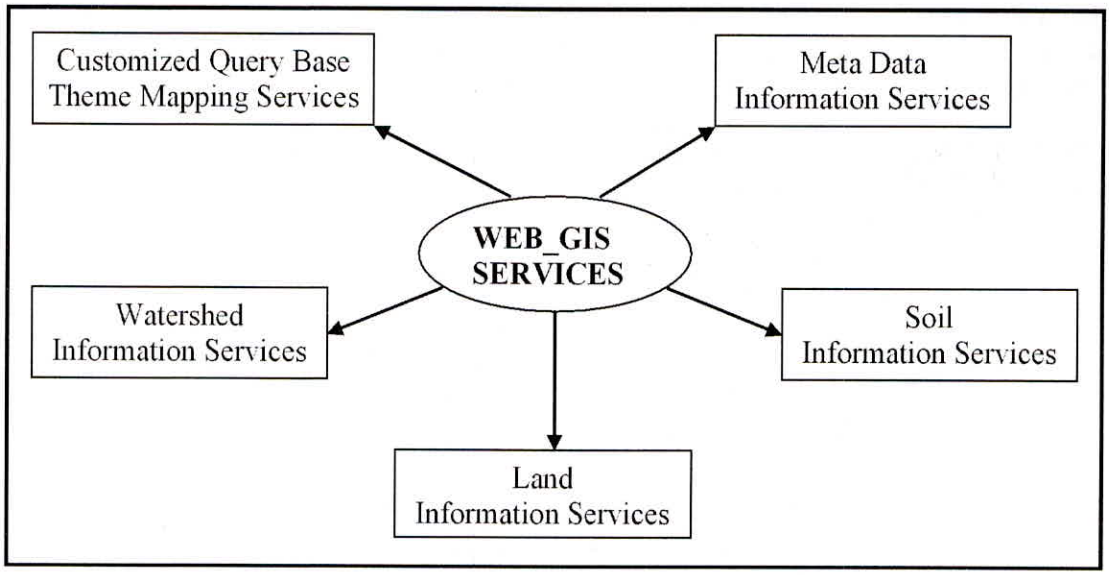

Fig.9: Components of Web based GIS Services

Enabling Spatial Web Technology

GIS Web Services are deployed through standard Web Protocols including Hyper Text Transfer Protocol (HTTP) and Extensible Markup Language (XML). The XML-based Simple Object Access Protocol (SOAP) to communicate, and therefore, they are compatible with the majority of Web Services frameworks available today such as Microsoft's NET.

Platform Free Spatial Data Base

SLUSI has contemplated to generate platform free spatial data base for dissemination to the local users considering the limitation in accessing information through GIS based Web services. Such endeavour on the part of SLUSI would enable to use spatial data as hard copy print out for water resource development which will be provided to the State and District authority in a DVD. The villagers or concerned person interested in developmental programme may access the microwatershed maps along with other soil and land information to apply their wisdom for conservation of natural resources at ground level.

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