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SISDP - Update Project

Technical guidelines for Products & Services Under "SIS-DP Update" Project

Reference document for products & services under Bhuvan Panchyat – III *viz.* Land & Water Resources and Amenities Development Planning under SISDP-Update project

National Remote Sensing Centre

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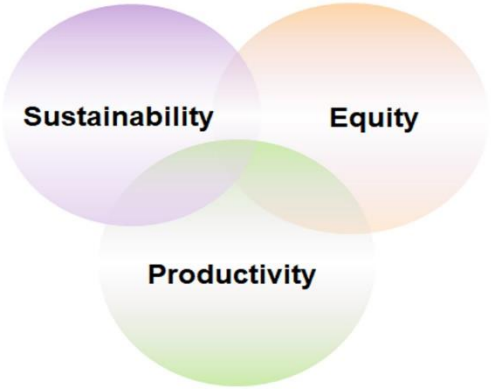

SISDP-U

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15	Abstract: This document will provide input, methodology, analysis and decision rule to SISDP-U software team for preparing products & services such as land, water and amenities development plan that are to be rendered through Bhuvan Panchayat version 3.0 portal prepared under SISDP-Update project. Besides, this will serve as reference document for these products and services.				

सारांश

यह दस्तावेज़ 'अंतरिक्ष-आधारित प्रौद्योगिकी के सहयोग से संसाधन के प्रबंधन हेतु विकेंद्रीकृत नियोजन- अद्यतन (एसआईएसडीपी-यू)' सॉफ्टवेयर टीम को भूमि, जल और सुविधाओं के विकास की योजना जैसे उत्पाद और सेवाएँ तैयार करने के लिए इनपुट, कार्यप्रणाली, विश्लेषण और निर्णय नियम प्रदान करेगा, जो एसआईएसडीपी-यू परियोजना के तहत तैयार भुवन पंचायत संस्करण **3.0** पोर्टल के माध्यम से प्रदान किए जाने हैं। इसके अलावा, यह इन उत्पादों और सेवाओं के लिए संदर्भ दस्तावेज़ के रूप में भी काम करेगा।

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List of Acronyms

ADP	: Amenities Development Plan
CGM-RCs	: Chief General Manager – Regional Centres
FAO	: Food and Agriculture Organisation of the United Nations
FSI	: Forest Survey of India
GIS	: Geographic Information System
GPDP	: Gram Panchayat Development Plan
GPS	: Global Positioning System
IMSD	: Integrated Mission Sustainable Development
ISRO	: Indian Space Research Organisation
LRDP	: Land Resource Development Plan
LULC	: Land Use Land Cover
MoPR	: Ministry of Panchayat Raj
NIC	: National Informatics Centre
NRSC	: National Remote Sensing Centre
RRSC-N, E, W, C, S	: Regional Remote Sensing Centre – North,East,West,Central,South
SIS-DP	: Space based Information Support for Decentralized Planning
WRDP	: Water Resource Development Plan

1.0 Introduction

1.1 Background

Effective utilization of natural resources and their management are extremely essential for national development. Hence, there is a need to catalyse the planning process at grassroots level as Land is a limited resource and has pressure from social, economic and environmental needs, including urbanization, industrialization, mining, transportation, rural development, protection of environmentally sensitive zones and resource areas. Unplanned development in rural, peri-urban areas and that too in the vicinity of national and state highways also has adverse social, environmental and health hazards.

The conventional techniques employed to provide spatial information on natural resources are highly tedious, time consuming and more often subjective; whereas satellite remote sensing with synoptic and regular coverage has the requisite potential to provide up to date information in a timely and more objective manner. Remote sensing (RS), Geographic Information System (GIS) and Global Positioning System (GPS) constituting the emerging field of geospatial technology offer great promise for generating spatial information on natural resources at national and subsequent disaggregated levels. With advancements in space technology, availability of high-resolution data and advanced processing techniques, the remote sensing technique has become a powerful tool for mapping and monitoring of natural resources. These techniques have immense potential for providing spatial information on natural resources resource mapping and monitoring at regular intervals.

To facilitate the decentralised planning at the grass root levels, there was a need to generate a uniform standard database on the Resources information across the country using geospatial techniques. To meet this requirement, SIS-DP Phase I project was formulated by NRSC during 2010-2012 period to provide basic planning inputs derived from satellite data and was implemented in partnership with State Remote Sensing Application Centres in the country. The objective of SIS-DP project was to make the geo-spatial information available to people at grassroots level to help them in planning, implementation and monitoring of various developmental schemes in scientifically informed ways. One of the major deliverables of this project are the updated thematic & base layers on 1:10,000 scale using satellite imagery.

These maps are extremely useful in meeting the current requirements of developmental, planning, implementation and monitoring activities at Panchayat/Village Level.

Recently in January 2020, based on the experience gained in execution of SIS-DP Phase I project activities and continuous feedback received from various stake holders on project components on database, implementation and capacity building exercise, a strong need is felt to continue this activity. Under Phase I, the thematic database was generated using the satellite imagery of the year 2010-2011 and is about 8 years old. The database needed an update using latest available satellite data as a primary input which will be useful in preparing developmental plans and monitoring activity. Hence SISDP-Update was launched in January 2020 where thematic mapping is being carried out using latest high-resolution satellite data for the entire country. It is well known that, for planning developmental activities at gram Panchayat (micro) level, larger scale maps are essential. Most of the features that are mapped under land cover and land use are dynamic in nature and need to be updated regularly using the latest possible satellite data and ancillary information. This will help the planners and the decision makers to access the latest LULC and other thematic maps for their planning activities. Hence, it was proposed to generate a new LULC thematic layer using latest available high-resolution satellite data sets.

In 2016, Ministry of Panchayati Raj came up with the Rural Area Development and Plan Formulation and Implementation (RADPFI) Guidelines. This exercise is to verify its applicability at the ground level. The 73rd amendment to the Constitution of India has paved the way for democratic governance in rural areas. Taking it further ahead the XIV Finance Commission award has created an opportunity for responsive local governance at Gram Panchayat level through Gram Panchayat Development Plan (GPDP), that are to be prepared by the Gram Panchayats incorporating the functions devolved to them as per state Panchayat Acts. Developmental planning is a complex process of decision making based on the information about the status of resources, socio-economic conditions and institutional constraints. Reliability of the databases, both the spatial and non-spatial, is therefore crucial to the success of the developmental planning.

1.2 Gram Panchayat Spatial Development Planning initiative (GPSDP)-Pilot Project

Ministry of Panchayat Raj (MoPR) held a meeting with premier institutes of Planning and Technology in July, 2020 under the Chairmanship of Secretary, Ministry of Panchayati Raj along with representatives from NIC and NRSC for taking up Gram Panchayat Spatial Development Planning (GPSDP) for 34 Gram Panchayats (GP) spread across 15 states in a pilot phase. National Informatics Centre (NIC) & National Remote Sensing Centre (NRSC), as technology partners of the Ministry, provided the technical information along with spatial data. School of Planning & National Institutes of Technology as Partner Institutions (PI) in this venture carried out the spatial planning and social survey exercise. Satellite data, updated thematic maps on Land use/ Land cover, drainage & surface water bodies, Transportation network on 1: 10,000 scale or better; legacy data *viz.*, soil, geomorphology, DEM, Slope, Contours, ground water potential, ground water quality of observation wells, *etc.* on 1:50,000 scale were used in the GPSDP planning. The water resources and land resources developmental plans have also been generated based on multi criteria analysis of resources layers. The GPSDP planning for 34 GPS spread across the country has been prepared and submitted to the ministry.

During the GPSDP pilot phase it was felt that there should be a method of generating specific products and thematic services for the GPSDP planning by analysing the updated thematic layers. Towards this a inter- RCs committee was constituted to look into the development of thematic products and services.

1.3 Thematic committee for land, water resources & amenities development plan

At the behest of Project Director (SISDP-Update) two committees were formed to develop product and services under Land & Water resources Development Plan and Amenities development planning vide letter no NRSC: RRSC/SISDP-U/65/2021 dated 17th June 2021 *viz.* Thematic and Software team to host them in Bhuvan Panchayat - 3.

In India, Gram Panchayat (GP) is the basic planning unit in the bottom-up model of decentralized developmental planning. Land resources development planning in rural areas is a subject matter of local authorities from Panchayati Raj Institutions (PRIs). For the local planners, arriving at a decision while land use planning is a challenging task and often

conventional methods are relied upon with poor or limited expertise in GIS (Paul, Chowdary, Dutta, & Sharma, 2017). While native and traditional technologies and knowledge has to be protected, there is also need for new technologies and know-how should be developed, and adjusted to local conditions. In order to avoid haphazard development, endeavours are being made to orient the space technology towards providing technical assistance in preparing the scientifically justified sustainable development plans.

Department of Space, Govt. of India has developed a web-GIS based geo-platform named 'Bhuvan' where Panchayat-level developmental planning is also being facilitated (http://bhuvan.nrsc.gov.in). 'Space-based Information Support for Decentralized Planning (SIS-DP)' was a project initiated by Department of Space (DoS), Govt. of India, where country-wide large (1:10,000) scale thematic database was prepared using 2.5m spatial resolution ortho-rectified satellite data product. The database is being hosted on Bhuvan Panchayat Web-GIS Portal (www.bhuvan-Panchayat.nrsc.gov.in) for dissemination up to the grassroot-level users.

Over the period, along with the outreach efforts for empowering the PRIs, it has been recognized that the geospatial thematic information needs to be harnessed to a further level for being capable to assist in decision making process. Specifically, there is a requirement of the composite map products derived by optimization mathematical modelling techniques like Multi-Criteria Decision Making (MCDM) (Pathak, *et al* 2019 and Indalawadi Report, 2019).

2.0 Generation of comprehensive development plan for GP

Conservation and sustainable management practices requires the adoption of basic ecological principles in the management of natural resources to ensure the sustainability. To improve the land resources, it is imperative to first improve the water resources of the region. So both land development and water development plans should complement each other. Recently, Ministry of Panchayati Raj has come out many schemes for rural planning which emphasis the use of natural resources management. The SVAMITVA scheme, a new initiative of the Ministry of Panchayati Raj is a scheme which will help in streamlining planning and revenue collection in rural areas and ensuring clarity on property rights; the scheme will also enable creation of better-quality Gram Panchayat Development Plans engaging Drone Surveying technology. This is a step further towards e-Governance in Panchayati Raj Institutions (PRIs) across the

country through decentralized planning. Similarly, the guidelines for annual planning of MNREGA also have thrust on Natural Resources Management, agriculture and livelihood related work on individual's land for sustainable livelihood.

Land evaluation in its broad sense covers from the setting of goals to land suitability evaluation, including environmental, economic and social analysis. Descriptors for land-use types, land qualities and land characteristics as relevant to different kinds of land use are necessary. Guidelines are available on land evaluation for:

Rain-fed agriculture (FAO, 1983);
Irrigated agriculture (FAO, 1985);
Forestry (FAO, 1984);
Extensive grazing (FAO, 1991)

Table -1: Sustainable Development Goals of relevance to land resource planning
(Ziadat, Bunning, Pauw, & De, 2017)

1.4	By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance.
2.3	By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment.
2.4	By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality.
11.3	By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries.
11.a	Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning.
12.2	By 2030, achieve the sustainable management and efficient use of natural resources.
13.2	Integrate climate change measures into national policies, strategies and planning.

13.b	Promote mechanisms for raising capacity for effective climate change related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities.
15.3	By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world.
15.9	By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts.
16.7	Ensure responsive, inclusive, participatory and representative decision making at all levels.

A list of the thematic resources layers which will be used for preparation of the LRDP and WRDP are given below. The details of the layers are in the subsequent chapters.

Layers used for generation of LRDP in GIS environment are

1) Land use/ land cover
2) Land Capability Classification
3) Ground water potential
4) Slope
5) Soil parameters (1:250k or 1:50k) - Soil texture, Soil depth
6) Land degradation with severity classes - Soil erosion
7) Existing infrastructure: transportation

Layers used for generation of WRDP in GIS environment are

1) Land use/ land cover
2) Slope
3) Stream order
4) Soil 1:250k or 1:50k in which soil texture only is considered
5) Geomorphology

Other ancillary information useful would be, Climate, Geology, Vegetation *viz.*, Forest types, species, Land tenure *viz.*, reserved forest, national park, conservation sites, Farming system

2.1 Land Resources Development Plan

Land Resources Development Plan is achieved using a decision model that involves the logical combination of thematic maps as well as the ground and field knowledge. Suggesting the alternate land use planning after assessing the lands potential. It encompasses land evaluation

and land-use planning which is the systematic assessment of land potential and alternatives for optimal land use and improved economic and social conditions through participatory processes that are multisectoral, multi-stakeholder and scale-dependent.

Generally, LRDP is generated using a decision model that involves the logical combination of thematic maps as well as the ground and field knowledge. For arriving at the suitability of a particular land use activity in the study area, thematic maps *viz.* land use/cover, soil, slope and groundwater potential maps which were generated using remote sensing and GIS were integrated. Expert's knowledge and the field situation are also considered for formulating the alternate land use plans. The detailed methodology of generating the LRDP is given in the subsequent chapters. A few of the alternative land use suggestions are listed below:
Intensive agriculture (Suitable for rainfed area), Agro-forestry, Agro-horticulture, Horticulture, Grazing / pasture land, Silvi-pasture, Fodder cropping & fuel wood plantation in marginal land, Production forestry, Afforestation, Reclamation of wasteland, Aquaculture, Recreational / Industrial.

2.1.1 Land Resources Development Plan products

a) Intensive Agriculture: Agriculture is the practice of cultivating crops which generally provide products like food, fibre, fuel and raw materials *etc.* Fertile & productive soils, availability of water resources and gentle slope are the pre-requisite for agriculture. In the present context, the cropping intensity of a parcel of land may be increased by introducing new crops in the single or double crop areas. Crop intensification is defined as a process of increasing the utilization or productivity of land currently under production. It is normally achieved either by increasing the yield per unit area of individual crops or by increasing the number of crops sown on a particular area of land, or both.

b) Agro-horticulture: Agro-horticulture is a practice of cultivating agriculture and horticultural crops in a single parcel of land in a cropping system, *i.e.*, in sequence or mixed/intercropping cropping. This kind of practice demands highly productive and fertile soil along with ample water availability. Horticultural crops generally fetch more commercial products and are treated as cash crops, hence in present context it is encouraged to introduce horticulture crops as an alternate crop in the existing agriculture based cropping system to increase the farmers' income.

c) Agro-forestry: Agroforestry is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, *etc.*) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence (FAO). There are both ecological and economical interactions among different components in the system. It is considered the bio-diversity and sustained production system. Being a multifunctional system, it is able to provide wide range of economic, sociocultural and environmental benefits. The products of the system are timbers, fruits, crops and other associated products like rubber, wax, honey *etc.* In the present context, the short-term/alternate agriculture crops may be introduced in between spaces of the trees for maximum utilization of space and natural resources, like light, water and soils.

d) Horticulture: Horticulture, the branch of plant agriculture dealing with garden crops, generally fruits, vegetables, and ornamental plants. Horticulture crops are generally high-value and intensively cultivated food and ornamental plants, which demands very fertile soils with assured water supply. The management practices are more intense in comparison to the agricultural crops, hence needs experienced man power. In the present context, priorities are fixed to introduce the horticulture crops in the suitable areas, with good, productive soils with ample source of water.

e) Silvopasture: Silvopasture is one of the oldest forms of agriculture which increases the farmland utilization. It is a distinct form of agroforestry by integrating the trees, forage and grazing of domesticated animals in a mutually beneficial way. It helps in improved sustained and improved productivity due to simultaneous production of tree, forage and livestock. This system also has a great role to play in harvesting the benefits of carbon sequestration. Introduction of native grasses and nitrogen-fixing legumes, as well as rotational grazing system may increase the soil health. In the present context, the system may be adopted in non-agricultural lands with moderately good soil and intermittent water availability.

f) Grazing/Pasture land: Pasture lands are mainly enclosed tracts of farmland, grazed by domesticated livestock, such as horses, cattle, sheep, or swine. The grazing vegetation mainly consists of grasses, legumes and non-grass herbaceous plants. Grazing by livestock is a means of deriving food and income from lands which are generally unsuitable for arable farming. A proper land use and grazing management technique balances between maintaining forage and livestock production, by maintaining the biodiversity and ecosystem services. The proper grazing management allowing sufficient recovery periods for regrowth, keeping a low density

on a pasture to overcome overgrazing, controlled burning of the land for helping regrowth of plants *etc.* Although grazing can be problematic for the ecosystem, well-managed grazing techniques can reverse damage and improve the land health. In the present context, the emphasis may be given to bring some non-arable waste lands under the grazing category towards increasing greenness in the environment as well as improved livelihood.

It also includes Fodder & fuel wood - Fodder cultivation is an integral part of the agriculture and animal husbandry system. Fodders are the agricultural products that are feed to the animals. Sometimes the fodders are intentionally grown in fields to support the animal husbandry, or else the weeds in the agricultural fields are also treated as fodders. The fuel trees are the trees which are mainly used by the rural people as a source of fuel wood during cooking. Both the leaves and branches are used for this purpose. The fodder & fuel wood is a unique and multipurpose land use system where the space is utilized to grow both fodder and fuel wood. The trees are grown at certain distance and the intermediate spaces are used for growing the fodders. It is an example of multi-storied cropping system, utilizing maximum of the available natural resources. In the present context, the areas with limited soil productivity, water resources and slight to moderate slope are targeted for introduction of the fodder & fuel wood system.

g) Production forestry: The production forestry is a land use system with natural forests, seminatural forests, and tree plantations designated primarily for the production of forest products such as timber, pulp, and fuelwood. Forests have been a key source of economic development for many countries and environmental services, linking forestry with economics and climate and water regulation for the welfare of the welfare of the people in the region. Production forestry generally embraces a broad range of concerns, in what is known as multiple-use management, including timber, fuel wood, wildlife habitat, recreation, biodiversity, erosion control and watershed management *etc.* In the present context, the effort may be directed to introduce forestry in the arable wastelands as well productive lands by addressing the proper reclamation practices.

h) Afforestation: Afforestation is the introduction of forest or trees in a land where previously there was no tree cover. Afforestation can be done through tree planting and seeding, naturally or artificially. Afforestation is very much useful for capturing the carbon, improving the soil health, increasing soil organic carbon content as well as avoiding desertification. Reforestation is also a kind of afforestation, which means alteration of a non-forested area to

a forested area through tree planting and seeding, *i.e.*, it is restoration of deforested area. The major reason for afforestation is for the ecosystem, *i.e.*, to restore an area that has been destroyed due to previous overuse of the land, to reduce the amount of erosion in the soil, to make soil more fertile *etc.* The future forest may be source of timber, fruits, wax, honey, rubber, habitat for animals *etc.* In the present context, arable wastelands, productive lands, perennial fallow lands with moderate soil productivity may be targeted for afforestation.

i) Reclamation of wasteland: The term wasteland is applied to land that was biologically unproductive as a result either of natural factors *e.g.* desert climate, mountainous topography or of human impacts *e.g.* soil erosion, overgrazing, or salinization. Waste land is defined as "degraded land that can be brought under vegetative cover' with reasonable effort and which is currently under-utilized and land which is deteriorating due to lack of appropriate water and soil management or on account of natural causes". Wasteland means low-quality land from an agricultural point of view, often referred to as degraded land. Local village revenue maps as well as the agricultural statistics define wasteland as uncultivated, non-forested land (which they divide into cultivable and uncultivable waste) while the categories used for interpreting remote sensing images are based on vegetation cover, soil characteristics, and spatial patterns *e.g.* gully formation. Land degradation in general, implies temporary or permanent regression from a higher to a lower status of productivity through deterioration of physical, chemical and biological aspects. The physical processes which contribute to land degradation are mainly water and wind erosion, compaction, crusting and water logging. The chemical processes include salinization, alkalization, acidification, pollution and nutrient depletion. The biological processes, on the other hand are related to the reduction of organic matter content in the soil, degradation of vegetation and impairment of activities of micro-flora and fauna (RSAA, NRSC, Project team, 2006).

j) Aquaculture: Aquaculture is the controlled process of cultivating aquatic organisms, especially for human consumption. Aquaculture can happen all over the world, mainly in coastal ocean waters, freshwater ponds and rivers, and even on land in tanks. The methods of aquaculture differ from species to species, starting from hatcheries, growing, processing, transport *etc.* To meet the food security of ever-increasing population aquaculture became a major alternative food source. It is a method used to produce food and other commercial products, restore habitat and replenish wild stocks, and rebuild populations of threatened and endangered species. Hence, it has major role in maintaining biodiversity, water and

carbon cycles. In the present context, the existing waterbodies along with non-arable wastelands may be suggested to convert into aquaculture system. In some cases, the aquaculture ponds can be the water source for the adjoining agricultural fields.

k) Recreational/Industrial: Recreational lands are the lands which are generally used for recreational purposes, like parks, playgrounds, tracking sites, sport fields, boating sites, beaches, camping sites *etc.* The waterbodies, coastal sandy areas, forests, high slope hilly areas, non-arable wastelands may be targeted for developing some recreational facilities. An industrial area is an area which is planned for the purpose of industrial development. These are usually located on the edges of, or outside, the main residential area of a city, with good transportation access, including rails and roads. The industrial area becomes a livelihood support for the adjoining as well as distant areas. In the present context, the non-arable wasteland, permanent fallow lands *etc.* with proper transport network and other amenities may be targeted for proposing new industrial areas. ***These lands are assessed for suitability for agriculture purpose, hence relatively poor land without type of industry with contrasting requirement of recreation and industrial are clubbed. Other considerations viz. availability of electricity, connectivity is dealt in amenity plan separately.***

Relative weights of input layer were assigned using analytic hierarchy process (AHP). The pairwise comparison method was developed by (Saaty, 1980) in the context of the AHP. This method involves pairwise comparisons to create a ratio matrix. It takes as an input the pairwise comparisons and produces the relative weights as output. Specifically, the weights are determined by normalizing the eigenvector associated with the maximum eigenvalue of the (reciprocal) ratio matrix.

2.2 Water Resources Development Plan

Similarly, Water resource development plan (WRDP) is another important plan. The water resource development plan includes identification of suitable zones for taking up locale specific activities in the study area which are generally the areas, where certain type of water resource activity is recommended for implementation. Water conservation measures like percolation tank, farm ponds and recharging bore wells, dug wells *etc.* fall under location specific activities. The main purpose of these activities is to improve the ground water condition within the GP area which means measures need to be taken to store the water as

well as allow water to percolate in to the ground by holding the water in water harvesting structures as much as possible. Locally these waters harvesting structure are called with different names: Talab/bundhis, Saza kuva, Johad, Nada/bundha, Kund/tanka, Kui, Nadi, Jhalar, Baori. In addition to this to meet the drinking water requirements of the population within the GP.

The detailed methodology for locating the suitable zones for location of various recharge structures, integrating different thematic layers *viz.*, drainage network with drainage order buffer map, soil, slope and land use/cover and runoff potential are given separately in the subsequent sections.

2.2.1 Water Resources Development Plan products

a) Contour Trenching: Trenching in general, is one of the major engineering measures for erosion control in non-arable lands and is mainly aimed to slope stabilization and drainage line treatment (Shiksha, 2021). Contour trenching practices are performed mainly to enhance agriculture by retaining the water flow on the sloping land. Ditches are dug along the slope in such a way that they follow contours and run perpendicular to the flow of water. The soil excavated from the ditches are used to form a berm on the down side of slope. Contour trenching play important role in stabilizing soil erosion by arresting sediment that would overflow during rainfall events. Contour trenching also promotes infiltration of rain water that maintains soil moisture condition for the vegetation to grow. Mainly two types of contour trenching practices are carried out in India continuous contour trenching and stagger contour trenching. Continues contour trenching are constructed in the series of channels/embankments at suitable spacing along the contours with gentle sloping land. Stagger contour trenching are constructed in shorter length in a row along the contour with interspace and straight line. Slope should be between 10-25% as for higher slopes plantation is better strategy and for lower slopes contour bunding can be done.

Figure -1: Continuous contour trenches

(People's Science Institute, 2021)

Figure -2: Staggered trenches

(Ministry Agriculture, Government of India., 2007)

b) Earthen Contour Bunds: Earthen contour bunds are constructed across the sloping (5% - 10%) land very closely. They act as barrier to arrest the flow of water to reduce to velocity of runoff. These type of bunding helps in conserving topsoil erosion and improving productivity. Bunding also helps in preserving soil moisture so that chemical fertilizer can be used effectively. Bunding could be done on both cultivated and uncultivated land. Bunding should not be done on slope more than 10%. This is because on such steep slopes, the velocity of run-off will break these bunds.

Figure -3: Earthen Contour Bunds

(Greener.LAND, 2021)

Contour bund and farm bund: Bunding or construction of small embankment is carried out to reduce the length of slope**.** Contour bunds are constructed with the aim of arresting soil erosion and improving the soil moisture profile. The bund should be spaced in such a way so as to intercept the erosive velocity. The spacing should not be too close to interfere with the farming operations.

Farm bunds are constructed on agricultural land to reduce the velocity of runoff water and to hold the water in the catchment for a longer period. Ideally, bunds on farms should be made on the contour line. But this creates several problems for farmers. Contour bunds divide the field into irregular sections. In such a situation, it becomes inconvenient to manoeuvre tillage machinery for operations such as ploughing and line-sowing. Due to these difficulties, what is normally practiced in the name of farm bunding is bunding along the field boundaries. **Bench terraces** are constructed to divide a steeply-sloped hilly land into a series of level or nearly level strips or benches running across the slope (Moodle for watershed planning and management, 2021).

c) Loose Boulder Check Dam/Gully Plugs: Check dams are constructed across the drainage or channel to arrest the water flow. Check dam or gully plugs reduces the velocity of surface runoff subsequently they play vital role in reducing the soil erosion. Big check dams retain water for long time and allowing water to percolate for ground water recharge. Water retained by the check dams also used for irrigation purpose. Loose boulder check dams/ gully plugs are usually made of stone. Slope of drainage is very important which directly contributes in runoff and this factor is taken as base for the design of check dams size and location also the locations of gully plugs. Bed slope of the drainage line at that point is above 20% because the check will not be able to withstand the high velocity of water flow, however it can be constructed in the section of drainage line where bed slope is less than 20%.

Figure -4: Loose Boulder Check Dam/ Gully Plugs

(Megamanual.geosyntec, 2021)
(Guillermo Tardío, 2016)

d) Gabion Structures: Gabion structures are created within the drainage channel to slow down the velocity of concentrated runoff or to stabilize the slopes with seepage problem. Gabions are rectangular baskets fabricated from a hexagonal mesh of heavily galvanized steel wire. Stones within the wire mesh are stacked tightly one another to form a gravity-type wall for stability and their weight to resist hydraulic and earth forces. Gabion structures are also mainly used for soil- water interfaces, water turbulence and control the water velocity. Stability of embankment and side walls is questionable than gabion structure is preferred as it is economical. Higher slopes will store less water compared with low upstream slope, however for higher slopes gully pugs are recommended.

Figure -5: Gabion Structure

(Baba Amte Centre for Peoples Empowerment, 2021)
(Megamanual.geosyntec, 2021)

e) Earthen Dams (Nalha bund) and Percolation tank: These structures are constructed across the nalas. The main objectives of the nala bunding and percolation tanks are to impound surface runoff coming from the catchment and to facilitate percolation of store water into soil sub strata with a view to raise ground water level and also to increase soil moisture in the

influence zone of nala. These structures also play important role in arresting the soil erosion and act as barrier in transportation of soil along the runoff. A percolation tank is generally constructed in low level wasteland or a small drain. Permeable formation in the reservoir bed is an essential requirement of percolation tank.

Figure -6: Earthen Dam (Nala Bund)

Figure -7: Percolation Tank

(Pawar, 2007)

f) Minor irrigation tank Construction-wise there is not much difference between a percolation tank and a minor irrigation tank, except for providing outlets for surface irrigation and the depth of the cut-off trench. The cut-off trench is to be provided below the earthen bund with depth limited to one fourth of the height between bed level and full storage level (PHED, Government of Meghalya, 2021).

g) Farm pond: Farm ponds are small water bodies formed either by the construction of a small dam or embankment across a waterway or by excavating or dug out. The water is usually harvested from a small catchment area and then used for irrigation during prolonged periods. Benefit of farm pond are as follows – 1) It collects excess runoff during rainy period. 2) Stored

water can be used for supplemental irrigation to crops. 3) It is useful as drinking water for cattles during drought situation. 4) It can be used for spraying pesticides. 5) It conserves soil and moisture.

Figure -8: Farm pond

(TNAU AGRITECH Portal, 2021)

h) Khadin : It providing agriculture in the driest climates. A Khadin, also called a Dhora, is an ingenious construction designed to harvest surface runoff water for agriculture. Its main feature is a very long (100-300 m) earthen embankment built across the lower hill slopes lying below gravelly uplands. Sluices and spillways allow excess water to drain off (R. K. Goyal, 2018).

i) Subsurface dykes (across channel bed): Where the catchment is large and the underground strata are favourable, sub-surface flows may continue throughout the year, long after surface flows cease to exist. At places, they are also referred as underground bhandara. They are to be located on higher order of drainage more than 6th order.

2.3 Amenities Development Plan

The amenities and facilities in a Village/GP can be classified under major three aspects *viz.* Physical (Housing, Roads, Drainage, Connectivity, Drinking water, STPs, Post & telegraph, STD booths *etc.*), Social (Health, Education, Community Centres, *etc.*), Economic (Milk collection centre, Godowns, Market Yards, Financial institutions, *etc.*). The facilities/amenities vary in terms of the area & population serviced by the existing resource. Basically, from the Census, information is available, *viz.* population, (male & Female), sex ratio, literacy, population less than 6 years, workers (primary, secondary and tertiary), non-workers *etc.* These numbers have to be projected based on the existing population growth rate, location of the village / GP with respect to the nearest urban centre *etc.* for planning of a new facility or computing the

adequacy of the existing resource. Rural Area Development Plan Formulation and Implementation Guidelines (RADPFI) have been drafted for carrying out the spatial planning of the villages. The norms for planning of each facility have been described in detail in this report. The information on the existing amenity already available is also an important input to be considered before planning. The information on the existing resource has to collected through actual physical survey or through already collected from other available sources viz., assets information available in NIC, respective states geoportals, Mission Antyodaya *etc.*

Using the SISDP-U thematic data, information on the existing transport connectivity, closeness to the existing urban centre, regional setting of the village/GP, the existing drainage and surface water bodies, existing of industries, agriculture area, forest area *etc.* can be generated as special products which will help in the planning of amenities. Apart from this a detailed GP level survey using mobile apps would also help in understanding the need of amenities and its planning.

Education – School, vocational centre, skill development, graduation college, library, literacy rate, school drop-out, sex-ratio in higher education, teacher to pupil ratio

Health - Primary health / Sub/ Community health centre, Hospital with In-patient Facility, Veterinary clinic / hospital, Chemist/pharmacy Shop, Diagnostic Centre

Socio-economic – Village common resources, Public transport system, Internal village road, Distance from town, Railway, Recreational system/playground, Community water harvesting, Drainage facility, Bank, ATM

3.0 Decision rules for generation of comprehensive development plan

3.1 Land Resources development plan (LRDP)

A spatial model is to be developed in open source environment. The model will use various thematic layers *viz.* land use / land cover, land capability classification, ground water prospectus, slope, surface soil texture, land degradation with severity classes, and soil depth as input. Each input layer has standard classes *e.g.* crop land in land use / land cover layer. Each input layer classes have been assigned normalised weights in the range of 1 to 10 based on its importance with respect to each land resources development product (**Annexure I - *a to g***). However, there are certain classes for which there is no possible product suggested

e.g settlements, they are indicated with 'Nil' value which need to be excluded for further processing.

This will generate temporary layers of each product (11) for each input theme layer (7) i.e. total 77 outputs. Each input layer was also normalised by assigning relative weights to each layer in the range of 0 to 1 for each product, such that sum of all weights should be equal to one. To arrive at above relative weights of inputs layer for each product more than one expert opinion is incorporated through Analytical Hierarchy Process (AHP) technique) in percentage terms through paired matrix of input layer and products ***Annexure II*** (Pathak *et. al.*, 2019)

Weighted sum for each product has to be performed *i.e.* sum of normalised weight multiplied by relative input layer weight. This will generate favourability layers for each of the LRDP product viz. Intensive agriculture, Agro-horticulture, Horticulture, Agro-forestry, Silvi-pasture, Grazing / pasture land, Production forestry, Afforestation, Reclamation of wasteland, Aquaculture, Recreational / Industrial. Final LRDP product layer will be assigned based on highest favourability by overlaying favourability layer of each product.

Base layer derived from land use / land cover layer (settlement & transportation class 1 to 10, and water body classes 31 to 33) need to be overlaid on final LRDP product. Command area has plan for development by authority and therefore should be avoided.

Two layers namely Command area and land Degradation has to be procured from Bhuvan and/or other source within NRSC for the purpose of separating Irrigated area and severity class of wasteland

3.2 Water resources development plan (WRDP)

A spatial model is to be developed in open source environment. The model will use various thematic layers *viz.* land use / land cover, slope, stream order, buffer of 50 m on either side of stream (1^{st} to 3^{rd} order) and 75 m for 4^{th} order and above, surface soil texture, geomorphology as input. Each input layer has standard classes *e.g.* 1^{st} order stream in stream order layer. Each input layer classes have been assigned binary "Yes" or "No" condition based on suitability of each product (***Annexure***

to e). An area is assigned to particular WRDP product if "Yes" condition for each input layer is satisfied. Conditional operator will work across layer with "AND" condition.

The products (Contour Trenches, Contour Bunds, Loose Boulder Check Dam, Gabion Structures, Nala bund, Percolation tank, Minor irrigation tank, Farm pond, Farm bund, khadin, and sub-surface dyke) are divided into Area (zone) based products and location-based products. For area-based product the major activity is to *in-situ* conserve the moisture or water storage, they are depicted with yellow fill in annexure. Location based product within 50m stream buffer area is to be suggested for soil conservation and water harvesting. The area-based products are 5 in number - Contour Trenches, Contour Bunds, Percolation tank, Farm pond, and, khadin and location-based products are 5 in number - Loose Boulder Check Dam, Gabion Structures, Nala bund, Minor irrigation tank, and sub-surface dyke.

The location based WRDP products will be generated for 50m stream buffer area only and for remaining area, the area-based product will be generated. Hence, there is no necessity of any condition as in the case of stream order. However, for minor irrigation a buffer of 250 meter should have more agriculture land for conveyance system.

Base layer derived from land use / land cover layer (settlement & transportation class 1 to 10, and water body classes 31 to 35) need to be overlaid on final WRDP product.

3.3 Amenities development plan (ADP)

The amenities and facilities location in a GP are to mapped using mobile application or shared from other sources. Highest priority to each sector-wise is to be assigned to all the assets. If Distance of facility from major settlement determines their ranking and beyond a cut-off distance the asset/facility is to be created *i.e.* considered as gap area. On the other hand, if facility already exist is not considered for development planning. Similarly, administrative & revenue assets location are decided based on criteria other than analysis by GIS. However, distance from major town can be generic product which can be prepared with available data.

Points to be considered for automation:

Issues that need to be addressed for making the models more **significant** and **automated**:

- The overlay should be raster-based rather than vector-based since all the possible combinations are not feasible to be hard coded in if-else statements for LRDP
- For WRDP, binary “Yes” conditions within class of input layer with “OR” operator and across layer “AND” operator is to be checked.
- Criteria needs to be relooked as at many locations, misguiding suggestions may appear
- Layer weights need to be critically derived as per the field-based reasoning, a feedback mechanism will help improving the final outcome through post field comparison.
- Criteria need to be separately made for each of the 20 Agro-ecological regions as defined in India or modified suitably.
- Models need to be worked upon for inter-operability to make them run on any machine with an open source software.
- Model output must be checked in the field and referential refinement be done if significant deviation observed.
- In case of availability of *khasra* map majority of the development product can be assigned to *khasra* as unit for ease of implementation.
- In case of more than one product has similar favourability, the higher priority shall be assigned in ascending order of product.
- Process should start with buffer area and clipped with administrative boundary after overlaying the base layer.
- GUI needs to be designed and developed for making a user-friendly software package

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Annexure

Annexure I - a: Normalised weights of land use / land cover for Land Resources Development plan

Sl. no.	Classes	Intensive Agriculture	Agro-horticulture	Agro-forestry	Horticulture	Silvipasture	Grazing/Pasture land	Production forestry	Afforestation	Reclamation of wasteland	Aquaculture	Recreational / Industrial	Flag /Eliminate
1	Core Urban (CU)	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	Y
2	Peri-Urban (PU)	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	Y
3	Other Urban Areas(OU)	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	Y
4	Village Settlement (VS)	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	Y
5	Mixed Village Settlement (MV)	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	Y
6	Hamlet & Dispersed Household (HD)	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	Y
7	Other Rural Built-up Areas (OR)	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	Y
8	Industrial area (IA)	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	Y
9	Transport Network (TN)	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	Y
10	Transport Infrastructure (TI)	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	Y
11	Crop Land (CL)	10	6	6	6	1	1	1	1	NIL	NIL	NIL	P
12	Fallow Land (FL)	9	10	10	10	1	1	4	4	NIL	NIL	NIL	P
13	Agriculture Plantation / Orchards (AP)	8	8	8	9	1	1	1	1	NIL	NIL	NIL	P
14	Aquaculture (AC)	1	1	1	1	1	1	NIL	NIL	NIL	10	NIL	P
15	Closed Forest (CF)	1	1	1	1	1	1	NIL	NIL	NIL	NIL	NIL	P
16	Open Forest (OF)	1	1	1	1	5	3	7	10	NIL	NIL	NIL	P
17	Forest Plantation (FP)	1	1	1	1	1	1	NIL	NIL	NIL	NIL	NIL	P
18	Swamp area / Mangrove (SM)	NIL	NIL	NIL	NIL	NIL	NIL	4	4	NIL	4	NIL	P
19	Grasslands / Grazing Lands (GG)	2	2	2	2	8	10	4	4	NIL	NIL	NIL	P
20	Salt Affected Land (SA)	2	2	2	2	6	6	4	4	6	NIL	5	P
21	Gullied land (GL)	1	1	NIL	NIL	7	3	3	6	7	NIL	5	P
22	Ravinous Land (RL)	1	1	NIL	NIL	6	3	3	6	7	NIL	NIL	P
23	Dense scrub land (DS)	4	4	4	4	6	6	4	4	5	NIL	6	P
24	Sparse scrub land (SS)	3	3	3	3	7	7	6	6	6	NIL	6	P
25	Barren Rocky (BR)	1	1	NIL	NIL	2	2	1	1	NIL	NIL	7	P
26	Stony Waste (SW)	1	1	NIL	NIL	3	3	3	3	1	NIL	7	P
27	Sandy area - Desertic (SD)	1	3	3	3	3	3	3	3	5	NIL	7	P
28	Sandy area - Coastal (SC)	3	3	3	3	4	4	4	4	5	NIL	7	P
29	Sandy area - Riverine (SR)	6	6	6	6	5	5	6	6	NIL	NIL	NIL	P
30	Waterlogged (WL)	2	NIL	NIL	NIL	1	NIL	NIL	NIL	6	5	5	P
31	River (RI)	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	Y
32	Stream (ST)	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	Y
33	Canal / Drain (CD)	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	Y
34	Lakes / Pond (LP)	1	1	1	1	1	1	1	1	NIL	10	NIL	p
35	Reservior/Tank	1	1	1	1	1	1	1	1	NIL	10	NIL	p
36	Snow covered area (SN)	1	1	1	1	1	1	1	1	NIL	NIL	NIL	p
37	Glacial area (GL)	1	1	1	1	1	1	1	1	NIL	NIL	NIL	p
38	Shifting Cultivation area (SC)	10	1	10	10	1	1	6	6	NIL	NIL	NIL	p
39	Mining / Quarry / Dump (MQ)	1	1	1	1	1	NIL	4	4	8	NIL	9	p
40	Rann (RN)	1	1	1	1	1	1	NIL	NIL	NIL	NIL	9	p
41	Salt pan (SP)	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	9	p

Annexure I - b: Normalised weights of Land Capability Classification for Land Resources Development plan

Sl. no.	Classes	Intensive Agriculture	Agro-horticulture	Agro-forestry	Horticulture	Silvipasture	Grazing/Pasture land	Production forestry	Afforestation	Reclamation of wasteland	Aquaculture	Recreational / Industrial
1	I	10	10	8	9	3	3	3	1	3	1	2
2	II	8	8	6	8	4	4	4	2	3	1	3
3	III	6	6	4	7	5	5	4	4	4	1	3
4	IV	4	4	4	5	6	7	4	4	5	1	4
5	V	1	1	4	3	8	7	4	4	6	1	6
6	VI	1	1	3	1	6	6	3	3	6	1	7
7	VII	1	1	1	1	5	6	1	3	7	1	8
8	VIII	1	1	1	1	5	8	1	4	8	1	9

Annexure I - c: Normalised weights of ground water prospectus for Land Resources Development

Sl. no.	Classes	Intensive Agriculture	Agro-horticulture	Agro-forestry	Horticulture	Silvipasture	Grazing/Pasture land	Production forestry	Afforestation	Reclamation of wasteland	Aquaculture	Recreational / Industrial
1	Water Body Mask	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	10	NIL
2	Very good to good	10	10	8	10	4	4	3	2	8	2.5	5
3	Good	9	9	7	9	4	4	3	2	7	2.5	4
4	Good to moderate	8	8	6	8	5	5	3	2	6	4	3
5	Moderate	7	7	5	7	6	6	4	3	5	4	3
6	Moderate to Poor	6	6	4	6	7	7	5	4	4	1.5	2
7	Poor	2	2	2	2	7	7	6	5	3	2	2
8	Poor to Nil	1	1	1	1	8	8	7	6	2	2	1
9	Settlement	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
10	Good but Saline	2	2	2	2	6	6	6	6	7	6	6
11	Saline	2	2	2	2	4	4	4	4	4	4	4

Annexure I -d: Normalised weights of slope for Land Resources Development

Sl. no.	Classes	Intensive Agriculture	Agro-horticulture	Agro-forestry	Horticulture	Silvipasture	Grazing/Pasture land	Production forestry	Afforestation	Reclamation of wasteland	Aquaculture	Recreational / Industrial
1	0-1	10	8	8	9	6	6	7	7	10	10	10
2	1-3	9	9	9	9	6	6	7	7	8	8	10
3	3-8	8	7	7	7	6	6	6	6	6	6	10
4	8-15	6	6	7	6	8	8	6	6	4	1	6
5	15-30	2	3	4	3	6	4	5	5	1	1	4
6	30-45	1	1	1	1	4	3	4	6	1	1	4
7	>45	1	1	1	1	1	1	1	7	1	1	4

Annexure I - e: Normalised weights of surface soil texture for Land Resources Development

Sl. no.	Classes	Intensive Agriculture	Agro-horticulture	Agro-forestry	Horticulture	Silvipasture	Grazing/Pasture land	Production forestry	Afforestation	Reclamation of wasteland	Aquaculture	Recreational / Industrial
1	Sandy	3	3	5	4	4	4	4	4	1	3	4
2	Loamy	10	10	6	9	4	4	4	6	1	6	4
3	Clayey	8	5	6	6	6	6	6	6	1	10	3
4	Coarse loamy	5	5	6	5	7	7	7	7	1	5	4
5	Clay loam	9	8	7	8	6	6	6	6	1	9	4
6	Sandy clay loam	6	6	7	7	7	7	7	7	1	8	4
7	Silt	6	6	6	6	6	6	6	6	1	7	4
8	Silty loam	7	7	5	8	5	5	5	5	1	6	6
9	Silt clay	8	8	6	6	6	6	6	6	1	7	4
10	Silt clay loam	7	7	6	7	7	7	7	7	1	6	4
11	Sandy clay	7	7	7	7	7	7	7	7	1	5	5
12	Clay skeletal	5	5	5	3	4	4	6	6	1	4	6
13	Gravelly sand	2	2	3	2	2	2	2	2	1	3	6
14	Gravelly loamy sand	3	3	4	3	3	3	3	3	1	3	6
15	Sandy loam	6	4	6	4	6	6	6	6	1	4	6
16	Gravelly clay	4	5	6	5	7	7	8	7	1	3	6
17	Gravelly clayloam	4	4	8	6	8	8	7	8	1	3	6
18	Gravelly silt loam	4	4	7	5	8	8	8	8	1	3	6
19	Gravelly loam	3	6	8	6	8	8	8	8	1	3	6
20	Gravelly sandy loam	3	3	6	3	8	8	8	8	1	3	8
21	Gravelly Sandy clay loam	4	6	8	7	8	8	7	8	1	3	6

Annexure I - f: Normalised weights of land degradation severity for Land Resources Development

Sl. no.	Classes	Intensive Agriculture	Agro-horticulture	Agro-forestry	Horticulture	Silvipasture	Grazing/Pasture land	Production forestry	Afforestation	Reclamation of wasteland	Aquaculture	Recreational / Industrial
1	Water erosion-A1 Sheet - Slight	9	9	9	9	9	9	9	9	1	10	7
2	Water erosion-A2 Sheet - Moderate	8	8	8	8	8	8	8	8	2	8	7
3	Water erosion-A3 Sheet - Severe	6	6	6	6	6	6	6	6	4	6	7
4	Water erosion-A4 Rills	5	5	5	5	5	5	5	5	6	6	6
5	Water erosion-A5 Gullies	3	3	3	3	3	3	3	3	8	4	1
6	Water erosion-A6 Ravines - Shallow	3	3	3	3	3	3	3	3	9	3	1
7	Water erosion-A7 Ravines - Moderately deep to deep	2	2	2	2	2	2	2	2	10	2	1
8	Wind erosion-B1 Sheet - Slight	8	8	8	8	8	8	8	8	5	10	7
9	Wind erosion-B2 Sheet - Moderate	7	7	7	7	7	7	7	7	6	8	7
10	Wind erosion-B3 Sheet - Severe	5	5	5	5	5	5	5	5	8	6	7
11	Wind erosion-B4 Stabilized dunes	7	7	7	7	7	7	7	7	5	8	6
12	Wind erosion-B5 Partially-stabilized dunes	6	6	6	6	6	6	6	6	6	7	6
13	Wind erosion-B6 Un-stabilized dunes	4	4	4	4	4	4	4	4	9	6	6
14	Water logging-C1 Surface ponding -Seasonal	6	6	6	6	6	6	6	6	6	7	1
15	Water logging-C2 Surface ponding - Permanent	2	2	2	2	2	2	2	2	9	8	1
16	Water logging-C3 Sub - surface Waterlogging	4	4	4	4	4	4	4	4	9	7	1
17	Salinisation/Alkalization-D1 Saline - Slight	6	6	6	6	6	6	6	6	5	7	6
18	Salinisation/Alkalization-D2 Saline - Moderate	5	5	5	5	5	5	5	5	6	6	6
19	Salinisation/Alkalization-D3 Saline - Severe	4	4	4	4	4	4	4	4	7	5	2
20	Salinisation/Alkalization-D4 Sodic - Slight	6	6	6	6	6	6	6	6	5	7	2
21	Salinisation/Alkalization-D5 Sodic - Moderate	5	5	5	5	5	5	5	5	6	6	6
22	Salinisation/Alkalization-D6 Sodic - Severe	4	4	4	4	4	4	4	4	7	5	6
23	Salinisation/Alkalization-D7 Saline Sodic - Slight	6	6	6	6	6	6	6	6	5	7	6
24	Salinisation/Alkalization-D8 Saline Sodic - Moderate	5	5	5	5	5	5	5	5	6	6	3
25	Salinisation/Alkalization-D9 Saline Sodic - Severe	4	4	4	4	4	4	4	4	7	5	2
26	Salinisation/Alkalization-D10 Rann	3	3	3	3	3	3	3	3	9	4	6
27	Acidification-E1 Acidity - Moderate	6	6	6	6	6	6	6	6	5	6	5
28	Acidification-E2 Acidity - Severe	5	5	5	5	5	5	5	5	6	5	4
29	Glacial-F1 Frost heaving	2	2	2	2	3	3	3	3	1	4	1
30	Glacial-F2 Frost shattering	2	2	2	2	3	3	3	3	1	4	1
31	Anthropogenic-G1 Industrial-effluent affected areas	2	2	2	2	3	3	3	3	9	4	5
32	Anthropogenic-G2 Mining & dump areas	3	4	4	4	5	5	5	5	6	6	4
33	Anthropogenic-G3 Brick kiln areas	3	3	3	3	4	4	4	4	9	6	5
34	Others-H1 Mass movement / Mass wastage	3	3	3	3	4	4	4	4	9	2	1
35	Others-H2 Barren rocky/ Stony waste	2	2	2	2	2	2	2	2	9	3	7
36	Others-H3 Miscellaneous-Riverine sands / Sea ingress areas	5	5	5	5	4	4	6	6	1	7	1
37	N - Normal	10	7	10	10	10	10	10	10	1	10	1

Annexure I - g: Normalised weights of soil Depth for Land Resources Development

Sl. no.	Classes	Intensive Agriculture	Agro-horticulture	Agro-forestry	Horticulture	Silvipasture	Grazing/Pasture land	Production forestry	Afforestation	Reclamation of wasteland	Aquaculture	Recreational / Industrial
1	Extreamly shallow	4	3	4	3	5	9	5	5	7	1	6
2	Very shallow	5	4	5	4	5	9	5	5	6	1	6
3	Shallow	6	6	6	5	8	9	7	7	6	1	6
4	Moderately shallow	8	9	5	8	7	7	7	7	5	1	5
5	Moderately deep	9	10	7	9	6	6	6	6	5	3	5
6	Deep	10	10	7	10	6	5	6	6	4	5	5
7	Very deep	10	10	8	10	6	4	6	6	4	5	5
8	No data	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL

Annexure II: Relative layer weights through Analytical Hierarchy Process (AHP) for Land Resources Development

Sl. no.	Classes	Intensive Agriculture	Agro-horticulture	Agro-forestry	Horticulture	Silvipasture	Grazing/Pasture land	Production forestry	Afforestation	Reclamation of wasteland	Aquaculture	Recreational / Industrial
1	Soil texture, erosion and depth★	0.15	0.17	0.12	0.15	0.12	0.12	0.11	0.11	0.25	0.07	0.06
2	Slope	0.06	0.06	0.08	0.08	0.09	0.11	0.10	0.09	0.06	0.08	0.09
3	Ground Water Prosepects	0.16	0.15	0.15	0.16	0.11	0.09	0.08	0.07	0.05	0.14	0.10
4	Land Capability Classification	0.08	0.08	0.09	0.08	0.11	0.11	0.15	0.15	0.12	0.10	0.19
5	Land use/cover	0.55	0.54	0.56	0.53	0.57	0.57	0.56	0.58	0.52	0.61	0.56

*The average weightage of soil group (texture-depth-degradation)

Annexure III -a: Binary condition of land use / land cover for Water Resources Development

Sl. No.	Class	Contour Trenches	Earthen Contour Bunds	Loose Boulder Check Dam / Gully Plugs	Gabion Structures	Earthen Dams (Nala bund)	Percolation tank	Minor Irrigation Tanks (Surface Water)	Farm Ponds	Subsurface dykes (across channel bed)	Arable Areas (Khadins)
1	Core Urban (CU)	N	N	N	N	N	N	N	N	N	N
2	Peri-Urban (PU)	N	N	N	N	N	N	N	N	N	N
3	Other Urban Areas(OU)	N	N	N	N	N	N	N	N	N	N
4	Village Settlement (VS)	N	N	N	N	N	N	N	N	N	N
5	Mixed Village Settlement (MV)	N	N	N	N	N	N	N	N	N	N
6	Hamlet & Dispersed Household (HD)	N	N	N	N	Y	N	N	N	N	N
7	Other Rural Built-up Areas (OR)	N	N	N	N	Y	N	N	N	N	N
8	Industrial area (IA)	N	N	N	N	N	N	N	N	N	N
9	Transport Network (TN)	N	N	N	N	N	N	N	N	N	N
10	Transport Infrastructure (TI)	N	N	N	N	N	N	N	N	N	N
11	Crop Land (CL)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
12	Fallow Land (FL)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
13	Agriculture Plantation / Orchards (AP)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
14	Aquaculture (AC)	N	N	N	N	N	N	N	N	N	N
15	Closed Forest (CF)	Y	Y	Y	Y	Y	Y	N	N	Y	N
16	Open Forest (OF)	Y	Y	Y	Y	Y	Y	N	N	Y	N
17	Forest Plantation (FP)	Y	Y	Y	Y	Y	Y	Y	N	Y	Y
18	Swamp area / Mangrove (SM)	N	N	N	N	N	N	N	N	N	N
19	Grasslands / Grazing Lands (GG)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
20	Salt Affected Land (SA)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
21	Gullied land (GL)	N	N	Y	Y	Y	Y	Y	Y	Y	Y
22	Ravinous Land (RL)	N	N	Y	Y	Y	Y	N	N	Y	N
23	Dense scrub land (DS)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
24	Sparse scrub land (SS)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
25	Barren Rocky (BR)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
26	Stony Waste (SW)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
27	Sandy area - Desertic (SD)	N	N	Y	Y	Y	Y	Y	Y	N	Y
28	Sandy area - Coastal (SC)	N	N	Y	Y	Y	Y	Y	Y	N	N
29	Sandy area - Riverine (SR)	N	N	Y	Y	Y	Y	Y	Y	N	N
30	Waterlogged (WL)	N	N	N	N	N	N	N	N	N	N
31	River (RI)	N	N	N	N	N	N	N	N	Y	N
32	Stream (ST)	N	N	Y	Y	Y	N	Y	N	Y	N
33	Canal / Drain (CD)	N	N	N	N	N	N	N	N	N	N
34	Lakes / Pond (LP)	N	N	N	N	N	N	N	N	N	N
34	Reservoir / Tank (01)	N	N	N	N	N	N	N	N	N	N
37	Glacial area (GL)	N	N	N	N	N	N	N	N	N	N
38	Shifting Cultivation area (SC)	N	N	N	N	N	N	N	Y	N	N
39	Mining / Quarry / Mining Dump (MQ)	N	N	N	N	N	N	N	N	N	N
40	Rann (RN)	N	N	N	N	N	N	N	N	N	N
41	Salt pan (SP)	N	N	N	N	N	N	N	N	N	N

Annexure III -b: Binary condition of slope for Water Resources Development

Sl. No.	Class	Contour Trenches	Earthen Contour Bunds	Loose Boulder Check Dam / Gully Plugs	Gabion Structures	Earthen Dams (Nala bund)	Percolation tank	Minor Irrigation Tanks (Surface Water)	Farm Ponds	Subsurface dykes (across channel bed)	Arable Areas (Khadins)
1	0-1	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
2	1-3	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
3	3-8	N	Y	Y	Y	Y	Y	Y	N	Y	Y
4	8-15	Y	N	Y	Y	N	N	N	N	N	N
5	15-30	Y	N	N	Y	N	N	N	N	N	N
6	30-45	N	N	N	Y	N	N	N	N	N	N
7	>45	N	N	N	N	N	N	N	N	N	N

Annexure III -c: Binary condition of stream order for Water Resources Development

Sl. No.	Class	Contour Trenches	Earthen Contour Bunds	Loose Boulder Check Dam / Gully Plugs	Gabion Structures	Earthen Dams (Nala bund)	Percolation tank	Minor Irrigation Tanks (Surface Water)	Farm Ponds	Subsurface dykes (across channel bed)	Arable Areas (Khadins)
1	1st			N	Y	N		N		N	N
2	2nd			Y	Y	Y		N		N	N
3	3rd			Y	Y	Y		N		N	N
4	4th			N	Y	Y		N		N	Y
5	5th			N	N	N		Y		N	Y
6	6th			N	N	N		Y		Y	Y
7	7th or above			N	N	N		N		Y	Y

Annexure III -d: Binary condition of surface soil texture for Water Resources Development

Sl. No.	Class	Contour Trenches	Earthen Contour Bunds	Loose Boulder Check Dam / Gully Plugs	Gabion Structures	Earthen Dams (Nala bund)	Percolation tank	Minor Irrigation Tanks (Surface Water)	Farm Ponds	Subsurface dykes (across channel bed)	Arable Areas (Khadins)
1	Sandy	N	N	Y	Y	Y	Y	Y	Y	N	N
2	Loamy	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
3	Clayey	Y	N	N	N	Y	N	Y	Y	Y	Y
4	Coarse loamy	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
5	Clay loam	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
6	Sandy clay loam	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
7	Silt	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
8	Silty loam	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
9	Silt clay	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
10	Silt clay loam	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
11	Sandy clay	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
12	Clay skeletal	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
13	Gravelly sand	Y	N	N	N	Y	Y	Y	Y	Y	Y
14	Gravelly loamy sand	Y	N	N	N	Y	Y	Y	Y	Y	Y
15	Sandy loam	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
16	Gravelly clay	Y	N	N	N	Y	Y	Y	Y	Y	Y
17	Gravelly clayloam	Y	N	N	N	Y	Y	Y	Y	Y	Y
18	Gravelly silt loam	Y	N	N	N	Y	Y	Y	Y	Y	Y
19	Gravelly loam	Y	N	N	N	Y	Y	Y	Y	Y	Y
20	Gravelly sandy loam	Y	N	N	N	Y	Y	Y	Y	Y	Y
21	Gravelly Sandy clay loam	Y	N	N	N	Y	Y	Y	Y	Y	Y

Annexure III -e: Binary condition of geomorphology for Water Resources Development

Sl. No.	Class	Contour Trenches	Earthen Contour Bunds	Loose Boulder Check Da	Gabion Structures	Earthen Dams (Nala bund)	Percolation tank	Minor Irrigation Tanks (Surface Water)	Farm Ponds	Subsurface dykes (across channel bed)	Arable Areas (Khadins)
1	Structural Hills	N	N	Y	Y	N	N	N	N	N	N
2	Denudational Hills	N	N	Y	Y	N	N	N	N	N	N
3	Peidmont Zone	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
4	Pediplain	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
5	Alluvial Plain	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
6	Flood Plain	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
7	Eolian Plain	N	Y	N	Y	N	N	Y	Y	Y	Y

Annexure IV : Office order of formation of thematic team to develop product and services under land, water & amenities development plan in BP-3

NATIONAL REMOTE SENSING CENTRE
REGIONAL CENTRES - HEADQUARTERS

No. NRSC:RRSC/SISDP-U/65/2021 June 17, 2021

OFFICE ORDER

One of the important objectives of the SISDP-Update Project is to develop Product and Services for Gram Panchayat Spatial Development Planning (GPSDP) including

1. Land Resources Developmental Plans (LRDP),
2. Water Resources Developmental Plans (WRDP) and
3. Amenities Development Plans (ADP) based on RADPFI.

Though we have demonstrated few LRDP and WRDP and hosted in Bhuvan Panchayat 3 (BP3) web portal there is no further progress.

In this regard the following 'Thematic Team' and 'Software Team' are constituted to develop the products and services under WRDP, LRDP and AMP and host them in BP3.

Thematic Team

1. Dr. S. Pathak (Team Lead)
2. Mr. Sagar S. Salunkhe
3. Dr. Sudha Ravindranath
4. Dr. Ramasubramonium
5. Dr. Milind W
6. Dr. Jugal Kishore Mani
7. Dr. Prabir Kumar Das
8. Mr. Y.K. Srivastava

Software Team

1. Dr. D. S. Prakash (Team Lead)
2. Dr. Vinod Sharma
3. Mr. Gaurav Kumar
4. Dr. Anju Bajpai
5. Mr. T.P. Girish Kumar
6. Ms. Kushboo Mirza
7. Mr. N.R. Shankar Ram
8. Mr. Ashish Kumar Jain
9. Mr. Vinod P V

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The thematic team shall work on:

1. Identifying the products that need to be developed under WRDP and LRDP and ADP.
2. To finalize the input data, algorithm and decision rules for each of the WRDP and LRDP interventions and ADP.
3. Preparation of a technical document for each of the products and services describing the scope, data used, decision rules and algorithms and outputs with proper references. These technical documents will be the reference document for the products and service in BP3.
4. The thematic team shall provide the document to the software team as and when it is completed but not later than three weeks.

The software team shall work on:

1. Implement the WRDP, LRDP and AMP based on the Guidelines documents provided by the thematic team and host them in the Bhuvan Panchayat 3.
2. Prepare the required documentations for this development including user manuals.
3. The software team shall take 4 weeks time to complete the task.

The team shall consult for technical guidance with Dr. V. M. Chowdary, DPD (Geospatial Database), Dr. D.S. Prakash, DPD (Software Development) and Dr. K. Chandrasekar, DPD (Capacity Building).

(C.S. Jha)
Project Director, SISDP-Update&
Chief General Manager, RCs

डॉ. सी. एस. झा / Dr. C.S. JHA
उत्कृष्ट वैज्ञानिक एवं समूह महाप्रबंधक (से.कें.)
OS & CGM (RCs)

To: All Concerned
cc: GD (PPEG)
cc: Director, NRSC – For Information please.

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