# A GIS approach on Landscape Assessment with integration of various parameters of Watershed Development Program in Kalyanpura Watershed, Bhilwara, Rajasthan.


**Chiranjit Guha** [1] and **Sanjay Joshie** [2]

[1] Senior Project Officer, Foundation for Ecological Security

[2] Regional Team leader, Foundation for Ecological Security

F33, Subhash Nagar Extn East, Bhilwara, Rajasthan



## Abstract:

Watershed development and management is consisting of various parameters which directly influence the daily life of local people. Watershed development program includes social development of the community in each and every aspect and simultaneously the natural resource management by considering ecological health. By word, it is easy to describe all these parameters, but, in real sense it is difficult to play with by understanding the influence of each and every parameter to each other. It is because of one parameter is complementary to another. Land and Water are the main influencing zone to restore and managing natural resources. To deal with various phenomenon of land and water, a brief and regional set up of the earth sciences in a broad sense of the watershed area has to be taken in project objectives and if required, detailing of the related parameters also. Scaling and integration on a spatial platform has been established through GIS approach for such case and that has been overlaid on revenue maps. Geological (geo-hydrological) parameters of the area have been linked with physiographic pattern of the area and then land use classification has been established by using Remote Sensing techniques. These all are cross checked with field reality and finally has been put in a single platform of GIS and analyzed with all spatial and temporal scale. The treatment plan has been developed on the basis of above mentioned parameters and revenue maps have been geo-referenced and digitized to overlay on the final output. The final map is showing the treatment plan for each and every land for best possible development in terms of betterment of natural resource management.


## About the Author:


**Mr. Chiranjit Guha M.Tech (Applied Geology)**

Master of Technology (Applied Geology)

From Indian Institute of Technology, Roorkee.

Bachelor of Science (Geology Honours)

Presidency College, Kolkata

Working as Senior Project Officer in Foundation for Ecological Security.

E mail ID: chiranjitguha@gmail.com,

Contact No: +91 – 94130-54809

Mr. Sanjay Joshie

M.Sc (Soil Science)

PanthNagar University.

Working as Regional Team Leader in Foundation for Ecological Security

Email ID: sanjayjoshie@yahoo.com

Contact No: +91-9460200406

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**Introduction:** Landscape assessment and management planning by considering the possible parameters of it is not only difficult but also it is complex. There are various processes of integration of social science, technology and natural resources in a single platform to understand an area at any temporal and spatial scale, but these processes are more conceptual and difficult to translate at every level. Assumptions and ambiguity decrease the originality of the main theme. With help of Spatial analysis by Geographic Information System of the different data set, an approach has been made to integrate different data set in a single platform with correlations to each other and that yield a better picture to make understanding of the area and therefore conservation measure planning depending upon the themes.

**Project Details:** Watershed development programs for sustainable development in different aspects of rural part of any country consisting of betterment of water regime, natural resources and other inter related functions which are directly or indirectly relating the local livelihood components and also the health components. Since it is linked to natural resources, and unit is being considered as a geographic boundary, the planning would be towards the landscape where the linkage between land use and land cover with other components can be integrated. In landscape management, ecology is another component which is one of the main objectives to protect and restore the nature. Therefore linking of different components is necessary during planning and interventions. Still it is difficult to deal with all the parameters of watershed management and putting these in a single platform. Conceptually, the planning can be done by understanding a unit area with every possible parameter, but that is difficult and translation of this concept by any means is more complex. In Geographic Information System (GIS) integration of parameters with help of other technologies like Remote Sensing, Scientific research can be done by putting them in a single platform. In the following section, the methodology of the landscape assessment has been exemplified with an example of watershed program.

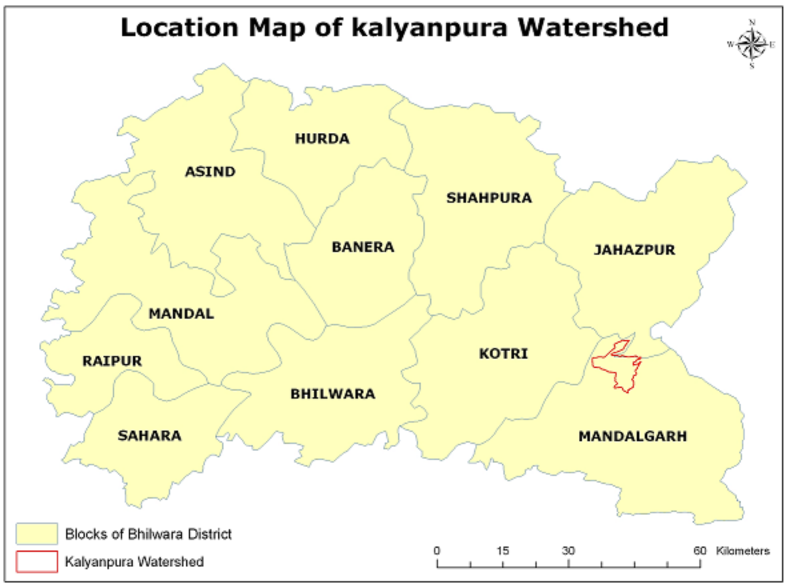


Fig.1: Location map of Kalyanpura Watershed in Bhilwara district

Kalyanpura watershed is situated in Mandalgarh block of Bhilwara district in Rajasthan. The project initialized in the year 2006 with Public Private Partnership between Govt. of India, Govt. of Rajasthan and Indian Tobacco Company (ITC). This is a watershed of approximately 5000 hectare area and drainages are tributary of river Mej (a tributary to Chambal). During planning of the interventions, different surveys have been conducted in the area. Mainly land use, land cover of the area have been classified, topographical and geological survey have been done, ecological parameters have been taken under consideration after a detailed ecological survey, local livelihood pattern and socio economic condition have also been considered during planning. Then all these data have been converted to the spatial database which has been used in GIS to analyze and integrate as different layers. Finally five types of spatial database have been constructed, Topographic data, Geological data, Ecological data, Demographic data and Socio-Economic data. The method described here is showing the integration process of first two data types and intervention planning according to these data. More on it, the revenue maps (cadastral maps) have been geo-referenced and digitized and have been overlaid. These maps give the detail planning on revenue land no wise map with each and every aspects with respect to topography, land use land cover and geo-hydrology.

## Parameters & Method Used for Integration:

**1. Topography:** In topographic data, mainly, contours and drainage lines have been digitized in ARC-Info (ARC-GIS 9) from the Survey of India (SOI) topo-sheets and then digital elevation model has been generated with help of ARC (command prompt) and Spatial Analyst tool has been used. With the help of Spatial Analyst, from the digital elevation model, the total area has been classified according to its slope variation.
The 0-1% of slope has re-coded by number 1, 1-3% slope by 2, 3-5% slope by 3, 5-10% slope by 4, 10-25% slope by 5, 25-50% slope by 6 and >50% slope by 7. By this way, the total watershed area has been classified with 7 class intervals. In ARC-GIS, by using classification tool, the polygon coverage have been constructed after classify the area according to these 7 categories.

**2. Land use land cover:** Secondly, the Land Sat imageries have been classified in three categories, Agriculture land, non agriculture land (all types of land except agriculture and water body) and Water body with the help of Erdas Imagine software. The LISS3 and PAN images have been classified and ground truthing has been done with GPS survey of the area. These three classified land use also again

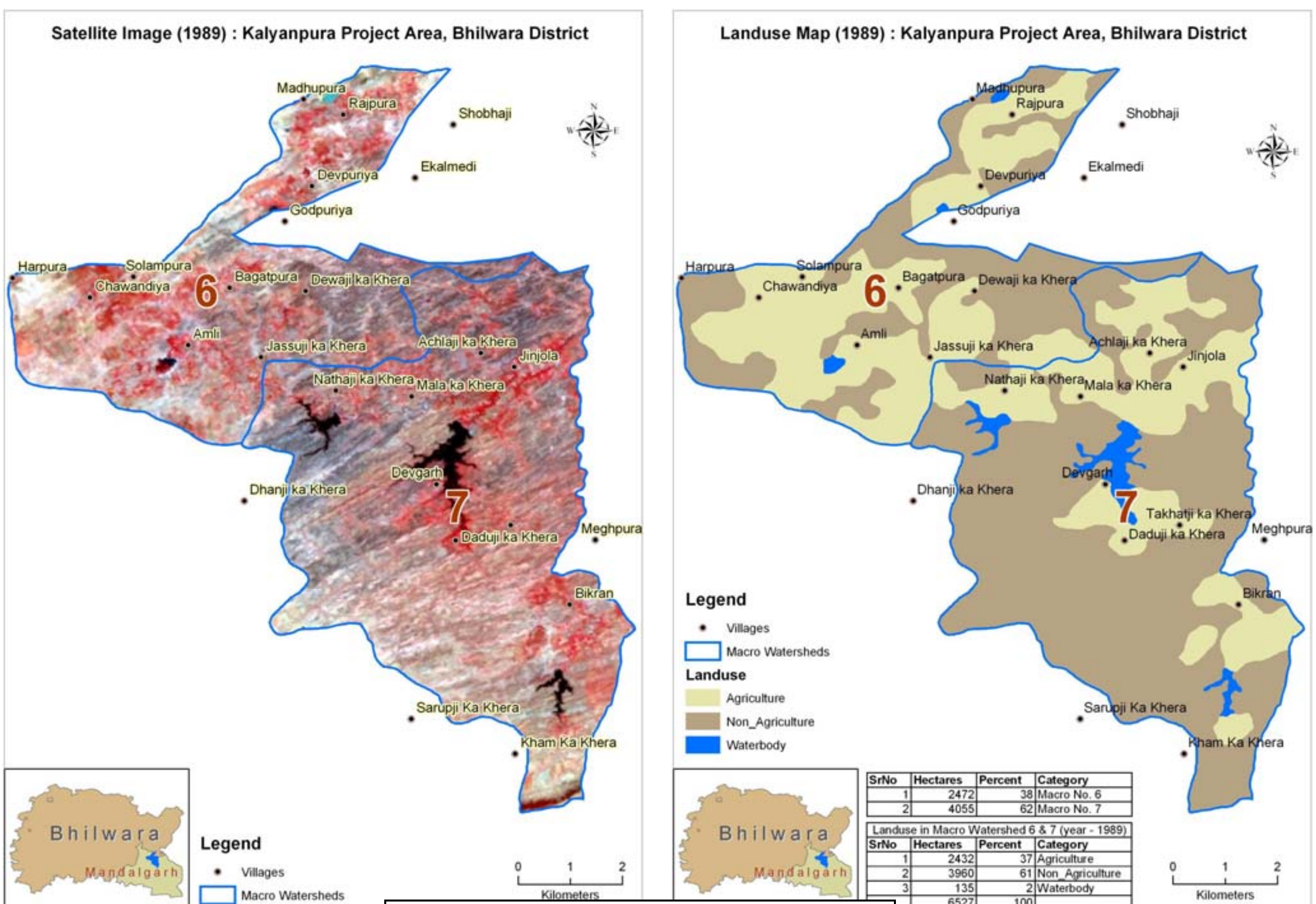


Fig.2: Land use Classification Map

recoded by 1,2 and 3 respectively. Again with the help of ARC-Toolbox, the raster images have been converted to the polygon coverage for this area, according to the recoded numbers.
These two polygon coverages or layers then spatially integrated with help of GIS. In background, a matrix has been designed. Combination of the numbers in two layers gives the influence of slope and land use in a single platform. 7*3= 21 types of combinations classify the area with 7 classes of slopes and 3 types of land use.

**Table 1: Matrix Table for Integration of Land Use and Slope.**

| LAND USECODE | SLOPECODE | Luse & slope Combinations | Combination actuals |
|---|---|---|---|
| 1 (Agriculture) | 1 (0-1% slope) | 11 | Agriculture with 0-1% slope |
| 2 (Non Agriculture) | 2 (1-3% slope) | 12 | Agriculture with 1-3% slope |
| 3 (Water Body) | 3 (3-5% slope) | 13 | Agriculture with 3-5% slope |
| | 4 (5-10% slope) | 14 | Agriculture with 5-10% slope |
| | 5 (10-25% slope) | 15 | Agriculture with 10-25% slope |
| | 6 (25-50% slope) | 16 | Agriculture with 25-50% slope |
| | 7 (>50% slope) | 17 | Agriculture with >50% slope |
| | | 21 | NonAgriculture with 0-1% slope |
| | | 22 | NonAgriculture with 1-3% slope |
| | | 23 | NonAgriculture with 3-5% slope |
| | | 24 | NonAgriculture with 5-10% slope |
| | | 25 | NonAgriculture with 10-25% slope |
| | | 26 | NonAgriculture with 25-50% slope |
| | | 27 | NonAgriculture with >50% slope |
| | | 31 | Waterbody with 0-1% slope |
| | | 32 | Waterbody with 1-3% slope |
| | | 33 | Waterbody with 3-5% slope |
| | | 34 | Waterbody with 5-10% slope |
| | | 35 | Waterbody with 10-25% slope |
| | | 36 | Waterbody with 25-50% slope |
| | | 37 | Waterbody with >50% slope |

**3. Geo-Hydrology:** The geological study has been conducted in a grid based pattern with 30” by 30” interval. The base map has been generated by ARC-GIS to make the grid maps where digitized watershed maps have been considered for reference in field. Within the Geo-hydrology study lithological mapping has been done with 1:10000 scale and then drainage analysis has been conducted. Detailed 2D mapping has been done and rock samples have been collected from different grids. These samples have been analyzed under polarized microscope for better understanding of the rock properties. After completion of surface mapping, geophysical survey (Resistivity survey) have been conducted and simultaneously pumping test has been carried out in different grids to identify the aquifers and the flow path, recharge capacity of the area. Storativity, Transmissivity and specific yield has been calculated and aquifer boundaries have been delineated. There are 4 unconfined aquifer systems have been identified on the basis of geo-hydrological survey. These aquifers are having different storativity and transmissivity. The recharge paths are trending towards north-west direction. These paths are due to secondary porosity along the fractures which developed along the foliation plane. This area is highly foliated and the slope of the fractures is gentle at shallow depth and steeper at greater depth. Very local scale foldings are present and enormous quartz vein intrusions made the area complex in terms of ground water movement at local scale. But regionally the ground water flow direction is almost North-West trending.

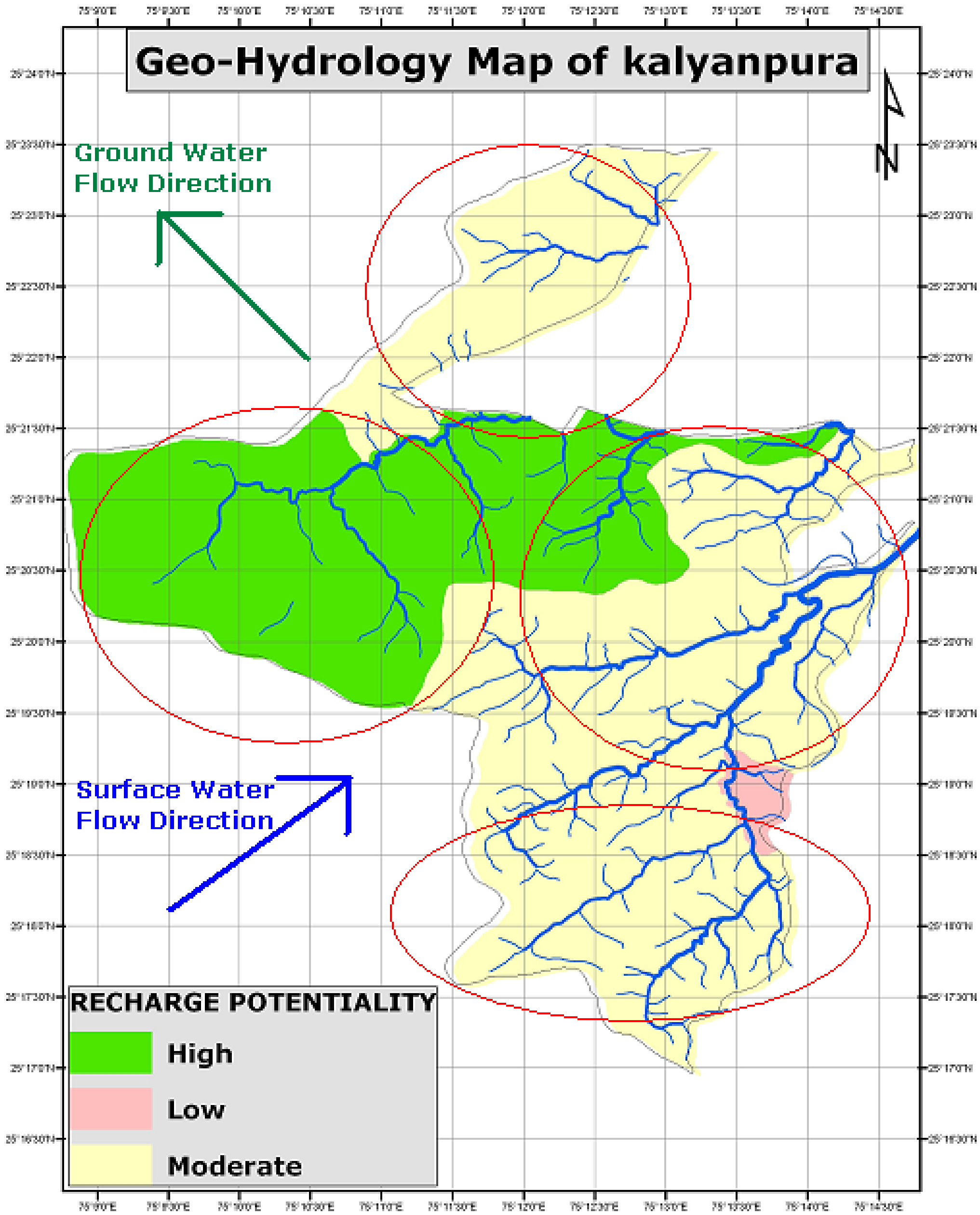


Fig.3: Geo-Hydrology map of Kalyanpura Watershed

Analyses of all the possible geological and hydrological parameters classify the area in three categories, High recharge area, Moderate recharge area and Low recharge area. This recharge area again recoded by 1, 2 and 3 numbers respectively and polygons made by ARC-Info with these three categories. The study also found a special case in terms of ground water flow which indicates the surface runoff direction and ground water flow path are at almost right angle to each other.

The earlier matrix again spatially integrated with the geo-hydrological layer (with three recoded categories). In this matrix, the earlier 21 combinations of land use and Topography have been combined with 3 classes of recharge potentiality and a new layer has been generated with 21 * 3 = 63 possible combinations. This integrated layer is giving the details of the area pixel wise on the basis of topography, land use and recharge potentiality.

**Table 2: Matrix Table for integration of land use, topography and recharge potentiality.**

| SLOPE | | COMBINATION OF LANDUSE & SLOPE | RECHARGE CODE | COMBINATION OF LANDUSE, TOPOGRAPHY & RECHARGE POTENTIALITY | | |
|---|---|---|---|---|---|---|
| PERCENTAGE | RECLASSIFIED CODE | 11 | 1 | 1101 | 1102 | 1103 |
| "0-1" | 1 | 12 | 2 | 1201 | 1202 | 1203 |
| "1-3" | 2 | 13 | 3 | 1301 | 1302 | 1303 |
| "3-5" | 3 | 14 | | 1401 | 1402 | 1403 |
| "5-10" | 4 | 15 | | 1501 | 1502 | 1503 |
| "10-25" | 5 | 16 | | 1601 | 1602 | 1603 |
| "25-50" | 6 | 17 | | 1701 | 1702 | 1703 |
| >"50" | 7 | 21 | | 2101 | 2102 | 2103 |
| | | 22 | | 2201 | 2202 | 2203 |
| LANDUSE | | 23 | | 2301 | 2302 | 2303 |
| TYPE | RECLASSIFIED CODE | 24 | | 2401 | 2402 | 2403 |
| Agriculture | 1 | 25 | | 2501 | 2502 | 2503 |
| Non-Agriculture | 2 | 26 | | 2601 | 2602 | 2603 |
| Waterbody | 3 | 27 | | 2701 | 2702 | 2703 |
| | | 31 | | 3101 | 3102 | 3103 |
| RECHARGE POTENTIAL | | 32 | | 3201 | 3202 | 3203 |
| TYPE | RECLASSIFIED CODE | 33 | | 3301 | 3302 | 3303 |
| High | 1 | 34 | | 3401 | 3402 | 3403 |
| Moderate | 2 | 35 | | 3501 | 3502 | 3503 |
| Low | 3 | 36 | | 3601 | 3602 | 3603 |
| | | 37 | | 3701 | 3702 | 3703 |

Based on the above mentioned parameters, 14 types of watershed intervention plans have been designed. It has been observed that some combinations can be treated with same types of interventions. Accordingly the 63 combinations of the integrated layers have been recoded with these 14 types of interventions and Polygons have been assigned with these intervention codes with the help of ARC-GIS tools. Finally, the intervention map has been generated on the basis of Land Use, Land Cover, Topography and Recharge potentiality of the area.

**Revenue Details:** Revenue maps (1:4000 scale) have been georeferenced with the help of Garmin GPS in field survey and ARC-GIS georeferencing techniques have been used for georeferencing of these maps to put revenue details in spatial and digital format. As it has been georeferenced and digitized, the digital geo-coded revenue maps have been overlaid on the intervention map which made on the basis of land use, topography and recharge potentiality. This final map indicates the best intervention plan on different land and therefore one can easily make the plan of watershed project on the land of each and every individual.

**Table 3: Intervention Matrix**

| CLASS CODE | COMPOSITION | | | CONSERVATION MEASURE |
|---|---|---|---|---|
| | LUSE CODE | SLOPE | RECHARGE POTENTIAL | |
| 1 | 1 | 1,2 | 1,2 | Maintanance of bunds, supply of fertiliser and good for irrigation |
| 2 | 1 | 1,2 | 3 | Grassland development, construction of farm pond |
| 3 | 1 | 3,4,5 | 1,2,3 | Cultivation with terracing and agroforestry |
| 4 | 1 | 6,7 | 1,2 | Increase of time for surface water availibility for recharge by structures |
| 5 | 1 | 6,7 | 3 | Surface storage structure for soil moisture, irrigation and domestic uses |
| 6 | 2 | 1,2 | 1,2 | Afforestation with suitable species |
| 7 | 2 | 1,2 | 3 | Bunding, terracing shallow rooted low water requirement short duration crops |
| 8 | 2 | 3,4,5 | 1 | Afforestation with contour trenching |
| 9 | 2 | 3,4,5 | 2,3 | Bunding, shallow rooted crops with irrigation facilities |
| 10 | 2 | 6,7 | 1 | Afforestation with contour trenching |
| 11 | 2 | 6,7 | 2,3 | Spot planting in crevizes of rocks having soil |
| 12 | 3 | 1,2,3,4,5 | 1,2 | Construction of new wells near by the waterbody (after checking the GW flow path) |
| 13 | 3 | 1,2 | 3 | Plantation of trees surround the waterbody to low down the evaporation |
| 14 | 3 | 3,4,5 | 3 | Construction of WHS at the outlet to maximize the storage |

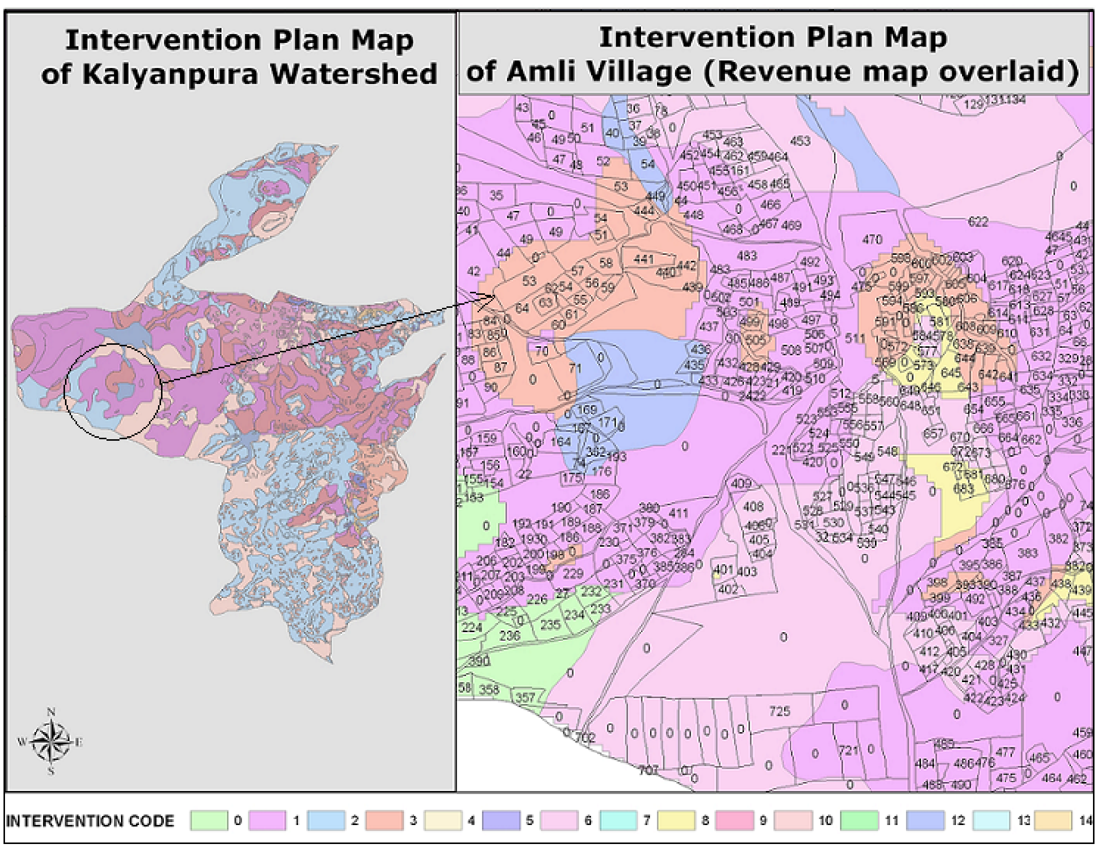


**Fig.4: Intervention Map based on Land use, Topography, Recharge potentiality**

**Conclusion:** This final layer is actually showing the exact intervention planning to the particular land. This will help the planners to make the plans according to the land use, topography and recharge potential at village level. Land number wise details (owner of land, agriculture status, irrigation etc) would be merged during the planning of watershed intervention. By this way, the other different spatial and non spatial data set layers (exmp: ecological variations, biophysical parameters, demographic data, and socio-economic conditions) can be integrated as one by one layer and more combinations can be generated in GIS in a simple way which will describe the area in more details. With these layers, a complete development plan can be retrieved out for enhance the livelihood of the local people with considering ecological health of the area with proper management of natural resources. This kind of planning is necessary to reduce land degradation, positive impact of soil and water regime and environment. By this way, best possible techniques through integration of several important spatial and non spatial data can be put in a single platform to understand the area with help of GIS technology.

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