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LAND USE ZONING PRACTICE AT MICRO LEVEL IN NEPAL: AN ASSESSMENT

Research

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There are no conflicts of interest for any of the authors.

ABSTRACT
Land use zoning at the micro level is designating permitted uses of certain parcels of land by local communities through the legal permission of local government. The local government has to designate various zones for different uses of land, such as agricultural, residential, commercial, industrial, public use etc. the paper stressed on practice of using of land based on scientific land use zoning which has rigorously analyzed by using the multi criteria decision analysis and separate one set of land uses from another. The paper further emphasizes on the a detail study of land use pattern, land system, land type, land capability, geology and natural hazards in order to formulate a classification scheme for land use zoning. The main task of land use zoning has to prepare a scientific and comprehensive land resource inventory at at micro level and assess and delineate land use based on land types, associated soils and land capability classes with a view to formulate a sound and sustainable land use planning.

INTRODUCTION
Land use zoning is assessed based on the suitability of sustainable use for a specific purpose so that land use zoning differs from land capability classification in a sense that land capability is general classification of land based on arability and productivity of soil without degradation or offsite effects of farming whereas land use zoning is suitability classification of land for various land use purposes. Land use planning simply means the systematic assessment of physical, social and economic factors as to encourage and assist land users in selecting options that increase their productivity in sustainable way and meet the needs of society. FAO has rightly stated that the systematic assessment of land and water potential, alternative patterns of land use and other physical, social and economic conditions, for the purpose of selecting and adopting land-use options which are most beneficial to land users without degrading the resources or the environment, together with the selection of measures most likely to encourage such land uses (Anderson, 1971).

Land use planning demands an integrated and strategic approach at national, regional and local levels to meet all needs. Land use planning should consider the sustainability, social impact and an assessment of what the land is capable of supporting and sustaining into the future and in the interests of the wider community. Clawson and Stewart (1965) said that the demand on the use of our land to achieve many objectives requires the application of a rigorous process of planning. For example, some areas of land can support a wide range of uses whereas other areas support a small range of uses. Effective planning involves anticipation and an understanding of land use and land management practices, and the participation by land users, planners, public, and deci-

sion makers in the planning process.

Soil surveys most commonly are made for areas that have more than one kind of important land use and for users who have varied interests and needs (Major, 1951). These needs may be few and noncomplex in areas of extensive land use where change is not expected or they may be many and complex in areas of intensive land use where changes are expected. The predictions of soil surveys serve as a basis for judgment about land use and management and provide information about soil resources needed for planning development of new lands or conversion of land to new uses. This is important in planning specific land use and the kind and intensity of land management needed, including those operations that must be combined for satisfactory soil performance. Soil surveys are also useful in helping to locate possible sources of sand, gravel, or fertile topsoil for cultivation. Thus, intended land use and its economic feasibility can be determined with the soil surveys and ultimately by land use planning(Pumell,1951;Burley, 1961;FAO,1993).

Agriculture is the major sector in the country Nepal, which provides employment to more than 65 percent of the people, contributing 33 percent in the national GDP. Low agriculture production is the major problem in Nepalese agriculture posing food security problem in the country. Recent data have framed the downward trends of agricultural productivity and stagnant production trends of major cereal crops like rice, maize and wheat. Recent available information clearly state that Nepal is going to face a food crisis soon as production of food per capita has been declining. It has become a growing problem for many households. Nepal as a whole has also been considered as a food insecure country. Land availability per capita is also declining more or less at the same rate as there is less scope to move to non-farm sector.

The major cause of low agriculture production is the cultivation of crops and soil management without scientific land resource data. Thus, land resource inventory data is necessary for environment friendly agriculture sustainability. In this context, the Government of Nepal has recently formulated the 20 year Agriculture Development Strategy (ADS) emphasizing to increase agriculture production to solve the food and nutritional security problems of the country safeguarding the environment. Also, the National Land Use Policy-2012 has been declared, which is focused to increase the productive capacity of land.

In Nepalese context, land-use planning can be applied at three broad levels: national, district and local. For local level planning, information regarding the natural resource, socio-economic and demography of the area is essential for effective planning which provides a guideline for selection of land and what activities can be performed, when, how, and who is responsible for those activities. However, Nepal has only regional level data base on land use, land system and land capability which were produced by Land Resource Mapping Project (LRMP, 1986a). Realizing this fact, the Ministry of Land Reform and Management of Government of Nepal established the National Land Use Project (NLUP) to generate the necessary data bases of the land resources at the area i.e. micro level. (GON, 2012).

The National Land Use Policy 2015 has emphasized to manage land use in accordance with the land zoning policy of Government of Nepal which categorizes six land zones such as agricultural area, residential area, commercial area, industrial area, forest area and public use area. The policy has mentioned the land characteristics, capability of the each category of land zones. Besides this, the policy has pointed to form Land Use Council at the top of district and local level i.e. municipality/rural municipality to implement the micro level databases on natural resources. Therefore, the present study is an attempt to point out the land use zoning practices in at micro level in Nepal with a view to prepare a scientific and comprehensive land resource inventory at micro level and assess and delineate land use based on land types, associated soils and land capability classes in order to formulate a sound and sustainable land use planning.

Study Area

Inarwa village development committee (AREA) of Rautahat District, part of Narayani Zone central Nepal locates in Terai and is well built up in terms of service, roads and transport, business, education, agriculture, economy, population dynamics, and is growing rapidly towards a developed village . It had nine wards as it was separate AREA now it merged into ward no 2 and 3 of Baudhi Mai Village Government. The spatial coverage of the AREA accounts 688.936 1hectare. The major livelihood of people living in the AREA observed to be agriculture; farm based micro entrepreneurship, daily wages laboring and seasonal migration outside the country for searching job. Some households who belong to marginalized groups found landless. They manage their daily needs by working as laboring either as agriculture labor or any other forms of laborers. The AREA comprises of many types of castes/ethnicities like Kurmi, Kanu, Teli, Dhobi, Chamar, Dusar, Kalawar,Koiri, Banof and other Madeshi marginalized groups. The AREA has 705 households with 5800 total population which composed by 3014 male and 2786 female. The average family size of the AREA is 8. Geographically, it extends from 85˚13'43" east to 85˚15'48" eastern longitudes and 26 53'27" north to 26.55'24" northern latitudes with having an area of 6.89 spkm with 3.59 km north-south length and 3.46 km east-west width (Fig-1).

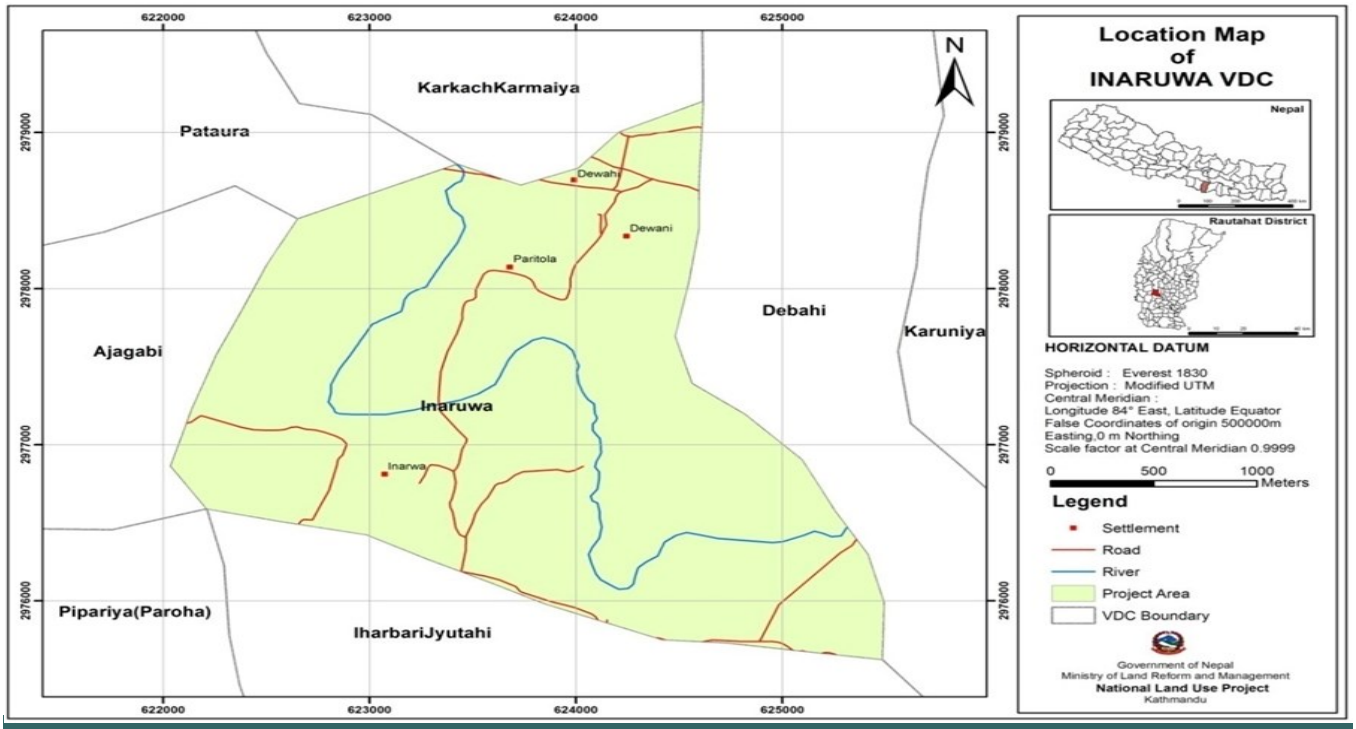


Figure 1 : Location Map

The physical condition, geological structure, topographic features and visible terrain indicate that the study area falls under the flat terai land that of gangetic part which formed in various stages of fluvial systems. The elevation, slope and relief features vary right from north to south as well as east to west. Generally, elevation and slope both are descending order from northern part to south. The elevation ranges from 15.23-91 m msl. The topography is plain with gentle slope(Fig-2).

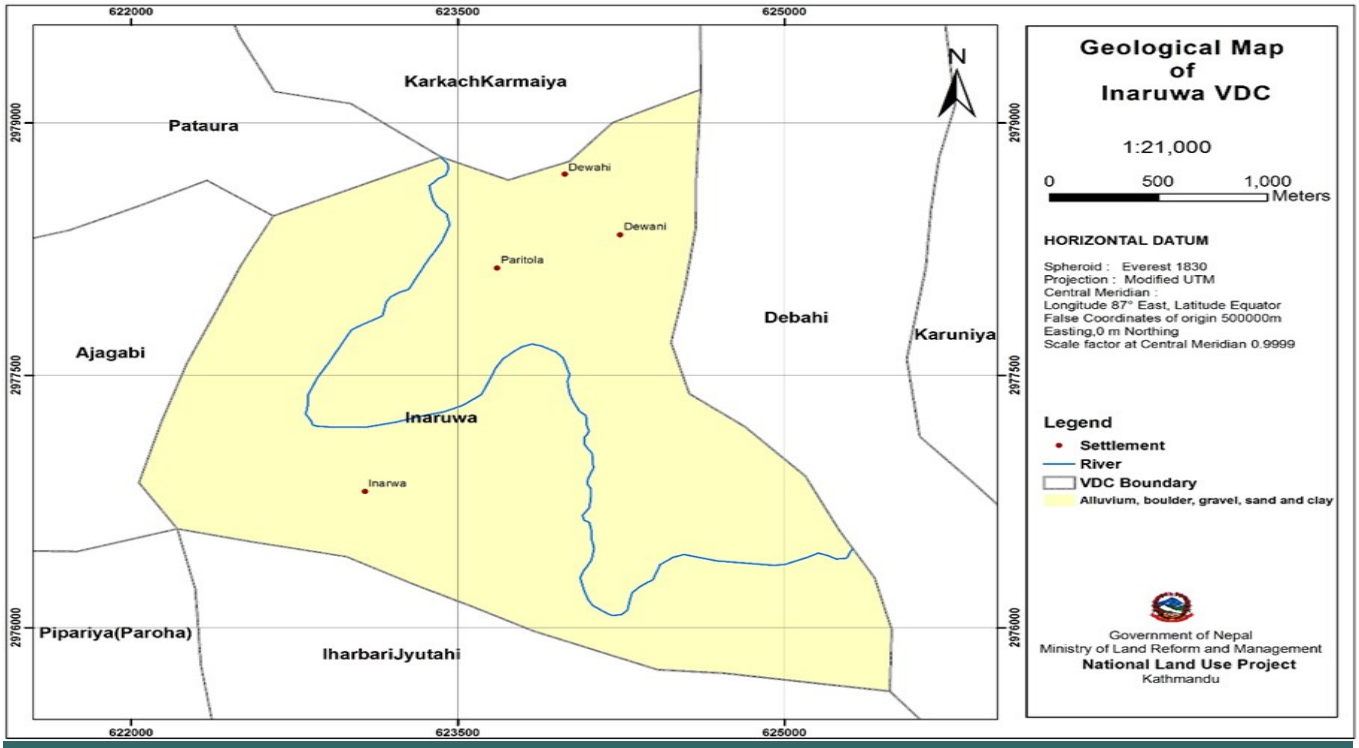


Figure 2 : Geological Map

Situated in the Terai belt, it adjoins with southern circuit of the Siwalik with slight gradient towards north. Several wide but swallow depressions (1-3m), observed in old river channels, bisect the area creating somewhat drainage pattern. River terraces are slightly higher than the river beds. Terraces generally form gradual slopes over the river bed. The area is composed of quaternary river valley deposits. Geological sections along the river banks show that a mixed bed of river gravel and boulder beds cemented loosely by sand, clay and silt clay underlie the upper beds of yellow to dark grey clay and silt clay. Boulder and gravel beds are of 1-2 m to 8-10 m thick. Size of boulders are up to a meters but they are in general 20-50cms. Boulders and gravels are mostly rounded to sub-round. Compositions of boulders are mostly quartzite, schist and gneisses. Due to the plain landscape, drainage management is not properly well. So somehow hazards occur here. Mostly area of the AREA consist Plain and Flat. The Slope of the land form of the AREA is 1-3 degree(Fig-3).

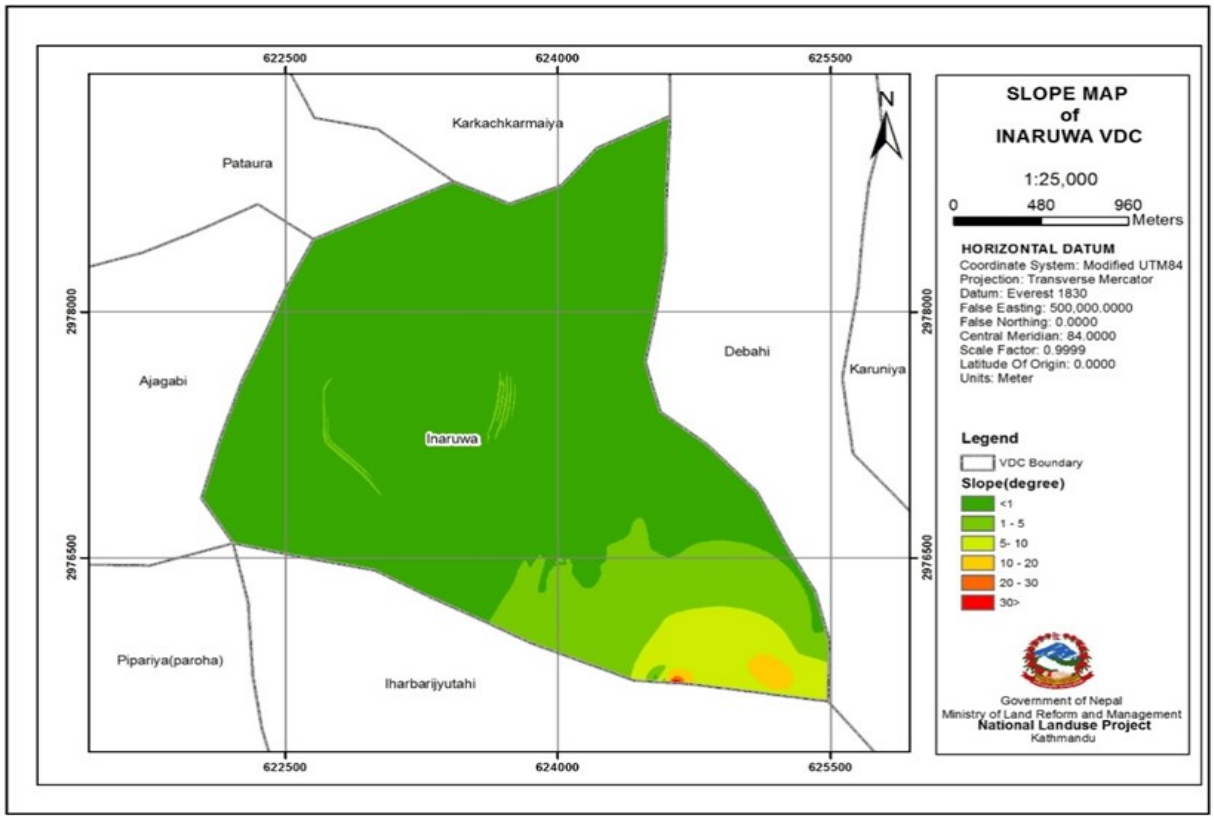


Figure 3 : Slope Map

The Lalbakaiya is the main river of the AREA which originated from Mahabharat range and flows in the central part of the Rautahat district. The drainage pattern of the AREA seems from north to south and Lalbakaiya river drains towards the border area of India. Small streams meet together and confluence into Lalbakaiya River and flow to southern part of the district. After crossing across the border area, Lalbakaiya River meets the Bagmati River. In the summer season, small rivers and streams are filled with huge volume of water creates the situation of floods whereas most of the streams and small rivers have no water. They are seasonal and create the problems of flooding and site cutting(Fig-4).

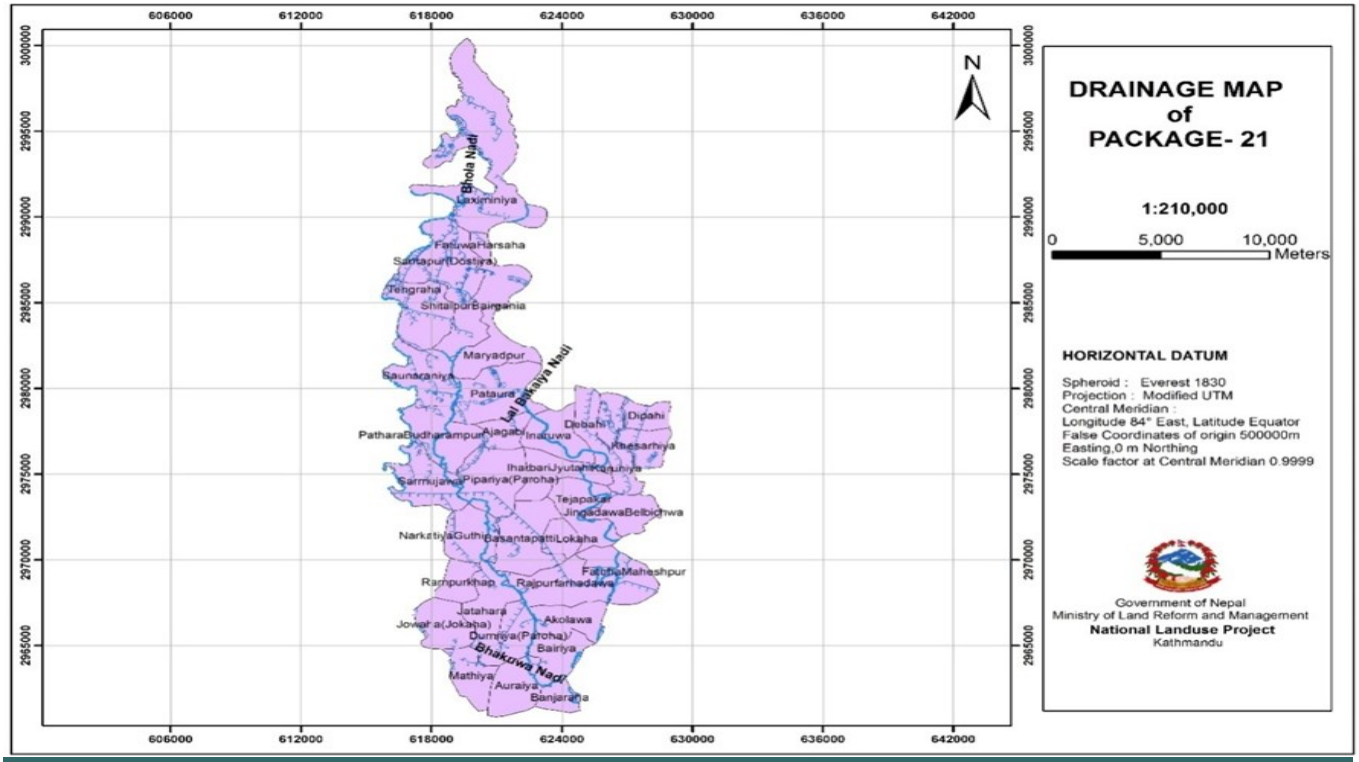


Figure 4 : Drainage Map

The climate of study area is subtropical humid. The total rainfall of five different years (2011to 2015) is presented in table 1 and temperature (maximum and minimum) of five different years is presented in table 2. The meteorological data of the study area is taken from 'Gaur' based meteorological station under department of hydrology and meteorology, Ministry of Environment, Government of Nepal.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (mm)
2011	0	0	0	0	17	23	536	436.6	282.4	0	0	0	1295
2012	0	0	0	150.8	42.6	180	472.8	213.8	43.9	0	0	0	1103.9
2013	0	0	0	0	12.5	103.5	412.7	489.2	123.7	12	0	0	1153.6
2014	0	35.5	0	0	67.1	100	276.8	255.6	289.5	0	0	0	1024.5
2015	0	0	43.8	40.2	27.3	87.4	276.3	237.1	329.3	23.5	0	0	1064.9
Avg. rain-fall	**0**	**7.1**	**8.76**	**38.2**	**33.3**	**98.78**	**394.92**	**326.46**	**213.76**	**7.1**	**0**	**0**	

Table 1: Rainfall (mm) distribution (2011-2015)

Source: Department of Hydrology and Meteorology,2017

year	Temp	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly Avg
	max	11.1	11.9	18.5	27.9	30.1	30.0	29.5	29.7	29.6	25.9	19.7	14.4	**23.2**
2010	min	6.2	7.0	10.5	19.9	24.4	24.9	24.2	24.1	24.8	21.0	15.5	9.8	**17.7**
	max	10.4	11.6	17.0	26.7	29.1	29.9	31.1	30.9	25.8	14.5	11.9	11.4	**20.9**
2011	min	7.5	7.9	10.7	17.3	21.3	21.5	24.7	23.3	20.8	10.9	8.3	8.0	**15.2**
	max	10.5	11.6	17.0	27.2	29.8	29.0	29.2	29.8	DNA	27.2	17.6	11.4	**21.8**
2012	min	7.5	7.9	12.2	19.4	24.2	23.1	23.1	22.3	DNA	19.2	12.8	8.5	**16.4**
	max	10.3	10.7	15.9	27.0	30.0	31.4	30.1	30.2	29.4	27.0	18.7	10.5	**22.6**
2013	min	7.5	7.5	10.1	15.6	19.6	25.9	25.5	24.9	24.4	20.8	14.3	8.7	**17.1**
	max	9.9	11.0	16.1	24.4	30.4	31.1	29.4	29.7	DNA	DNA	DNA	DNA	**22.8**
2014	min	7.1	7.8	11.9	20.3	24.1	25.3	24.3	24.1	DNA	DNA	DNA	DNA	**18.1**
Avg Max Tem.		**10.4**	**11.4**	**16.9**	**26.6**	**29.9**	**30.3**	**29.9**	**30.1**	**28.3**	**23.7**	**17.0**	**11.9**	
Avg Min Tem.		**7.2**	**7.6**	**11.1**	**18.5**	**22.7**	**24.1**	**24.4**	**23.7**	**23.3**	**18.0**	**12.7**	**8.8**	

Table 2: Average maximum & minimum temperature (2011-2015)

Source: Department of Hydrology and Meteorology,2017

Methods

Land use and land zoning assessment of the study area has been carried out based on multi criteria decision analysis using analytical hierarchy process (AHP)for various data layers and setting appropriate and established criteria that best suit the locality. These data layers are soil structure, topography, drainage, and moisture regime incorporated in the land capability classes along with socio-economic and cultural features such as population dynamics, road access, distance from river and proximity or contiguity to existing urban or semi-urban settlements. For optimum use of land resources of the study area broad land use zones like agricultural, residential, commercial, and industrial, forest, public service, mining and minerals, cultural and archeological, riverine and lake, excavation area and other category of land use were identified using, multi criteria decision analysis technique (Jenny, 1941;Chaudhaury&Jansen, 1999;Jensen, 2005).

With the help of detailed soil analysis of soil pits from each land system in field and soil laboratory, land system and land capability of the study area were established. Soil fertility has analyzed from the soil nutrients and minerals. With the help of soil deficiencies like topographic, drainage, erosion, fertility each land system unit is classified for different level of exploitation or conservation. Land units which can give best agricultural production are kept for the cash and grain crops. Less suitable land units for agriculture are suggested for potential residential, commercial and industrial areas. Potential residential areas are allocated with reference to risk free zones (flood, fire, landslide, seismic, industrial etc.). Erosion prone areas and river banks are given special attention for agro-forestry practices or plantations (Selby, 1991).

Soil Profile

Soil is the upper portion of the earth's crust. Soil is the more physically, chemically, and biologically altered portion of the earth's crust. Soil is the zone of interaction between the underlying rock material and the earth's atmosphere and biosphere. Hence, underlying geology act as a parent material on which soil has evolved. Soil parent material may be rock that has decomposed in place, or material that has been deposited by wind, water, or ice. The character and chemical composition of the parent material plays an important role in determining soil properties, especially during the early stages of development. In the study area, the soils are derived from three major parent materials, described below:

Native bedrock: Native bedrock offers in-situ earth material on which soils are developed. These in-situ materials are direct product of the physical and chemical weathering of the rock. Soils formed in situ reflect the characteristics of the bedrock on which they occur. Native bedrock comprises of the sandstone-mudstone or conglomerate sequence of sedimentary rock belonging to the Siwalik Formation The bedrock is gently to steeply dipping and consists of dense network of joints and fractures giving rise to dip and anti-dip slopes. These geological characteristics coupled with faults and thrusts have influenced to form scarp or cuesta or hogbacks which have a bearing on the geomorphic processes and in situ soil formation through action of solar insulation, physical and chemical action of water. Soils developed on such bedrock are loamy skeletal or coarse loams, less than 1 meter to bedrock. Texture variability reflects bedrock variability. Associated soil groups are typic, lithic, anthropic and dysctrocrepts and ustocrepts. Soils derived from the native bedrock are classed under land system unit 7 and 8 (LRMP, 1986).

Colluvial materials: It includes all those affected by gravity, which occur on the sloping land and on foot slope. Landslide and debris flow deposits are considered to be colluvial. Soils formed on colluviums tend to have a high proportion of angular stones of all sizes throughout the profile, the result of mixing during down slope movement. Soils developed on the colluviums belong to LRMP (1986)'s Land System Map unit 7 and 8. Well differentiated horizons are not found on these soils because of the great mixing that occurs with down slope movement. Lack of obvious soil horizons is a good indicator of a colluvial slope.

Alluvial parent materials: These are those deposited by moving water bodies such as rivers and streams. The texture of the deposit depends on the energy of the water body. Alluvial parent materials varies from coarse textured consisting a larger proportion of sands, gravels, cobbles and boulders to very fine textured silt and clay materials towards south as one moves from the Siwalik foothills. Alluvial type of parent material is associated with such landforms as piedmont, old streambeds, flood plains, fans, and levees. The following table presents

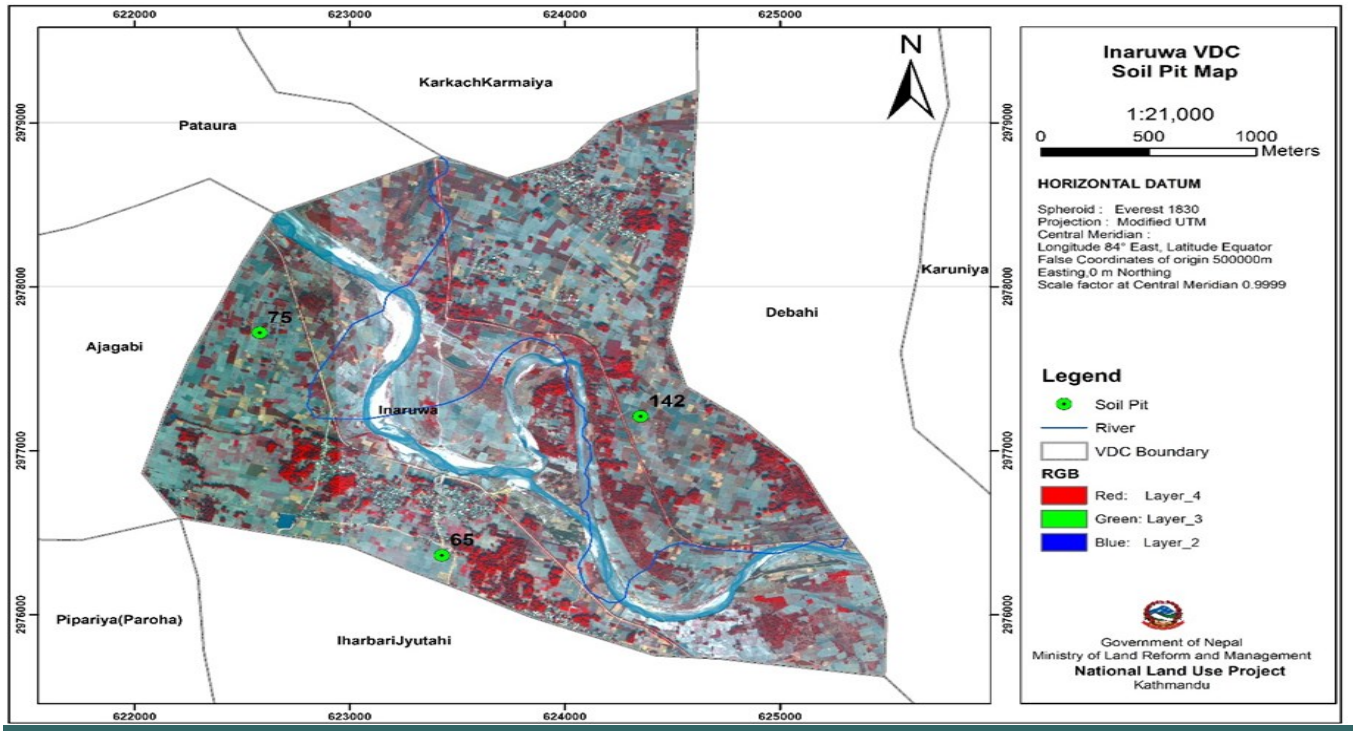


Fig-5: Soil Map

It is evident from the Fig-5 that the soil types of the area are based on the morphological, chemical and physical properties of soil acquired from the soil study by digging the soil pit and soil mapping unit level. Based on soil taxonomy system soil types of the area are classified into orders, four suborders, five great groups and five subgroups (Shansudheen,et.al,2005; USDA, 2014). Among the incept soils Humic Dystranthreps occupied 29.16% followed by hsumicudepts (8.68%0 and Lithic durastepts (4.46%). Whereas Arglaquic xeric Argial-

bollos type of Mollisols soil occupied more than 57% .

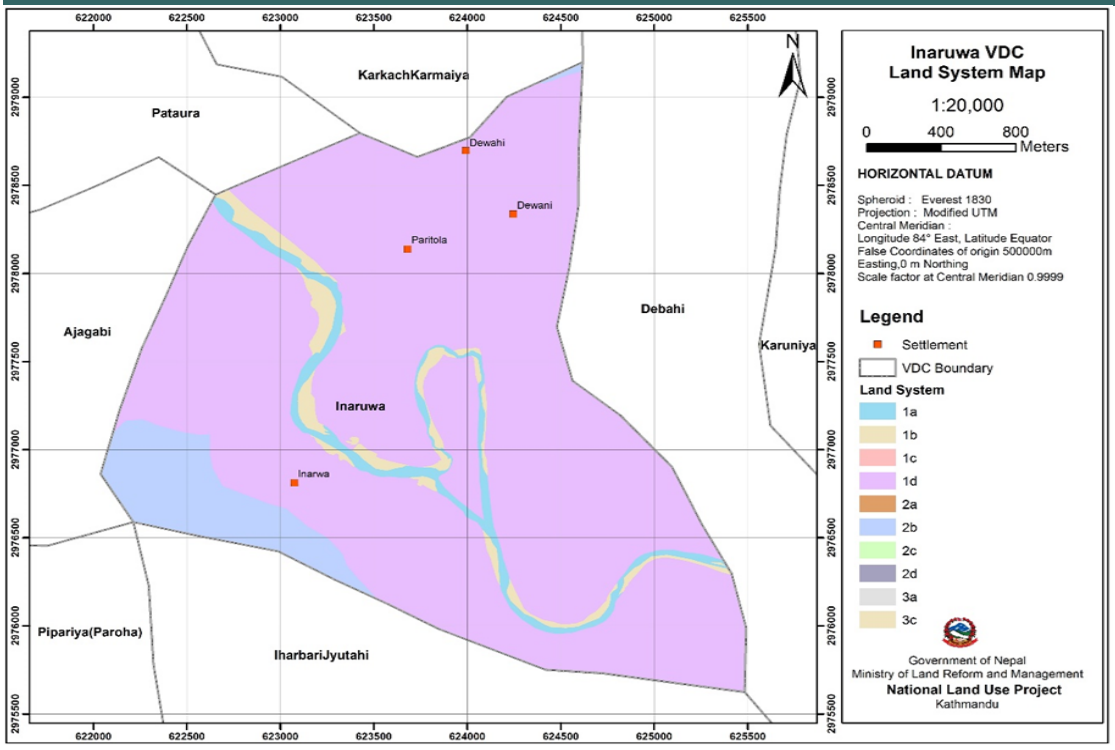
In case of Suitability ratings for eleven land use zones was developed using multi-criteria analysis in a GIS environment. Suitability ratings were based on land capability, present land use, socio-economic and demographic characteristics, accessibility to infrastructure and services. Land capability maps was also developed using GIS based MCA analysis, which incorporate soil parameters, fertility, erosion susceptibility, terrain constraints and surface drainage (wetness).

Land Form and Land System

Landform is further subdivided into land units basically defined by the mapable size of land surface for demarcation in landscape by the user. It is characterized by landscape features. The land units in the study are intermediate position level, depressions and Khola, sandbar and flood plain. Among the land units defined by LRMP (1986b) land system, land types are demarcated considering the local situation of land units representing microrelief differences based on the local slope and elevation and its orientation. Landform affects soil formation and its profile development in association with the steepness of land and slope direction. The land units defined by LRMP are further subdivided based on local field variation associated with the different land use practices. Two land systems (1 and 2) and four land units (1a, 1b, 1d and 2b) were identified in the study area with 1d. The majority of land of the area accounts 85.7 % (23.51ha) of total land followed by 2b. Intermediate position level and 1a. Present river channel. The active alluvial plain occupied the highest portion of land (92.66 %) followed by

Landsystem	Landform	Landunit	Area (ha)	Area (%)
1	Active Alluvial Plain (depositional)	1a. Present river channel	24.45	3.55
1	Active Alluvial Plain (depositional)	1b. Sand and gravel bars	23.51	3.41
1	Active Alluvial Plain (depositional)	1d. High terrace	590.41	85.70
2	Recent Alluvial Plain lower piedmont (depositional and erosional)	2b. Intermediate position level	50.57	7.34
Total			**688.94**	**100.00**

Table 3: Land system/land type of Inaruwa AREA, Rautahat



Source: Field Survey, 2017

The land system of the study area is presented in fig -6

Fig- 6: Land System Map

Risk Areas within the study area

Risk is considered one of the important factors for zoning. Residential and commercial areas are allocated on such land which are under no or low risk of flooding, bank cutting, industrial and fire hazard (SEP,2015). Residential and commercial areas are not proposed within the periphery of 500m from brick or cement factory, 200m of petrol pump, and specified buffer distance of transmission line. Most of the agricultural areas are safe however some of the agricultural area along the Lalbakaiya river bed have high risk of flooding and bank cutting. Every year the villagers lost huge amount of property and human life due to floods, droughts, cold wind wave (SHITLAHAR). The floods of Lalbakaiya river lost large scale of cultivated land and also the siltation and sedimentation on crop land in the village rise on. Similarly, land resources such as soil quality, forest richness, and portable water have reported to be depleted, natural resources and natural environment both are polluted day by day and local people have facing the problems of diseases infection, shortages of livelihood sources and highly polluted surrounding where they live Alternative use of such kind of land is horticulture production. But in long term, the banks of such river and stream needed to be well embanked so that the land under flood risk could be used for more potential crops production and other uses. The area under the high hazards is prohibited for residential and commercial use and proposed for agricultural activities or open area for now. The topography of this area is nearly flat and not susceptible to landslide and some accidental fire risk may occur during hot and dry season in settlement or in industrial areas. Industrial and other risks are not reported. Potential risk in this area observed to be flood related with rainfall. This can be due to either flood or earthquake sensitivity. Return period of flood is shorter in comparison to catastrophic earthquake. The potential of seismic activities and earthquake may exist but it cannot be predicted in absence of appropriate data and technology. However, the built up areas and settlements are normally developed without following the building codes and appropriate safe materials. Serious geological fault lines are not identified. However, there is a need to get ready to face earthquake risk in any time that may strike in future. Department of Geology, Nepal; points out that the study area is less than 100 PGA gal. No high tension electric lines are there.

Present land Use and Potential Land Use Zone

	Present Land Use		Land Use Zoning		Change	
Class	**Area (Ha)**	**Percentage (%)**	**Area (Ha)**	**Percentage (%)**	**Area (Ha)**	**Change (%)**
Agricultural	598.96	86.94	576.68	83.71	-22.28	-3.72
Commercial	0.83	0.12	1.86	0.27	1.02	122.81
Cultural and Archeological	0.31	0.05	0.31	0.05	0.00	-0.16
River and Riverine	48.57	7.05	48.57	7.05	0.00	0.00
Industrial	0.00	0.00	3.30	0.48	3.30	-
Public Service	6.09	0.88	14.35	2.08	8.26	135.67
Residential	34.16	4.96	43.87	6.37	9.70	28.41
Total	**688.94**	**100.00**	**688.94**	**100.00**	**0.00**	**0.00**

Table -4: Present Land Use and Potential Land Use Zone

Source: Field Survey, 2017

Table-3 clearly shows that how much area of agriculture is converted into residential, commercial and other zones. About 22.28 ha of agricultural land is converted in to other land use zones, mainly in residential, public service zones. For new residential area about 9.70 ha and for commercial area about 1.02is allocated. The study area has a nominal growth of population and economic activities are also growing gradually. It is, therefore, some additional land is proposed to accommodate residential and commercial needs in future. Within the proposed residential, commercial and public use area, various government institution, service centers, infrastructure development area and open spaces are also included. Around 8.26 ha of land (from agriculture, Residential,

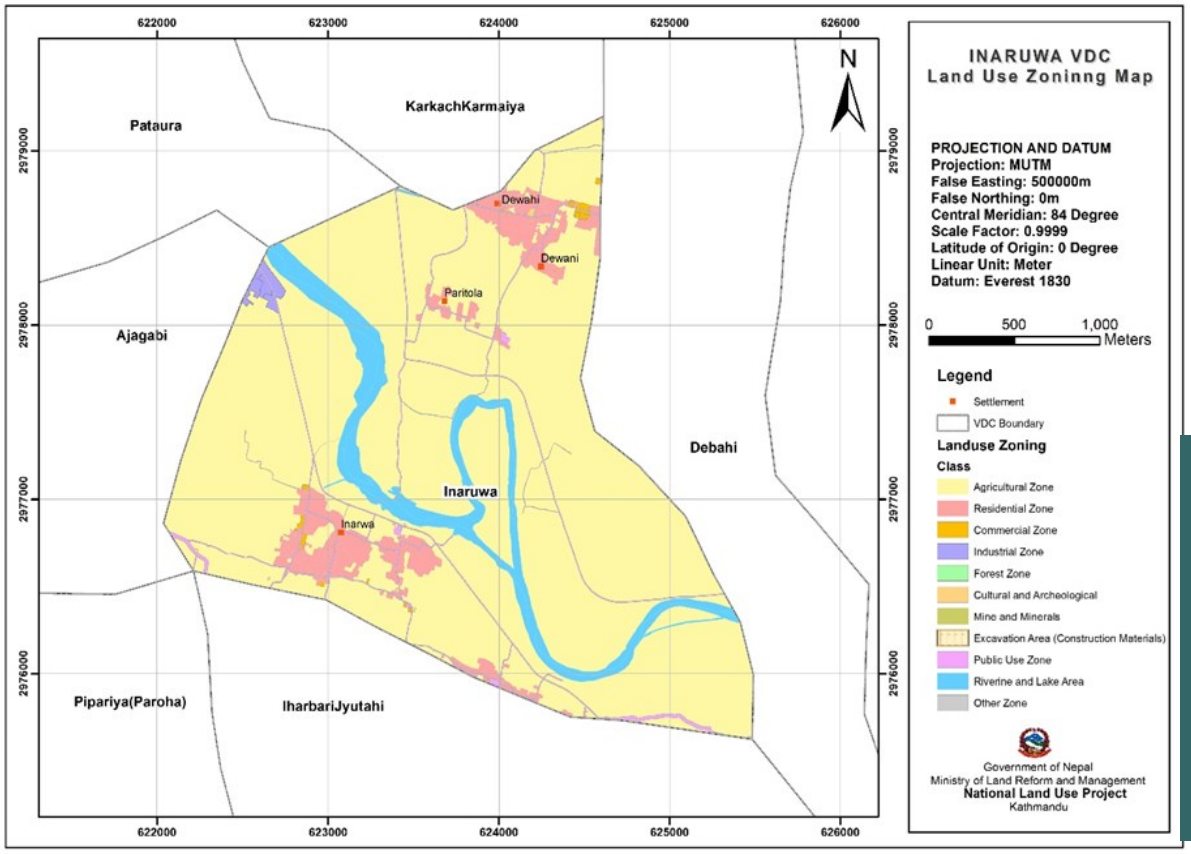
Commercial area) has shift to public use area. This is mainly because of allocation of land for right of way of various district road, feeder roads and strategic road. This right of way (RoW)of different road can be used for future road extension and construction of various other utility service. Other land use zones are either unchanged or the change is insignificant.

Land Use Zone

After analyzing the multi criteria analysis different potential Land zoning has allocated in low risk area. Land use zoning exercise has allocated maximum area for the agricultural zone (83.71%) followed Riverine and Lake (7.05), Residential zone (6.37%), Public Service(2.87%).The land use zoning of the study area has been pre-

S.N	Class	Area (Ha)	Percentage (%)
1	Agricultural	576.68	83.71
2	Commercial	1.86	0.27
3	Cultural and Archeological	0.31	0.05
4	River and Riverine	48.57	7.05
5	Industrial	3.30	0.48
6	Public Service	14.35	2.08
7	Residential	43.87	6.37
Total		**688.94**	**100.00**

Table-5: Areal coverage of different land use zones



Source:

Fig-6: Land Use Zon-ing

Conclusion

It is concluded that the land systems (1 and 2) , land units (1a, 1b, 1d and 2b) two soil orders (Entisols and Inceptisols), three suborders, seven greatgroups and seven subgroups were found from the intwnsive field survey by using geo-science technology including Remote Sensing (RS), Geographic Information System (GIS) and Geographic Positioning System (GPS), visual interpretation and computer aided technology in integrated way. Among Incept sols Lithic Humicudepts found high than others. The total nitrogen content in soil observed to range from very high to very low with medium N content soil distributed almost all parts of the study area except some eastern parts. Available phosphorus found to range from medium to very low with low and very low P content soil distributed mostly in the area. Medium and low K was revealed in this area. Available Boron content found to range from medium to very low with low B content soil found distributed mostly in the AREA. Available Zn ranges from medium to very low with low and very low Zn content soil found in most parts of the area. The soil pH ranges from very acidic to neutral with moderately acidic soil found in most part of the area. Available SOM in was medium to very low with diverse distribution. Thus, the actual landforms and land units and soils types based on their classification revealed to promote agricultural activities in the area. The database of soil resources, landforms, landsy stems and units could be very useful for the concerned authorities to formulate planning to cope with the unplanned settlements, low agriculture production, land degradation problem and climate change induced disasters in the study area.

For this, proper irrigation and drainage system has to be developed in the area, that create an opportunity to grow crops more than two times in a year and may play a vital role to enhance the life standard of the area. Similarly, cereal crops; potato, cauliflower, cabbage, tomato, Cucumber, radish, pumpkin, mango, litchi, and banana cultivation should be promoted in order to increase the household income level of the area. Prime agriculture lands have to be preserved for high productivity of per land unit and better food production Fisheries and fish farming are to be promoted for materializing the high potentiality of fish farming in the area. River site conservation and river bank embankments initiations have to be taken in Lalbakaiya river north south west part of the area which create flooding and bank cutting problem. Village level greenery and forest promotion actions are essential in the area. Physical infrastructure developments are to be extension in such area where the agricultural production is very low and soil is poor. Human settlements development efforts are needed to make the settlement safe, equipped by social and physical infrastructures. So that human settlement should be far from the potential risks like fire, flood (i.e. far from the major rivers), and industry pollutions etc. Being zoning criteria are subjective, it is necessary to adopt scientific guideline to develop a micro zoning by the local government on the basis of this study. The land resource of the area is less deteriorated. Therefore, land use planning should be started on the basis of prepared based on the findings of this study. Land use act is the most important tool to take this policy in action. Therefore, it is essential to formulate land use act and enact in order to implement the scientific plan of land resources development.

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