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[Research]

Land use planning for land management using the geographic information system (GIS) in the Loumir watershed of Guilan province in northern Iran

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ABSTRACT
Land use planning is a science that determines the type of land use through studying the ecological character of the land as well as its socio-economic structure. It is possible to plan for the appropriate use of the land and to enhance the present management of the land use by utilizing Geographical Information System (GIS). To this end, our investigators identified and took steps toward developing maps to determine the ecological and socio-economic resources of the Loumir watershed that encompasses an area of 20884.94 hectares. Digital maps were inputted along with explanatory data into an ArcGIS software application. In addition, all digital maps of layers including, elevation, slopes and aspects, soil texture, depth and structure, geology, iso-hyetal, iso-thermal, iso-evaporation, soil erosion, vegetation or canopy percentage, climate and water resources have been integrated- superimposed in the ArcGIS environment based on the Makhdoom analytical and systematic analysis model. Finally, land use planning maps of the Loumir Watershed were developed considering the ecological and socio-economic characteristics of the area. The results of the evaluation of the area indicated land use appropriateness and allocation as follows: 6.07 percent for level 1 of agriculture, 1.1 percent for level 2 of agriculture, 4.34 percent for level 1 of forestry, 53.31 percent for level 2 of forestry, 11.01 percent for level 3 of forestry, 0.42 percent for conservation, 0.13 percent for level 1 of range management, 6.16 percent for level 2 of range management, 14.71 percent for level 3 of range management, 0.34 percent for aquaculture and 2.41 percent for ecotourism.

Keywords: Land use planning, Geographic Information System, Loumir watershed.

INTRODUCTION
Land use changes are altering human and natural systems globally and regionally (Turner and Meyer, 1994; Solecki, 2001). Globally, nearly 1.2 million km^2 of forest and woodland areas and 5.6 million km^2 of grassland and pastureland have been converted to other uses and over the last three centuries, 12 million km^2 of cropland were lost (Ramankutty and Foley, 1999). Land degradation and the loss of land productivity are two of the foremost environmental problems of our time. These problems relate to the reduction of land resource potential by either one or a combination of processes acting on the land such as water and wind erosion, sedimentation, loss of soil structure and fertility, salinization and other acts of nature that result in long-term reduction of diversity of vegetation and net primary production (Ward *et al*., 1998).

The intensity of land use changes in response to world population growth and their consequences for the environment warrant in-depth studies of these transformations. Several organizations have initiated various international interdisciplinary research projects during the past two decades for this purpose. These include the International Geosphere-Biosphere Project (1988) and the land use and cover change program (Messerli, 1997). Both of these projects indicated the need to construct an accurate and up-to-date database concerning these changes, their meaning or pace and other explanatory factors prompting their appearance (Mather, 1999). All of these changes, especially the loss of agricultural land, have the potential to undermine the long-term harmony of humans with their environment and threaten food security (Wu *et al.*, 2006).

Land use, in general, consists of the coordination of the relation between humans and the land and their activities on the land for the proper and long-term use of provisions for the betterment of the material and spiritual condition of the society over time. Land planning requires extensive infrastructural research and keeping the economic condition of the area under study in mind. It can be undeniably stated that land use planning of an area without considering the socio-economic condition of that area is virtually impossible (Makhdoom, 2001).

While a part of an area in theory possibly has the potential for a certain use, it may be practically impossible to implement. Hence, one must base the ecological potential of an area for a certain use on the socio-economic ability of that area in addition to its ecological conditions. On the other hand, the lack of necessary knowledge of land potential and the irrational use of the land by humans bring about further reduction of land resources.

Land is a limited and vulnerable resource that if not used properly is renewable and everlasting. Remote sensing and Geographic Information Systems (GIS) have been widely applied in identifying and analyzing land use and land cover changes (Rossiter, 1990).

These days, it is possible to combine various ecological and socio-economic data through the utilization of GIS, which results in using less time and expense (Saroensong *et al.*, 2006). This tool enables us to gather and process different data with the precise and calculated outputs needed for land use planning. This tool helps to preserve the natural resources of the area as well as to resolve present problems and difficulties and, alternately, be an effective help to enhance and advance the present management system.

MATERIAL AND METHODS

Loumir watershed with an area of 20884.94 hectares is one of the basins located in the western Guilan province of northern Iran (Fig 1). This area is located between longitudes 48° 39´ 30˝ and 49° 3´ 30˝ west and geographical latitudes 37° 31´ 30˝and 37° 38´ 30˝ north. This watershed borders Naavroud Basin to the north and Shafaroud Basin to the south. On the east side, it ends by the Anzali-Talesh asphalt road and, to the west; it ends at Ardabil province borderline. The typical landscape of the case study area has shown in Figure 2.

Fig 1. The location of the study area.

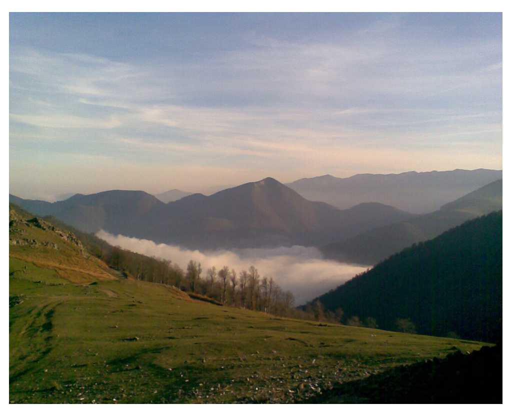


Fig 2. Typical landscape of the study area.

The average annual precipitation in the watershed is 1150 mm of which the principal share of it, meaning a third of the annual rainfall, precipitates in autumn. The minimum and maximum amount of the rainfall in the basin ranges between 500 mm and 1800 mm respectively. The average temperature in the basin per year stands at 11.4 degrees Celsius and the potential evaporation and condensation measured through Torrent White method equals 662 mm.

The climate of the basin as determined by the DeMartin method is very humid. However, the level of humidity decreases at higher altitudes. The average relative humidity fluctuates between 50 and 80 percent in the months of July and October respectively. The minimum and maximum altitudes in the basin area are 80 meters and 2850 meters respectively with the average slope measuring 44.67 percent.

The Loumir watershed comprises 22 physiographic units. Fig 3 shows the layout of the units map. Table 1 lists the relevant statistical information for the Loumir watershed.

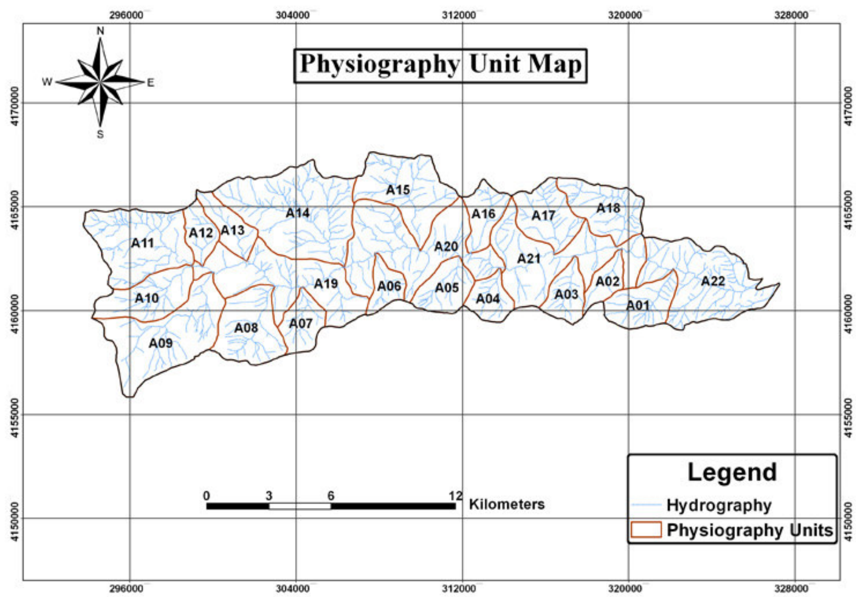


Fig 3. Physiographical units of the study area

Table 1.

Sub-basin	Area (Ha)	Minimum altitude (m)	Maximum altitude (m)	Altitude difference (m)	Length of the primary waterway (km)	Form Factor (Horton)	Average altitude (m)
A1	625.88	195	11461	996	3.422	0.397	695.66
A2	298.64	247	1273	1026	2.388	0.214	736.81
A3	423.22	325	1309	985	3.423	0.382	869.49
A4	376.08	449	1567	1118	2.866	0.539	1163.1
A5	529.82	543	1698	1155	3.301	0.486	1172.86
A6	306.72	740	1866	1126	3.058	0.34	1336.97
A7	457.26	958	2152	1195	3.223	0.4	1558.99
A8	962.08	1021	2254	1233	4.346	0.506	1594.87
A9	1633.40	1335	2872	1537	7.511	0.305	2133.69
A10	796.92	1444	2633	1189	4.763	0.271	1945.68
A11	1412.77	1444	2444	2299	7.048	0.419	2025.85
A12	338.40	1391	2183	791	3.285	0.104	1912.58
A13	428.72	1197	2180	2063	4.456	0.246	1743.59
A14	2179.34	841	2153	1312	6.224	0.406	1483.86
A15	1200.00	644	1754	1110	6.015	0.455	1294.97
A16	451.57	539	1603	1065	3.578	0.345	1138.04
A17	736.61	344	1477	1133	4.195	0.544	1506.52
A18	820.32	258	1155	897	5.844	0.431	661.009
A19	1648.97	840	1876	1036	8.971	0.307	1116.72
A20	1951.42	443	1704	1261	9.938	0.311	1022.55
A21	1620.86	234	1455	1222	7.951	0.281	711.1
A22	16.85.99	79	883	805	6.288	0.486	343.76
	20884.94 Total Area						

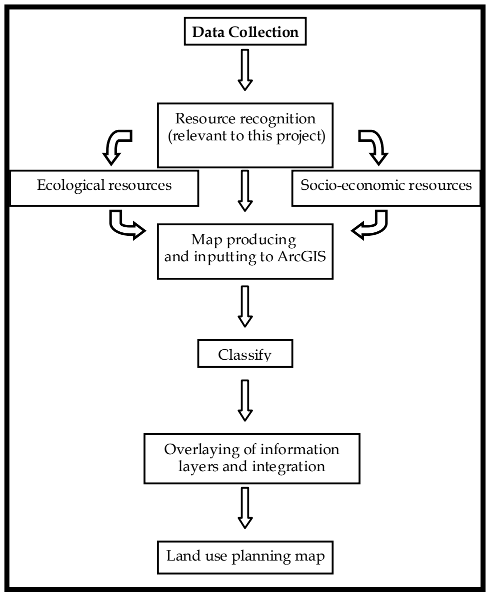


Fig 4. Operational process of the procedures

In this study, a systematic method known as the Makhdoom Model (Makhdoom, 2001) was used for the analysis of maps in relation to the ecological and socio-economic resources of the Loumir watershed**.** The different kinds of maps were used in this research to determine the ecological resources of the area under study were Digital Elevation Model (DEM), slope and aspect, soil texture, soil depth, soil structure and erosion, geology, iso-precipitation (iso-hyetal), iso-thermal, iso-evaporation, canopy percentage and climate in addition to water table.

The socio-economic resources of the area under study consisted of its socio-political characteristics, population composition, relative earning conditions, immigration condition, present land utilization, agriculture and animal husbandry conditions, hygiene, health, education and other public services.

To achieve a systematic analytical model, all maps layers were converted from a vector format to a raster format in the ArcGIS software environment. In the next step, all raster layers were obtained, which represent the information layers used for study of the basin. These maps were operated using ArcGIS and the appropriate utilization of each section was determined and prioritized.

Many of the prepared spectra were seen fit for two or three appropriate uses by the systematic model to first determine and subsequently select the best utilization for the area considering the socio-economic status of the area. Alternately, the investigative team prepared and submitted the utilization map of the land use planning in the Loumir watershed.

RESULTS

All produced maps to recognize of land use condition in the Loumir watershed were revealed (From Figure 5 to Figure 12).

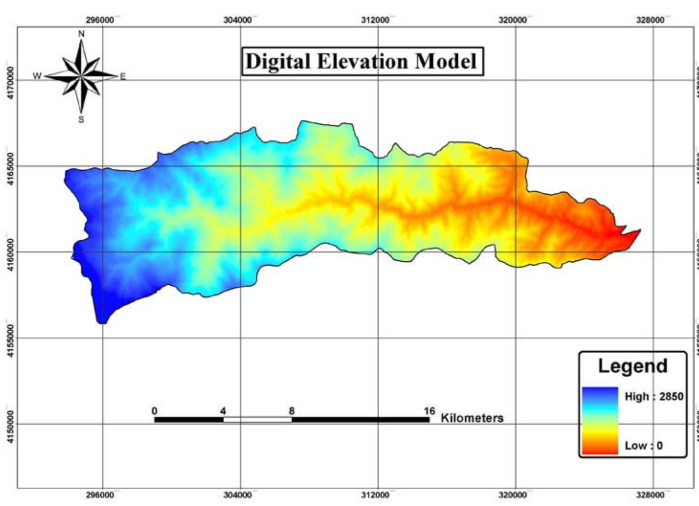


Fig 5. DEM of the study area

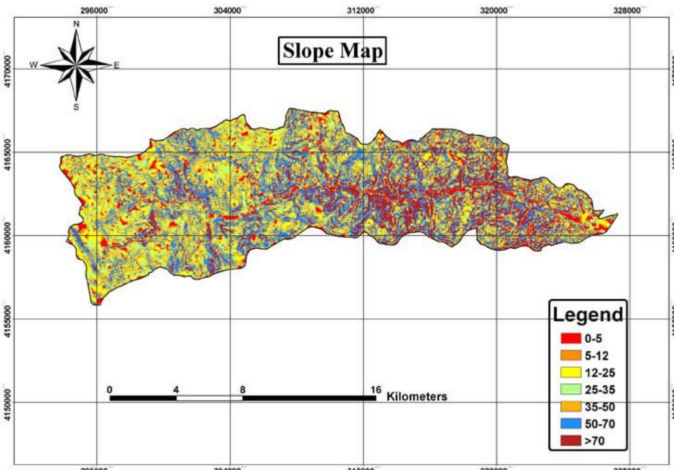


Fig 6. Slope map of the study area (%).

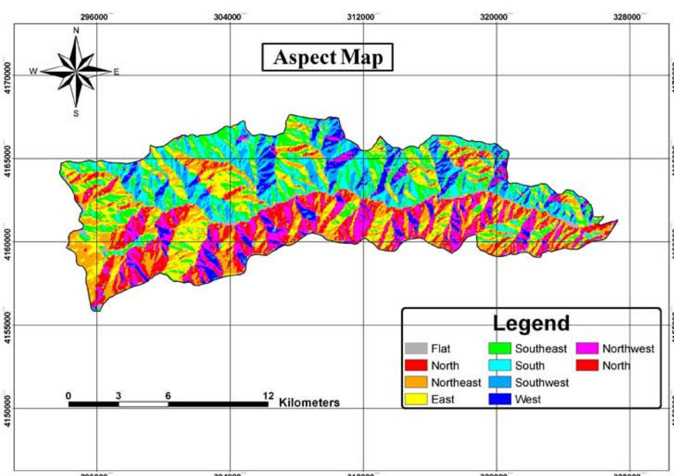


Fig 7. Aspect map of the study area.

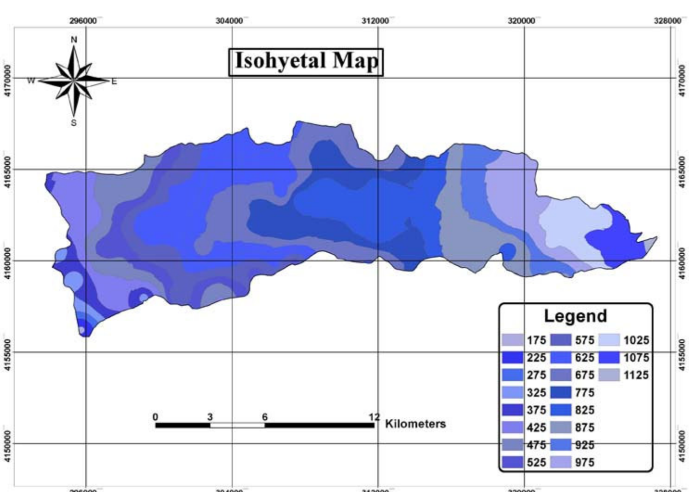


Fig 8. Isohyetal map of the study area (mm).

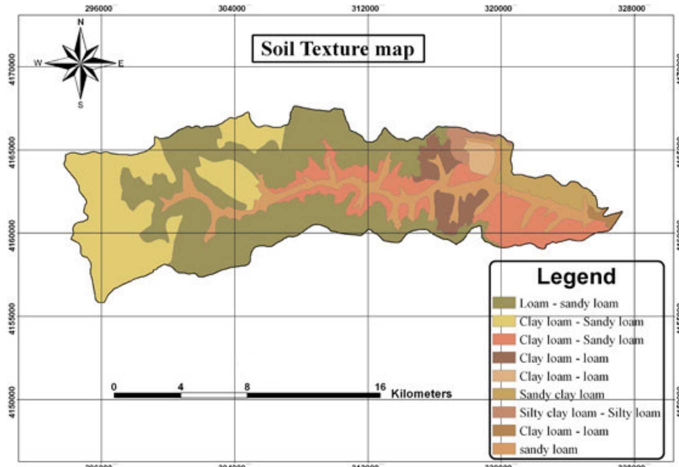


Fig 9. Soil texture of the study area.

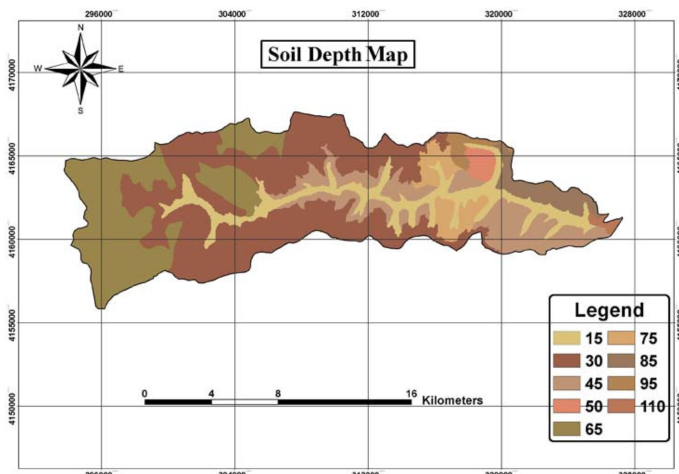
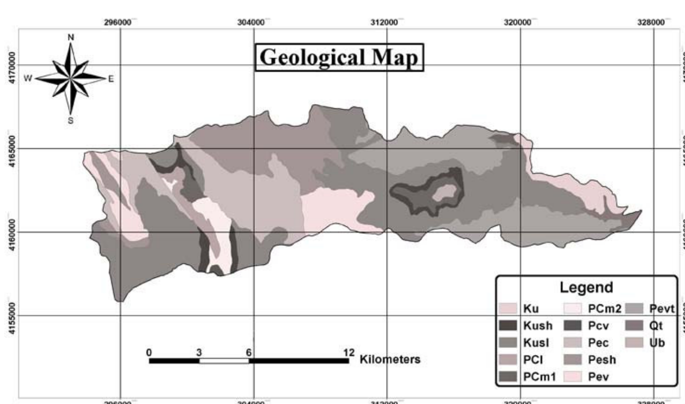


Fig 10. Soil depth of the study area (cm).



Ku: Alternation of limestone, sandy limestone
Kush: Gray silty to sandy calcarious shale and limestone
Kusl: Sandy limestone
PCl: Crystallized massive schowagrina bearing limestone
PCm1: High grade metamorphic rocks.(mainly moscuvite)
Pcm2: Lower grade metamorphic rocks.(mainly philite)
Pcv: Diabasic and basic rocks
Pec: Polygenetic conglomerate
Pesh: Grey silty shales, tuff, andesitic lava
Pev: Andesit, andesitic basalt and tuffs
Pevt: Andesit tuff, lava and lava breccia
Qt: Terraces and fans
Ub: Ultrabasic rocks.(mainly serpentinite)

Fig 11. Geological map of the study area.

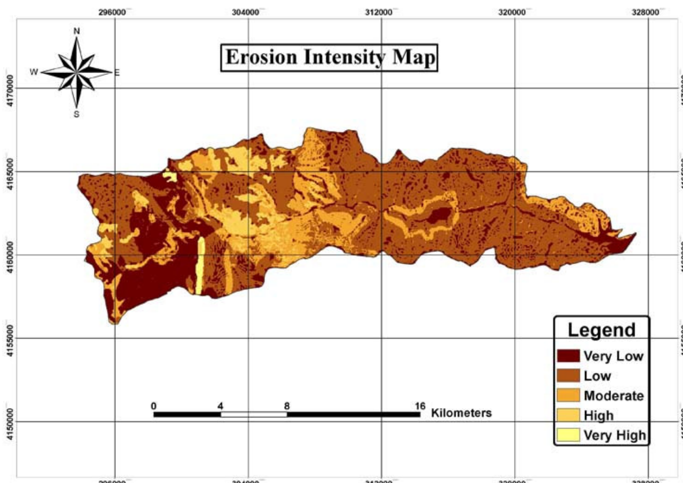


Fig 12. Erosion intensity map of the study area (EPM).

Using the available mapped information layers representing the ecological resources of the area and overlaying of these maps in ArcGIS environment based on systematic analytical model (Makhdoom, 2001) in addition to combining the obtained results while considering the socio-economic condition of the area and its existing potential resulted in developing, an appropriate land use map was produced for the Loumir watershed. The results of the evaluation of the area based on maps obtained indicated land suitability and allocation as follows: 6.07 percent (1267 hectares) for level 1 of agriculture, 1.1 percent (230.08 hectares) for level 2 of agriculture, 4.34 percent (905.89 hectares) for level 1 of forestry, 53.31 percent (11134.4 hectares) for level 2 of forestry, 11.01 percent (2299.9 hectares) for level 3 of forestry, 0.42 percent (87.99 hectares) for conservation, 0.13 percent (27.8 hectares) for level 1 of range management, 6.16 percent (1287.18 hectares) for level 2 of range management, 14.71 percent (3071.48 hectares) for level 3 of range management, 0.34 percent (70.49 hectares) for aquaculture and 2.41 percent (502.73 hectares) for ecotourism. Figure 13 shows land use planning map for the Loumir Watershed.

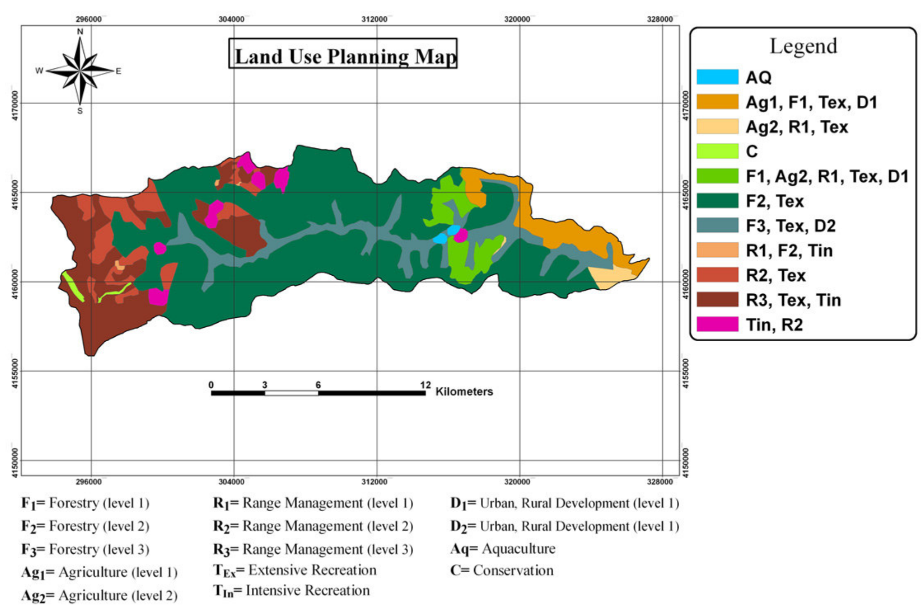


Fig 13. Land use planning map of the study area.

DISCUSSION AND CONCLUSION

Determination of the appropriate land use for the purpose of best utilization of the land in the country and preventing further destruction of resources due to population increase can and will be an effective step in devising strategies for stable expansion (Bocco *et al.*, 2001; Prato, 2007). The precision of GIS output is considerably higher than that of manual methods and claims have been made that from the time point of view computerized methods take about one third of the time needed for manual methods employed when organizing a land use planning project

Through employing GIS and combining the various raster layers of the area, which in reality represent its ecological resources, one can obtain a map for appropriate land utilization of the area. However, determination of priorities for appropriate land use from obtained maps can not be adequately precise without considering the socio-economic condition of the area or the tendency of area residents to utilize the land for certain specific uses.

Studies have demonstrated that farmers have an excellent understanding of their biophysical environment, and it is nearly impossible for land resource professionals to develop this insight owing to the time involved to do so. Hence, local knowledge is a necessary complement to scientific knowledge (Cools *et al*., 2003).

Through examining the prepared land planning maps, we determine that we cannot only use environmental units for just a single purpose; the potential exists for multiple uses. However, in any one unit, no more than a single type of utilization can, ultimately, be implemented (Makhdoom, 2001).

Hence, under special circumstances and only through considering the socio-economic conditions of the area and its residents' way of life as well as their tendency and desire to use the land for specific utilization, must the best use for each unit be determined and prioritized. To this end, it is best to consider the following points in prioritizing our findings.

In units situated close to villages in an area and since multiple uses are possible, the priority is with the use presently in place. In units with soil erosion vulnerability that presently enjoy fairly stable surface vegetation covering, the priority is with the status quo since slightest miscalculation and/or mistake could result in irreversible damage to the area. In units where there are no socio-economic limitations, the priority is with the one demonstrating the highest potential (Espejel *et al*., 1999).

The priority of land use in some of the units is determined based on political needs, and the possibility for changing it does not exist (Pierce *et al*., 2005). In some units where one use has no advantage over another and from the priority point of view are close, multiple uses may be proposed (Makhdoom, 2001).

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