UML Based Integrated Resources Management Model for Arid Zone

R.Trinadha Raju[1] and R. Manimanjari[2]

[1]GeoRIST, Panjagutta Hyderabad, India
[2]DrBVR Institute of Technology, Narasapur, India

Abstract

Resource management in general and water resources management in particular is of utmost priority for semi arid and arid climatic zones. An approach adopted here is of integrated in nature with assisted tools appropriate for the decision making model. Sustainability of the mechanism that often in place for an arid system seldom coherent as erratic rainfall is common phenomenon in the arid region. Situation often forces the region into a distress both in terms of quantity and quality aspects of the eco-system and collapse of the biotic and vegetative components lead to the disaster that always looms the area. A decision-process model developed here using UML technology for aiding and mitigating the agro-hydro-eco-sociological order found to be significant use for arid zone management.
Keywords: Decision Support Model, UML-System, Resources modeling and Sustainable study.

Introduction

Earth ecosystems cover about 28% of our planet, but only 25% of these ecosystems are green, while the reminder are characterized by sparse vegetation cover that shows the color of the soil beneath. Much of the sparse vegetation is found in arid and semiarid deserts. Climatic changes have controlled desert production over long periods of time, but the spatial variability of desert vegetation includes both regular changes as well as changes caused by disturbance. Desertification is the process of land disturbance that ultimately leads to the transformation of productive land into these ecological wastelands.

The goal of this study is to establish a tangible mechanism for resource management in a semi arid-arid climatic zone. As the pressure for limited resources in the desert area is tremendous and particularly worse in densely populated regions. Many studies have been carried out with special emphasis on a particular parameter of the region or a comprehensive study that may limit the use to a particular region itself (Bajpai, V.N. et al. 2001). Remote sensing images have been a great help in specification and delineation of themes for resource planning, in addition GIS tools too made greater inroads into desert studies. However, these tools at times may not significantly aid the decision makers that are often a small cooperative society. In order to manage natural resources in a semi-arid/arid zone in general and water resources in particular, we propose a model that works on Unified Model Language. As the proposed system embeds all the required information into a database that may not be a unique but facilitates creation of an integrated database of an arid eco-region. These data include maps, remotely sensed images and field measurements. Extent of this study was to begin assessing the condition and effect of disturbance on the land/resource by its activity. Sample area has been selected for study because it represents a wide variety of land uses within a relatively homogeneous natural landscape. Land holding is primarily by small farmers and the practice quite often is homogeneous where traditional practices prevailed and some mining interests yet exist throughout the area. Overall, the diversity of land use and the factors that force change within the area make this region a natural choice to study the effects of anthropogenic disturbance on flora and fauna in a desert environment.

Desert alone is home to many endangered plants and animals, yet the human dimensions of desert life appear to be an all important factor that really controls the biodiversity of the region. Although much contemporary conventional wisdom puts high value on economic aspects of public and private management of desert resources, there is considerably less consensus about the value of biodiversity in a desert. Naturalists, ecologists, and conservation biologists understand how flora and fauna are linked together by the chains of climate and habitat. Yet little is known or understood about the role that both the variety and variability of living organisms have on the overall integrity of the desert ecosystem. Caretakers of the public lands promote conservation to preserve and maybe enhance biodiversity while developers of private lands suggest that growth and prosperity derive greater benefit by improving the desert landscape because the added economic value is greater than the natural value of this vast, empty world of searing heat and drought. This delicate line of argument can only be met by information technology; an effective management tool delivered that no doubt handy for mitigation of important ecosystem.

Location

Application of the model is aimed at a location (1500 sq. Km) that may represents an ideal situation and a basin, located in the semi - arid zone of Thar desert in western Rajasthan has distinct morphological variations ranging from high extensive ridges of hard rocks to the vast alluvial plain blanketed by sand dunes and dotted with hills in the west (Kar, A., 1992). Deposition in the basin has taken place on an uneven basement and is net result of the streams supplying material of all size grades, typical of arid / semi-arid zone. Geologically, the area has the rocks of the Arvalli and Delhi Super groups (Precambrian) along its eastern boundary, rocks of Malani Igneous suit (Post Delhi: Precambrian) right from the north to south, and rocks of Marwar Super group (Cambrian) in the northeast. The western and central part of the basin is occupied by desert sand (Taylor et al., 1955; Gupta et al., 1980)., which overlies Quaternary alluvium It is located between latitudes 23º 41' N and 27º 05' N and longitudes 71º 04' E and 74º 42' E. Fig. 1 shows the location map of the study area.

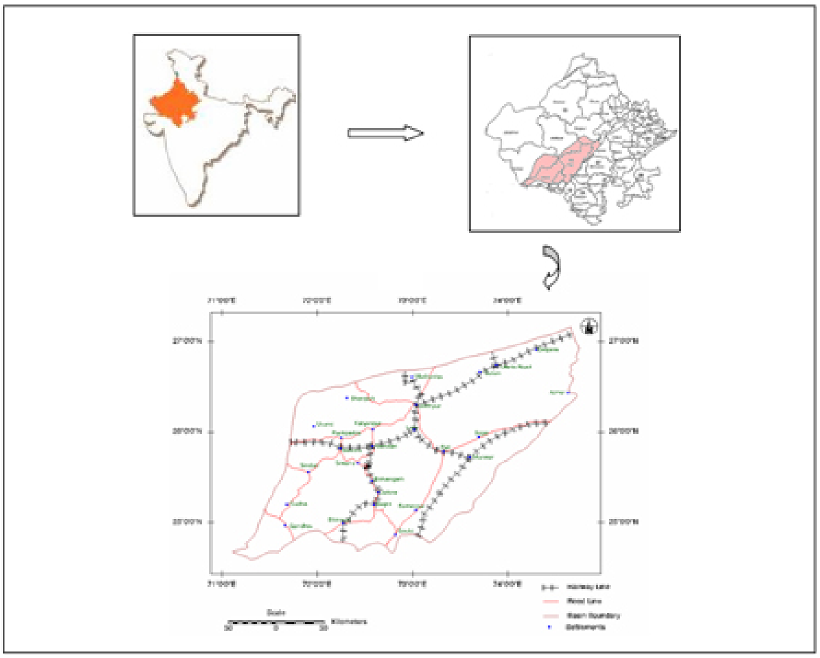

Fig 1: Location Map

Dry lands, in arid, semi-arid and dry sub humid regions, are more prone to degradation on account of climatic constraints, fragility of natural resources, and high pressures of humans and animals, as well as urbanization (Walid A. Abderrahman and M. Rasheeduddin, 1994). Arid areas are the worst affected, especially in the western part of Rajasthan state that includes the Thar Desert. Recurrent drought, high wind, poor sandy soils and very high human and livestock demand for food, fodder and fuel wood are causing over-exploitation of fragile resources, resulting in wind and water erosion, water logging, salinity-alkalinity and vegetation degradation.

Traditional practices of water storage and conservation and mixed farming that integrates perennial trees and grasses with crop cultivation and livestock rearing, which proved as best practices for sustainability and resource conservation, are now disappearing. As a consequence, about 92% area in arid Rajasthan is now affected by desertification. About 76% area is affected by wind erosion of different intensities, and 13% by water erosion.

Methodology and Tools

The fundamental problem in desert landscapes is to study and calibrate the relationships between incoming solar radiation, the losses due to absorbed photo synthetically active radiation (PAR), and changes in surface reflectance caused by degradation and regeneration. Ultimately these changes have a fundamental affect on the biotic components of desert habitats. Satellite imagery can be used to construct vegetation maps of desert landscapes, but imagery is also particularly useful to assess disturbances in desert ecosystems and the effect on biodiversity. The thematic maps prepared by digitizing and then geo-correcting for mosaic. An Area of Interest layer was prepared and saved as a separate file. This was utilized later on for extracting data for the study area from IRS mosaic data.

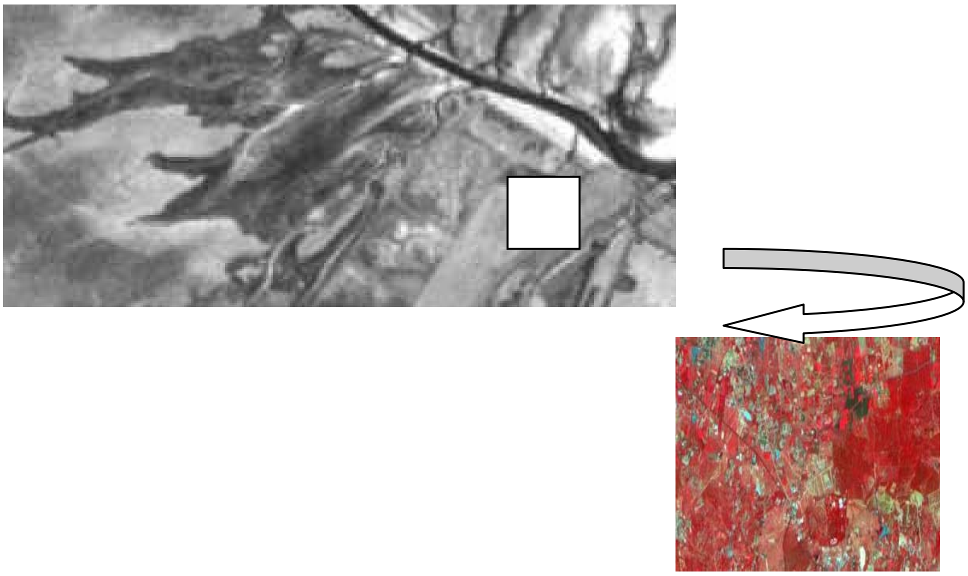

Fig 2: Focus Area (IRS 1C Pan and LISS III)

Published Hydrogeomorphic maps (Rajesh Kumar. et al, 2005) have been used to understand the major variations in morphology for the identifying the groundwater prospective zones in the area. Distinctive hydrogeomorphic units identified on images are Playa, Flood plain, Palaeochannel, Valley fill, Intermontane valley, Alluvial plain, Buried Pediplain, Aeolian plain, Dune complex, Pediplain, Buried pediment, Pediment, Structural hill, Residual hill, and Denudational hill. These units have been found to control the groundwater regime. Likewise, Land use Land cover layer, Soil layer, Slope layer and Rainfall layer has been prepared.

Integration

Sustainable management of scarce resources in the desert zone, and water in particular, requires a complex and interdisciplinary methodology. The approach is based on the integration o Socio-economic analysis and indicators, defining scenarios, and a set of quantitative simulation models to explore them. The main components are object data bases of geo-referenced data and a GIS to compile consistent data for the case studies, including socio-economic data and indicators, and asset of models including dynamic land use change model, a water resources model with embedded estimation tools for rainfall-runoff modeling, irrigation water demand estimation, water allocation, surface and groundwater quality and water quality. The model results are summarized as indicators, and used for discrete optimization multi-objective multi-criteria methodology that is designed for wide participation.

Action plan for the area: Idea is to integrate various parameters involved in Agro-Hydrological-Environmental system as themes (derived from IRS-1C images). Group of scientists comprising Soil Science, Agronomy, Hydrogeology, Meteorology and Social Science disciplines involved in deriving a mechanism for sustainable development Two developmental modules derived as follows.

BILWRU : Basic Integrated Land-Water Resource Unit.

ROLUF: Recommended Optimal Land Use Form.

A combination of above BILWRU will be given a ROLUF Number thereby specific recommendation for sustained development in terms of Agricultural, Environmental, Hydrological and Slope Stability.

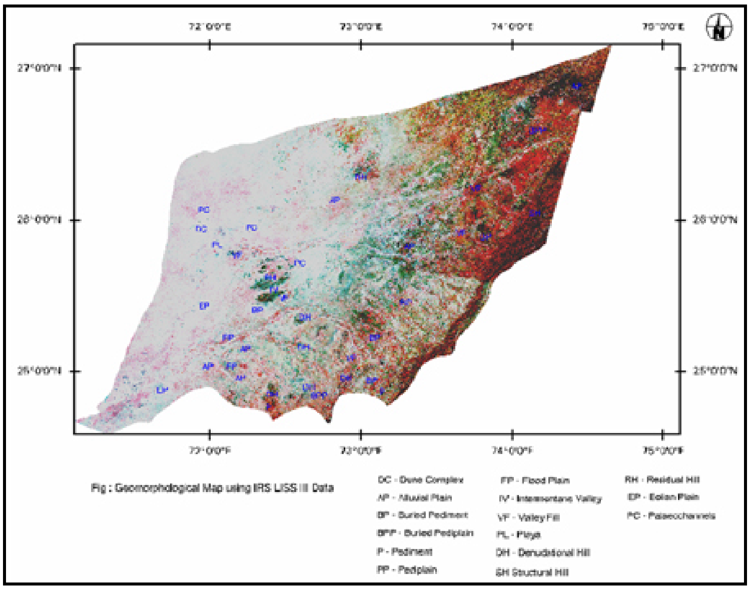

Fig 3: Hydrogeomorphological interpretation of the basin using IRS LISS III data

Creation of spatial data structure, query relations and data attribution was needed. The system provides spatial information on road network, resources, economic scenario, demographic and literacy, agricultural and industrial activities and economic status.

System facilitates any query and the combination of queries for analyses and suggests developmental combinations based on the socio-economic sub model of the region.

IRS satellite images that of considerable usage in dealing with parameters estimation as vital inputs for process on finite land and water resources balance and conservation configuration. Conservation methods derived using remote sensing data are include sand dune stabilization, wind erosion control, soil and water conservation.

Watershed development, agro-forestry, social forestry and joint forest management, salinity control, etc., are other suggestions embarked through this study.

Data for Conservation Measures

Promising technologies for shelterbelts, border row plantation, plantation of tree belts across the wind and alternating with crop/grass rows that utilize remunerative native/exotic trees, shrubs and grasses for food, fuel, fodder, fruits, minor forest products like gum and resins, have also been developed for the farmers who are the major users of sand dunes in the region. Shelterbelts of a three-row wind break of Acacia tortilis, Cassia siamea and Prosopis juliflora as the side rows and Albizzia lebbek as the central row has proved promising.

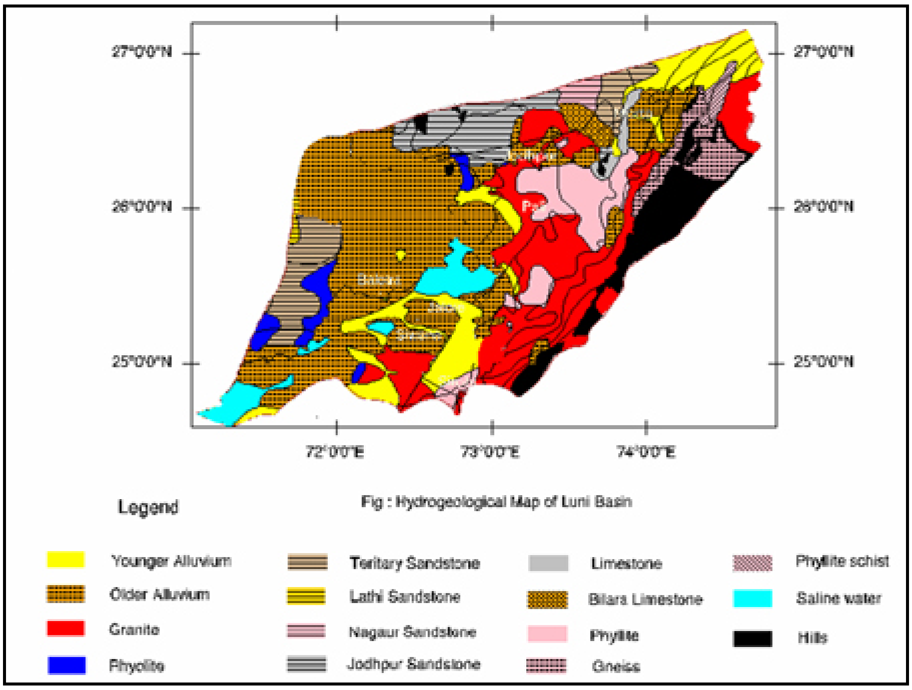

Fig 4: Hydrogeological Map of the Study area (after Ground Water Atlas of Rajasthan)

A number of diversified farming systems have been evolved for low-rainfall areas, which include agro-forestry, agri-horticulture and agri-silvi-pasture, to sustain livelihood during crop failure and to maintain livestock during drought. Improved practices for pasture and rangeland management, especially through silvi-horti-pastoral systems and rotational grazing, and rehabilitation of mine spoils through vegetative means have been developed and are being propagated by R&D institutions.

For water erosion control on arable lands, contour cultivation, bunding, graded bunding and bench terracing are adopted in conjunction with minimum tillage, cover crops, inter-cropping, strip cropping, contour vegetative barriers, etc. For non-arable lands check dams, gully plugging, stabilization of gully heads and vegetative measures are advocated. These measures and appropriate land uses are integrated on catchments basis with due regard to capability of the land. Rain water conservation, its harvesting and efficient utilization are in-built in watershed management programmes. Combating desertification through land care while enhancing agricultural productivity is the underlying principle for sustainable land management in the desert area.

Application of Unified Modeling Language:

Using software development capabilities, development of applications for resource management system using VB, UML and specialized GIS COTS products. In the scenarios where full-fledged MDA is perceived to be too complex, it still use custom code generation to improve quality of the total solution. MDA stands for Model Driven Architecture is a standard proposed by OMG, an international standards body. At the core of MDA is UML (Unified Modeling Language) that is used extensively in the industry for capturing requirements and design (Grady Booch et al., 1999).

MDA is an approach that leverages the requirements that were captured by business analyst to generate 60-80% of the application code and the developers are only left with the task of coding the pure business rules. This allows for high quality software in terms, consistency of the presentation, code quality based on industry best practices, and low maintenance. This is also helps in technology obsolesce as code for the new target platform can be generated when better technologies arrive in the market. Legacy applications can be easily web enabled based on the existing DB schema as in fact DB schema is also a model of the application in some respects.

What MDA can do in managing an Institute called “Integrated Resources Management Model for Arid Zone”. Below is a diagram that shows how requirements are captured in UML

Use cases form the basis for product functionality.

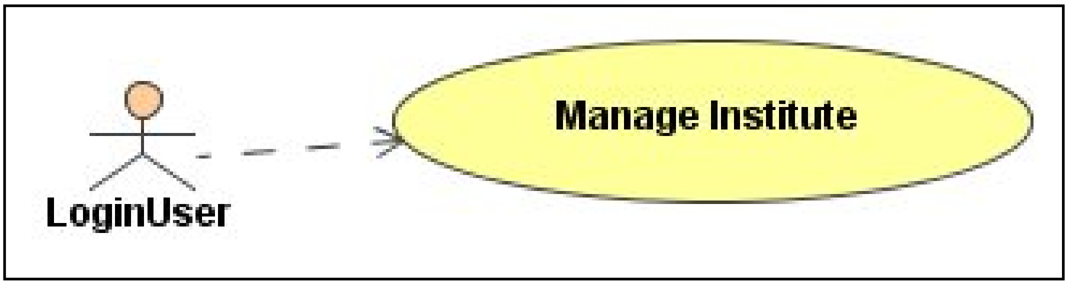

Fig 5: UML User Diagram

Workflow forms basis for how each function is accomplished by the system and what the end user interaction with the system. The flow diagram shows the workflow to manage Resources Management information. Class Diagrams form the basis for how the system is designed and how the data will be stored in the database. The following is a simple class diagram for Management Model, which has all categories and combinations.

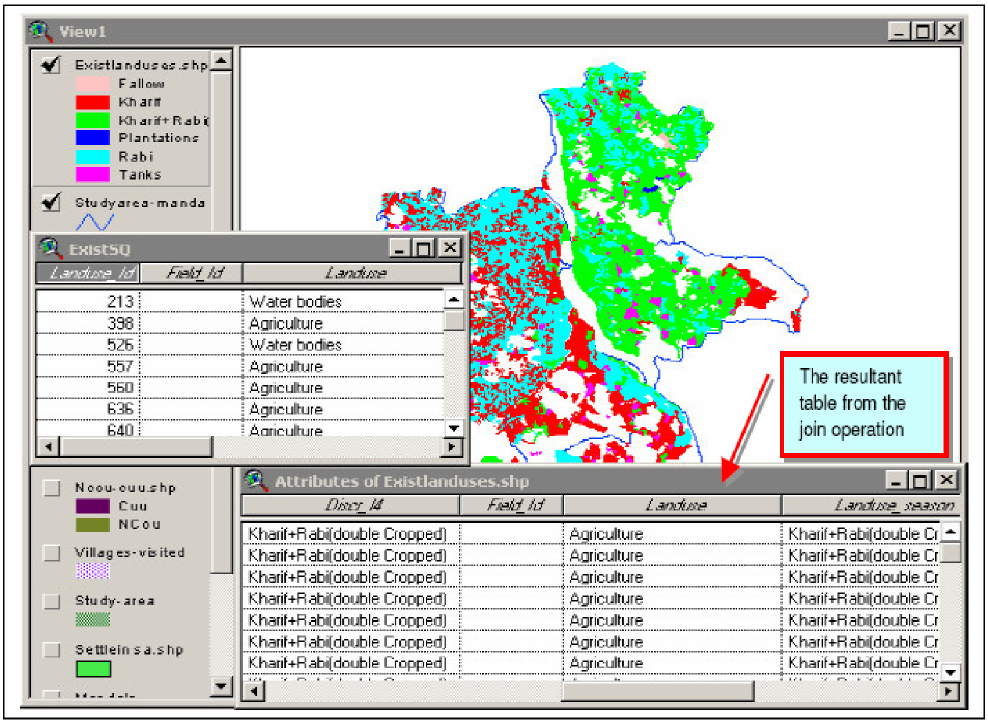

Fig 6: Screen showing query result

Conclusion

1. Integrated management tool having embedded with IRS data with synoptic coverage of 1420 km, was observed to be extremely useful for regional Agro-hydro-Eco-Sociological interpretation of different enhanced and transformed products prepared using digital image processing techniques.
2. UML found to be a very effective language for arid zone modeling where manipulation and updating the data and features is possible.
3. Integration query shells found concurrent with the UML model. Testing of the solutions generated by conventional tables and that of model are correlated. Degree of agreement seems to be excellent.
4. Study area, an important geomorphic element in the Thar desert of India has distinct hydrogeomorphic unit's e. g. playa, flood plain, palaeochannel, valley fill, intermontane valley, alluvial plain, buried pediplain, aeolian plain, dune complex, pediplain, buried pediment, pediment, structural hill, residual hill, and denudational hill. These units control the distribution of surface and subsurface water and the model tested here successfully proved that it could be used generally with little customization.

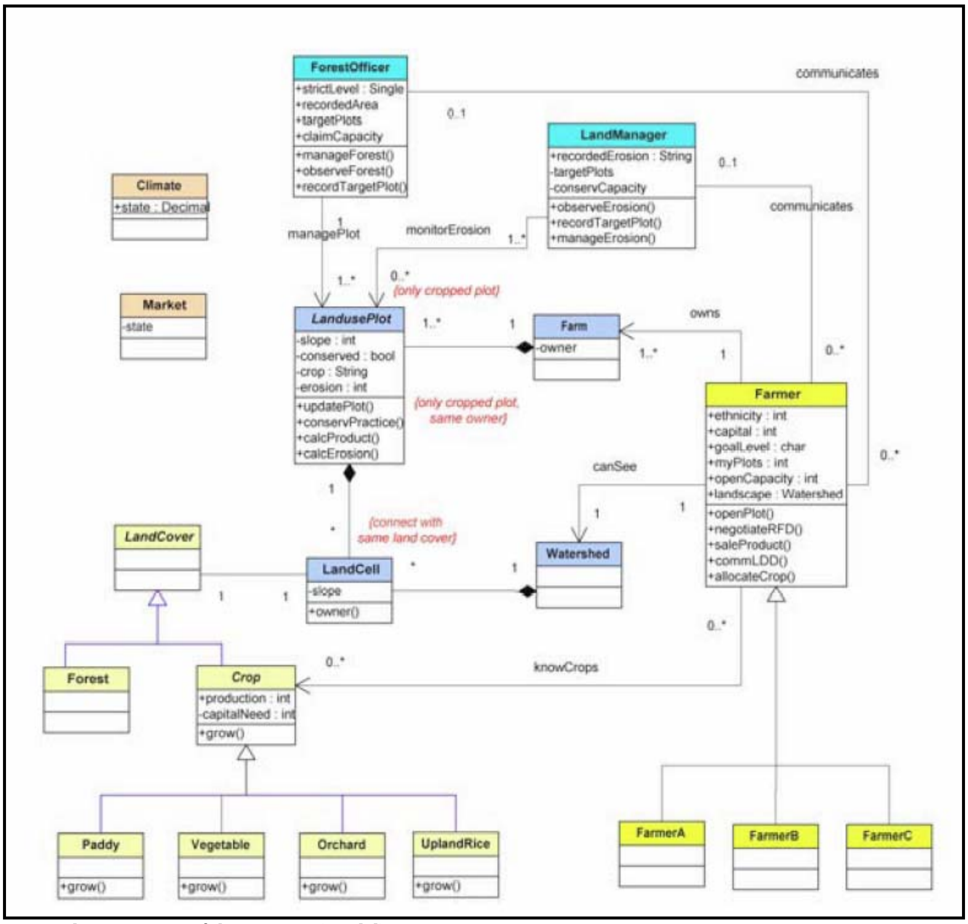

Fig 7: Class Diagram of the System (Model)

5. Improvement of the system can be possible with incorporation of more conservation and engineering parameters. Hydrogeological and ecological investigations are also suggested for incorporation at the locations for feasibility analysis.
6. A set of modular soil water balance models for wheat and other crops and irrigation models, developed and tested in earlier studies were adopted for use in the study area. From the soil water balance model, information on scheduling (depth and timings) of crops is derived

References

Bajpai, V.N., Saha Roy, T.K. and Tandon, S.K. 2001. Hydrogeomorphic mapping on satellite images for deciphering regional aquifer distribution: case study from Luni river basin, Thar Desert, Rajasthan, India. Proc. Regional Aquifer Systems in Arid Zones- Managing non-renewable resources, pp. 45-58.

Grady Booch, James Rumbaugh and Ivar Jacobson. 1999, The Unified Modeling language User Guide, Addison Wesley.

Gupta, S.N., Arora, Y.K., Mathur, R.K., Iqbaluddin, Prasad, B., Sohai, T.N. and Sharam, S.B. 1980. Lithostratigraphic map of Aravalli region: Southern Rajasthan and Northern Gujarat. Geol. Survey of India.

Kar, A. 1992. Geomorphology of the Thar desert in Rajasthan. In: Sharma, H. S. and Sharama, M. L. (Eds), Geographical Facets of Rajasthan. Ajmer; Kuldeep Publications pp. 298-314.

Rajesh Kumar.et al. 2005. Hydrogeomorphological mapping on satellite images for deciphering regional groundwater prospective zones of the Luni river basin, Western Rajasthan, India .

Taylor, G. C., Roy, A.K., Sett, D.N., Sen, and B.N. 1955. Groundwater geology of the Pali region, Jodhpur division, Western Rajasthan. Bulletin of the Geol. Soc. of India, series B, Engineering and Groundwater, No. 6 .

Walid A. Abderrahman and M. Rasheeduddin. 1994. Future Groundwater Conditions under long term water stresses in an arid Urban area, Water Resource management, Vol.8, No.8.