GIS CREATION OF AMUR RIVER BASIN FOR LAND-USE MANAGEMENT: RESULTS AND PROSPECTS (AMUR RIVER BASIN: RUSSIA, CHINA, MONGOLIA)

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1. INTRODUCTION

An increased interest to ecological problems in Amur River basin lately predetermines a necessity of studying versatile regional uncoordinated data, which are hard to unite them correctly. Amur River basin is a large complete geosystem which parts are placed in four countries namely: Russia, China, Mongolia and DPRK. In this respect, Amur River Basin is the largest trans-boundary geosystem of sub-regional level (Ganzey, 2004) in Asia. The area of the region makes more than 2 mln. square km, with population of over 40 million people. There are a great variety of natural resources.

For our researches we consider, the river watershed, particularly of regional dimension, can be representing as the integral complex geosystem (Reteyum, 1978; Korytny, 1991 and others). Watersheds are related with the processes of the biosphere's purification. The exchange of matter, energy, and information takes place through watersheds. These geosystems are also comfortable to analyze technogenic flows and anthropogenic impact on cycle of matter. It is a vast experience of watershed and landscape management including GIS using as well (Schaller, 1994; Bedford, 2004; Landscape planning…, 2005; Blaschke, 2006).

Full planning and implementation of the balanced economic and land-use policies should be carried out with taking into consideration of similar activities on contiguous frontier territories of neighboring countries. Take under consideration an interdependence of the processes of nature management on frontier territories of the adjacent countries and within the integral geosystem, we believe that analysis and planning for sustainable development should be implementing in uniform information space. So, the planning of the sustainable land/nature management can be realized taking into account the large volume of diverse information about the territory of the particular project. The spatially distributed information translated into the cartographic language is, for a long time, the basis of planning of actions for the regional development. The maps, set of maps, atlases were always essential for the activity of such kind (Ormeling, 1995). A necessity to work out the specific GIS-support and mapping for the sustainable land use and landscape planning as a sort of complex ecologic-geographical mapping and analysis was discussed time and again also (Chen Shupeng, 2004; Madden, 2007). We consider this question as a creation of the geoinformation-analytic base for solving of the problems for permanent territories management and sustainable development. We consider that concept "Geographical Informational Layer" reflects the property of the geographical space more exactly. For regional researches we use this term as conform to “digital layer”, “digital coverage”, “database layer of geographic information system”.

Geo-Informational Space is multi-level, poly-layer, territorially and inter-componently structured information model of Geographical Space (Ermoshin, 2006). When creating the GeoInS of each particular nature-conservative and nature-management project, there is a certain specificity in both structural and information aspects. At the same time, it is possible to define general methodical, structural and geoinformation concepts and rules.

Earlier we defined the key problems should be solved for GIS creation; problems of the transboundary geoinformation space forming and ways of there decision (Ermoshin, 2004, Baklanov and other, 2005)**.** The characteristic and, at the same time, specific feature of the projects uniting the transboundary territories is an inconsistency between initial data for territories of different countries. It is necessary to take into account that all these data on the Chinese, Russian and Mongolian sides of the Amur Basin was and will be received from various sources, and then should be processed, corrected and interrelated. Therefore, prior to the beginning of the works it is preliminary necessary to stipulate all possible technical parameters of collection of the information namely: scales, projection, detailed, classifications, language, etc to avoid possible problems.

Table 1. Geo-Informational Space forming and mapping for nature management

MAPPING TYPE	TYPE OF TERRITORY DIVISION	TYPE OF GEOINFORMATION	STAGE OF FORMATION OF GeoInS
Inventory	*Division into districts* (typological and individual) - division of common geographical space according to its numerous properties on the basis of specified classifications including hierarchical ones.	General	Production of the system of inventory cells. Formation of information thematic cores of the polystratified GeoInS.
Evaluative	*Division into districts* according to new characteristics without division and integration of inventory cells. *Zoning* is integration of inventory cells according to some general properties or characteristics.	Special	Determination of relations in the structure of inventory cells. Increase in the density and saturation of the GeoInS – forming of additional individual layers.
Predictive-recommendation	*Functional zoning* - integration of inventory and evaluative cells on the principle of possible management and use.	Evaluative and management	Production of the administrative in formation block of the GeoInS

It is appropriate to draw a parallel between the order of the GeoInS forming, its basic blocks and basic types of mapping: inventory (universal), evaluative, prediction-recommendation (Table 1). The interrelations between the columns of Table will consist in the fact that the basic thematic and, partially, individual layers will conform to the inventory, individual (specific) ones to the evaluative while administrative to the prediction-recommendation type.

2. RESULTS AND DISCUSSION

When realizing each particular project for planning and solving problems of nature management on the territory of any level, all the stages - from inventory to recommendation - should be executed (Table 1). Actually, the sequence of activities on creation of information support for the Amur-Project management is realized in four phases. At the first phase, the structural layer-by-layer model of GeoInS including the following blocks: general geographic, general thematic, specific thematic, evaluative, and management ones have been developed (Fig. 1). The technological outline of coordination of information cartographical blocks with each other has been defined (Yermoshin and other, 2007).

At the second phase, the information layers of the natural and social-economic blocks were formed and mutually coordinated as uniform layers for the whole basin. Thus, the general geographic layers like DEM using SRTM data, hydro-network, roads, borders, and settlements have been compiled. The general thematic layers of geological patterns, vegetation, soils, Geomorphological zoning have been compiled also. At that, a special attention was paid to formation of unified classifications and legends. The specific thematic layer of modern land-use in Amur River basin on the basis of decoded satellite images of LANDSAT - ETM taken in 2000-2001 has been compiled. The specific thematic layer of historical land-use for 30-40 years of XX century has been compiled also. For compilation this map we used old topographical maps different scales and countries where these printed. All digital layers are created on Arc/INFO and ArcGIS platforms with detail endues, corresponding to the scales of 1:1 mln, 1:2.5 mln.

All layers having the common boundaries conform sequentially with each other much as it occurs in case of complex and atlas mapping and form the through logical spatial series. Essentially, each series has, at least, one intersection with other ones. Thus, most of layers have, expressly or by implication, common invariants. As examples of the most evident successive notional relations of electronic layers in the form of series can serve the following ones: hydrologic network – relief – road network – settlements – land owners; hydrologic network – boundaries – protected territories – recreation resources; hydrologic network – vegetation – landscapes – functional zones (Yermoshin and other, 2007).

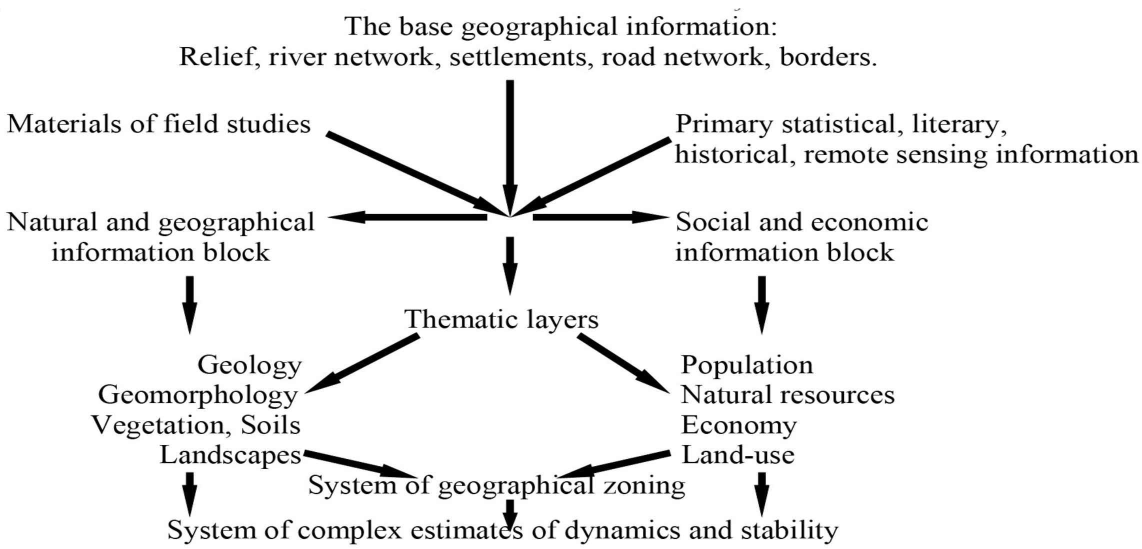

Fig. 1. Structure of GIS-support for The Amur River Basin Project

The features of creation, classifications, legends for some digital thematic and geographical layers: geological structure, vegetation, soils, modern land-use in Amur River basin" (on the base of remote sensing data) were discussed in detail more than once (Yermoshin and other, 2007; Ermoshin, 2008; Ermoshin, Pshenichnikova, 2008). In this article we show the main data spatial distribution of nature parameters for the Amur River Basin (Tables 2-4). Not whole types of vegetation and sols show at tables 2, 3, but those with largest squares only. Therefore the sum of percent is less than 100.

Larch wood takes in the maximal areas and on a share of mountain larch wood is 22 percent of a total area, and share of plain larch wood – about 10 percent. Shrubs of various kinds are situated at valleys and plains mainly and occupied about 10 percent also. The vegetation of steppes is concentrated mainly in western sharply continental part of Amur Basin. Dry and meadow steppes take in almost 13 percent of territory. Cedar and cedar-broad-leaved forests are very important for landscape. They are situated at low and middle mountain mainly and occupy 11.6 percent. At last, agricultural grounds belong more than 12 percent.

Data on spatial distribution of predominant soils are resulted in table 3. Here are shown prevailing only ground which total area exceeds 3 percent. The others numerous types of soils have the limited distribution, but, nevertheless they have great value for characteristic of landscapes. Different subtypes Cambisols have the greatest distribution in Amur Basin. Cambisols as Soils of Broad-Leaved Forests and Wooded Steppe have received 20 percent and Cambisols as Soils of Taiga and Coniferous Broad-Leaved Forests have received 18 percent. Except for them often enough there are also various subtypes Hydromorphic Soils: Gleysols – more than 9 percent; Histosols - more than 6.5 percent of basin.

Table 2. Main Data Spatial Distribution of Vegetation of the Amur River Basin

CLASS	TYPE	AREA th.km.sq	AREA percent
Forest and Shrubs of plain and plateau	Larch	202	9.9
	Broad-leaved	89	4.3
	Small-leaved	58	2.9
	Shrubs	47	2.3
Vegetation of river valley	Shrubs	155	7.5
	Grass / Damp grass	58	2.8
	Swamp	36	1.8
Steppe	Meadow steppe	152	7.4
	Arid steppe	108	5.3
Forest of mountain	Larch	451	22.0
	Dark coniferous	100	4.9
	Cedar / Cedar- broad-leaved	56	2.7
	Broad-leaved	95	4.6
	Small-leaved	86	4.2
Agricultural land		275	13.4

Table 3. Main Data Spatial Distribution of Soil for the Amur River Basin

CLASS	TYPE	AREA th.km.sq	AREA percent
Soils of Taiga and Coniferous Broad-Leaved Forests	Haplic Podzols	118	5.8
	Dystric and Gleyic Cambisols	308	18.0
Soils of Broad-Leaved Forests and Wooded Steppe	Eutric and Dystric Cambisols	417	20.5
Soils of Steppe	Haplic Phaeozems	63	3.1
	Calcic Kastanozems	75	3.7
Hydromorphic Soils	Umbric and Mollic Gleysols	186	9.1
	Fibric and Terric Histosols	135	6.6
Alluvial And Marshy Soils	Fluvisols	69	3.4

Data on spatial distribution of Geomorphological zones are resulted in Table 4 and Figure 2. The Digital layer "Geomorphological structure (Geomorphological zones)" is very important at carrying out of landscape mapping and serves as information morphological basis for it. Drawing up a legend and a map is lead in conformity with following classification: High Mountain, Middle Mountain, High Plateau, Low Mountain, Plateau, Hill Mountain, Hills, Plain, Depression, and Valley.

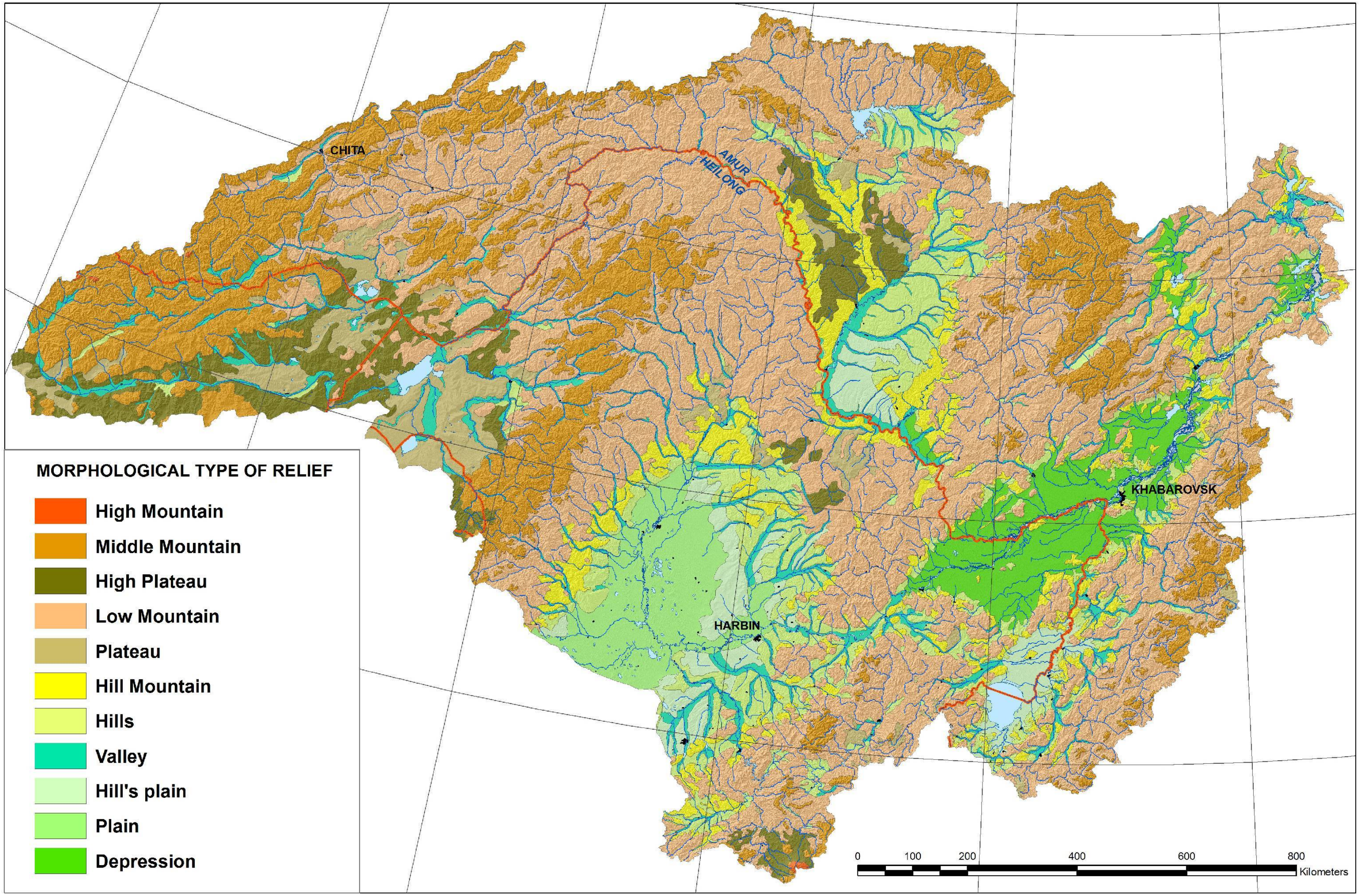

Fig. 2. Geomorphological zoning map of Amur River Basin

Table 4. Main Data Spatial Distribution of Geomorphological Zones for the Amur River Basin

TYPE	ALTITUDE (m)	SLOPE INCLINE (degree)	AREA th.km.sq	percent
High Mountain	**More 1800**	**15 - 45**	**0.8**	**0.04**
Middle Mountain	**850 - 1800**	**12 - 25**	**361.5**	**17.6**
High Plateau	**600 - 1500**	**5 - 12**	**100.4**	**4.9**
Low Mountain	**300 - 900**	**10 - 20**	**861.6**	**42.0**
Plateau	**300-900**	**2 - 5**	**79.1**	**3.9**
Hill Mountain	**200 - 400**	**4 - 10**	**122.7**	**6.0**
Hills	**100 - 300**	**2 - 5**	**152.3**	**7.4**
Plain	**50 - 300**	**0 - 3**	**140.6**	**6.9**
Depression	**0 - 150**	**0 - 1**	**101.0**	**4.9**
Valley	**0-200, 400-800**	**0 - 2**	**117.8**	**5.7**

Delimitation of units the specified morphological types of a relief was realized in an interactive mode in program ArcGIS9.3. The basic sources of data for Geomorphological mapping have served Digital Earth Model and the scanned topographical maps of scales 1:1000000 – 1:200000 depending on complexity of a relief. Key parameters of heights and slope incline on which combination mapping typological units, are resulted in table 4. The maximal areas in basin are taken in Low Mountain and Middle Mountain – 42 percent and 17.2 percent accordingly. Approximately equal areas are taken in Plateaus, Hill Mountain, Hills, Plains, Depression and Valleys. Their squares are in a range from 5 up to 7.4 percent from the area of Amur Basin.

3. PROSPECTS FOR FURTHER INVESTIGATIONS

All of presented map and digital layers combine the informational basis for the landscape map making and defining of the criteria and indexes of sustained nature management in the Amur River basin. During the next three years we plan to realize the new Project "Environmental Criteria and Restrictions in the Programs for Sustainable Nature Management in the Amur River Basin". These activities make up the third and fourth stages of our investigations.

The planned project implementation involves analysis of environmental condition of the Russian part of the Amur River basin, development of a system of environmental criteria and restrictions of the economic activities and land use in the Russian part of the Amur River basin to substantiate sustained nature management, to forecast and assess possible changes and to develop measures for improvement and preservation of high quality of the environment and regeneration of renewable resources.

The following works will be conducted for the project implementation:

1. Complex assessment of the Russian part of the basin
   - general geographical description and assessment of natural resource potential of the Russian part of the Amur River basin;
   - socio-economic description and assessment of the basic types of nature management in various parts of the territory, including traditional nature use by small aboriginal peoples;
2. Analysis of environmental problems in the Amur River basin
   - analysis of environmental problems of the nature use, environmental hazards and risks, modern biodiversity state and nature protection;
   - cause-consequence analysis of the environmental problems and hazards, forecasts of possible changes in the environmental condition;
3. Landscape mapping
   - creation of landscape map of the territory, assessment of disturbance and pollution level, natural and nature resource environment;
   - landscape-geochemical zoning of forest and wetland ecosystems of the Russian part of the basin on the basis of data on input of water-dissolved iron;
4. Development of the ecological-economical balance model in the programs of sustained nature management of basin geosystems;
5. Development of the system of environmental criteria and indexes of sustained nature management on the basis of analysis of landscape structure of the territory, implementation of functional zoning of the Russian part of the Amur River basin with singling out of priority, possible and forbidden types of nature management, compiling of corresponding maps and diagrams;
6. Preparation of proposals for use of the project results
   - preparation of definite proposals on improvement and preservation of high quality of the environment;
   - preparation of organizational proposals for the efficient implementation of the project recommendations.

Study, analysis and forecasting of the dynamics of ecosystem condition will provide information basis for the strategy of sustained development of the regions for nature management optimization. The obtained results will serve as a starting point for long-term monitoring. There will be obtained data on the present condition of Amur River basin ecosystems, their composition, structure and functional role for preservation of sustainability in view of the global changes of the environment conditioned by natural and anthropogenic factors.

The results of the project will be recommended for planning of social and economical development of krays and oblasts of southern Far East of Russia. They will also be used at the development of corresponding Russian-Chinese and Russian-Mongolian agreements aimed to the improvement of environmental situation in the Amur River basin.

4. CONCLUSION

The special information support for the nature-conservative projects, planning the sustainable development of territory should be realize by means of forming of the Geoinformational Space of territory as the subjective and objective informational reflection of the geographical space.

The general geographic layers, the general thematic layers and specific thematic layer of modern and historical land-use for the Amur River basin has been compiled. All digital layers were created on ArcInfo/ArcView and ArcGIS platforms with detail endues, corresponding to the scales of 1:2.5 mln. (regional level).

The geoinformation space of Amur River Basin as geosystems (ecosystems) of regional dimension is created on unified methodological basis with use of the uniformed principles, generalized available and new data for the river basin. Spatial data are free accessible and can be use as safe and correct information basis both in regional planning and management, and in further scientific researches.

It is the informational basis for a landscape map making and defining of the criteria and indexes of sustained nature management in the basin at the next Project "Environmental Criteria and Restrictions in the Programs for Sustainable Nature Management in the Amur River Basin"

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