THE BASIC FEATURES OF LAND-USE IN AMUR RIVER WATERSHED

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INTRODUCTION

Research of interactions «land-ocean» draws more attention of experts of various scientific fields. It is explained by a variety of diverse links between them and by complexity of studying them. At that it is abundantly clear that the changes of natural environment occurring on the continent influence the sea systems. Changes in the last ones, in turn, affect stability of in-land systems.

The Sea of Okhotsk is one of the main fishing areas in the Far East of Russia. This sea plays an essential role in economies of Japan, Republic of Korea and other countries. The studies in last years [1] revealed that phytoplankton development in Northern Pacific is restrained by a low degree of utilization of nitrates, phosphates and silicates dissolved in sea water because of low contents of dissolved iron in waters. In result the efficiency of phytoplankton is decreasing that brings to reduction of main fishing resources stocks. Since, due to considerable entry of dissolved iron with waters of Amur River, the Sea of Okhotsk does not belong to the similar water bodies, but significant changes in land tenure within its watershed result in reduction of this element entry. It can cause a decreasing of phytoplankton efficiency and it can have serious economic consequences. The major factors of formation of dissolved iron is a presence of great volume of organic stuff and anaerobic conditions. Therefore, the role of forest and wetland ecosystems, which recently are undergone with significant transformations by row of reasons in Amur River watershed is great in regulation of volumes of its entry.

This circumstance served as a basis for initiation of the international research Amur-Okhotsk Project financed by Japanese government. The main purpose of the project is to develop a plan of sustainable land-use in Amur River watershed for conservation of present efficiency of the Sea of Okhotsk's ecosystem.

It is necessary to note that active surveys of the areas within the watershed of Amur River have been begun already in the end of the XIX - beginning of the XX century, and it is associated with names of so well-known travelers and scientists - naturalists like Venjukov M.I., Maak R.K., Maksimovich K.I., Przhevalsky N.M., Obruchev V.A. and others. Besides that, the Chinese part of Amur River watershed permanently attracted attention of Russian researchers. D.N.Anuchina's works [2, 3] were ones of the first, which in a complex considered natural features, population and an economy of Manchuria.

A huge role in studying the natural environment of the Far East of Russia and Manchuria was played by Komarov V.L. [4] which ideas about zoning of 4 natural areas and 4 florae areas of the same name (Manchurian, Daurian, Okhotsk and Siberian) have been

widely recognized and commented in floristic, botanic and geographical, and landscape aspects [5].

A great volume of research works of both scientific, and scientific and applied character, has been fulfilled by Amur Expedition, organized in the beginning of the last century [6-8] to study an opportunity of economic development of Amuro-Ussuriiskii krai, further resettlement of peasants, development of trade and industry.

During the post-war time the works devoted to the economic and geographical characteristic of Manchuria have been published [9, 10].

An essential contribution to accumulation of extensive material about differentiation of natural environment in Amur River watershed has been made by the Russian-Chinese Joint Amur Expedition under the Council on Industrial Forces Organization of the USSR Academy of Science, and by Heilongjiang Expedition of the Chinese People's Republic, carried out the surveys in the second half of the 50s of the last century [11]. The results of these surveys became the basis for fulfilling a whole series of thematic works, in which natural environment of Amur River watershed was considered not only within the separate countries, but also as an integral geographical formation, which parts are interconnected closely. Among these works it is necessary to mention about soil and geographical zoning of Amur River by Liverovskii Yu.A. and Rubtsova L.P. [12]; a vegetation map of Amur River watershed [5, 13]; Nikolskaya V.V.'s work devoted to studies of morpho-structures of Amur River watershed [14]; and a number of others. It is necessary to point out also to works of Murzaeva E.M. [15], Efremov Yu.K. [16] of the same period, devoted to the characteristic of nature and economy of Northeast China.

Modern interest to the studies of trans-boundary watershed of Amur River is proved by publication of works devoted to the trans-boundary diagnostic analysis of Ussuri River [17] and of Khanka Lake [18], to researches of issues of its economic development [19, 20], water and environmental problems [21], land resources assessment [22], trends of economic interaction between the Russian Far East of Russia and Northeastern China [23]. The common feature of the works in last years is that the analysis of situation within the watershed is made as a rule by large units of administrative and territorial division (ATD) situated on its territory. Use of such data is associated with that the information about separate parts of Amur River watershed is often incomplete, diverse, and dissimilar in details, methods of data collection and processing.

Since the unified data on land structure for the surveyed territory are also absent, the map of "Modern Land-Use Zoning Map of the Amur River Basin" has been made in the scale 1 : 2,500,000 (Fig. 1).

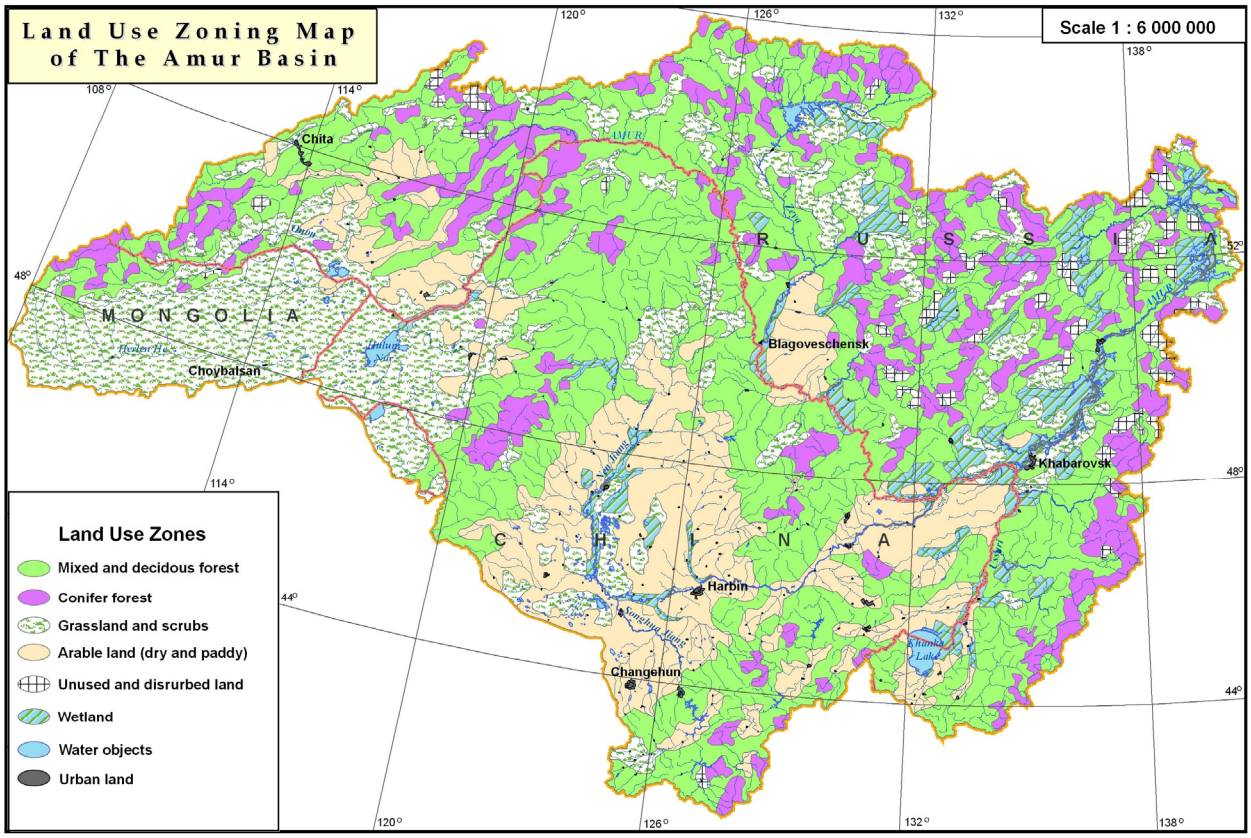

Figure.1 Modern Land-Use Zoning Map of the Amur River Basin. By figures are numerated: 1 - deciduous and mixed forests and sparse forests; 2 - coniferous forests; 3 - meadows, steppes, bushes; 4 - agricultural lands; 5 - disturbed and unused lands; 6 - large settlements; 7 - water bodies; 8 - boggy and humidified lands; 9 - state boundaries; 10 - border of the watershed.

MATERIALS AND METHODS

A set of satellite images of Landsat-7 (USA) in 2000-2001 was the initial basic information for compilation of the layer "Modern Land-Use In Amur River Watershed". The composite compilations of the average resolution from 30 m and more mainly have been used in the work. The satellite images of Landsat TM with resolution 15-30 m have been used to specify some most disputable territories. Decoding was made in GIS ArcView 3.3 software using a special extension Image Analysis to form shape files and the subsequent their converting to

Arc/Info coverings. Besides direct interactive expert decoding of satellite images, the following sources have been used as reference and correcting information converted to electronic raster and then to vector format: 1. A map of vegetation of Amur River watershed in the scale 1:2,500,000 edited by Sochava V.B. [13]; 2. A map of vegetation of Mongolian National Republic in the scale 1:3,000,000 (1990); 3. A map of vegetation of China from the Vegetation Atlas of China in the scale 1:1,000,000 [25]; 4. Raster topographical maps in the scale 1:500,000.

Specific and at the same time most typical feature of the projects fulfilled on trans-boundary territories consists in discrepancy of initial data on the territories of different countries [26, 27]. It resulted in a set of problems of geo-information exchange, geo-

information flows and forming of uniform geo-information space. We highlight here only those which have a direct attitude to the theme of the present survey.

1. Along the state boundary, all information layers, both common geographic and thematic ones to a variable degree, are not coincided with each other practically if they are taken from the sources of different countries.
2. Distinctions in contents of concepts of similar objects, for example, nature reserves, types of land-use, etc. make impossible their direct combined use.
3. Different assessments of anthropogenous factors, ecological standards and restrictions demand for special re-calculations.
4. Various approaches to the classification of complex objects (roads, settlements, types of vegetation, types of land-use) are used. Various substantial concepts, principles, grounds, and not coinciding number of gradations can be used in classifications [27].

All the mentioned problems are solved step by step, first of all conceptually, then technologically and practically. Conceptually - the general bases of classifications are defined and agreed usually towards simplification. Technologically - the principles and sequence of overlapping of information layers along the state boundaries are determined on the basis of invariant geographical structures and lines of geographical space like watercourses, roads, etc. Practically - the united layers are unified and formed, the topology of objects is compiled, and the layers are correlated among themselves forming horizontal and vertical structures of geo-information space.

The same problems were solved in drawing up of a map of modern land-use in Amur River watershed. First of all, it was necessary to make a uniform classification of types of land-use since the classifications accepted and used in Chinese People's Republic, Russia and Mongolia differ essentially. Since the approaches to mapping land-use in Mongolia and in Russia are similar, we give more details to the Chinese classification.

In Chinese People's Republic the unified "through" state classification of lands embracing various levels of analysis, from the small-scaled level up to middle and large scaled level, is accepted. In total, three classes differing in detail of description of typological characteristics of lands are used. The categories of lands of the first class reflect their most general properties allowing to allocate, for example, 'cultivated lands", 'forest lands', "meadows", 'water bodies', 'industrial lands', 'unused lands', and to generate from them a legend at drawing up of maps in the scale 1:2,500,000 and smaller. The maps made in the scale 1: 1,000,000 use more fractional typological characteristics. For example, the type 'cultivated lands' is subdivided into the subtypes 'paddy fields' and 'dry agricultural lands' (arable lands). The forest lands and meadows are subdivided into subtypes depending on density of wood stands or on density of a grassy cover. Thus, the territories with density of wood stands over 30 % belong to the forest lands, the territories with density of stands from 10 to 30 % belong to sparse forests, etc.

From our point of view, use of the state classification of lands accepted in the Chinese People's Republic for charactering modern land-use in Amur River watershed, narrows a volume of helpful information on character of economic activities in its limits though it essentially simplifies its mapping. In our country more complex and detailed typification of

land-use (land tenure) has been accepted and realized in statistics. However, it practically was not applied to mapping of large territories because of its ambiguity.

The classification of forest lands has been corrected. In addition to the density of wood stands their typological characteristics have been introduced. The coniferous, mixed, deciduous forests, sparse forests, and other forests have been defined in forest lands in result (Fig. 1). For details please see the paper "The basic geographical information for GIS of Amur River basin" (Yermoshin et al., this book).

DISCUSSION OF RESULTS

We determined the total area of Amur River watershed as 2.05 million km^2. There is a little difference from the data given in other sources. Distinctions in estimation of the watershed area are associated with inclusion or without inclusion of several closed watersheds in the southern areas of East Mongolia and in the southwestern part of Autonomous Region of Inner Mongolia of the Chinese People's Republic into its composition. The area of the watershed changes at that from 1.8 up to 2.09 million km2. According to our data, the Russian part of the watershed takes 49.3 % of the watershed territory or 1.01 million km2, the Chinese part - 42.2 % (0.86 million km2), the Mongolian part - 8.5 % (0.18 million km^2).

The natural and climatic conditions in Amur River watershed considerably change in both latitudinal and meridional directions. Several vegetation zones like mountainous tundra, taiga, a zone of mixed broadleaved forests, a forest-steppe zone, steppe, semi-desert are defined there. Climatic conditions change from arid ones to superfluous damp ones. All that determines a natural variety of land resources of the watershed which have been subject to active economic development for last 125 years [19].

At present forest areas occupy over a half (54.3 %) of the watershed territory. Over 30 % of this area is occupied by mixed and coniferous woods situated mainly in the Russian territory. It is necessary to note that majority of fire-sites, loggings and sparse forest are also located in the Russian territory that reflects adverse trends in forest management, developed on our territory in the 1990s of the last century. Deciduous forests occupying about 15 % of all forest lands, dominate in the Chinese part of the watershed.

The agricultural lands occupying nearly 20 % of its territory are the second type of lands by the area in the watershed. The lion's share of cultivated lands including irrigated, is located in the Chinese part of the watershed. Prompt reduction of wetlands is one of the consequences of its active agricultural development. According to the Chinese researchers [28] a share of wetlands on Sanjiang Plain for the period from 1950 to 2000 reduced 52.5 %, from 32.4 thousand km^2 up to 9.2 thousand km^2, at the same time the share of agricultural lands has increased from 10.2 % up to 55.1 %. At that, most part of wetlands is located still on the Russian territory.

Table 1. The types of land-use developed in the watershed area.

Type of land-use	Area, km^2	Russia, %	Mongolia, %	PRC, %
Coniferous forests	277.6	77.1	3.0	19.9
Mixed forests	347.3	66.5	1.8	31.7
Deciduous forests	316.2	37.4	1.0	61.6
Sparse forests	145.4	73.1	3.2	23.7
Fire-sites	27.1	97.1	1.8	1.1
Other forest lands	5.4	Not determined	41.1	58.9
Meadows	257.2	9.5	54.7	35.8
Bushes	121.7	67.7	4.7	27.6
Reclaimed lands	26.0	9.1	Not determined	90.9
Not reclaimed agricultural lands	347.5	23.3	0.7	76.0
Lakes	10.6	48.9	7.7	43.5
Water reservoirs	2.5	81.9	Not determined	18.1
Wetlands	140.0	68.1	0.1	31.8
Settlements	2.7	37.2	Population less 100 thousand people	62.8
Not used lands	0.7	93.0	Not determined	7.0
Waste lands	0.2	83.6	Not determined	16.4
By-golets bushes with mountainous tundra	13.3	96.1	1.0	2.9
Loggings	8.7	77.7	Not determined	22.3

Meadows and bushes totally make about 20 % of the area of Amur River watershed also.

The Russian part of the watershed partly or completely covers the territories of 6 administrative units in the south of the Far East, the Chinese part - three units, and Mongolian - four units (Table 2).

The territorial distribution of types of modern land-use reflects both natural and climatic conditions of the territory, and also national features of nature management, historical and modern trends in development of economy of the countries. Figure 2 shows modern land-use in Amur River watershed in the context of administrative units.

The main tracts of coniferous forests on the Russian territory are in Khabarovskii Krai, Amurskaya and Chitinskaya oblasts - 73.4; 68.7 and 48.3 thousand km2 correspondingly. The mixed forests are dominating type of vegetation, their main share is concentrated in the same administrative units. Deciduous woods prevail in Amurskaya Oblast, Khabarovskii Krai and in Chitinskaya Oblast. Amurskaya Oblast also takes leading position in the area of sparse

forests (39.9 thousand km2) and in the area of meadows and bushes vegetation (36.2 thousand км2).

Wetlands are widespread in Khabarovskii Krai and in Amurskaya Oblast, 48.6 and 28.2 thousand km2 correspondingly. The area of wetlands in Primorskii Krai is much less, 6.8 thousand km2.

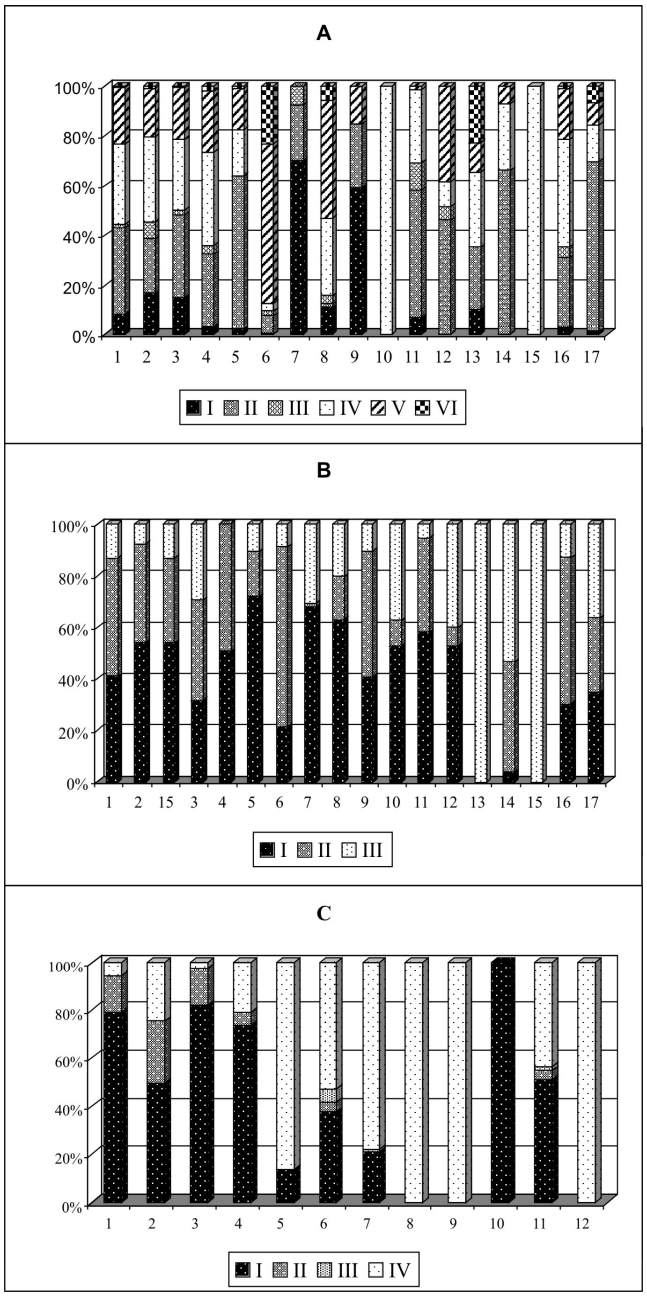

Figure.2 Structure of land-use in Amur River watershed according to the administrative units.

A - Russian portion of the watershed: I - Primorskii Krai; II - Khabarovskii Krai; III - Evreiskaya Autonomous Oblast; IV – Amurskaya Oblast; V – Chitinskaya Oblast; VI – Aginskii Buryatskii Autonomous Okrug.

B - Chinese part of the watershed: I - Heilongjiang Province ; II - Inner Mongolia Autonomous Region ; III - Jilin Province.

C - Mongolian part of the watershed: I - Hentei Aimak; II - Tuva Aimak; III - Sukhebator Aimak; IV - Dornod Aimak.

Types of land-use. Forests: 1 - coniferous; 2 - deciduous; 3 - mixed; 4 - sparse forests; 5 - fire-sites; 6 - meadows; 7 - reclaimed lands; 8 - not reclaimed agricultural lands; 9 - lakes; 10 - water reservoirs; 11 - wetlands; 12 - residential territories; 13 - unused lands; 14 – by-golets bushes with high-mountainous tundra; 15 - waste grounds; 16 - bushes; 17 - timber cuttings; 18 - other forest lands.

Table 2 Units of administrative-territorial division in China, Russia and Mongolia, situated in Amur River watershed.

Administrative unit	Area, thousand km^2	Area in the watershed, thousand km^2	Watershed share of the administrative unit, %
People Republic of China			
Heilongjiang Province	454.0	442.7	97.5
Inner Mongolia Autonomous Region	1183.0	296.7	25.1
Jilin Province	187.0	125.5	67.1
Russia			
Primorskii Krai	165.9	101.0	60.9
Khabarovskii Krai	788.6	313.7	39.8
Evreiskaya Autonomous Oblast	36.0	36.0	100
Amurskaya Oblast	363.7	315.3	86.7
Chitinskaya Oblast	412.5	224.5	54.4
Aginskii Buryatskii Okrug	19.0	19.0	100.0
Mongolia			
Aimak Hentei	80.3	73.0	91.0
Aimak Tuve	74.0	9.5	12.9
Aimak Sukhebator	82.3	7.54	9.1
Aimak Dornod	123.6	85.1	68.9

The main tracts of lands used in agricultural production are situated in Chitinskaya Oblast, 38.2 thousand km^2 and in Amurskaya Oblast, 25.1 thousand km^2. Irrigated lands prevail in Primorski Krai that is associated with rice growing in several frontier areas.

The forests most subjected to fires are in Khabarovskii Krai. There are observed 16.1 thousand km^2 of burned down or dead forests that makes 61.5 % of the area of similar lands on the Russian territory. Their share in Amurskaya and Chitinskaya oblasts is also great, 18.4 % and 16.6 % correspondingly.

Most active loggings are in Khabarovskii Krai and in Amurskaya Oblast. At that, the share of the logging area in Khabarovskii Krai exceeds over 2 times the same average share in other regions of the Russian part of Amur River watershed.

On the Chinese territory the coniferous forests occupy the largest area within the Great Khingan Ridge in Inner Mongolia Autonomous Region, 25.3 thousand km^2. The area of coniferous forests in Heilongjiang Province, 22.5 thousand km^2 slightly cede to them. Mixed forests prevail in Heilongjiang Province, 59.7 thousand km^2 that makes 54.2 % of the area of these forests on the Chinese territory. The share of mixed forests in Inner Mongolia Autonomous Region and in Jilin Province is less, 32.5 % and 13.3 % correspondingly. The Heilongjiang Province also has the largest areas of deciduous forests, 105.2 thousand km^2. Sparse forests and bushes are most widespread in Inner Mongolia Autonomous Region that is

caused both by natural and climatic features of the territory, especially in its southern portion, and by industrial loggings of timber within the Great Khingan Ridge till 1998. Decoding of satellite images allowed us to reveal the other feature of modern state of forests on the Chinese territory. There is observed the considerable divergence between the data of the Atlas of vegetation of Chinese People's Republic [25] and the decoded data. For example, the northern portion of the Great Khingan Ridge is shown in the Atlas of vegetation as a zone of practically continuous distribution of coniferous forests. However, the decoded data show that at present the deciduous forests dominate there, and the coniferous and mixed forests are typical in the central and southern portions of the Great Khingan Ridge.

A high share of timber cuttings in Jilin Province, 36.3 % of the logging area in the Chinese part of the watershed appeared to be unexpected also. It is necessary to note that the center of timber cuttings in the Chinese People's Republic has moved to the artificial forests, partly created for these purposes. Besides that, it is necessary to take into account that the used data can not reflect the present situation in full because the objects of the area less 50 km^2 have not been displayed on final map, in practice forest tracts of the smaller areas are frequently cut down.

The main areas of agricultural lands, reclaimed lands, wetlands which shares are 63.1 %, 67.8 % and 58.3 % of the area of similar categories of lands in the Chinese part of Amur River watershed, are situated in Heilongjiang Province. It is interesting to compare the data on irrigated lands, received in result of decoding satellite images, and the official statistical data. A large portion of irrigated lands in Heilongjiang Province is used for rice growing. The statistical data show [29] that in Heilongjiang Province in 2001 paddy fields occupied 1598 thousand hectares, the decoded data practically completely coincide with these figures, or 1600.9 thousand hectares.

In the Mongolian portion of Amur River watershed the forested territories are situated in Hentei, Tuva and Dornod aimaks. At that, most part of coniferous, mixed and deciduous forests locate in Hentei Aimak, 79.1 %, 82.1 % and 49.3 % of the area of these forests of the whole Mongolian territory correspondingly. There are also 73.5 % of sparse forests, and nearly 51 % of bushes of this portion of the watershed.

Dornod Aimak is also characterized with a wide spectrum of land-use. Deciduous forests dominate among forested lands, which share makes 24.7 % of these forests in the Mongolian portion of the watershed. The share of coniferous and mixed forests is much less, 5.6 % and 2.3 % correspondingly. Sparse forests and bushes are widely distributed, 21 % and 43.5 %. Approximately a half of meadows of the Mongolian portion of the watershed is concentrated in this aimak. There are also 86.5 % of its agricultural lands.

Despite of small area of Tuva Aimak in Amur River watershed (5 %), over 15 % of coniferous and mixed forests, 26 % of deciduous forests, and 8 % of meadows and bushes of the Mongolian portion of Amur River watershed is distributed there.

CONCLUSION

The map "Modern land-use in Amur River watershed" in the scale 1:2,500,000, compiled by results of decoded satellite images Landsat TM, has allowed us for the first time from unified positions and in uniform scale to assess a character, structure, national features of land-use on the territories of Mongolia, Chinese People's Republic and Russia, included in Amur River watershed. Chinese portion of the watershed is the most economically developed one.

Comparison of the compiled map with thematic maps from the Atlas of vegetation of China [25], and with the map of vegetation of Amur River watershed [13] shows essential simplification of structure of forests towards a prevalence of invaluable woods. Especially it concerns to the northern portion of the Great Khingan Ridge, Less Khingan (both in Russian, and in Chinese portions), northern portion of Sikhote-Alin Ridge, and Chitinskaya Oblast. These changes resulted from active policy of industrial timber cutting existed on the Chinese territory of the watershed up to the end of the 1990s last century, proceeding timber cuttings on the Russian territory, and also forest fires, annually arising, especially on the Russian territory. 78 % of the cut forests in Amur River watershed and 97 % of the burned forests are on the Russian territory.

A significant expansion of the area of agricultural lands that occurred in the Chinese People's Republic in the 1990s and in 2000-2001 has been observed. These changes at first concern Sanjiang Plain, and eastern foothills of the Great Khingan. In many cases it is associated with reduction of the area of wetlands and forests. Most part of wetlands is still concentrated in the Russian portion of the watershed (in Amurskaya Oblast, Evreiskaya Autonomous Oblast and Khabarovskii Krai).

These essential distinctions in modern land-use on the territory of countries belonging to Amur River watershed stipulate an existence and development of sharp transboundary environmental problems. Among them are impoverishment of biodiversity, disturbance of migration ways of wild animals and their forage reserve, fragmentation and partly destruction of habitats, increased fire danger, high risk of flooding, contamination of surface waters, water and atmospheric transfer of polluting substances.

The compiled electronic map is, in first, an information basis for carrying out of the further analysis of system of land-use in Amur River watershed, and, in second, as an electronic layer it is a component of forming geo-information space of the whole Amur River watershed.

Development of the unified policy of ecologically balanced land-use agreed between the countries is necessary for improvement of ecological situation in the watershed.

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