Landscape and Climate Specifics for Water Sensitive Urban Design in Vladivostok

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Abstract. The article concerns with the conditions and special aspects of urbanized areas’ natural hydrological cycle recovery in monsoon climate and hummocky topography conditions of Southern Primorye through the example of Vladivostok. Natural infrastructure and catchment area original state and anthropogenic transformation in urbanization process of Murav’ev-Amursky peninsula Southern part is analyzed. Through the natural landscapes estimation three types of catchment areas due to seasonal changing of their contribution to river system water content were defined. Their correlating with the transport infrastructure and industrial areas locations made it possible to find out problematic areas and water system restoration reserves.

1. Introduction

Hydrological cycle natural performance recovery problem is nowadays regarded in the scores of concepts adapted to regional conditions, but the differences between them are not radical [1]. The most well-known are: - Water sensitive urban design, WSUD [2]; - Low impact urban design and development, LIUDD [3]; - Sponge city concept [4]. Water sources responsible treatment urban design concepts have been developed and implemented in many large-scale urban planning projects of the following companies: – De Urbanisten; - Turenscape Landscape Architecture. Necessary guidelines for water-saving urban design are established by the City Councils of Oakland, Wellington, Vancouver [5]. Water-saving urban design is only particularly used in Russian practice for the water and green systems creation [6]. For the Southern part of Russian Far-East and its biggest city – for Vladivostok - this problem hasn't been explored in its architectural and urban-planning aspect.

2. The problem

Nowadays Vladivostok area hydrological cycle and its natural performance recovery specifics are defined by the monsoon climate and hummocky topography, significantly modified by urban infrastructural development. Stiff and rutted forestless slopes up to 150-200 meters high; streets running in the flat-lying valley bottoms; transport hubs, public spaces and industrial areas located in the city lowlands are creating good conditions for the fast flows, soil ablation, mudflows evolving and fast flooding. City's river system significantly damaged by human activity also is not capable of receiving rainfall floods during tropical cyclones and providing stable watering of the city area during the dry season.
Predominance of the surface runoff together with direct anthropogenic impact is one of the basic reasons for city greenery degradation in conditions of rainy and dry seasons alternation typical for monsoon climate. The lack of spring humidity was covered with the sea fog moisture in the natural conditions. On the windward slopes and watersheds of the presently lost woodlands rainfalls could be observed under the trees’ crowns on foggy days. The moisture collected by the leaves and needles was enough to damp dry soil and support river system water content before the rainy season [7]. During the second half of summer these slopes preserved areas from tropical floods, and in windy wintertime served as natural snow collectors.

Contemporary water sources responsible urban design methods are first of all based on giving the lost natural features back to urbanized areas. Natural landscapes initial characteristics research and their further man-made changes level estimation are the basement for urban planning, architectural and landscape design activities development for the city environment renovation. Southern Primorye natural landscape and climate features as well as Vladivostok urbanized landscapes (often developed with no connection to its’ natural background) diversity should define the wide range of these activities. So, to develop a program for Vladivostok urbanized areas natural hydrological cycle recovery, firstly we need to explore initial natural landscapes contribution to water system in its natural condition, and then to estimate urban landscapes modern condition as a result of their man-made transformation. Regarding vast woodlands and islands with natural hydrological cycle inside the borders of Vladivostok city district, this research deals with the main housing development footprint - from the seaside water area to Sedanka-Parokl highway.

3. Pre-urbanistic period city area landscape model
The main features of Vladivostok landscape are defined by the hummocky ridge Bogataya Griva stretched almost in meridional direction, rutted in latitudinal direction by the deep river valleys and surrounded by the water area of Peter the Great gulf. The city natural infrastructure in the borders of main development footprint is formed by the extensional watersheds and river valleys of latitudinal direction, water-collecting basins' lowlands and hills’ offsets of predominantly meridional direction, and irregular coastline.

Extensional watersheds of latitudinal direction and their offsets stretched along the meridian are shaping the first - landscape subsystem of city's natural infrastructure. Until recently, apparently before 60th, the landscape subsystem was free of housing development and mainly saved the forest cover. This allowed it to keep city rivers water content supporting function. With the beginning of a “bigger” Vladivostok development the watersheds, especially in the central part of a city, were developed, and the greenspace area was significantly reduced (figure 1).

Figure 1. Vladivostok landscape natural infrastructure (visuals – Y Marus); city natural framework and catchment area (visuals – A Smelovskaya).
Natural infrastructure’s water subsystem is represented by the river beds of latitudinal direction, existing and lost inflows and streams, stretched along the meridian, and by the seaside waterfront. The lost watercourses - city streams and affluents replaced by the streets network - in fact are still implementing watercourses’ function during rainfalls, and should be regarded as a part of a city water framework to restore the natural hydrological cycle on its area (figure 2).

Figure 2. River system and its interaction with the street network, transport and industrial city areas (visuals – A Smelovskaya).

The city area water-collecting network in its natural condition before the middle of the XIXth century was represented by the areas of three types:

1) Slopes covered with forests opened to south-eastern summer monsoons and slopes at the point higher than 150 m (areas which were actively collected and accumulated fogs’ moisture during spring period in May-June and slanting rains moisture all warm season long);

2) Northern orientation slopes and shaded terrain areas protected from strong winter insolation (city areas which accumulated snow until the plus temperature and had an impact on supporting rivers’ water content in March and April before the foggy season)

3) Terrain areas neutral to vector climatic factors impact on precipitation and surfaces moisturizing regime (figure 3)

Aerial mapping is implemented according to Vladivostok wind and insolation regime modeling [8].

4. Natural landscapes transformation in the anthropogenic development process

During the anthropogenic development period the water-collecting network was dramatically changed. To estimate its current state, the following factors were considered: (1) permeable surfaces ratio for different types of city landscapes - the leading factor in defining changes of natural hydrological cycle (based on a classification suggested by the National Research Council, USA [9]) and (2) housing height and its existing woodlands correlation - additional factor influencing precipitation event character and surface moisturizing in monsoon climate.

The high-density quarter development of the city center is notable for minimal greenery and small specific area of permeable surfaces, but at the same time its average height of 4-7 floors is not influencing wind regime and hydrometeors fallout character too much. Most area of this high-density part of a city is shaded. The main block of 4-6 stories ribbon development of 60th-70th is currently almost fully concealed with high trees, and their grass plots provide significant proportion of permeable coverings. Spatial characteristics of this development type match the natural spatial
characteristics of greenspace and almost don't influence the areal wind regime while saving summer and winter precipitation events character close to natural. Insolation regime of this development type is also close to natural, typical for the broadleaf woodlands during the warm season. The fall of 80th-90th ribbon development and nowadays office and dwelling high-rise development outside the limits of natural spatial characteristics of greenspace had significantly changed initial wind and insolation regime and eliminated the possibility to restore it with creating woodlands. The proportion of permeable coverings in this development type is significantly reduced and their considerable part is given to stony artificial slopes with no trees or green plots. Industrial and transportation areas are notable by almost total absence of permeable surfaces and greenspace and their considerable part is given to neutral for the vector climatic factors influence areas.

Figure 3. Vladivostok catchment area estimation before urbanization and its current state (visuals – A Smelovskaya).

5. Results

As can be seen from the above, the city catchment area in the borders of main housing development footprint is currently represented by the following areas: - close to natural landscapes by its hydrological cycles: mainly greenspace and park areas (30% of overall territory); - low-rise development areas on stiff slopes in the city center and villa development of the suburbs - these areas have about 10-20% of permeable surfaces (5% of overall territory); - ribbon development of 60th, where non-permeable surfaces take about 35-50% (10% of overall territory); - urban landscapes where non-permeable surfaces take 75-100% with inconsiderable influence on precipitation events (industrial, transport and storage areas, quarter development, public spaces and embankments of the city center (25% of overall territory); - urban landscapes where non-permeable surfaces take 75-100% with significant influence on precipitation events caused by housing development height and spatial configuration (high-rise hotspot development, high-rise ribbon development of dwelling complexes and communities) (10% of overall territory). The rest 20% of the city area occurs to ballast pits, ash-disposal areas, bare places and forestless slopes (covered by rocky and clayey soils, construction debris, particularly grassy and twiggy growth).

It is necessary to develop specific natural hydrological cycle restoration approaches for each aerial type regarding regional landscape and climatic conditions (figure 4).
6. Discussion
The comparison of Southern part of Murav’ev-Amursky peninsula natural infrastructure and catchment area structure of pre-urbanistic period with the contemporary urban fabric and development structure of Vladivostok reveals complete disregard of landscape and climatic features in regards of supporting its natural hydrological cycle and providing sustainable city development. Actual building codes do not contain directives for creating city environment sustainable to climatic changes, providing natural ecosystem restoration and creating comfortable conditions for the citizens on this background. For example, Vladivostok city district General plan deals only with distributing multiple functions in continuous development within the main housing development footprint with no limitation to reduce existing greenspace [10].

Correlation of the first type catchment areas diagram with the General plan reveals that slopes and tops of hills which still remain woodlands and provide the water content for the Eastern part of the city river system during spring-summer period are given for dwelling and socio-economic development due to 2018 General plan. These areas include Zelyonyi Ugol ward, Uliss bay, Ayaks bay seaside perspective development. The negative implication of this approach are obvious not only in climatic deterioration of the city’s central part (Eastern woodlands are still protecting housing development from the humid sea-turns), but firstly in continuous degradation of its water system.

7. Conclusion
To create the sustainable city environment, we need to regard the city area as a whole united system where the catchment area characteristics provides needed water content for the city river system through implementing approaches to renovate and restore the natural surfaces permeability not only within the designated water areas but in the entire territory of the city. The natural framework-catchment area model developed in this research should become a background for further suggestions on Vladivostok urban fabric and housing development transformation to address its landscape and climatic features.
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