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МОДЕЛИРОВАНИЕ ОКРУЖАЮЩЕЙ СРЕДЫ ПРИБРЕЖНЫХ ГОРОДОВ: ГОРОДСКИЕ ПЕЙЗАЖИ КАК СЛОЖНЫЕ, УЯЗВИМЫЕ И ДИНАМИЧНО РАЗВИВАЮЩИЕСЯ СТРУКТУРЫ

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***Аннотация.** Область исследования сосредоточена на при-
брежном городе Тайбэй. Экологические изменения города были
обнаружены с помощью геопространственного анализа спут-
никовых снимков. Площади, занимаемые различными типами
ландшафта, были проанализированы. Было обнаружено, что
разные части города развиваются с разной скоростью и ин-
тенсивностью из-за сложного сочетания антропогенных и
природных факторов. Результаты показали урбанизацию, де-
градацию зеленых ареалов, увеличение площадей застроенных
территорий с 1990 года.*

***Ключевые слова:** урбанизация, Тайбэй, экология города, модели-
рование.*

ENVIRONMENTAL MODELLING OF COASTAL CITIES: URBAN LANDSCAPES AS COMPLEX, VULNERABLE AND DYNAMICALLY DEVELOPING STRUCTURES

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***Abstract.** The study area is focused on the coastal city of Taipei.
The environmental changes of the city were detected by geospatial
analysis of the satellite images. The areas occupied by different
landscape types were calculated and analyzed. It was detected that
various districts were developing with different rate and intensity
due to the complex factors of both human and ecological origin. The*

results showed urban development, decline of green areas, increase of urban spaces since 1990.

Keywords: *city development, Taipei, urban ecology, modeling.*

The study area is located in the city of Taipei, Taiwan. Recently, the process of urbanization has become more notable in the East Asia. Since past decades, Taipei undergone serious urban changes as residential structure of the vacant land areas is developing and requires modifications. The development of urban landscapes in Taipei has unique feature; that is, the Taiwan's exceptional economic and industrial growth since 1980s, which is often referred as «industrial wonder of Taiwan». The country quickly transformed from an agriculture-based traditional economy into a highly industrialized society.

As a result, Taiwan has now a new face of high-technology oriented, economically restructured economy, which is a part of the global network of economies and capitals, playing important role both in the Asia–Pacific region and in the global production chains. Necessarily, this caused notable changes in the face of the country, modifying both its social and natural landscape patterns. Thus, Taiwan is nowadays a highly urbanized country with almost 80% of the total population of Taiwan living in urban areas. However, intensive urbanization necessarily create new conditions for human-nature co-existence, since rapidly growing city and high urbanization rate affect biodiversity and ecosystems sustainability in the coastal area. The process of urbanization includes transformation of landscapes: natural land cover types, typical for the area are being modified into artificial surfaces and the area of city enlarges.

Anthropogenic pressure increased rapidly due to the expansion of the city area. Intense urbanization affects complex interrelations of natural and urban ecosystems, changes their structure, size and shape, which gradually became a serious environmental problem. At the same time, Taipei has unique coastal landscapes with high environmental value, outstanding natural beauty, rare and extinct species. In vies

of this, environmental monitoring should be considered for effective city management and nature conservation on the island. Various research publications were reported on the environmental and anthropogenic interactions on Taiwan Island. In an overview of these studies on the environment in various regions of the island and consequences of the urban growth on the ecosystems were extensively used as substantial reference books, journals and textbooks. Analyzing the most recent research finding on Taiwan landscape studies, following papers were given particular attention. Studies of the urban structure of Taipei city have been performed recently using applied methods of space syntax measurement to assess accessibility of street configuration and city public transportation networks [12]. With the essential infrastructure, roads, properties, housing and building construction, business and administration structure adopted from the Japanese urban town planning system, the capital Taipei is a highly complex multi-functioning and planned urban system. It includes a highly developed artificially planned street configuration and a dense public transportation networks with metro lines and buses [12]. According to the energetic intensity, the urban landscapes in Taipei metropolitan area are divided into several types: urban core, residential districts, service and manufacturing districts; agricultural areas, newly developed suburbia and natural areas. This division also indicated the intensity of the human pressure on the urban landscapes. Accordingly, the surroundings of the Taipei metropolitan region have the least anthropogenic pressure. Nevertheless, suburban areas are often notable for their valuable natural environment and resource bases, which provides essential energy and resources for the balanced ecosystem functioning of urban ecosystem.

The landscape diversity is the most clear attribute of the landscape health and stability in the landscape ecology context since it responses to the urbanization and its relationships with other aspects of landscape. Therefore, the landscape diversity is considered as a crucial criterion in the planning and evaluation

of the landscape [6], [2]. For instance, the landscape diversity was used to detect correlation between changes in landscape diversity and spatial pattern of landscape elements caused by land cover changes [11]. Moreover, there is a significant correlation (75%) between the landscape diversity and degree of urbanization in Taipei city. Predictably, the landscape diversity is higher in the rural and less urbanized areas, while it increases in the urban areas due to the domination of the human-induced landscape types and reduced number of natural patches within the city.

Regions land cover types	1990, %	2005, %
Region I: "urban areas"	17,1	21,9
Region I: "urban vegetation"	5,7	4,1
Region I: "forests"	19,8	18,6
Region I: "grasslands"	21,4	18,3
Region II: "urban areas"	79,3	83,2
Region II: "urban vegetation"	4,3	5,2
Region II: "forests"	32,7	31,8
Region II: "grasslands"	15,9	14,7
Region III: "urban areas"	24,3	38,2
Region III: "urban vegetation"	3,7	4,3
Region III: "forests"	42,4	41,8
Region III: "grasslands"	13,8	12,1

Table 1: Calculated changes in land cover types within the city of Taipei. comparison of landscape changes in urban area, 1990–2005.

The patch size is important both for landscapes sustainable functioning and for the landscape management and planning. Thus, patch configuration is a crucial criterion for such applications as habitat design, watershed management, forestry, setting of electoral district boundaries and local authority planning [1], [8]. It is demonstrated recently [7] that bird diversity in the Taipei basin shows different distribution patterns for urban and suburban bird communities, respectively. Thus, metropolis and consequences of urban

space cause changes in the spatial characteristics of bird communities at the landscape level, which proves that urbanization cause decrease in species diversity, in general. Natural land cover types, typical for the given area are being transformed into human-affected artificial surfaces [3]. The landscape fragmentation indicates loss and significant damage of the habitat patches, reduced size and modified shape of the selected patches.

The urban system of Taipei metropolitan region can be clustered into six homogeneous urban zones of ecological energetics demonstrating that urban center of Taipei is notable for the high level of consumption of non-renewable energy sources (water, petroleum, natural gas, fertilizers, electricity, etc.), high anthropogenic, economic and industrial impacts. Other consequences of urbanization include significantly altered aboveground net primary productivity and soil respiration rates, compared with natural ecosystems [5], air pollution and decreased water quality. The uncontrolled urbanization causes also gradual limitation of the land and water resources, which leads insufficient infrastructure within the city and consequently, contributes to the development of densely concentrated mixed types of land use. About 45% of the Taipei city is categorized as restricted with regard to availability and usage due to its topography, while only 14% (46.30 sq.km) is available for residential and commercial development [12]. Nowadays, new city face consists of built-up new apartments, buildings, office centers, residential areas, re-structured districts. This process is reinforced by the average structure age of the buildings and modernization [8]. Overall, the city structure, such as streets configuration or public transportation networks, have a substantial impact on the face of urban landscapes. For instance, modification in the city planning in Taipei causes redistribution of the urban activities which, in turn, affect landscapes [10].

At the same time, Taiwan Island has unique natural landscapes with high environmental value, outstanding natural beauty, rare and extinct species. In vies of this, conservation

efforts initiated starting 1980s which, however, mainly focused on natural ecosystems outside cities. Green spaces, located in the urban areas, create habitats for diverse floral and fauna species and contribute significantly to the conservation of urban diversity. Therefore, a balance between man and nature should be strictly maintained in the city and urban landscapes protection actions should be taken. The Cultural Heritage Preservation Act enacted in 1981, replied to this need by selecting nature reserves and listing protected species [4]. Nowadays there are several Natural Parks and reservation zones existing in the island which contain unique land cover types and strictly protected areas for nature conservation.

Taipei urban landscape consists of different types of patches, including built-up areas and natural landscapes. The structure of landscape, shape and configuration of different land cover types change significantly according to the urban district location and the level of urbanization in this specific area. The classification of the land cover types in the Taipei metropolitan area includes following 10 major types: 1) Forests; 2) Wetlands; 3) Grasslands; 4) Open fields with little or no vegetation; 5) Rivers, channels; 6) Lakes, ponds; 7) Cultivated lands 8) Livestock farms, agricultural facilities; 9) Parks and squares; 10) Urban built-up areas. Using physio-geographic and social data on Taipei, the region was divided into three distinct regions, as follows: Region I located on the left bank of Tamsui river, “agricultural” area; Region II the core, old city of Taipei; Region III the region located southwards from the core city. The calculation of the changes in the landscapes were performed for each area and each land cover type respectively. Using calculations of the land cover types that belong to the assigned areas on the classified images in 1990 and 2005 respectively, the results have been received and summarized in Tab.1.

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