

LAND AREA INCREASE IN UKRAINIAN PART OF THE DANUBE DELTA

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Abstract. *The quantitative indicators of land growth in the Ukrainian part of the Danube delta are considered. Comparison of Landsat satellite images in three key areas of the delta showed that for the period 1975-2020 the area of wetlands at the mouth of the Chilia channel increased by 1448 hectares due to the accumulation of sediments between the Starostambul and Limba branches and their overgrowth with vegetation. In the area of the Bystroe channel, the area of new lands increased by 1037 hectares due to the artificial deepening of this channel for the Ukrainian ships passage into the Danube River and the deposition of sediments along the coast. A slightly smaller increase in land cover (797 ha) was found in the northern part of the coast of the Ukrainian part of the delta, where saline and carbonate soils are formed. In the future, active land growth is expected in the Musura bay between the mouths of the Starostambul and Sulina branches, ie at the contact of Ukraine and Romania. Some changes in these parameters are expected after a powerful flood in 2021, which will become known after the establishment of a relative equilibrium between the processes of accumulation and erosion after this extreme event.*

Key words: delta, land area, river runoff, space imagery

Introduction. In last century a powerful process of large rivers flow regulation and intensive water resources use has covered most of our planet [2, 3]. High dams began to block rivers, to create huge reservoirs, accumulate in them both river water and sediments. With such a deep transformation of water and solid runoff in rivers, geomorphological processes in their deltas have changed significantly. The formation of new morpho-elements of deltas has slowed down, deltaic landscapes have begun to dry up, often - to be subject to salinization, degradation, and in arid regions – even desertification [4, 5]. And the sea edge of many deltas

began to erode due to reduced sediment inflow, waves, currents, etc. Such a fate did not bypass our main Ukrainian rivers – the Dnieper, the Dniester, as well as the large cross-border river Danube, part of the delta of which belongs to Ukraine.

Under such conditions, the long-term growth of "wetlands" in the deltas of the Dnieper and Dniester, which are formed in large estuaries, has slowed down. However, a controversial situation exists in the Danube Delta, which is washed by the Black Sea. This huge delta is formed by three channels (courses), of which the largest northern (Chilia) channel forms the Ukrainian

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part of the delta, and the central (Sulina) and southern (St. George) – the Romanian part (Fig. 1 and 2).



Fig.1. Danube Delta (Landsat-8 satellite image)

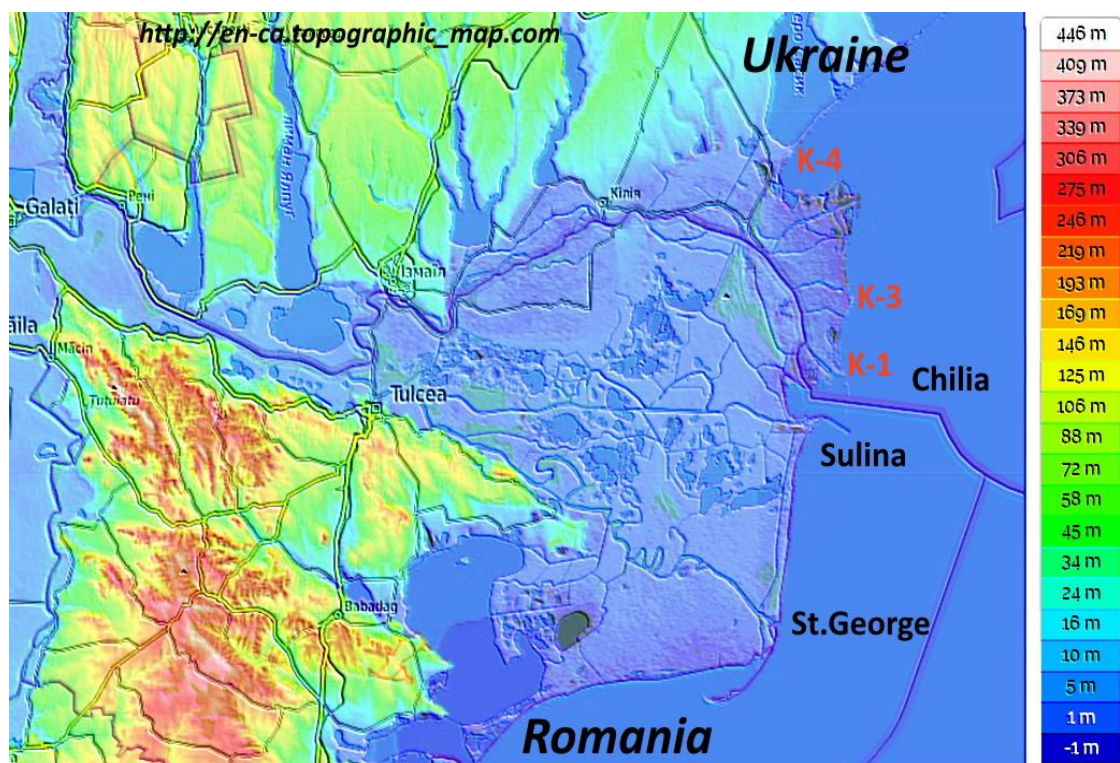


Fig.2. Digital map of the Danube Delta

In the past, most of the water and sediments runoff in the Danube delta flowed into the Chilia channel, ie in the Ukrainian part of the delta. Accordingly, the increase in the land area of the Chilia

part of the delta was the largest. In recent decades, part of the river flow along the Chilia channel has been gradually declining due to the water resources use and even the construction of a special

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stone spur at the top of delta to redistribute runoff in favor of the Sulina branch.

According to [1], all water runoff in the Danube river was 194 km³ in 1840-1920, but 212 km³ in 2003-2016. However, sediment runoff decreased from 62.8 till 24.9 million ton for that period. And Ukrainian part of the water and sediment becomes less.

Research methods. Delta changes were monitored by analyzing Landsat 2, 4-5, and 8 space images over a long period from 1975 to 2020. In the Ukrainian part of the delta, 3 key sections were selected in the north (key 4 in the area of the Ochakiv course), in the middle (key 3 in the area of the Bystre course) and in the south between the Ukrainian and Romanian parts of the delta (key 1 between Chilia and Sulina channels). Another 4 keys were selected in typical areas of the Romanian part of the delta [7], but they are not analyzed in this article.

Analysis of results. Our field research in 2012 [5-7] showed that the runoff along the Chilia channel is still predominant so far. And the analysis of space images in 2020 confirmed that today the growth of land resources in the Ukrainian part of the delta continues [8]. At the same time, in the some south-eastern parts of the Romanian part of the delta, erosion processes and a decrease in the area of the wetlands predominate. The calculation of areas in key plots of the Ukrainian part of the delta showed that in the mouth of the Chilia channel (

called below the village of Vilkovo as the Starostambul branch) the increase of wetlands for the period 1975-2020 amounted to 1448 hectares due to sediment accumulation and development of hydrophytic and hygrophytic vegetation. New wetlands are formed there mostly along the northern part of the Musura bay, where territory between the Starostambul and Limba branches belongs to Ukraine. At the same time, formation of the spit "New Earth" between the mouth of the Starostambul and Sulina branches promotes the intensification of accumulation processes and the formation of new wetlands (Fig. 3). Slightly less (1037 ha) of new lands were formed in the area of the Bystre branch, where the riverbed deepened for the passage of Ukrainian vessels into the Danube and sediments accumulated along the coast (Fig. 4). Silty-sandy material is deposited between the Bystroe and Vostochnoye branches and slowly begin to overgrow with vegetation. The rock-fill spur near the Bystre channel also contributed to the accumulation of sediments along the coast between the Podennoye and Bystroe channels [1] due to alongshore currents.



Fig. 3. Increase in the area of wetlands at the mouth of the Chilia channel (key 1)



Fig. 4. Increase in the land area near the Bystre channel (key 3)

About 797 ha of new wetlands were formed in the north of the delta in the Jebriyanska bay. They are formed by sediments of active and dying channels of the Ochakivsky branch system, deposits of sand and shell fragments brought by sea waves and currents, as well as organic matter of dying vegetation, especially in the western part of the bay. So called “Salt Kut” (“Salt

Corner”) gradually turned there into an isolated lake, and salt-resistant vegetation (herbaceous and shrubby) is formed on its banks (Fig. 5). In the easternmost part of this territory (Prorva, Potapovsky and Gneushev branches), the processes of accumulation and erosion alternate, leading to the displacement of shoals (spits) in their mouths.

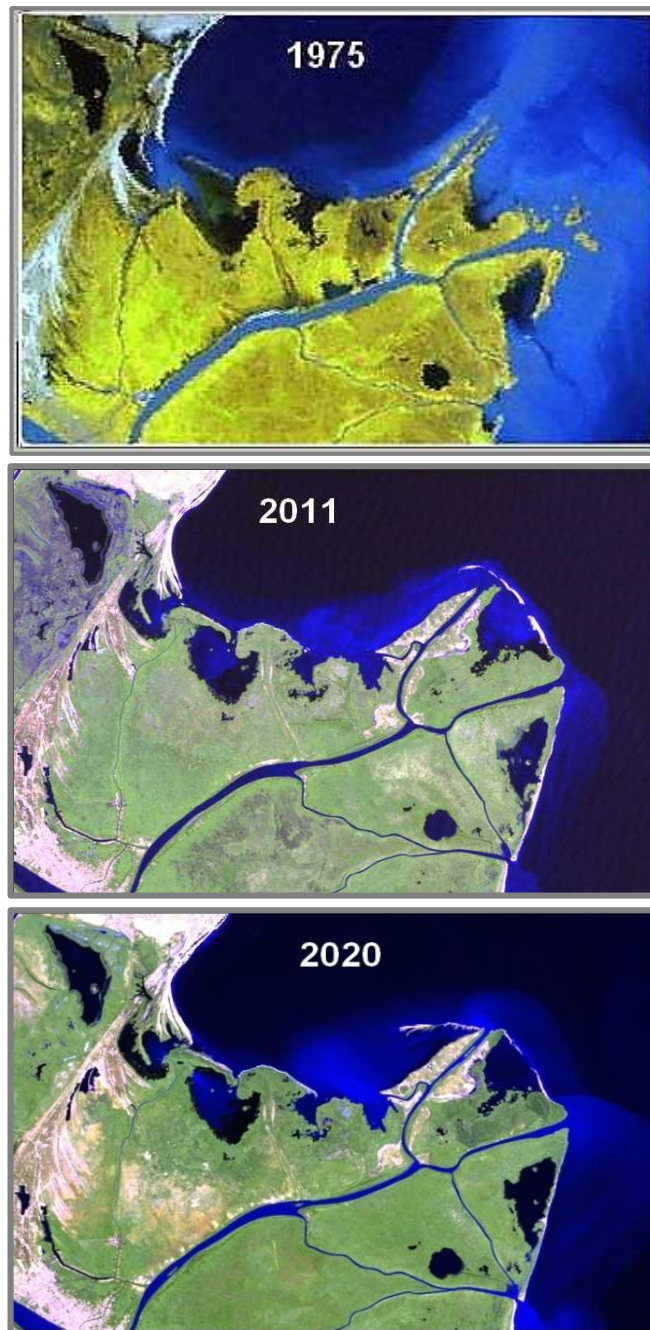


Fig. 5. Land growth in the area of the Ochakiv branch (key 4)

Conclusion. In general, the Ukrainian part of the Danube Delta (within the named large key areas) increased by 3,282 hectares between 1975 and 2020, despite a decrease in the inflow of water and sediments along the Chilia course over the years. In addition, there is a noticeable reduction in flooding of wetlands, especially in Zhebriyivsky floodplains. Landsat-8

space images also show areas of alluvial deposits more clearly, which indicates a certain drying of these areas. When evaluating the obtained results, it should be borne in mind that the authors do not know the exact passage of the state border of Ukraine and Romania through the newly created spit "New Land" between the Chilia and Sulina riverbeds.

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Our aim was to estimate the general trend of land cover change in the Ukrainian part of the delta. Much more detailed quantitative investigation of land cover change in 2001-2016 has been made by Russian scientists [1]. According to them, in this century Ukrainian part of the delta increase with average rate 88.2 hectare per year.

It is worth noting that strong and prolonged rains this summer in Europe have noticeably increased the runoff of water and sediments (Fig. 6). So they can make some changes in the specified parameters of the increase in the land surface in Ukrainian part of the delta. However, the quantitative indicators of this process can be estimated after the so-

called "time lag" between the extreme event (flood) and the equilibrium state on the coast.



Fig. 6. Ukrainian part of the delta in 2021 after strong rains in Europe.

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ПРИРІСТ ЗЕМЕЛЬ В УКРАЇНСЬКІЙ ЧАСТИНІ ДЕЛЬТИ ДУНАЮ

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Анотація. Розглянуті кількісні показники приросту земель в Українській частині дельти Дунаю. Порівняння зображень супутників Ландсат на трьох великих ключових ділянках дельти показало, що за період 1975-2020 рр. площа

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новостворених перезволожених земель в усті Кілійського русла Дунаю збільшилась на 1448 га завдяки акумуляції наносів між протоками Старостамбульська та Лімба і їх поступовому заростанню рослинністю. У районі русла Бистре площа нових земель збільшилась на 1037 га внаслідок цільового поглиблення цього русла для проходу українських суден у Дунай та відкладання накопичених при цьому наносів уздовж узбережжя. Деяко менший приріст земельного покриву (797 га) було виявлено у північній частині узбережжя української частини дельти, де формуються засолені й карбонатні ґрунти. У перспективі активний приріст земель очікується в затоці Мусура між устями проток Старостамбульська й Суліна, тобто на контакті України та Румунії. Певні зміни вказаних параметрів також можливі після потужної повені на Дунаї влітку 2021 року, але вони стануть відомими після встановлення відносної рівноваги ("time lag") між екстремальною подією (повінню) й процесами акумуляції й ерозії в устях проток.

Ключові слова: дельта, земельний покрив, річковий стік, космічний знімок