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Climatic Conditionality of Soil Washout from the Surface of Mountain River Basins and its Mapping Using GIS Technologies

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Abstract. The article discusses the issues of studying climatic conditionality and mapping the intensity of soil loss from the surface of catchment areas of mountain rivers in Uzbekistan and adjacent territories using GIS technologies. Data on the runoff of suspended sediment from rivers were used as source materials. Flush maps were compiled separately for the Chirchik, Akhangaran, Kashkadarya and Surkhandarya river basins. It is shown that the highest values of washout intensity are confined to altitudes of 1100-1700 meters, and their lowest values correspond to altitude intervals below 1100 and above 2500 meters. The reasons for the differences in the zonal intensity of soil loss have been identified.
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1.Introduction.

The issues of studying climatic conditionality and mapping the intensity of soil loss from the surface of mountain river basins have both scientific, theoretical and applied significance. As is known, in the studies of A.I.Voeikov and others, the dominant role is given to climate among the natural factors influencing the hydrological regime of rivers. According to the results of the study by K.S. Kabanova, G.V.Lopatin, O.P.Shcheglova, F.Kh. Khikmatov and several other authors, this judgment is quite valid for river sediment runoff - the main indicator of the intensity of soil washout from the surface of their swimming pools. Summarizing the results of research by previous scientists, O.P. Shcheglova notes that the runoff of suspended sediment is a product of the climate of river basins, against the background of other additional factors (Shcheglova, 1984; Khikmatov, 2011). The value of O.P. Shcheglova’s research results lies in the fact that she has developed various versions of the genetic analysis method, which are entirely based on the use of climatic observation data carried out at hydrometeorological stations and posts. The variants of the genetic analysis method developed by O.P. Shcheglova made it possible to take a new approach to the very urgent, in practical and scientific terms, problem of mapping sediment runoff - an indicator of the intensity of soil washout from the surface of mountain river basins (Khikmatov, 2011).

It is also known that the question of the methodology for mapping sediment runoff - an indicator of the intensity of washout from the surface of mountain river basins, was widely raised by her in the 60s of the last century in connection with the creation of a series of complex atlases of Azerbaijan, Armenia, Georgia, Tajikistan and Uzbekistan (Shcheglova, 1984). During these years, T.G.Svatkova and I.S.Fedorova studied in detail the compatibility of maps of river turbidity and the intensity of soil loss from the surface of mountain river basins with other maps of natural elements. Further, M.I.Iveronova notes that the current method of uniformly distributing the removal of fine earth from mountain river basins over their entire area is too rough and does not satisfy either the demands of practice or the requirements of geomorphological analysis (Iveronova, 1968). Subsequently, A.N.Vazhnov and S.G. Musoyan pointed out that when constructing soil washout maps, it is advisable to consider their altitudinal zones separately, using the results of actual observations of suspended sediment runoff (Vazhnov and Musoyan, 1975).

Based on the provisions stated above, it can be said that the river sediment runoff observed in the lower or trailing posts of rivers cannot be mapped uniformly over the entire area of its basin. In such conditions, some scientists recommend drawing up a series of maps that provide a relationship between soil loss and changes in natural elements in different altitudinal zones (Shcheglova, 1984).

2. Main results and their discussion.

In this work, when determining the characteristics of changes in the quantitative values of the intensity of washout from the surface of mountain river basins along altitudinal zones, we were based on the results of various variants of the method of genetic analysis of suspended sediment runoff, developed by O.P. Shcheglova (Shcheglova, 1972; 1984). Since the analysis of the genesis of sediment runoff or water turbidity in mountain rivers allows, firstly, to determine the average value of the amount of soil washout from the surface of their basins and, most importantly, to more accurately estimate the differential washout modules (MR, t/km ^{2} year) by altitude zones. Secondly, the magnitude of zonal washout from the surface of river basins can be determined based on the quantitative values of flow turbidity measured at the lower or trailing hydrological station. After this, based on a genetic analysis of suspended sediment runoff, the contributions of the main components of runoff - rain, snow, glaciers, and channel runoff, which are inherent in certain high-altitude zones of river basins - are assessed (Shcheglova, 1972; 1984). Calculating the amount of flushing from the surface of various altitudinal zones of the basins of the rivers under study, using the method of O.P. Shcheglova, is based on the hydrological patterns of forming their solid and liquid runoff.

For example, according to the method of O.P. Shcheglova, the amount of soil washout due to rainwater is calculated using the following expression:

$$M_{\partial i}=10\,\rho_{\phi}\cdot x_{\partial i},$$

where: $M_{\partial i}$ - belt washout by rainwater in the i-th altitudinal zone, t/km ^{2} . year, calculated as the arithmetic mean over the years of processing;

$x_{\partial i}$- zone norm of liquid precipitation in a given altitude zone, m; ρ_{ϕ}- fictitious turbidity, kg/m^3 , this erosion characteristic was introduced by O.P.Shcheglova. According to its definition, the ratio of the mass of fine earth carried out by rain runoff on average per year to the average long-term volume of precipitation in the same catchment area has the dimension of river water turbidity.

When calculating the amount of zonal washout from the surface of the basins of the rivers under study by melted snow water, another method was used. The altitudinal positions of the snowmelt front and the lower boundary of the snow cover are determined by the hypsographic curve, which makes it possible to determine the area simultaneously involved in snowmelt and washout. As is known, as snow reserves are depleted, this area moves up the basin during the flood. Knowing the monthly removal of fine earth by melt water and the area involved in its formation, it is possible to calculate the average monthly melt snow washout from the area simultaneously active in a given month. By summing the monthly values of melt washout in each of the altitudinal intervals, it is possible to calculate the total annual washout of fine earth by melt water and the average long-term values (Shcheglova, 1984).

As noted by O.P. Shcheglova, the glacial component of the runoff is involved in flushing during the melting of glaciers and glaciers - from July to September. In her opinion, it is not yet possible to differentiate it within the glacial region. Therefore, in this work we limited ourselves to determining the average flushing modulus for this entire area.

It is accepted here that the removal of fine earth by melted snow waters in certain months of high water can only take place in the part of the catchment area limited between the front and rear of snowmelt. Its value was calculated by dividing the glacial component of fine earth removal by the entire area of the glacial zone. To obtain a total belt washout, its zonal basin components must be supplemented with channel washout values. Taking into account the experience of O.P. Shcheglova, the values of channel erosion are averaged over the entire area of the basin.

The methodology proposed by O.P.Shcheglova makes it possible to determine quantitative values of the intensity of washout for each altitudinal zone of a given river basin. This provision served as the basis for creating a differential map of soils for the Surkhandarya River basin (Table 1).

Table 1. Height limits (m) of distribution of various washout zones in the Surkhandarya River basin

No. p/p	River basin	Washout zones, t/km ^{2} ·year							
		>50	50-100	201-300	301-400	401-500	501-750	751-1000	1001-2000
1	Karatag			900-1700	1700-3000	3000-4000_		700-900	600-700
2	Sherkent			800 -1700	1700-4200		500-600	600-800	
3	Tupalang			1100-1500	1500-2500	2500-4100	600-700	700-1100	
4	Sangardak			1600-1900	1900-3700		500-800	800-1600	
5	Khalkazhar			1600-3000			600-1100	11:00-16:00	
6	Sherabaddarya	300-400	400-1100	1100-2700					

Note: there are no flush zones 101-200 and >2000.

Identified by O.P. Shcheglova, i.e. The dependence of changes in belt washout on height were used to compile a map of the washout module from the surface of the river basin. Surkhandarya (Fig. 1).

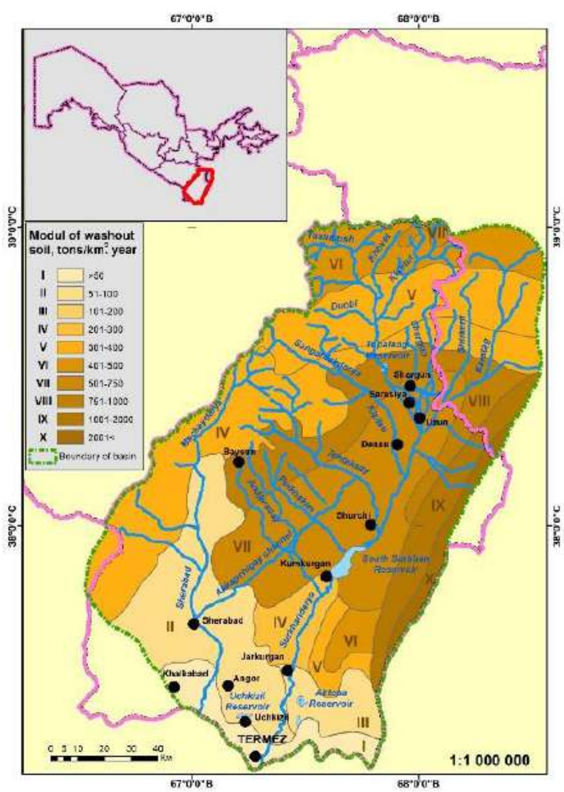

Figure 1. Map of washout module from the surface of basin of Surkhandarya river

Using the curves of the dependence of belt washout on height, maps of soil washout from the surface of the Chirchik, Akhangaran and Kashkadarya river basins were also compiled (Fig. 2,3,4). For this purpose, as mentioned above, quantitative indicators of changes in washout in altitudinal zones were determined. These indicators, using standard MapInfo and ArcGIS programs, were transferred to a hypsometric basis.

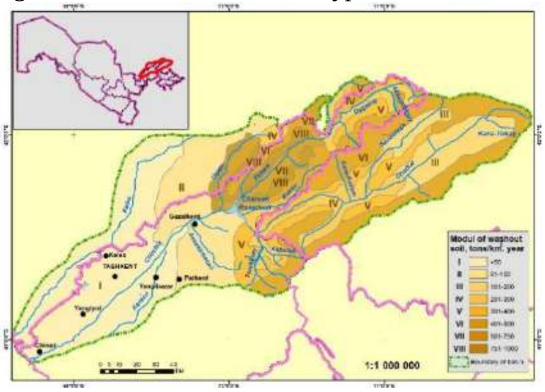

Figure 2. Map of washout module from the surface of basin of Chirchik river

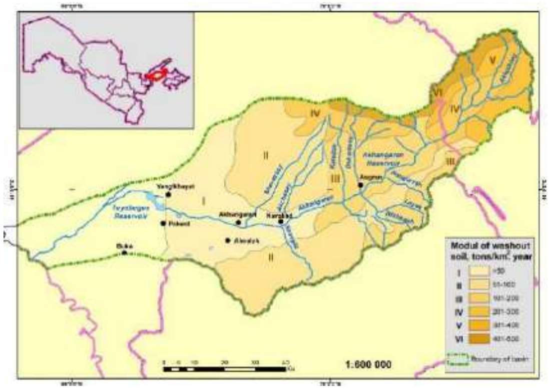

Figure3. Map of washout module from the surface of basin of Akhangaran river

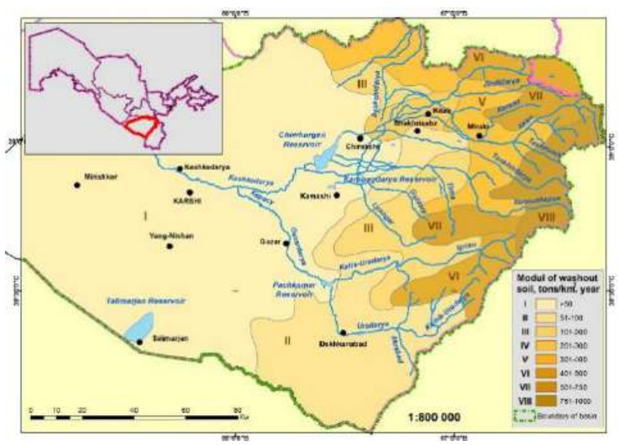

Figure 4. Map of washout module from the surface of basin of Kashkadarya river

It should be noted that O.P. Shcheglova, when mapping soil washout from the surface of river basins, identified 9 zones: <50, 50-100, 100-200, 200-250, 500-1000, 1000-2000, 2000-5000, 5000-10000 and >10000 t/km2. year [5]. These zones were clarified and distributed taking into account the natural features of the Chirchik, Akhangaran, Kashkadarya and Surkhandarya basins (Table 2).

Table 2. The scale and number of identified zones in maps of washout from the surface of river basins in Uzbekistan

Pool maps	O. P. Shcheglova		Authors	
	scale	zones	scale	zones
Chirchik	Scheme maps	3	1:1 000 000	8
Akhangaran		3	1:600,000	6
Kashkadarya		5	1:800,000	8
Surkhandarya		8	1:1 000 000	10

It is known that the number of gauging stations that measure water turbidity and suspended sediment flow in rivers is limited. Therefore, to provide more detailed coverage of the intensity of washout from the mountainous part of Uzbekistan and adjacent territories, a number of methods were used. As a result of their application and generalization of the source materials at our disposal, additional data were obtained, which led to an increase in the number of washout zones (Table 2).

Analysis of the compiled flush maps showed that the values of the flush modulus correspond to zones with altitudes from 1100 to 2500 m, and their minimum values, i.e. with a lower value of the washout modulus correspond to zones below 1100 м. and also above 2500 m, where rocks resistant to washout are common. Thus, the geography of water erosion on maps of belt washout from the surface of mountain river basins of Uzbekistan mainly corresponds to the picture of specific water content, i.e. belt drain. However, local features of moisture and the structure of the earth's surface in individual areas leave their mark on the general pattern.

3. Conclusions.

Constructed maps of belt washout from the surface of mountain river basins of Uzbekistan and adjacent territories characterize changes in the intensity of water erosion with height. They can be used to assess the loss of soils from the surface of unstudied river basins. In this case, the curves of belt washout from the surface of the analogue basin and the hypsometric curve of the studied basin should be used. It is even more rational to carry out calculations for unstudied rivers, especially within the lower mountain zone, based on the belt turbidity curves proposed by O.P. Shcheglova.

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