

DESERTIFICATION AND SUSTAINABLE AGRICULTURAL DEVELOPMENT OF TAJIKISTAN

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ABSTRACT:

Tajikistan is mountainous agricultural area and its sustainable development depends on proper farming and livestock. During the Soviet period Tajikistan specified on the cotton, sub-tropical cultures, vineyard etc., which determined the main directions of the Republic's industrial development. The collective and state farms have been organized. In 1930-40 years hundreds thousands of rural people were moved to develop valley zone. The Tugai forests, stone sandy-salinized soils, rainfed lands were cultivated. However after 1992 general fell of farming culture, lack of work capacity of irrigation networks caused the weakening of agricultural industry. The steep slopes' development, overgrazing, basic anti-erosion measures ignoring are the main causes of desertification development in rainfed and pasture zones. The main reason of desertification and fell of the agriculture in irrigated lands are the non-observance violence of irrigation norms and techniques, which often cause the raise of underground water, gully erosion and landslide. For the sustainable farming in mountain conditions, necessary to organize farming based on landscape agriculture. In different natural zones depending on slope steepness, soil features and other natural conditions we propose the complex of agriculture cultures.

1. INTRODUCTION

Tajikistan includes the highest mountain system the Pamirs Alai that is continuation of Hindu-Kush -Himalayas. The changes of modern land surface take place under the influence of the soil degradation, such as erosion (all varieties of erosion), internal erosion, landslide, karsts etc. Tajikistan is mountainous agricultural area and its sustainable development depends on proper farming and livestock. In the mountainous region haymaking and pasture lands situated on the eroded lands and very steep slopes. In these places the economic activity of human (incorrect land usage especially) often lead to intensive development of dynamic processes and change of biodiversity. Soil washout processes development didn't influence only on index of conditions of vegetation on the pasture, it also led to reconstruction of the landscape. The mountainous rangeland in Tajikistan, because of different economical usage, which stipulated by natural and historical conditions, can be divided into five different categories. They are summer pastures, winter pastures, irrigated pastures, spring-autumn pastures and year round pastures. Change of biodiversity and intensive development of the dynamic processes on the above mentioned pastures goes differently and has typical peculiarities which depend on natural and economic factors. All pasture lands on mountain territory of Tajikistan subject to dynamic processes very strong. The soil degradation is wide spread in the mountain ecosystems and annually this area increases. 97.9% of the territory of Tajikistan is subjected to soil degradation. In 1973 this index came to 68%. During 60-80th years many soil degradation problems were investigated

2. MATERIAL AND METHOD

The research conducted over the whole territory of Tajikistan in field, experimental, expeditionary and laboratory conditions. The expeditionary methods (S.S.Sobolev, 1949) allowed

measuring the washout of soil by investigating the volume of rill erosion on the elements of the relief forms. The rain off and the washout of soil have been studied on the permanent plots rain off, length 5-30 m, width 3-5 m, slope steepness 5-28 degrees and on different slope expositions. The dynamic of the development of the gully erosion has been studied by the stationary method during 25 years on 250 gullies in all of the natural geomorphologic zones. The spreading of the soil degradation (surface, rill, gully, irrigation and other varieties erosion) has been studied on the base of space photos, our worked up methods for the mountain territory (Akhmadov, 1979).

3. RESULTS AND DISCUSSION

3.1 Pasture Zones

In the valley and low mountain zones the winter pasture is situated, where the precipitation's falling winter-spring periods. The characteristic feature of Tajikistan winter valley pasture is the tugai or riparian forest. Here we can observe the wide spread desert pasture. In the upper boundary of middle and high mountain zones the summer pasture is situated. 89% of its territory is strongly or very strongly eroded.

This ecosystem created by a dense thicket *Elaeagnus*, *Tamarix*, *Haloxion* and grassy vegetation can be found in valleys and terraces of rivers. These unique foodplain forests play the major role in preserving the region's biodiversity. With lay to offer in the low mountain winter pasture zone dry period and the precipitation fall insignificantly. Grassy vegetation is fully dry up. However the intensive grazing summer destroys small trees and biodiversity is changes. 59, 4% of winter areas are strong and very strong eroded. 17, 3% is middle eroded, 10, 3% are weak eroded (Akhmadov, Breckle, Breckle, 2005). On the strongly eroded slope the grassy vegetation fully or almost fully

destroyed. First *Strigosilla*, *Veronica* etc. settles. Last on the slope settle cereals which assist further strengthening their.

The spring-autumn pasture serves of the outrun cattle with the winter pasture on the summer pasture and back. For Tajikistan the outrun cattle breeding stipulate for natural condition. The high and middle mountain pastures partly are covered by snow. The cattle difficulty becomes to obtain haymaking and they outrun in the winter pasture and in the summer grassy vegetation fully burn of their little watering places dry and the cattle outrun to the summer pasture. The length of outruns come to 200-500 km. During the time of the outrun on the stripe which wide till 200 m the cattle eat whole biomass. Therefore in the zone of cattle outrun the grassy vegetation fully destroyed. Their nature renewal unsatisfactory. The soil is very strong eroded here. At the results of destruction grassy vegetation the some steep outrun plots gullies erosion's intensive development. The characteristic feature of the mountainous outrun stripes that on their surface absent grassy vegetation. There are a lot of gullies here. Because of this outrun plots transfer on the new place. All erosion processes begin again. Species composition has been changed. The intensity at irrational pasture usage in the mountainous conditions leads to many negative consequences. In the sparse forest which intensive usage same with winter pasture and sometimes with summer pasture, the cattle fully destroys forest bedding, perennial and annual grassy vegetation. The surface of the mountainous slopes becomes "futile".

3.2 Agriculture Zones

During the Soviet period Tajikistan specified on the cotton, subtropical cultures, vineyard etc., which determined the main directions of the Republic's industrial development. The collective and state farms have been organized. In 1970 the irrigated lands per capita were 0.17 ha, in 1998 – 0.10 ha, and in 2010 this number will decrease to 0.09 ha. The decrease of the irrigated lands per capita is not only subject to the population growth, but also to the land occupation by the industrial and civil building, where the technogene erosion is intensively developed. Every year 200-300 ha of irrigated lands used for these purposes. In present, nearly 100,000 ha of irrigated lands are in meliorative-unfavorable conditions.

General fell of farming culture, lack of work capacity of irrigation networks caused the weakening of agricultural industry. The 76,000 ha of irrigated lands are subject to the second salinization and total area of natural salinization is 34,000 ha; 30,000 ha are used as rainfed lands because of the complex of anthropogenic factors; nearly 7,000 ha is unused because of different reasons. Agriculture, livestock and the process of desertification are in close interaction. The irrational use of land resources, spread of agricultural lands instead of rangelands, overgrazing and very favorable natural conditions for soil degradation development brings to the intensive development of different desertification types. The desertification process itself affects badly on soil biodiversity, as vegetation cover, as soil fauna. The natural process and human activities are the united chain.

The cultivation of agriculture and livestock in different natural zones has developed differently. The valley zone is mainly used for growing of technical and subtropical cultures. The irrigated pasturelands occupy small territory and used early. In the south and north of Tajikistan in the zone of winter pastures the wind erosion is widely spread. The sandy massifs have alluvial origin and represented by small sand accumulations.

Until 1992, these lands were planted with *Haloxylon* afforestation. However, during the 1992-95 period much of those forests were destroyed by local population and the wind erosion has developed with new strength. The sandy massifs began moving to the irrigated lands, cotton fields. In present, because of regulation of the grazing the forest massifs quickly restored and began their soil protecting action again. In the north of the Republic the destruction of the Tugai forests is still going on, which causes the development of the wind erosion. The sandy massifs are rarely observed here, and mainly the deposit accumulation occurs at the bottom of the negative relief forms. The overgrazing increases the process of intensive wind erosion development here. The speed of the blow-off of the soil goes up to 20mm/ year.

3.3 Human Desertification

However the intensive desertification development is connected to irrational use of pasture and agriculture lands by society. In 1960-80s, huge massifs were irrigated, tremendous hydro-technical and meliorative works have been conducted, anthropogenic desertification increased by several times. Thousands ha of irrigated lands turned to useless.

In the valley zone the soil degradation is presented by all varieties of dynamic processes. The main reason of the intensive development of desertification is human factor. Depending on how long the lands have been irrigated, all irrigated lands can be divided into 5 categories.

The intensive desertification development is observed in newly irrigated lands. The example of this may be Yavan valley, where 42,000 ha are eroded out of 48,000 ha; the gully area makes up 4,500 ha.

The density of gullies on the newly irrigated lands comes to 46 unites per square kilometer and the index of the length of gullies - to 7.6 km. per square kilometer. Easily eroded mountain rocks, immense human load, the week shocks of earthquakes and other factors are the reasons of the intensive development of erosion. This lead to the formation of gigantic gullies and powerful landslide. In the valley zone the surface natural erosion is very weakly developed. The wide erosion is widely spread in the south and north of Tajikistan.

Besides the gully erosion in the considered zone the landslides wide spread. Both these processes in irrigated zones are interconnected and cause huge harm to the agriculture and livestock.

Until 1992, the low-mountain zone was used for rain fed gardening and winter pastures. In present, this zone is used as rainfed lands for cereal crops cultivation. The area of the pasturelands is highly decreased, so they became overloaded by grazing. Moreover, these pasture lands were used year-round. Thus, the productivity of these lands has decreased significantly and process of desertification has become more intensive. The interconnection between the society, agriculture, livestock and desertification is clear here.

The natural soil degradation is more intensively going in the low mountain zone than in the valley zone and the index of the human erosion decreases. The density of natural gullies and their total length increase. The washout of soil and rain off of the arable lands comes to 17 thousand ton per ha. The highest index of the soil wash out can be watched in the winter pastures and in the areas of different species of vegetation and it comes to 57-126 tons per ha. The intensive development of the soil

degradation depends on the complex of natural factors and on the peculiarity of the growth of Pistachio. Besides, the intensive development of the erosion is connected with the peculiarities of the index of the precipitations and dynamic of the leaf surface.

In low mountain zone depending on the agriculture crops, the soil washout occurs differently (Table 1).

The maximum index of natural soil wash out and rain off observed in the middle mountain zone. The intensity of the development of the human erosion decreases. This is connected with the peculiarity of the nature factors and the decrease of the areas of cultivated lands.

The influence of the human factors in the high mountain zone is decreasing and of the nature factors is increasing. The main

cause of the desertification development in high mountainous zone is the climatic factor. Depending on the complex of nature factors in different parts of high mountainous zone the soil washout comes to 10 - 1200 tons/ ha.

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Agriculture lands, vegetation cover (VC), slope steepness (degree)	October-May		
	Rain off	Rain off coefficient	Washout
Fallow, 9	2.6-152.5	0.084-0.32	3.2-137.5
Rainfed, 10	4.7-108.4	0.082-0.43	4.6-104.3
Perennial plants, with VC 80-95%, 5-8	1.2-24.5	0.012-0.014	0.05-0.067
Perennial plants with VC 40-50%, 6-7	3.6-87.4	0.054-0.067	0.127-7.6
Perennial plants with VC 30-40%, 7	4.5-89.7	0.052-0.072	0.247-8.4
Spring crops, 8	124.3	0.61	82.4
Winter crops, 8	1.6-84.4	0.012-0.084	0.086-16.4

Table 1 Surface Rain off (m³/ha) and Soil Washout (ton per ha) in Rainfed

The high mountain regions are used as summer pastures, thus causing the intensive development of pasture erosion.

One of main factors of the desertification in the natural belts is intensive grazing in the result of the intensive grazing in all zones "sheep paths" are formed. The straight-line slopes are turned into the micro stepped slopes and the biodiversity fully changes. The maximum quantity of "sheep paths" comes to 14 thousand units per square km (Akhmadov, Breckle, Breckle, 2005).

3.4 Natural Soil Degradation

The natural soil degradation is more intensively going on the low mountain zone than in the valley zone and the index of the human erosion decrease. The density of natural gullies and its total length increase. The washout of soil and rainout of the arable lands and winter pastures comes to 17 thousands ton per ha.

The maximum index of natural soil washout and rain off is observing in the middle mountain zone. The intensity of the development of the human erosion decrease. This is connected with the peculiarity of the nature factors and the decreasing of the area of cultivated lands. The soil degradation in the nut forests with the plenitude 0,6 is almost absent (0,003-0,005 tons per ha) but then the plenitude is 0,1-0,3 its index comes to 0,7-4,0 tons per ha. However, the soil washout in the juniper forests comes to 0,6-100,0tons per ha. The smallest index of the erosion is observed under the grassy vegetation.

The influence of the human factors in the high mountain zone decreasing and of the nature factors is increasing. The soil degradation is displayed differently in the different parts of the

high mountain zone. Here the soil washout comes to 0,6-5,0 tons per ha. The wind erosion is widely spread around the Pamirs lakes.

After the breaking-up of the USSR and the civil war in the Tajikistan(1992) new factors of the soil degradation development appeared. It was not typical for the investigated areas.

The lack of fuel becomes the reason of cutting of valuable mountain forests. It increases the development of erosion processes and expands the areas of "futile" lands. There are *Haloxylon* forests in the south part of the Republic, which protect soil from wind erosion. However, because of lack of fuel they are cut down. Barkhans and dunes are moving to the agriculture areas. Now these lands have turned to the sandy areas.

3.5 Development of New Lands

The population growth in the valley zones of the Republic compelled the people to cultivate the former abandoned lands in the mountains and to cut the unique mountainous forests for agricultural needs. The incorrect cultivation of these lands causes the intensive development of erosion and landslide, gully erosion particularly and the formation of "moon" landscape.

The problem of insufficient food after the civil war in the mountainous areas of Tajikistan became very important. It forced the population to cultivate very steep slopes (till 35 degrees) under cereal cultures, which resulted in the intensive development of erosion and destroyed the fertile horizon of the soil during the short period of time (2-3 years). It leads to change of the landscape. On these slope the line erosion and the

landslides are intensively developing. The washout of soil comes to 17 thousand tons per ha

All of aforementioned factors that strengthen the development of the desertification in the mountainous territory give us the foundation to define the new type of desertification that is the mountainous desertification.

3.6 The Effectiveness of the Antierosion Measures (AEM)

The effectiveness of AEM depends on combination of the nature factors. There is a complex of AEM for each high – natural zone.

Combat to Desertification in the valley zone must be carried out in two directions: first – raise of soil resistance to wash out; second – correct using of the irrigated lands and application of progressive soil protective irrigation techniques. The main effective the AEM must be: cessation of cultivation of one – year cultures on the steep slopes (more than 12 degrees); the use of eroded lands under perennial grass and gardens; deep cultivation across the slope; introduction of modern surface methods irrigation; minimizing the excessive water and other. The gullies lands must be filling-up. It is proposed to plant the 2-10 rows shelter belts of dry-steady trees in the wind erosion zone. Arrangement of trees and quantity of rows depended on of directed and speed of the wind.

One of the most perspective methods of afforestation of half sands is air-seeding. However our research showed that because of little sand this method would be ineffective for Tajikistan, that's why we recommend the auto – seeding.

For protection of the soil degradation in the low mountain zone (500(900)-1500 m asl) necessary to take the system agromeliorative measures and forest – meliorative measures. This zone use as rainfed for a long time, therefore all AEM must be directed to the further stopping and relation of the erosion processes. Here necessary to take the complex of the AEM – prophylactics measures, agro – meliorative measures, hydro – technical measures etc.

The middle mountain zone (1500-2500 m asl) using as summer pasture. The areas of the rainfed lands are insignificant. Therefore the main AEM is pasture – ameliorative measures and agro – ameliorative measures. Here especially must be sparely attention afforestation of the steep slopes.

In previous years buffer zones and "handing" gardens have been widely used in the Low Mountain and middle mountain zones of Tajikistan. Now such application is very rare.

The high- mountain zone (more than 2500 m asl) in the main using as the summer pastures and therefore pasture ameliorative measures play the important role. Application of the insignificant standards of mineral fertilizer and regulation of grazing are very effective specially. Other AEM are small effective.

4. CONCLUSIONS

In the development of the desertification in present the anthropogenic factor plays main role. The rational use of the land resources will enable the further development of the agriculture and livestock.

However the unwise nature use for immediate profit has catastrophic consequences.

The rational use of foothill and mountain territories is one of the reserves of increasing of value of agriculture production that has a huge opportunity for agro production complex.

There is necessary to development the scheme of production usage of biological resources, biodiversity and feature of those growing according to the vertical zonality on the base of learning of production resources.

The development annual and perennial cultures on the slopes is to be done in view of nature-cimatic features and their effectiveness.

There is necessary to use the pasture lands to destination and to ferbid to use these lands for crop production.

There is necessary also to accept of complex of antierosive measures.

REFERENCES

- Akhmadov, K.M., 1997. Development of the Erosion Process in Tajikistan. Dushanbe: p. 49 (Russian).
- Akhmadov K.M., Breckle S.-W., Breckle U., 2005. Land Use Chang and Mountain Biodiversity. Taylor & Francis, London-New York: pp. 239-247
- Sobolev, S.S., 1949 Development of the Erosion Process in USSR European part. Moscow - Leningrad. Vol. 1: p. 305 (Russian).