Watershed management study Muminabad, Caritas RBP II

Technical report on tree related topics

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Beda Romer, August 2005

Introduction

Background and Goal of the Study

Caritas Switzerland is working with the Local Development Muminabad (LDM) project in Muminabad since 1999 and with the Riverbank Protection (RBP) project since March 2004. In order to strengthen the research aspect for flood protection, the second phase of RBP (July 2005 – June 2006) started a watershed management study of the problematic Hojahakik watershed above Muminabad Town.

Frame of the study

In a first step it is foreseen to analyze the problems connected to land use change and its influence on erosion and water household. Based on this knowledge, technically feasible measures for reduction of erosion and the high water peak should be pointed out.

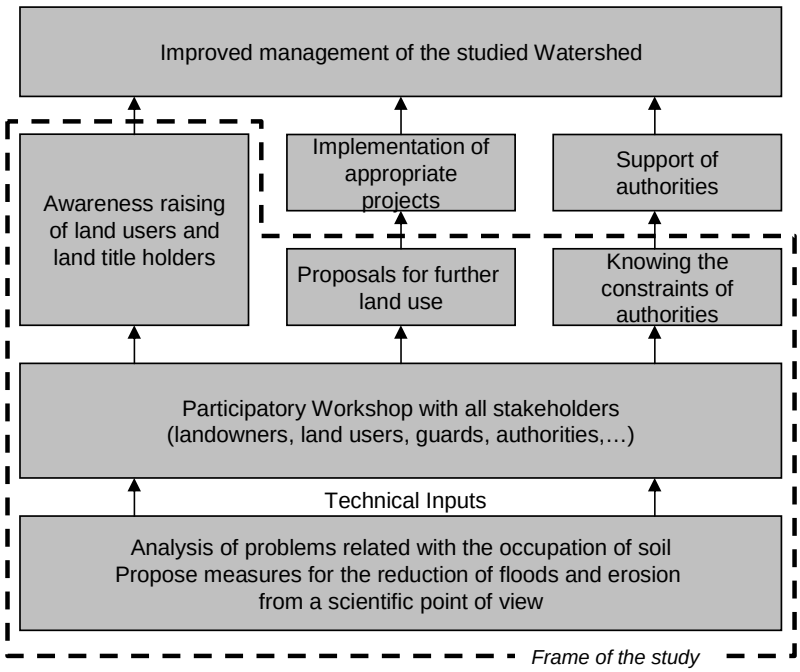

Figure 1: Frame of the study

Measures including trees normally tend to have long-term effects and require a consequent management over a long time. It is necessary to attain the acceptance and the support of the land users in order to guarantee the success of such long-term measures. Therefore it is indispensable to find solutions in close collaboration with all stakeholders.
This will be done in a second step of the study. With a type of participatory workshop it will be tried to integrate all land users and officials to discuss the reasons for current problems (not only from the part of land users but also from the part of authorities), to raise the awareness for the sustainability and to find together propositions for improved land use.

The technical and scientific frame elaborated in the first step will give inputs to the workshop participants in order to help them coming up with suitable solutions. This report is meant as a part of the first step. It is supposed to provide scientific support for questions related with trees and reforestation.

The proper implementation of the agreed measures won't take place within the frame of the study.

Land-use and deforestation history of the Hojahakik Watershed

From 1933 till 1948, the northern side of Hojahakik was cropped by the Kolkhoz. **From 1948** on, when Lezhoz took over the responsibility of the whole Hojahakik (and also the neighbored Chorvodor) watershed, the arable plots were given up and transformed into pasture grounds. Eventually bushes and trees established sparsely on this land. The biggest part of the Lezhoz territory was used either as pastureland or was covered with forests.

In **1978,** the Lezhoz, under the direction of an inhabitant of Hojahakik village, created terraces on the left side of the valley. To ensure the complete compaction of soil and development of terraces, the planting of trees started only two years later. From 1980 till 1982 several kinds of fruit trees were planted on the entire terraced lands.

Till 1985, the Lezhoz tended and controlled the newly created orchard which consequently developed quite well under these optimal conditions. As a side effect of the strict control also the forests in the remote areas of the valley developed positively in terms of density and diversity.

After 1985, the Hukumat arranged for the change of ownership on the territory of Hojahakik. The use rights passed from the Lezhoz to a bee-keeping Sovhoz. This Sovhoz decreased the maintain efforts for the orchard and wasn't able to maintain the severe control in the watershed. As a consequence a lot of fruit trees around the village dried and were cut. It was also the beginning of a modest cutting of firewood on the northern-oriented pasture and in the easily accessible parts of forests.

After the fall of the Soviet Union in **1990,** the reliable and cheap supply of energy in form of coal and gas stopped and in consequence the cutting of fresh wood for firewood increased drastically. During the 90ies practically all shrubs on the pasture disappeared and also the lower parts of forests were deforested. Only the area in the environs of the village and in difficult reachable areas escaped cutting.

In 1999, Saidov Nabod bought the fruit garden of 22 ha in both, the Hojahakik and the Chorvodor Watershed. Since then, a guard has been responsible for the conservation of cultivated and wild trees in the orchard.

Overview of the Watershed

Biophysical conditions

Situation: The Watershed is east-west oriented with the entrance on the western side. Due to the different expositions the two sides of the valley have different climatic conditions; the risk of droughts and high temperatures are lower on the north-oriented hills.
Strong winds mainly occur in autumn and winter. These seasonal winds blow from South thus introducing and deposing sand and snow behind the Southern ridge. As a consequence the snow lies longer on the side of Hojahakik village than on the opposite pasture.

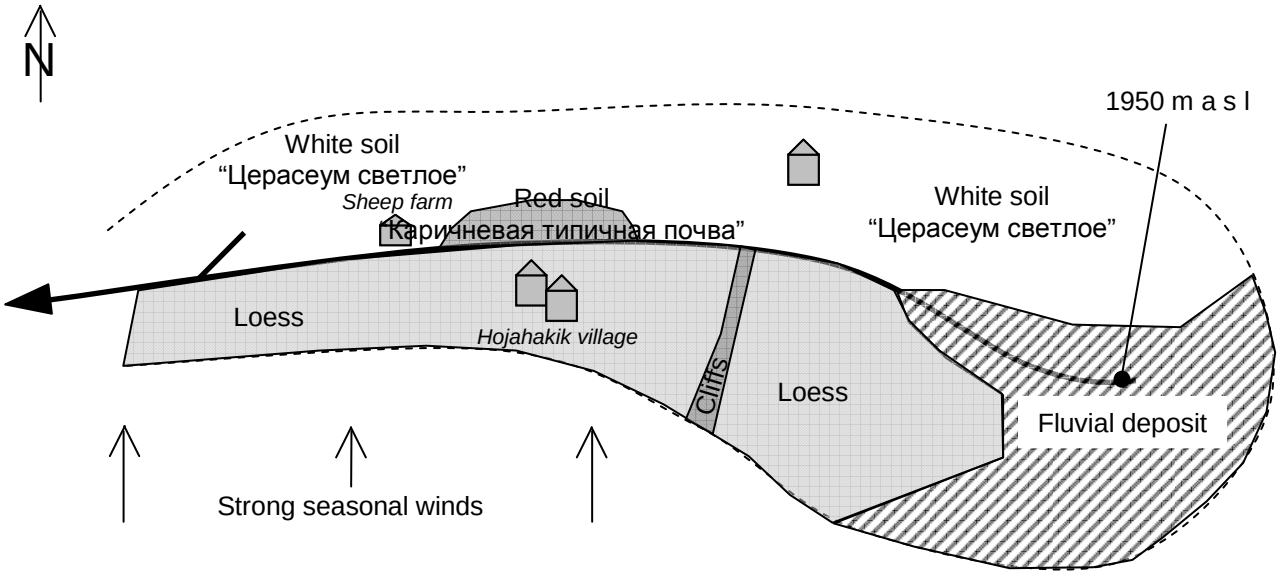

Figure 2: Soil map of Hojahakik Watershed

Rainfall: Since 1950 there is a rainfall measuring station south of Muminabad in function. Annual precipitation varies from 500 to 1400 mm. As the trend line indicates, there is no significant change (increase or decrease) of the annual values for the last 50 years. The main rainfall season is spring with maximum in April (180mm as an average). Summer is almost dry, what results in a complete drying out of Muminabad mountain streams.

Vegetation: The natural woody vegetation of the lower parts consists of almond, red hawthorn and dog rose on both sides of the river. Walnut can only be found at the left side while drought resistant shrubs like Judas tree and cotoneaster prevail on the exposed soils at the right side (see also Annex 3).
The region is warm during whole year and the length of growing period is very long. Therefore, till about 1500masl, the growth of medium mature vines, and till an altitude of 1900masl early and very early mature sorts of vine is possible. Early sorts of apricot can potentially be grown till some 2500masl. The upper limit of grain crops in Muminabad district can be found above 3000masl.

Sub-perimeters

The past land use, the ownership and the biophysical conditions have influence on the actual land cover of the watershed. Six zones (subsequently called 'sub-perimeters') with different land-cover types can be distinguished (see figure):

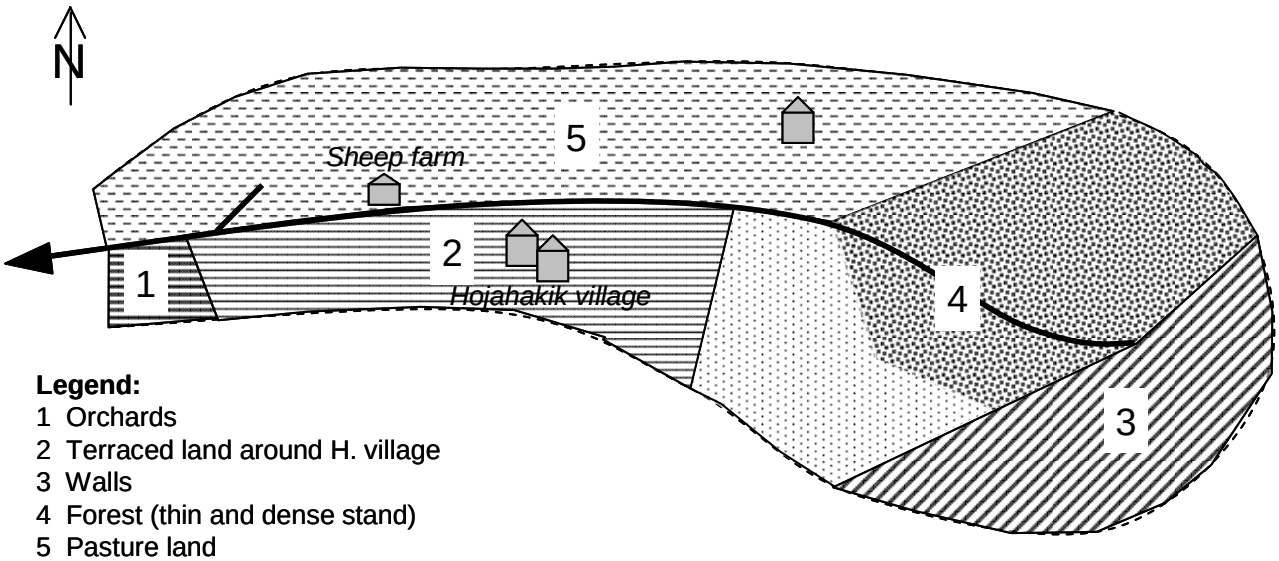

Figure 3: Sub-Perimeters

In chapter 'sub-perimeters' every zone will be described as regards appearance and management. Based on these descriptions, the influence on water- and soil conservation and its improvement by means of management and technical measures will be discussed.

It is clear that the sub-perimeters are not isolated from each others. The change in management of one sub-perimeter has down-stream effects (e.g. less riverbank erosion by decreasing the annual high water line) and can also influence the regions upstream. The two most important topics in this context are grazing management and deforestation. Stronger regulation and control of them will shift the pressure on other areas. The problem about deforestation is globally addressed in the chapter below while the grazing management is outside of the cope of this report.

Reforestation and Firewood issues

Reforestation and bio-engineering measures including trees can only be successfully realized if the control on deforestation is gained. Otherwise planted or naturally regenerated trees will be subject to cutting before the full protective effect is attained. The first and foremost reason for cutting is the need for firewood of local people.

Deforestation: origin and habits

During the soviet epoch the inhabitants of Tajikistan profited of the all-time supply of affordable energy sources as gas and coal. After the fall of Soviet Union also the energy supply stopped and mainly people in remote rural areas had to find alternative means for heating and cooking. The cheapest available energy source was found in organic matter as wood, dung and residues of crops.

Nowadays many household of Muminabad Town depend on the firewood from Hojahakik and Chorvodor valleys. People collect firewood mainly in the forest area since the pasture are largely bare of shrubs and the territories around the villages are well protected (villagers from Hojahakik village normally collect firewood only on their land plots around the village) The preferred species for firewood are *Lonicera sp., Cercis griffithii, Acer Semenovii* and others (for a detailed survey see Annex 3)

Fruit trees are seldom cut since it is recognized that they are better utilized for fruit production. Also *Salix* and *Crataegus sp.* are rarely cut because of their bad burning properties (low energy content). In addition to this, *Crataegus sp.* is forbidden to cut by a Muslim rule. If planning a reforestation these preferences and cautions regarding the cut of different tree species should be taken into consideration.

The excessive collecting of firewood led to deforestation on pastureland. But also a part of the forests and many of the juniper trees, which are known to have an enormous importance for erosion control, disappeared.
The low growing Juniper trees are also undergone to illegal harvest. Although the transport from the forest to Muminabad Town is difficult, people use this species as construction wood.
The ecological department of the local Hukumat and the guards of the Sovhoz are not able to ensure an effective protection. The most efficient protection of new established measures is likely to be reached under the following preconditions:

- ⇒ the guard lives near the area to protect
- ⇒ the guard has a personal interest in the protection of trees and shrubs (e.g. he gets a part of the produced fruits or wood, he gets a good salary, he helped implementing the measure, he understands the erosion problematic, he is united with the area to protect…)

However, it is obvious that the complete protection of the forests in Hojahakik watershed will automatically lead to a bigger pressure on tree resources elsewhere thus only relocating the problems. The destructive collecting of firewood[1] in forests can only be stopped if control is combined with the reduction of firewood demand. The ladder can be reached either by lowering the needs (e.g. insulation improvement, more efficient stoves…) or by replacing fuelwood with other energy sources.

Energy sources: Possibilities and perspectives

Electricity: The government of the Republic of Tajikistan planned to supply the whole country year-round with permanent electricity till 2009. Even if this ambitious goal will be reached, it is still doubtful that firewood will be replaced in a large scale. Electricity based heating systems require also corresponding installations and are therefore related with important expenditures.
But in any case, electricity can replace organic matter for heating energy. It will relief the pressure on forest wood.

Gas: Gas stoves are valuable alternatives to electric ranges while electricity isn't provided all the time. One bottle of gas costs about 20 Somoni?? Normally, gas isn't used for room heating.

Coal: In the vicinity of Muminabad there are no exploitable coal sources available. The nearest mine lies in Shurobod. Due to the high transportation costs this coal costs at least 200 Somony/ton[2], which is often above the financial possibilities of households. The prices are unlikely to decrease in future.

Tapak[3]: The production of tapak is limited by the amount of produced dung. The increase of tapak production is only possible with an increase of livestock. Nevertheless there exists still the possibility of higher efficiency of dung-energy by installation of biogas technology.
But in any case the use of dung for firewood breaks the nutrition cycle. The loss of minerals decreases the fertility of soils unless removed matter is replaced with chemical fertilizers (which are often too cheap for farmers. They normally use it only on arable land plots).

Firewood; based on the assumptions made above, firewood is likely to keep on playing a central role in the energy supply of Muminabad's private households, at least in the next few years.

1 Firewood means the wood of shrubs and trees used for energy needs. The conversion factor of $1m^3$ of firewood is about 700kg.
2 The energy content of 1 ton of hard coal is equal to 2.057 tons of fuelwood
3 The energy content of 1 ton of tapak is equal to 0.843 tons of fuelwood

Currently there are four different sources for firewood;

- firewood provided by the Lezhoz of Muminabad
- wood originating from homegardens
- wood originating from leased or owned land (agroforestry systems, orchards)
- wood collected in forests and pastures (Hojahakik and Chorvodor watershed)

The amount of firewood provided by Lezhoz comes exclusively from sanitary cuts. It is determined by the 'Agency for the Protection of Nature' in Dushanbe. The yearly amount doesn't exceed 600 m^3 per year (300m^3 loosely packed and 300m^3 bundled; together about 112 tons). It isn't probable that this rather low amount will significantly increase in future.

Homegardens are small land plots (max. 0.25 ha) around the households. Because of the proximity, these lands profit from a high caretaking; homegardens are normally well irrigated and fertilized. Muminabad's households grow many different trees for subsistence need around their houses; fruit trees, construction wood (normally poplar) and sometimes also willows for firewood (willows are pollarded repeatedly every 3 to 4 years). Homegardens have a big potential of fuelwood production; for instance homegardens in Indonesia (sub-humid climate, seasonal rainfall, 1053 trees per ha) are reported to produce 5.1 t/ha*y. [1]
However, an increase of firewood production in homegardens is rather unrealistic. On the one hand the density of trees is already very high and on the other hand woodfuel production has not first priority in homegardens. Fruit trees have a higher importance for the families' self supply and reach also economically higher prices than firewood[4]. So it can be concluded that it is much more attractive for farmers to produce fruits and buy energy with the generated income.

Wood from agroforestry systems with fruit trees is under the average land hold size not likely to cover the entire firewood needs of farmers' households. An example of the region showed that an apple orchard of 1.5 ha covers only 30% of household's firewood needs. But anyway, the extension of agroforestry is a promising possibility to decrease the pressure on the forests.

The easiest and least expensive possibility for local people to get firewood is the forest. In summer and autumn up to 20 donkeys per day transport the wood (mostly branches of shrubs) from the forests and pastures of Hojahakik watershed down to Muminabad town. Each donkey is charged with 4 bundles[5]. To know if the current annual amount of wood evacuated from Hojakakik forests can be grown within one year a rough calculation of the sustainability will be done below.

Annual amount of wood production of the Hojahakik forest (fresh weight)	
Ca. 40 ha forest	
Natural increment 3-5 m^3/ha (value for small-leafs forests in Tajikistan [2])	
Total 120 - 200 m^3 =	**120-200 to**

Annual amount of wood evacuated of the Hojahakik forest (fresh weight)	
20 donkeys per days * 100 – 150 days = 2000-3000 bundled donkey loads	
65 kg per bundled donkey load	
Total	**130-195 to**

Figure 4: Calculation of annual growth and exploitation

[4] An apple tree can produce up to 100 kg apple, which are sold for 0.5-2 somoni per kg. 100 kg of firewood, the amount a willow or a mulberry tree can produce in about 5 years costs less than 20 somoni
[5] 1 bundle measures about 0.09m^3. It makes 0.36m^3 or 65 kg per donkey load (This figure corresponds approximately to the carry capacity of donkeys. The weight of charge depends also on the age and constitution of a donkey)

The calculation can't be done very precisely because of a lack of basic data; increment and number of loaded donkeys per year could only be found out approximately. With these vague indications it isn't clear if the use exceeds production. The value ranges of growth and exploitation are similar. However, it is said that the forest area slightly decreased during the last years; therefore it can be guessed that the yearly exploitation is (at least locally) higher than the annual growth.

Besides the frequent methods to cover a part of firewood needs on household level (homegardens, agroforestry solutions on leased lands, buying of firewood and wood of forests) there exists a second basic solution of the firewood-problem; community-based farm forestry. This option for firewood cultivation is not common in Muminabad. The establishment, the maintenance and the management should be accomplished at the community level. It is important that this wood will be sustainable and mainly farmed as fuel and not as timber. There is a large potential for mitigating the energy problematic [3] However, there are a lot of difficulties to deal with; how to take decision, who to design as responsible for planning, how to implement and control the plantation, how to distribute the wood afterwards...

Also the location for such communal firewood production can be difficult. It should be open or communal accessible land (and not private owned land). Furthermore it will be advantageous if the chosen land presently isn't used (for example as pasture) because otherwise opposition and use conflicts can be generated. One plot that fulfills these two preconditions is the land around the village Hojahakik. The land isn't used and it is to sell. In addition it is already terraced and has good ecological potential for growing of trees.

Preferred characteristics of a firewood tree: Fast growth and high reproduction rate by high and constant sprouting ability; high resistance to diseases, drought, low temperatures, and competing weeds; deep root system, low water competition; foliage with high potential as fodder; nitrogen fixer and slope-stabilizer [4]

Willow species hardly grow on the rain fed lands. But Russian olive, walnut and some introduced species (*Robinia pseudoacacia*, *Ailanthus altissima, Pinus eldarica, Cyparis arizonica*) could be valuable alternatives. Seeds and seedlings of such introduced species are available in the botanical garden in Kulob. However, if a native species can fill the need, it should be given priority over introduced species in the selection process. Natives often have advantages; they are already adapted to the environment and growth of natural stands can provide some indications of possible performance in cultivation [5]. But certain exotic trees achieve faster growth and earlier returns.

[6] Fresh weight estimated assuming 1000kg/m^3

Sub-Perimeters

Orchard

Description: 22 ha of the terraced orchard established by Lezhoz belong to Saidov Nabod. The biggest part of it lies outside the watershed of Hojahakik. Only few hectares make part of the left entrance of the valley. Six employees work on this land.

Current management: The trees were planted in 8 x 8m scheme, what allows mechanized agriculture works between the rows. However, nowadays grain crops are planted only in few rows. The main share of orchard is used for haymaking and fruit production. There are several different kinds of fruit trees; apple (4 sorts), cherry (2 sorts), apricot, plum, pear, quince and almond.
During the soviet period the yield was very high; 400 – 500 tons of fresh fruit were harvested on the total area of orchard. Nowadays the harvest is expected to be lower because of a worse management (dried trees aren't replaced, earth around trees isn't loosened, fruits aren't treated chemically,…). The trees are yearly pruned.

Proposed measures for improved erosion control: Thanks to the terraces and the high vegetative cover of trees the orchard bids a good protection against erosion. Therefore no urgent measures can be proposed. Only small improvement regarding water and soil conservation can be reached by:

- ⇒ Replacing failed fruit trees
- ⇒ Covering fallows (in inter-row spaces) with green manure

Terraced land around Hojahakik village

Description: The terraces around the village were created in the same years as the orchard at the entrance of the valley. After Lezhoz had to give up the territory it wasn't maintained anymore. At the moment the area is to sell.

Current management: The few remaining fruit trees aren't tended anymore. Many wild bushes and trees (e.g. *Crataegus sp., Prunus sogdiana, Prunus cerasus*…) have grown naturally on and between the terraces. Most of the territory is neither ploughed nor grazed.

Proposed measures for improved erosion control: The land isn't used optimally regarding the economic output. But in terms of erosion control the terraced land with the wild vegetation isn't problematic at all. As mentioned above this land might possibly apt for communal firewood production. In case of replanting the terraces, a previous mending of the terraces has to be considered. Some technical hints concerning reforestation can be found in annex 1. However, the most difficult obstacle of installing a kind of communal forestry will be the social component.

Walls

Description: In the very beginning of the channel almost vertical 80 – 100m high walls of tertiary bedrock can be found. Below the bedrock wall are young (quaternary) deposits, mainly originating from locations above. It is obvious that permanent erosion takes place.
Sediment potential for K. mountain stream is mainly fed by the quaternary deposits at the top of the mountain range. [6]

Current management: The walls aren't used by people.

Proposed measures for improved erosion control: Due to the strong erosion, all vegetative measure will be worn away before the biological stabilization sets up. Structural or combined measures are connected with exorbitant expenditures.
Because these walls - which are the main source for sediments – are impossible to stabilize, the sediment transportation of Hojahakik River can't be decreased significantly.

Forests

Description: In the bottom area of the valley exist also forests besides the walls. The forests consist of many kinds of shrubs and also some tree species (*Juniperus semiglobosa, Juniperus serafshanica, Salix sp.*). A big part of the area belongs to the Sovhoz 'Bustan'. The thicket on the left side belongs to Mr. Nurulloh. It stands on a recent land slide zone.

Current management: People from Muminabad town collect firewood in the whole accessible forested area. They started cutting shrubs in the easily accessible areas near the channel and than progressed upwards. This kind of strip felling allows the shrubs to regenerate. After some years the cutting will start again in the redeveloped areas.

Proposed measures for improved erosion control: Forests have a high importance for the decrease of the outlet peak after rainfall. Furthermore the erosion in forests is low because of several protective properties of trees and shrubs (interception, transpiration, improved infiltration of water, stop of sediments and run-off water). Therefore the conservation of a dense forest is the main goal for this sub-perimeter. It can be achieved by a more sustainable management of the forest:

- ⇒ Collect in one season not more wood as possibly can grow within one year (see calculation of sustainable amount). If the intensity of cutting exceeds the production of the forests, the sprouting capacity of shrubs will exhaust and deforestation will take place.
- ⇒ Cut only branches from shrubs which are able to sprout again after cutting (by stump- or root suckers). Junipers shouldn't be cut.
- ⇒ The rotation period should allow all cut shrubs to sprout and develop new fruits. Fruits are important for further spread of trees and have a vast importance for the wildlife.[7]
- ⇒ Cutting shouldn't take place in spring and summer. The best moment for collecting firewood is after trees have stopped with assimilation (after leaf fall). During the autumn and winter the trees normally allocate important matters in stem and root system. Therefore they are not that sensitive to pruning as during vegetation period.
- ⇒ Grazing shouldn't be practiced in recently cut parts of the forest. Livestock will additionally weaken the vegetation through browsing and trampling damages.

Important note: Cutting trees in forests is generally forbidden unless the ecological department of the local Hukumat gives the permission. Therefore it will be delicate to propagate the above mentioned management guidelines. All written material (as brochures or signs) that asks people for the sustainable harvest of firewood of forests is illegal and must be avoided. However, fact is that people collect firewood even though it is forbidden and since this habit can't be stopped easily, it should at least be tried to reduce its damages on forests.
It isn't forbidden to sensitize people for the mechanisms of forest growth and the influence on regeneration processes of a forest. A possible frame for the sensitivity building can be given by workshops. The target group should be young men because it's them who are normally occupied with collecting of firewood in Muminabad.

Pasture

Description: The pasture extends on the right side of river between the entrance of the valley and the cliffs that separate pasture from forest area. The main part belongs to the Dehkan farm of Mr. Mahmadov. Some few hectares around the village on the right side belong to Mr. Bozor.
The western half of pasture is totally deforested and suffers obviously from overgrazing. Here top soil erosion takes place. Around a singular arable land plot, a ditch was dig in order to keep animals off. In ravines, erosive processes have created several big holes.

[7] Coppice (low forests) in Switzerland have normally a rotation period of 10-30 years

Also the steep banks near the riverbed were eventually deforested. Here evident proofs of heavy loading with livestock can be found. These lower parts of pasture are almost bare of vegetation cover. The foot of riverbank is obviously eroded in springs when the water level of Kojahkik River is higher. At altitude of 1680 m at the right side, a landslide occurred in 1993.[6]
On the upper parts of eastern pasture ground grass cover is well developed and some wild bushes and trees (*Lonicera sp., Rosa canina, Crataegus sp*. and *Amygdalus bucharico*) can be found.

Current management: The owner of the land doesn't use the pasture for grazing his own livestock; he brings the animals to more remote areas. But the farmers of Hojahakik valley are allowed to put their livestock (50 cattle and about 90 smaller ruminants) on the pasture. The lower part of the pasture (near the river) seems to be more frequented than the higher parts.
In the higher parts, where still a sparse stocking of trees remained, there is still deforestation in process. Mainly the hawthorn trees are currently pruned or felled.

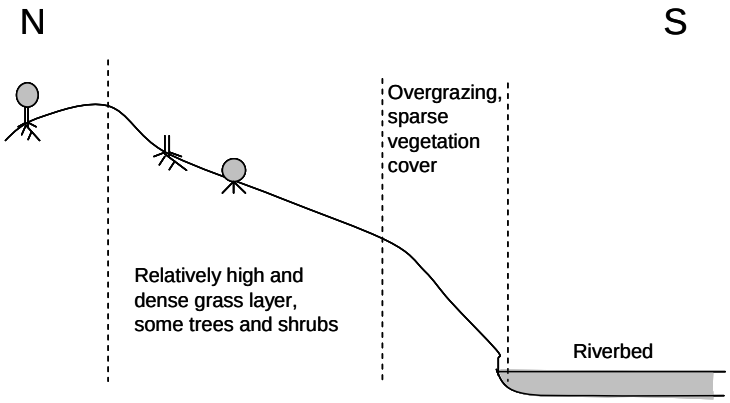

Figure 5: Profile of pasture

Proposed measures for improved erosion control: This zone is partly in a very critical state. If no measures are taken for stopping the degradations processes, it is likely that in few years very strong erosion will take place. Hojahakik is in a relatively early stage of erosion compared to other watersheds in Muminabad district. Only minor indicators of erosion can be found while in other areas of the district huge gullies developed in ravines and ditches. However, the started erosion should be stopped as long as it is possible with the help of relative cheap and simple means. There are two types of measures proposed; a kind of 'symptom fight' and 'cause fight'. An efficient control of erosion can be gained in fighting both, the origin and the resulting degradation processes.

'Symptom fight' (short term measures for stopping or revising started erosion processes)

- ⇒ Stabilization of slopes along the river: Due to the embankment erosion some parts of the pastureland slipped down. The instable and uncovered topsoil should be replanted and protected from livestock. For more detailed information see annexed fact sheet.
- ⇒ Prevent further erosion in ravines: In natural state the ravines are densely filled with different shrubs. Their root system prevents erosion. In order to reintroduce ravine stabilization they are proposed to be reforested. For more detailed information see annexed fact sheet.
- ⇒ Prevent gully erosion in the ditches around cropping fields: The ditches in direction of the slope offer a potential starting point for gully erosion. The process can be revised by installing obstacles (of concrete, stone or wood) in the ditches. Eventually sediments will fill the space behind these 'little dams'. In the meantime a life-fence can be grown at the edge of the land plot. For more detailed information see annexed fact sheet.

'Cause fight' (long term measures for sustainable land use)

- ⇒ Grazing management: The top-soil erosion in the western and lower parts of the pasture can be authoritatively reduced by introducing a smart grazing management. Also the creation of tracks in steep lands, the browsing of shrubs and the invasive development of weed can be defused. Rotation systems have a lot of positive effects among them also the regeneration of a closed vegetation cover and finally the better conservation of soil and water. However, propositions concerning the technology and the approach for improved management of grazing livestock can't be discussed within the frame of this paper.

⇒ Stop clear cuttings on pasture / Reforestation: The cutting of hawthorn and other wood on pastureland should be stopped. As discussed above, this goal should be attaint not only by strict control but also by the creation of other energy sources and/or the decrease of demand of firewood. Only if these two preconditions are fulfilled it makes sense to considerate reforestation. A better grazing management and less wood cuttings given, it is even likely that natural regeneration will start (After 1948, when ploughed land turned to pasture area, the regeneration also set up naturally). For more detailed information concerning reforestation see annexed fact sheet.

⇒ Embankment protection: In order to prevent further embankment erosion (and consecutively also land slides near rivers) they should be protected. Whether it is possible only by means of vegetative measures is not sure. Due to the strong water flow in spring, vegetative measures as willow protection may be of a minor effect and can be even washed away. A combined solution with technical measures as gabions, stone walls or woody constructions seems to be more promising.

Annexes

Annex 1	Fact sheets on proposed measures
Annex 2	Planting technologies for different slopes
Annex 3	List of shrub and tree species mentioned in this report

Glossary

Hukumat	Local administration office
Sovkhoz	State farms. The land and all other property belongs to the state, the workers are employees of the state with fixed salaries and the state absorbs all the profits and losses of the Sovkhoz
Lezhoz	Governmental forestry office
Kolkhoz	Collective farms. Apart from the land, the capital and the productive assets belong to the workers
Dehkan farm	Dekhan Farms can be either small, independent farms or large, collective farms. They are private and independent from state in terms of investment decision.
Tapak	Tapak is the name for the traditional dried cake consisting of dung and straw.
Fuelwood	Wood of shrubs and trees used as energy source
Embankment	Inclined natural or artificial boundary of a watercourse.

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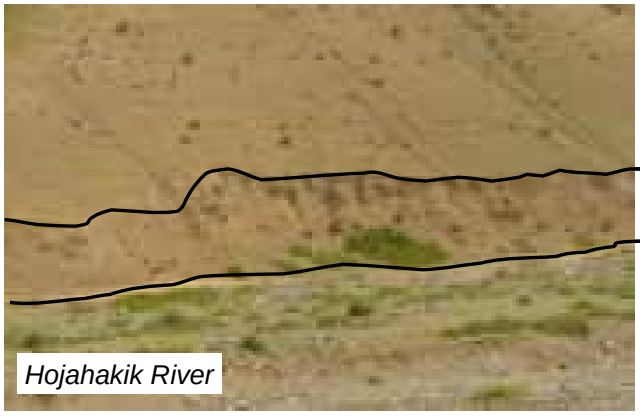
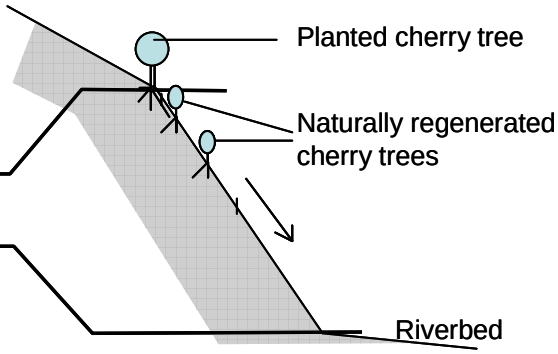
Slope stabilization with cherry trees — Annex 1





Profile scheme

Target area
Large parts of the lower left bank of Hojahakik River recently slipped down. The top edge of the gliding zones is about 10 – 30 m above the level of riverbed. The total length of edges makes up approximately 1km.

Description
Due to the embankment erosion some parts of the pastureland slipped down. To protect these steep and loose soils from topsoil erosion and in order to stabilize the soil structure, plants should be installed which are able to cover the soil and to root in deeper areas.
Therefore a line of trees will be planted at the upper zone of the target area. The planting will be done in individual holes ('Plashadkas', see annex 2) and should take place in autumn or spring. In the first two years the planted trees should be irrigated. (Bottle irrigation)

Material
Sour cherry (1-3 plants per meter): purchase in a nursery or transplantation from natural regeneration
Mulching material: straw, hey or branches with leaves

Effects
Sour cherry yields and regenerates very quickly. The heavy fruits will fall down the slope and germinate on lower parts. The sour cherry is able to produce root suckers. This is an additional method for covering and stabilizing quickly the soil. It can be expected that the slope will be grown with naturally regenerated trees within 3-5 years after establishment of the measure.

Advantages
Very cheap possibility to afforest a relative large area with minimal inputs in labour

Deep and stable rooting

Fruit trees are rarely cut

Disadvantages
The development of trees is less secure and more slowly than ordinary forestation with seedlings

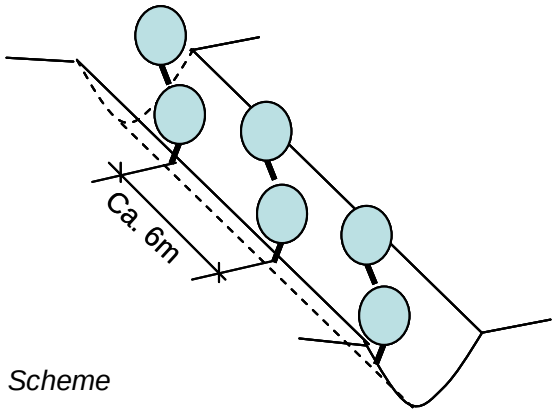
To reach a maximal effect this measure should be combined with vegetative measures: e.g. strip planting, contour planting of shrubs

Remarks
The instable and uncovered topsoil should be protected from livestock. It is suitable to protect the newly planted seedlings from browsing (e.g. wrapping seedlings in thorn bushes)

Source/Experiences
Experience with this technology has been made in the experimental station of Kasang (near Faizabod).

Planting shrubs in ravines — Annex 1

Hojahakik Watershed



Scheme

Target area
Numerous ravines can be found in the lower parts of the pasture on the left bank. Most of them are bare of vegetation cover and run the risk of gully erosion.

Description
Inside the ravines bushes are planted. The bottom of the ravine is under water during spring while in summer and autumn no water flows. Tree species like willow or poplar, which could support temporary flooding, would dry out after spring. Therefore drought resistant species are planted at both sides of ravines in a chess-like scheme.

Material
Tree species which are adapted to both, dry and temporary wet conditions are: *Eleagnus angustifolia, Ulmus Androssovii, Amygdalus bucharico, Rosa canina, Cercis griffithii* (these species can also be found naturally grown in ravines and creeks). *Eleagnus angustifolius* can be easily propagated by vegetative methods while the other indicated species need to be grown in tree nurseries.

Effects
The root systems protect both, the sides and the bottom of ravines. Bushes therefore help that soil isn't washed or crumbled away. Low branches and stems reduce the water speed in times of high water.

Advantages
Deep and stable rooting of the sides of ravines

Disadvantages
Propagation and planting of the shrubs and trees is quite costly

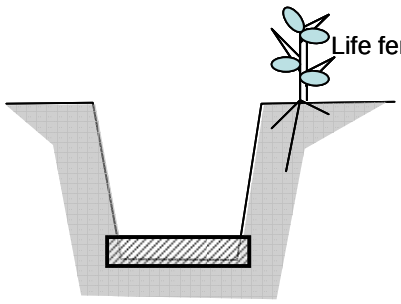
The bottom of ravines is only weakly stabilized.

Remarks
Planting different species enhances the biodiversity and decreases the risk of failure.
A combination with a kind of rake consisting of short willow switches which are put in the bottom of ravine may be tested for improved protection of ravine bottoms.

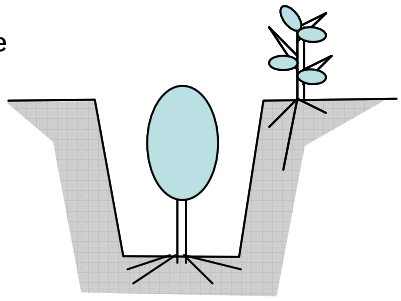
Source/Experiences
In Degras, such ravine-stabilizations were conducted with wild cherries. Mr. Rahmov from ecological department of Hukumat of Muminabad can provide further details.

Prevention of gully erosions in ditches / Planting of life fences Annex 1

Artificial ditch near Faizabad



Profile of a threshold in a ditch



Profile of a ditch protected by trees

Target area
In the western part of the pasture one can find a huge land plot which is protected from livestock by a ditch of more than 1m depth. The sides in direction of slope are likely to erode in the form of gully erosion. The ditches above and beyond the land have little significance for gully erosion (but they still have an influence on the water balance and on the stability of the whole land plot).

Description
Either biological (trees, shrubs, robust weeds) or structural (obstacles of concrete or wood) or combined solutions are installed on the bottom of the ditches. The distance from one obstacle to the other depends on the slope and on the type of obstacle.
Life fences are cheap alternatives to ditches. Seedlings (in the case of hawthorn and dog rose) or sticks (in the case of Russian olive) are planted in a short distance from each other (20-40cm). In the first three years the plants have to be protected from livestock but afterwards the fence protects plots from livestock.

Material
In the case of artificial obstacles: concrete, planks, net of branches, big stones…
In the case of biological obstacles: water-supporting trees and shrubs (elm, cherry, pine, poplar…). Suitable species for life fences are *Eleagnus angustifolia, Crataegus sp*. and *Rosa canina.*

Effects
Both, the biological and the structural obstacles are supposed to reduce water speed and to hold soil particles back. In the case of thresholds, the ditch might eventually be refilled with soil.

Advantages
Erosion stops quickly

Vegetative measures are relatively cheap

Disadvantages
Solutions including concrete are expensive, wood is likely to be cut/stolen

Frequent control and caretaking necessary

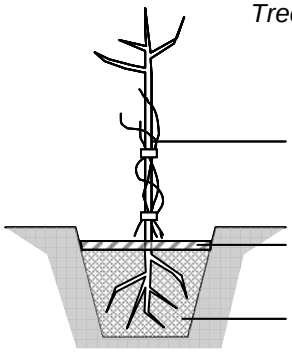
Life fences have a shading and 'place wasting' effect

Remarks
Life fences have generally many positive effects and a wide range of application.

Source/Experiences
The solution with sour cherry trees planted in ditches is being proven in the FAO-Watershed management project near Faizabad. There also several live fences were installed.
The threshold solution is applied in many small temporary and permanent watercourses in Europe. If it works also in the conditions presented in Hojahakik must be tested previously.

Clear-cut (in front) and stocked parts of pasture in Hojahkik Watershed

Tree planting scheme



Target area
In the Hojahakik Watershed, there are two areas where a type or forestation should be considered; the treeless parts of pasture (with the prime goal of soil and water conservation) and the unplanted terraces around the Hojahakik village (with the prime goal of firewood production).

Description
Trees and shrubs are planted in holes and according to the slope (see annex 2). The distance depends on the tree species. Maximal distances: 4m (shrubs) – 8m (walnut).

Material
Proposed trees for the forestation of pastureland: *Crataegus sp., Pyrus Bukharica, Amygdalus bucharico, Eleagnus angustifolius, Pinus eldarica, Lonicera sp., Cotoneaster sp.* Proposed timber trees for the terraces: *Juglans regia, Eleagnus angustifolius, Pinus eldarica*. In ravines: *Populus sp*. and *Salix sp*.
Furthermore individual protections (thorn shrubs or sticks), mulching material, dung as fertilizer and irrigation systems (e.g. bottle irrigation) have to be provided.

Effects
In the first years, trees have only a punctual effect. But after some years they develop multiple functions in terms of protection and production. The hole-planting and the mulching practice are special adoptions for dry areas; weed is removed and suppressed, water is collected, soil moisture is better conserved.

Advantages
Trees and shrubs decrease the discharge after heavy rainfall

Trees and shrubs create stable areas that reduce or eliminate wind and water soil erosion

Improvement of soil chemical, physical and biological characteristics

Disadvantages
Need watering and protection against browsing and trampling damages (at least in the first some years)

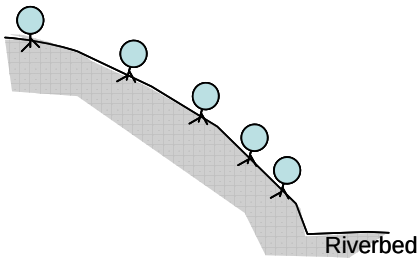
Reduction of the grazing area

Artificial reforestations are not as adapted to the given conditions as natural regeneration

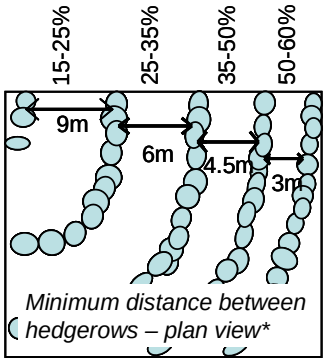
Remarks
It doesn't make sense to reforest the pasture unless the tree cuttings are stopped in this region.

Source/Experiences
The Lezhoz of Muminabad is experienced with reforestations. They also run their own tree nursery with walnuts. Fruit trees are available in the tree nursery of Kulob. The botanical garden may provide a wide-ranging supply of seedlings.
An example of a productive forestation can be found near Kulob (Junction to Muminabad)

Steep bare slope in Hojahkik Watershed



Hedgerows - side view



*Minimum distance between hedgerows – plan view**

Target area
On the deforested pasture land, the reforestation could also be designed in the form of hedgerows instead of the usual row- or chess- scheme. This type of planting would have an experimental character since it is uncommon for the region.

Description
On sloping land, hedgerows are planted on the contour, creating 'contour hedgerows'. The slope of the land determines the minimum distance between hedgerows necessary for erosion control. The steeper the slope, the closer together the hedgerows need to be to act as an erosion barrier.

Material
Mainly shrubs are suitable for planting the contour lines. The species should be adapted to the site factors and easy to reproduce (barrier planting requires huge amounts of seedlings)
Proposition: *Cercis griffithii* and *Calophaca grandiflora* (Both of them Nitrogen fixing Leguminous)

Effects
Vegetative contour barriers are viable vegetative means for the reduction of erosion instead of expensive terracing.

Advantages	**Disadvantages**
See also 'Reforestation'	See also 'Reforestation'
Very efficient erosion control	Hedgerows hinder the free pasture of livestock
Nitrogen fixing shrubs enhance the fertility of soils	Most of the suitable shrubs are not available in tree nurseries
Terraces are eventually built in a natural way	Relatively big expenditures for the installation

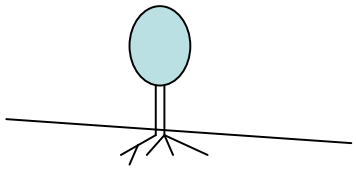
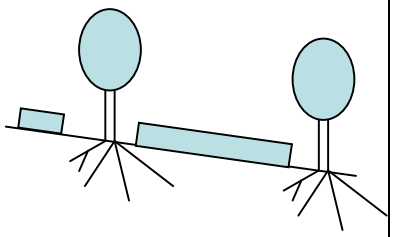
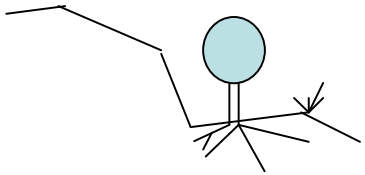
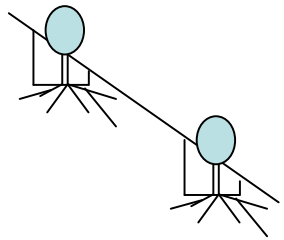
Remarks
For optimum erosion control, particularly on steep slopes, a pair of hedgerows about 0.5-1 meter apart is recommended. The double hedgerow further reduces the effects of erosion in a heavy rain.

Source/Experiences
A kind of vegetative barrier control has been implemented in the FAO Watershed management in Faizabad. But there exclusively weedy plants (Alfalfa, Esparzet) were utilized. Hedgerows have been used in many tropical areas (often in combination with alley cropping) for many years.

* Source: USDA NRCS (1991): Vegetative Row Barriers. *[Ideal scheme may be different under the present conditions!]*

Planting technology for different slopes

Annex 2

Slope	Slope till 8º	Slope between 8º and 12º	Slope between 12º and 35º	Slope over 35º
				
Technical measures, type of agriculture	Arable cropping possible No technical measures necessary	Planting of tree with stable and long root system. Intercropping between rows possible	Creating of terraces Planting trees in the middle of the terrace Planting some protecting weed on the edge of the terrace Two rows are possible in case of terrace surface >6m	Building of holes ("Plashadkas") with areas of 1-2m^2. Distance between the trees 6m. Chess scheme for the maximal protective effect.
Suitable tree species	Adapted convenient trees, different fruit trees	e.g. Walnut, Fruit trees…	e.g. Pistachio, Walnut and Almond…	e.g. Juniper, Almond, Pistachio…
Water supply	Usually irrigated land	Irrigated and rain fed land	Irrigation only in the first 2-3 years common Minimal precipitation 450 -600 mm per year Mulching with hey and straw recommended (1m^2, thickness 10 cm)	
Further information	Rare in Hojahakik valley. Normally not problematic in terms of soil erosion.		Create the terraces in the way that the created surface is backward sloped Possible to create natural terraces by means of contour planting Planting in individual holes ("Plashadkas") also possible	Prepare planting ground with 6-8 cm natural fertilizer (dung and earth mixed together) Maximal slope about 45º

List of shrub and tree species mentioned in this report — Annex 3

The following woody plants are currently present in Hojahakik Watershed

Name				Common site		
Latin	**English**	**Tajik**	**Russian**	**Forest**	**Pasture**	**Cultivated**
Acer Semenovii*	Maple	Фарк, зранг	Клён 6 Семенова	X		
Amygdalus bucharico	Almond	Бодом	Миндаль бухарский		X	X
Armeniaca vulgaris	Apricot	Зардолу	Абрикос			X
Berberis heterobotrys	Barbary	Зелол 3 навъ	Барбарис разнокистевидный	X	X	
Cercis Griffithii*	Judas-tree	Шулаш	Багряник Гриффита	X	X	
Cotoneaster sp*	Cotoneaster	Иргай	Кизильник	X	X	
Crataegus darvasica	Hawthorn	Дулона 6 навъ	Боярышник дарвазский	X	X	
Cydinia oblonga	Quince	Себи бихи	Айва			X
Elaeagnus angustifilia	Russian olive	Синчит	Лох узколистный			X
Ficus carica	Fig-tree	Анчир	Инжир обыкновеннее			X
Juglans regia	Walnut	Чормагз	Орех грецский		X	X
Juniperus seravschanca/ semiglobosa	Juniper	Арча-Ардач	Можжевельник		X	
Lonicera sp*	Honeysuckle	Бушол	Жимолость	X	X	
Pistacio vera	Pistachio	Писта	Фисташка			X
Populus alba	White poplar	Сафедор	Тополь	X		X
Populus nigra	Lombardy poplar	Ар-ар	Пирамидальный тополь			X
Prunus cerasus	Sour cherry	Олуболу	Вишня краноплодная		X	X
Prunus Simonica	Plum, Simon plum	Олу	Слива			
Prunus sogdiana	Cherry-plum	Олича	Алыча согдийская			
Pyrus Bukharica	Wild pear	Муруд, Нок	Груша Бухарская		X	
Pyrus sp.	Pear	Муруд, Нок	Груша			X
Rosa canina	Dog rose	Хуч, Гулхор	Шиповник		X	
Salix ?	Yellow willow	Зард- бед	Ива	X		
Ulmus Androssovii	Elm-tree = alums	Карагоч, сада	Вяз Андросова		X	
*Calophaca grandiflora		Каин, Кинга	Калофака	X		
*Exochorda Alberti	Turkestan pearl bush	Тлех, Тнллех	Экзохорда Алберта	X		
*Celtis caucasia	Caucasian sugar berry	Туг, Тагдан	Каркас кавказский	X		

* Commonly collected in forests (as firewood)

The following trees can't be found in the watershed for the moment. All of them are exotic to Tajikistan:

- Robinia pseudoacacia (engl. Acacia)
- Ailanthus altissima (engl. Tree of heaven)
- Pinus eldarica
- Cyparis arizonica