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Scope and constraints for tree planting in the irrigated landscapes of the Aral Sea Basin: case studies in Khorezm Region, Uzbekistan

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Abstract

A wealth of research papers, reports, and newsprint demonstrate the wide international interest in the ecological deterioration in the Aral Sea Basin in Central Asia (CA). The demise of the Aral Sea is a symptom that results from intensive agricultural activities aiming at maximizing agricultural production while neglecting environmental sustainability, as exemplified by the land use patterns also prevalent in the Republic of Uzbekistan, one of the five newly established states in CA. The environmental degradation is acute and continues, since various factors conducive to it have not been eradicated.

This discussion paper deals with the potential role of forestry-based production systems and in their contribution to counterbalancing the ecological landscape demise in the region. This discussion paper starts with a brief overview of environmental conditions in CA, followed by a discussion of forestry and agroforestry in CA's irrigated semi-arid and arid landscapes. The paper focuses on Uzbekistan, and more specifically the province (viloyat) of Khorezm, which is located at the southern rim of the Aral Sea Basin and serves as an example for the Middle Asia lowlands.

The results of surveys on farmers' perception of forest and tree products, as well as the outcomes of field measurements of the productivity of tree stands and agroforestry systems, regional forestry governance, and the market situation for timber products are discussed. Following data mining of secondary sources, field, market and household surveys, combined with in-depth analyses using remote sensing techniques, the paper re-assesses the tree resources of Uzbekistan and concludes that the present use and management of trees and forests is inadequate. Well-designed multi-species windbreaks are absent (single-tree rows of mulberry comprise about 50% of the present tree strips), only 70% of the tree windbreaks were oriented in the North-South and North/West-South/East directions, from which the highest wind speeds (>3 $m\ s^{-1}$) are generally measured, and the majority of the investigated tree strips did not satisfy the minimal height of 5 m. More than half (55%) of the strips did not stretch over the entire length of the related field. However, other structural criteria such as stand porosity and width had acceptable values. In the hedgerow systems monitored tree planting schemes varied considerably but on average were much lower compared to the recommended planting schemes by forestry administrations as the perennial crops were of more importance to the farmers. The farmers planted mostly fruit trees to increase income and improve their food basket, but none of the ca. 100 interviewed was ecologically motivated. However, the total land area of the various surveyed agroforestry systems on both private and rented land was the largest where tree age did not exceed 12 years, thus indicating the interest of tree planting.

The surveys results are followed by a review of forestry policies in Uzbekistan. The paper concludes with a set of recommendations concerning managerial and research needs for forest and agroforestry systems in irrigated drylands of CA, and outlines the opportunities and need for external support at both the country and sub-regional level. Despite the role trees could potentially play, the lack of training of the farming population, reduced capacities of the forestry administration and their staff as well as shortcomings in the forest legislation have resulted in many underperforming "goodwill" efforts. Due to the complexity of the social, economical and physical components and their interdependencies, this paper calls for integrated knowledge generation, concerted action and for administrative and research support. The crisis in the Aral Sea Basin has a strong global dimension, which calls for targeted support at both country and international donor community levels.

1 Introduction

Central Asia (CA) once formed a vital and a vibrant part of the famous Great Silk Road, the trade route that linked China to the West, where valuable goods like silk and spices went westwards and wool, gold and silver went east. From the days of the Great Silk Road, CA has served as a crossroads for cultures, trade, and ideas. This historic and economic background, together with the desert climate as a consequence of the rain shadow of the Pamir mountains and the presence of a large river system originating there, causes a history of over 5000 years of irrigated agriculture in Middle Asia (as the flatlands of Central Asia west of the Pamir are sometimes called; cf. Breckle 2002). Till today, the population of the Middle Asian drylands has been highly dependent on irrigated agriculture and animal husbandry.

Natural forests occur along the rivers (tugai forests; Schlüter et al., 2005; Treshkin, 2001) and in mountainous areas. The largest populations of natural woody vegetation are found in the desert areas and classified by the local forest service as “desert forests” (cf. Chapter 3). Various tree species were introduced in the agricultural area, and some of them have adapted to the harsh ecological conditions of CA’s irrigated drylands, which are characterized by high summer and freezing winter temperatures, and often fertility declined, saline soils.

Agroforestry systems have been traditionally developed and intensively managed all over CA e.g., in river oases and transitional habitats in the vicinity of deserts. However, the economic and political changes during the Soviet period clearly defined strategic regions e.g., CA for cotton production. During the last 15 years, the need to generate state income in the newly independent states erected in CA, have further increased the pressure on apparently “unproductive” forests and tree stands, which historically had been an important part of the ecological and agricultural systems. With the development of the centrally organized and managed agricultural production systems (kolchoz and sovchoz) in the former Soviet Union (USSR), including those in CA, the agricultural land use became focused on annual crop production. Land was divided into large productions units, and trees and forests, which occupied fertile land along the river banks or hindered setting up the infrastructure necessary for a highly mechanized, irrigation-based agricultural production, were sacrificed. Not only has the natural tugai forest mostly disappeared (Treshkin, 2001), agroforestry systems developed and maintained over thousands of years with many fruit-bearing trees, small forest patches and field border plantings (Blinovsky, 1956; Cherdantsev, 1950) were also destroyed ignoring thus the traditional advantages for the ecology and landscape development.

Yet, during the Soviet period, trees were being introduced in the agricultural areas for preventing wind erosion and improving the microclimate in the adjacent cropped fields. Planting of tree shelterbelts or their single component – windbreaks required withdrawing a part of land from agricultural planning. The planting strategy was based on recommendations resulted from extensive research covering a wide spectrum of subjects related to the tree shelterbelt systems. As the main purpose of such plantations was ecological, and the planting was imposed on land of the state-run collective farms, the local population could not influence the decisions about the location and species choice for shelterbelt planting. Moreover, the people were not allowed to harvest the tree products and hence generally had low interest in maintaining these plantations. This situation has hardly changed after independence in 1991 as the decision-making opportunities of the rural population in Uzbekistan still are strongly limited by the state order system with strict quotas on crops to be fulfilled (ZEF, 2003).

However, following independence, the population has gained access to limited pieces of private parcels such as kitchen and home-stead gardens managed in private ownership. The opportunities people engaged in were materialized in the rapid development of agroforestry systems that nowadays mainly consist of intercropping annual staple crops (e.g., wheat, maize, potatoes or sunflowers) with trees. The trees have played a major role in providing fruits and woody products, such as timber and firewood, but also can be used as fodder and offer possibilities for bee foraging (Khamzina, 2006). Yet, these alley or hedge row cropping systems have been developed by the land users on a trial-and-error basis and with materials available at hand, but with little scientific support, as previous research was oriented towards agroforestry systems where trees fulfilled exclusively ecological purposes. Hence, when multipurpose trees were introduced for satisfying construction and firewood needs, agroforestry principles were hardly taken into account. For example, only scarce information is available on planting densities, suitability of tree species, or the management of the competition between annual and perennial crops.

This discussion paper starts with a brief overview of the CA region followed by aspects related to forestry and agroforestry in CA's irrigated semi-arid and arid landscapes, with a strong focus on Uzbekistan, and more specifically the province (viloyat) of Khorezm, which serves as an example for the Middle Asia lowlands of the region. Next, the results of surveys on farmers' perception of forest and tree products, as well as the outcomes of field measurements of the productivity of tree stands and agroforestry systems, and the overview of the market situation for timber products are presented and discussed. The surveys' results are followed by a review of forestry policy strategies in Uzbekistan. The paper concludes with a set of recommendations concerning managerial and research needs for forest and agroforestry systems in irrigated drylands of CA, and outlines the opportunities for external support at both the country and sub-regional level.

This paper, by presenting results of a joint German-Uzbek research program on economic and ecological restructuring of land and water use in the Aral Sea Basin (Vlek et al., 2003; ZEF, 2003; Martius et al., 2004a, b), introduces the topic whereas a range of follow-up studies providing more details are reported elsewhere (Khamzina et al., 2006a, b; Lamers et al., 2005;

Tupitsa, 2006). A central idea of the project is to set aside land for ecological purposes while compensating agricultural production losses through more efficient land and water use. Introducing and maintaining trees and forests in a landscape is well-known to provide many ecological benefits (Young, 1997) and service functions (Daily, 1997). To strengthen the role of trees and forests in the landscape of Khorezm, we started out with data mining and an analysis of the current condition of trees, plantations and forests in Khorezm. We have found that traditional use and management of trees and forest is accompanied by various shortcomings and avoidable problems in forest and agroforestry systems management, which are worthwhile to be highlighted and discussed. In this paper we have attempted to combine the complexity of this interdisciplinary approach, which is characterized by the integration of productivity with environmental, economic, and social aspects.

To achieve farmers' acceptance of tree planting we believe that it is necessary to emphasize a quantitative approach to estimate the advantages of trees for overall (agro-) ecosystem stability, i.e., measuring the direct benefits such as timber, fruit and fodder production. Another effect of trees and forests is the shelter they provide for humans and cattle, and, not least, there are aesthetic values of trees in a landscape. At the same time, the needs of agriculture as the prime activity of the region cannot be neglected, and the needs of the people who traditionally, over the past 5000 years, depended on agriculture. We therefore propose to improve the integration of the foresters' knowledge on planting trees in the farmer's land use decisions regarding the design of plantations and proper silvicultural management.

2 Central Asia Region - a region in transition

The collapse of the USSR in 1991 led to the formation of the five Central Asian Republics (CARs)[1]: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan (Fig. 1). CA is bordered by the Russian Federation to the north-west, the Caspian Sea to the west, Iran and Afghanistan to the south, and the People's Republic of China to the east. The total area of CA is 3,882 mln km^2 which is larger than the Indian subcontinent (Table 1).

Table 1: Aral Sea Basin characteristics by country

Country	Area, km^2	Population, mln	Irrigated area, ha	GDP, mrd USD	Foreign debts, mrd USD
Kazakhstan	2,717,300	16.1	796,542	18.2	6.18
Kyrgyzstan	198,500	5.0	398,271	1.3	1.70
Tajikistan	143,100	6.1	716,887	1.2	0.88
Turkmenistan	488,100	4.9	1,752,392	4.3	2.02
Uzbekistan	447,400	25.3	4,301,326	13.6	4.16
Total	3,994,400	57.4	7,965,420	38.6	14.94

Source: Saigal, 2003

The combined population of CA was approximately 57 mln in 2002 with an estimated population growth rate of 4.1% (Saigal, 2003). Uzbekistan has the largest population (Table 1). Aside from a densely populated strip across the north of Kazakhstan bordering Russia, most of CA's 57 mln people reside within the irrigated areas where water is provided by the two large rivers flowing to the Aral Sea: the Syr Darya and the Amu Darya.

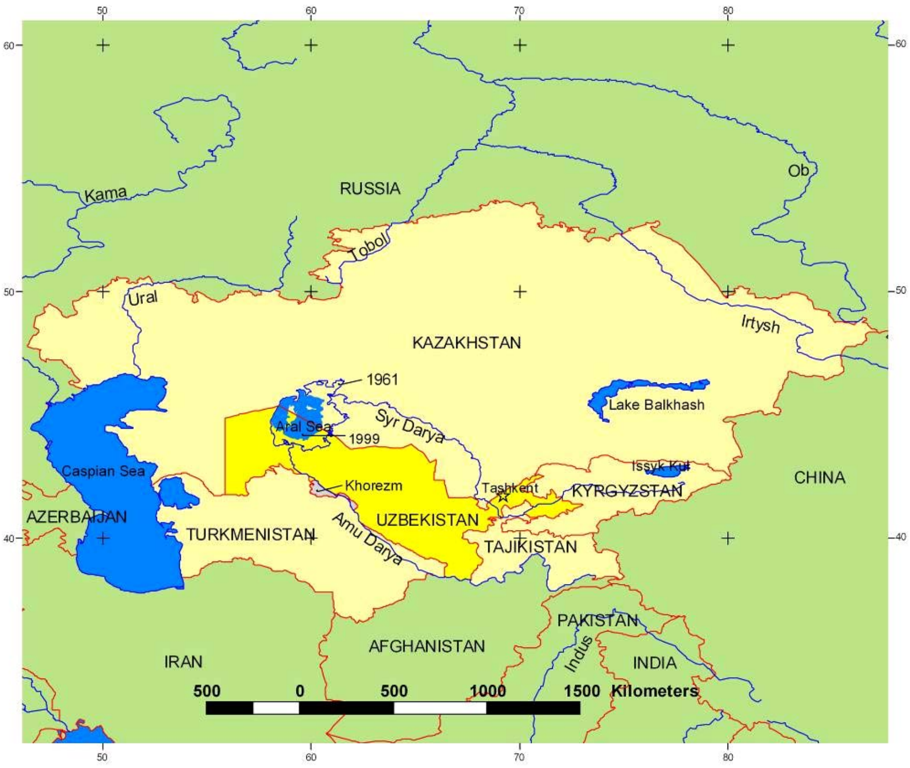
The upstream countries Kyrgyzstan and Tajikistan are mountainous and their economies largely depend on agriculture, whereas in the downstream countries Kazakhstan, Turkmenistan and Uzbekistan industry is of relatively large importance, although agriculture still prevails in the national economies. The latter countries also possess fossil fuel reserves, especially oil and gas in the Caspian Sea coastal region of Kazakhstan and Turkmenistan, and coal in several parts of Kazakhstan that place them among the most richly endowed energy producers in the world.

[1] Northern Afghanistan is hydrologically and ethnically linked to the Central Asian states. It lies in the upstream catchment of the Amu Darya River, and it is ethnically linked with Tajikistan, Uzbekistan and Turkmenistan with which it shares a common border.

2.1 Forestry in Central Asia

The prevailing extremely continental climatic conditions with low temperatures in the winter, hot and dry summers and little precipitation throughout the year broadly determine the extent and forest types across Central Asia. Relatively sparse and unevenly distributed, natural woody vegetation is restricted to juniper and nut-bearing species in Western Tyan-Shan mountains and Pamir-Alay mountain ranges, to riparian *tugai* consisting mostly of Euphrates poplar in floodplains of the rivers, and bushy vegetation in the two sandy deserts of Central Asia, Kyzylkum and Karakum (Drobov, 1951). The actual amount of forest resources possessed can be only approximately quantified given the discrepancies between categories and definitions used in national forest inventories and those used by the Forestry Department of FAO (FRA, 2005), and the fact that no official forest inventory, e.g., in Uzbekistan has been conducted since the independence.

Figure 1: Map of Central Asia and Uzbekistan showing Khorezm province and Aral Sea's borders in 1961 and 1999



Source: ArcGIS database, 2006

Uzbekistan's data adapted to FRA's classification (Table 2) shows that forest covers about 10% of the total land area of the country, including 7.7% of forested area and 2.2% of other wooded lands such as sparse forest stands. Of the forested area, only 1.7 % or roughly 56,700 hectares is classified as primary forest (FRA, 2005), which is nature reserves – the territory assigned for biodiversity conservation where any human activity is completely prohibited. These forests are mainly located in the desert (sandy) zone (about 85%), mountain areas (some 14%) and in the plain lowlands, (irrigated) valleys and *tugai* flood-lands (1.5%) (Khanazarov and Kayimov, 1993; GEF & UNDP, 1998; UN Timber Statistics, 2004; the Main Forestry Department, 2005). This locally used forest classification is based on distinguishing three forest classes: desert, plain and mountain forests which are corresponding to geo-morphological altitudes in the country - plains (including desert), foothills, mountains and high mountains (Vildanova, 2005).

Table 2: Summary on forest resources in Uzbekistan

National statistics	
Total area*	44,740,000 ha
Land area*	42,540,000 ha
Inland water*	2,200,000 ha
Forested area and other wooded land**	4,199,000 ha
Forested area**	3,295,000 ha
…of which primary forest (nature reserves)**	56,700 ha
Other wooded land**	904,000 ha
Other land**	38,341,000 ha
Forested area and other wooded land as % of the land area	9.9 %
Forested area as % of the land area	7.7 %
Primary forest as % of the forested area	1.7 %
Total population*	26,900,000
Land area per inhabitant	1.6 ha
Forested area and other wooded land per inhabitant	0.15 ha
Forested area per inhabitant	0.12 ha

Sources: *The World Fact Book, 2005; **FRA, 2005

However, a comment is needed about the Uzbek concept of “forests”. Main woody species of the so-called “desert forests” (Fig. 2), concentrated on the lower areas and with access to the groundwater table, are *Ammodendron conollyi* Bunge, *Calligonum arborescens* Litv., *Haloxylon persicum* Bunge ex Boiss. & Buhse, *H. ammodendrom* (C. A. Mey.) Bunge, and *Salsola richteri* (Korovin, 1962).

Figure 2: View of 'desert forest' near Lake Shorbankul, Khiva desert forest zone, forest compartments 36-39 of the Regional Forest Service

These are better seen as bushes than as trees, as they reach an average height of 4 m (although their root systems may penetrate the soil down to more than 6 m to reach the groundwater (Breckle, 2002)). The standing volume of this forest type is generally low ranging from 2.5 m^3 ha^{-1} in Tuyamuyun desert forest area to 3.3 m^3 ha^{-1} in Khiva desert forest area for mature trees (Regional Forest Inventory, 1990) and making an economical timber production virtually impossible. In fact, the Uzbek concept of "desert forest" can hardly be seen as corresponding to a forest in the classical view of foresters or botanists. Therefore, the desert forests mainly fulfil ecological functions such as providing a natural protection against soil erosion, as well as maintaining biodiversity at higher levels.

With the decay of the social services and the agricultural support during the post-independence period of 1991-1992, rapid increases in rural poverty have ensued (ZEF, 2003). Diminishing livelihood opportunities for rural communities, largely caused by the economic transition, have led to an increased push for liquidation of natural assets and consumption of capital stocks, resulting among others in a large-scale deforestation. From the beginning of the last century in the countries of CA the area of forests has undergone a 4-5 fold decrease, especially during the last decades (GRIDA, 2006). Large areas of the desert, *tugai* and mountainous forests have been converted drastically by human activities into arable land. Treshkin et al. (1998) reported a reduction in the *tugai* area in the Amu Darya delta from about 300,000 ha in 1930 to about 35,000 ha in 1990. Moreover, various habitat pressures lead to the danger of extinction for a constantly growing number and range of indigenous species, with several having been re-classified from "rare" to "disappearing" status since the collapse of the USSR (GEF & UNDP, 1998).

2.2 Uzbekistan – A representative for Central Asia

With a population of about 25 million, Uzbekistan covers 447,000 km^2. This makes Uzbekistan the third largest in population number and fourth largest in area of the former Soviet Union republics. Uzbekistan is bordering Tajikistan in the southeast, Kyrgyzstan in the northeast, Kazakhstan in the north and northwest, Turkmenistan in the southwest and Afghanistan in the south (Fig. 1).

2.2.1 Climate

Climatically, Uzbekistan is a part of the "dry mid-latitude desert" which is characterized by hot summers and cold winters, with temperatures rising to +45 and falling as low as -20 ^{o}C. In the Middle Asia lowlands, the climate of Uzbekistan is defined as an arid, sharply continental, known for abundance of solar radiation, small cloudiness, and poor precipitation (Glazirin et al., 1999). About half of the annual precipitation of 110-200 mm falls in spring, about a quarter throughout the winter months, a small part in fall, and an insignificant part during summer.

2.2.2 Land use

The landscape of Uzbekistan consists of mountainous areas, foothills and desert plains. Topographically, this part of Uzbekistan is mostly flat or slightly hilly sandy desert, sometimes with dunes; or it consists of flatlands in intensively irrigated river valleys. The elevation varies from 12 m above the sea at the lowest point to 4,300 m at the highest point in the mountains. The vast plains, linked with foothill sloping plains, are characterized by slight surface partition and absolute absence of permanent watercourses. About 75% of the territory is desert or semi-desert, and only 4 mln hectares of the area are cropped, whereas 15% is mountains and 10% foothill plains.

Water is the basis for intensive irrigated agriculture, which is the backbone of the economy in Uzbekistan. The two main rivers, Amu Darya and Syr Darya terminate in the Aral Sea. These two river basins have over 30 major tributaries. More than 20 large and mid-sized reservoirs and 60 large canals have been constructed for irrigation in the two basins since the 1950s. Irrigated agriculture accounts for 85% of the total water use in the country, while irrigated land constitutes 54% of the irrigated area in the entire Aral Sea basin (Box 1).

Box 1: Land degradation

> Up to 50 % of the irrigated lands of Uzbekistan are exposed to varying degrees of salinization (UNEP and Glavgidromet, 1999). In the case of land salinity, the role of inappropriate irrigation practices by far surpasses natural causes. **Likewise, vegetation degradation is caused by livestock overgrazing, cutting of trees and shrubs** for firewood, discharge of drainage water into desert depressions and excessive watering. Drying of the Aral Sea and exposure of toxic materials that have been deposited on the former Aral Sea bed also are said to be a serious problem (Jensen et al., 1997; O'Hara et al., 2000). Land degradation has been a crucial factor in the decline in living standards due to the loss of soil fertility and crop yields (UNEP and Glavgidromet, 1999).

2.2.3 Khorezm – the study zone

Khorezm is an administrative province (viloyat) of Uzbekistan in the lower Amu Darya Basin, located at 220 km south of the present shores of the Aral Sea. Khorezm represents a 260,000 ha artificial watershed consisting of irrigated farmland (Salaev et al., 2006). The climate is within the range described above for Uzbekistan, with a larger restriction on rainfall (an average annual rainfall of about 80-100 mm is observed). Due to a high groundwater table, hydromorphic soils affected by salinity are pre-dominant. During 1988-2001, land area of Khorezm having GW levels shallower than 2.0 m averaged 84%, while areas with elevated GW salinity of 3-10 g l^{-1} averaged about 10% of the total irrigated area (MAWR, 2001).

The evaporation of the shallow GWTs has caused a secondary soil salinization throughout the entire irrigated area of Khorezm (FAO, 2003). Moderate and highly saline soils are mostly concentrated in Khazarasp (86%), Koshkupyr (77%), and Yangibazar (51%) districts (tumans). In the other tumans of Khorezm, such soils are found on about 32% of the irrigated land (MMTU, 1997). High soil salinity impedes crop growth; crop yields may be suppressed by 10-20% even on weakly saline soils (Kaurichev, 1989).

Organic matter contents in soils of Khorezm (mostly aridic and gleyic calcaric (sodic) Arenosols and calcaric Cambisols) ranges from 0.7 to 1.5% whereas a cation exchange capacity varies between 5-10 cmol(+) kg^{-1}. Total N and P contents in Khorezm soil types are also low, usually ranging 0.07-0.15% and 0.10-0.18%, respectively. Available K content is classified as low and moderate (Fayzullaev, 1980). Consequently, the natural fertility of the soils in Khorezm is characterized as rather low and cultivation of most agricultural crops requires high inputs of chemical fertilizers.

3 Agroforestry systems

The cultivation of perennial crops, primarily trees and shrubs, is a special form of land use practiced world wide by small holders as well as grown by large estates (Ruthenberg, 1980). In principle, four levels of plantings can be distinguished (Ruthenberg, 1980).

- A scarce planting of perennial field crops, usually on small areas;
- The area attributed to perennial crops is extended. The perennial field crops are usually inter-planted with arable crops;
- Perennial crops predominate in the mixed-cropping systems and young stands of tree crops usually are inter-planted with arable crops;
- As the perennial crops more and more create shade, intercropping becomes less important.

ICRAF (http://www.worldagroforestry.org/) advocates a simple definition of agroforestry when stating “the use of trees on farms”. Yet, Martin and Sherman (1992) argued that that this simple definition does not account for “the integrated concepts associated with agroforestry which makes this system of land management possibly the most self-sustaining and ecologically sound of any agricultural system”. They advocate therefore for a definition of agroforestry as “the integration of trees, plants, and animals in conservative, long-term, productive systems”.

FAO (2005) classifies agroforestry systems in two basic categories: simultaneous and sequential systems.

- In a simultaneous system “trees and crops or animals grow together, at the same time on the same piece of land”. Consequently trees and crops compete at the same time for light, water and nutrients. Managing this competition to obtain an optimal performance is a major challenge to agroforestry systems and can be achieved by appropriate spacing, the proper selection of tree species based on the growth rate, the rooting zone (the trees’ roots should reach deeper than the crops’ roots) and a canopy that provides during the crop growth a minimum of shade to prevent out-shading of crops. Well-documented examples are boundary plantings and all kinds of hedges and windbreaks, alley cropping, parklands and , silvo-pastoral systems, agro-forests, and shaded perennial crops.

- In sequential systems “crops and trees take turns in occupying most of the same space”. Generally, i such systems the planting of trees follows that of the crops. The competition between crops and trees is managed mainly by both a judicious time management and appropriate selection of tree species, which is guided by the principle that trees ”should grow rapidly when crops are not growing, recycle nutrients from deep layers, fix nitrogen and have a large canopy to help suppress weeds”. Worldwide, cropping systems such as shifting cultivation, relay intercropping, improved fallows, or taungya (a system “in which small-scale farmers are given agricultural plots and subsidies on state forest land in return for planting and maintaining trees on the plots”; cf. McCall and Skutsch (1993)) belong to the sequential systems.

The many advantages and disadvantages of agroforestry systems have been well-documented. A comprehensive interpretation of agroforestry systems in arid and semi-arid zones is given by Kessler and Breman (1991). They concluded that trees are not always and everywhere profitable, and that the properties of woody species should be carefully balanced with the objectives and conditions at each site.

Despite the more or less detailed definitions, it is a common understanding that agroforestry is a land use approach that intends to improve productivity by planting crops and trees simultaneously or sequentially on the same area. It can be applied most effectively on land unsuitable for monocrop situations. Depending on the species, trees may function as a green manure to enrich the soil, serve as a feed source, a ground cover for stabilizing soils and control erosion, provide firewood and construction materials, and produce fruits. Used this way, agroforestry systems may contribute to the rehabilitation of degraded soils, stimulate productivity, and provide increased rural household income. While using various criteria, the agroforestry systems monitored here are screened from this perspective.

4 Overview on tree species, natural and artificial forest systems in Khorezm

The trees and forest stands in the Khorezm oasis of the Amu Darya River are integrated into the agricultural intensive land use systems. All trees are used directly in forestry or agroforestry systems, with their purported function being an increase in the yield of crops, the production of construction and fuelwood, or the prevention of desertification at the margins of the Khorezm oasis. Natural woody vegetation is almost entirely limited to a small strip of *tugai* floodplain forest at the margins of the Amu Darya River. Furthermore, transition vegetation is found at the borders of the desert, and spontaneous secondary vegetation settles on abandoned land and along irrigation and/or drainage channels (Fig. 3). The management of the river oasis considerably extends the area of tree growth but makes trees dependent on irrigation.

The existing set of indigenous tree species is only usable for a few purposes, mainly wood production. Therefore, the majority of the actually used species was introduced, either long time ago, as is the case of mulberry trees, used as a fodder tree for silk worms in sericulture, during the beginning of the Russian occupation such as elm species, or very recently, such as the fast growing (mostly hybrid) poplar varieties for timber production.

Figure 3: Secondary vegetation dominated by *Elaeagnus angustifolia* alongside an irrigation channel in Khorezm

The trees can be classified according to their main purpose into four major groups (Table 3):

1. Trees in windbreaks. During the Soviet period about 40 thousand ha of protective shelterbelts were planted in Uzbekistan, but to a much lesser extent in Khorezm compared to other viloyats. Till nowadays, the main purpose of tree planting within the agricultural area remains the protection from wind erosion (Fig. 4).

Figure 4: View of osage orange (left) and poplar (right) tree strips in Khorezm

It is widely known that windbreaks significantly increase the yields of crops at the sheltered fields as witnessed by various research conducted in Uzbekistan (e.g., Kayimov 1993). However, the construction of effective windbreaks should follow some "architectural" guidelines to achieve optimal protection. Some general recommendations are given in section 8.2. A first rough overview of the existing windbreaks in Khorezm, based on an intensive survey over a transect expanding from the Amu Darya at the northern part of Khorezm till the marginal sites west of Khiva, showed that only very few "windbreaks" met these requirements. In some areas, the windbreaks consist of only short rows of small trees with many gaps in between, or missing at all. The majority of these lines of trees are constructed as a double row of mulberry trees which serve as a fodder bank for silk worms to satisfy the country's sericultural needs. The trees are coppiced annually for silk worm feeding and re-sprout during the summer, but are usually not higher than 2 or 3 m (Fig. 5). Clearly, the utilization as fodder trees for silk production surpasses their function as windbreaks.

Figure 5: Coppiced mulberry trees along roads

2. Cash-crop trees. These are used for:
   - Timber production. At present, the trees used for this purpose almost exclusively are introduced poplar varieties (Fig. 6).

Figure 6: Poplar plantations in Khorezm

Nevertheless, in former times, elm (*Ulmus* spp.) played a major role in constructions in Khorezm. In the historical city of Khiva, roof constructions or ornamental columns of ancient buildings were made from elm wood (Fig. 7, left), and we found remainders of elm trunks with a diameter of almost 75 cm close to a farm house in Khonka tuman. Such columns are not locally manufactured anymore as trees of the needed size have become extremely rare and can be found mostly as single trees where they are intended for sanctuary and recreational use only (Fig. 7, center). The wood of elm trees is used by artisans, who make various souvenirs for sale at Khiva market (Fig. 7, right)

Figure 7: Elm tree and its products

- Fruit trees: apple, apricot, cherry, mulberry, and pear trees, rarely quince, jojobe and sporadically fig trees (Fig. 8).

Figure 8: Apple trees intercropped with wheat (left) and pear orchard (right)

- Fuelwood, which can be harvested from any species, however, with differing quality (Khamzina et al., 2006).
- Fodder trees: mulberry for silkworm feed, desert shrubs (saltwort, salt cedar, etc.) grazed by goats and sheep (Fig. 9).

Figure 9: Feeding silkworms (left); goats and sheep grazing in desert (right)

3. Trees used for ecosystem protection: Trees and shrubs (mainly saxaul) are sometimes planted alongside the margins of the oasis to prevent wind erosion and sand movement. Also, trees preserved in the remnants of the natural *tugai* forests at the shores of Amu Darya (Fig. 10), notably in the Baday-Tugai reserve across the river in Karakalpakstan, reduce water erosion and conserve biodiversity.

Figure 10: *Tugai* forest stands in Khorezm (left); *tugai* forest patch in Baday-Tugai, Karakalpakstan (right)

4. Ornamental trees. In cities and villages trees are planted around farmhouses, along the streets or in small parks. Next to their aesthetic values these trees provide shadow - the feature much appreciated during the hot summer months. Most commonly, elm trees are found shading the entrance of farmhouses or the regionally typical outside dining places.

Most of the aforementioned species are multipurpose trees. The fruits of *M. alba* are eaten fresh, collected for jam production, and in spring the leaves are used as silk worm fodder. Older trees of other species in tree windbreaks are cut for fuelwood or for construction purposes, although the quality of the wood from intensively pollarded trees is rather poor.

Table 3: Multipurpose tree/shrub species for agroforestry in Khorezm

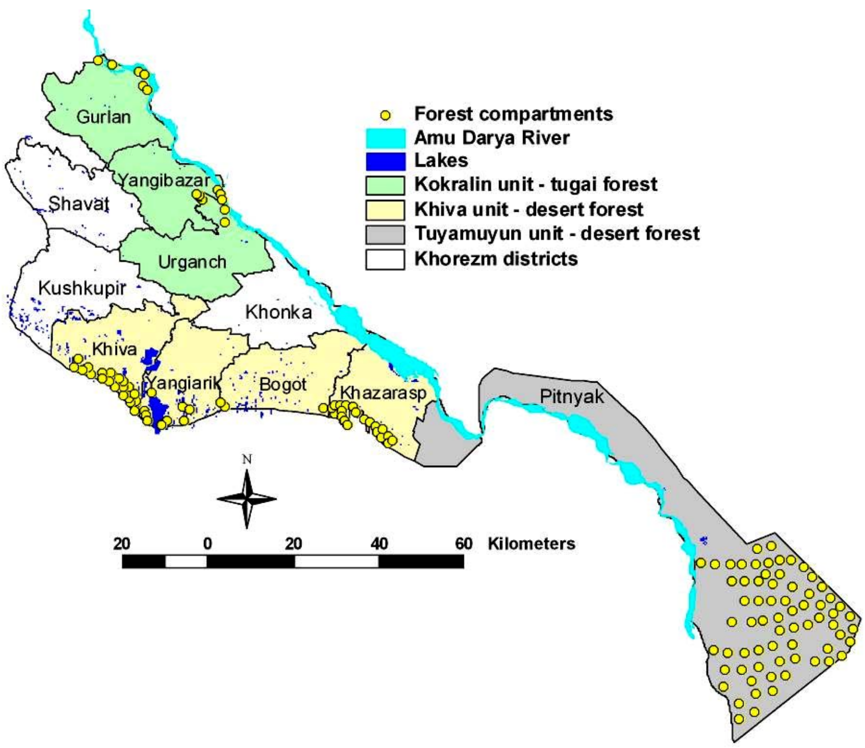
English (Latin name)	Local name	Common use	Special use
Black poplar (*Populus nigra var. pyramidalis* (Rozan) Spach)	Mirzaterak	Construction and fuelwood, charcoal, windbreak and shelterbelt	Timber, ornamental
Black locust (*Robinia pseudoacacia* L.)	Oq akas		Land reclamation through N fixation, leaf fodder, bee foraging, ornamental
Chinese cedar (*Biota orientalis* (L.) Franco)	Tuya		Oil, medicinal products, ornamental
Eastern redcedar (*Juniperus virginiana* L.*)*	Archa		Oil, medicinal products, ornamental, wildlife (fruits are eaten by birds)
Euphrates poplar (*Populus euphratica* Oliv.)	Turanga		Timber
Hybrid poplars (e.g., *Populus nivea x Populus tremula)*	Terak		Timber
Honey locust (*Gleditchia triacantos* L.)	Gleditchia		Resins, gums, medicinal products; fodder (immature pods), bee foraging, ornamental
Maple (*Acer negundo* L., A. *ginnala* var. *semenovii* (Regel & Herder) Pax	Zarang		
Siberian elm (*Ulmus pumila* L.*)*	Urus gujum, kayragoch		Timber, wood handicraft, ornamental
Swamp ash (*Fraxinus pennsylvanica* Marshall)	Shumtol		Timber, ornamental
Osage orange *(Maclura pomifera* (Raf.) C. K. Schneid.*)*	Maklura		
Willow (*Salix nigra* Marshall)	Kora tol		Basket manufacture, can be used to produce high quality paper, bee foraging, ornamental
Apricot (*Prunus armeniaca* L.)	Urik	Food, fodder, bee foraging, fuelwood, charcoal	
Apple (*Malus spp.*)	Olma		
Cherry (*Prunus cerasus L.*)	Olcha		
Jujube (*Ziziphus jujube* Mill)	Chilondjida, unabi		
Peach (*Prunus persica* (L.) Batsch)	Shaftoli		
Pear (*Pyrus communis* L.)	Nock		
Russian olive (*Elaeagnus angustifolia* L.),	Djida		Land reclamation through N fixation, medicinal products, gums
White mulberry (*Morus alba* L.).	Oq tut		Silk worm feed
Quince (*Cydonia oblonga* Mill.)	Bekhi		

Source: Own survey (2002), some info on special uses adapted from Forestry Compendium (2000).

5 The regional forest service

The responsibilities for forest land in Uzbekistan is distributed among various institutions such as the Main Forestry Department under the Ministry of Agriculture and Water Resources of the Republic of Uzbekistan, the State Committee on Nature Protection, and other institutions (Republican Scientific Production Center for Decorative Gardening and Forestry, Hokimiyat of the Tashkent Region, etc.). These organizations are all governmental agencies and state institutions. The largest owner of forest is the Main Forestry Department. It manages up to 93.5% of forest lands in Uzbekistan (webpage of the Main Forestry Department http://www.msvx.uz/rus/forest.html). The Main Forestry Department has regional branches and services. Khorezm native forests are administered by the Regional Forest Service which consists of three main territorial units: Kokralin, Khiva and Tuyamuyun, comprising two native forest zones in Khorezm - desert and *tugai* (Fig. 11).

Figure 11: Extent of *tugai* and desert forest zones



Source: Regional Forest Inventory, Khorezm, 1990

The remaining patches of *tugai* forests are located mostly in Kokralin territory including Gurlan, Yangibazar and Urganch administrative tumans. Desert zone is found in Khiva and Tuyamuyun territories. Khiva forest territory comprises the area of Khiva, Yangiarik, Bogat and Khazarasp tumans. Tuyamuyun territory covers Pitnayk tuman. No forest compartments are found in three administrative tumans - Shavat, Kushkupir and Khonka (Fig. 11).

In Khorezm 137 forest compartments were established, which were unequally distributed over the three forest territories. The largest number of the compartments was established in Tuyamuyun (71) and Khiva (51) forest territories on the southern and south-eastern parts of Khorezm. These forest compartments were located mainly on depression areas with numerous drainage salty lakes (including the largest in Khorezm, Shorbankul lake) surrounded by sandy deserts. Fifteen *tugai* forest compartments were established on the remaining patches and strips of *tugai* growing along the Amu Darya River banks in the northern-eastern part of Khorezm (Fig. 11).

Forest inventory is a component of the forest management plans in accordance to Article 16 of the Forest Law of Uzbekistan. *Urmon-Loyiha* (formerly *Lesproekt*) Research and Development Forest Enterprise of the Main Forestry Department is directly responsible for undertaking the forest inventories in Uzbekistan. During the Soviet period, one of the tasks of the forest service was assistance to *Lesproekt* in undertaking the regional inventory of trees and forest patches every 10 years, and thus contributed to the national inventory. The inventory covered all categories of land in the "state forest fund" which included not only the actually forested areas but also sparse plantations, fire sites, areas under dead or cut trees, glades, and abandoned plots (the latter categories were meant for reforestation and silvicultural activities). The inventory system was obligatory for all the republics of the USSR. The latest inventory was carried out in 1988-1990, but was only partially completed. Since that time the information about the land belonging to the forest fund has been estimated from the annual reports on economic activities of the forest service. An updated inventory of trees and forest patches for Khorezm, based on modern GIS-based analysis of aerial photographs, is therefore one of the accomplishments of the present project (Tupitsa, 2006), and may form the basis for introducing modern inventory techniques in Uzbekistan.

Another responsibility of the forest service is the management and protection of the *tugai* forest reserves, the area of which, however, decreased very rapidly in the last 20 years (Treshkin, 2001). The dominant tree species of *tugai* forests are poplars (*Populus euphratica* and *P. pruinosa;* (Ozolin, 1990)). *Tugai* trees have much lower diameter growth than plantation trees resulting in a higher wood density and consequently in a higher quality timber. However, *tugai* poplars are known often to succumb to a stem rot which considerably worsens the wood quality. The *tugai* forests, being the main source of wood for the rural population, have been experiencing an enormous deforestation pressure.

Box 2: Degradation of the *tugai* forests

The degradation of the *tugai* forests is primarily related to the drastic decrease in discharge of the Amu Darya River in its lower reaches and the delta. Upstream management of river flows, to meet irrigation needs, has adversely influenced the conditions for regeneration of riparian species by disrupting the natural pattern of flood events (Treshkin, 2001). The progressing soil salinization and lowering of the groundwater table due to the absence of seasonal flooding have reduced the areas suitable for growth of the *tugai* species (Kuzmina and Treshkin, 1997). The direct anthropogenic pressure such as approved and uncontrolled cuttings, fires, and overgrazing together with poor management and mere absence of updated inventory information have made the situation critical (Fig. 12). Consequences of the *tugai* forest disappearance are an expansion of the desert, loss of biodiversity, decreasing productivity of agricultural fields due to sand deposition from the desert, increasing water and soil erosion, and reduction of the phyto-remediation ability of the *tugai* (purifying contaminated drainage effluent from agricultural fields).

Figure 12: Soil salinization in a forest patch (left); uncontrolled cutting (right)

Finally, the forest service has the task of establishing, and subsequently, managing tree plantations at various sites. The main species used is poplar of different varieties, but ash and elm trees are also planted in smaller quantities. The plantations are usually regularly irrigated, with the exception of a poplar plantation close to the border of Turkmenistan (Bogat, Forest compartments 44-45). Trees at this site located at the marginal end of the irrigation system, close to a drainage collector, do not receive water regularly and often partially lose their foliage already in early September. At a nearby site, another plantation of saxaul trees (*Haloxylon aphyllum, H. percisum*) established in 1997 at a very sandy soil, as a protection against sand movement and desertification, has remained in good condition even under irregular irrigation. The regional forest service plans to expand the area of plantations considerably.

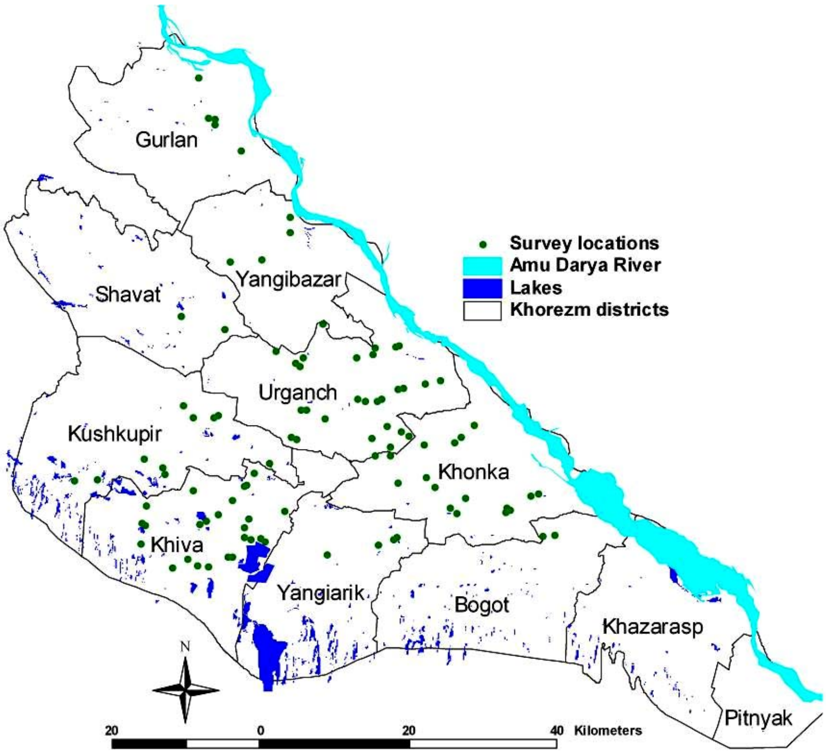
6 Survey on contributions of farmers to agroforestry systems in Khorezm

As one of the first project activities regarding forests, a survey was carried out in 2003 addressing the farmers' preferences for tree species planted in the agroforestry systems, and the intended use of the tree products.

6.1 Methodology

The survey was conducted employing the Rapid Rural Appraisal methodology (Carruther and Chambers, 1981; Hildebrand, 1981; Hondale, 1979) from June through July 2003 with 96 private owners or land renters[2] in nine tumans of the Khorezm viloyat (Fig. 3).

Figure 13: Survey locations of agroforestry systems in Khorezm



[2] Since 1998, three main farming systems have been functioning in Khorezm: state farms (there are only two of them left in the region), private farms (independent enterprises engaged in agricultural production on rented land), and *dehkan* farms (household plots in lifelong hereditary possession).

The interviews were conducted in the Uzbek language. Only those farmers that had participated in a former study of ZEF/UNESCO in 2002-2003, on diseases and damages to trees and shrubs (Ruzmetov, unpublished) were surveyed. Since the criteria for selecting the households in the former study were similar to the current one, the time consuming and expensive site- and participant selection was avoided. Moreover, the participants needed only a limited introduction and explanation on the objectives of the study and on the expected collaboration. The survey was partly based on an open guideline interview, partly on a questionnaire, and in addition some direct measurements were taken. Field users were asked in detail about the land tenure of the fields, and the purpose of the trees and crops. In addition, information about the tree species, number of trees, planting schemes, age of the stand, and the field size was gathered.

6.2 Results and discussion

The surveyed people enumerated only eight tree species that they were planting (Table 4).

Table 4: Tree species planted in hedgerow systems, in % (N=96)

Tree species	Hedgerow system										
	Trees/ Food crop	Trees/ Feed	Trees/ Vege-tables	Trees/ Food crop/ Vege-tables	Trees/ Feed/ Vege-tables	Trees/ Food crop/ Feed	Pure stand	Trees/ Cash crop	Trees/ Food crop/ Feed/ Cash crop	Trees/ Food crop/ Feed/ Vege-tables	Total
Prunus armeniaca	15	2	1	3	1	-	-	1	2	-	25
Malus spp.	24	5	8	1	3	4	1	2	1	4	54
Prunus cerasus	1	1	-	-	-	-	-	-	-	-	2
Morus alba	-	1	2	-	-	-	-	-	-	-	3
Populus spp.	2	1	-	-	1	-	-	-	-	-	4
Prunus spp.	1	-	1	-	-	-	-	-	-	-	2
Pyrus communis	4	-	1	-	-	-	-	-	-	1	6
Prunus persica	1	-	-	-	-	-	-	-	-	-	1
Cydonia oblonga	2	-	-	-	-	-	-	-	-	-	2
Total	50	10	14	4	5	4	1	3	3	5	100

Some, such as apple (*Malus* spp.) and apricot (*Prunus armeniaca*) were planted by many of the surveyed farmers, but other species, such as pear (*Pyrus communis*) or mulberry (*Morus alba*), were planted only by a few. Six or seven different species of apple (*Malus spp*.) are found in the region (director of the Institute of Fruit Trees, personal communication). Most tree species were planted in orchards. Mulberry occurred more often in two-row strips between cropped fields or along roads.

Each tree species has its specific use and appreciation by the households (Table 5). This confirms that the perennial crops play a major role in providing not only woody products for small holders such as timber for construction and firewood but also non-woody products including fruits, leaf fodder for livestock, bark, flowers, roots, tubers and sap. Surveyed households related the importance of trees to their main concerns of increasing income and improving food basket. A notable feature of poplar tree (*Populus* spp.) was its use as timber. Ecological or agricultural arguments, such as the enrichment of soils, the prevention of soil erosion or maintaining and improving soil fertility, were not mentioned at all. Some species were recognized for their nutritive value for people (home consumption) and feed (silk worm).

Table 5: Intended use of tree products, in % (N=96)

Tree species	Intended use						Total
	Sale	Con-sumption	Con-struction	Feed	Other use	Sale & Consump-tion	
Prunus armeniaca	18	-	-	-	-	7	25
Malus spp.	38	2	-	-	1*	14	54
Prunus cerasus	1	-	-	-	-	1	2
Morus alba	1	1	-	1	-	-	3
Populus spp.	1	-	1	-	1**	1	4
Prunus spp.	2	-	-	-	-	-	2
Pyrus communis	4	-	-	-	-	2	6
Prunus persica	1	-	-	-	-	-	1
Cydonia oblonga	2	-	-	-	-	-	2
Total	68	3	1	1	2	25	100

* State paid labor to provide fruits for kindergartens and schools
** Scientific experiment on irrigation and planting density

There is a growing tendency of farmers to rear livestock (Müller, 2006), and keepers are therefore in need of an alternative feed resource for their animal production, especially in the more arid regions. The leaves from trees and shrubs could fill the gap of feed scarcity and serve as a fodder bank. On the other hand, the leaf production of trees *per se* would be insufficient to relieve bottlenecks in livestock production in arid regions. Yet, the higher contents of nutritive substances of tree leaves and fruits suggest the opportunity to supplement the low quality roughages after the growing season (cf. Khamzina et al., 2006a).

Stand density mostly varied between 120 and 420 trees ha^{-1} (Table 6), irrespective of the species, yet some stands of very low (5 trees ha^{-1}) or very high (20,408 trees ha^{-1}) density were observed. The recommended planting density according to the Institute of Fruit Trees in Khorezm is 208 and 416 trees per hectare correspondingly for drupaceous and seminal species (with planting scheme 6x8 and 6x4 m, respectively). Apparently, the farmers tend to modify the planting schemes according to their preferences or due to an unawareness of such recommendations.

Stand density with respect to tree age appeared very variable, but over 70% of the stands were not older than 20 years. Elder stands usually had a sparse density of not more than 300 trees ha^{-1}, as thinning becomes necessary with time to avoid overshadowing of annual crops under the stand.

The monitored stand densities appear too low to achieve potential benefits of trees such as biodrainage or nutrient pumping. Also, the shallow groundwater level throughout Khorezm precludes from deep-rooting and therefore nutrient re-allocation from deeper layers to the upper horizons cannot take place. The narrowly spaced contour plantations of *Morus* spp. may even contribute to nutrient leakage from the fields because twigs, branches and foliage are regularly pollarded for feeding silk worms. Before the leaf shed at the end of the growing season, most minerals are moved to perennial plant parts. But early in the season, when the leaf harvest usually occurs, pollarding breaks the cycle and leads to an overall nutrients loss.

Table 6: Stand densities according to tree species, in % (N=94)

Stand density (trees ha^{-1})	Tree species									
	Prunus armeniaca.	*Malus* spp.	*Prunus cerasus*	*Morus alba*	*Populus* spp.	*Prunus* spp.	*Pyrus communis*	*Prunus persica*	*Cydonia oblonga*	Total*
5-69	1	1	-	1	1	-	-	-	-	4
123-156	10	5	-	-	-	-	-	1	-	16
208-286	6	35	1	-	-	1	3	-	1	48
313-333	-	3	-	-	-	-	1	-	-	4
400-417	4	9	-	-	-	1	2	-	-	15
625	3	1	-	-	-	-	-	-	1	6
1,111-1,667	-	-	-	2	2	-	-	-	-	4
4,444	-	-	1	-	-	-	-	-	-	1
20,408	-	-	-	1	1	-	-	-	-	2
Total	24	54	2	4	4	2	6	1	2	100

* Inaccuracies are due to rounding

The inter-planting of trees with staple crops is a well-known strategy to harness the potential of the staples when the trees are young and do not yet yield an economic benefit. When the trees mature, they compensate for the reduction in crop yield through products that fulfill various household needs. The annual crops were dominated by wheat and vegetables; sometimes both were even planted together (Table 7). The staple winter wheat usually matures in June-July, a period of the year, which coincides with maturation of tree fruits and the many vegetable crops such as tomatoes cultivated on the plots. In contrasts, crops such as maize and sorghum usually mature later in the year, when the fruits from trees normally have been harvested.

The observed low stand densities together with the mentioned objectives income generation and food basket complementation indicate the farmers' preferential concern about their annual rather than the perennial crops. The simultaneous maturing of annual crops and perennial tree products on a field may explain the resulting low stand densities as well. Rice, the third most cultivated crop in the region (Djanibekov 2006), was hardly found within any agroforestry set-up. Technically this would hardly be feasible as the wetland rice is constantly flooded with water, thus reducing the oxygen availability for the roots of other crops.

Table 7: Distribution of annual crops according to tree species, in % (N=96)

Annual crops	Tree species									
	Prunus armeniaca	*Malus spp.*	*Prunus cerasus*	*Morus spp.*	*Populus spp.*	*Prunus spp.*	*Pyrus communis*	*Prunus persica*	*Cydonia oblonga*	Total*
Pure tree stand	-	1	-	-	-	1	-	-	-	1
Wheat	9	19	1	-	-	-	4	1	2	36
Feed	3	7	1	3	3	-	-	-	-	19
Sunflower	1	-	-	-	-	-	-	-	-	1
Vegetables	1	7	-	-	1	-	1	-	-	10
Cotton	-	1	-	-	-	-	-	-	-	1
Wheat/Cotton	1	1	-	-	-	-	-	-	-	2
Wheat/Feed	4	8	-	-	-	1	-	-	-	14
Wheat/Vegetables	2	1	-	-	-	-	-	-	-	3
Feed/Vegetables	1	2	-	-	-	-	-	-	-	3
Wheat/Sorghum/Sunflower	1	1	-	-	-	-	-	-	-	2
Wheat/Vegetables/Feed	1	4	-	-	-	-	1	-	-	6
Wheat/Cotton/Feed	-	1	-	-	-	-	-	-	-	1
Total	25	54	2	3	4	2	6	1	2	100

*Inaccuracies are due to rounding

Given the relatively shallow groundwater table throughout Khorezm and the combination of fruit trees with arable crops such as wheat and sorghum, it seems very likely that the roots of both the annual and perennial crops compete for nutrients and water in the same soil layers. Even tree species known as deep rooting, such as *E. angustifolia* and *U. pumila* (Forestry

Compendium, 2000), appear to have an overwhelming part of their total root biomass in the upper horizons (Khamzina, 2003). Although many shallow coarse roots are pruned during tillage activities every season, root system excavations showed that root dry matter within 1.0 m soil depth still averaged to 68% and 99%, respectively, for the two mentioned species. Single roots of *U. pumila* individuals had a maximum radial extension of up to 27 m, thus growing far into the adjacent cropped area (Khamzina, 2003).

Among the surveyed agroforestry systems the largest were those where tree age did not exceed 12 years thus indicating the increasing interest of tree planting on both private and rented land. Analysis of area size with regards to plantation age indirectly shows that the total amount of private land under trees almost doubled, thus indicating a strong increase of the number of private land owners after independence in 1991; although the mean area of the private farms hardly changed over the past 20 years. Yet, the mean and the total area of rented land allocated to hedgerow systems have gradually increased during the past two decades (Table 8).

Table 8: Area size (ha) of agroforestry systems according to land tenure and plantation age

Land tenure	Plantation age					
	1-12 yrs		13-20 yrs		>20 yrs	
	total	mean	total	mean	total	mean
Private farm	27.5	1.3	19.0	1.7	7.5	0.8
Rented	65.2	2.5	22.9	1.8	10.1	1.0

6.3 Conclusions

Our overview of the existing farmer-driven agroforestry systems in Khorezm shows that fruit species, mainly apple and apricot, dominate. The trees are often sub-optimally spaced from a pure forestry viewpoint, because of being often associated with annual crops, mainly wheat. Farmers rarely planted timber species such as poplar in their agroforestry systems. A knowledge transfer about silvicultural treatments seems to be necessary to improve the management of such plantations and the forestry service should take on this role.

7 Private wood production and the timber market

7.1 Methodology

The previous chapter showed that farmers at present prefer planting fruit trees. Given the importance of wood for timber or fuelwood, an additional survey was conducted to assess the potential of plantations for wood production. For comparison, inventories were carried out in orchards, in a desert forest and in a research plantation near Khiva. The dimensions of the trees (height, diameter, age) were measured for estimating the amount of annually produced volume of wood.

7.2 Results and discussion

Some private farmers planted poplar for their own wood supply and for sale at the market. A typical example was a 1.14 ha hybrid poplar plantation at the farm of Sabir Raimberdiev in Khonka tuman (Table 9). The six-year-old trees were irrigated several times a year. Due to the farmer's reluctance of "wasting" land, the trees were densely planted with almost 8,000 individuals per hectare. As a result, the majority of the trees reached a height of about 10 m and a mean diameter of 6 cm. The mean annual wood production of >22 m^3 ha^{-1} yr^{-1} appeared to be the highest among all investigated plantations. In all cases, the wood production of the irrigated poplar plantations was higher than that of natural *tugai* forest where all species together produced an annual wood volume of about 6 m^3 ha^{-1} yr^{-1}. At a drier site (Karakum mixed, Table 9) and an abandoned research plantation in Khiva desert territory (Forest compartments 36-38 of the forest service) the wood production was within range of the *tugai* forest's; in both cases the established trees relied on groundwater for survival and growth.

Wood was only a by-product in the various orchards where trees are much more widely spaced. Consequently, the timber production was relatively low. Not very surprisingly, shrubs and small trees in the desert "forests" showed the lowest figure with a wood volume growth of only 0.03 m^3 ha^{-1} yr^{-1}.

Table 9: Wood production and structural features of 10 plantations in Khorezm

Location	Shavat*	Gurlan*	Yangiarik*	Khonka*	Gurlan**	Khonka***	Khonka****	Khiva***	Khiva***	Khiva*****
Species	Hybrid poplar.	Hybrid poplar.	Hybrid poplar.	Hybrid poplar.	*Populus euphratica*., *Elaeagnus angustifolia*, *Tamarix* spp.	*Morus alba*, *Prunus armeniaca*	*Malus* spp.	*Malus* spp., *Prunus armeniaca*	*Elaeagnus angustifolia*, *Juniperus virginiana*, *Prunus armeniaca*	*Tamarix* spp., *Haloxylon aphyllum*
Density, trees ha^{-1}	5,500	10,530	6,640	7,860	2,500	460	500	470	1,600	1,920
Diameter, cm	5.6	4.5	6.1	6.0	7.1	18.9	9.2	16.5	12.4	0.8
Height, m	5.5	6.1	7.5	11.0	5.5	7.0	4.9	4.8	8.8	0.7
Age, yrs	4	4	5	6	1-28	21	11	12	8	3-10
Wood production, m^3 ha^{-1} yr^{-1}	9.2	10.6	14.9	22.8	6.4	2.4	2.3	0.7	5.8	0.03

*Timber plantation; ***Tugai* forest; ***Mixed fruit plantation; ****Pure fruit plantation; *****Desert forest
Wood production was estimated as basal area * height/2.

Considering the small number of existing plantations in Khorezm (see chapter 8.2), poplar plantations only can satisfy to a very limited extent for the timber demand. The levels of wood increments (Table 9), however, indicate a high potential to increase the timber production with poplar. Uzbekistan in total is dependent to a high degree on the imported wood which is transported mainly from the northern boreal zone in Russia through Kazakhstan (UN Timber Statistics, 2004). More than half of the wood sold in Khorezm is imported coniferous wood brought in from that source (interviews at the local wood market in Urganch city).

Next to this, a considerable proportion of the market share is taken by local wood, mostly in the form of thin straight boles (round wood) from poplar varieties (Fig. 14), exclusively sold for construction purposes (mainly roof construction). Poplar boles available at the market did not exceed 25-30 cm in diameter and 12 m in length. The prices varied, depending on the wood quality, between 45 and 65 USD per m^3 (Table 10). The highest prices were offered for second-hand wood, since this was drier and often of better proportions.

Figure 14: Wood market in Khorezm

Year ring counts showed that wood of an age of about 25 years at yield was sold at higher prices than stems of similar diameter but from 11-15 year-old trees, showing that the wood density was directly reflected in the prices.

Table 10: Prices of poplar boles at the wood market in Urganch

Diameter, m	Working length, m	Price, USD per m^3	Age, yrs
0.09	4	46	-
0.10	5	59	5
0.14	6	60	5-7
0.17	7	61	8-10
0.19	7	56	8-10
0.20	10	53	9-11
0.22	10	66	15

One of the larger tradesmen owned about 1,500 locally produced stems, mainly of medium quality. He estimated his profit at 25% but was not able to tell neither the transportation charges nor the cost for the bark removal. Another timber producer claimed that profit was probably higher, given the difference between price at plantation and price at the market being about 100%. In total, during our survey in summer 2003 the poplar section of the market in Urganch numbered approximately 5,000 stems corresponding to a total value of 30,000 USD.

Using an average price for local wood of about 25-30 USD per m^3 (paid by the tradesman to the farmer), and the maximum yield of a poplar plantation as stated above, a mean potential gross yield of approximately 550-660 USD ha^{-1} yr^{-1} results, which shows the potential for additional income generation if this was shifted towards a stronger forest product orientation, based on adequate silvicultural technologies.

8 Windbreaks as a special case of agroforestry: their importance and development

About 80-85% of the Uzbekistan territory suffers from strong winds, dust storms and *garmsels* (hot dry winds) (Gintzburger et al., 2003). Harmful winds are characteristic for the western and central part of Ferghana valley, Surkhan-Sherabad valley, Karshi steppe and Bukhara oasis (FAO, 2003). These phenomena affect agriculture by decreasing soil and air humidity, blowing off the upper, the most fertile soil layer, and destroying crops.

A wealth of literature shows that tree windbreaks play a positive role in microclimatic change and protection of neighboring fields (e.g., Rocheleau et al., 1988). Strong winds can lose about 50-80% of their velocity passing through optimally designed strips of trees (Molchanova, 1986). Consequently, relative air humidity raises between 1 and 13% (Botman, 1986) while the air and soil temperatures drops by 1.5-2.0 and 3-4^{o}C respectively (Kayimov et al, 1990). The average increase in crop yield on the adjacent agricultural land of 10% was reported by Dolgilevitch (1983) whereas Moshaev (1988) stated that 20% can be reached under an optimal structure and after the trees in the windbreaks have reached their final height.

Long-term studies and practice in establishing protective tree belts have led local practitioners and researchers to recommend that 0.5-1.0, 1.5-2.0 and 2.5-3.0% of land in regions affected by weak, moderate and strong winds respectively must be reserved for windbreaks (Kayimov, 1993). Moderate wind speeds of 3-4 and 4-5 m s^{-1} on sandy and loamy soils respectively are capable of blowing off surface soil particles (Molchanova, 1986). Thus, for effective protection of soil from wind erosion in Khorezm, at least of 1.5-2% of the irrigated arable land should be allotted to tree windbreak planting (e.g., Molchanova, 1987).

The decree "Reform in Nature" issued in the former USSR in 1947 and periodically updated, forced the administration of all Soviet republics to establish, on a contractual basis, protective forest stands within agricultural land and on ravines and slopes. Thus, during 1966-1992, windbreaks were planted on about 40,000 ha agricultural land and on about 1,425,000 ha of steppe (to protect pastures) (Moussabekov unpublished report). After 1992 this practice almost completely came to a halt, probably due to the change of management, the liquidation of many organizations, and the transformation of collective (*kolkhoz*) and state farms (*sovkhoz*) into *shirkats* and *dekhkan* farms, but mainly due to absence of finance for protective forest planting during the transition period. Moreover, at the farm level there is a poor awareness of the necessity of the tree windbreaks which are today cut down or die due to a lack of care.

However, a recent overview revealed many reforestation attempts. The regional forest services and some specialized farm units maintain nurseries to attend the demand for poplar cuttings and mulberry trees, and also some new organizations (NGO's) build up nurseries. A GTZ-funded project in Karakalpakstan aims at the afforestation of wider areas on the desiccated bed of the Aral Sea with saxaul (*Haloxylon aphyllum, H. percisum*) and some shrub species to combat desertification, wind erosion, salt- and dust transfer and to increase the productivity of the desert pastures.

To make an overview on the present situation of windbreaks in Khorezm we carried out an inventory on the occurrence and structure of windbreaks along two transects using remote sensing techniques.

8.1 Methodology

Obtained from Uzbekistan authorities, low-altitude aerial photographs (scale 1:20,000) have been used to identify and analyze the existing windbreaks in Khorezm region. Methods included photo-interpretation techniques using a VISOPRET12 analytical stereo plotter with AUTOCAD and ArcGIS software and field measurements. An in-depth analysis of two transects laid out in NS (32,000 ha) and WE (23,000 ha) directions in Khorezm was conducted (Fig. 15), covering a gradient from the Amu Darya floodplain forest over intensively used agricultural land to the desert forest of the Karakum (Tupitsa, 2006).

8.2 Results and discussion

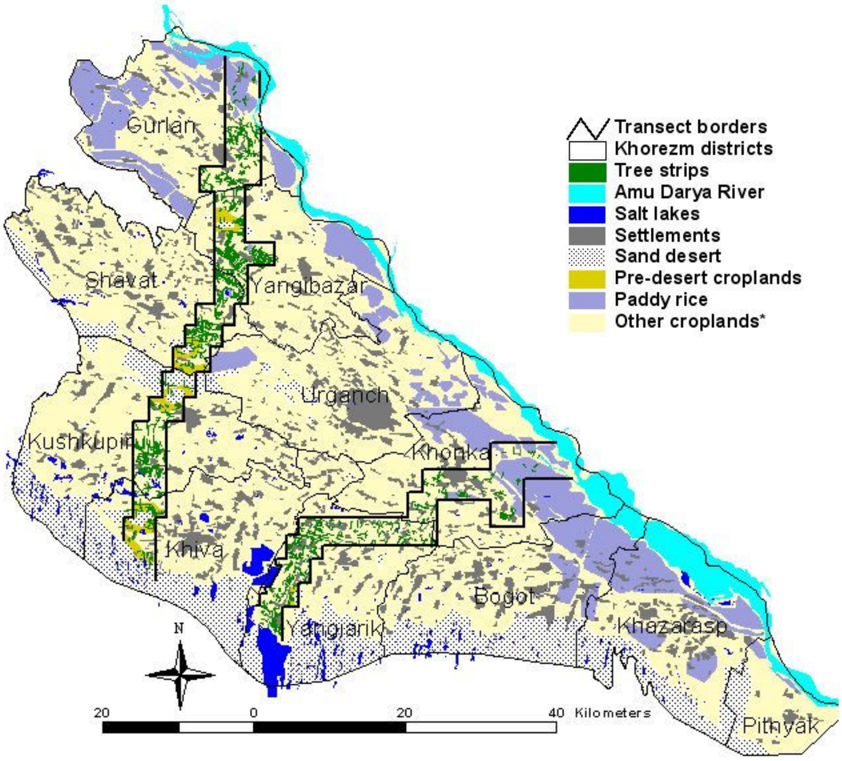
We have identified more than 2.3 thousand tree strips stretching over a total of approximately 700 km in the cropland area or 39 thousand hectares of two transects (Table 11 and Fig. 15).

Table 11: Overall distribution of tree strips in the transects

Transect statistics	NS extent	WE extent	Total
Transect area, ha	32,020	23,020	55,040
Cropland area*, ha	22,292	17,059	39,351
Area under the strips, ha	270.0	181.0	451.0
Number of the strips	1,374	949	2323
Total length of the strips, km	408	265	673
Area under the strips/cropland, %	1.2	1.1	1.2
Number of the strips per 100 ha cropland	6.2	5.6	5.9
Length of the strips per 100 ha cropland, km	1.8	1.6	1.7

* The area of inland water, urban areas, roads, sands, native forests and plantations were excluded from the transect area.

Figure 15: Interpreted tree strips inside of NS and WE extents in Khorezm



*Including rotated winter wheat and rice crops

The land covered with the tree strips amounted to 450 ha (about 1%) of cropland area. The NS and WE extents expressed similar patterns of the tree strip number and strip length per unit cropland, almost 6 tree strips per 100 ha and 2 km per 100 ha, respectively (Table 11). However, the spatial distribution of the tree strips on the cropland area inside the two transects was unequal. Table 12 shows the distribution of the tree strips by administrative tumans of Khorezm which were covered by the transects.

Table 12: Distribution of tree strips by administrative tumans

Tuman	Cropland in the transects, ha	Area under the strips, ha	Number of the strips	Length of the strips, km	Area under the strips per cropland area, %	Number of the strips per 100 ha cropland	Length of the strips per 100 ha cropland, km
Gurlan*	6,324	65.5	438	98.5	1.0	6.9	1.6
Yangibazar*	4,998	63.2	259	109.3	1.3	5.2	2.2
Shavat*	4,324	67.0	313	86.4	1.5	7.2	2.0
Kushkupir*	4,105	46.8	214	75.1	1.1	5.2	1.8
Khiva*	2,541	27.5	150	38.4	1.1	5.9	1.5
Yangiarik**	8,418	112.5	612	115.7	1.3	7.3	1.7
Khonka**	8,641	68.5	337	79.2	0.8	3.9	1.4
NS extent	22,292	270.0	1,374	408.0	1.2	6.2	1.8
WE extent	17,059	181.0	949	265.0	1.1	5.6	1.6
Total	39,351	451.0	2,323	673	1.2	5.9	1.7

*NS and **WE extents

The area of the tree strips varied from 0.8-1.1% with an extended area of paddy rice crop at the margins of Amu Darya River in west (Khonka) and north (Gurlan) of Khorezm and the pre-desert croplands (Kushkupir and Khiva), up to 1.3-1.5% coincided with the differing agricultural use dominated by cotton, rotated winter wheat and paddy rice fields, feed crops and orchards in the central parts of NS (Shavat and Yangibazar) and WE (Yangiarik) extents (Table 12 and Fig. 15). The actual share of the tree strips in Khorezm was lower than recommended minimum of 1.5-2.0%.

Further analysis included the assessment of the identified tree strips for their potential effectiveness as windbreaks based on the recommendations from local and international sources (Box 3).

Box 3: Windbreak requirements

Classification of tree strips

- **Living fences.** In most living fences, the majority of plants are short, rarely over 2 m high, and the fence as a whole is dense and impenetrable. Trees or shrubs are planted close together in one or more rows. The main purpose is limiting access to agroforestry systems. Living fences may have a windbreak effect, particularly for protecting small gardens, orchards or tree nurseries. A living fence may also be planted on one side of a larger windbreak to limit access and protect the windbreak from browsing.
- **Trees and shrubs on borderlines and boundaries.** The most common form of boundary plantings consists of a single line of widely spaced trees and shrubs. Trees planted along boundaries are distinct from living fences, which may be placed along boundary lines but are intended primarily as physical barriers.
- **Windbreaks.** The strips of trees and/or shrubs planted to protect fields, homes, canals or other areas from wind erosion and deposition of blown soil particles. Large-scale, wide strips or blocks of trees planted for this purpose are often called windbreaks. Windbreaks are planted for many reasons: to reduce soil erosion, to improve the microclimate for growing crops and to shelter people and livestock. They can also serve other functions, such as fencing and boundary demarcation.

Optimal field windbreak structure and design

- **Height (H).** The size of both shaded and sheltered zones behind a windbreak depends on the windbreak height, which is why shade and shelter effects are expressed in terms of windbreak heights, minimal of 5 m and as high as possible.
- **Porosity.** The degree of wind speed reduction depends on the "openness" of the windbreak (its porosity). Maximum shelter is best achieved with a dense windbreak which means less than 30% porosity. A medium porosity windbreak (roughly 50-60%) will also provide adequate shelter.
- **Length.** To decrease wind erosion at the windbreak sides, the latter should extend about 15m beyond the sheltered field.
- **Width.** Secondary criteria, minimum 2 rows or a number of rows sufficient to ensure the health of the windbreak trees and to maintain the appropriate porosity.
- **Orientation.** Effective windbreaks should lie perpendicular to the prevailing wind direction.
- **Species composition and configuration.** An optimal windbreak species design includes one row of tall trees, then a row of medium trees and two rows of shrubs. Inter-row spacing is site-specific but generally about 3-4 m.
- **Spacing.** As a minimum - 5H for shading, 10H - to fulfil windbreak function, and up 200-400 m on irrigated lands.
- **Condition.** This includes tree age, health and damage status and maintenance.

For more information see Abel et al., 1997; Bolin et al. 1987; David and Rhyner, 1999; MA, 1972; Molchanova, 1986.

The situation relative to the potential effectiveness of the tree windbreaks in Khorezm can be summarized as follows:

- Over 70% of the tree strips had acceptable (medium and high) porosity. Double-row tree strips (about 60%) prevailed over those consisting of a single row. Yet, almost 60% of the investigated tree strips did not satisfy the minimal height of 5 m, which is a primary criterion of optimal windbreak design. Besides, more than half (55%) of the tree strips did not stretch along the entire length of their related field.
- Only 70% of the tree strips were oriented in the desirable NS and NW-SE directions, since the highest wind speeds (>3 m s^{-1}) are generally prevailing from E and NE directions (MDB, 2003-2004).

- There are no multi-species tree strips in the area. The single-species rows of *Morus alba* comprised about 50% of the strips, while *Salix* spp., hybrid poplar varieties (*Populus* spp.), *Elaeagnus angustifolia* and *Populus euphratica* made up 22, 19, 5, and 4%, respectively.
- Tree strip conditions based on tree health and damage rated as fair to good in the investigated transects. However, the field tree strips tended to exhibit serious management related problems; in particular, maintaining the correct stand density and structure during the harvesting. Thus as *M. alba* trees had inadequate stand height (usually not exceeding 1.5-2.0 m) and canopy density because of being annually coppiced (branches with leaves) for silkworm feeding. *Salix* spp. are heavily pollarded for local and artisan uses. Also, the tree strips of *Populus* spp., which are used as a source of construction wood and poles, are not harvested in an appropriate way.

The inventory revealed the existence of numerous tree strips; however, their structure and layout must be improved to gain the expected windbreak efficiency according to the recommended requirements. The results of this study will help specialists and farmers targeting their efforts, by pointing out, with the use of produced GIS maps and databases, priority sites where windbreaks have to be established or replanted. Additionally, the practical recommendations for windbreak maintenance including adequate harvesting techniques will be provided.

9 The legal framework

It is necessary to strengthen the role of trees in the irrigated landscape of Uzbekistan with a legislative framework supporting re- and afforestation. Some existing legislative uncertainties about the responsibilities of the forest service for tree plantings outside the well-defined forest fund area and ambiguity in the local forest terminology are outlined below.

State forest management is based on a special legislation, the main documents of which are: the Forest Code of the Republic of Uzbekistan; "Regarding Nature Protection" (1992); "Regarding Especially Protected Territories" (1993); and "Regarding Protection and Use of Animal and Vegetation World" (1997), and UN Agenda 21 (2000). In contrast to e.g., the German forest law, with its clear definition of the minimal size and the composition of forests to distinguish them from groups or lines of trees, there is no equivalent definition in the Uzbek "*Law About Forests*" adopted on April 15, 1999. However, the law does not consider the following tree formations as a part of the state forest fund:

- Trees and groups of trees, field protecting windbreaks, trees and shrubs which are planted for other purposes on agricultural land;
- Tree plantings along railways, roads and canals;
- Public tree plantings of any size in cities and villages (e.g., parks);
- Private trees in gardens and household areas.

In the past the windbreak planting within the agricultural area was coordinated by the forestry entities and financed by the state after elaboration and official approval of the planting procedure. The forest service was responsible for the plantation management during the first four years of growth. Next, the plantations were inventoried and, in case of their satisfactory condition, handed over and currently are under the responsibility of former *kolhozes* who lack knowledge and motivation for proper windbreak management.

The responsibilities for the tree formations, not included from the forest fund, are not defined clearly in the forest law, but are partly stated in Article 15 of the law under *The Categories of Forest Protection*: "…the Cabinet of Ministers is directly responsible for the decision making regarding the categorization of forest protection on the request of the Main Forestry Department under the Ministry of Agriculture and Water Resources". In accordance to significance and functions of forests, they can be divided into a few categories:

- Restricted windbreaks along rivers, lakes, reservoirs and other water bodies;
- Restricted windbreaks protecting spawning sites of valuable fishes;

- Forests protecting fields and soils;
- Restricted windbreaks along rail- and motor roads;
- Forests of desert and semi-desert zones;
- Cities' and forest parks;
- Forests of green zones along cities/towns, settlements and industrial centers;
- Forest having sanitary functions adjacent to resorts;
- The most valuable forestlands (e.g., tugai);
- Fruit and nut-bearing forests;
- Forests of state reserves;
- Forest of national parks;
- Forest monuments and wildlife research areas.

Box 4: Legal framework

Uzbekistan, like the other CARs, has adopted a number of laws to protect the environment. Approximately one hundred legislative acts that directly or indirectly relate to natural resource use have been passed since Uzbek independence. The main limitations of the legislation are: **serious inconsistencies, weak administrative capacity to implement the law and considerable scope for bureaucratic discretion in application of laws and regulations.** Enforcement of environmental regulations and norms depends on strengthening the capacity and oversight of the local branches of the Ministry of Nature Protection. Legislative reform is an ongoing process. In this context, attention needs to be paid to strengthening the laws relating to land use and water resource management.
Source: Saigal (2003), page ix

An additional uncertainty is the categorization of forest based on the classification used in Uzbekistan, as already mentioned in Chapter 2.1. For example, in Khorezm almost 39,000 ha (Regional Forest Service, 2002) is considered as covered by forest area according to the law. Of this, only 1,000 ha (ca. 3 %) i.e., those parts which belong to *tugai* forest, have a clear forest structure in the botanical sense of the word. The largest area (desert forest) is covered with combined desert vegetation, mostly herbaceous plants and woody shrubs less than 5m tall and characterized by a very low productivity. Also, there are some discrepancies in the methods for estimating forest cover between national and FRA (2005) classifications, e.g., thresholds, which separate actual forest ('land covered by forest' and 'forest' categories according to local and FRA classification, respectively) from low density forest ('sparse forest stands' and 'other wooded land' according to local and FRA classifications, respectively). Locally, a single threshold of 30% or less of canopy cover per unit land area is used to define 'sparse forest stands' (http://www.wood.ru). In the mean time, FRA 2005 uses a group of thresholds to define 'other wooded land', such as a minimal area of 0.5 ha with trees higher than 5 m and a canopy cover of 5-10%, or areas under trees which are able to reach these thresholds *in situ*; or land with a combined cover of shrubs, bushes and trees above 10% (FRA, 2005). Since more than a half

(38,000 ha) of the desert forest in Khorezm is reported as 'covered by forest' while in fact there are no trees in the desert but woody shrubs and herbaceous plants, it is more appropriate to classify such area as 'other wooded land' or 'sparse forest stands' which is best fit to the "combined cover of shrub, bushes and trees above 10%" category. However, the law is very progressive, as it considers the desert forests, which fulfill the functions detailed in Article 3 of the Forest Law, the protection of the land, in this case from wind erosion.

Given the existing classifications in the forest law, the maintenance or expansion of windbreaks is hindered. In response to this fact, in 2002 a board at the Ministry of Agriculture and Water Resources discussed the "Measures on windbreak organization for the improvement of ecological conditions in Uzbekistan". The outcome of this discussion was the recommendation to the Uzbek Scientific and Production Center (and, in particular, Republican Scientific Production Center for Decorative Gardening and Forestry (formerly the Forestry Research Institute) together with the forestry departments), to draw up an inventory of existing windbreaks, to elaborate assessment and plantation techniques, and to update the knowledge for the implementation of windbreaks. The German-Uzbek Project has been involved in both tasks in close collaboration with the mentioned organizations and will provide the first results in the near future.

10 Conclusions and recommendations

The preliminary data collected and discussed in this paper demonstrate that, despite a long tradition of incorporating trees within the agricultural production systems in CA, there is much room for improvement. This justifies not only in-depth research, but especially an in-depth study of lessons learned from other regions in the world. Various options are mentioned below.

10.1 Getting the basics right: The need for integrated scientific investigation

There is a lack of data on different tree characteristics important to the rural population in CA, and in Uzbekistan. Better data on tree productivity, growth characteristics, and constraints (such as salinity intolerance), but also on market options, requirements for fuelwood, timber and other tree products, and their acceptance in the market would allow the formulation of strategies and policies with respect to planting trees in general or within agroforestry hedgerows systems in particular. When the planting of multipurpose trees and shrubs is envisioned, knowledge about the establishment and growth potential of the species as well as the energy provision by firewood, and the nutritive value as fodder for livestock, is indispensable to back-up a wise choice. Recently, results of research have become available (Khamzina, 2006), but these cover only the performance of trees at the early stage of growth and much more detailed analysis will be needed.

Also, the establishment of agroforestry systems often goes in line with high initial investments. Profits from perennial crops often take several years to become tangible. This makes comprehensive economic assessments of tree production imperative.

10.2 Farmers' perspective: the key to implementation

Agroforestry research, which is by nature often a long-term endeavor, can gain substantially from local knowledge. If the introduction of improved agroforestry elements into the presently practiced systems is considered as the key component for improved resource management, awareness about farmers' motivation and perception of the new systems is indispensable, and this requires additional social science-driven research into, for example, on the site-specific identification and selection of trees for multiple purposes, the collection of farmers' knowledge about local tree and bush species and their uses, which may guide the selection of appropriate species and varieties for agro-forestry purposes.

In addition, agroforestry systems demand different skills and knowledge of the small holder as well as a different mechanization level compared to conventional arable cropping practices. All this requires adequate, in-depth technology adoption, and the necessary training, e.g., in agroforestry-oriented farmer schools.

10.3 Improving and strengthening the role of the regional forest service

In the rural society of Khorezm, the focus on agricultural production typically is on annual crops. Trees mostly occur in combination with annual crops only and are a part of agroforestry systems that offer a wide range of options for improvement. Local timber production is hardly existent, despite the increasing demand for construction and fuelwood. In timber plantations dense spacing is often practiced which intends using the sparse available land more effectively but in fact can lower the productivity of plantations.

Given by the limited responsibilities and possibilities of the Forest Service there is little space for a state timber production in Khorezm. The existing production is exclusively focused on introduced poplar varieties. The other major task is the protection of the remainders of natural riparian *tugai* stands and the desert forest. Moreover, the responsibilities for management of windbreaks and orchards are unclear or remain in the hands of the farmers.

The Forest Service and the Republican Scientific Production Center for Decorative Gardening and Forestry need to engage more in the management of windbreaks, timber plantations and afforestation, as they have the manpower, skills and tools, but not the funds. They should be mandated to more intensively transfer their knowledge to the farmers and should interest them in new approaches for an improvement of the landscape ecology, show new options to increase their economical situation, e.g., by participating in developing agroforestry-oriented curricula for the upcoming farmer schools. The national and regional forestry administration need to be encouraged by their international partners to engage in the presently ongoing international development activities, e.g., the CACILM process (ADB, 2004) of improving land management in the context of the Convention for Combating Desertification (UNCCD).

10.4 Improving the legal framework situation

Strengthening the role of the forest service requires some clarification in the existing legal framework defining responsibilities for managing plantations within agricultural areas. Therefore, it’s imperative to create a legal base confirming the importance of the development of the protective forest planting on arable land as a means of soil fertility protection and stabilization. The law could consider e.g., (i) withdrawing a part of arable irrigated land out of the agricultural rotation for windbreak planting, (ii) withdrawing agricultural land of marginal quality (which can be already abandoned from cropping due to degradation) for afforestation. This would lay a ground for elaboration of decrees detailing the procedure of protective forest planting. Moreover, while considering the long-term investments such as timber production and soil conservation practices, the farmers should be more flexible in the choice of crops/species grown and should be secured in their rights to access and use the land resources.

However, both economic and social arguments demand public financing of forest services. In particular, when functions and topics related to forestry and ecology, though important, may not be taken up by farmers, e.g., when they cannot afford it. This includes “social determinants of government level support” (Cary, 1993) such as education and training for basic qualifications of forestry staff, advice and information delivery, test and pilot programs, aspects with long-term consequences such as safeguarding the natural resource bases, or activities in distant and faraway regions. Moreover, the government of Uzbekistan may intensify their focus on regulation, policy formulation and quality control in the forestry sector. Thus, the strategic planting of shelterbelts and their proper maintenance needs to be centrally coordinated and should remain responsibility of the forest service, as well as the adequate dissemination of the information among rural population about the importance and benefits of tree planting.

11 References

Abel N., Baxter J., Campbell A., Cleugh H., Fargher J., Lambeck R., Prinsley R., Prosser M, Reid R., Revell G., Schmidt C., Stirzaker R. and Thorburn P. (1997): Design principles for farm forestry. A guide to assist farmers to decide where to place trees and farm plantations on farms. Rural Industries Research & Development Corporation (RIRDC)/ Land & Water Resources Research (LWRRDC)/ Wood Products Research & Development Corporation (FWPRDC) Joint Venture Agroforestry Program, Thebarton, Australia, 102 pp.

ADB (2004): Asian Development Bank Program concept for pipeline entry for the global environment facility for Central Asian countries initiative for land management (http://www.gefonline.org/projectDetails.cfm?projID=2504).

Agenda 21 (2000): Natural resource aspects of sustainable development in the Republic of Uzbekistan. Division for Sustainable Development UN ESA (http://www.un.org/esa/agenda21/natlinfo/countr/uzbek/natur.htm#forests)

Blinovsky K.V. (1956): Trees and shrubs for planting in populated areas of Northern and Southern Turkmenistan. Proceedings of Turkmen Botanical Garden. Ashgabad, pp. 13-20 (in Russian).

Bolin M., Oliver R., Brady S. et al. (1987): Illinois Windbreak Manual. Soil Conservation Service, U.S. Department of Agriculture, pp. 2-10.

Botman E.K. (1986): An impact of proper maintenance on shelterbelts efficiency in rain-fed lands. Protective Forest Planting 23: 88-94.

Breckle S.-W. (2002): Walter's Vegetation of the Earth. The Ecological Systems of the Geo-Biosphere. Springer, Berlin, Heidelberg, 527 p.

Carruther I. and Chambers R. (1981): Rapid appraisal for rural development. Agricultural Administration 8: 407-422.

Cary J.W. (1993): Changing foundations for government support of agricultural extension in economically developed countries. Sociologica Ruralis 33 (3/4): 336-47.

Cherdantsev G. (1950) cited by Krauze I. (1874): Regarding agriculture in Khiva. IIRGO 10 (1): 40-46 (in Russian).

Daily G.C. (1997): Nature's services: Societal dependence on natural ecosystems. Island Press, Washington, DC.

David C.A. and Rhyner V. (1999): An assessment of windbreaks in central Wisconsin. Agroforestry Systems 44: 313-331.

Djanibekov N. (in preparation): A micro-economic analysis of farm restructuring in Khorezm region, Uzbekistan, PhD thesis, Center for Development Research (ZEF), Universität Bonn, Bonn.

Dolgievich M.I. (1983): A few methodological research questions of agricultural efficiency in agroforestry systems. Institute of Agroforestry Reclamation (VNIALMI) series publications 2 (79): 26-41 (in Russian).

Drobov P.V. (1951): The forest of Uzbekistan, Tashkent (in Russian).

FAO (2003): Gateway to land and water information: Uzbekistan National Report 5.1 Land-related constrains to sustainable agriculture. (http://www.fao.org/ag/agl/swlwpnr /reports/y_nr/z_uz/uz.htm).

FAO (2005): Unasylva - No. 185 - Forest influences. Nutrient cycling and agroforestry in Africa. (http://www.fao.org/documents/show_cdr.asp?url_file=/docrep/ w0312e/w0312e06.htm).

Fayzullaev B.F. (1980): Water and solute regime of the soils developed on various alluvial sediments of the Amu Darya River (in the Khorezm Oasis). SANIIRI, Tashkent, pp. 1-25 (in Russian).

Forestry Compendium (2000): Global Module (data base). CAB International, Wallingford, UK.

FRA (2005): Global Forest Resources Assessment. Uzbekistan Country Report. Forestry Department. FAO, Rome.

GEF & UNDP (1998): Republic of Uzbekistan Biodiversity Conservation: National Strategy and Action Plan (http://bpsp-neca.brim.ac.cn/books/actpln_uzbek/index.html).

Gintzburger G., Toderich K.N., Mardonov B.K. and Mahmudov M.M. (2003): Rangelands of the arid and semi-arid zones in Uzbekistan. V.Howe and CIRAD Editing and Publication Service, Montpellier, 426 p.

Glazirin G.E., Chanishev S.G. and Chub V.E. (1999): Brief outlines of climate in Uzbekistan. Chinor ENK – Galaba, Tashkent, 29 p. (in Russian).

GRIDA (2006): State of Environment of the Aral Sea Basin. Regional Report of the Central Asian States 2000. Forest Resources. (http://enrin.grida.no/aral/aralsea/ english/forest/forest.htm).

Hildebrand P.E. (1981): Combining disciplines in rapid appraisal: the Sondeo approach. Agricultural Administration 8: 423-432.

Hondale G. (1979): Rapid reconnaissance approaches to organisational analysis for development administration. Institute of Development Studies, University of Sussex, Brighton, UK.

Jensen S.R., Zmazhitova, and Zetterstorm R. (1997): Environmental Pollution and Child Health in the Aral Sea region in Kazakhstan. The Science of the Total Environment 206: 187-193.

Kaurichev I.S. (1989): Soil science. Agropromizdat, Moscow, 719 p. (in Russian).

Kayimov A.K., Botman E.K, and Bozjko P.V. (1990): Impact of agroclimatic resources on the biomass in the agroforestry landscapes with different forest coverage in the Golodnaya Steppe. Protective forest planting and the environment 27: 70-76 (in Russian).

Kayimov A.K. (1993): Biocenoses of forest-agrarian landscape of the irrigated lands. FAN, Tashkent, 132 p. (in Russian).

Kessler J.J. and Breman H. (1991): The potential of agroforestry to increase primary production in the Sahelian and Sudanian zones of West Africa. Agroforestry Systems 13: 41-62.

Khamzina A. (2003): Root development of tree species under different soil and water conditions in irrigated and marginal areas of Khorezm Region. Midterm report. Center for Development Research (ZEF), Bonn.

Khamzina A. (2006): The assessment of tree species and irrigation techniques for afforestation of degraded agricultural landscapes in Khorezm, Uzbekistan, Aral Sea Basin. PhD thesis, Center for Development Research (ZEF), University of Bonn, Bonn, 139 p.

Khamzina A., Lamers J.P.A., Worbes M., Botman E. and Vlek P.L.G. (2006a): Assessing the potential of trees for afforestation of degraded landscapes in the Aral Sea Basin of Uzbekistan. Agroforestry Systems 66: 129-141.

Khamzina A., Lamers J.P.A., Martius C., Worbes M. and Vlek P.L.G. (2006b): Potential of nine multipurpose tree species to reduce saline groundwater table in the lower Amu Darya River region of Uzbekistan. Agroforestry Systems 68 (2): 151-165.

Khanazarov A.A. and Kayimov A.K. (1993): Forest resources of Uzbekistan. Tashkent, 63 p. (in Russian).

Korovin E.P. (1962): Vegetation of Central Asia and South Kazakhstan. Gosizdat UzSSR, Tashkent (in Russian).

Kuzmina Z. and Treshkin S. (1997): Soil salinization and dynamics of Tugai vegetation in the Southeastern Caspian Sea Region and in the Aral Sea Coastal Region. Eurasian Soil Science 30(6): 642-649.

Lamers J.P.A., Khamzina A. and Worbes M. (2005): The analyses of physiological and morphological attributes of 10 tree species for early determination of their suitability to afforest degraded landscapes in the Aral Sea Basin of Uzbekistan. Forest Ecology and Management 221: 249-259.

Law about Forest of the Republic of Uzbekistan (1999): No.770-1. Adopted 15 April 1999. Tashkent. (http://www.cawater-info.net/library/rus/land/04.txt) (in Russian).

MA (former Ministry of Agriculture of the Soviet Union) (1972): Department of Shelterbelt Systems in Collective and State Farms. Shelterbelts and their Arrangement Booklet (in Russian).

Martin F.W. and Sherman S. (1992): Agroforestry Principles. Echo technical Note, 11 pp. (http://www.echonet.org/tropicalag/technotes/Agrofore.pdf).

Martius C., Lamers J.P.A., Ibrakhimov M. and Vlek P.L.G. (2004a): Towards a sustainable use of natural resources in the Aral Sea Basin. In: Bogena H., Hake J.-F. and Vereecken H. (eds.) Water and Sustainable Development. Schriften des Forschungszentrums Jülich, pp 117-134.

Martius C., Lamers J.P.A., Wehrheim P., Schöller-Schletter A., Eshchanov R., Tupitsa A., Khamzina A., Akramkhanov A. and Vlek P.L.G. (2004b): Developing sustainable land and water management for the Aral Sea Basin through an interdisciplinary research. In: Seng V., Craswell E., Fukai S., and Fisher K. (eds.) Water in Agriculture. Proceedings of a CARDI International conference "Research on water in agricultural production in Asia for the 21st century", Phnom Penh, Cambodia, 25-28 November 2003, ACIAR Proceedings No. 116, Canberra, pp. 45-60.

MAWR (the Ministry of Agriculture and Water Resources) (2001): Hydrologic Amelioration Expedition (database).

McCall M.K. and Skutsch M.M. (1993): Taungya farmers of Hambanatota. (http://www.odi.org.uk/fpeg/publications/rdfn/15/rdfn-15d-ii.pdf; checked 2.1.2006).

MDB (2003-2004): Meta-database of the German-Uzbek project in Khorezm (http://131.220.109.8/mdb/index.php).

MMTU (Mott MacDonald Ltd, Temelsu International Engineering Services Inc., and Uzgipromeloivodkhoz Institute of the Ministry of Agriculture and Water Management) (1997): Report, Drainage Project, Phase I: Data collection and review.

Molchanova A. (1986): A role of field windbreaks on irrigated lands. Protective Forest Planting 23: 102-109 (in Russian).

Molchanova A. (1987): Instructive guidelines on designing and growing protective forest plantations and on agro-technical anti-erosion measures in Uzbek SSR. Tashkent (in Russian).

Moshaev V.G. (1988): Regional natural management: problems, methodology and methods, Barnaul, pp. 89-90 (in Russian).

Müller M. (2006): A general equilibrium approach to modelling water and land use reforms in Uzbekistan. PhD thesis. Center for Development Research (ZEF), Rheinische Friedrich-Wilhelms-Universität Bonn, Bonn.

O'Hara S.L., Giles F., Wiggs S., Mamedov G., Davidson G., and Hubbard R.B. (2000): Exposure to airborne dust contaminated with pesticides in the Aral Sea Region. The Lancet 355: 627-628.

Ozolin G.P. (1990): Turanga in Middle Asia and Kazakhstan. Protective forest establishment and the environment, State Forest Committee of the USSR. Middle-Asian Research Institute of Forestry, Tashkent pp. 118-128 (in Russian).

Regional Forest Inventory, Khorezm (1990): The complete report by *Lesproekt* and the Regional Forest Service, Urgench (in Russian).

Regional Forest Service (2002): Khorezm Annual Report (in Uzbek).

Rocheleau D., Weber F., and Field-Juma A. (1988): Agroforestry for in between places. In: Agroforestry in dryland Africa. International Council for Research in Agroforestry (ICRAF), Nairobi, Kenya, pp 163-191.

Ruthenberg H. (1980): Farming Systems in the Tropics. with contributions by MacArthur J.D., Zandstra H.D., and Collinson M.P. Clarendon Press, Oxford, 313 p.

Saigal S. (2003): Uzbekistan: Issues and approaches to combat desertification. Asian Development Bank, Tashkent, Uzbekistan. Discussion draft, 51 p.

Salaev O., Ruecker G., Strunz G., Lamers J.P.A., and Martius C. (in preparation): Khorezm Data Almanac 2005.

Schlüter M., Savitsky A.G., McKinney D.C., and Lieth H. (2005): Optimizing long-term water allocation in the Amudarya river delta – A water management model for ecological impact assessment. Environmental Modeling and Software 20: 529-545.

The Main Forestry Department (2005): Ministry of Agriculture and Water Resources of the Republic of Uzbekistan. (http://www.msvx.uz/rus/forest.html) (in Russian)

CIA (2005): The World Fact Book (https://www.cia.gov/cia/publications /factbook/index.html).

Treshkin S.Y., Kamalov S.K., Bachiev A., Mamutov N., Gladishev A.I. and Aimbetov I. (1998): Present status of the tugai forests in the lower Amu Darya basin and problems of their protection and restoration. In: Ecological research and monitoring of the Aral Sea Deltas. UNESCO Aral Sea Project 1992-1996, Final Scientific Report, UNESCO, Paris.

Treshkin S.E. (2001): Transformation of tugai ecosystems in the floodplains of the lower reaches and delta of the Amu Dar'ya and their protection. In: Ecological research and monitoring of the Aral Sea Deltas. A basis for restoration. A Basis for Restoration Book 2. UNESCO Aral Sea Project, 1997-2000. Final scientific reports. UNESCO, Paris, pp. 189-216.

Tupitsa A. (in preparation): The functional assessment of native forest stands, tree plantations and field shelterbelts in Khorezm, Uzbekistan, Aral Sea Basin. PhD thesis, Center for Development Research (ZEF), Rheinische Friedrich-Wilhelms-Universität Bonn, Bonn.

UNEP and Glavgidromet (1999): National Action Programme to combat desertification in Republic of Uzbekistan, Tashkent, 117 p.

UN Timber Statistics 2004 (http://www.timberweb.com/UNData/Uzbekistan.html).

Vildanova G. (2005): Uzbekistan. Overview of forestry. Country statement. Workshop "Capacity building in sharing forest and market information", Prague, Check Republic. (http://www.fao.org/regional/SEUR/events/Krtiny/docs/UzbR_en.pdf).

Vlek P.L.G., Martius C., Wehrheim P., Schöller-Schletter A. and Lamers J.P.A. (2003): Economic Restructuring of Land and Water Use in the Region Khorezm (Uzbekistan) (Project Proposal for Phase I). ZEF Work Papers for Sustainable Development in Central Asia. 75 p. (http://www.khorezm.uni-bonn.de/downloads/WPs/ZEF-UZ-WP01_proposal.pdf; checked 17.1.2006).

Young A. (1997): Agroforestry for soil management. CAB International, Wallingford, UK.

ZEF (2003): Economic and Ecological Restructuring of Land- and Water Use in the Region Khorezm (Uzbekistan). A Pilot Project in Development Research. Project Phase II: Field Research and Development of a Restructuring Concept (2004-2006). ZEF, Bonn, 58 pp. (http://www.khorezm.uni-bonn.de/downloads/ZEF-UZ-Proposal-Phase2.pdf; checked 17.1.2006).

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