Agricultural biodiversity in transition agriculture: Fruit tree genetic resources in rural Uzbekistan

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Introduction

Central Asia is one of the world centers of agricultural diversity, and this study focuses on fruit and nut trees and grapes. From the time of Silk Road until the present, home gardens have been repositories of important agricultural genetic resources, part of the cultural traditions and local economy. Household production of fruits and nuts remained important through the Soviet era, and despite the collectivization of agriculture, small-scale family production continued to constitute a large part of the national and international supply. In the time since independence, household production has only increased in importance in Uzbekistan, as the new nation has sought to begin to change the land tenure from the collective farm model, and more importantly as households have needed the diversified production from home gardens to survive the economic crisis of transition. The contraction and transformation of the state sector has created a need to document how the seed systems supplying the diversity of genetic resources in home gardens is a combination of formal and informal sources.

This paper will describe and analyze the diversity of agricultural genetic resources of fruits and nuts in a rural economy in transition. A review of the literature will discuss studies of rural economies in transition, the case of rural Uzbekistan, and the current paths towards land reform. A case study utilizing an original household survey from a series of rural villages near Samarquand, Uzbekistan is presented to show a quantitative portrait of fruit and nut production. The empirical section will present data on the diversity of household gardens, elements of the seed system where households source genetic material, and the relationship between diversity and the different tenure regimes.

This research is being carried out as part of an international collaborative project between the International Plant Genetic Resources Institute (IPGRI) and national partners

within Uzbekistan under the auspices of the systemwide project on Collective Action and Property Rights (CAPRI). The institutions are mentioned because this has steered how the methodology for the project has been shaped and creatively adapted to the research questions. First of all, while the main agricultural issues in Uzbekistan are the production of cotton, and management of water resources and the related environmental issues, the genetic resources focus of this study is towards fruit and nut tree production, and this has guided the analysis away from large national issues of state farms and collective enterprises towards households and village institutions. Second, the project is seeking to examine the local – household and village level - effects of changes in land tenure and social institutions, in a way to link these social and economic changes to genetic resource management. Third, the project includes studying farmer seed systems as a form of collective action, combining government and market sources, with informal, neighbor to neighbor genetic resource networks. Finally the analysis of garden diversity call for a synthesis of methodology from targeting conservation efforts at varieties and populations within a single crop species, with research tools from the studies of home gardens and agroforestry where there are many species grown together. This synthesis of methodology will also seek to link social networks to the agricultural biodiversity being conserved.

Background on Uzbekistan

Uzbekistan is a hotspot of both agro-biological and cultural diversity. Over sixty distinct cultural and linguistic groups exist in Uzbekistan alone, and it is a center of origin for over 40 crops including apple, peach, plum, almond, walnut, pistachio, grapes, and such horticultural crops as garlic, melon, spinach, etc. Vavilov described the area in his early collecting missions, and described the combinations of wild forests of fruit and nut trees next to ancient oasis cities inhabited for millennia. Although the Soviet modernization of agriculture lead to centralized planning of widespread monocultures on vast irrigated acreages, significant diversity was maintained in household garden plots where traditional agricultural practices and inherited varieties were maintained free from state planning. The warm climate and irrigation infrastructure of Uzbekistan led it to be used by the Soviets to supply fruits and vegetables to the northern cities, and there was a small but significant infrastructure and trade in these crops.

The Soviet agricultural research system was well developed, and Soviet botanists actually pioneered the study of wild and farmer varieties of crop plants. However, as in most areas, the state sector contracted in the 1990s. The Shreder Institute and its regional research stations are in charge of fruit and nut genetic resources for Uzbekistan. The stations are faced by limited funding for activities necessary to keep their collections alive, and have largely limited other activities, despite the huge benefits to local farmers. These experiment stations actually play a dual role, collecting and conserving traditional varieties, but also making selections and providing both improved and local genetic materials for planting.

The issue of agricultural biodiversity is also related to other important environmental issues in Uzbekistan. One pressing issue is the diversification of the overall economic system away from the cotton monoculture. The cotton production system is notoriously reliant on intensive chemical inputs, and inefficient irrigation infrastructure. The diversification into different fruit, nut, and vegetable crops, especially ones that draw on local genetic resources, has the potential to reduce polluting inputs, and provide more economic options than the single dominant cash crop. From the point of view of the individual farmer, given that cotton is subject to production orders, and most of fruit and vegetable production is not, when given the option farmers seek to move out of cotton into these other activities.

Home Gardens and Rural Poverty in Uzbekistan

Home gardens are the focus of this study not only because of their role in the conservation of crop genetic resources, but because they are critical components of household income and represent a key sector in the agricultural economy of Uzbekistan. Home gardens have been the major source of fruit and vegetable crops in Uzbekistan, and this general tendency holds for Central Asia, and in Russia and the Commonwealth of Independent States (Lerman, Csaki and Lundell 2004, Seeth et al, 2003). In Uzbekistan home gardens are not only oriented toward home production, but satisfy more than half of national demand in fruits and nuts, furnishing a significant share of the export market in those commodities (Thurman and Lundell 2001, Lerman 1998). Despite the collectivisation of the vast majority of land during the Soviet period, individual initiative was always permitted in household gardens. In the perestroika period of economic

opening at the end of the Soviet Union (1986-1991), initiative in garden production was encouraged, and the Soviet Union used this resilient sector of the economy to face falling production on the state-run farms (Seeth et al 2003). Growing fruits and tending vegetables is a fundamental feature of culture in rural Uzbekistan.

Furthermore recent studies have shown that gardens are central to household strategies to survive the poverty and economic collapse in the post-Soviet era. In Uzbekistan, Kandiyoti, in preparatory studies for the World Bank living standards assessment, raises several issues of how garden production was a strategy for the rural poor. In an assessment of Rural Poverty carried out by the Expert Center, access to garden lands provided a significant buffer to the income shocks of the early nineties. In data on rural Russia, Wengen found that gardens composed around 30% of the incomes of rural poor, and Seeth, et al. found gardens to be the second most important source of income in rural households, ranging from 10-50% of income. In Uzbekistan this is exaggerated by the fact that many parts of the rural economy remain without cash; households may work for the shirkat for access to benefits or payment of gas and electric utilities, but sales of horticultural goods are a rare source of actual cash income (Bloch 2002).

Despite the legal monopoly of the Shreder institutes on supplying fruit varieties, village social networks have always remained an important component of access to genetic resources (Thurman and Lundell 2001). In the soviet system, households received genetic material through the collective farm bureaucracy, but as the collective farms have transformed, their role in mediating genetic resources has decreased. Increasingly, regional and district bazaars have grown to supply both household demand for fruit varieties through the expansion of entrepreneurial market traders. The combination of these different sources, government, market, and social networks means that the seed system underpinning home gardens is a combination of national and local institutions and community level collective action.

Land Reform in Uzbekistan

The process of land reform in Uzbekistan is complicated by the divergence between legal frameworks and actual implementation, by regional differences, and even by the different names used. For this paper a series of reducing simplifications will be

used that may not apply in every case, but can describe the general situation. First of all, following independence the state farms, *Kholkoz*, were transformed into independent entities, *Shirkats*, which is technically a joint-stock company that the former workers hold shares in. In most cases the *Shirkat* is basically a continuation of the *kholkoz*, including the same leadership. However there are some cases with newer forms of production, including short term and medium term leasing of land, and renting and leasing of tractors and other services. There is a range of how independent and entrepreneurial the new *Shirkat* leaders are: some more encouraging of land reform, more integrated into market forms of management. In many other cases the Shirkats are basically indistinguishable from the Soviet era counterparts.

In the rural areas each household is allotted a parcel of land for use as a garden, usually around the home, *hovli*. In these gardens the families usually have 10-15 sotkas of land (0.10 to 0.15 ha) where they combine fruit and nut trees, grape vines, staple crops such as potatoes and cabbage, other vegetables for household or market, and raise livestock and corresponding forages such as maize. These lands are given to the households by the shirkat, as all lands, and indeed the villages themselves basically belong to the shirkat. A new family wishing to establish a new household has to petition the shirkat for a grant of land, which is often difficult and may require political connections or their cash equivalence. Many households include 3-4 generations and garden work is a shared enterprise.

One important land reform for this case study is the expansion of garden plots, where all families living on a Shirkat were eligible to receive an additional plot of land for own production. Although this does not appear in the sample survey, the findings of the survey on garden diversity are relevant to this smallest form of land tenure. The households working on collective farms were organized into work units, or *Pudrats*, usually an extended family or a group of families. Currently these *Pudrats* compose an intermediate form of tenure arrangement, with households either leasing land, or contracting to work a part of the shirkat under various forms of sharecropping or profit sharing arrangements.

Households with a small amount of land (less than 1 ha) who seek to be recognized as independent entities can be recognized as *Dehkan hojalik* farmers.[1] The *Dehkan hojalik* can operate independently from the Shirkat, and can bring their produce to market. While not every household plot is automatically a *Dehkan hojalik*, this land tenure form offers the opportunity for independence to successful small garden farmers. Although this sector was not widely found in the survey sample, again the conclusions about garden genetic resource management are relevant to this new tenure form.

The larger scale of land reform is the creation of private farmers, called *Firmer hojalik*, who apply for land from the local Shirkat and hokimiyat and are leased between 5-15 hectares of land on a long-term lease. In the cases that we interviewed, the successful private farmers, *Firmer hojalik,* had usually been involved in the previous state farm leadership and were able to utilize wealth and political connections to get their land holdings. This can be intentional, as wealthier farmers and brigade leaders and agronomists are more likely to be successful when their land is decoupled from the collective farm. On the other hand this bias in the land reform process is typical of the corruption throughout post-Soviet Uzbekistan and in many ways inherited from the bureaucratization of state-led farming. Even after these private farmers are given land titles, there is a range of the degree with which they are independent of production orders, or the type of treatment they receive from the district leader (hokimiyat) or farmers association. One interesting case for agricultural biodiversity is private farmers who lease orchards or vineyards from a Shirkat, and how their management may affect planting decisions in the future. As the private farmers are more entrepreneurial and dealing with larger harvest, the ability to market export crops, or to contract to processing firms may have an effect on what varieties are planted.

Land Reform Literature

A recent new literature has started to look at how the new tenure regimes are evolving in rural economies in transition. In looking at tenure reform it is important to look at land tenure as a bundle of different rights, to land and other inputs, as well as

[1] The term Dehkan can also be used to refer to a peasant or small farmer in general. Furthermore the term Firmer is confusingly similar (if not adapted from) the English word "farmer". In the presentation here *Dehkan hojalik* and *Fermer hojalik* are used in the new legal sense of independent legal entities representing new tenure classes as recognized by Uzbek law.

freedoms to make independent production and marketing decisions. Kandiyoti (2002) has found that Shirkat managers and pudrat families depend on and need each other, and she asserts that the negotiation of contracts has a large social component shaped by this interdependence. A family may prefer to continue as a pudrat in order to receive some benefits from the shirkat. Pomfret (2000) has compared the land reform in Uzbekistan to that in China, where it unleashed a huge boost in agricultural productivity, largely based on the ability to change production technology and shift the output mix. Pomfret finds stagnant growth in productivity due to incomplete tenure reform and the "draconian taxation of agriculture" in the cotton sector. However he does note dynamism in household and small producers not producing grains or cotton.

Amelina and Gershenson (2002), working in Russia find that there are different implementations of the land tenure reforms, which they link to the fact that some farmers stay dependent upon shirkats in order to get subsidized inputs. However Amelina and Gershenson seek to counter the image of small-scale producers as stuck in small-scale agriculture, they find that small rural producers can diversify find efficiencies and become profitable. Brooks and Lerman (2001) study of Turkmenistan asserted that the effective level of transferability is more important than actual title to land. In a comprehensive review of agriculture in transition, Rozelle and Swinnan (Forthcoming) compose a scale of transition that includes a range of agricultural market liberalization measures. In another cross-country comparison including Central and Eastern Europe, Macours and Swinnan (2002), focus on the creation of markets in a range of key inputs, and show relationships to the degree of productivity growth during the early period of transition.

Empirical Section: Analysis of Diversity

This case study will be used to illustrate several aspects of agricultural diversity: a general description of diversity at the household level, a crop by crop analysis to look at the diversity within and across crops, documentation of the sources and supply of genetic material, and description of the different tenure regimes. In defining the units of measurement, there is an issue of which diversity and which aspects of that diversity to look at. Because the unit of sampling was the household, the data will first be used to

explore overall household diversity, then crop by crop within overall diversity (meaning gardens and elsewhere), and finally attempting to break the diversity out by home gardens, pudrat, firmer land types. Within the measurement of home garden diversity we will also need to look at different levels of diversity, by variety and species, and by area dedicated to each.

The methodology for applied studies of on farm in situ crop genetic resource conservation is being developed for a variety of crops by academic researchers in collaboration with the International Plant Genetic Resources Institute. The starting point for this paper is the targeting of interventions for in situ conservation – understanding the social and economic forces that characterize the households who steward diversity, and the social and economic processes which create and maintain diversity. There are a few ways in which the crop genetic resources for these perennial tree crops differ from the annual, usually cereal crops which are most often studied. First of all most of the fruit trees and grapes are clonally propagated, which is more difficult than seed reproduction but produces perfect genetic similarity. Therefore the stewards of this diversity are not managing crop populations as the case for grain crops, but are replacing or renewing genetic lines. There are fewer individuals in each garden, but in total for a household there are often more varieties and species than in the annual crop case. The fact that they are perennial means that individual plants can live 20-30 years, which has several implications, including: genetic resource issues are not made very frequently and not in the annual sense that a cross-section household survey is directed at; trees can be inherited - without a crop choice being made; someone leasing or renting lands with trees or vines already planted does not make genetic resource decisions. Finally, fruit crops do not provide subsistence for a household, even in rural villages there can be relatively developed commercial markets for these fruits, even for traits such related to export markets, or processing characteristics.

The data used here is from an original household survey carried out in May-July 2003, in the districts of Urgut and Bulungur, in the province of Samarquand, Uzbekistan. A series of villages were selected in different regional units of shirkats and selsoviets to take into account regional heterogeneity in distance to markets, agro-ecological conditions, and other conditions. Households were selected at random within the

villages, and a household survey was applied that takes had six sections: family, land, production characteristics, crop diversity, social institutions, and markets and sales. The analysis here is primarily from the crop diversity and land modules.

The first layer of diversity is the overall level of diversity for each household, we begin by looking at counts of varieties, counts of species, and diversity indices for each household. Table 1 presents the summary statistics. There are 386 households surveyed, 182 in Urgut and 186 in Bulungur. The average number of fruit and nut species grown by each household is 4.9, and counting by varieties the average number was 7.1. The count by species means that a household which grew [apple, grape, apricot] would receive a count of three. The count by variety means that a household which grows [apple1, apple2, grape1, grape2, apricot1] would receive a count of 5. This distinction is important to the analysis. This general level be explored graphically for the whole sample and then will be broken down in the crop level analysis.

[Table 1 - Overall Diversity Statistics]

In this Table the diversity indices are presented for each household. These diversity indices are constructed by using a count of the number of trees or vines each household has, and deriving the proportional abundance from the share of the total planted to each. The Simpson index, presented here in the inverse form $1-\sum_i p_i^2$, represents the dominance within the garden of individual species – a household diversity evenly distributed across varieties will have a higher index. The Shannon index, $\sum_i p_i \ln p_i$, takes into account both the number of species and the evenness of their proportional abundance, so having a greater number of varieties, or the evenness of the planting to different varieties can both increase the diversity index. The summary statistics for the two regions surveyed is shown, but at this aggregate level there is no significant difference between the regions. This indicates that pooling the two regions in the cross-section is suitable for exploring heterogeneity across households.

Within the construction of the Diversity indices it is interesting to look graphically at the different assumptions of the diversity metric. The indices were calculated both for varietal diversity across all crops, and for species diversity across all crops (just as the two counts were in the table above). Whether the analysis is for

genetic resource conservation or for impacts on household livelihoods, the overall diversity of households or the diversity of species grown could be a target. Figure1 presents a graph comparing the index of diversity across all varieties for all species (Shannon-all) to diversity where varieties are grouped within each species (Shannon-byspecies), and similarly for the Simpson diversity index. The indices are calculated only for the homegarden plots (excluding the leased plots which tend to be larger and monocrop plots – this will be addressed later in the paper)

[Figure 1]

The way to read this figure is that the upper left corner represents households with few species and more varieties, the lower right corner represents households with more species and less varieties within each species. However, the indices are also measuring the evenness of the distribution – and whether it is weighted towards evenness or if most of the garden is concentrated in just one or two varieties. The points cluster along a line where the species and variety divisions coincide – a household with diversity even across species would fall along this line (in the Simpson the index is the same, in the Shannon the index scales up by the number of individuals). The trend line in the graph is included to show a correlation can be fit to examine whether households with more varietal diversity are households with more species diversity, and the R-squared of 0.7 and 0.6 show that much of the variance is explained but not all. We can see from this figure that it would be possible to target households with high diversity in both all species and varieties within species. However these indices are not correctly specified to correct for land area, bias from using a common set of varieties and other known restrictions.

To understand the underlying distribution of crops and varieties, it is necessary to look at diversity by each crop species. The crop varieties grown in the sample are: grape, apple, apricot, walnut, peach, plum, sweet cherry, mulberry, fig, quince, almond, pomegranate, pear, and prune. In Figure 2 a histogram of the count of the number of varieties grown is shown for grape, walnut, apple, and apricot.

[Figure 2]

Including all 368 households, it is clear for each crop some households do not grow any, shown by having zero varieties. In the case of apricot and walnut most households 63% have just one variety of apricot, and 70% have one variety of walnut. However in the

case of grape 47% have two or more varieties, and 41% have two or more varieties of apple.

In Table 2, summary statistics for a subset of cases is presented, for grape, apple, apricot, walnut, sweet cherry, peach and mulberry – it would be difficult to present all of the crops in a single table. The first line shows the number of households growing each crop. It can be seen that there is no crop that all households grow, and a range of how common a given crop is. Apple is the most common, followed by grape, walnut and apricot.

[Table 2 - Descriptive Stats by Crop]

The average number of varieties follows the trend described from the histograms, within households growing grapes the average is 2.3 different varieties, but for most other crops, the average number of crops is close to 1. This finding is similar to household level crop diversity studies in the cereal crops. The next set of data describes the characteristics of the crop grown. The number of individuals is the number of vines or trees, and this is much higher for grapes because there are some households with leased grape plantations with larger numbers. In general these distributions are highly skewed, even for minor crops principally grown in gardens, by many households with one or two and fewer households with several. The percent of new trees is calculated from asking the households how many immature trees they had not bearing fruit yet. Fruit trees may take 5-10 years until they bear fruit, and this is taken as an indication of the level of turnover of trees – the rate at which households need to replace genetic material and how frequently they can decide whether to change species or varieties. Across all crops a quarter to a fifth of all vines and trees are recently planted. Following the counts above, the diversity indices are very low within crop – showing high concentration even in multiple variety crops. Finally the data on sales shows that a small percentage of households are actually selling – and this is concentrated in certain crops like grapes, apples and walnuts.

Another way to look at the potential targeting of whether there are high diversity households is to look at the correlation of variety richness across species. This simple species by species correlation of the number of varieties is presented in Table 3.

[Table 3 Pearson Correlations between species]

The Pearson correlations in this table are low in general, meaning that in most cases whether a household grows multiple varieties in one crop is not related to whether they do so in another crop, in the most common crops multiple grape varieties does not mean multiple apple varieties. Because this is for all households, for many crops these correlations are also driven by the zero-one decision, showing that a household will grow that crops at all, in the less common crop, growing peach is correlated to growing cherry at 0.33 (because the average number of varieties is one). This is apparent in that a less important crop like cherry, with only 50%, of households growing is weakly correlated to walnut mulberry and peach, while grape, grown by 78% of households is only correlated with apricot, and only at 0.13.

Seed System

Seed system is a general term for looking at the way household source crop genetic resources, and the empirical approaches are being developed by participants at this conference (in this volume). In the case of fruit trees, as mentioned previously it is not seeds, but clonally propagated young saplings and vines which are used. In Table 4 the sources of genetic material are presented for each of seven crops. At the bottom the sources are presented by percentage of total, and grouped: parents, siblings, children, neighbor, friend, other relative – are grouped as informal, and Shreder and shirkat are grouped as official.

[Table 4: Source of Genetic Material – Social Relation]

There is no single source that dominates the seed system. The Bazaar is the most common source, composing over 50% for apple, apricot and peach. Grapes, one of the most commonly grown, is most evenly sourced between own-sources, combined informal sources, and the bazaar. For grapes this may reflect that it is relatively easier to propagate by using cuttings than for a tree. Official sources are never more than 12%, but in any case the varieties from the bazaar may be indirectly Shreder varieties. The high percentage of own and informal sources shows that the informal seed system is incredibly important for these households, despite 70 years of Soviet rule and continued centralization of the rest of the agricultural sector. Certainly for cotton, and many other crops the government retains the Soviet monopoly on seed supply. While the

government retains a technical monopoly on fruit varietal release and breeding, the informal sector is obviously very robust.

A second component of the seed system is *where* genetic resources are sourced. In this case for each crop the households were asked where the saplings came from. Table 5 presents a picture of the seed system by geographical location, with each household referencing their answer to their own household. A small number, 2-5%, are sourced from immediate neighbors, while the mode is to source from the same village. The categories of the same shirkat and same selsoviet (an administrative unit), are not necessarily mutually exclusive (but only one answer is recorded) and basically correspond to receiving the variety from the neighboring villages.

[Table 5: Source of Genetic Material – Location]

In every case except apricots and apples, the majority of households reported sourcing from within the same village. In general, it is convincing that these proportions are relatively constant across crops. There are contrasts, such as that grapes are only sourced outside of the local area 10% of the time, while apples are the most frequently sourced from outside, at 26%. There is also contrast where in Table 4 the households reported receiving 40-60% of the material from the bazaar, but in Table 5 40-60% is within the same village. Because the bazaar is usually at the district level, this appears to be a contradiction, but there may be more sub-district bazaars that cater specifically to genetic resources, or households may seek sellers from their local area when at a district bazaar.

Finally the survey also recorded whether the household reported selling vines or saplings to other households for planting. Table 6 presents supply data for a subset of grape, apple, apricot and cherry. The majority of households do not supply material, but 5-9% do on a small scale, and fewer still supply on a large scale.

[Table 6: Material Sold or Supplied to other Households]

Grapes present an interesting case where 20% of households distributed varieties, and 10% supplied more than 50 vines. For the tree fruits a more likely pattern of 5% supplying other households at a small scale, and 1% supplying at a larger scale. This distribution may be fairly typical for the informal network of seed systems, a few select nodal farmers supply most people in the village, a few more households engage in

occasional exchange of materials, and the large majority of households are net recipients of genetic material.

Turning to the land tenure characteristics, the primary level of analysis is the household plot. Table 7 presents summary statistics for the household plot, and for an additional garden plot if the household has one, with data presented by region. While almost all households have a garden plot, only a few have a secondary plot. Part of the agricultural reform in Uzbekistan has been to give additional tamorqa lands to households. This is not apparent in the survey – only 10% and 13% of households in Urgut and Bulungur, respectively.

[Table 7 Characteristics of HH Land Parcels]

The average garden size is 0.17 ha. in Bulungur and 0.15 ha. in Urgut. The median area is 0.15 ha. in both districts, indicating the distribution is relatively even. The age of parcels shows that most have been held by households since the Soviet era, and correlate with the age of the household head. In Bulungur, 55% of households received a tamorqa in the last ten years – this is possibly the result of land reform. Conversely, only 23% and 25% of households have received their plots in the last ten years. When households were asked how long the households would officially have it, almost all households responded that the garden plots were inheritable.

The newer forms of land tenure in Uzbekistan are leaseholders from the shirkats. In the survey sample this appears to take three forms, working the land in a share arrangement called pudrat, receiving the land for working as a Firmer, or leasing land from the shirkat. Summary statistics describing these arrangements are shown in Table 8. In Urgut there a large number of households, 101, work Shirkat lands, almost all as pudrats. The average land size is 0.22 ha. which is only slightly larger than the garden plots, and the lower median of 0.20 ha. shows a downward skewed distribution. In Bulungur there were only 49 households working Shirkat lands, 60% of which as pudrat and 40% with some other lease arrangement. The average land area in Bulungur is much larger at 0.68 ha, and the median of 0.70 indicates a rightward skew to the distribution. Finally in the entire sample of 368 households, there are only 12 households in the new land tenure category of Firmers. While this low number may be a sample selection problem, it also indicates how few of rural households are benefiting from the land

reform process. The average land area for the firmer is much higher at 2.8 h, and the median at 3.0 ha indicates some households have far more.

[Table 8 - Characteristics of Shirkat and Firmer Land Parcels: Dependence upon Shirkat]

In the rental category, most households in all categories pay the Shirkat for their lease with a share of the harvest, and thus are basically sharecropping for the same farms where they formerly worked as employees. This is also typical in rural Uzbekistan where the agricultural economy does not have a lot of cash, but more often households receive production inputs and some benefits from Shirkat membership in return for the harvest of there land area. The Firmers are relatively more independent, but surprisingly 58% report selling some of their harvest to the shirkat.

In Table 8 There are three variables on the independence of household choices from the shirkat. Of the most importance to genetic resources, just 4% of pudrat hh in Urgut, and just 17% in Bulungur chose which crop they would plant, and while slightly higher, only 25% of firmer households chose the crop. HH make slightly more decisions on inputs, 23% and 21% in Urgut and Bulungur, but notably double, or 45% for the firmers. When asked whether the households was allowed to choose which plot they were able to work, 41% in Urgut, 60% in Bulungur, and 55% of the firmers were able to choose. The last category of questions is about how dependent the households were on the shirkat in other ways. The requirement to perform *hashar*, or work brigade duties, providing free labor to the Shirkat, was reported by 81 and 97% of households in pudrat, and only 38% of firmer. However 70 -76% reported some other obligation. In Urgut 33% and in Bulungur 21% of households reported receiving a salary from the shirkat, but none of the firmers did. However half of households in Urgut reported receiving some other form of benefits, and 67% of the households in Bulungur, but only 38% of the firmer households.

Finally, the same households working shirkat lands were asked how long they had worked the same parcel, how long they thought they could continue to farm it, and how long they could officially farm it.

[Table 9 - Characteristics of Pudrat and Firmer Land Parcels: Perceptions of Tenure]

In Urgut 90% reported that they had used the pudrat for 2-5 years, 79% thought they could use it for more than five more years, but 42% reported that officially it was only theirs year by year, renewable by shirkat authorities. For the pudrat and lease in Bulungur, 66% reported farming the same plot for the last 2-5 years, a more even breakdown left only 52% reporting a long term future of more than five years, and 51% reported that the shirkat could change their land allocation each year. A major contrast is firmers, where 80% reported working the same parcel for 2-5 years, 88% reported they could farm it for greater than 5 years, and 90% reported that there official lease was longer than five years (usually the official, national norm of 20 years) .

The impacts of tenure reform on diversity start from what crop is planted on the parcels. Table 10 presents summary statistics on which crops are planted on the Shirkat lands worked as Pudrats or leased to Firmers.

Table 10 : Crop Planted on Shirkat/Leased Land

There are far more pudrats on the Shirkats in Urgut, and the majority of them are planted to Tobacco. There is a joint venture processing factory with British American Tobacco in Urgut, and the factory contracts to the shirkats, who contract out the parcels to the workers. However there are many shirkats in Urgut with grape plantations, the region is known for raisin production, and there are a significant number (31) of households with grape pudrats. In Bulungur there are half as many pudrats in the sample, but a similar number (31) are also involved in working a share of the shirkat's grape fields. The number of firmers is very small, but 2 are involved in fruit production and 4 in grape production. In All categories, apples are the most common fruit orchard crop.

These number represent a small share of the overall sample, which makes it difficult to make major conclusions about diversity. However, looking at the most common crop, grape, is an indication of overall trends. Table 11 presents the number of grape varieties grown, and the sources.

Table 11: Grapes on Shirkat/Leased Land

With these small numbers, none of these statistics appear to be significantly different than the garden plots. The percentages for the Bulungor firmers are not statistically significant because there are only 4 of them. For the number of grape varieties grown, 46-55% of households grow one variety. This is interesting because in half of the cases the

households are working pudrat lands that have multiple types of grapes planted. Looking at the seed sources, the bazaar is the most common source of vines in Urgut, followed by own sources. There appear to be many cases in Urgut with tiny plots being worked from the Shirkat that have been planted by households. In Bulungur it is the official sources that dominate, mostly the Shirkat, who had planted the vines originally. At the larger and larger scale of production – there are farmers who have orchards of multiple species, and vineyards of multiple varieties. As the case with seed sources, there appear to be a small number of farmers, 20-30 in a sample of 386, who are dedicated to large scale commercial production of grapes and fruits.

Analysis and Policy Discussion

The data presented here has been used to illustrate the situation for the diversity of fruits and nuts from a case study in two districts in Samarqand, Uzbekistan. The underlying issues for this study are the ways in which rural households use home gardens in surviving the process of economic transition, and the ways in which land reform may influence crop diversity. Home gardens in Uzbekistan are diverse, with low numbers of varietal diversity within each crop, but diversity across species. There are a few crops such as apple and grape which are planted by most households, and then several other species planted by about half of the households. There is not a high degree of correlation of diversity across crops, but some correlation across the minor species, indicating that a few households have more extensive collections of fruit trees. The seed system is constituted by a robust combination of self-supply, informal local village networks, the bazaar, and official sources. Most material is sourced locally, within the same village or same district as the household. Very few households supply genetic material to other households – indicating an elite of nodal farmers sought out for informal sources. The combination of self-supply and informal local sources indicates that a degree of collective action exists where households conserve and exchange genetic resources outside of market or official channels.

Future work in this area will be to look at identifying and targeting high diversity households, and developing case studies for interesting households with particularly significant diversity profiles, or important roles in the informal seed system. This research has been designed to address the dual roles of conservation of genetic resources

as an environmental good stewarded by home gardens, and access to genetic resources as an economic asset of households. Genetic resources an the diversity of both crops and varieties within crops can provide resilience for households, if one tree or one variety fails due to weather conditions, the others can be utilized. These fruit crops have a high value in the markets – high enough that even when households have a small production they can lead to cash income. Therefore access to planting material, and of marketable varieties is a unique form of economic opportunity for rural households, who have few other options within the villages. Households access genetic resources through a combination of market access and collective action amongst exchange networks. From the household perspective, the seed system will remain a combined form of collective action, where households use social networks to share information on varieties and their traits even when turning to markets for genetic material.

The genetic resources are also nested within the overall livelihood strategies of households, for example apricots can be sold fresh, dried, in preserves or as seeds, and mulberries provide leaves for silk production and fruit for market or preserves. Each of these utilization decisions, which may impact which or how many varieties are grown, is linked to other households decisions on labor allocation, inter-temporal cash needs, etc. Furthermore the fruit and nut sector is dynamic, in contrast to other sectors of Uzbekistan's agriculture. Domestic markets are robust for both fresh and dried products, and new processing facilities are buying fruit as inputs. Networks of regional and national traders supply national markets in metropolitan areas, and export markets in Russia, based largely on production by households in rural villages. Access to sources of genetic resources will remain fundamental to the dynamism of this sector.

Most of the diversity is contained in the home gardens, which are small, at an average of 0.15 hectares, but fairly evenly distributed. New, post-Soviet tenure forms include sharecropping and leasing from the shirkat, and leasing as independent farmers. All of these tenure forms reported some degree of dependence on the shirkat, through salary or benefits, because the shirkat controls what crop is grown, or by controlling other inputs, how it is grown. Few of these new tenure types are dedicated to fruit and grape production, but those that are have a similar diversity profile in terms of number of varieties grown and the sources of genetic material.

The tenure system is changing, but lags in implementation means the actual rate of reform is very slow. There has been a national policy of moving slowly on all types of economic reforms, which the government has called "Uzbek gradualism". Compounding this is the fact that the actual reforms have been slowed by rent-seeking behaviour on behalf of national, regional, and local leadership. National legislation is passed creating new tenure access laws, but the institutional hierarchy and power structure remain intact. Transformation of the agricultural sector follows a pattern set in other economic reforms: a local political elite is transformed to a local economic elite; economic decisions are centralized through input contracting and bribes rather than through technical decisions made by planning authorities. While these processes were reported in qualitative or informal research methods during this study, their extra-official nature makes them more difficult to establish as statistical results from survey data. However there are a few policy imperatives that result here. The home garden sector is the most independent of all tenure forms, and therefore likely to be quite responsive to new market opportunities. Within the other land tenure categories the degree of independence can be understood as a bundle of property rights, in this case not only access to land, but to capital, inputs, machinery, and water, and each of these may have a degree of common property or negotiated access. Finally within the choice of crops, the horticultural sector crops discussed here are relatively far more independent from government control. Households in all forms of tenure reported that growing fruit allowed them to access free and cash based markets, in contrast to cotton or grains which were subject to production quotas and arbitrary pricing. The greater degree of independence offered by this more secure form of property right is linked to higher diversity. Because the household sector can also combine property rights to land, water, and own labor, the resulting autonomy leads to greater ability to plant diverse gardens of fruits and nuts.

From this study it appears that the seed system is meeting household demand through a combination of different sources. Institutionally there is a decline in the role of the government sector, as public sector resources decrease, and a concomitant rise in the private sector propagators and traders of genetic material. One issue of key policy importance is whether the entrepreneurial sector will be able to meet the demands of the new tenure system, or be able to replace government sourcing through collective farms

with local traders. In qualitative interviews the market traders reported that their operations and sales had grown substantially in recent years in order to supply households investing in newly leased lands. This is also significant where the survey shows few leaseholders planting horticultural crops, but they may be turning to the bazaar as their principal source of genetic material at a much higher than the population as a whole. Ironically while it may appear that these market traders may be supplanting the state sector, the traders themselves may increasingly depend on the Shreder institute as a primary source of planting material, as well as propagation techniques, cultivation advice etc. However policies must also take into account the important role documented here of local breeders and local exchange networks; while market sources may be growing, they are still only a part of a complex combination of seed sources

Therefore one of the key policy interventions may be to insure that the public sector maintains key roles that would correspond to similar institutions in market economies. The excellence of the Shreder institutes should be economically and institutionally supported in the areas of public science such as collection and conservation of germplasm, evaluation of cultivars and provision of stock materials for propagation. The independent sector should be fostered and allowed to flourish and a system of access should be developed where entrepreneurial propagators or breeders can access training, information and materials in an open manner. A longer term intervention would also include measures to insure quality control, including measures for variety registration and labeling of true varieties as a way to encourage market based supply. Finally there could also be measures to increase the flow of information in the opposite direction, field and market studies to inform traders and Shreder scientists what varieties or traits of varieties it is that households are demanding. In the interest of conserving local varieties this could mean traits that could be incorporated to lead to continued cultivation. Furthermore the property rights over genetic resources themselves should not be transferred completely to government or private interests. The broad use of self and informal sources of genetic material, mediated through collective action, means that the property rights to these varieties should remains as “common heritage” or public domain types of property rights.

Policy efforts to encourage in situ conservation of specific varieties could start with the targeting of specific households as mentioned above. As discussed in Figure 1 there are a variety of ways that the empirical methods employed in this study can be employed to identify high diversity households. Furthermore, seed system characteristics such as the use of local networks as measured in Tables 4 and 5 can be used to target households and institutions where genetic resources are sourced. These targeting measures can be used to identify households, or through regression analysis to identify economic or social processes that correlate with high levels of diversity. Finally this quantitative analysis can be combined with qualitative analysis on which types of varieties are of specific local interest or agronomic analysis of which types of varieties are of scientific interest.

There are broader policy approaches that may target conservation in order to slow the process of genetic erosion. One is to help ensure that local markets are able to reward the specific qualities of local varieties. Households surveys, group surveys, and qualitative surveys all revealed significant interest in the local diversity and genetic resources. Therefore the communities would probably respond well to such efforts as diversity fairs, or participatory diversity collections and evaluations. An important further area for research and investigation that this study has uncovered is to understand the small number of households who practice key activities supplying genetic resources. Fundamental new questions are to find which households plant fruit trees from seed, graft their own saplings, or serve as a local node in the exchange of materials. The identification of these households was not possible with the random sampling procedure used in this study and would require a new sampling procedure based on snowball sampling or a network design. It would be even more useful to combine and contrast the resulting data with the data presented here and the background information on economic and social contexts of the households.

Table 1 - Overall Diversity Statistics

	All HH		Urgut	Bulungur
	mean	stdev	mean	mean
n	368		182	186
Count all	7.14	3.41	7.87	6.44
Count by species	4.89	1.81	4.96	4.83
Shannon	1.30	0.57	1.31	1.29
Simpson All	0.61	0.24	0.60	0.61

Table 2 - Descriptive Stats by Crop

	Grape	Apple	Apricot	Walnut	Cherry	Peach	Mulberry
Number of HH with	288	330	245	281	182	159	42
Ave number of varieties	2.32	1.68	1.08	1.11	1.29	1.07	1.19
Household Averages							
Number of trees, vines	161.84	15.65	2.98	4.72	26.29	3.48	3.67
Percent new trees	0.17	0.23	0.27	0.26	0.25	0.26	0.16
crop Diversity Index	0.15	0.08	0.02	0.02	0.05	0.01	0.05
Percent HH who sell	0.26	0.16	0.04	0.17	0.08	0.04	0.10

Table 3 Pearson Correlations between species

	Grape	Apple	Apricot	Walnut	Mulberry	Peach	Cherry
Grape		0.06	0.13*	0.07	0.06	-0.06	0.05
Apple			0.18**	0.07	0.04	0.13	0.11
Apricot				0.12*	0.09	0.11	0.12
Walnut					0.15*	0.17**	0.16**
Mulberry						0.14*	0.28**
Peach							0.33**
Cherry							

*Correlation is significant at the 0.05 level (2-tailed).

**Correlation is significant at the 0.01 level (2-tailed).

Table 4: Source of Genetic Material – Social Relation

	Grapes	Apples	Apricots	Walnuts	Peach	Cherry	Mulberry
No Answer	10	7	13	12	5	2	2
Parents	40	24	13	28	3	8	4
Sibling	7	3	4	6	2	2	
Children	3	1					
Neighbor	20	5	6	9	5	14	3
Friend	6	5	1	3	3	5	1
Relative	16	12	6	12	4	12	1
Own Source	85	34	54	83	45	44	9
Bazaar	65	205	124	120	82	79	16
Shirkat	26	7	4	2	2	3	3
Shreder	10	25	18	4	7	10	2
Other		2	2	2	1	3	1
Total HH	288	330	245	281	159	182	42
Self	30%	10%	22%	30%	28%	24%	21%
Informal	32%	15%	12%	21%	11%	23%	21%
Bazaar	23%	62%	51%	43%	52%	43%	38%
Official	13%	10%	9%	2%	6%	7%	12%

Table 5: Source of Genetic Material – Location

	Grapes	Apples	Apricots	Walnuts	Peach	Cherry	Mulberry
No Answer	11%	13%	13%	12%	14%	9%	10%
Next Door	5%	2%	2%	2%	3%	4%	5%
Same Village	62%	38%	42%	59%	52%	57%	52%
Same Shirkat	10%	12%	12%	6%	9%	12%	12%
Same SelSoviel	2%	9%	9%	6%	6%	6%	10%
Other	10%	26%	22%	14%	16%	13%	12%
Total HH	288	330	245	281	159	182	42

Table 6: Material Sold or Supplied to other Households

		Grapes	Apples	Apricot	Cherry
Number Supplied	0	82%	93%	93%	93%
	1to50	9%	6%	7%	5%
	50+	9%	1%		1%

Table 7 Characteristics of HH Land Parcels

	Bulungur		Urgut	
	Household Plot	Additional Tamorqa	Household Plot	Additional Tamorqa
N	185	26	177	19
Average size (ha.)	0.17	0.17	0.15	0.13
Median Size (ha.)	0.15	0.15	0.15	0.12
Did you choose this plot	34%	56%	60%	59%
Are you the legal owner	91%	100%	88%	88%
How long have you farmed it				
0-10yrs	23%	55%	26%	18%
10-20yrs	34%	18%	24%	27%
>20yrs	43%	27%	51%	55%
How long do you have it officially				
0-5yrs	2%		1%	6%
Inheritable	98%	100%	99%	94%

Table 8 - Characteristics of Shirkat and Firmer Land Parcels: Dependence upon Shirkat

	Shirkat		Firmer
	Urgut	Bulungur	Bulungur
n	101	49	12
Mean area (ha.)	0.22	0.68	2.80
Median area (ha.)	0.20	0.70	3.00
Pudrat	97%	60%	
Lease without pudrat	3%	40%	
Rent - cash	16%	14%	8%
shares	79%	83%	58%
Both	5%	3%	0
HH chose which crop to plant	4%	17%	27%
HH made input decisions	23%	21%	45%
HH chose plot	41%	60%	55%
HH has other obligations	76%	79%	70%
HH recieves salary	33%	21%	0%
HH receives benefits	50%	67%	38%
HH owes work brigade	81%	97%	38%

Table 9 - Characteristics of Pudrat and Firmer Land Parcels: Perceptions of Tenure

		Pudrat		Firmer
		Urgut	Bulungur	Bulungur
How long have had it	1year	2%	25%	7%
	2-5yrs	89%	66%	79%
	gt5yrs	9%	8%	14%
How long do you think you can farm it	1year	11%	26%	13%
	2-5yrs	11%	22%	0%
	gt5yrs	79%	52%	88%
How long do you officially have?	1year	42%	51%	0%
	2-5yrs	23%	38%	10%
	gt5yrs	35%	11%	90%

Table 10 : Crop Planted on Shirkat/Leased Land

	Urgut	Bulungur	
	Pudrat	Pudrat	Firmer
n	101	49	12
Fruit Tree	2%	13%	18%
Grapes	31%	67%	36%
Wheat	4%	2%	27%
Tobacco	58%	0%	0%
Other Crops	5%	17%	18%

Table 11: Grapes on Shirkat/Leased Land

	Urgut	Bulungur	
		Pudrat	Firmer
One Variety	55%	46%	25%
Two Varieties	31%	36%	25%
> 2 Varieties	14%	18%	50%
Bazaar	43%	35%	50%
Self	28%	15%	
Informal	11%	8%	
Official	18%	42%	50%

Figure 1 – Diversity Indices: Variety vs Species

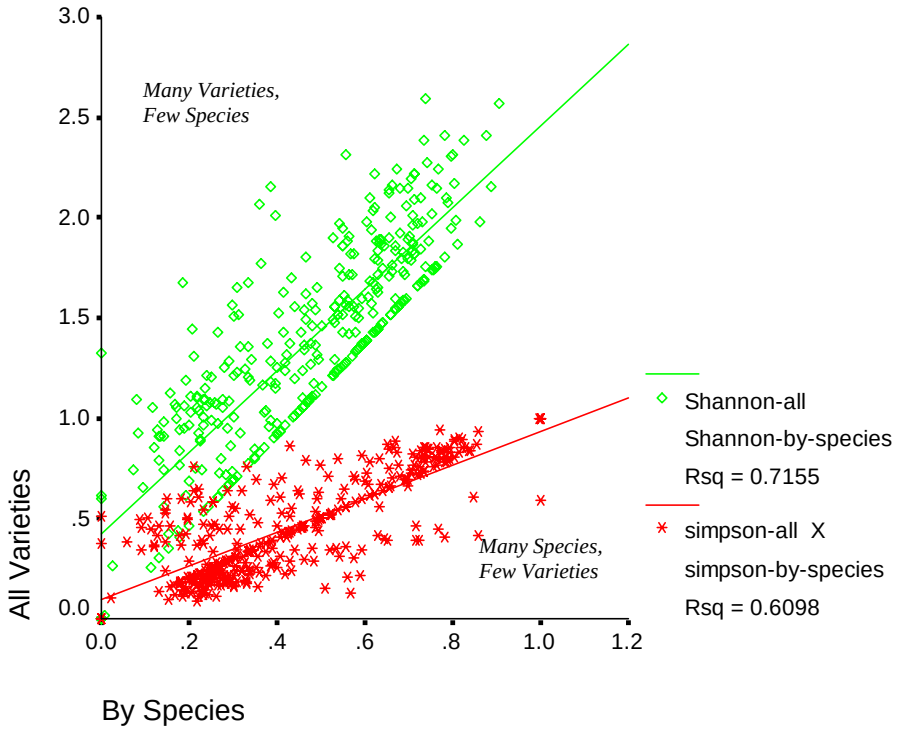
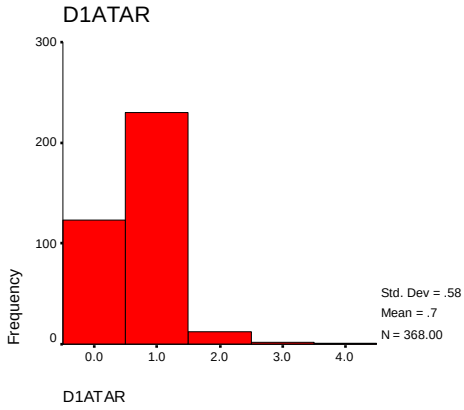
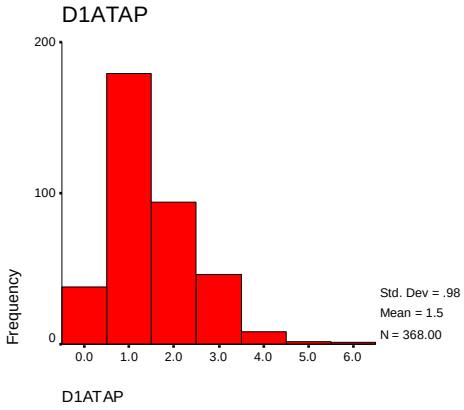


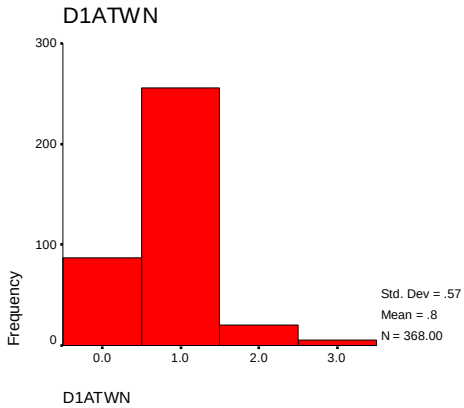
Figure 2 - Histograms: Numbers of Varieties



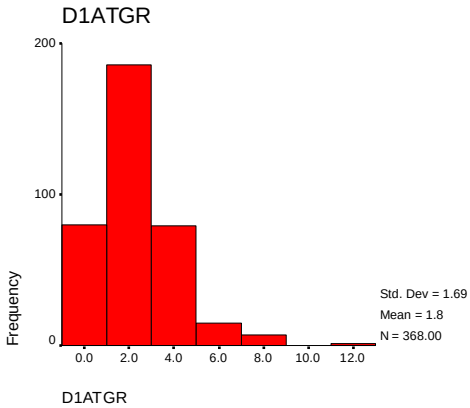
2a- Apricot



2c – Apple



2b - Walnut



2d- Grape

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