December 2015

Integrated Systems Analysis and Modeling in Aral Sea Region: A demonstrative case in Karakalpakstan, north-western Uzbekistan

Report

Agropastoral livelihood system typology for coping with socio-ecological diversity: A demonstrative case in Karauzyak, Karakalpakstan, Uzbekistan

Davran Niyazmetov[1,2], Inna Rudenko[1,2], Quang Bao Le[3], Akmal Akramkhanov[4]

[1] Khorezm Rural Advisory Support Service (NGO "KRASS"), Urgench, Uzbekistan; dniyazmetov@me.com, irudenko@mail.ru

[2] External Partner, CGIAR Research Program in Dryland Systems

[3] CGIAR Research Program on Dryland Systems c/o International Center for Agricultural Research in the Dry Areas (ICARDA), Amman, Jordan; E-Mail: q.le@cgiar.org

[4] International Center for Agricultural Research in the Dry Areas (ICARDA), Tashkent, Uzbekistan; E-Mail: a.akramkhanov@cgiar.org

1. Introduction

Republic of Karakalpakstan (Karakalpakstan) is located in the Northwest of Uzbekistan, and embraces the vast dry lands in the low reaches of the Amudarya river Basin and also the Aral Sea. Harsh environmental conditions, with cold winters and hot summers, largely impact the productivity of crop and livestock in the study area, which are characterised as generally low. Reflecting external conditions, the vulnerability of the livelihood system in Karakalpakstan is very high and the area is considered to be one of the regions with low income in Uzbekistan. Hence, crop and livestock production under ongoing land degradation and scarce irrigated water resources is a huge challenge for rural households in the Aral Sea Region. To mitigate negative impacts of Aral Sea disaster, it is necessary to formulate optimal rural livelihood strategies, via modeling of current crop and livestock subsystems in selected sites.

Current research has been initiated within the framework of "Integrated Systems Analysis and Modeling in Aral Sea Region" activity in Uzbekistan, by ICARDA, DS-CRP.

Two villages in Karauzyak district of Karakalpakstan have been selected for the survey and analysis: one, located to the South from the district center and having more favorable conditions, and the other one, located to the North from the district center and having harsh climatic conditions and greater impact of the Aral Sea Disaster.

Integrated system modelling offers the opportunity to better understand the issues farmers are facing and for identifying and testing potential solutions. However, capturing

farming systems heterogeneity constitutes an important step in integrated farming systems modeling (Le, 2005). They exhibit different biophysical and socio economic settings in relation to their livelihood endowment and orientation, which change over time.

The specific objectives are to (i) identify main factors discriminating agricultural livelihoods at village level and (ii) identify and characterize agricultural livelihood types in the Karauzyak district based on two villages.

2. Methods and materials

Conceptual framework

Households-farms have different characteristics on biophysical resources (e.g. land, water and trees), economic resources (e.g. financial and infrastructures) and socio-demographic resources (e.g. labour, capabilities and networks). These features create heterogeneity since they are different for each household-farm in a given location. Identification of and accounting for this heterogeneity is important for a successful design of efficient and resilient agropastoral systems, and proper policy interventions.

The Sustainable Livelihood Framework serves to view a household-farm as a whole by taking into account all of its characteristics (features).

These features can be combined within five general groups of capital: human capital (demography, education and profession of household members), natural capital (i.e., land, both own and leased), physical capital (agricultural equipment, transportation assets, etc.), financial capital (income from all sources, savings, livestock), and social capital (social status, networking, public activity). The current state of these capitals dictates various livelihood strategies of household-farms. Consequently, this study used the Sustainable Livelihood Framework as a guide to identify and describe agricultural livelihood types in the study site.

2.1 Description of study site

2.1.1 Karauzyak district of Karakalpakstan

The study district – Karauzyak – is one of the 14 districts of the Republic of Karakalpakstan. It was established on the 26th of September, 1975. The district is located in Northeastern part of Karakalpakstan.

Total territory of Karauzyak district is 5.9 thousand km², of which agricultural arable land covers ca. 32.2 thousand ha, arable land – ca. 18 thousand ha, pastures – 380.1

thousand ha, and plots of local population ('tamorka') cover 2.2 thousand ha. Climate is sharp continental with average air temperature in January of 6 …8^0 C below zero, in June of 28 …32^0 C above zero. In July-August the temperature can rise above 450 C.
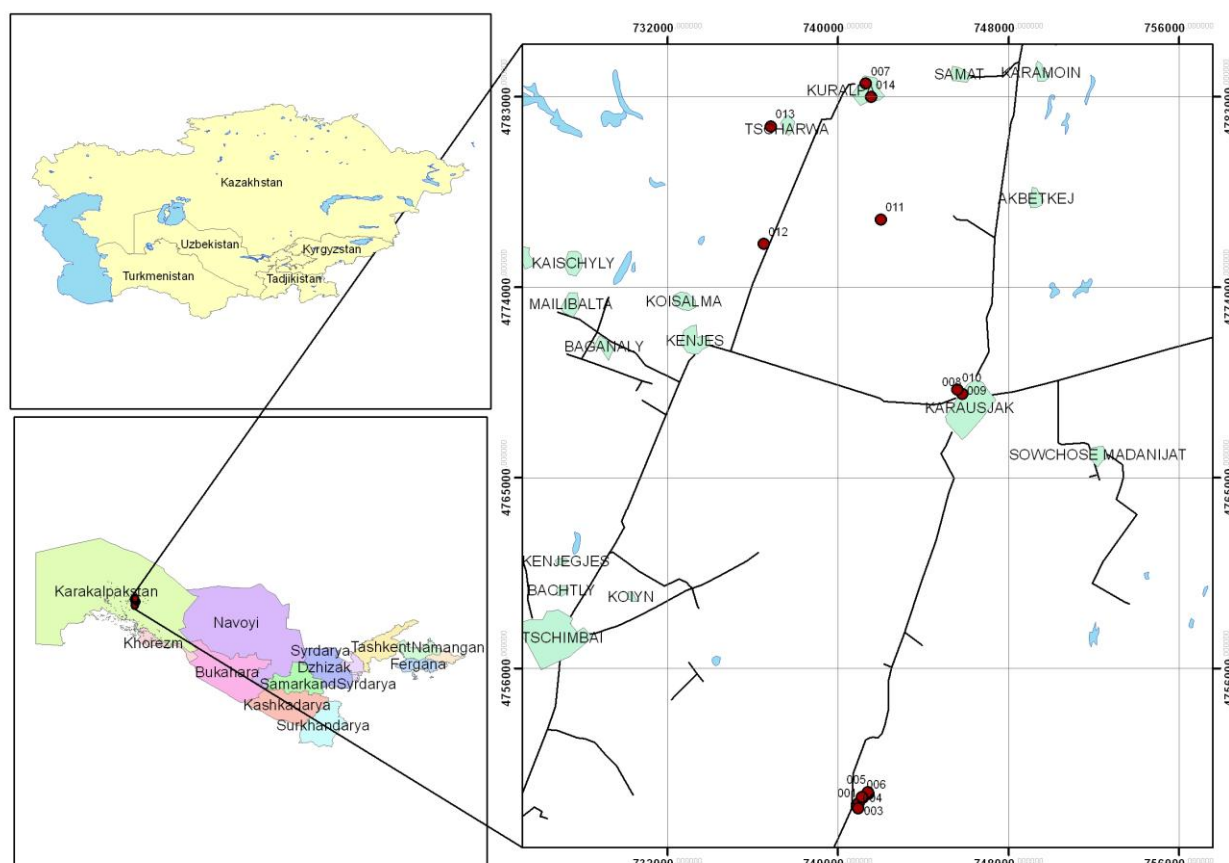

Figure 1. Locations of surveyed sites

Source: GIS lab of NGO "KRASS"

Administratively Karauzyak district is comprised of 1 urban settlement (SCC), 4 Mahallya Citizen Councils (MCC), 8 Village Citizen Councils (VCC). Two Village Citizen Councils (VCC) in Karauzyak district have been selected for the survey, representing 25% from total number of village settlements in the district: "Karabuga" located to the South from the district centre and having more favorable conditions, and "Algabas" located to the North from the district centre and having harsh climatic conditions and greater impact of the Aral Sea Disaster. Out of total 1,384 households in selected two villages, 100 households were surveyed, constituting over 7% of total households that is assumed to be sufficient for such reconnaisance study to get an overview of the villages and hence the district.

Demographic indicators

Total population as of January 1, 2015 reached 50,306 people, forming 7,781 households (families). Gender-wise, population is balanced with 0.5% overbalance of men (Table 1). Population-wise Karabuga and Algabas are almost identical, whereas more families live in Karabuga – 709 households vs. 675 households in Algabas.

Table 1. Households and population of the Karauzyak district

№	VCC	Households	Population	Including	
				Men	Women
1	Karakol	712	5,215	2,615	2,600
2	Berdakh	882	5,495	2,749	2,746
3	Algabas	675	5,208	2,638	2,570
4	Koybak	228	1,446	725	721
5	Madaniyat	896	5,640	2,830	2,810
6	Karauzyak	710	5,058	2,532	2,526
7	Esimozek	370	2,421	1,215	1,206
8	Karabuga	709	4,920	2,470	2,450
	Total for VCC	5,182	35,403	17,774	17,629

Annual population growth in Karauzyak district stands at 1.5%. Age structure of the population includes 36.2% of children (below 16 years of age), 56.9% of grown-up or able-bodied population (for women below 55 years and for men below 60 years of age) and 6.9% of elderly people (above 55 for women and 60 years of age for men).

Economic and agricultural indicators

The economy of Karauzyak district is based primarily on agricultural production, i.e. on cotton and wheat cultivation.

Some industrial branches are developed with 31 enterprises, providing employment for 420 workers and producing output worth 3.8 billion UZS. In 2014 industrial branches also earned export revenue to the region worth 127.5 thousand USD.

According to official statistics, in the first half of 2015 agricultural producers provided 485 tons of meat, 1,250 tons of milk, 1,595 thousand eggs and 1,329 tons of wool. The major contributors to total animal husbandry agricultural output were local rural households (except for the wool and fish), which produced and marketed 98.8% of meat,

98% of milk, 88.9% of eggs, 71.6% of karakul (astrakhan fur). Agricultural enterprises were second large contributors and private farms contributed the least (Table 2).

Table 2. Agricultural (animal husbandry) production in Karauzyak district in January-June 2015

Agricultural (animal husbandry) products	Unit	Total	Agricultural producers	Rural households	(%)	Private farms
Meat	tons	485	3.5	479.3	98.8	2.2
Milk	tons	1,250	23	1,224.9	98.0	2.1
Eggs	thousand	1,595	160	1,418	88.9	0.21
Wool	tons	1,329	356	34.1	2.6	17
Karakul	tons	1,529	356	1,095	71.6	78
Fish	tons	61	29	16	26.2	16

According to official statistics rural household possess the main amount of livestock animals (Table 3), including cattle, cows, sheep, horses, poultry and goats (not in official statistics). Baseline survey showed that goats are preferable animals in the Northern part of Karauzyak district, such as for example Algabas VCC, due to more drastic climatic conditions (colder winters and less fodder stock) since sheep are more sensitive animals compared to goats.

Table 3. Number of cattle and poultry in Karauzyak district in January-June 2015

	Total	Agricultural enterprises	Rural households	Private farms
Cattle	29,230	648	28,455	127
including cows	9,691	186	9,447	58
Sheep	79,135	19,850	58,410	875
Horses	1,447	59	1,364	24
Poultry	125,079	2,600	121,129	1,350

With regards to agricultural plant production official statistics reports production of wheat, potato, vegetables, melons and fruits in Karauzyak district. Again rural households were the main contributors to most of the crops in 2014, except wheat, which was to a large extent produced by private farms (Table 4).

Table 4. Agricultural (plant growing) production in 2014

	Unit	Total	Rural households	Private farms	Agricultural enterprises
Wheat	tons	7,256.8	633	6,586.8	37
Potato	tons	140	140		
Vegetables	tons	435.7	435.7		
Melons	tons	148	148		
Fruits	tons	30.1	25.6		4.5

Social development indicators

With regards to social indicators, Karauzyak district has 1 Social Support Fund, which distributes pensions to 4,914 people (as of January 2015), including age retirees and disabled persons. This fund also provides social (hardship) allowances to 414 residents of Karauzyak district.

Karauzyak population can receive medical treatment in 1 hospital with 135 beds and 1 out-patient's clinic in Karauzyak district center. There are also 11 village medical points (in VCCs and MCCs), which provide medical checks and first aid to the residents of villages. In total 64 medical doctors and 495 nurses work in the medical sector of Karauzyak district. There are 5 libraries in Karauzyak district, 1 music school and 1 cinema theatre.

As in the rest of Uzbekistan, education sector is set up to have secondary educational institutions (colleges or lyceums) in each district. Thus, there are 3 colleges in Karauzyak district with 1,378 college students (above 15 years of age).

Primary educational institutions – schools are located in each VCC, in total there are 32 schools in Karauzyak district educating 6,084 children of school age (7 to 15 years old) with the help of 1,167 school teachers. Some VCCs and district center have kindergartens – 9 kindergartens in total for Karauzyak district with the capacity to accept 895 children of pre-school age.

Infrastructure and communal services (gas, tap water, electricity) development

The general trend of energy supply in Karakalpakstan follows rest of the country pattern, i.e. the closer to administrative centers or cities, the more reliable is gas supply. Furthermore, there were some complaints of rather low quality, warn-out state and deterioration of gas supplying pipes.

With regards to drinking water supply, most villages in Karakalpakstan have installed tap water system, which often do not function. So, rural households rely on pumps and wells near their houses for drinking water, which can be of unsatisfactory quality (saline, with sand, etc.).

All villages in Karakalpakstan are connected to electricity and gas supplying grids, which are often outdated and require maintenance. For both energy sources there are often cuts, the supply of especially gas is erratic especially with remoteness from administrative centers. Nevertheless, in rural houses there is a heating system, including water (gas) boiler and heating pipes and radiators in the rooms.

In general, rural households believe that local administration (Village Citizens Council - VCC) is responsible for creating favorable conditions, initiating maintenance works of the pipes system and negotiating gas supply with district administration. In those villages with active VCC heads there is centralized energy supply.

For backstopping heating options, many rural houses have alternative heating stoves, operating on fuelwood (tamarisk, other local shrubs and trees) and coal (the so-called 'Leninskaya pech', 'kontramarka'), but heating limited rooms in the house. Still some more advanced households keep boiler type of the heating system, but switch it to liquid gas tanks. In rare occasions households may use electric heaters, but in limited period due to erratic electricity supply and low direct current voltage.

In those remote villages not supplied with gas, villagers have outside cooking facilities – cooking stoves, operating on fuelwood (cotton stems or twigs of trees) and used all year round. Some rural households construct their heating stoves (Leninskaya pech', 'kontramarka') so that they have some flat surface for cooking purposes in winter, but have to cook outside during summer. Some better off rural households have equipped their ordinary gas stoves with liquid gas tanks for cooking purposes (one filling supports cooking energy requirement for up to 3 months) and can use such gas stove all year round.

2.1.2 Karabuga

Karabuga is one of the eight VCCs in Karauzyak district. Total population of the village comprises 4,920 people (as of January 1st 2015), living in 709 rural households.

According to Karauzyak administration, Karabuga is a well-to-do village with rather wealthy households. The village is favorably located in the upstream of an irrigation channel. Moreover, villagers have pumps and can easily cope with water shortages

during agricultural season. There is enough land, even more than villagers can handle. There is a possibility to add some land to agricultural production upon sufficient labor for agricultural production.

The houses in Karabuga are well constructed with households' land plots located close to the house and in many occasions with additional land plots (*tamorka)* within farmers' fields. There are several big orchards with various fruit trees, including the newly established. There are some plans to develop fruit processing capacities in the near future in Karabuga.

According to official statistics as of August 1st 2015 there were 3,293 heads of cattle, 6,857 small ruminants (mostly goats) and over 13 thousand poultry in Karabuga.

The villagers are hard-working and experienced agricultural producers, easily managing subsistence production. The number of private farms is low. There is 1 one prominent cattle breeding farmer, who produces and sells milk in Nukus, both for consumers and processors.

With regards to social infrastructure, there are 4 schools, 1 kindergarten, and a newly built restaurant for celebrating local feasts, weddings. There is 1 medical point, providing first aid and medical treatment and awareness campaigns against diseases, including animal transmitting diseases. A vet station provides veterinary services to the villagers, such as vaccination of animals, curing of animals and treatment against pests and parasites. There is 1 militia base and postal office in Karabuga.

2.1.3 Algabas

Algabas is the other surveyed village out of eight VCCs in Karauzyak district. Algabas includes 19 auls. Total population of the village comprises 5,208 people (as of January 1st 2015), living in 675 households, but 779 families since it happens that one household may be comprised of more than 1 family (sons get married and stay and live in one house). Besides rural households (*dehqons*) there are 27 farmers in Algabas, which fulfill state ordered production of cotton and wheat.

According to Karauzyak adminstration, Algabas has the worst socio-economic and climatic conditions. This VCC is located to the North of the district, at the tail end of the irrigation channel and thus facing stronger deficits of irrigation water and higher temperature extremes (above +50ºC in summer and below -20ºC in winter). Villagers are not very wealthy; there are not many big houses, not much vegetation in Algabas.

With regards to infrastructure, Algabas is connected to gas supply and electricity, but cuts are frequent, especially in late autumn-winter-early spring. Heating of the houses is possible only with fuelwood, or coal.

With regards to transportation, there are some bus routs from Karauzayk center to other districts and Nukus city. In order to get to Karauzyak district center private cars or taxis are used.

Each VCC has a female consultant who acts as intermediary between regional/local government and villagers with regards to various topics including health, agriculture, human and animal diseases, trainings, etc. According to the consultant of Algabas, female villagers lead harder life, since much housework is on their shoulders coupled with low energy supply for cooking, heating and cleaning. On the other hand female villagers are more active and eagerly participate on seminars, meetings, trainings. The peculiarity is that elderly females, or at least after getting married (on average at the age of 18-20) are allowed to be active in public life of the village.

Since it is hard to do agriculture in Algabas, there is high seasonal labor migration to basically Kazakhstan (closest to Karakalpakstan and similar language). Besides, very many families, Kazakhs by ethnicity, have already left the village. Currently migration is lower, when girls leave the village after marriage, or educated villagers find jobs in Nukus or even Tashkent.

Rural households manage to grow forage crops, very little vegetables. Local people lead very simple lives, do not have ambitions to become rich or have better houses and cars.

There are 4 schools, but no kindergarten, 1 medical point, providing first aid and medical treatment. There is 1 militia base and postal office in Algabas VCC. Finally, a veterinary station provides veterinary services to the villagers of Algabas VCC.

School education provided in the village is of satisfactory quality and as a result only 5-10 teenagers manage to enter University. In case a teenager starts higher education on contractual terms, some parents, who can afford such education, sell livestock in order to cover educational fees. Girls with higher education have higher chances for a good marriage outside the village.

2.2 Household-farm sampling and surveys

In total 100 households living in 2 Village Citizen Councils "Karabuga" and "Algabas" have been randomly selected and interviewed. Of great help and support have been the head of local administration, his assistants, the Head of the Veterinary Service and

Heads of the Village Citizen Councils. The consultants of the Village Citizen Councils (females) helped to find interviewees, set contacts with local population and provide some local statistics. Since the interview took place in the peak agricultural season, sometimes there were problems with finding the respondents or with keeping them for 2 hours during the interview. Thus based on the advice of the Village Citizen Councils consultants, a mix of individual and group interviewing methodology was applied. Group interviews took place sometimes in the local houses, sometimes in the office of Village Citizen Councils or in the buildings or local schools, medical stations or even kindergarten.

Interviewing of key informants

Key informant interviews – UNDP office in Nukus for contacts, head of local administration and his assistants, Head of the Veterinary Service, heads of Village Citizen Councils of selected areas Karabuga and Algabas, consultants from Village Citizen Councils. The letters of support (Annexes 2 and 3) from ICARDA-CAC to Khokim of Karauzyak district as well as to the Head of the UNDP office in Nukus were of great help to set up contacts with key informants and for collection of secondary data.

The questionnaires were guided by the Sustainable Livelihood Framework covered mainly household characterization (e.g. demography, education and profession), farm lands inventory and land tenure, agricultural and farm tools inventory, crop and livestock production, off-farm income and remittance.

2.3 Identification of household-farm types

The identification of the agricultural livelihood types in Karauzyak combined multivariate analysis and expert knowledge. The methodological flowchart is shown in Figure 2. The multivariate analysis consisted in two steps. The first step used Principal Components Analysis (PCA) for identifying the main factors that discriminate household-farms. The collected multidimensional dataset was prepared by selecting main variables per capital with reference to the Sustainable Livelihood Framework (Table 5). The PCA was run with the varimax option and only Principal Components (PC) with Eigenvalues of at least 1 (>=1) were considered. The second step consisted in K-mean cluster analysis (K-CA). The key variables, contributing most to the factors loadings (Loadings>=0.6) from the PCA results, were used. The knee method was employed to decide on the optimal number of clusters. ANOVA was used to characterize identified agricultural livelihood types and the results were confronted to expert knowledge.
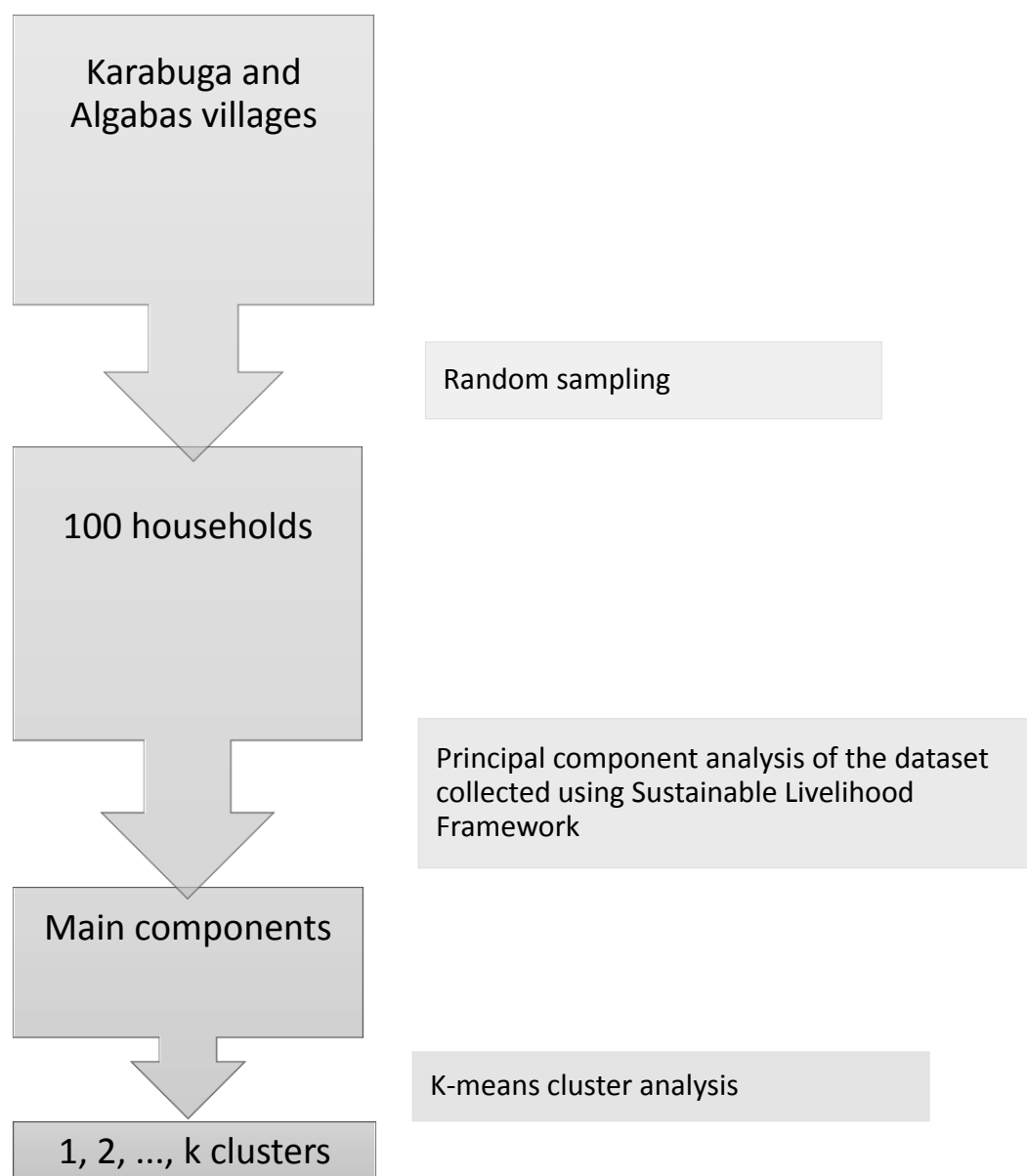
Figure 2. Methodological flow chart of household livelihood typology analysis.

Table 5. Household variables for Principal Component Analysis.

Livelihood asset	Variable	Variable definition	Source*
Human	$H_{HEADAGE}$	Household head age (year-old)	D
	$H_{HEADEXP}$	Experience of the HH head in Agriculture (years)	D
	H_{NBEDUC}	Number of members with bachelor or higher degree in the household	C

	H$_{SIZE}$	Household size (no. of people in the household)	D
	H$_{LABOUR}$	Number of workers of the household (labour)	C
	H$_{DEPEND}$	Dependency ratio of the household	C
	H$_{NONAGROINC}$	Number of household members with non-agriculture income	C
	H$_{EXTSERV}$	Households that have interest in Extension services (1=yes, 0=no)	C
Physical	H$_{DFMARKET}$	Distance to nearest food market from household house (km)	D
	H$_{DLMARKET}$	Distance to nearest livestock market from household house (km)	D
	H$_{CAR}$	Number of cars possessed by the household	D
	H$_{TRACTOR}$	Number of tractors possessed by the household	D
	H$_{TRACTANIM}$	Number of traction animals (horse and mule) possessed by the farm	D
	H$_{GSFACILITY}$	Number of grain storage facilities possessed by the household	D
Natural	H$_{HOLDINGS}$	Farm land holdings (ha)	D
	H$_{HOLDINGCP}$	Farm land holdings per capita (ha/person)	C
	H$_{FALLOWCP}$	Farm fallow land per capita (ha/person)	C
	H$_{CULTLANDCP}$	Farm cultivated land per capita (ha/person)	C
	H$_{SHFALLOW}$	Share of fallow area in land holdings (%)	C
	H$_{SHCOTTON}$	Share of cotton area in land holdings (%)	C
	H$_{SHCEREAL}$	Share of cereals area in land holdings (%)	C
	H$_{SHMFCRP}$	Share of marketable food crops area in land holdings (%)	C
	H$_{LUCP}$	Livestock unit per capita (LU/person)	C
	H$_{LUHA}$	Livestock unit per ha of cultivated land (LU/ha)	C
	H$_{PUCP}$	Poultry unit per capita (PU/person)	C
Financial	H$_{SHRFINC}$	Share of household farm income in household annual gross income (%)	C
	H$_{SHREMITINC}$	Share of remittance income in household annual gross income (%)	C
	H$_{SHNOFFINC}$	Share of Off-farm income in household annual gross income (%)	C
Social	H$_{LEADCOM}$	Household head leadership in the community (1=yes, 0=no)	D
	H$_{PUBORG}$	HH member participates in any public organization (1=yes; 0=no)	D
	H$_{SATCSDM}$	Level of satisfaction with HH member contribution to social decision-making (1=satisfied; 2=partly satisfied, 3=not satisfied)	D
	H$_{ACSBRW}$	Household access to reliable sources of borrowing (1=Yes; 0=No)	D

Note: [a] D = Direct extracted from the questionnaire; C = Compound information calculated based on information coded in the questionnaire.

3. Results

3.1 Farming main settings in Karauzyak

In Karauzyak, households have an average size of nearly 6 members and are dominantly headed by males: only 13% of households' heads were female. Literacy rate in Uzbekistan and Karakalpakstan is reported to be 99%. Virtually all citizens throughout

the country do have school education since primary and secondary education is mandatory and free of charge for everyone. In all surveyed households, eligible members (as per age) have at least a college degree (secondary education). Therefore, it is more appropriate to look at households where members have at least a bachelor's degree. Table S1 shows that in 32% of households there is at least one male with a bachelor's or higher degree and in 30% - a female with the same degree. So, in terms of access to higher education there is no gender issue. It is prestigious to have a university degree in rural areas, and therefore parents support their children, regardless of sex, in entering the university.

There is no independent public organization/public fund operating in Karauzyak. Except for those that are established and monitored by the government at all levels, such as Farmers Council for example, Village Citizens Council. Only 10% of respondents acknowledged their participation in public organizations, by which they meant Village Citizens Council (Table S1).

Natural capital of the household consists of the land leased from the state. All land resources in Uzbekistan are the property of the state, which regulates and monitors the land use. Most of the available arable land resources are devoted to agricultural production either by the farmers (registered legal entities) or by *dehqons*. Whereas the farmers lease the land from the state for the period of up to 50 years, *dehqons* get the land for life-time inheritable use. According to the Land legislation *dehqons* may lease land of the maximum size of 0.12 ha for house buildings/dwellings and additional 0.12 ha for cultivating agricultural crops, which however depends on the availability of 'free' land in the given district or region. Households mainly use land plots as backyard kitchen gardens or a specified area within the main farmland of the farmers, and are free to choose their crops and sell at their own discretion. Most of the land owned by respondents is cultivated via surface irrigation (87%) and average land holding per person is about 0.07 ha.

Despite most of the households are predominantly poor, most of them would like to have additional plots in particular for production of fodder crops. In reality, due to constant growth of population (1.5% per year) on the one hand and due to limited available land resources on the other hand it is very difficult to get such additional land plots from regional administration. In such cases, agricultural area (cotton fields mainly) would have to be taken out of agricultural production and transferred to households, which is not desirable by the administration.

Traditionally, livestock are considered to be a good, reliable and fast paying off investment option. Many rural households, which plan to have weddings or other big celebrations or if the household has teenagers ready to attend or already enrolled at universities, the family can fast sell the cattle and get the required funds to cover expenses for celebrations or educational fees. Thus, livestock for households is one of the essential sources of food and income. However, for most of them the number of livestock and their variety is constrained by the income and fodder availability. Only 0.67 unit of livestock accounts for one person in surveyed households. Most widespread kind of livestock among respondents in Karauzyak district of Karakalpakstan is milk cows (present at 67% of households), since milk is a significant part of the daily nutrition of rural people. Non-milk cows are the second most popular animals and present at 44% of households. Among small ruminants the most widespread are goats, especially she-goats (20%). Sheep and rams are bred by few households and horses and mules are present at 14% of households.

Enhancing food security is one of the key challenges that impacts livelihood strategy of rural households. Most of the surveyed households (67%) worried if they were capable of securing sufficient food products every month. Households applied different strategies to mitigate or resolve issues with food products availability during last 30 days. The most applied strategy is to get food for debt from local shops or get help from relatives, friends or community members – 57% of households rely upon this. Another way of dealing with this issue was to spend savings for food, which is applied by 45% of households. In a little more than quarter of households (27%), elder members consumed less food so that children could have enough food. Nearly quarter of households (24%) met their demand for food at the expense of decreasing healthcare costs. The same number of households sold poultry for this reason. There are households that had to sell small ruminants (18%) and cattle (11%) to buy food.

3.2 Main factors discriminating agricultural livelihood types in study sites

The PCA results revealed 8 factors with total Eigen values of at least 1 (Table S2). The 8 factors beard 81.1% of initial total variance. The factors were named after variables with greater loadings and most correlated to the factors as shown in Table 6. The most discriminating factors of household-farms in study sites, with at least 10% of initial total

variance, were PC1, PC2, PC3, and PC4, which were highly correlated with Natural capital ($H_{HOLDINGS}$ with loadings b=0.97), Physical capital ($H_{DFMARKET}$ with loadings b=0.98 and $H_{DLMARKET}$ with loadings b=0.97), Financial capital ($H_{SHRFINC}$ with loadings b=0.91 and $H_{SHREMITINC}$ with loadings b=0.86), and Human capital ($H_{HEADAGE}$ with loadings b=0.82 and $H_{HEADEXP}$ with loadings b=0.80). The PC1 was named Land PC, the PC2 – Market PC, the PC3 – Income PC, and PC4 – Age Experience PC. These four factors represented 19%, 14%, 12%, and 10% of initial total variance, respectively. Other discriminating factors were PC5 to PC8, which carried less than 10% of initial total variance (5-8%) each. The PC5 was most correlated with human capital (H_{SIZE} and H_{LABOR} with loadings b=0.84 and b=0.74 respectively). The PC5 was named Labor PC, and it carried 8% of initial total variance. The PC6 was most correlated with Natural capital (H_{LUCP} with loadings b=0.84) and named Livestock PC. It carried 7% of initial total variance. PC7 was correlated with financial capital ($H_{SHNOFFINC}$ with loadings b=0.92) and carried 6% of initial total variance. This PC7 was named off-farm income PC. The last PC (#8) is mostly related to social capital and is clearly correlated with $H_{SATCSDM}$ (b=0.90), carrying 5% of initial total variance.

Table 6. Rotated Component Matrix (i.e., loadings) using Varimax rotation method and Kaiser Normalization of first eight PCs

Livelihood asset	Variable	Principal components							
		1-Land PC (19%)	2-Mark. PC (14%)	3-Inc. PC (12%)	4-Age. Exp. PC (10%)	5-Lab. PC (8%)	6-Liv. PC (7%)	7- Off Inc. PC (6%)	8-Soc. PC (5%)
Human	$H_{HEADAGE}$	0.003	-0.101	0.072	**0.821**	0.28	-0.03	0.072	-0.001
	$H_{HEADEXP}$	-0.11	-0.109	-0.055	<u>0.802</u>	0.386	0.042	0.036	0.052
	H_{NBEDUC}	0.347	0.02	0.363	0.035	0.381	0.473	0.005	-0.057
	H_{SIZE}	-0.08	-0.026	-0.041	0.106	<u>0.839</u>	0.015	0.17	0.147
	H_{LABOUR}	0.013	0.007	-0.121	0.166	<u>0.741</u>	-0.018	-0.146	-0.09
	H_{DEPEND}	0.087	-0.202	-0.151	<u>-0.718</u>	0.226	-0.165	0.04	0.038
	$H_{NONAGROINC}$	-0.009	-0.183	0.433	0.116	0.422	0.088	0.45	-0.412
Physical	$H_{DFMARKET}$	-0.009	<u>0.982</u>	0.054	-0.001	-0.013	-0.045	0.061	0.029
	$H_{DLMARKET}$	0.009	**0.974**	0.093	-0.021	-0.021	-0.042	0.064	0.03
	H_{CAR}	0.46	-0.194	-0.049	-0.185	0.134	0.289	-0.074	-0.351
	$H_{GSFACILITY}$	0.698	-0.201	0.12	-0.116	0.123	-0.014	0.127	-0.168
Natural	$H_{HOLDINGS}$	<u>0.969</u>	0.057	0.013	0.01	0.012	-0.015	-0.027	0.122
	$H_{HOLDINGCP}$	<u>0.963</u>	0.074	0.013	-0.025	-0.113	-0.048	-0.053	0.07
	$H_{CULTLANDCP}$	<u>0.963</u>	0.074	0.013	-0.025	-0.113	-0.048	-0.053	0.07
	H_{LUCP}	0.084	-0.11	0.001	0.19	-0.154	<u>0.839</u>	0.019	0.151
	H_{LUHA}	-0.226	0.018	-0.015	-0.036	0.096	<u>0.837</u>	-0.027	-0.151
Financial	$H_{SHRFINC}$	-0.046	-0.15	<u>-0.911</u>	-0.091	0.117	-0.001	-0.077	-0.066
	$H_{SHREMITINC}$	0.052	0.034	**0.858**	0.05	-0.088	0.015	-0.478	0.015
	$H_{SHNOFFINC}$	-0.023	0.157	-0.152	0.045	-0.019	-0.024	<u>0.921</u>	0.068
Social	$H_{SATCSDM}$	0.071	0.009	0.055	-0.01	0.073	0.012	0.041	<u>0.905</u>

<u>**Note**</u>*: **Mark** = Market, **Inc** = Gross Income; **Age Exp** = Age and Experience; **Lab**= Labour; **Liv**=Livestock, **Off Inc**= Off-farm income, **Soc**=satisfaction with social activity. Numbers in parenthesis are percentages of total variance of original variables explained by the principal components. Bold and underlined are the high loadings, indicating most important original variables representing the principal components and used for clusters analysis.*

3.3 Agricultural livelihood types in study sites

The typology analysis results revealed three agricultural livelihood types based on the survey results in given sites. The Table 7 highlights keys variables for which the three agricultural livelihood types were found different. In addition, the Table 8 compares average land use and crop yield per cluster for the main group of crops, vegetables, in the study site.

Livelihood type I: Educated, land-poor, livestock- and poultry-rich, off-farm-income-oriented farms

This agricultural livelihood type I represents 10% of the study sample. This type is characterized by its clear orientation to off-farm activities for income generation. In each household there is at least one member (1.44 on average) who has a university degree (bachelor's or higher). This results in a higher average number (1.89) of members who have non-agro income sources. Those with university degrees work usually at local public organizations such as schools, hospitals, kindergartens. And this type has the least degree of dependency rate (0.4) among all types.

Consequently, land holdings per household is the smallest in this type – 0.06 ha, or 0.01 ha per person. This type of household-farms use their small land plots (77% of total area, on average) mostly for cultivating vegetables and watermelons. At the same time, this livelihood type is better endowed with livestock (1.61 per person) and poultry (1.59 per person) than other two types. However, they mostly use livestock and poultry for own consumption and not for marketing purposes to generate income. Also this type has more cars on average (0.22) than other types.

As a result this type is much less dependent on farm income (6.4%) and income from remittances (6.7%), which means that, they rely upon off-farm income – 86.9%.

In terms of social networking, this type is fully satisfied with community activities, and there is one community leader in this type (11% of households). As a result, 78% of households in this type have a reliable informal source of borrowing within a community. We can only assume (since there is no data on absolute income values) that this type is better off than other two ones, based on its education status, social roles and income sources.

Livelihood type II: Farm-income-dependent, less educated, land-poor, poultry-turned farms

The agricultural livelihood type II represents 16% of the study sample. The main features of this group of farm-households are:

- Lack of higher education among members of the households (19%). This makes harder for this group to find high-paid jobs;
- Small amount of land plots: 0,17 ha per household or 0.03 ha per person. Reliance upon farming urges this type of farm-households to optimize their land use. As a result this type has the highest average yield of vegetables (68% of land use) among all types, which is 6.7 ton per ha. Consequently, this type of households sells some share of vegetables in local markets.
- Dependence upon farm activities (54% of total income) and remittances (16%) as income sources.
- This type has the highest rate of dependency (0.49).
- Households have more poultry (0.94) than livestock (0.54).
- This type is less socially active than other ones. However, few households in this group are not satisfied with how community decisions are made and executed.

Livelihood type III: Land-rich, poultry-turned, off-farm-income-dependent farms

This type III represents the majority of the study sample - 74%. The key indicators that distinguish this type of farm-households are the highest availability of the land and diversification of land use, rather high social activity.

Land holdings per household is 0.45 ha, or 0.09 ha per person in this type. Contrary to previous two types, this type uses less than half of its land for cultivation of vegetables (47.9%). The other half of the land is used mainly for fodder crops, beans, watermelons and fruits. However, regardless of the available land, only 6.5% of total average household income comes from farm activities. Whereas, as in type I, off-farm activities generate 92.6% of total income - the highest share among all types. This sounds somewhat controversial, given land, livestock (0.54 per household) and poultry (1.02) availability in this type. Also, the type III uses land much more efficiently than type I: the average annual yield of vegetables is 5.1 ton per ha (vs. 1.1 ton/ha of type I). Based on income shares, we can assume that prevailing majority of products from farming activities are consumed within households and not marketed for income. Another feature of this type is its social activity: 14% of it participates in public organizations, with 3% that have community leaders.

Table 7: Descriptive statistics of the agricultural livelihood types in Karauzyak. Key variables for which there are significant differences among types are highlighted in bold.

Livelihood asset	Farm type (Size)	Type 1: Educated, land-poor, livestock- and poultry-rich, off-farm-income-dependent farms 9					Type 2: Farm-income-dependent, less educated, land-poor, poultry-turned farms 16					Type 3: Land-rich, poultry-turned, off-farm-income-dependent farms 71				
					95% Conf. Interval					95% Conf. Interval					95% Conf. Interval	
	Variable	Mean	Std. Error	Std. Dev.	Lower Bound	Upper Bound	Mean	Std. Error	Std. Dev.	Lower Bound	Upper Bound	Mean	Std. Error	Std. Dev.	Lower Bound	Upper Bound
Human	$H_{HEADAGE}$	49.22	3.64	10.91	40.84	57.61	49.31	2.68	10.70	43.61	55.01	49.37	1.31	11.07	46.75	51.99
	$H_{HEADEXP}$	26.11	3.51	10.52	18.03	34.20	26.38	2.24	8.96	21.60	31.15	23.04	1.49	12.59	20.06	26.02
	H_{NBEDUC}	**1.44**	0.53	1.59	0.22	2.67	**0.19**	0.14	0.54	-0.10	0.48	0.66	0.11	0.92	0.44	0.88
	H_{SIZE}	5.78	0.57	1.72	4.46	7.10	6.13	0.44	1.75	5.19	7.06	5.34	0.19	1.64	4.95	5.73
	H_{LABOUR}	3.78	0.57	1.72	2.46	5.10	3.56	0.45	1.79	2.61	4.52	3.13	0.16	1.36	2.80	3.45
	H_{DEPEND}	0.40	0.07	0.22	0.24	0.57	0.49	0.04	0.17	0.40	0.58	0.45	0.02	0.17	0.41	0.49
	$H_{NONAGROINC}$	**1.89**	0.31	0.93	1.18	2.60	1.44	0.29	1.15	0.82	2.05	1.52	0.12	1.00	1.28	1.76
	$H_{EXTSERV}$	0.44	0.18	0.53	0.04	0.85	0.56	0.13	0.51	0.29	0.84	0.54	0.06	0.50	0.42	0.65
Physical	$H_{DFMARKET}$	22.67	1.86	5.57	18.39	26.95	20.25	1.30	5.21	17.47	23.03	20.58	0.61	5.11	19.37	21.79
	$H_{DLMARKET}$	21.67	1.72	5.15	17.71	25.62	20.00	1.40	5.59	17.02	22.98	20.58	0.61	5.16	19.36	21.80
	H_{CAR}	**0.22**	0.15	0.44	-0.12	0.56	0.06	0.06	0.25	-0.07	0.20	0.11	0.04	0.32	0.04	0.19
	$H_{TRACTOR}$	0.11	0.11	0.33	-0.15	0.37	0.00	-	-	-	-	0.04	0.03	0.26	-0.02	0.10
	$H_{TRACTANIM}$	0.11	0.11	0.33	-0.15	0.37	0.13	0.09	0.34	-0.06	0.31	0.20	0.06	0.52	0.07	0.32
	$H_{GSFACILITY}$	0.00	-	-	-	-	0.13	0.09	0.34	-0.06	0.31	0.15	0.04	0.36	0.07	0.24
Natural	**$H_{HOLDINGS}$**	**0.06**	0.02	0.05	0.02	0.10	0.17	0.06	0.24	0.04	0.30	**0.45**	0.09	0.73	0.28	0.62
	$H_{CULTLANDCP}$	**0.01**	0.00	0.01	0.00	0.02	0.03	0.01	0.03	0.01	0.05	**0.09**	0.02	0.15	0.06	0.13
	$H_{SHCOTTON}$	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-
	$H_{SHCEREAL}$	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-

	H$_{SHMFCRP}$	**77.22**	14.60	43.81	43.55	110.90	68.14	10.49	41.97	45.78	90.51	**47.88**	5.07	42.70	37.77	57.98
	H$_{LUCP}$	**1.61**	0.51	1.53	0.43	2.79	0.54	0.15	0.59	0.22	0.86	0.54	0.09	0.75	0.36	0.72
	H$_{LUHA}$	142.40	19.41	58.23	97.64	187.17	21.44	6.25	25.01	8.12	34.77	12.59	1.86	15.67	8.88	16.30
	H$_{PUCP}$	**1.59**	0.55	1.65	0.33	2.86	**0.94**	0.30	1.18	0.31	1.57	1.02	0.14	1.19	0.74	1.30
Financial	H$_{SHRFINC}$	6.44	3.31	9.94	-1.20	14.08	**54.06**	6.94	27.76	39.27	68.86	**6.45**	1.21	10.18	4.04	8.86
	H$_{SHNOFFINC}$	86.89	5.79	17.38	73.53	100.25	29.69	5.01	20.04	19.01	40.37	**91.58**	1.50	12.64	88.59	94.57
	H$_{SHREMITINC}$	6.67	5.53	16.58	-6.08	19.41	**16.25**	7.58	30.30	0.10	32.40	1.97	1.07	9.04	-0.17	4.11
Social	H$_{LEADCOM}$	**0.11**	0.11	0.33	-0.15	0.37	0.00	-	-	-	-	0.03	0.02	0.17	-0.01	0.07
	H$_{PUBORG}$	0.00	-	-	-	-	0.00	-	-	-	-	**0.14**	0.04	0.35	0.06	0.22
	H$_{SATCSDM}$	1.00	-	-	-	-	1.13	0.09	0.34	0.94	1.31	1.13	0.04	0.38	1.04	1.22
	H$_{ACSBRW}$	**0.78**	0.15	0.44	0.44	1.12	0.63	0.13	0.50	0.36	0.89	0.69	0.06	0.47	0.58	0.80

Table 8: Primary land use and yield performance of identified ALSs (average per ALS)

Agricultural Livelihood System	Land use (ha)	Crop yield (ton/ha)
	Vegetables	Vegetables
ALS 1: *Educated, land-poor, livestock- and poultry-rich, off-farm-income-oriented farms*	0.054	1.1
ALS 2: *Farm-income-dependent, less educated, land-poor, poultry-turned farms*	0.039	6.7
ALS 3: *Land-rich, poultry-turned, off-farm-income-dependent farms*	0.026	5.1

Conclusion

Under the severe climate of cold winter and hot summer, the productivity of crop, livestock and fishery in Karakalpakstan are low. Reflecting such conditions, the level of livelihood in the area is also low and the area is considered to be one of the most depressed regions in the Republic of Uzbekistan. Gross Regional Production (GRP) of Karakalpakstan in 2014 amounted to 3,632 billion UZS, which constituted ca. only 2.5% of the GDP of Uzbekistan. GRP per capita in 2014 in Karakalpakstan was 2,047 thousand UZS. Average monthly salary in 2014 hardly reached 211 thousand UZS (one of the lowest economic indicators in Uzbekistan).

Both surveyed villages apply certain livelihood strategies prominent in rural areas of Uzbekistan and Karakalpakstan, including: (1) subsistence agriculture, (2) seasonal labor migration, (3) official jobs at state-funded or budget organizations, (4) some entrepreneurial (non-agricultural) activities. There are very few jobs available in the community. Most people are employed by farmers or do seasonal work at farms, cultivating cotton. Though, this activity doesn't generate much income: people get paid with cotton by-products, such as cotton stems.

According to the Land legislation dehqons may lease land of the maximum size of 0.12 ha for house buildings/dwellings and additional 0.12 ha for cultivating agricultural crops, which however depends on the availability of 'free' land in the given district or region. Households mainly use land plots as backyard kitchen gardens or a specified area within the main farmland of the farmers, and are free to choose their crops and sell at their own discretion. Most of the land owned by respondents is cultivated via surface irrigation.

Crops are vital for households to survive in rural areas. Since most of the households own small plots of land they usually cultivate food crops such as vegetables, watermelons, fruits and beans. Majority of the surveyed households cultivate food crops (vegetables, beans, fruits, etc.) for own consumption; cultivate fodder crops to feed their livestock, and limited amount of fruits and vegetables for sale.

With regards to livestock production the most widespread kind of livestock among respondents in Karauzyak district of Karakalpakstan is milk cows, since milk is a significant part of the daily nutrition of rural people. Non-milk cows are the second most popular animals and present at about half of households. Among small ruminants the most widespread are goats, especially she-goats. Sheep and rams are bred by few households and horses and mules are present at even fewer households. Because of subsistence type of agricultural production of the surveyed households, many of the

surveyed households possess poultry. It is undeniable that men are key decision-makers regarding livestock production.

The principal component analysis revealed 8 factors that differentiate household-farm. Among them the most discriminating factors were related to land holdings, income shares, and experience in agriculture.

The cluster analysis resulted in three agricultural livelihood types for household-farms in the study site.

The agricultural livelihood type I (educated, land-poor, livestock- and poultry-rich, off-farm-income-oriented farms) comprises 10% of the study sample. As the name suggests, this type of households is characterized by its adherence to off-farm activities (86.9% of total income) for income generation with more highly educated members. Land holdings per person are 0.01 ha. At the same time, this livelihood type is better endowed with livestock (1.61 per person) and poultry (1.59 per person) than other two types. However, they mostly use livestock and poultry for own consumption and not for marketing purposes to generate income. It can be assumed that the type I is better off than other two ones, given its education status level, social roles and income sources.

The agricultural livelihood type II (farm-income-dependent, less educated, land-poor, poultry-turned farms) represents 16% of the study sample. This type depends on farm activities (54% of total income) and remittances (16%) as income sources. Members of the most of the households (81%) don't have a university degree and this makes it harder to find high-paid jobs. This group is regarded as land-poor since land holdings per person are 0.03 ha. But, this type uses available cropland more efficiently than others: average yield of vegetables is the highest among all types, which is 6.7 ton per ha. And households in this type have more poultry (0.94 per person) than livestock (0.54).

The agricultural livelihood type III (land-rich, poultry-turned, off-farm-income-dependent farms) is dominant and represents the majority of the study sample – 74%. The key factors that distinguish this type of farm-households are ample land holdings (0.09 per person) and diversification of land use (cultivation of vegetables accounts for only 47.9% of total land use). However, large land holdings didn't convert into higher farm income: only 6.5% of total average household income accounts for farm activities. This sounds a bit dissonant, given rich land, livestock and poultry availability in this type. Considering income shares, it is assumed that prevailing majority of products from farming activities are consumed within households and not marketed for income.

According to the local government, Karauzyak district faces some problems including: availability and access to water, irrigation water; underdeveloped industry; lack of working places; population is passive in terms of seeking addition income sources, improving livelihood. In the view of local administration efforts of both national and international organizations should be geared towards solving these issues.

In contrast, opportunities for growth in household-farms appear to be limited by very small farm sizes. Leasehold of land in these household-farms means that increasing farm size through land purchase is impossible and, indeed, even informal land rental for these farms is said to be rare. Further, their use for subsistence and thus as safety nets encourages risk avoidance strategies through diverse cropping patterns. And while this means that household needs are usually covered, it also means that marketed surpluses are small and, as a result, cash earnings are limited.

It is apparent that actions aimed at rural economic growth will have agriculture at their core, but emphasis on the wider rural economic development will also be important since, worldwide, experience shows that agricultural growth alone is insufficient to raise rural income substantially. This is because agricultural earnings accrue mainly to those with access to the key factors of production (land and water) and because the linkages between agricultural growth and incomes in the rural sector as a whole are weak. As a result, addressing non-agricultural incomes and, hence, non-agricultural income sources is essential in rural growth.

Appendices (Support materials)

Table S1. Main farming system characteristics in Karauzyak

H_Size	5.5
H_Female Head (%)	13
H_Illiteracy (%)	1
H_ Bachelor degree (%) : female	30
H_Bachelor degree (%) : male	32
H_Network membership (%)	10
H_Holdings (ha/person)	0.07
H_Livestock (unit per person)	0.64
H_Food availability concern (%)	67

Note:

Table S2. Total variance explained by extracted components, using Principal Component Analysis (PCA) as extraction method. Only PC with Eigen value >= 1 are retained. Note: The Principal Components with Eigenvalues less than 1 are not showed.

| PC	Initial Eigenvalues				Extraction Sums of Squared Loadings				Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumul.[a] %		Total	% of Variance	Cumul.[a] %		Total	% of Variance	Cumul.[a] %
1	3.83	19.17	19.17	3.83	19.17	19.17	3.71	18.54	18.54	3.83	19.17
2	2.83	14.15	33.32	2.83	14.15	33.32	2.16	10.81	29.35	2.83	14.15
3	2.41	12.05	45.37	2.41	12.05	45.37	1.99	9.94	39.29	2.41	12.05
4	2.02	10.09	55.46	2.02	10.09	55.46	1.99	9.92	49.21	2.02	10.09
5	1.55	7.74	63.20	1.55	7.74	63.20	1.98	9.88	59.09	1.55	7.74
6	1.43	7.14	70.33	1.43	7.14	70.33	1.76	8.80	67.89	1.43	7.14
7	1.12	5.61	75.95	1.12	5.61	75.95	1.38	6.91	74.80	1.12	5.61
8	1.03	5.15	81.10	1.03	5.15	81.10	1.26	6.29	81.10	1.03	5.15

Note: [a] Cumul.= Cumulative
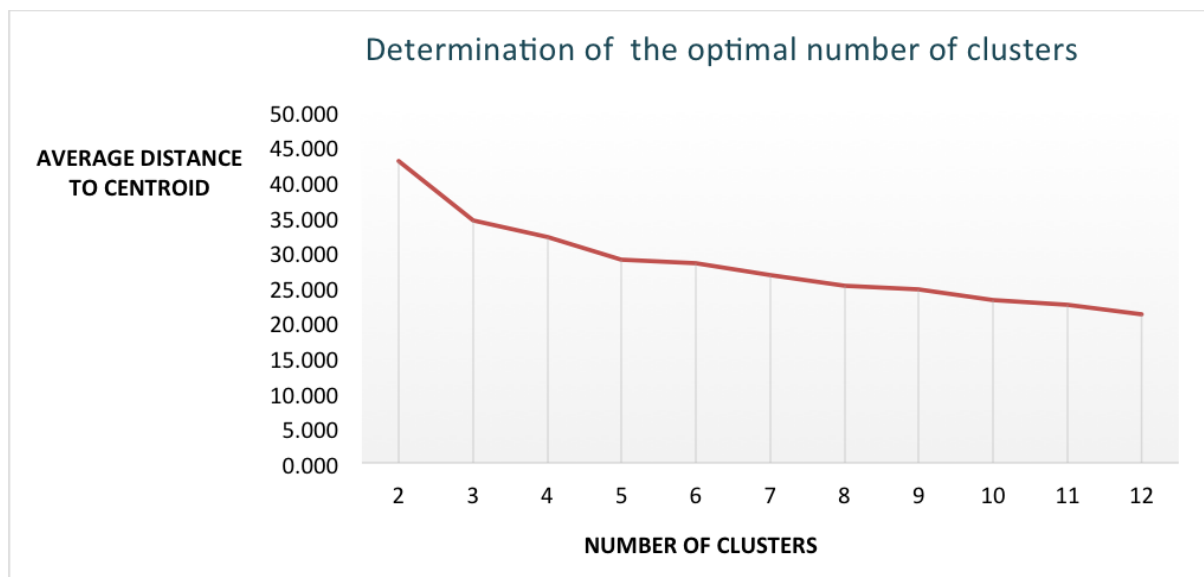
Figure S1. Knee curve showing relationship between the Mean Distance to Cluster Centroids versus number of cluster k. The number of optimal clusters is decided at the point of inflexion of the curve (knee), which is 3 in our case.

RESEARCH PROGRAM ON
Dryland Systems

CGIAR

The CGIAR Research Program on Dryland Systems aims to improve the lives of 1.6 billion people and mitigate land and resource degradation in 3 billion hectares covering the world's dry areas.

Dryland Systems engages in integrated agricultural systems research to address key socioeconomic and biophysical constraints that affect food security, equitable and sustainable land and natural resource management, and the livelihoods of poor and marginalized dryland communities. The program unifies eight CGIAR Centers and uses unique partnership platforms to bind together scientific research results with the skills and capacities of national agricultural research systems (NARS), advanced research institutes (ARIs), non-governmental and civil society organizations, the private sector, and other actors to test and develop practical innovative solutions for rural dryland communities.

The program is led by the International Center for Agricultural Research in the Dry Areas (ICARDA), a member of the CGIAR Consortium. CGIAR is a global agriculture research partnership for a food secure future.

For more information, please visit

drylandsystems.cgiar.org

Led by:

ICARDA
Science for Better Livelihoods in Dry Areas

In partnership with:

ICRISAT
Science with a human face

Bioversity International

CIAT

CENTRO INTERNACIONAL DE LA PAPA
CIP

World Agroforestry Centre

ILRI
INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE

IWMI
International Water Management Institute