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Livelihood type-specific behaviours regarding household choices in land use and management practices

Technical Report 1

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Introduction

This report focuses on the analysis of livelihood type-specific behaviors regarding household choices in land use and management practices. This is a contribution to the overarching framework of "Integrated Systems Analysis and Modeling in Aral Sea Region" activity within Dryland System CRP. The report is based on further analysis of baseline data collected within "Innovation Platform" activity, surveyed and reported in 2015 (Rudenko 2015). Preliminary analysis of household survey data including description of the study area and the content of the questionnaire was presented in the report of Niyazmetov et al. (2016). Insights from this analysis contributed to formulation and drafting of a journal manuscript (Report 2, draft prepared in journal paper format) entitled Agricultural livelihood types and type-specific drivers of production diversification: an evidence from Karauzyak, Karakalpakstan, Uzbekistan.

Methodology for identification of livelihood types in Karauzyak

For the analysis of livelihood type-specific behaviors in the Karauzyak district, the livelihood types was determined using a two-step process. The first step included the use of Principal Component Analysis (PCA) to identify a limited number of "strong" independent variables that are uncorrelated with each other from the existing dataset. In this respect, PCA assisted in the identification of a limited number of uncorrelated variables that contain most of the variance thereby reducing the number of variables in the analysis. PCA was undertaken using the statistical package STATA version 11. After running the PCA, the number of principal components (PC) are selected using the following two criteria: PCs with eigenvalues ≥ 1 were retained; and that PCs should represent sufficiently high variance. However, final decision on the variable was left to the author and was based on logical reasoning. Additional PCs were chosen with eigenvalues <1 in order to ensure a high variance explained by the PCs at 80%.

In the second step, after identifying the number of PCs that contributed to achieving the highest variance and with eigenvalues of ≥ 1, the scores of PCs were computed for the observations. These computed scores were used further for k-means cluster analysis to identify livelihood types. The number of clusters were decided upon using the cluster-analysis stopping rule (index) that was computed for each cluster solution. The Calinski-Harabasz (1974) pseudo-F index in the cluster-analysis rule was considered where larger values for cluster solution indicated more distinct clustering.

Variables which were used for principal component analysis were selected under the guidance of Sustainable Livelihood Framework (SLF), that gives broad explanation of the livelihoods of the poor and reveals major factors that influence people's livelihoods (*source:* DFID). SLF provides five livelihood assets, that include Human capital, Natural capital, Financial capital, Physical capital and Social capital, based on which this study selects related factors from the existing dataset.

It is of note that some variables from the dataset were not used in the analysis, even if they were considered important variables representing the main livelihood assets. This approach was implemented due to missing information for some observations.

PCA results

The PCA revealed the main factors discriminating among smallholder systems. In Table 1, PCs were labeled after the variables that have the highest loading within each component. In the PCA 10 principal components were selected that explained 81% of the initial total variance (Table 2). To determine the PC loadings the orthogonal rotation is applied. In this respect, the most discriminating factors among households with at least 10% of the initial variance are PC1, PC2 and PC3. PC1 with the highest initial variance (11.7%) is highly correlated with the share of non-agricultural income (loading =0.63) representing the financial assets of the household and labeled as Non-agro Income PC. Following this, the PC with 10.2% of initial variance is highly correlated with grain storage facility (loading =0.56) which represents households physical capital and labeled as Grain Storage PC. PC3 with 10.1% of initial variance correlates with total owned land hectare (loading = 0.67) which also represents households physical capital and labeled as Land PC. Remaining PCs, from PC4 to PC10, each with initial variance of between 6-9% were considered as factors of Age (PC4), Labor (PC5), Dependency (PC6), Plot (PC7), Market distance (PC8), Remittance (PC9) and Social (PC10) in accordance to their highly correlated variables within the components.

Table 1- Rotated component matrix of first ten principal components

	PC 1-Non-agro income	PC 2-Education /Storage	PC 3-Land	PC 4-Age	PC 5-Labor	PC 6-Dependency	PC 7-Plot	PC 8-Distance	PC 9-Remittance	PC 10-Social
	11.7%	**10.2%**	**10.1%**	**8.8%**	**8.5%**	**7.0%**	**6.7%**	**6.5%**	**6.1%**	**5.6%**
Age of HH head	0.03	0.02	-0.03	**0.71**	-0.06	0.00	-0.02	0.06	0.03	-0.05
Experience of HH head	0.01	-0.08	0.00	0.61	0.12	-0.04	0.11	-0.04	-0.06	0.01
Education of HH head	0.19	**0.51**	-0.07	0.04	-0.03	-0.14	-0.08	0.20	-0.14	0.02
Number of HH members	-0.06	-0.07	-0.07	0.10	0.59	0.11	-0.11	0.13	0.11	0.06
Number of HH labor	-0.08	0.02	0.11	-0.04	**0.67**	-0.22	0.04	-0.21	-0.20	0.03
HH dependency ratio	0.06	-0.18	0.05	-0.01	-0.03	**0.78**	-0.01	-0.03	-0.03	0.01
HH members with non-agricultural income	0.30	0.19	0.01	-0.01	0.37	0.21	0.04	0.07	0.23	-0.16
Distance to livestock market	-0.05	0.07	0.06	0.00	0.00	-0.05	0.02	**0.72**	0.16	0.22
Distance to food market	0.10	-0.01	-0.12	-0.07	0.00	-0.07	0.14	-0.47	0.30	0.25
Amount of HH autos	-0.08	0.39	-0.04	-0.18	0.13	0.34	0.06	0.00	-0.11	0.02
Grain storage facility amount	-0.02	**0.56**	0.01	-0.05	-0.02	-0.10	0.14	-0.05	0.08	-0.09
Total own land (ha)	0.00	-0.02	**0.67**	0.00	0.05	0.02	0.02	0.05	0.01	-0.03
Own land (ha) per capita	0.04	-0.01	0.65	-0.03	-0.05	0.00	0.03	0.03	-0.01	0.00
Plot (ha) per capita	0.01	0.03	0.16	0.04	-0.07	-0.12	**0.67**	-0.12	0.02	0.10
Livestock per capita	-0.14	0.14	-0.11	0.13	-0.02	0.30	0.54	0.07	-0.01	-0.02
Livestock per ha	-0.21	0.40	0.19	0.24	-0.14	0.17	-0.41	-0.33	0.11	0.29
Share of agricultural income	-0.61	-0.01	-0.02	-0.03	0.05	0.02	0.04	-0.01	0.03	-0.01
Share of income from abroad	-0.04	-0.04	0.01	-0.02	0.02	-0.05	-0.01	0.03	**0.85**	-0.05
Share of non-agro income	**0.63**	0.02	0.02	0.01	-0.01	0.03	-0.01	-0.09	0.00	0.05
Level of satisfaction with contribution to social decision-making	0.06	-0.07	-0.04	-0.04	0.05	0.01	0.06	0.10	-0.06	**0.86**

Table2 –Variance of principal components explained before and after rotation

Principal Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.06	15.3%	15.3%	2.33	11.7%	11.7%
2	2.47	12.3%	27.6%	2.03	10.2%	21.8%
3	2.29	11.5%	39.1%	2.03	10.1%	31.9%
4	1.88	9.4%	48.5%	1.75	8.8%	40.7%
5	1.46	7.3%	55.8%	1.71	8.5%	49.2%
6	1.34	6.7%	62.5%	1.40	7.0%	56.2%
7	1.13	5.7%	68.1%	1.34	6.7%	62.9%
8	1.02	5.1%	73.2%	1.30	6.5%	69.4%
9	0.84	4.2%	77.4%	1.21	6.1%	75.5%
10	0.74	3.7%	81.1%	1.13	5.6%	81.1%

Optimal number of clusters

PC scores were computed for each observation through the predictive option in STATA and observations were assigned into cluster groups. Several cluster solutions were computed and four clusters were selected using cluster-analysis stopping rule, since Calinski and Harabasz (1974) pseudo-F index was the highest for four clusters indicating more distinct clustering (Table 3).

Table 4 presents the dominant discriminating factors between livelihood types and provides statistical significance levels for mean differences between clusters. Variables in bold are the main discriminating factors that were found through PCA. Each variable in the table is labeled with statistical significance if means between livelihood types were found to be significantly different. The most distinct and significantly different mean values of variables are highlighted in bold. Pair-wise comparisons of means between livelihood types were also considered in performing ANOVA. Due to the incomplete data for some of the households with regard to the factors of interest, only 92 households were eligible to be assigned into cluster groups.

Table 3 - Cluster-analysis stopping rule (index)

Number ofclusters	Calinski/Harabasz pseudo-F
2	12.97
3	11.83
4	**13.35**
5	9.53

Table 4 - Descriptive statistics of the agricultural livelihood types with combination of ANOVA test results

	Livelihood type 1: Relatively young, small, land-rich and distant from livestock market (11 households)		Livelihood type 2: Less educated, big, livestock rich, agriculture dependant, (19 households)		Livelihood type 3: Closer to livestock market, land poor, food market distant (34 households)		Livelihood type 4: Relatively old, educated, agriculture independent (28 households)	
Variables	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Age of HH head* **	**41.182**	5.582	51.158	8.591	43.088	7.751	**59.429**	8.426
Experience of HH head***	**15.909**	11.247	28.526	6.031	**15.176**	8.365	**34.964**	7.652
Education ratio of HH **	0.105	0.124	**0.026**	0.064	0.172	0.225	**0.174**	0.193
Number of HH members***	**4.364**	1.286	**6.316**	1.668	5.118	1.320	6.214	1.287
Number of HH labor* **	**2.545**	0.934	3.789	1.813	2.794	1.122	3.893	1.499
HH dependency ratio	0.773	0.455	0.507	0.535	0.737	0.619	0.600	0.589
HH members with non-agricultural income***	1.273	0.786	**0.842**	0.898	1.500	0.862	**2.286**	0.937
Distance to livestock market* **	**21.818**	5.564	20.579	6.077	**11.512**	10.570	16.291	8.938
Distance to food market**	**9.955**	11.272	15.076	9.283	**19.768**	7.426	16.382	10.043
Amount of HH autos	0.091	0.302	0.105	0.315	0.235	0.431	0.036	0.189
Grain storage facility amount	0.091	0.302	0.053	0.229	0.206	0.410	0.143	0.356
Total own land (ha)* **	**0.400**	0.160	0.111	0.098	**0.038**	0.042	0.116	0.097
Own land (ha) per capita***	**0.096**	0.043	0.018	0.016	0.008	0.010	0.020	0.017
Plot (ha) per capita	0.027	0.043	0.023	0.019	0.014	0.015	0.027	0.025
Livestock per capita***	0.242	0.381	**1.224**	1.141	0.501	0.641	0.823	0.844
Livestock per ha	1.793	3.360	42.516	40.555	70.186	285.085	33.339	51.394
Share of agricultural income***	10.000	30.000	**56.316**	26.658	13.971	18.577	**5.393**	7.300
Share of income from abroad	0.000	0.000	4.737	13.068	2.941	11.942	9.643	23.957
Share of non-agro income* **	90.000	30.000	**33.158**	21.292	86.029	18.577	94.607	7.300
Level of satisfaction with contribution to social decision-making	1.091	0.302	1.158	0.375	1.059	0.343	1.071	0.262

*** - statistically significant at 1 percent level, **- at 5 percent, * - at 10 percent

Livelihood types

Based on the PCA and k-means cluster analysis, the study identified four types of agricultural livelihoods in the study site. Based on results presented in later tables, the following types of agricultural livelihoods are characterized.

Livelihood type 1: *Relatively young household heads, small household size, land rich, but distant from livestock markets*. 11 households (12% of sample) belong to this livelihood type. Household heads are relatively young with an average age of 41, which would indicate limited agricultural experience (15 years on average) that proved to be statistically significant. These households also have relatively few members (on average 4 persons in the household) and a small labor force (on average around 2-3 workers). The livelihood is disadvantaged with the

location being distant from functional livestock markets (on average 21 kilometers). Contrasting these constraints, these households are typically located close to food markets (on average 10 kilometers). The households are asset rich in land (average size is 0.4 hectares) in contrast to other livelihood types, and they are also rich in land size per household member.

Livelihood type 2: *Less educated household members, large household size, livestock rich and agricultural income dependent.* This type includes 19 households (21% of sample size). This type includes households that have relatively few members in the household that have a high level of education. Usually households have relatively more members (on average around 6-7 people), and members (on average at least one member per household) who have non-agricultural income. These households are also rich in livestock having on average > one livestock unit per member. Major share of household income comes from agriculture (on average 56%).

Livelihood type 3: *Land poor, distant from food market, but easier access to livestock market.* The major share from the sample (34 households or 37%) were assigned into this group. The mean values depict mostly average characteristics for most of the discriminating factors in contrast to other livelihood types. However, these households are land poor, owning on average 0.038 hectare. Locations of the households are relatively far from the food markets (on average 19.7 kilometers). Considering that the households are relatively closer located to the livestock market, they cannot take advantage of easier access since this livelihood type has limited numbers of livestock.

Livelihood type 4: *Relatively old household heads, educated members, and agriculture independent.* The livelihood type with 28 households (representing 30% of our sample). Heads of households are relatively old (on average 60 years old) with rich agricultural experience (on average 35 years). These households have on average relatively more members with higher education. On average more than two members in a household have non-agricultural income and the share of household income from agriculture is at the minimum level amounting on average to 5.3%.

Agriculture is not major source of income for most of the livelihood types, except for livelihood type 2 (whose income comes mainly from agriculture). Interestingly, livelihood types 1, 3 and 4 generate a major portion of their incomes from non-agricultural activities.

Analysis of livelihood type-specific behaviors regarding crop choices

Table 5 presents crop types cultivated by the livelihood types and the entire sample. The most cultivated crop type across all the livelihood types was vegetables. Seventy-five percent of households sampled cultivate vegetables, followed by fodder crops (39%) and watermelons (31%). These three cultivated crops formed the basis of further analysis. Livelihood type 1 indicates that a relatively small number of households are engaged in cultivation of agricultural crops, where fodder crops were cultivated by 36% of households and vegetables by 27% of households. Cultivation of vegetables is quite common in livelihood type 2, where almost 79% of households cultivate vegetables. Other dominant crops that were cultivated in livelihood type 2 were fodder and watermelons (42% respectively). Vegetables were also commonly cultivated in livelihood type 3, where 76.5% of households engaged in their cultivation. Fodder and watermelons are cultivated by 23.5% and 20.6%, respectively. In livelihood type 4, vegetables are cultivated by all the livelihoods. Interestingly, in livelihood type 4, which was characterized as the least dependent livelihood type on agricultural income, most of the households were engaged in the cultivation of other crops i.e. fodder, watermelons and fruit trees are cultivated by 53.6%, 43% and 39% of households, respectively.

Table 5 - Summary statistics on crop cultivation by livelihood types

Crops	Livelihood type 1: Relatively young, small, land-rich and distant from livestock market (11 households)		Livelihood type 2: Less educated, big, livestock rich, agriculture dependant, (19 households)		Livelihood type 3: Closer to livestock market, land poor, food market distant (34 households)		Livelihood type 4: Relatively old, educated, agriculture independent (28 households)		Total sample (100)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Cotton	0.0%	0	5.3%	0.23	2.9%	0.17	0.0%	0	2.0%	0.14
Wheat	0.0%	0	5.3%	0.23	2.9%	0.17	0.0%	0	2.0%	0.14
Rice	0.0%	0	0.0%	0.00	0.0%	0.00	0.0%	0	0.0%	0.00
Beans	0.0%	0	26.3%	0.45	0.0%	0.00	10.7%	0.31	9.0%	0.29
Vegetables	**27.3%**	0.47	**78.9%**	0.42	**76.5%**	0.43	**100.0%**	0	**75.0%**	0.44
Watermelons	9.1%	0.30	**42.1%**	0.51	**20.6%**	0.41	**42.9%**	0.50	**31.0%**	0.46
Fodder	**36.4%**	0.50	**42.1%**	0.51	**23.5%**	0.43	**53.6%**	0.51	**39.0%**	0.49
Fruittrees	0.0%	0	21.1%	0.42	11.8%	0.33	**39.3%**	0.50	20.0%	0.40

In order to identify underlying factors that influence crop choice decision of households the study runs multi-nominal regression. Considering that each household in the sample might produce more than one type of crop, this study uses only one crop type per household that was prioritized by respondents in the survey. In cases where respondents prioritize all crop types at the same level (several cases in the survey), the crop type with the largest plot size was chosen for the estimation. Moreover, considering that each livelihood type contains small number of

observations (households) and large number of explanatory variables, multi-nominal regression was undertaken for the entire sample.

Table 6 presents the regression results for entire sample and the results would suggest that the overall model is statistically significant.

Table 6 - Multi-nominal logistic regression estimation for crop choice by whole sample, using "no crop cultivation" as a base case

Variable	Vegetables			Watermelons			Fodder		
	Coef.	s.e.	z	Coef.	s.e.	z	Coef.	s.e.	z
Age of hh head	0.077*	0.044	1.770	0.106	0.077	1.390	0.046	0.048	0.960
Education ratio of hh	-0.428	2.013	-0.210	-4.973	5.371	-0.930	-2.579	2.548	-1.010
Members of hh	-0.201	0.299	-0.670	0.655	0.508	1.290	-0.094	0.323	-0.290
Labor of hh	0.243	0.309	0.790	-0.301	0.436	-0.690	-0.090	0.333	-0.270
Dependency ration of hh	-0.273	0.659	-0.410	-0.252	1.318	-0.190	-0.042	0.725	-0.060
Livestock amount in hh	0.584**	0.254	2.290	0.631**	0.266	2.380	0.685***	0.257	2.660
Total own land (ha)	-3.090	5.878	-0.530	11.575	13.818	0.840	-1.441	5.735	-0.250
Plot area (ha)	-10.044	6.586	-1.530	-9.611	14.255	-0.670	1.732	6.294	0.280
Own farm income	0.025	0.028	0.880	0.047	0.034	1.390	0.029	0.029	0.980
Can you rely on state subsidy in case of harvest lost (yes=1, no=0)	-2.373*	1.220	-1.950	-1.049	1.843	-0.570	-0.569	1.142	-0.500
constant	-1.587	2.140	-0.740	-11.104	4.969	-2.230	-2.578	2.490	-1.040
							Observations =		97
							LR chi2(30) =		78.22
							Prob > chi2 =		0.0000
							Pseudo R2 =		0.3411

Dependent variables: Crop, *** significant at 1% level, ** significant at 5% level, * significant at 10% level

Age of household's head had a positive impact on the cultivation of vegetables and it is statistically significant at 10% level of confidence. Keeping all else constant, increasing age of the household head increases the chances for vegetable cultivation. A further significant factor found is household's livestock numbers had a positive impact on choice of vegetables and statistically significant at 5% level of confidence. The higher the number of livestock in a household, ceteris paribus, the higher is the probability that the household will cultivate vegetables. Interestingly, the availability of state subsidies in case of harvest lost had a negative impact on choice of vegetables, but weakly significant at 10% level of confidence. If households rely on state subsidies in the case of harvest lost, ceteris paribus, the probability that vegetables will be cultivated declines. The impact of all other factors were found to be statistically non-significant for choice of vegetables.

With respect to choice of watermelons, only households livestock numbers had a positive influence, significant at 5% level of confidence. Other factors were found to have no statistically significant effect on choice of watermelons. Livestock number had a positive effect on choice of fodder as a crop to be grown by a household and was highly significant (1% level of confidence). Similar to watermelons no other factors in the model were found to have had a statistically significant effect on choice of fodder.

Analysis of livelihood type-specific behaviors regarding fertilizer uses

Table 7 - Summary statistics of fertilizer application by livelihood types

Fertilizer application	Livelihood type 1: Relatively young, small, land-rich and distant from livestock market (11 households)		Livelihood type 2: Less educated, big, livestock rich, agriculture dependant, (19 households)		Livelihood type 3: Closer to livestock market, land poor, food market distant (34 households)		Livelihood type 4: Relatively old, educated, agriculture independent (28 households)		Total sample (100)	
	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.
fertilizer	45.5%	0.52	89.5%	0.32	85.3%	0.36	100.0%	0	84.0%	0.37
fertilizer_mechanized	0.0%	0.00	0.0%	0.00	2.9%	0.17	3.6%	0.19	2.0%	0.14
fertilizer_manual	36.4%	0.50	42.1%	0.51	82.4%	0.39	85.7%	0.36	69.0%	0.46
fertilizer_mixed	9.1%	0.30	47.4%	0.51	0.0%	0.00	10.7%	0.31	13.0%	0.34
fertilizer_manual_men	27.3%	0.47	73.7%	0.45	79.4%	0.41	92.9%	0.26	75.0%	0.44
fertilizer_manual_women	0.0%	0.00	5.3%	0.23	0.0%	0.00	0.0%	0	1.0%	0.10
fertilizer_manual_both	18.2%	0.40	10.5%	0.32	2.9%	0.17	3.6%	0.19	6.0%	0.24
accident_prevention_during_ferti	45.5%	0.52	63.2%	0.50	79.4%	0.41	89.3%	0.31	73.0%	0.45
aware_harmful_conseq_for_woman_f	36.4%	0.50	78.9%	0.42	73.5%	0.45	67.9%	0.48	68.0%	0.47

Table 7 provides the summary statistics for fertilizer application practices by the livelihood types and entire sample. The results suggest that fertilizer application is common across most livelihood types. All households from Livelihood type 4 apply fertilizers to their plots. In Livelihood type 2 and Livelihood type 3 between 85-89% of households apply fertilizers. With respect to Livelihood type 1, only 45% of households apply fertilizers, and one of the reasons for this might be that households in this livelihood type have larger lands and, accordingly, fertilizers would be very costly and unaffordable. Mechanized application of fertilizers is not common across all the livelihood types. Fertilizers are applied predominantly manually, across Livelihood types 1, 3 and 4. In Livelihood type 2, half of the households use manual application and remaining households use mixed (mechanized and manual) application. Men are predominantly responsible for the manual application of fertilizers across all livelihood types. In 6% of households, fertilizers are manually applied by both men and women and these

households exist in each Livelihood type. Most of the households who apply fertilizers follow safety precautions during application of fertilizers, although considerable number of households are not aware of human health hazards associated with fertilizer application. Sixteen households out of 84 households who apply fertilizers are not aware of the health consequences. These households are in every Livelihood type and, interestingly, in Livelihood types 4.

From Table 9 only livestock number within a household had a positive effect on fertilizer application by a household.

Table 9 - Binary logistic regression estimation for fertilizer application

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Logistic regression                                     Number of obs   =         97
                                                        LR chi2(8)      =      30.47
                                                        Prob > chi2     =     0.0002
Log likelihood = -28.202475                             Pseudo R2       =     0.3507
```

fertilizer	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
HH_head_age	.0377751	.0431608	0.88	0.381	-.0468184	.1223686
hh_high_ed~o	.8407544	2.306143	0.36	0.715	-3.679204	5.360712
hh_members	-.1922213	.2586565	-0.74	0.457	-.6991788	.3147361
hh_labor	.3795365	.2989364	1.27	0.204	-.2063681	.9654412
hh_livestock	.7241518	.322332	2.25	0.025	.0923926	1.355911
Total_ha_own	.8201525	5.265795	0.16	0.876	-9.500615	11.14092
plot_area	-5.887325	5.902015	-1.00	0.319	-17.45506	5.680412
own_farm_i~e	.0224917	.0285249	0.79	0.430	-.0334161	.0783995
_cons	-.8457947	2.116544	-0.40	0.689	-4.994144	3.302555

Analysis of livelihood type-specific behaviors regarding soil conservation practices

Soil conservation measures were not commonly practices by households sampled (Table 10). Zero-tillage practices was undertaken by 13% of households in the entire sample. These households are from Livelihood type 3 and Livelihood type 4. Possible drivers associated with the adoption of zero-tillage practices are analyzed below.

Table 10 - Summary statistics on soil conservation practices by livelihood types

Soil Conservation Practice	Livelihood type 1: Relatively young, small, land-rich and distant from livestock market (11 households)		Livelihood type 2: Less educated, big, livestock rich, agriculture dependant, (19 households)		Livelihood type 3: Closer to livestock market, land poor, food market distant (34 households)		Livelihood type 4: Relatively old, educated, agriculture independent (28 households)		Total sample (100)	
	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.
Zero tillage application	0.0%	0	0.0%	0	20.6%	0.41	21.4%	0.42	13%	0.34
Vegetables crop rotation	27%	0.46	68%	0.47	67%	0.47	82%	0.39	64%	0.48

Fodder crop rotation	27%	0.46	47%	0.51	17%	0.38	42%	0.50	32%	0.46
Watermelons crop rotation	9%	0.3	36%	0.49	20%	0.41	39%	0.49	28%	0.45

Crop rotation are practiced mainly with respect to vegetables, fodder and watermelons. The majority (more than half) of households in Livelihood types 2, 3 and 4 practice crop rotations with respect to vegetables. In Livelihood type 1, 27% of households practice vegetables crop rotation. Fodder crop rotation is moderate across all types of Livelihoods and predominantly in Livelihood types 2 and 4. Watermelon crop rotation is least practiced in Livelihoods 1 and 3, but at the moderate level in Livelihoods 2 and 4.

Table 11 provides regression output for binary logistic regression estimation of zero-tillage. The dependent variable in the model is practice of zero-tillage. The estimated model for the entire sample proves to be statistically significant at 5% level of confidence. However, total own land size had a negative impact on the uptake of zero-tillage practices and was statistically significant at 5% level of confidence. Livestock number at a household level had a positive impact on zero-tillage and statistically significant at 10% level. Cultivation of vegetables by households had a negative effect on zero-tillage practice and was statistically significant at 10% level of confidence.

Table 11 - Binary logistic regression estimation for zero-tillage

Varaible	Sample			Livelihood type -3			Livelihood type -4		
	Coef.	s.e.	z	Coef.	s.e.	z	Coef.	s.e.	z
Age of hh head	0.011	0.034	0.320	-0.011	0.090	-0.120	-0.040	0.105	-0.390
Education ratio of hh	0.995	1.690	0.590	-0.007	2.631	0.000	-23.303	18.206	-1.280
Labor of hh	0.288	0.213	1.350	0.458	0.557	0.820	-0.139	0.512	-0.270
Total own land (ha)	-10.935**	4.937	-2.220	-11.837	14.940	-0.790	-3.922	8.499	-0.460
Livestock amount in hh	0.094*	0.056	1.690	0.335	0.225	1.490	0.706	0.502	1.400
Vegetables (dummy)	-1.258*	0.740	-1.700	-2.189*	1.276	-1.710	-0.183	1.869	-0.100
constant	-2.698	1.804	-1.500	-1.867	4.225	-0.440	0.709	7.198	0.100
	Observations =		97	Observations =		34	Observations =		28
	LR chi2(30) =		16.52	LR chi2(30) =		13.83	LR chi2(30) =		12.69
	Prob > chi2 =		0.011	Prob > chi2 =		0.0316	Prob > chi2 =		0.048
	Pseudo R2 =		0.216	Pseudo R2 =		0.3999	Pseudo R2 =		0.436

*** significant at 1% level, ** significant at 5% level,* significant at 10% level

Running the same model Livelihood type 3 indicated that the effects of total own land size (negative) and livestock number (positive) at the household level are still the same, but no more statistically significant. This may in part be due to the limited number of observations used in the regression. However, the effect size of cultivation of vegetables increases and is still weakly significant at 10%. Finally, with respect to Livelihood type 4, the results indicate that none of the factors had a statistically significant impact on zero-tillage practice.

From Table 12, results show that age of household's head had a positive effect on practice of vegetables crop rotation and was statistically significant at 5% level. Table 13 would suggest that total land size had a positive effect on fodder crop rotation practice and was statistically significant at 10% level of confidence. Livestock number had a positive effect and is significant at the 1% level.

As in the case of fodder crop rotation, livestock has statistically strong positive effect on watermelons crop rotation practice.

Table 12 - Binary logistic regression estimation for vegetables crop rotation

Logistic regression — Number of obs = 97; LR chi2(6) = 10.86; Prob > chi2 = 0.0928; Log likelihood = -57.997829; Pseudo R2 = 0.0856

vegetable~on	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
HH_head_age	.0471511	.0240819	1.96	0.050	-.0000484	.0943507
hh_high_ed~o	1.572641	1.341144	1.17	0.241	-1.055953	4.201235
hh_labor	.1641302	.1699597	0.97	0.334	-.1689848	.4972451
Total_ha_own	-1.926203	1.56014	-1.23	0.217	-4.984021	1.131615
hh_livestock	.007453	.0466855	0.16	0.873	-.0840489	.0989549
hh_depende~o	.1437519	.4000995	0.36	0.719	-.6404287	.9279324
_cons	-2.325679	1.352914	-1.72	0.086	-4.977341	.3259826

Table 13 - Binary logistic regression estimation for fodder crop rotation

Logistic regression — Number of obs = 97; LR chi2(6) = 18.67; Prob > chi2 = 0.0048; Log likelihood = -50.662485; Pseudo R2 = 0.1556

fodder_cro~n	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
HH_head_age	-.0043524	.024953	-0.17	0.862	-.0532595	.0445546
hh_high_ed~o	-.3463069	1.383084	-0.25	0.802	-3.057102	2.364488
hh_labor	-.192995	.1903603	-1.01	0.311	-.5660943	.1801043
Total_ha_own	2.863758	1.675609	1.71	0.087	-.4203742	6.147891
hh_livestock	.1988395	.0592241	3.36	0.001	.0827624	.3149166
hh_depende~o	-.694297	.4659317	-1.49	0.136	-1.607506	.2189123
_cons	-.6668654	1.438901	-0.46	0.643	-3.48706	2.153329

Table 14 - Binary logistic regression estimation for watermelons crop rotation

Logistic regression — Number of obs = 97; LR chi2(6) = 20.08; Prob > chi2 = 0.0027; Log likelihood = -46.34465; Pseudo R2 = 0.1781

watermelon~n	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
HH_head_age	.0392564	.0250949	1.56	0.118	-.0099286	.0884415
hh_high_ed~o	.7534686	1.34679	0.56	0.576	-1.886191	3.393128
hh_labor	-.0113014	.1888715	-0.06	0.952	-.3814826	.3588799
Total_ha_own	-1.481492	2.29489	-0.65	0.519	-5.979393	3.016409
hh_livestock	.1737486	.0547727	3.17	0.002	.066396	.2811011
hh_depende~o	-.3706573	.4707312	-0.79	0.431	-1.293273	.5519588
_cons	-3.473702	1.492082	-2.33	0.020	-6.398129	-.549276

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Table 15 - Summary table of findings

	Livelihood type 1	Livelihood type 2	Livelihood type 3	Livelihood type 4
Characteristics	Relatively young household heads, small household size, land rich, and distant from livestock markets. 11 households (12%)	Fewer educated household members, large household size, livestock rich and agricultural income dependent. 19 households (21%)	Land poor, distant from food market, but easier access to livestock market. 34 households (37%)	Relatively old household heads, more educated members, and agriculture independent. 28 households (30%)
Crop cultivation (Share in group involved in cultivation)	Relatively small amount of households are engaged in cultivation of agricultural crops, where fodder crops are cultivated only by 36% of households and vegetables by 27% of households	Cultivation of vegetables is quite common. Other crops that are cultivated by 42% of households are fodder and watermelons	Vegetables also commonly cultivated. Fodder and watermelons are cultivated by 23.5% and 20.6%, respectively.	Vegetables are cultivated by all the livelihoods. Most of the households are engaged in cultivation of other crops, i.e. fodder, watermelons and fruit trees are cultivated by 53.6%, 43% and 39% of households, respectively.
Factors found to influence the choice of vegetables	*Estimations could not be undertaken per each livelihood type due to small size of observations and, hence, degrees of freedom. The study estimates the model for the entire sample:* Age of household's head has positive impact on cultivation of vegetables and it is statistically significant at 10% level. Keeping all else constant, increasing age of hh head increases chances for choosing vegetables to cultivate. Another significant factor found is household's livestock number, has a positive impact on choice of vegetables and statistically significant at 5%. The higher the number of livestock in a household, ceteris paribus, the higher is the chance for cultivating vegetables. Availability of state subsidy in case of harvest lost has a negative impact on choice of vegetables, but weakly significant at the 10% level. If household can rely on state subsidy in case of harvest lost, ceteris paribus, the potential for cultivating vegetables deceases.			
Factors found to influence on choice of watermelons	Only households livestock numbers had a positive influence. Other factors, were found to have no significant effect on choice of watermelons			
Factors found to influence on choice of fodder crops	Livestock number had a positive effect on choice of fodder with a highly significant (p=0.01). Similar to watermelons, no other factors in the model were found to have a significant effect on choice of fodder.			
Fertilizer application	Only 45% of households apply fertilizers	Approximately 89% households apply fertilizers	Approximately 85% households apply fertilizers	All households apply fertilizers
Factors affecting on fertilizer application	Only livestock number of a household has a positive significant effect on fertilizer application			
Zero-tillage	Don't practice	Don't practice	20.6% of households	21% of households
Factors affecting on zero-tillage practice	Total own land size had a negative effect (stat. sig. at 5%), household livestock numbers had a positive impact (stat. sig. at 10%); cultivation of vegetables by households had a negative effect on the adoption of zero-tillage.			
	-	-	Cultivation of vegetables by households has its negative effect (stat. sig. at 10%)	

Factors affecting Vegetables crop rotation	Household's head had a positive significant effect on practice of vegetables crop rotation
Factors affecting on Fodder crop rotation	Total land size had a positive effect and statistically significant at 10% level. Livestock numbers had a highly significant positive effect on fodder rotation
Factors affecting on Watermelons crop rotation	Livestock had a significant positive effect

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