

Livelihood strategies of farmers in Bolivar, Ecuador

Assets, livelihood choice and well-
being in rural households

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Problem statement

- Bolivar province is relatively rural and households depend heavily on agricultural production
- Households face several challenges:
 - Price and income uncertainty due to unequal access to markets, overproduction and shortages during certain seasons
 - Low crop yields due to environmental conditions, use of traditional technology
 - Conditions lead to overuse of natural resources, expansion of crops to fragile areas
 - Except for migration, there are limited opportunities outside of agriculture

Problem statement

- Activity diversification is a natural response for poor households in the province
- Ability to uptake alternative activities is determined by levels of human and other assets:
 - Low levels of education
 - Unequal distribution of physical and natural assets
 - Lack of adequate infrastructure like roads, schools, irrigation, potable water
 - Slow accumulation of financial assets due to transaction costs and incomplete or missing markets
 - Lack of trust in social organizations

Objectives

- To identify successful livelihood strategies and analyze factors affecting adoption of such strategies
 - Describe and characterize the livelihood strategies realized by residents
 - Identify the determinants of adoption of alternative livelihood strategies
 - Establish the relationship between livelihood choices and household wellbeing
 - Determine household changes in well-being from policy change

Methods

- Survey data on household characteristics and assets, livelihood strategies, and well-being.
- Identify livelihood strategies using a clustering protocol and hierarchical cluster methods
- Estimate impacts of variables that affect the probability of livelihood adoption using a multinomial logit model
- Correct for selectivity bias while measuring the impact of livelihood strategy adoption on household well-being
- Use results from econometric models to examine impacts of policy change in education and irrigation on livelihood adoption and well-being

Cluster methods

➤ Cluster protocol

- Identify activities or combination of activities engaged in by the households
- Intensity that each household devotes to each activity
- Use additional variables where necessary

➤ Variables used

- Agriculture production
 - Crop production
 - Livestock production
- Agricultural wage work
 - Work in other farms
- Off farm wage work
 - Own business activities
 - Remittances
 - Rural non-farm labor market

➤ Additional variables used

- Natural and physical assets
- Own consumption share
- Percentage of farm land dedicated to crops and pasture

Hierarchical cluster method

- Used to test and corroborate the classification resulting from the cluster protocol
- The squared Euclidean distance was used to define similarities among households
 - Low Euclidean distance=more alike
 - High Euclidean distance=more unlike
- Ward's method was used as the agglomerative linkage. This method links households with the lowest increase in the error sum of squares

Standardization formula

$$Z_{ij} = \frac{x_{ij} - \mu_i}{\sigma_i}$$

Error sum of squares

$$\sum e^2 = \sum_{j=1}^n (z_{ij} - \mu_i)^2$$

Multinomial logit model

➤ Allows us to

- Identify which variables affect household decisions to adopt different livelihoods
- Estimate the relative probability of selecting a particular livelihood strategy
- Determine the marginal effect of one unit change in households characteristics on the relative odds ratio

➤ Assumptions

- Error terms assumed to be logistically distributed
- Livelihood strategies do not have specific order; no implicit ranking
- Livelihood strategies are unique and mutually exclusive

Livelihood adoption and well-being

Consider the following model of household well-being: $\ln y_{ik} = \Omega \beta_k + u_i$

The essential problem is we do not observe y_{ik} for strategies (out of a universe of M such strategies) that household i does not adopt

Define y_k^* to be a latent variable for unobserved income in the k^{th} strategy and express

$$y_k^* = \xi \lambda_k + \eta_k$$

Livelihood adoption and household well-being

Outcome K is chosen if $y_k^* > \max (y_j^*)$ for $j \neq k$

Define $\varepsilon_k = \max(y_j^* - y_k^*)$ for $j \neq k$

Then $\varepsilon_k = \max(\xi\lambda_j + \eta_j - \xi\lambda_k - \eta_k)$ which leads to a multinomial logit specification of the determinants of livelihood adoption (under assumptions laid out above)

Because livelihood choice and well-being outcomes are jointly determined we need to account for selection into the livelihood choice. Standard method in a binary case is to use Heckman's correction

Livelihood adoption and well-being

Define $\Gamma = \{\xi\lambda_1, \xi\lambda_2, \dots, \xi\lambda_M\}$

Then, following Bourguignon, Fournier and Gurgand (2005), the selectivity correction can be based on:

$$E(u_i | \varepsilon_i < 0, \Gamma) = \int \int_{-\infty}^0 \frac{u_i f(u_i, \varepsilon_i | \Gamma)}{P(\varepsilon_i < 0 | \Gamma)} d\varepsilon_i du_i = \lambda(\Gamma)$$

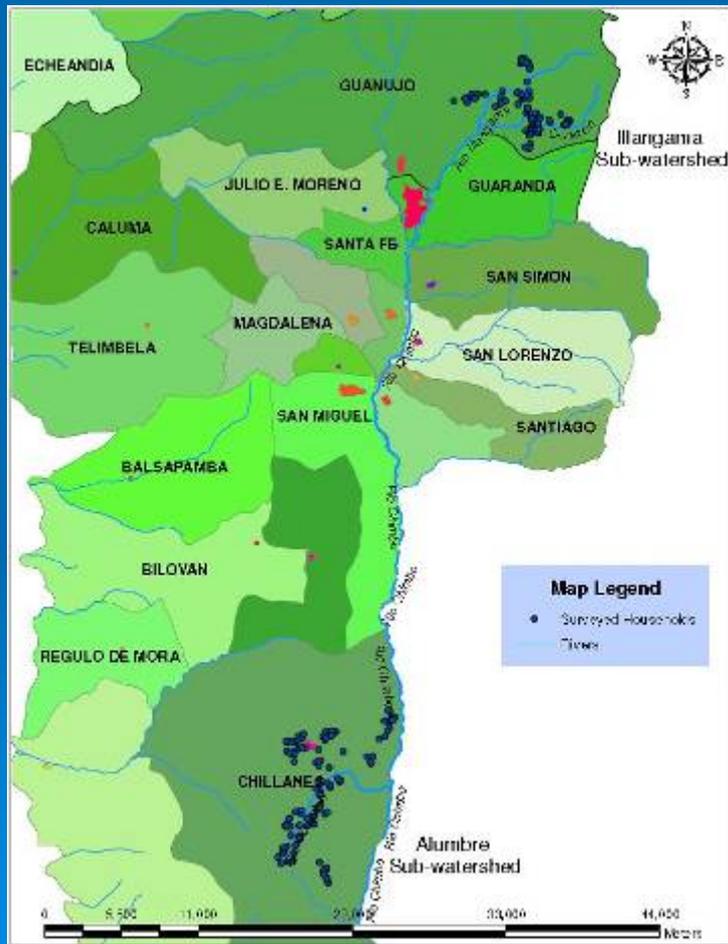
Consistent estimation of B can be based on:

$$\begin{aligned} \ln y_{ik} &= \Omega\beta_k + \tau(P_1, P_2, \dots, P_M) + w_i \\ &= \Omega\beta_k + \lambda(\Gamma) + w_i \end{aligned}$$

Selection bias correction model

We use a variant of the original Dubin-McFadden correction to ensure unbiased estimators

Data collection



- Household survey was designed by INIAP and Virginia Tech scientists to gather information about households and their livelihoods
- During September and November, 2006 the surveys were undertaken by INIAP technicians and undergraduate students from Bolivar University (UEB)
- The data set contains information from around 1,500 persons from 286 households

Summary statistics

Human assets	Alumbre	Illangama	t-test or pr-test
Indigenous households %	35	100	0.00
Household members	4.70	5.75	0.00
Dependency ratio %	29	44	0.00
Household head female %	17	13	0.32
Household head age (yr)	55	43	0.00
Household highest level of education (yr)	12.51	12.08	0.60
No education %	3	2	0.50
Primary education %	36	36	0.97
Secondary education %	53	57	0.44
Secondary education+%	8	5	0.30
Household average education females (yr)	7.95	6.57	0.04
Household average education males (yr)	8.48	9.04	0.45

Financial, public and social assets	Alumbre	Illangama	t-test or pr-test
Credit %	5	6	0.64
Distance to closest paved road (km)	0.63	4.77	0.00
Distance to closest river (km)	1.72	0.62	0.00
Distance to closest town (km)	2.57	1.51	0.00
Distance to closest city (km)	4.16	9.49	0.00
Participation in civil societies %	23	85	0.00
Family members that migrate %	40	53	0.03

Background information

Income	Alumbre	Illangama	t-test or pr-test
Crop agriculture %	100	100	.
Average income \$	1262	2077	0.00
Livestock %	41	85	0.00
Average income \$	368	545	0.00
Own business %	20	21	0.80
Average income \$	1299	1229	0.85
Agriculture wage %	51	16	0.00
Average income \$	508	522	0.87
Off farm wage %	40	51	0.07
Average income \$	1425	957	0.09
Member migrates?	24	8	0.00
Average income \$	994	563	0.02
Social help %	4	14	0.00
Average income \$	180	180	.

Expenditures	Alumbre	Illangama	t-test or pr-test
Total Average Expenditures \$	1387	2297	0.00
Expenditures per capita \$	295	399	0.00
Ratio of food expenditure-income	0.17	0.16	0.65
Ratio of expenditures-income	0.72	0.73	0.81

Variables: multinomial logit model

Variables	Description
Livelihoods (dependent var.)	Livelihood strategy chosen
Farm surface	Total farm size in hectares
Irrigation	Whether or not the farm has irrigation access
Physical assets	Total estimated value in dollars of productive tools, small livestock and cattle
Education	Whether or not the individual in the household with highest level of education attained secondary education
Soil productivity	Measure of soil quality (GIS)
Age and square age	Household head age
Household size	Number of members that are part of the household
Dependency ratio	Percentage of members below 18 years old and above 71 years old
Watershed	Whether or not the households are located in the Alumbre sub-watershed
Altitude	Altitude location of the household in kilometers
Distance to rivers	Distance to the closest river in kilometers (GIS)
Distance to towns	Distance to the closest town where usually are located the closest school (GIS)
Distance to cities	Distance to the closest main city where usually are located the markets (GIS)

Findings: Livelihood clusters

➤ Four livelihood strategies were identified:

- Diversified households
- Engaged in agricultural markets
- Rural non-farm economy
- Agricultural consumption and wage work

Livelihoods	%	Households	Members
Diversified households	27	78	432
Engaged in agricultural markets	37	105	576
Rural non-farm economy	17	50	218
Agricultural consumption and wage work	19	53	241
Total	100	286	1467

Diversified households

- Almost one third of the households in the Chimbo watershed adopt this strategy
- Households in this livelihood do not receive more than 70% of their income from any single activity, and mainly get income from agriculture and off farm activities
- The total farm land is almost equally distributed between pastures and crops
- Highest participation in civil organizations and family members that migrate
- Most are indigenous
- Relatively high levels of expenditures per capita

Variables	Value
Agriculture income share %	0.45
Agriculture wage share %	0.02
Off farm income share %	0.53
Own surface with title %	0.84
Alumbre watershed %	0.46
Land area	3.82
Irrigation access %	0.23
Value physical assets \$	2008
Credit access %	0.08
Distance to closest river (km)	1.12
Distance to closest city (km)	7.21
Participation in civil organizations %	0.60
Family members that migrate %	0.71
Mestizo households %	0.31
Household head male %	0.88
Secondary education or plus %	0.65
Expenditures per capita \$	325
Ratio of food expenditures-income	0.17

Engaged in agricultural markets

Variables	Value
Agriculture income share	0.87
Agriculture wage share	0.03
Off farm income share	0.10
Own surface with title %	0.87
Alumbre watershed %	0.37
Land size (ha)	6.79
Irrigation access %	0.33
Value physical assets \$	2348
Credit access %	0.03
Distance to closest river (km)	0.86
Distance to closest city (km)	7.58
Participation in civil organizations %	0.55
Family members that migrate %	0.39
Mestizo households %	0.25
Household head male %	0.90
Secondary education or more %	0.65
Expenditures per capita \$	432
Ratio of food expenditures-income	0.14

- This is the most common livelihood
- Households in this livelihood get around 90 percent of income from agricultural production
- Dedicate relatively high percentage of land to commercial crops (roots and a mixture of grains and legumes)
- This group of farmers owns the most land, physical assets, and one third of the farms have irrigation access.
- Intensively use pesticides and fertilizer for production and has the highest percentage of producers that have received technical training
- More than half belong to a social organization and almost all the household heads are males
- Highest level of income and expenditure

Rural non-farm economy (Livelihood C)

- Fewest households in this cluster
- Receive almost 80 percent of income from activities not related to their own farms
- Almost all the households within this livelihood are from Alumbre and are near the main city
- Own smallest amounts of natural and physical assets, and one quarter of the total land is untitled
- Just one third of the producers participate in social organizations; highest percentage of mestizos households
- This group has lowest expenditures and income

Variables	Value
Agriculture income share %	0.12
Agriculture wage share %	0.14
Off farm income share %	0.74
Own surface with title %	0.77
Watershed Alumbre %	0.98
Land size (ha)	3.59
Irrigation access %	0.06
Value physical assets \$	856
Credit access %	0.12
Distance to closest river (km)	2.05
Distance to closest city (km)	3.61
Participation in civil organizations %	0.26
Family members that migrate %	0.54
Mestizo households %	0.64
Household head male %	0.82
Secondary education or more %	0.66
Expenditures per capita \$	280
Ratio of food expenditures-income	0.17

Agricultural consumption and wage work

Variable	Value
Agriculture income share %	0.39
Agriculture wage share %	0.57
Off farm income share %	0.05
Own surface with title %	0.77
Alumbre watershed %	0.85
Land size (ha)	1.64
Irrigation access %	0.09
Value physical assets \$	496
Credit access %	0.00
Distance to closest river (km)	1.58
Distance to closest city (km)	5.17
Participation in civil organizations %	0.38
Family members that migrate %	0.13
Mestizo households %	0.53
Household head male %	0.72
Secondary education or more %	0.45
Expenditures per capita \$	219
Ratio of food expenditures-income	0.22

- Relatively small landholdings
- Two thirds of income is derived from agricultural wage and one third from agriculture
- Income and expenditures per capita are, on average, less than one dollar per day
- Almost all the producers in this livelihood are from Alumbre and own smaller amounts of land and the lowest amount of physical assets
- Around half of the households are indigenous and have the higher percentage of female household heads
- This group has the least education and fewest family members who migrate

Livelihood Strategies Choice



- The multinomial logit model shows the sign and strength of impacts of variables on the odds of choosing a livelihood strategy
- Model was run with and without geographic variables that influence the decision of the households
- These geographic variables are used as instrument variables for the selection model; they do not determine wellbeing except through their impact on livelihood choice
- The comparison group in the multinomial logit model are households engaged in agriculture markets

Diversified households

vs.

Engaged in agricultural markets

- Higher amounts of natural assets like farm surface and irrigation access decrease the probability of diversifying
- Soil productivity positively associated with income diversification
- Households that farther from rivers and the main cities will be more likely to engage in diverse activities
- Education negatively associated with diversification
- Location is a key determinant of livelihood strategy adoption

Variables	Coefficients	P> z
Alumbre watershed	-1.903	0.22
Altitude	-0.341	0.02
Farm surface	-0.097	0.01
Irrigation access	-0.590	0.07
Soil productivity	0.724	0.03
Physical assets	0.012	0.13
Age	-0.152	0.03
Square age	0.001	0.06
Household size	0.083	0.06
Dependency ratio	-0.015	0.85
Education	-0.164	0.06
Distance to river	0.447	0.06
Distance to town	-0.083	0.69
Distance to city	0.153	0.09
Constant	12.703	0.01

Rural non-farm economy

vs.

Engaged in agricultural markets

Variable	Coefficients	P> z
Alumbre watershed	2.931	0.30
Altitude	-0.158	0.53
Farm surface	-0.155	0.05
Irrigation access	-0.932	0.17
Soil productivity	0.039	0.93
Physical assets	0.014	0.04
Age	-0.094	0.37
Square age	0.001	0.33
Household size	-0.071	0.63
Dependency ratio	0.106	0.07
Education	0.416	0.37
Distance to river	0.552	0.02
Distance to town	-0.048	0.12
Distance to city	0.027	0.77
Constant	2.797	0.75

- Farm area and value of physical assets are important determinants of engagement in non-farm rural economy
- Distance to water sources positively associated with non-farm economy (relative to agricultural markets)
- In this particular livelihood increasing the natural assets will reduce the probability to engage in non-farm activities, while increasing physical assets has a positive impact although these variables do not have statistic significance

Agriculture consumption and wage work

vs.

Engaged in agricultural markets

- Higher amounts of physical assets and farm surface reduce the likelihood of being engaged in agriculture wage work relative to agricultural markets
- More dependency associated with this livelihood strategy
- Education also negatively associated with wage work and self-consumption orientation

Variables	Coefficients	P> z
Alumbre watershed	0.764	0.72
Altitude	-0.124	0.12
Farm surface	-0.067	0.08
Irrigation access	-0.332	0.11
Soil productivity	-0.263	0.09
Physical assets	-0.122	0.00
Age	-0.073	0.44
Square age	0.001	0.54
Household size	-0.015	0.89
Dependency ratio	0.073	0.03
Education	-0.697	0.10
Distance to river	0.280	0.25
Distance to town	-0.070	0.77
Distance to city	0.128	0.14
Constant	5.026	0.44

Livelihood strategy selection

- Variables like natural and physical assets generally had the expected positive effect on the probability of engaging in agricultural activities while reducing the probability of engaging in non-farm activities
- In general increasing education will increase engagement in livelihoods not related to agricultural production or agricultural wage work
- Location-specific assets were generally significant determinants of livelihood adoption



Livelihood strategies and wellbeing



- In order to estimate the relationship between livelihood choice and household well-being we used the Dubin-McFadden correction for selection based on the multinomial logit results
- This model enables us to measure the counterfactual: what would have been the level of well-being had the household adopted an alternative livelihood strategy?

Household well-being: Diversified households

- Once livelihood choice is controlled for, several assets still are important determinants of household well-being
- Access to land is most important; as is access to financial and physical assets
- Household size negatively associated with well-being

Variable	Coef.	P> t
Alumbre watershed	-0.087	0.79
Ln farm surface	0.158	0.02
Irrigation	0.103	0.14
Productive soil	-0.003	0.98
Ln physical assets	0.042	0.16
Credit	0.315	0.07
Female household head	-0.315	0.04
Age	-0.003	0.90
Square age	0.000	0.89
Ln household size	-0.277	0.07
Dependency ratio	-0.189	0.52
Education	0.003	0.18
Correction coefficient 1	-0.185	0.33
Correction coefficient 2	-0.590	0.33
Correction coefficient 3	-0.465	0.49
Correction coefficient 4	1.308	0.01

Household well-being: Engaged in agricultural markets

- Access to land, physical assets, financial assets all important
- Human assets important, especially access to labor. Education has positive effect on HH well-being, but not statistically significant

Ln wellbeing from Livelihood B	Coef.	P> t
Alumbre watershed	-0.609	0.01
Ln farm surface	0.298	0.00
Irrigation	0.105	0.21
Productive soil	0.052	0.59
Ln physical assets	0.064	0.09
Credit	0.434	0.07
Female household head	0.236	0.07
Age	0.028	0.14
Square age	0.000	0.09
Ln household size	0.419	0.01
Dependency ratio	-0.439	0.12
Education	0.075	0.14
Correction coefficient 1	-0.640	0.25
Correction coefficient 2	-0.221	0.31
Correction coefficient 3	-0.680	0.21
Correction coefficient 4	0.659	0.18

Household well-being: Rural non-farm economy

Variable	Coef.	P> t
Alumbre watershed	0.370	0.54
Ln farm surface	0.193	0.00
Irrigation	-0.411	0.10
Productive soil	-0.245	0.03
Ln physical assets	-0.060	0.05
Credit	0.271	0.11
Female household head	0.014	0.91
Age	0.035	0.13
Square age	0.000	0.19
Ln household size	-0.023	0.88
Dependency ratio	0.424	0.20
Education	0.042	0.08
Correction coefficient 1	-1.805	0.02
Correction coefficient 2	-0.508	0.36
Correction coefficient 3	0.209	0.08
Correction coefficient 4	1.171	0.06

Household well-being: Agriculture consumption and wage work

- Returns to assets are minimal (mostly statistically insignificant) in this livelihood
- Strong evidence of selection bias

Variable	Coef.	P> t
Alumbre watershed	-0.463	0.15
Ln farm surface	0.064	0.35
Irrigation	0.191	0.26
Productive soil	0.002	0.99
Ln physical assets	-0.019	0.55
Female household head	0.092	0.34
Age	0.045	0.09
Square age	0.000	0.08
Ln household size	0.103	0.51
Dependency ratio	0.439	0.12
Education	0.065	0.63
Correction coefficient 1	-2.372	0.00
Correction coefficient 2	-2.085	0.01
Correction coefficient 3	-1.545	0.03
Correction coefficient 4	-0.452	0.01

Estimated wellbeing for households engaged in agricultural markets

- Provide information about relative returns, conditioned on household asset base, of moving into alternative livelihood strategies
- Also examining changes in policy: how changes affect livelihood adoption and well-being

Households within livelihood B

Variable	Mean	Std. Dev.	Min	Max
Wellbeing	2369.86	1645.70	441.00	12625.00
Estimated welfare if households belong to				
Livelihood A	1965.37	705.43	630.15	3945.69
Livelihood B	2209.63	1036.43	540.80	7129.07
Livelihood C	1860.32	1347.36	745.62	8489.87
Livelihood D	831.82	467.25	14.62	1827.74

Next steps

- Use geo-referencing to link current situation to erosion, water quality, etc.
 - Incorporate household model results into watershed modeling
 - Simulate policy change:
 - $\Delta\text{policy} \rightarrow \Delta\text{livelihoods} \rightarrow \Delta\text{well-being}$
 - $\Delta\text{policy} \rightarrow \Delta\text{livelihoods} \rightarrow \Delta\text{environmental quality}$
- Use stakeholder assessments to uncover reasons behind some of the anomalies

Thank you

