Spatial Analysis of ‘Food Poverty’ in Ecuador

A. Farrow, C. Perea, E. Barona, G. Hyman, G. Lema, C. Larrea

POVERTY MAPPING
GEOGRAPHY OF POVERTY
GEOGRAFÍA DE LA POBREZA
GÉOGRAPHIE DE LA PAUVRETÉ

ECUADOR

Abstract

Almost one fifth of Ecuador’s inhabitants are undernourished [1] and over a quarter of children under 5 years of age are affected by chronic under nutrition [2] . This situation is deteriorating. Ecuador has been ‘dollarised’, privatised and decentralised, and due to *El Niño* related floods and the economic crises of the past five years poverty has increased by 50% and now afflicts three-quarters of Ecuador’s population [3],[4] .

In this study we identify the lack of access to food within Ecuador and search for linkages between ‘food poverty’ and the spatial dimensions of the wider socio-economic and biophysical environment. We add value to existing studies by analysing explicitly the role of environment, access, distance and spatial structure in poverty and food security.

We aim to assist a variety of institutions in targeting both their resources and their research, particularly the capacity of the Ecuadorian government to design policy or development interventions necessary to improve food security.

Data

Food Poverty Data

We have estimated food consumption per person per fortnight for all households in the 1990 and 2001 population censuses. We constructed an explanatory model of food consumption per person using household characteristics extracted from living standards measurement surveys (LSMS) of 1995 and 1998 [5],[6] . We deem households ‘food poor’ when their food consumption is insufficient to satisfy their nutritional requirements. We aggregated the households for each *parroquia* (district) and produced summary variables (and standard errors) that describe the distribution of food consumption. These variables include mean food consumption per person and the proportion of ‘food poor’ in the population of the *parroquia* – commonly known as the headcount ratio.

Biophysical and Socio-economic data

Table 1 shows the source of the biophysical and socioeconomic data used in this study:

Source Name	Institution	Dataset
INFOPLAN	ODEPLAN	Actual land use Potential land use Poverty (total consumption) Population density
Sistema de monitoreo socio ambiental	EcoCiencia	Populated places
Censo agropecuario 2000	INEC	Actual land use Irrigated land Land tenure
WorldClim	UC Berkeley	Precipitation
Almanaque Electrónico del Ecuador	Alianza Jatun Sacha – CDC / DINAREN	Administrative divisions 1998 Navigable Rivers Transport infrastructure
DINAREN	DINAREN	Administrative divisions 2001
SRTM	NASA/USGS	Elevation Slope
El Niño Impact Study	ISS	Cantons affected by 1997-98 El Niño
Modelled data	CIAT	Accessibility to Local and Provincial markets Consecutive Dry months Land Use Conflict
Local Case Studies	CIAT/Universidad Técnica de Manabí	Manabí El Niño household survey

Spatial Analysis of ‘Food Poverty’

Spatial structure of food consumption in Ecuador is not random

We use the area centroids of each *parroquia* in continental Ecuador[7] to create semi-variograms to explore the spatial variation of food consumption.

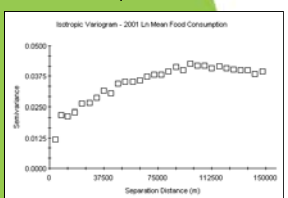

Figure 1. Semi-variogram of (ln) mean food consumption for 2001 using intervals of 5km up to a maximum of 600 km. This variable shows spatial dependence up to 120 km and the intercept of the variogram (nugget variance) indicates that about one third of the variation is not accounted for between parroquias. This pattern of spatial dependence is similar for the ‘food poverty’ headcount ratio and for data from 1990.

UNEP

CIAT

Contact and Acknowledgements

Andrew Farrow
Land Use Project
Centro Internacional de Agricultura Tropical (CIAT)
Tel. + 57 2 445 0000 ext. 3493
Fax + 57 2 445 0073
E-mail: a.farrow@cgiar.org
http://www.ecuamapalimentaria.info

The authors would like to acknowledge:

The Government of Norway for funding this study, DINAREN, ODEPLAN, Alianza Jatun Sacha – CDC, NASA/USGS, INEC, World Bank, Lautraro Andrade (REDPESA), Malki Saenz (EcoCiencia), Marcelo Moreano and Carmen Galarza (World Food Programme – Ecuador), Fernando Carvajal (FAO – Ecuador), Hernán Caballero (UTM - Portoviejo), Veronica Proaño (IIRR – Ecuador), Andy Nelson (Univesity of Leeds)

‘Food Poverty’ hotspots

Food consumption in Ecuador is non-random and displays spatial patterns or ‘hot spots’ of worse then average values of the ‘food poverty’ headcount ratio. In an analogy with disease mapping we use the Geographical Analysis Machine (GAM) [8] to find clusters of *parroquias* where the food poverty headcount ratio is significantly different from the expected (global) incidence at multiple scales (Figure 2).

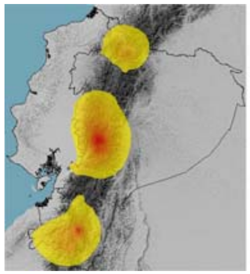

Figure 2a. ‘Food Poverty’ clusters -1990

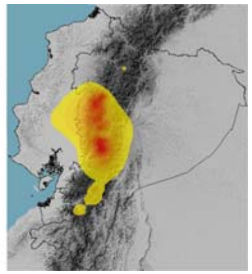

Figure 2b. ‘Food Poverty’ clusters - 2001

Changes in ‘Food Poverty’: 1990-2001

Comparison between 1990 and 2001 data shows that the number and location of food poverty ‘hot spots’ have both changed (Figure 2). The spatial pattern of change shows clearly that the proportion of food poor has deteriorated mainly in the coastal provinces, and most dramatically in the north-western province of Esmeraldas (Figure 3) These areas were seriously affected by heavy rains during the 1997-98 El Niño event (Figure 4). The results of a χ^2 test of association between *parroquias* that have deteriorated and those that suffered losses due to El Niño show the association is highly significant and support our hypothesis that deterioration in food poverty is associated with the effects of El Niño.

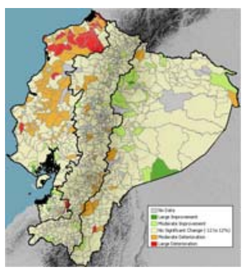

Figure 3. Changes in ‘Food Poverty’ headcount ratio between 1990 and 2001

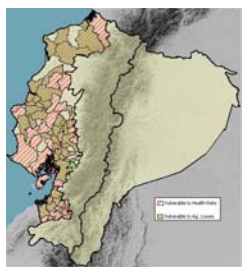

Figure 4. Areas vulnerable to agricultural losses and increased health risks [9]

Determinants of ‘Food Poverty’

We produced a national level linear stepwise regression model which produced poor results with low adjusted r^2 values. To improve the predictive power of the model we split the data to represent three biophysical and cultural regions: costa, sierra and oriente.

Our dependent variables are estimations rather than observations. We have therefore run simulations of the regression models randomly adding or subtracting a percentage of the standard error to the dependent variable (Table 2).

Region: Costa Dependent variable: 2001 ‘Food Poverty’ Headcount Ratio (conservative)					
N = 76	Without Error Simulation	With Error Simulation			
		Min	Mean (1)	Mean (2)	Max
Adjusted R^2	**0.7709**	**0.6534**	**0.7458**	**0.7492**	**0.8155**

Variable	Description	Significance of variable pr > | t |				
		Without Error Simulation	With Error Simulation			
			Min	Mean (1)	Mean (2)	Max
DEN_2001	Population density of parroquia (persons/km2)	**	**	**	**	**
PR_RIE1	Proportion of Productive Units Irrigated	**		*	*	**
MN_A_P_R	Mean Accessibility to Provincial Capitals adjusted by Proportion of Population in Rural Areas (min)					**
TASA_8290	Population growth rate per parroquia 1982 – 1990	**		*	*	**
MN_DRY	Mean number of consecutive months with < 60mm precipitation	**	·	**	**	**
MN_P_CR	Mean proportion of parroquia suitable without limitations for arable crops	·				**
PR_IND2	Proportion of productive land individually owned					**
MN_STIT	Mean size of farms without legal title	**		·	*	**

** significant at 99%, * significant at 95%, · significant at 90%

We have observed that national values of correlation mask the spatial structure of food poverty. Figures 5-7 show the spatial variation of correlation [10] between access to markets and the 2001 Food Poverty headcount ratio.

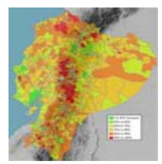

Figure 5. ‘Food Poverty’ headcount ratio - 2001

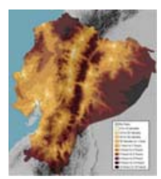

Figure 6 Accessibility to Provincial Capitals [11]

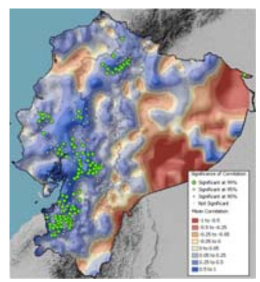

Figure 7. Interpolated surface of mean cross-scale variations in correlation. Significance of correlation using moving window of size 100 km

Geographically Weighted Regression [12]

Instead of 8 independent variables (as in Table 2) we have included all 12 that entered the models for the costa and sierra regions. The adjusted R^2 for the global model is 0.44, this improves to 0.61 when we use geographical weights.

Figures 8 - 9 show the spatial variation in the regression coefficients. The maps show in green those areas where the variable has greater power of determination than in the global regression. Areas in blue are where the variable has less power of determination and areas in red show where the variable has an inverse power of determination.

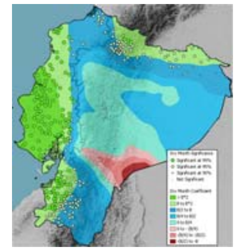

Figure 8. Interpolated surface of the partial regression coefficient and significance of consecutive dry months when predicting the 2001 headcount ratio

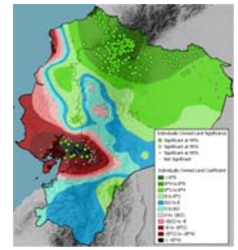

Figure 9. Interpolated surface of the partial regression coefficient and significance of the proportion of land owned by individuals when predicting the 2001 headcount ratio

Dissemination

A web-site http://www.ecuamapalimentaria.info has been created in collaboration with the Ecuadorian network of food security projects (REDPESA). The web site allows users to view the data produced during this study using ESRI ArcIMS software (Figure 10). These data and complete metadata can also be downloaded from the website.

Figure 10. Website and ArcIMS Web Application with HTML Viewer

Notes and References

[1] FAO, 1999. ***Perfiles Nutricionales por Países***: Ecuador. FAO, Roma

[2] Larrea, C., Freire, W., and Lutter, C., 2001. ***Equidad desde el principio: situación nutricional de los niños ecuatorianos***. OPS – MBS, Washington, D.C.

[3] Larrea, C., Andrade, J., Brborich, W., Jarrín, D., and Reed, C., 1996. ***Geografía de la pobreza en el Ecuador***. PNUD-FLASCO, Quito, Ecuador.

[4] Larrea, C., and Sanchez, J., 2001b. ***Pobreza, Empleo y Equidad en el Ecuador: Perspectivas para el Desarrollo Humano***. UNDP.

[5] Larrea, C., 2003a. ***Metodología para la elaboración de Mapas Parroquiales sobre Consumo de Alimentos por Habitante en el Ecuador: 1990-1995***. Unpublished report, Quito, Ecuador

[6] Larrea, C., 2003b. ***Mapas Parroquiales de Consumo de Alimentos por Habitante: 2001***. Unpublished report, Quito, Ecuador.

[7] In this study we do not consider the parroquias in the Galapagos islands.

[8] Openshaw, S., 1987. ***An automated geographical analysis system***. *Environment and Planning A* 19, 431-436.

[9] Vos, R., Velasco, M. and de Labiastida, E., 1999. ***Economic and Social Effects of "El Niño" in Ecuador***. 292, Institute of Social Studies, The Hague.

[10] Nelson, A., 2004. ***gwc.exe - geographically weighted correlation***. Unpublished software. Leeds, UK

[11] Farrow, A. and Nelson, A., 2001. ***Accessibility Modelling in ArcView 3: An extension for computing travel time and market catchment information***. Software manual, http://www.ciat.cgiar.org/access/pdf/ciat_access.pdf, CIAT, Cali, Colombia

[12] Brunsdon, C., Fotheringham, A.S., and Charlton, M.E., 1996. ***Geographically Weighted Regression: A Method for Exploring Spatial Nonstationarity***. *Geographical Analysis*, 28(4), 281-298

http://povertymap.net