An attempt to integrate multiple perspectives to improve pro-poor policies

2 Contrasting and harmonizing representations

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Abstract

This paper is the second of a two parts publication that addresses the issue of bringing together different representations of poverty to improve the design of pro poor policies We examine how various poverty indicators can be represented and contrasted to improve the design and impact of poverty alleviation policies The argument is illustrated with the country case study of Honduras for which classic indicators as well as locally derived indicators of well being were obtained for various levels of aggregation from village up to country We compare at

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municipality level how a classic poverty measure which is used by Honduras policy makers compares with the one computed based on local perceptions and examine the extent of under coverage and leakage of targeted policies that would rely on either measure We show that the choice of indicator and the scale of analysis determine the perceived geography of poverty profiles which will significantly influence their interpretation and consequently the relevance of poverty alleviation programs We suggest taking advantage of inexpensive information technology that can be harnessed to bring together these different viewpoints in a user friendly transparent and adaptive manner

1 Introduction

After decades of massive investments in poverty alleviation programs it is fascinating to find how little is known about poverty measurement and how unreliable poverty estimates are It is therefore not totally surprising to see that poverty is still extremely widespread and endemic in the world It is perhaps this proportion of the population for which the green revolution or structural adjustments have had no effects -or have had negative ones that is still as poor as it was decades ago The World Bank which is a key actor in helping developing countries to reorganize and invest in their growth has followed advises of an army of very talented economists and implemented well known strategies with roots in neoclassical economic theory In recent years though the World Bank realized that poverty alleviation and development were perhaps not as successful as expected and that a new rural development strategy was needed We do not think their decision to rethink their approach to development is only a question of public relations but is the result of a genuine interest in poverty alleviation

Participatory Poverty Assessments (PPA) which were popular in the 1990 s have brought a new dimension in the picture the poor were finally asked to say something about what is poverty While past PPA efforts were generally restricted to the scale of the community recent research is addressing methodological issues of combining qualitative and quantitative poverty measurement methods (Part 1

Ravallion 2001 Ravnborg 1999 Carvalho and White 1997) Discrepancies between results of independent qualitative and quantitative approaches are to be expected (Part 1 Bergeron et al (1998) McGee 1999 Kanbur *et al* 2001) and the question is no longer to decide which is the best one but to see what each approach can bring to a better understanding of the situation and a better operational setting An elegant way to combine qualitative and quantitative indicators is to convert the formers into a utility function that is then includes in an econometric model (Van Praag 1968 Ravallion and Lokshin 2001) The combination of qualitative and quantitative approaches in an iterative process of hypothesis formulation survey design measurement representation and socialization should lead to a much better solution that each one taken separately

Two schools of thoughts are currently associated with poverty appraisal efforts (Christiaensen 2001) So called quantitative poverty assessments follow a logical positivism paradigm where there is a single external reality that can be captured by proper analysis of 'hard data and then transferred to the poor via policies and investments Qualitative poverty assessments on the other hand suppose multiple perceptions of reality and imply a commitment to empowerment which put them in the traditions of interpretivism and constructivism At the extremes of these schools of thoughts one can find on one hand a universal 1$/day poverty threshold that determine the faith of foreign aid money on the other hand an impossibility to accept objectivity which dooms poor communities to remain unique and misunderstood While part 1 of this paper tends to favor a positivist view by quantifying well being perceptions Part 2 (this paper) is more in the domain of constructivism

In Part 1 we have proposed simple ways to compute poverty indices derived from traditional expert advise as well as from PPAs Many methodological bottlenecks are avoided by using raw unit level census data instead of aggregated data At the same time having access to a gold mine of data and having the flexibility to produce poverty indices tailored to specific needs carries an unexpected side effect a feeling of anguish in front of this complexity and the multiplicity of choices (Tufte 1997 Tukey 1977 Fisher 1986) To increase the distress even more we added the spatial dimension i e poverty maps used either to communicate a message or to find spatial patterns to target our interventions

In this paper (Part 2) we present several methods to contrast or harmonize different representations of poverty (by varying indices aggregation levels and map classification choices) and illustrate the effect these representations may have on poverty alleviation policy We complete the study by outlining the functionalities of a simple user friendly interface to raw census data to allow various representations to be generated and explored freely from the World Wide Web

2 Materials and methods

1 Poverty indicators from the Honduras Population Housing and griculture censuses

In Part 1 we have introduced the Honduras unit level census and GIS databases that were used to compute and map poverty indices at various levels of aggregation

In a first step we adopted a classical approach and showed how a strict Unsatisfied Basic Needs index can be constructed from the variables found in the Population and Housing censuses This was illustrated with an index which consisted in a linear combination of three indices and was labeled UBN3 Then we added a variable related to education attainment to the UBN3 index making it more similar to UNDP Human Development Index and called it UBN4 Aggregation was done by counting the number of households in an aggregation unit having an UBN index in the poorest quintile These headcount indices (labeled PUBN3 and PUBN4) were mapped for village municipality and department by choosing a classification by quantiles of the distribution (suitable for use in a targeted allocation of funds scheme) and a double ended chromatic scale to highlight extreme values (i e poorest and richest) It was made clear that the choice of census variables the acceptable threshold (poverty line) and the weights for combining them into a single index were somehow arbitrary (i e our expert choice) and that any individual may come up with a combination that better suits his experience or needs It was also evident that PUBN3 and PUBN4 although very closely related by construction were not as highly correlated as we would have expected (see also Section 2 2) and that the maps produced showed marked dissimilarities (figure 5 of Part 1)

In a second step we introduced the results of an independent study (Ravnborg 1999) which was a PPA that was designed to enable the extrapolation of poverty indicators which were defined based on the perception that local informants have of households in their community Ravnborg (1999) found 11 indicators that were *a priori* valid for three Honduras Departments and we explained how we extracted proxies of these indicators from raw census data In this case we had to use all three censuses (9 proxies) to have a picture of poverty consistent with the PPA The resulting well being index (WBI) was averaged at village municipality and department level and was mapped using the same quantile classification and double ended chromatic scale for consistency In addition to standard choropleth mapping we introduced a new plot (the geographical starplot) where the value of the 9 proxy indicators can be assessed at once in geographical space (figure 9 of Part 1) This was an example on how mapping can be used to effectively convey multidimensional information in a snapshot

Indicators have to be obtained and summarized for as many purposes as there are decision makers In practice though aggregation often means oversimplification we go from extremely detaıled census ınformatıon to gross summary statıstıcs (e g mean ıncome by department) that dılute the underlyıng complexıty There ıs no technıcal constraınt to gıve full access to the census data to all wıth a palette of aggregatıon procedures that wıll capture complexıty whıle preservıng anonymıty (Duke-Wıllıams and Rees 1998, Dale 1998 see also sectıon 3 2) However much effort ıs stıll needed to provıde user frıendly aggregatıon and summary *methods* ınstead of the usual summary *data*

In Sectıon 2 2 we examıne how the choıce of ındıcators and aggregatıon levels can change the composıtıon of poverty profiles We gıve an example ın Sectıon 3 on one possıble use of raw ınformatıon to antıcıpate the ımpact of targeted ınvestments

2 Matchıng perceptıons and hıghlıghtıng spatıal patterns

Sınce centurıes researchers have ınvestıgated ways to lınk the dısplay of data (and ınformatıon) ın map form (and other forms) from varıous perspectıves and for varıous purposes (Monmonnıer 1996 Tufte 1983 1990 1997) In recent years some consensus about general semıology guıdelınes seems to be takıng shape (Brunet 1997 Tufte 1983 Monmonnıer 1996 Brewer and McMaster 1999) but most map users and producers wıth the exceptıon of some Census and statıstıcs bureaus) are unaware of the advances ın thıs actıve field of research Clearly today s GIS mainstream packages would benefit from introducing more clever data classification and display techniques available in some small non-commercial packages (Mazurek 2002) Dissemination of statistical government digital data in a better understandable way is also a subject of concern (Carr *et al* 2000)

In addition to customized indices and aggregations thematic maps offer a powerful opportunity for matching perceptions and representations and to stimulate dialogue We have to be aware that the most popular thematic map format i e the chloropleth carries an intrinsic bias by default (Monmonnier 1996) and comparing maps made with different biases can rapidly become nonsense Drastically visually different maps are obtained by changing the class breaks i e it is very easy to lie (let us say show a particular viewpoint) with a poverty map and the users have to be aware of the power of visual representation There is no reason to be satisfied with one pre cooked poverty map when affordable information technology is there to help experiment with several indices and several representations

A great flexibility in the selection of indices and of map categories is a blessing but can be a curse as well Without guidance an inexperienced user will be quickly overwhelmed by the innumerous possibilities to specify indicators data ranges and categories in addition it is very easy to fool an observer by classifying data in a way that will bias the interpretation (see section 2 1) The classification of continuous data (which is also an aggregation procedure) is also a delicate operation because it poses two problems giving a meaning of the classified map by choosing a classification method and the hypothesis of homogeneity of data and of spatial units within a class

Data can be classified based on rough statistical techniques (such as quantiles nested means equiprobability clinographic) and more complex ones that highlights patterns in their distribution with or without consideration about spatial contiguity (Cromley 1996 Lark 1998 Murray and Tung Kai Shyy 2000) These patterns can then be examined and contrasted to gain new insight on poverty causes or trends This flexibility is possible as long as the raw data is available which is often not the case especially with published historical data In fact the occurrence of fixed representations vastly exceeds the variable ones mainly because of the limitations of traditional presentation media Consequently we will have to cope most of the time with fixed representations such as official poverty maps and we need a way to compare them (Van Beurden and Douven 1999) We show in Section 2 2 how it is possible to classify raw data such as our <WBI> in a way that minimizes the difference with data from independent sources

For finding optimum data classification for choropleth display we have adapted a method described by Cromley (1997) which builds on pioneering work by Jenks (Jenks and Caspall 1971 Jenks 1976 Jenks 1977) The original concept is simple and elegant categories are constructed from raw data in a way that minimize a cost function with respect to user defined strategies The strategies selected by Cromley (1997) offer a wide range of possibilities to a user who wants to explore the data for their specific purposes and there is no restriction for adding other strategies Instead of the Lagrange multiplier relaxation method proposed by Cromley (1977) we used the genetic algorithm minimization procedure described by Burns (1998) Genetic algorithms are a flexible alternative that is robust to local minima they will not necessarily find the strictly optimum solution but one close to the optimum even for complex problems such as the ones requiring integer programming

The same strategy can be exploited to find a data classification that best matches another one (i e a reference) This is a new application of the technique where the goal is not to minimize a cost function inherent in the data but to minimize a cost function with respect to a reference independent map We have implemented several strategies to adjust a dataset to a reference map with T categories based on the contingency table constructed from the reference map and a map with variable class breaks In the case ordered categories (and when we expect the order to be the same - as in the case of poverty indices) the measure of similarity between both maps can be either tabular accuracy or Cohen's Kappa index of agreement (Cohen 1960) which is a tabular accuracy corrected for agreement by chance (necessary in case the size of the classes is not uniform) When we compare maps which order is unknown *a priori* we can chose the Rand index and Rand index corrected for agreement by chance (Hubert and Arabie 1985) We either minimize the total table error or the mean of errors for individual classes We can also relax the constraint on the number of classes By using a weighted index such as weighted Kappa (Cohen 1968 Næsset 1996) it is possible to account for internal variability of the map utility either because of known errors in one or several categories or to put emphasis on certain classes (e g the very poor category)

2 Results

1 Representations of Honduras poverty

In Part 1 indicators PUBN3 PUBN4 and <WBI> were mapped at various levels of aggregation using legend categories defined by quantiles of the data and a double chromatic scale The multiple dimensions leading to the WBI were also represented via geograpical starplots which is a promising way to represent data in an unbiased way (Figure 9 of Part 1)

Because geometric shapes and large masses of colors inevitably attract our eye it is tempting to start an ad hoc analysis of the regional patterns that appear on a choropleth map with a given legend and a given level of aggregation which can easily lead to invalid conclusions (Monmonnier 1996) We find in several Honduras official publications reference to a Poverty Belt which appears as a ring-like poor municipalities around Tegucigalpa (see Figure 2) Keeping in mind that PUBN4 includes an additional indicator on Education we find clusters of better off villages that are confined in a few departments Larger uniform investments in some departments such as the Francisco Morazan Department which Tegucigalpa is part of makes all surrounding areas look poorer and create the impression of a poverty belt Choropleth maps based on optimum classification strategies (which quantiles are not) are much better for the purpose of finding patterns in our data distributions (Section 1 2)

The regional picture becomes more synthetic as we aggregate at municipality and department levels but many villages that appear as poor on the village level map end up in a municipality or department that is not poor overall increasing the probability of inefficient targeting (and conflicts) as we decrease the level of detail Therefore targeting at municipal level for example will needs re targeting within the municipality (e g at village level) which is particularly true when there is a large variation of poverty profiles within a municipality (such as in the center of the country) Regional targeting is also improved by enabling better municipal-level targeting In this context an efficient representation of poverty profiles can be obtained by following the work of Carr *et al* (1998) who suggests the simultaneous display of geographical information and boxplots Figure 1 shows for each department highlighted on the micro maps on the left the distribution of village level <WBIc> for each municipality One can immediately evaluate for each department the overall <WBIc> the inequalities within each Department and Municipality and find – eventually a consistent regional pattern

The policy making world is populated mostly by people who have more experience in interpreting a table of summary statistics than a map With the pitfalls of choropleth maps and the difficulty of policy makers to truly integrate multiple dimensions (and a regional context) it is easy to understand why data tables are preferred (and perhaps it is better that it has been like that) Carr s work is a good example that both representations are not incompatible

[Figure 1 around here]

2 Issues for policy design

Indicators and Aggregation issues

We cannot emphasize enough how critical is our choice of poverty measure and the scale of analysis for planning McGee (1999) has studied the correlation between locally derived well being rankings and the classic poverty targeting by the Colombian government and concludes that the optimum for social policy delivery is probably a combination of both approaches (McGee 1999) Table 1 shows the correlation coefficients obtained between PUBN3 PUBN4 <WBI> and official data (FHIS 1992) from the Honduras Social Fund for Social Investment (FHIS its Spanish acronym) data at various aggregation levels (see also Figure 2) It gives an overview of the degree of compatibility between various representations of poverty and how this perception changes (or presist) with the level of aggregation For example a policy maker who is using Department level data can see how well this data correspond to village level data and therefore get a quick assessment of possible impacts at village level of a targeted policy that would be based on Department level data One can immediately see that correlation can be very low and that PUBN4 is more consistent across scales than the other poverty measures (which does not automatically imply that it is a better indicator)

Table 1 Correlatıon matrıx between several poverty measures at varıous aggregatıon levels Cells ın the upper rıght are shaded proportıonally to the correlatıon coeffıcıent (gıven ın the lower left) Correlatıon greater of 0 5 appear ın bold)

		Vıllage			Munıcıpalıty				Department			
		<WBI>	PUBN4	PUBN3	<WBI>	PUBN4	PUBN3	FHIS	<WBI>	PUBN4	PUBN3	FHIS
Vıllage	<WBI>	1										
	PUBN4	0 38	1									
	PUBN3	0 44	**0 84**	1								
Munıcıpalıty	<WBI>	**0 60**	0 31	0 30	1							
	PUBN4	0 28	**0 67**	0 47	0 43	1						
	PUBN3	0 29	**0 53**	**0 50**	0 48	**0 91**	1					
	FHIS	0 28	0 36	0 40	0 46	**0 65**	**0 78**	1				
Department	<WBI>	0 37	0 31	0 24	**0 62**	0 43	0 43	0 35	1			
	PUBN4	0 22	**0 61**	0 34	0 33	**0 81**	**0 63**	0 42	**0 55**	1		
	PUBN3	0 24	**0 57**	0 36	0 38	**0 77**	**0 66**	0 49	**0 63**	**0 96**	1	
	FHIS	0 23	0 47	0 35	0 38	**0 66**	**0 63**	**0 59**	**0 63**	**0 83**	**0 92**	1

It ıs amazıng to find such a low correlatıon between aggregatıon levels even for the same ındıcator e g 0 36 between department and vıllage level PUBN3 Thıs gıves an ıdea of the relevance of a polıcy desıgn based on aggregated data

The problem of low correlatıon between dıfferent poverty measures has been emphasızed by several authors Boltvınık (1996) after an exhaustıve revıew of poverty measurement methods concludes that *the choıce of the measurıng method determınes the level of poverty and the polıcıes requıred to address ıt* In a case study ın Ivory Coast (Glewwe and Gaag 1988) seven ındıcators of human well being were computed from household data and target population computed from these estimates the authors found that there was little overlap between population identified as poor according to each measure For Venezuela maps of poverty indices based on economic indicators were found to differ significantly form the ones based on data-driven composite indexes (Baker and Grosh 1994) Therefore it is not unfair to say that policies are typically more related to a choice by decision makers and analysts than to data-driven evidence

Classification issues

Figure 2 present three official poverty maps used by the Government of Honduras the 1994 map used by FHIS (Figure 2a) and two maps that appear in the most recent poverty reduction strategy paper (RdH 2001) one from SECPLAN which is based on 3 UBNs computed from the 1988 population and housing census (Figure 2b) and one from the seventh schoolchildren's height census for ages 6 to 8 (1997 Figure 2c) There is a large similarity between Figure 2a and 2b which reveals the weight of the population and housing census in the FHIS map However categories from both maps have been defined in a way that emphasize poverty if we look at the original data used by FHIS before aggregation (FHIS 1992) we find that what is considered 'acceptable or average correspond to a poverty index between 0 and 0 3 while the very bad category applies to indexes above 0 5 The same is almost true for Figure 2b a municipality will be considered as poor when more than 40%

of households have 3 UBNs Figure 1c which displays a population risk for chronic malnutrition shows another pattern for this other facet of poverty that not taken into account by UBNs Food Security is however one of the 11 *well-being* indicators obtained of Ravnborg (1999 also in Appendix 1 of Part 1) but for which no equivalent was available in the three censuses that we had access to

[Figure 2 around here]

For consistency we chose the same double ended chromatic pattern for all the poverty maps displayed in the two parts of this paper However the official maps are all using shades of red exclusively which strongly suggest that nothing is going well in Honduras There is no doubt that Honduras is a very poor country but it seems that the data suggest lower levels of poverty than the ones the government want to show The effect of color in the design of maps is known since centuries and the first ever poverty map also used of a color scheme that conveyed a suggestive meaning [2] (Booth 1902) In effect Booth s colored maps served as a

[2] Booth poverty map has the following classification and legend BLACK Lowest class Vicious semi criminal DARK BLUE Very poor casual Chronic want LIGHT BLUE Poor 18s to 21s a week for a moderate family PURPLE Mixed Some comfortable others poor PINK Fairly comfortable Good ordinary earnings RED Middle class Well to-do YELLOW Upper middle and Upper classes Wealthy

summary and translation of the data and so would be easily understandable by anyone As for the data and spatial dimensions the color dimension for data maps needs further thinking for simplification and synthesis (Tufte 1983 1990 1997) and formalization

When we look at all our poverty maps in sequence however consistent patterns seem to emerge for example it becomes clear that the western part of Honduras i e the departments of Choluteca Valle Intibuca La Paz and Lempira Ocotopeque Copan and Santa Barbara suffers from much higher poverty than the rest of the country This is consistent with a recent analysis of several existing studies which found that poverty tends to be concentrated in the departments of the southwest (Choluteca, Valle Intibuca, La Paz and Lempira) in which three quarters of the combined populations have income below the poverty line (Paes de Barros *et al* 2000 cited by RdH 2001) On the other hands a popular belief about marginality of the Northern Zone of Honduras (read concentration of poverty and isolation) is not noticeably sustained by the data

This stresses the importance of understanding fully the concepts behind the indicators used their distribution and their aggregation Handling this complexity is made easier by enabling the construction of poverty measures and representations adjusted to our specific needs (or to our capacity to induce change) in a flexible yet controllable way However one should be able to assess how representations match in particular between scales because conflicts arise from decisions and decision makers at various levels use data at various scales and aggregations levels (Van Beurden and Douven 1999)

Figure 3 shows our results obtained for two applications of an optimum classification strategy On the left we used the FHIS map as a reference then produced maps from the PUBN4 and <WBI> that maximize the overall Kappa index of agreement We see that in the case of PUBN4 and <WBI> we have a 47% and 39% improvement respectively over the match that we would have obtained with a random map On the right we show maps that minimize the total within class variation so that the overall variation is explained by the classification as much as possible (the group mean for a given class represents the best individual values within the class) The cost function this strategy is given by

$$c = \sum_{j} \sum_{i \in C_j} (X_i - \overline{X}_j)^2 \qquad \text{(Equation 1)}$$

where X_j corresponds to data within class G_j (e g proportion of poor)

Forcing the municipal <WBI> map to resemble the one from FHIS (maps on the left of Figure 3) gives a result that was expected it emphasizes poverty in Honduras with prevalence of very poor municipalities One can immediately see that targeting with this FHIS classification would miss a large number of rural municipalities from the viewpoint of the <WBI> In the case of PUBN4 the forced map share similar characteristics to FHIS s in the western part of the country but there are significantly less municipalities that appear as "Acceptable (0 22 0 305) and more in the category 'Deficient" (0 305 0 69) Perhaps FHIS should include more indicators in its poverty map order to account for various paths out of poverty that are somehow taken into account by the UBN4 The forced <WBI> map presents much more municipalities classified as Very bad (0 536-0 72)

The optimum classification provides a picture that is less biased as we move across different poverty indicators (rightmost maps of Figure 3) The <WBI> map present less clustering than the other two while PUBN4 shows large clusters in the poorer and richer categories and little emphasis in the middle category There is more consistency between the three maps concerning the better off categories which suggest that the indicators used by FHIS and UBN4 relate more to the better off One has to keep in mind that if one finds that households with observable poverty related attributes are geographically concentrated this does not necessarily mean that there are poor areas i e spatial poverty traps Strictly speaking this would be revealed by an econometric analysis of household data that would include spatial variables (Ravallion and Jalan 2002)

The fact that <WBI> present smaller clusters seems to indicate that regional effects are less sizeable than we may expect for the rural poor in Honduras This implies that in order to take geography into account in poverty analysis and targeting spatial variables will have to be updated and accurate Ravallion and Wodon (1999) have found in a study of household data in Bangladesh that there are sizable spatial differences in the returns to given household characteristics which (if it applies to Honduras) would result in the observed diffuse geographical clustering of the <WBI>

The degree of similarity between a reference map and a forced one or between two maps using the same optimum classification strategy gives an indication of the degree of similarity of each representation and therefore the likeliness of conflicts that may arise by using one or the other

[Figure 3 around here]

3 Discussion

In the previous sections we have introduced general representation methods and shown implications of classic aggregation and optimum classification in the context of decision making about Honduras poverty In this section we extend the analysis further and introduce new aspects of the use of microdata through two application examples In the first example access to microdata allows to anticipate the effect of a polıcy ın a targeted ınvestment context In the second we descrıbe our experıence for accessıng mıcrodata through the world wıde web

1 Ex ante evaluatıon of the ımpact of poverty targetıng programs

In Honduras poverty allevıatıon strategıes ınvolve socıal spendıng for ımprovıng human capıtal and ıntegratıon ın the macroeconomıc framework (RdH 2001) There are both targeted and unıform polıcy ınstruments to enable thıs effort The maın targeted socıal ınvestment program ıs admınıstered by the Honduras Fund for Socıal Investment (Fondo Hondureño de Inversıon Socıal FHIS) an entıty whıch was created as a safety net to an aggressıve structural adjustment program ınıtıated ın 1990 Founded by decreed ın 1990 the FHIS was conceıved as a socıal compensatıon ınstrument dırected prımarıly to allevıatıng poverty ın the short term It receıved clear ınstructıons to use statıstıcal ınformatıon to target monıtor and evaluate actıvıtıes The Fund was orıgınally conceıved as a temporary agency but ıts mandate has been extended ın 1994 and ın 1999 untıl 2012 Resources are allocated through demand drıven small scale projects wıth more resources per capıta beıng allocated for the poorest areas FHIS ıs structured around 4 programs 1) Infrastructure 2) Basıc Need 3) Credıt to the Informal Sector 4) Credıt and Technıcal Assıstance

To improve the targeting of its programs the FHIS developed a municipal level poverty map based on indicators of unsatisfied basic needs of the UBN GI kind (FHIS 1992 RdH 1994a RdH 2001) and started to use it as early as 1990 This was done in collaboration with Honduras Secretaria de Planificacion Coordinacion y Presupuesto (SECPLAN) and was the first time census data was used for a detailed poverty study in Honduras In 1994 another map was produced by FHIS as an unweighted sum of three indicators the percentage of households without access to water to basic sanitation and children s malnourishment rate As programs were being implemented different weights were given to the indicators (i e 40% for water 20% for sanitation 25% to children malnourishment) and the allocation of resources changed accordingly (Von Gleich and Galvez 1999) Apparently FHIS and SECPLAN use different approaches SECPLAN being a pure UBN GI one (RdH 1994a))

In the period 1990 1995 the Basic Needs program invested 21 3M$ out of 65M$ in the 118 poorest municipalities (Webb et al 1995) in 646 sub projects that were executed by NGOs in 100% of the cases Targeting helped FHIS succeeded in helping the poor in areas not reached by social services delivered by the state (through uniform programs) and it has been observed a decrease of the proportion of households lacking the basic needs addressed by FHIS[3] FHIS chose to target at

[3] Surprisingly school education which was strongly addressed by FHIS projects was not one of the indicators used for their poverty maps

municipal level because this administrative level often groups ethno historical populations because it represents the basic democratic instance There was as early as 1994 a plan to produce poverty maps at a finer level in a number of units (2000 3500) close to the village level which was a major challenge at the time We have not heard about the existence of this map but FHIS seems to be moving to village level targeting (RdH 2001)

In a targeted investment context our approach would help anticipate the impact of actual poverty reduction strategies based on how they may be perceived by the poor As an example we will analyze how targeting by FHIS differ from the one that would result from *well being* perceptions This is equivalent of running two parallel prioritizing exercises one by FHIS and one by a group of poor people contrast the results and negotiate tradeoffs The indicators chosen by FHIS are quite different than the ones that were derived from local perceptions If the poor have had the opportunity of doing the exercise they would probably have ended with something closer to our <WBI> maps We can therefore examine how these different perceptions can be harmonized As mentioned above FHIS Basic Needs program funded projects in the poorest 40% municipalities country (according either their 1990 or 1994 poverty index)

Among the various ways to contrast perceptions in a targeted investment context one can be to quantify the degree of hits and misses on the target population of a policy relying on a given perception Two viewpoints are then compared the one taken by the policy and related investments and the one of the target population For example we can assess the impact of FHIS investments on the rural poor (according the their index) by taking our <WBI> as the measure of poverty of the target population and estimating how they match If we take this particular example we would have three situations a) coincident targeting the situation where a municipality would receive funding for social investment because it is considered poor in terms of FHIS indicator and the target population would perceived itself as poor (as estimated by <WBI>) b) leakage the situation where a municipality would receive funding for social investment because it is considered poor in terms of the FHIS indicator and the target population would *not* perceived itself as poor c) undercoverage the situation where a municipality would *not* receive funding for social investment because it is *not* considered poor in terms of a the FHIS indicator but the target population would perceived itself as poor (as estimated by <WBI>) The maps of Figure 4 show how would be distributed social investments by FHIS or <WBI> in the 40% poorest municipalities and how this investment would be perceived by the rural poor (as estimated by <WBI>) i e coincident targeting leakage and undercoverage Note that FHIS considers total poor (urban and rural) whereas the <WBI> concerns only local perceptions by the rural poor

[Figure 4 around here]

Using the same example (FHIS targeting and impact measured by measuring coincident targeting with <WBI>) a synthetic measure of impact can be obtained by counting for a given target of poor municipalities (according to FHIS ranking) the number of poor households for which targeting is coincident with local perceptions (according to <WBI> ranking) and divide this number by the number of poor in the targeted municipalities according to local perceptions The variation of this impact measure in function of the target threshold (% poor municipalities in which to invest) is displayed on the graphs at the bottom right of Figure 4 for rural poor target (top left graph) as well as rural *and* urban poor target (bottom left graph) The dashed line corresponds to the case of a uniform (non targeted) policy and the dotted line to the case of perfect targeting (e g FHIS targeting policy based on the same index as the one used for targeting) Deviation above the dashed line indicates the improvement over uniform targeting that is expected On the rightmost graphs we look at the reverse situation how the impact of a policy that would be based on <WBI> would be perceived by a target population which would be defined according to the FHIS index We suppose that investments are uniform within a municipality

If we look at the leftmost graphs of Figure 4 (i e the expected impact of a policy based on FHIS) we find a small improvement over a uniform (or random) policy from the viewpoint of perceptions of the rural poor If we suppose that the <WBI> applies to all poor including urban ones (which is strictly speaking incorrect) the improvement would be minimal in the case of the worst 40% municipalities and we would see a worsening for the better off? Targeting with the <WBI> (rightmost graphs) seems to be a much better alternative in the case the FHIS criteria is used to measure the target population it provides a significant improvement of impact over a uniform or random strategy very similar for the rural and urban cases

The capacity to estimate the effect of uniform vs targeted social investments can help the implementation of Honduras poverty reduction strategy which seems to be moving in favor of uniform investment strategies over targeted ones (RdH 2001) Our politically naive" model can be vastly improved by adding a political feasibility constraint such as in Gelbach and Pritchett (1997) in which the total budget to allocate to pro poor policies varies with the priorities of voters To be truly useful this new type of models (which follows a games theoretic approach) requires detailed data that may exist in raw census databases However if the only data available is one that has been processed and aggregated for a different purpose then such a model cannot be calibrated properly and the resulting policy design will be probably too weak to be really useful

2 A user-friendly database in practice

We believe that three factors have contributed to an under representation and under use of census data in Honduras First there is no mechanism for implications of the central government at village level so the need for data at this level has never been a pressing issue This is changing with decentralization of responsibilities to Municipalities and the increased involvement of NGOs in all sectors including the ones related to poverty reduction (RdH 2001) The issue of empowerment of local decision makers is becoming key to sustainable development however it is the central government that has access to disaggregated data and possess the capabilities to process it Second processing and publishing data and maps has traditionally been tedious which implied that the exercise was done once and for all Nationwide household and village level databases can become very cumbersome to manage and difficult to interpret partly because of traditional high costs of data processing infrastructure especially for a developing country Third the old adage information is power" is probably well known by many who have little interest in sharing their information with the rest of the civil society

Those who use data to help decision making do not often perceive its limited availability as a constraint Few decision makers are aware of the implications of working with carefully chosen data (by someone else) and one that aggregated to a scale imposed by predefined boundaries a phenomenon also known as the 'ecological fallacy (Robinson 1950 Openshaw 1984) The ecological fallacy arises when area level aggregate statistics are used to obtain information that is subsequently assumed to apply at the individual level Openshaw and Taylor s (1981) found that changing the zonal boundaries have a drastic effect on the results of statistical analysis of data aggregated for the zones which questions the validity of any analysis done based on data for large administrative units However Tranmer and Steel (1998) propose an approach that allows for within-area homogeneity and correct aggregate-level statistics Recently these authors have shown that a multilevel model (i e with data aggregated at various levels) preserves the variation at a given level provided other levels are included in the model (Tranner and Steel 2001)

Information technology is now mature enough to permit to design user friendly databases to simplify operations and provide smaller and lighter aggregated datasets according to fixed or user defined areal units The pioneering work of Openshaw and Turton (1995 Turton and Openshaw 1996) demonstrated the feasibility of a low-cost system to query interpret and process raw census data (in this case the 1991 UK SAR) The existence of open source software communities combined with and the arithmetic increase of computer performance/price ratio and internet bandwidth provide an unique opportunity to developing countries to process and share its data efficiently and at low cost

We programmed a web interface to demonstrate to our partners the feasibility of a low-cost secure system that allows a non expert user to process unit-level data (Bleuse and Vallejo 2001) Functionalities include a) summary statistics (Mean Standard deviation min max) b) Headcount Indicators (% of variable X with respect to variable Y) c) Composite indicators (weighted linear combination of several variables) d) user defined SQL query e) Help/Tutorial f) Metada Queries can be performed on any of the census variables To ensure privacy of information aggregation levels range from *caserio* village municipality and department results are downloadable Possibilities for such a simple interface are countless For example it would make it easy for FHIS to target their infrastructure investments by computing (option c above) a village level distribution of housing types based on a user defined housing quality index from roof floor and walls type It also allows for sensitivity analysis by providing the flexibility of varying the composition of indices and their level of aggregation which result in a better appreciation of the robustness of the results (and therefore of the policy that is derived from these results)

In case the Honduras government decides to provide access only to a sample of anonymized records (SAR) such as in the 2% SAR of the UK (Dale 1998) sample size would have to be large if we are interested in village level information given the number of small rural villages in Honduras (75% have a population of less then 1000) However a sample of this size will not be small enough to preserve anonymity (Duke Williams and Rees 1998) In this case one could embed the SAR (or better the raw data) in the data processing that would correct aggregate level statistics in a way that is invisible to a user (Tranner and Steel 1998 Charlton 1998 Williamson et al 1998) Duke Williams and Steel (1998) give useful recommendations about safe strategies for publishing census data In the case methods for processing data would be provided as well it would be important to provide assistance in selecting a method and understanding its domain of application

The combination of Apache (the web server) MySQL (the RDBM manager) and PHP (the web interface to MySQL) has proven to be a powerful easy to implement stable and free alternative to large commercial systems National statistics or planning institutes of developing countries may have the financial resources which is often obtained by contracting a loan with a development bank to rely on an expensive system and therefore may not be interested in the risk associated with open source and free software Smaller organizations municipalities (more and more in an increasingly decentralized world) could implement a low cost web based RDBM system with subsets or anonymized samples of the census raw data in addition to their own data In any case the support of the open-source community may be more appropriate than the one large corporation are selling

Although the web is currently flooded with dumb map servers few applications in statistical cartography have seen the light of day, and they are mostly experimental ones (Andrienko and Andrienko 1999 Peterson 1999 Cartwright 1999 Carr et al 2000 Winter and Neumann 2000 Gaborit 2000) Statistical cartography involves complex design constraints Internet bandwidth concurrent processes display resolution and swiftness choice of statistical routines and graphical representations While giant technological progresses are happening in the internet world the best opportunities for developing countries are still pieces of code running on a personnal computer (Gondard and Mazurek 1999 Mazurek 2002) Nevertheless improvements in technology will not abstract us from understanding better the cognitive process involved in the production reading and use of a statistical map (see Mark *et al* 1999 for a review of cognitive models of geographical space)

Such systems will have to be stuffed with data aggregation and data mining tools and a capacity to define new areal units in order to give to people with diverse interests the security and freedom needed to make sense of the large amount of information that represent raw census and small-area datasets (Fisher 1986) There are more ways to aggregate data and give new meaning to it in addition to proportions and univariate statistics Gini coefficients concentration index location index shift and share analysis (Krumme 1969) etc In fact complex microeconomic studies can be realized from raw census data which are large exhaustive households surveys (King and Bolsdon 1998 Deaton 1997)

Because of the connection between the local and the regional the best practice is to work with various aggregation levels simultaneously (Subramanian et al 2001 Morehart *et al* 1999 Tranmer and Steel 2001) Examples of multiscale analysis with village level PUBN3 and PUBN4 can be found in Leclerc *et al* (2000) e g detecting the presence of child mortality hot spots and the correlation of poverty with environmental risk) which analysis can only be done reliably with small area data Turton and Nelson (2001) have also studied mortality rates in Honduras by applying tools of the Geographic Analysis Machine to raw population census data (Openshaw 1987, Openshaw *et al* 1987)

4 Conclusion

The observed divergence of the paths to poverty alleviation policy and action that are taken by different development actors calls for more participation negotiation and learning (Brock *et al* 2001) Many new initiatives invest heavily on horizontal networking (some with participation of the poor) with emphasis on information and communication technology Therefore we have explored ways to bring together different perspectives on poverty with a focus on data processing representation and use We have tried to demonstrate the great value adding potential of microdata such as raw censuses and presented examples on how the research products and information technology can be mobilized to bring transparency and rigor in the process Our goal was not to find the causes of poverty or explain its distribution (we think Hondurans are much better positioned to do so) but to provide means to reduce or at least control the inevitable *lie* -deliberate or not carried by data maps and statistics and the conflicts that these biases generate

The new Honduras poverty reduction strategy which includes the usual government responsibilities for policy design and social investment foresees an increased role of municipalities, communities NGOs and of the private sector It does not specifically address the way information technology will be harnessed to help this emerging process of *practical democracy* We hope that our paper provides elements of answer that will prove useful especially in the context of the 2001 Population and Housing census a gold mine of important information that all players in Honduras cannot afford to underutilize By presenting examples on how one can use the Agricultural census for poverty measurement we also show that this data is a necessary complement to the classic datasets and that agriculture specific questions need to be asked if one is to address rural poverty

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Figure Captions

Figure 1 An efficient representation of poverty profiles for decision making (in this case the local *well being* index) for each department (located on the left micromaps) a series of box plots showing the distribution within each municipality of village level <WBIc>

Figure 2 Three official poverty maps for Honduras (a) the 1994 map used by FHIS based on 2 UBNs and on malnutrition (b) map from SECPLAN which is based on 3 UBNs computed from the 1988 population and housing census (from RdH 2001) (c) map of the malnutrition risk from the seventh schoolchildren s height census for ages 6 to 8 (1997 from RdH 2001)

Figure 3 Bringing together various representations of poverty at municipal level i e the FHIS (unsatisfied basic needs and nutrition) our PUBN4 (unsatisfied basic needs and education) and the locally derived indicator <WBI> On the left legend categories are constructed to minimize Cohen s Kappa with respect to the FHIS map On the right the optimum classification strategy of Jenks (1976) is applied to highlight patterns in the data

Figure 4 Maps of Honduras with municipalities highlighted in white if among the 40% poorest according to <WBI> (*Targeting with <WBI>*) among the 40% poorest according to FHIS (*Targeting with FHIS*) poor according to FHIS and to <WBI> (*Targeting coincident*) poor in terms of FHIS but not in terms of <WBI>

(*FHIS leakage*) poor in terms of <WBI> but not in terms of FHIS (*FHIS undercoverage*) On the bottom right ex-ante impact plots plots of the number of poor (urban and rural) reached by a targeted policy based on a different indicator as the one used to define the target population

An attempt to integrate multiple perspectives to improve pro-poor policies

1 Deriving classic and local poverty indicators

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Abstract

This paper is the first of a two parts publication that addresses the issue of bringing together different representations of poverty to improve the design of pro poor policies We describe how various poverty indicators the classic ones such as unsatisfied basic needs as well as novel ones based on local perceptions can be obtained from census data and represented spatially We start by detailing the process of transforming raw (unit level) census data into tailor made poverty indices for different levels of aggregation from village up to country which are then

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compared to other published estimates We then extrapolate to country level indicators derived from local perceptions of household well being by means of proxy indicators computed from raw census data The derived poverty indices are validated for 12 communities and we examine the issue of extrapolation domain of these results Poverty profiles which show regional patterns are found to be very sensitive to the choice of indicator and the level of aggregation

1 Introduction

For many years economic analyses have demonstrated that increased food production should have a positive impact on alleviation of the world s poverty Poverty estimates were lumped figures generally using a Poverty Line approach with no distinction between the urban and the rural poor As a result of these encouraging findings FAO and Future Harvest Centers (supported by the Consultative Group for International Agricultural Research CGIAR) including CIAT have focused on alleviating hunger and poverty primarily through increases in food production which made them key actors in the green revolution In parallel the World Bank had relied on essentially two poverty alleviation strategies promoting structural adjustment (SA) in developing countries which countries implemented together with programs aimed to protect part of their population seemed vulnerable to the adjustment and funding programs on basic needs (mostly as a safety net to the SA) credit and infrastructure

Over the years linking these implicit and quasi unidimensional assumptions and the broader human conditions of well being and poverty has been called into question[2]

[2] Throughout this paper unless specifically noted poverty and well being will be used interchangeably to refer to a broadly defined but intuitively acknowledged human socio economic condition When italicized *well being* refers to concepts used by Ravnborg (1999)

This resulted in most development organizations committing to a better understanding of the dynamics of well being and poverty and trying to cope with the complexity that this new approach implies On the other hand there is increased concern about the relevance of the process engaged between development actors and about the paths that lead to poverty alleviation policy The role of the actors themselves seems to have more influence than the one of poverty measurement which is in contradiction with the accepted logical positivist view that technical poverty knowledge is directly linked to the policy message (McGee and Brock 2001)

The World Bank after a self assessment of the mitigated success of its strategy (partly in response to worldwide criticism) is also moving towards a more holistic approach A good example of the new World Bank' paradigm comes in the form of a large scale study referred to as *Voices of the Poor* (World Bank 2000) an unprecedented effort to gather using participatory methods perceptions and aspirations of 60 000 poor men and women from 60 countries However when the issue it to estimate global poverty rates it is still the concept of a 1$ (or 2$) per capita per day threshold that predominates (World Bank 2001)

Most development NGOs which have traditionally adopted bottom up approaches and focused on local development are now asking for better information and science to achieve impact beyond intervention areas and to connect their work with broader scale initiative (Webb *et al* 1995)

The focus of this two parts paper is to present on going work that examines methodological issues related to the characterization measurement representation and geography of poverty Although a large body of literature can be found on the subject traditional methods address facets of poverty not easily related to agriculture and NRM decision making (Carvalho and White 1997) In 1997 CIAT embarked on a research project that would define a unique approach to linking *ad hoc* measurements and geographical representations of poverty from community level locally constructed *well-being* rankings (Ravnborg 1999) to standardized maps of national level rankings Contrary to proposing a single unifying poverty index we support the design of indexes which target the specific needs of various decision makers This poses however a formidable challenge In effect a prerequisite for catalyzing collective action is a shared vision and shared visions cannot be created and communicated using unrelated component images Adopting a standard poverty measure helps everyone to rally to the same perception (for the good and the bad) while these different viewpoints on poverty that we propose to explore will have to be exchanged and discussed to catalyze collective action

In part 1 (this paper) we start by showing how the richness of raw (unit level) national census can be exploited to produce poverty indexes tailored to particular needs We then introduce results of an independent study where locally relevant indicators of *well being* were determined by analyzing information collected through participatory exercises in 90 Honduras villages We then link the independent *ad hoc* databases by standardizing the unit of analysis The result can be viewed as an example of a common knowledge base that can help bridge the communication gap between national perspectives and local community perspectives in which affordable information technology play a key role

In part 2 we examine methodological issues for contrasting several representations of poverty indicators (including the ones derived here) for various aggregation levels and classification choices to illustrate the effect they may have on poverty alleviation policy We complete the study by describing a prototype of a simple user friendly interface to raw census data to allow various representations to be generated and explored freely from the World Wide Web

2 Materials and methods

1 The Honduras Population Housing and Agriculture censuses

The 1988 Honduras Population and Housing censuses are the most recent and complete data set available about every single person and household in the country

They give a panorama of the composition of the Honduran society and of the life conditions of its inhabitants in 1988 They contain answers that the 4 255 105 individuals gave on a given Sunday (29 May 1988) to questions related to their education level profession or vocation family composition age mortality migration housing type and construction materials ownership type water supply assets etc In total 42 variables for 891 298 households and 49 for each individual in addition to 9 variables related to administrative localization of the household The data collection phase of population and housing censuses take only one day (it is done by a large number of civilians students etc) but it takes years to prepare and a year before the first results are published

The 1993 Honduras Agricultural census is the most exhaustive data set related to agriculture to cover all farms[3] in Honduras (317 199 to be precise) soon to be updated by the 2001 census[4] In total 161 variables covering land ownership

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[3] The statistical unit adopted was the Agricultural Holding defined as all land of at least 0 21 ha totally or partially used for agriculture or livestock rearing made up of one or more parcels laying in the same municipality kept under a single management without regard to title or legal form

[4] Honduras was approved in 2001 soft loans totaling $8 million to support the 16th national population census and the 5th national housing census The *Instituto Nacional de Estadisticas* has carried out the census in July 2001 together with an

agricultural production technology and labor as well as 6 variables about the farmer and 8 variables related to administrative localization of the farm The data collection coordinated by SECPLAN in accordance with the Ministry of Natural Resources was conducted 26 April 15 May 1993 Data on number and area of holdings land tenure and land use shown below refer to the 1989 Survey Data on temporary and permanent crops refer to the period 1 May 1992 30 April 1993 Data on livestock numbers refer to 25 April 1993 Many people state that agricultural censuses are error prone as farmers will avoid giving to government officials detailed information that would give the government a chance to invade their privacy

The census results are compiled at Municipality (Honduras *Municipio)* level (and higher levels Department Honduras *Departamento*) in tables distributed within several thick books (RDH 1989 1990a 1989 1990b 1994b) This tradition is likely to evolve in the near future as most developed Latin American countries can provide municipality level census data on line or on CD

In 1996 the Statistics Bureau of Honduras (the Direccion General de Estadistica y Censos DGEC a division of SECPLAN) now defunct and replaced by the National Statistics Institutes (INE) which is independent of SECPLAN provided us

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executing agency created for this purpose The Vth Agricultural census is planned for 2003 with a unique opportunity access to the complete censuses in a raw unit level format which we loaded in a large MySQL database Confidentiality was partially fulfilled by omitting the names of the individuals However geographical coding was still too fine to prevent disclosure of information about individual (Duke Williams and Rees 1998) The Population and housing censuses are linked through a 23 digits household ID which unfortunately has no coincidence with the Agricultural 12-digit one (at farm level) This means that we cannot join the three censuses at household/farm level The three censuses are loaded as 15 tables (1 for Population 1 for Housing 13 for Agriculture) that occupy a total 790 MB Tables are indexed through household or farm ID to speed-up queries from linked tables

The basic geographical database to be linked to the censuses consist in a *departamento* coverage (18 departments as polygons scale 1 100 000) a *municipio* coverage (292 municipalities as polygons scale 1 100 000) and an *aldea* coverage from SECPLAN (3729 villages as points scale 1 50 000 -note there are 3742 villages in the census) To uniformize representations at all administrative levels point coverages were also generated from the centroids of the *departamento* and *municipio* coverages and a polygon coverage was created that represent the Area of Influence of villages from the *aldeas* point coverage (Appendix 2) Departments have not changed since 1957 but *municipios* and villages are constantly evolving in the period 1974 1993 8 new *municipios* were created We have found two slightly different official coding of municipalities for 1988/1993 and were unable to obtain confirmation about which one is the correct one therefore we used the coding by DGEC Moreover there is one municipality for which no census information exists The village coverage prepared by SECPLAN was more difficult to check for consistency gazetteers being outdated and no other coverage being available for cross comparison We checked the village coverage in several steps 1) by doing a spatial join with the municipality coverage which allowed us to pinpoint villages that were coded as part of a different *municipio* than the one they were actually located in 2) we checked the proximity of villages which could not be too small (e g 300m) and also manually checked on official gazetteers We then assigned a quality code to each village (Couillaud 1998) The overall accuracy of the village coverage is very good only 147 villages had inconsistent codes the confusion being mainly between *aldeas* and *caserios* The *caserio* level (i e hamlet) is an even more detailed level found in the census (a village is made up of 5 10 several *caserios- there are 25533 caserios in the census*) but no official map exist or is likely to in the near future However one could think that it could be done for a region of interest i e a mayor could want to construct such a map for the municipality

2 Deriving compound indices from raw census data

Background

The methodology we followed here draws from the traditional unsatisfied basic needs (UBN) and its cousin the Human Development Index (HDI UNDP 2000) The UBN approach which has been the one adopted for at least 11 countries in Latin America because it incorporates important variables for the formulation of social policies (Boltvinik 1996) In the case of Honduras the Secretaria de Planificacion Coordinacion y Presupuesto (SECPLAN) made first use of census data for poverty targeting in 1990 and developed the methodology in the following years (RDH 1996) However the National Security doctrine stifled academic freedom and led to micro level economic or social analyses being abandoned especially in the countryside resulting in a shortage of information (Thorpe 1993)

It must be clear that our choice is not meant to be unique (or the best or CIAT s) and that the indicators selected are mainly illustrative Many prefer UBNs but censuses are so rich that many other indices can be defined to suit particular needs for example poverty line indices such as the FGR (Foster et al 1984) or decomposable inequality indices such as the one proposed by Theil (1989) They can be adapted twisted to highlight a particular interest or perspective or aggregation level

UBN methods involve the selection of a certain number of indicators that form a representative set of basic needs the definition of a normative threshold (i e minimum criteria to be satisfied for each need) and the combination into poverty indices and head counts Therefore according to this approach poverty is linked to a state of necessity a deficiency or deprivation of the goods and services necessary to sustain life to a minimum standard In the Latin America practice the UBNs are generally a set of poverty related factual indicators large number of people sharing a room improvised or inadequate housing inadequate water supply and inadequate sewer systems low school attendance for children and household capacity to generate income Other factors such as lack of participation in collective decisions social marginalization powerlessness etc are thought to be implicitly correlated to UBNs and therefore no attempt is made to measure these dimensions separately

The Honduras social investment fund (Fondo Hondureño de Inversion Social -FHIS) uses their own index (UBNs complemented by a malnutrition index) for targeting the projects for its Basic Needs program (RDH 1994a 2001 Webb *et al* 1996) the same index becomes the one that many outside FHIS will use Therefore we examine in part 2 (section 3 1 of part 2) how the risk of leakage and under coverage is related to the choice of indicators and the way they are computed We emphasize the need depending on the situation for a system to help the computation of customized made poverty indices with in parallel a rigorous and standard framework that would allow cross country comparisons

Methodology for UBNs

We followed a scheme very close to the one adopted in the elaboration of Bolivia s *Mapa de Pobreza* (Republica de Bolivia 1995) a multi institutional effort that took advantage of unit level census data to produce a very complete set of poverty data and maps for Bolivia More details can be found in Oyana *et al* (1998) The UBN index derived would fall into the category of UBN-GI (Generalized Improved Boltvinik 1997) since they include a wide range of variables such as non land assets or education The UBNs are computed for each household then aggregated at village municipality or department by counting the fraction of the population in a particular UBN stratum In Equation 1 the variables selected to build the UBNs are labeled x_j the subscript j representing the household and x the variable For certain variables such as the education level of a household j the value is computed for the household from the value for an each individual i forming the household Only the 1988 Population and Housing censuses linked at household level were used to derive these indicators

First we have to define x^* the normative threshold (or acceptable value) for variable x This is where the knowledge of the area and the local/national economy play a crucial role It is also at this step where subjectivity (and gross errors) can occur and lead to diverging conclusions For the current example the normative threshold that we used for a given variable was given by the average value of that variable for the country I that sense the poverty measure that we are developing here is more one of equity which can help orient an internal social adjustments

second we define an index of failure in obtaining x^* for household j cx_j is

$$cx_j = 1 - \frac{x_j}{x} \qquad \text{(Equation 1)}$$

computed as follows

The cx are then normalized between 1 and +1 to allow comparison if $cx_j < 0$ we divide cx_j by $\min(cx)$ and if $cx_j > 0$ cx_j is divided by $\max(cx)$ Put in other terms cx_j is a normalized distance between current condition and the condition defined by x^*

The compound indices UBN3 (a combination of 3 indices) and UBN4 (a combination of 4 indices which is closer to UNDP HDI) are obtained for each household by averaging several more specific indices which themselves are the result of the combination of more basic ones (i e the cx) This is detailed below (see also Figure 1)

For each household j we define

$$UBN3_j = \frac{(CV_j + CSIB_j + CIA_j)}{3} \qquad \text{(Equation 2)}$$

$$UBN4_j = \frac{(CV_j + CSIB_j + CIA_j + RE_j)}{4} \qquad \text{(Equation 3)}$$

where CV_j = lack of housing size and quality

$CSIB_j$ = lack of basic services and energy sources

CIA_j = lack of non land assets

RE_j = lack of education

Note that no information on land tenure appear in the Population and Housing censuses (but it does in the Agricultural one)

CV_j the <u>index of lack of housing size and quality</u> was derived from an index of the size of the house CEV_j and from an index of housing quality CMV_j

$$CV_j = \frac{(CMV_i + CEV_i)}{2} \qquad \text{(Equation 4)}$$

CMV_j is the average between lack of wall quality (cm_j) roof quality (ct_j) and floor quality (cp_j)

$CSIB_j$ the <u>index of lack of basic services and energy sources</u> is the average between the lack of basic services CSB_j and of energy source CE_j

$$CSIB_j = \frac{(CSB_i + CE_j)}{2} \qquad \text{(Equation 5)}$$

CSB_j is computed as the average of water source quality cag_j lack of water supply infrastructure ctu_j and lack of latrines csa_j CE_j is the average between the lack of electricity cal_j and of fuel cco_j (fuelwood excluded)

CIA_j the <u>index of lack of non land assets</u> is derived from three indicators the lack of household appliances (CBA_j) of means of transportation (CTA_j) and telecommunication (CCA_j) The first is the average of lack of sewing machine of refrigerator and stove The second is the average of lack of car of motorcycle/moped and of bicycle The third is the average of the lack of radio and television CIA_j is then computed as

$$CIA_j = 0\ 25 \times CBA_j + 0\ 4 \times CTA_j + 0\ 35 \times CCA_j \qquad \text{(Equation 6)}$$

The choice of weight in this equation is clearly a question of preferences or interests

RE_j the <u>index of lack of education</u> for each household is computed from data from individuals i belonging to household j The index of success of the individual within the household, $ane_{i,j}$ is computed as follows

$$ane_{i,j} = \frac{ap_{i,j} + as_{i,j}}{ap^* + as^*}\ al_{i,j} \qquad \text{(Equation 7)}$$

where

$ap_{i,j}$ is the number of years of schooling

$as_{i,j}$ is the index of school attendance in function of age

$al_{i,j}$ is the index of literacy

ap^* is the normative threshold for school attendance in function of age

as^* is the normative threshold for student status

The index of education deficiency for each individual $re_{i,j}$ is simply given by

$$re_{i,j} = 1 - ane_{i,j} \qquad \text{(Equation 8)}$$

Finally RE_j is computed as the average of the $re_{i,j}$ for household j

[Figure 1 around here]

Before proceeding further we would like to emphasize that indicators chosen to be included must have an objective social existence which ideally- would has to be validated with the poor themselves Ravnborg (1999) describes a methodology to obtain indicators in a participatory way which we describe in Section 2 3 Many have accepted the view that the idea of absolute need has no sense in societies in a constant process of change and adaptation and therefore discredit any attempt to quantify poverty Others such as Pradhan and Ravallion (2000) are finding innovative ways to obtain a subjective poverty line from qualitative assessments of perceived consumption By using a normative threshold defined by a country average we tend to examine equity issues and adjust to the reality of a country which may be safer than imposing our perception of an absolute threshold On the other hand doing so poses the hypothesis that there is one reality for all of Honduras one scale of values and this can lead to gross errors For example the fact of not having a automobile in a region where transportation is done on waterways is not necessarily a disadvantage while having a motorized boat is definitely a plus there is no information about ownership of a boat in the census

Aggregation of household-level indices

Household indices georeferenced for each village can be aggregated at virtually any scale given predetermined boundaries it can be village watersheds area of influence of a village (Appendix 2) municipalities department or country Aggregation which is a necessary step to protect the privacy of census information (Duke Williams and Rees 1998) has also the interest of synthesizing and reducing the volume of data to a more manageable level For poverty indices or each of their components we can produce mean or median values or count proportions of the population considered as poor

For illustration we chose a headcount approach and defined 2 indices P_{UBN3} and P_{UBN4} as the proportion of household, for a given aggregation level, which UBN (UBN3 or UNB4) is between 0 4 and 1 (i e Proportion of households which UBN is in the lowest 20% UBN range) This was done only when more than 50% of the households poverty index could be characterized for a given village In effect there are cases where the data is not complete and do not allow to compute an index from all the variables (regions of high population density are more error prone- see Leclerc *et al* 2000) Results are presented in the next section

All the steps to process unit level data into UBNs are realized through a series of Structured Query Language (SQL) scripts that allow full automation There is very little to do to put the power of the raw census in the hands of any user through the Internet A simple interface (e g on the web) can provide to a remote user the capacity to produce a poverty index for a special purpose thematic through SQL queries with any variables of interest any weights or ways of combining them and the choice of any aggregation level, on a central computing facility (Openshaw 1995) An example of low-cost user friendly web interface to unit census data is described in Part 2 (section 3 2)

3 The well-being index based on local perceptions

We briefly recall the work of Ravnborg (1999) on the identification extrapolation and quantification of local perceptions of poverty (or its antithesis *well being*) and development of regional poverty profiles The author conducted a traditional participatory *well being* ranking as a designed experiment which allowed for extrapolation to areas different than the ones studied This was a strategy to avoid what Rhoades (1999) in his essay about participatory methodologies describes as *the social under design of projects*" Instead of seeking representativity i e find standard villages in which to conduct the study the aim was to select a large set of contrasting villages This would maximize the chance of obtaining all possible indicators but also would allow to conclude if some indicators are found across all communities despite the dissimilarities that these indicators could be valid for all communities from which the sample was taken

First assumptions were made with respects to factors that would influence poverty in Honduras and a sampling was designed A series of villages were selected so as to represent as many combinations of 6 factors altitude basic services (education and water) population density, ethnicity gender composition and travel time to urban centers (>2000 inhabitants)

These factors were obtained from census data and the GIS database for all Honduras villages and a sample of 90 villages in 3 departments was chosen (Figure 2) using a maximum variation strategy In theory the indicators of *well being* obtained are valid for all villages that have the same combination of factors as the ones used in the sample In practice since there was consistency in the description of indicators even for contrasting villages it is likely that the extrapolation domain is much larger The problem of determining the extrapolation domain for these indicators is discussed in section 3 3

[Figure 2 Around here]

The *well being* ranking a participatory technique for obtaining insights into local perceptions of *well being* - and by inference poverty (Grandin 1988) was done in the 90 communities that formed the sample For each community 3 to 5 informants with different age gender occupation and ethnicity are selected This is to avoid the informant-related bias typical of this type of studies (Bergeron *et al* 1998) They are asked to examine a set of cards each of which representing a household and group the cards into piles (maximum 4) according to their perception of the well being or quality of life of the households (well-being' being a neutral concept in contrast to poverty") Generally we end up with one pile for the poor one for the not so poor and one for the non poor according to how the informant perceive poverty These categories and the classification of households are of course only valid for the community and not extrapolable to other ones The informants are then asked to describe the content of each pile in terms of their differences with the other piles

The descriptions are the base for the identifications of *well-being* indicators which are reinterpreted and made quantifiable by means of a standard questionnaire (we will later refer to this questionnaire as *well being* questionnaire) The authors obtained during 1997 from the 316 descriptions of *well being* almost 400 indicators that were subsequently reinterpreted and reduced to 11 a priori valid at least within the set of communities from which the sample was drawn These indicators were subsequently transformed into quantifiable ones which are summarized in Appendix 1 Once the score is given to each indicator for a household the resulting *well being* index (WBI) is simply the average of the score of all indicators that apply for that household Once all WBI are obtained the distribution is split into three categories (highest middle lower *well being* i e non poor not-so-poor poor) in order to reflect as much as possible the *well being* categories defined by the informants The poverty profile for a region (a watershed for instance) is then given by the proportion of households in each of these categories according to the various constituting *well being* indicators The *well being* questionnaire is straightforward and unbiased takes 15 30 minutes to complete for each household and can be used to obtain quickly and inexpensively a poverty profile for a region of interest

Ravnborg ends up with an index which does not look drastically different than other published ones (such as UBNs) but which has a major advantage it is entirely based on the perceptions that the poor have about poverty In a way it is a message from the poor about what really matters to them which they are addressing to decision makers The extrapolation and mapping of the *well being* index is no more than a translation of this message into a language more familiar to policy makers

A poverty profile for selected communities

The questionnaire has been employed by Ravnborg and her team to quantify the well being of 768 households as part of a larger study to identify factors that lead to certain preferences related to agriculture and NRM (Ravnborg 2002) The households were selected at random and belong to 12 communities (between 12 and 55 per village) distributed among 3 hillsides watersheds located in distinct social and climatic environments (see Figure 2 and Figure 10) This sampling design allows to derive statistically valid poverty profiles for each village and each watershed

Some hypothesis with a great extrapolation potential can be drawn from detailed analysis of the actual distribution of indicators and *well being* levels at various aggregation levels We used the WBI (the raw *well being* index before it is classified into 3 categories) to generate a the qq plots displayed in Figure 3 The vertical scale (which is the one defined by Ravnborg) goes from 33 (higher *well-being*) to 100 (lower *well being*) and the horizontal scale represent the quantiles of a standard distribution It appears that the WBI distributions can be modeled adequately by a normal distribution (i e data points generally adjust on the qq line) which have similar standard deviations (i e slope of the qq line is similar) in the order of 11 (i e 0 17 in a scale 0 1) This will help us improve our capacity to predict proportions of poor based on the average value of the WBI (see section 3 4)

[Figure 3 Around here]

4 Computing the well-being index from ancillary data

The question is now to examine how we will obtain the locally derived indicators from ancillary information such as censuses Two approaches are possible the first is to explain the WBI with census data (i e regression) the other is to compute it directly by averaging individual indicators (i e dumb average)

In the first case we could compute for each household a WBI in function of a series of explanatory variables found in the census for this household This could be done by multiple regression between the WBI obtained from the questionnaire (which we will label WBIq), and census variables provided we have census data for each household where the WBI questionnaire has been filled

$$WBIq=f(x_1 \; x_2 \quad x_N) \qquad \text{(Equation 9)}$$

With a sample of 768 we could include as much as 20 explanatory variables for example An economist would probably account for non linear relationships by using sub-models to fit the data, and then explain why the data is what it is by adjusting model parameters An example of this approach based on a consumption model is given by Hentschel *et al* (1998) In the case of poverty (beyond the consumption proxy used by these authors) we can imagine that such a model would be extremely complex and we might not have enough data to calibrate it Another way could be to use artificial intelligence techniques to fit the data to obtain an empirical model that can be used to run simulations (what if scenarios) with limited data availability (Leclerc *et al* 2000)

However we have to be aware of 2 constraints that prevent us from doing this The first which is critical is that in order to respect confidentiality we cannot locate in the census the exact households that were surveyed by Ravnborg and her team therefore we cannot calibrate our model at household level This is a similar situation as experienced by Bigman *et al* (1999) for poverty targeting in Burkina Faso the household consumption data was obtained from a Priority Survey (PS) of sample communities and the only data available for extrapolation outside the PS sample were mean values of explanatory variables In our case we have all the data at household level (survey as well as explanatory variables) so we can go a little deeper in our analysis by comparing the distributions of WBIq within a village to the distribution of explanatory variables from the census We have found that distributions of WBIq and indicators were similar between villages (Figure 3) and therefore the mean value of the WBIq for the village (<WBIq>) depends mainly on the average value of indicators and not on their distribution The second constraint which limits our capacity to perform geographical analysis is that the most detailed nationwide administrative level that is georeferenced in digital format and that can be linked to censuses is the village which means that we cannot map census data at a finer scale (such as *Caserio* or *Distrito Censal* two finer levels for Honduras census data)

Having these constraints present in mind two approaches are possible to compute <WBI> from the census (which we will label WBIc) The first would be to find the functional relationship between the average WBIq for a village and a series of explanatory variables from the census

$$\langle WBIq \rangle = F(\, x_1 \;\; x_2 \quad\; x_N \,) \qquad \text{(Equation 10)}$$

This could also be done by multiple regression or with neural networks then extrapolated to other villages $\langle WBIc \rangle = F(\, x_1 \;\; x_2 \quad\; x_N \,)$ Here the constraint comes from the fact that for a reliable estimate we need to have much more samples (i e number of villages where the WBI data has been collected) than we have explanatory variables This is not the case here as we only have 12 villages in the sample and 2-3 explanatory variables are not sufficient to describe poverty reliably We therefore have to approach the problem differently by computing a village average *well being* index as the average of *well being* indexes for each household of the village

$$\langle WBIc \rangle = \mathrm{mean}(WBIc) \qquad \text{(Equation 11)}$$

This is valid even if there are missing values for the WBIc as long as missing values are not counted to compute the mean Therefore we do not adjust or calibrate on actual WBIq only on the descriptions of the indicators The results can then only be validated *a posteriori* The procedure is described in more details in the next section

5 Finding proxy variables in the census and computing a well-being index

Taking together population housing and agricultural censuses 200 or so variables we should be able to obtain a good approximation of Ravnborg's 11 indicators (Appendix 1) However Ravnborg obtained a rather strict definition of how these indicators are quantified into 2 or 3 categories and combined to give the *well being* index The *well being* questionnaire has well defined questions that allow well defined calculations in this context but not necessarily in the context of the censuses Let us take the example of the indicator of <u>Health</u>

Table 1 *Well being* indicator related to Health (from Table 7 Appendix 1)

Indicator	value	Description
Health	67	No one in the house was sick or if someone were sick he/she paid for adequate health care either with own money or by selling assets
	100	Someone in the household has health problems and they were treated by asking relatives for money borrowing money or by going to the herbalist or they were untreated for lack of money

Clearly it is impossible to find this exact indicator in the censuses The population census would be an appropriate source for a proxy but we used, in fact an indicator that had no resemblance with this description (see Table 3) and found poor correlation for the 12 villages as it was to be expected (see section 3 2 and Figure 7) A simpler example is Cattle Ownership

Table 2 *Well-being* indicator related to Cattle Ownership (from Table 7 Appendix 1)

Indicator	value	Description
Cattle ownership	33	The household has cattle
	67	The household does not have cattle

This indicator can easily be found in the agricultural census but we have to be aware those agricultural censuses are notably error prone The farmer may declare fewer cows that he actually owns in fact the higher the well being the higher the probability of lying on assets (RDH 1994a) In addition the agricultural census was designed to provide reliable information at municipal level so data from individual farms has to be used with care

To increase the possibility of finding reliable proxies in the censuses we have to simplify Ravnborg s indicators We can redefine each of the 11 indicators so that they will represent only two states lower and higher *well being* and assign them a value of 1 and 0, respectively In other words we can set a threshold for each indicator which will mark the boundary between lower *well being* and higher *well being* This would not change significantly the value of <WBI> (when scaled within 0 1 instead of 33 100) and would simplify our task considerably

We reinterpreted Ravnborg s homogeneity plots (Figure 4) to obtain and indication on what this threshold can be for each indicator We delimited the boundary between lower middle and higher *well being* categories (thick solid line) As we can see the distinction between the higher and middle is much better defined (straighter boundary) than between the middle and lower *well being* categories Prediction of middle *well being* would certainly generate confusion with the lower *well-being* We can however draw a line between the two boundaries that allow to determıne what ıs the value of each ındicator the mıdpoınt value that separate the hıgher and lower *well beıng* (dashed lıne) We found that most of the tıme thıs dıvısıon occurs between one of the *well beıng* category and the next one but ın some cases ıt falls wıthın the mıddle one (e g market ınvolvement health source of ıncome) Note that the descrıptıon of mıddle and hıgh *well beıng* ındıcators (Appendıx 1) are more complex than the low *well beıng* one whıch ıs to be expected sınce low well beıng households have access to less optıons than the better off ones

[Fıgure 4 around here]

If we take the example of <u>Cattle Ownershıp</u> the boundary between the poorer and the rıcher would correspond to one cow (sınce the dıvısıon ıs much closer to the low *well beıng* category so the proportıon of poorer farmers accordıng to thıs ındıcator only ıs the number of farmers wıth no cows dıvıded by the total number of farmers The proportıon ıs also equal to the average value for thıs ındıcator when ıt ıs scaled ın the 0 1 range We repeat the procedure for all ındıcators and end up wıth an overall value for each vıllage

The censuses were then screened to ıdentıfy whıch varıables would provıde proxıes ı e ındıcators that most closely resembled the 11 of Appendıx 1 and ended wıth 9 *Ic* (Indıcator from Census) summarızed ın Table 3 Four proxıes can be obtaıned from the populatıon and housıng censuses and five from the agrıcultural census In the case of the population and housing censuses we restricted the calculation to rural households identified as such in the censuses[5] This accounted in 1988 to approximately 60% of the total Honduras population and 70 80% of the poor (RDH 1994a) An analysis of the population and housing census data has shown that some localities with rural characteristics have been classified as urban in the census and vice versa (RDH, 1994a) however we retained the urban/rural classification that appear in these censuses All farms of the agricultural census were assumed to be rural ones

If both censuses could be joined at household level it would be possible to compute a WBI for each household (Equation 9) then compute summary values for various levels of aggregation But it is not the case the Agricultural census is independent for the other two However since the WBI is a linear combination of I we can compute a $\langle WBIc \rangle$ for each village from the mean of each indicator

$$\langle WBIc \rangle = mean(\langle Ic_1 \rangle \ \langle Ic_2 \rangle \quad \langle Ic_9 \rangle) \qquad \text{(Equation 12)}$$

[5] when the population of village was less than 2000 all households were considered as rural For cities with population above 2000 people we have no information about the criteria used to discriminate rural and urban households and some confusion persists (RdH 1994a)

By looking at the distribution of variables in the two dimensional space of the homogeneity plot (Figure 4) and having in mind what census provide a value for these variables (Table 3) we find that all censuses are needed to cover the full range in both dimensions This means that using *Ic* from one census only will only give a partial and biased estimate of well being therefore all censuses are necessary and complementary On the other hand it looks like the two indicators that we were not able to obtain from the census (<u>money</u> and <u>food security</u>) can be taken out from the set with no significant loss of coverage and with minimal risk of bias

Table 3 Proxies of Ravnborg (1999) *well being* indicators obtained from the 1988 Population and Housing census and the 1993 Agriculture census of Honduras

Indicator	**Census variable**	**Census**
Cattle ownership	Total cattle heads	Agriculture 93
Hire day labor	Total workers with pay	Agriculture 93
Land ownership	Size of exploitation	Agriculture 93
Health	Number of children dead/total number of children Urban or rural area	Population 88
Sell day labor	Relation to head of family Activity Class of activity Urban or rural area Total hours worked/number of people in household	Population 88
Housing	Ownership Roof material Walls material, Floor material Urban or rural area	Housing 88
Animal ownership	Total number of pigs horses oxen mules chicken hens sheep other poultry rabbits	Agriculture 93
Market participation	Production of permanent crops other annual crops Quantity of basic grains sold/Production of basic grains	Agriculture 93
Income	Occupation code Urban or rural area	Population 88

3 Results

1 Census-based UBNs and their comparison with the WBI

The results of aggregation of UBNs at village municipality and department levels following the methodology of section 2 2 are presented in Figure 5 For more clarity at village level we complemented the point representation with a polygon representation (Fig 5 d) that corresponds to the area of influence of the village (Appendix 2) We have chosen to represent the PUBNs by quantiles because it corresponds better to the way funding is allocated at a given target level We also chose a double-ended chromatic scale where the hue/saturation combination is greater at the extremes of the distribution to highlight the poorest (bright red orange) and the richest (bright blue) One can immediately see that depending on the scale or on the poverty index chosen the map (and the message it conveys) changes noticeably even for closely related indices such as PUBN3 and PUBN4 (UBN4 includes an Education Attainment index in addition to the same indicators that form UBN3) On the village level maps one can also observe that high investments in Educations (which resulted in better off villages in shades of blue) tend to have been uniform within several departments

We can also investigate how certain variables such as the ones used for the definition of the UBNs are related For example we found that housing is an indicator that explains well other factors by analyzing the correlation at municipality level (n=291) between CV CSIB CIA and CE (Table 4)

Table 4 Correlation coefficients between Population and Housing census indicators computed from municipality level data

	CV (housing)	**CSIB (services)**	**CIA (non-land assets)**	**CE (education)**
CV	1	0 79	0 76	0 7
CSIB	0 79	1	0 58	0 51
CIA	0 76	0 58	1	0 59
CE	0 7	0 51	0 59	1

We compared our UBNs to another published poverty measures for which we have municipal-level data i e FHIS (1992) Although our UBNs proportions are consistently higher results are strongly correlated (particularly PUBN3 see Table 6) This is not entirely surprising since the same census data has provided a large part of the information used by FHIS

[Figure 5 around here]

On Figure 6 we can appreciate how the WBI computed from *well being* questionnaires (WBIq) compares to the PUBN3 and PUBN4 at village level On the horizontal scale we have plotted the proportion of households having the lowest *well being* level for each of the 12 communities where questionnaire data was obtained We do observe some correlation but the match is poor which is expected as these indices measure different aspects of poverty However it is quite alarming to realize how crudely poverty measures via UBNs (i e most of the official ones) seem to reflect the perceived poverty in these 12 communities However there is a substantial difference between data collection periods of the Population and Housing census (1988) and of the *well being* questionnaire (1997) If we assume that rural poverty levels have changed very little during this 9 years period which has been reported recently (UNDP 2000 RDH 2001) and confirmed by us in this paper (section 3 2) we could say that our UBNs overestimate the proportion of poor as perceived by themselves in better off villages Therefore unsatisfied basic needs may not be perceived as important indicators of well being by the rural poor in Honduras and it is probable that other dimensions have to be addressed to improve their life in a way that they will perceive as relevant to them

[Figure 6 around here]

Before we red too much into these results we should be aware that the problem of a low correlation between different poverty indicators has been observed in numerous cases (Henninger 1998 see also section 2 1 of Part 2) Because of a sense of confidence linked to a perceived exactness of census data and to the technical somehow linear nature of data processing it is tempting to draw convincing conclusions that will look absolutely valid but that in fact can be as biased as others

2 Validation of census-based village-average WBI estimates

We know that the local indicators that we are trying to model are semi quantitative that the quality of our census-based proxy indicators (Table 3) is variable (and this variability is virtually unknown) and we understand that one may legitimately question their validity in the present context To gain some confidence on the possible application of our method we can analyze our results for the 12 communities for which the *well-being* questionnaire data has been collected Because of the random sampling and the large sample size the comparison of distributions of WBIq and WBIc for these villages is possible and is statistically significant However one must keep in mind that 5 and 9 years have passed respectively between the time the *well being* questionnaire was filled (1997) and the time of the Agricultural and of the Population and Housing censuses This would account at least for some of the discrepancies between computed and observed values of indicators

Comparisons are displayed on Figure 7 where the first 3 rows of plots correspond to the 9 indicators found in the census while the last row corresponds to the WBI i e the average of three sets of indicators For each indicator two graphs are presented On the scatter plot (leftmost graph) both axis represent the average value for the indicator (scaled between 0 and 1) the x axis corresponds to the 1997 *well being* questionnaire (lets call them <Iq> - Indicator from questionnaire) and the y-axis to the <Ic> from either 1988 Population and Housing census or the 1993 agricultural census The dotted line indicates what is expected in case of perfect match while the solid line corresponds to a robust regression through the points (with equal weight) On the rightmost plot three box plots are displayed corresponding respectively to the 1997 *well being* data (<Iq>) to the <Ic> and to the absolute value of the difference between <Ic> and <Iq> The box plot is interpreted as follows the solid black box represent + one standard deviation about the mean the white line inside shows the median The whiskers are drawn to the nearest value not beyond a standard span from the quartiles

[Figure 7 around here]

We will explore the plots of Figure 7 from left to right row wise Note than lower values on the scales corresponds to a higher *well being* situation The results for the 9 indicators (first three rows) are analyzed below The reader can find in Table 3 more details on the composition of the Ic

Sell day labor the <Ic> from the population and housing census present lower values and a narrower distribution than observed in the *well-being* questionnaire data (<Iq>) This means that people day labor more than what we can deduce from the population and housing census Possibly this is related to a fear of being taxed (or of doing something wrong) or to the nature of the census question that was pointing more towards a permanent working status than a possibly temporal state

Income the <Ic> from the population and housing census consistently underestimate the sources of income other than agriculture

Cattle ownership the <Ic> from the agricultural census reflects accurately the *well-being* data, which makes this indicator quite reliable Note that the robust regression is fooled by a particular alignment of data points possibly because of the low dispersion of both indicators

Health the <Ic> from the population and housing census is much more scattered than the <Ic> from the *well being* data, and this probably reflects our inability to find a proxy which description is similar to the <Iq> However average values are very close but this is possibly coincidental

Housing the distribution of <Ic> from the housing census is very similar to the <Iq> one except for one outlier which makes this <Ic> a reliable indicator Apparently housing quality has not changed in the 1988 1997 period

Animal ownership the <Ic> from the agricultural census and the <Iq> follow very similar distributions making this indicator an accurate and reliable one

Hire day labor the <Ic> which comes from the agricultural census seem to consistently underestimate the proportion of people hiring day labor This can be explained by the fact that the agricultural census was done in April at the end of the dry (cropping) season when demand for day labor is low (the question related to the one month period preceding the census) The *well being* data was collected between March and October 1997 and therefore reflects better the temporal and geographical diversity of day labor market and the fact that even poor people may hire day labor some time during the year

Land ownership the <Ic> provided by the agricultural census spans a broader range than the <Iq> which possibly indicates a failure in the agricultural census sampling, to correctly include the landless or a fear from the latter to declare their actual land ownership status to government officials

Market participation the <Ic> provided by the agricultural census follow a distribution similar to the <Iq> one but aligns quite poorly on the ideal match line

Our results for the *well being* index are shown on the last row of Figure 7 On the scatter plots the y-axis represent the <WBIc> (the average value of several <Ic> see Equation 13) while the x axis represents the average value of the WBI as obtained from the *well being* questionnaire i e <WBIq> The first scatter plot (Figure 7j) corresponds to the average of all 9 <Ic> To investigate the effect of doubtful proxys on the resulting <WBIc> we took out the Ic corresponding to indicator Hire day labor and computed another <WBIc> (Figure 7k) then took out another Ic again that correspond to Health (Figure 7l) In all three cases the data points align well on the ideal line (left plot dotted line) and have similar ranges (right plot) which means that WBI obtained from the *well being* questionnaire in 1997 are reproduced by 1988/93 census data with a relative error of less than 10% Therefore we can conclude that there has been little improvement in the condition of the rural poor as measured from the viewpoint of perceptions during this 5 9 years period The Honduras structural adjustments in the 1990s and the safety nets that were put in place to counterbalance their possible negative impacts do not seem to have resulted in any improvement of the well being perceived by rural populations

Note that no adjustment was necessary our results come from raw calculation from carefully chosen unit level census data By averaging several indicators we reduce the effect of their respective error and end up with a more accurate and meaningful measure of well being which can be extrapolated to all villages for which raw census information exist

In slow developing countries such as Honduras therefore old censuses can retain a lot of value and can be exploited to extract good information for policy analysis and design However recent interview data (such as yearly household surveys) is needed to assess the relevance of older census data in more recent context

3 *Extrapolation domain for the well-being index*

Now that we have a *well-being* index computed for virtually all villages of Honduras, it is tempting to use our results beyond the domain it was designed to address As mentioned in section 2 3 indicators were obtained based on a sample of villages distributed in three departments these villages were chosen to be contrasting which was estimated based on the combination of six factors altitude basic services (education and water) population density ethnicity gender composition and travel time to urban centers

It would be naive to think that the well-being indicators would be automatically valid for all villages that present a combination of factors that can be found in the sample In effect we know that coastal villages or jungle villages of La Mosquitia (flat jungle in Eastern Honduras) live another reality than the one we observe in the sampled villages no matter what data (of variable quality) we may have for these villages On the other hand we have the intuition because we know rural Honduras quite well that the indicators of Appendix 1 apply to more villages than the ones of the three departments of the sample

How can we draw the boundary of the extrapolation domain? First we can safely suppose that our results are valid within the three departments from which the sample was drawn Because of our knowledge of Latin American hillside populations we are convinced that the indicators of Appendix 1 will apply to all Honduras hillsides but we are not in a position to prove it formally at this time

We can then try to move beyond by assuming that households with a typology corresponding to a sampled one will have a perception of poverty that is properly grasped by the indicators of Appendix 1 The question is therefore can we construct a valid typology of households and, by extension of villages - from our database and can we assess objectively the similarity of two households or villages? This would imply selecting a series of variables for the household then perform a cluster analysis Some of these variables should reflect the structure of the neighborhood and some regional influences The number of clusters chosen i e number of households types may be decided empirically or according to a given statistical measure Given the number of steps required and the assumptions involved the risk to completely miss important indicators is real and massaging our databases more will not help reduce it Expert knowledge may be a better alternative but again how can we be sure we are not extrapolating based on the anecdotal or worse prejudice?

Apparently the safest way to broaden the extrapolation domain is to select a sample that is more diverse thematically (i e probably some more factors than the 6 originally chosen) and geographically (to acknowledge the reality of regions) Within this sample the participatory work to obtain locally relevant indicators would have to be completed The process should be iterative once the indicators are obtained the relevance of the factors to select the sample is evaluated which may lead to a readjustment of the sample Once we are sure of the indicators and of their quantification into indexes we can locate proxies in the censuses and redo the calculations

4 *Well-being index profiles for the country*

According to Lok Dessalen (1995) a poverty profile is an analytical tool that summarizes poverty-related information and attempts to answer questions such as what are the poor why they are poor and where they live Doing a full profile nationwide is clearly beyond the scope of this paper and vastly exceeds the competence of the author However we can give a few hints on how to assemble display, and process the information to help the construction of a poverty profile

We will therefore explore in this section a few ways for summarizing poverty data and display it in map form

The <WBIc> have been computed for all villages where census data was available to define all 9 indicators (3712 villages out of a total of 3729 and 291 municipalities out of 292) As we noted before the Population and Housing and the Agricultural censuses cannot be joined at household/farm level therefore we cannot construct a complete household poverty profile Even if we could link the censuses at this level household/farm information may not be accurate enough to provide reliable profile for small villages However we can produce a reliable profile at municipal level based on information aggregated at village level This is useful for example for a mayor who requires a snapshot of the distribution of poverty in his jurisdiction

There are several ways to aggregate data and give new meaning to it but we will focus on the two most commonly used averaging and proportions (i e headcount) Because we have 4 indicators computed from the Population and Housing census (where the basic unit is the household) and 5 computed from the Agricultural census (where the basic unit is the farm) the village-level *<WBIc>* can be aggregated to municipality and department level as follows

$$< WBIc > = \frac{1}{N} \sum_{j} (n_j < WBIc >_j) \qquad \text{(Equation 13)}$$

Where

$$n_j = \frac{4nh_j + 5nf_j}{9} \qquad \text{(Equation 14)}$$

nh_j and nf_j being the number of households and farms in village j respectively and

$$N = \sum_j n_j \qquad \text{(Equation 15)}$$

the sum running on all villages j within the aggregation unit (municipality or department)

It is more common to see poverty profiles expressed not in terms of average values of an indicator but as a headcount index i e the number or proportion of people in poverty as defined with respect to a threshold value for a given indicator PUBN3 and PUBN4 derived in section 2 2 are examples of such indices that we were able to compute because they are based on the population and housing censuses which are joined at household level It is not the case of the WBI for which unfortunately we could only obtain average values for the villages because the three censuses were needed and could not be joined at household level Therefore we are in a position to produce useful headcount indices based on the WBI as long as we make a few assumptions on the shape of the distribution of household WBI in a village

The household information obtained by Ravnborg (1999) together with computer simulations will allow us to predict with reasonable accuracy the proportion of poor based on <WBI> for a village For more clarity in the discussion we will rescale the WBI between 0 1 instead of 33-100 On the last row of Figure 8 a we can observe that the proportion of households with a WBIq greater than a certain threshold (which we will call PWBIq) is linearly related to the <WBIq> with little relative error (7% in case of a threshold of 0 5) We could use the regression parameters to predict for all Honduras villages the proportion of poor based on their average <WBIc> but this would overlook important assumptions which have to be verified beforehand First we are certain that not all villages in Honduras have a distribution of household WBI similar to the ones of the 12 communities Second we do not know if the correlation between PWBIq and <WBIq> is good by coincidence or if it represents some remarkable property that we can safely rely on Computer simulations can help explore the possibilities and assess the domain of the feasible

A look at Figure 3 shows that the distribution of WBIq is reasonably normal with a standard deviation in the range 0 13 0 2 (when the WBIq are scaled in the range 0 1)

Our strategy was to generate random populations of household WBI from normal distributions of various widths and means and examine the relationship between the

PWBI computed from these populations and the mean WBI In other words we have generated a large sample of values from a WBI population having a given mean in the range 0 2 0 8 and a given width Generated WBI were truncated to stay within the range 0 1 which approximates the effect of skewed populations near the extremes The <WBI> and PWBI are then computed from each distribution and for threshold values ranging from 0 2 to 0 8 The effect of the width of the distribution was evaluated by varying the standard deviation from 0 1 to 0 75

The results are summarized in Figure 8 We can observe from the 5 first rows of Figure 8 a that when the distribution of WBI is not too narrow the PWBI and <WBI> are linearly related with a slope and intercept that do not vary much for a given threshold value (Figure 8 b) The slope does not even change much with respect to the threshold If we assume that the actual distribution of WBI within a village cannot be narrower than the ones we observed (Figure 3) we can use our regression results for prediction Table 5a reports the average value of the slope and of the intercept obtained for WBI distribution width ranging from 0 15 to 0 5 Table 5b reports the slope and intercept obtained from the WBIq (see last row of Figure 8 a) For a threshold of 0 5 we could predict the PWBIq from <WBIq> with 87% accuracy (instead of 94%) in addition PWBI from simulated data could be predicted within 5% On the other hand if we use regression parameters from the WBIq we are confident for the 0 5 threshold that we can predict PWBI from

<WBI> wıthın 18 6% ın 75% of the cases However we should be very careful before usıng any regressıon parameters for thresholds above 0 6

[Fıgure 8 around here]

Table 5a PWBI(T) = a<WBI>+b Sımulated Regressıon parameters and estımated relatıve error (<WBI> ıs scaled between 0 and 1)

Threshold (T)	**a**	**b**	**Error (WBIq)**		**Error (sımulatıons)**	
			Medıan	**3rd quantıle**	**medıan**	**3rd quantıle**
0 3	1 30	+0 11	10 6	12 7	4 7	8 2
0 4	1 61	0 17	10 7	14 9	4 6	8 1
0 5	1 72	0 36	12 9	15 2	5 0	9 6
0 6	1 61	0 44	20 6	32 4	8 8	17 2
0 7	1 32	0 42	59 8	122 7	12 9	30 1

Table 5b PWBIq(*T*) = a<WBIq>+b Regression parameters for questionnaire data and estimated relative error (<WBI> is scaled between 0 and 1)

Threshold (*T*)	a	b	Error (WBIq)		Error (simulations)	
			Median	**3^{rd} quantile**	**median**	**3^{rd} quantile**
0 3	1 17	0 27	2 9	5 3	13 7	19 8
0 4	1 86	0 22	4 2	7 3	13 6	18 5
0 5	2 00	0 44	6 1	9 7	11 1	18 6
0 6	2 23	0 81	13 0	17 9	20 6	32 4
0 7	1 74	0 72	23 0	74 8	37 4	90 1

What do these simulations teach us? First that there is no substitute to databases that are linked at household or farm level and that issues of confidentiality will have to be resolved if good analysis is what we aim at However we will always need important datasets for which only average values exist and it would be possible to do more with it provided we have good information on the distributions For example if our sample of WBIq was more exhaustive we could use the regression parameters of Table 5b with more confidence for villages outside the sample The work of Bigman et al (1999) is a good example of how such synergy between disjointed datasets can be achieved

Aggregatıon of Pwbi wıll be done as follow

$$PWBIc = \frac{1}{N}\sum_j n_j PWBIc_j \qquad \text{(Equation 16)}$$

wıth N and n defined by Equatıon 14 and 15

Fıgure 9 presents a serıes of maps dısplayıng varıous representatıons of the <WBIc>[6] On the left we have chosen the same representatıon as ın the case of Fıgure 5 ı e aggregatıon at Department and Munıcıpal level of vıllage level <WBIc> represented both as poınts (vıllage center) and polygons (vıllage AOI) and 5 <WBIc> categorıes defined as the quantıles of the dıstrıbutıons whıch gıve a good ıdea of how ınvestments may be allocated geographıcally We also used the same double ended chromatıc scale wıth darker saturated colors at the extremes On the rıght we have produced geographıcal star plots for the department munıcıpal and vıllage-level <Ic> whıch allows to grasp ınstantly how the 9 dımensıons of poverty descrıbed by the 9 <Ic> contrıbute to an overall <WBIc> For each star the length a branch ıs proportıonal to the <Ic> for one ındıcator the longer the branch the poorer ıs the Department Munıcıpalıty or vıllage along that dımensıon star area ıs proportıonal to the <WBIc> Regıonal patterns emerge naturally through

[6] Note that the PWBI and <WBI> beıng lınearly related maps produced from both ındıces wıll look remarkably sımılar

exploration of the geographical distribution of star plots This new type of plots which has not been reported before in the literature can improve significantly the efficiency of communicating of multidimensional data in a geographical context

[Figure 9 around here]

4 Discussion

Census data are large and exhaustive household surveys and as such are suitable for a broad range of microeconomic analyses (King and Bolsdon 1997 Deaton 1997) While it was not particularly challenging to demonstrate the feasibility of computing classic poverty indicators from raw census data, the extrapolation of locally derived poverty indicators is a different story The accepted view concerning the results of a PPA is that extrapolation depends exclusively on empirical generalization (Shaeffer 2001) Indeed Ravnborg (1999) obtained with a PPA 11 indicators that could be safely be used to describe poverty in 3 Honduras departments but the additional statistical design and subsequent analysis provided a way to quantify these indicators By finding proxies of these indicators in the censuses and map them we could demonstrate that PPAs could give results well beyond what we usually see

Although the maps produced for the various indicators at various levels of aggregation do show similarities (we try to measure poverty incidence after all) they are sufficiently different to justify questioning the relevance of the whole poverty measurement exercise Not only the indicators chosen give a different view of the poverty but also the way these indicators are displayed or aggregated have tremendous influence on perceived distributions This perception in turn is key to policy design which will have a direct impact on the incidence of poverty

The correlation coefficients obtained between PUBN3 PUBN4 and <WBI> data at various aggregation levels are given in Table 6 A look at the table helps to evaluate the degree of confidence to expect when basing a policy decision on a given indicator at a given aggregation level

Table 6 Correlation matrix between several poverty measures at various aggregation levels Correlation coefficient greater than 0 5 appear in bold

		Village			Municipality			Department		
		<WBI>	**PUBN4**	**PUBN3**	**<WBI>**	**PUBN4**	**PUBN3**	**<WBI>**	**PUBN4**	**PUBN3**
Village	**<WBI>**	1	0 38	0 44	**0 60**	0 27	0 29	0 37	0 22	0 24
	PUBN4	0 38	1	**0 84**	0 31	**0 67**	**0 53**	0 31	**0 61**	**0 59**
	PUBN3	0 44	**0 84**	1	0 30	0 47	**0 50**	0 24	0 34	0 36
Municipality	**<WBI>**	**0 60**	0 31	0 30	1	0 43	0 48	**0 62**	0 33	0 38
	PUBN4	0 28	**0 67**	0 47	0 43	1	**0 91**	0 43	**0 81**	**0 77**
	PUBN3	0 29	**0 53**	**0 50**	0 48	**0 91**	1	0 43	**0 63**	**0 66**
Department	**<WBI>**	0 37	0 31	0 24	**0 62**	0 43	0 43	1	**0 55**	**0 63**
	PUBN4	0 22	**0 61**	0 34	0 33	**0 81**	**0 63**	**0 55**	1	**0 96**
	PUBN3	0 24	**0 57**	0 36	0 38	**0 77**	**0 66**	**0 63**	**0 96**	1

Correlation between poverty indicators UBN3 (or UBN4) and WBI is low which was to be expected given the large difference in the concepts underlying the definition of these indicators Intriguingly correlation between UBN3 and UBN4 is not as high as we may expect (0 84 at village level) given the fact UBN4 uses exactly the same data and basic needs indicators as UBN3 the only difference being an additional indicator of education This is explained by the fact that Education is poorly correlated to Unsatisfied Basic Needs (Table 4) However the most striking result is that there is such a low correlation between aggregation levels even for the same indicator, e g 0 36 between department and village level PUBN3 This gives an idea of the validity at household level of a policy based on data aggregated at higher levels

McGee (1999) has compared side to side the poverty levels obtained via a PPA and via a classic approach used by the Colombian government to target its social programs The PPA elicited the views of poor people through standard well-being ranking while the official" view was given by SISBEN s family poverty indicator a weighted multicriteria index obtained trough a household questionnaire (Castaño & Moreno 1994) Spearman s rank order correlation test computed from household data gave a value of 0 44 for the village of Uribe (n=87) which is on the same order of magnitude as the village level correlation between PUBN3 or PUBN4 and <WBI> This means (roughly) that more than 50% of the households (or the villages in our case) are likely to question the relevance of pro poor government spending

Other studies have also highlighted the fact that the distribution of poverty is extremely sensitive to the choice of poverty indicators (Boltvinik 1996 Glewwe and Gaag 1988) In Part 2 we show that the spatial distribution of poverty patterns it is also very sensitive to classification strategies It is alarming to realize that decisions that will affect poor people s lives are made on such unstable foundations But the most insidious effect may be that we feel so confident in the correctness of our measurements because we use of accurate data and very reasonable indicators Few decision makers have realized this probably because it is painful to compute and compare many indicators it is annoying to find such a low correlation between these extremely rational and accurate indicators it is difficult to explain why there are differences and to justify the choice of one indicator over another

The challenge to empower people to extract meaningful information from census data is greater that we may initially think The poorest municipalities are almost guaranteed to receive aid money and every mayor would strongly defend the indicator that favors his municipality Preserving confidentiality of disaggregated data is still an unresolved issue

In Part 2 we address in more details these issues of poverty measures and representations in the context of policy design and community empowerment

5 Conclusion

Everyone agree that poverty is multidimensional is complex and that poverty estimates are subjective Despite this apparent consensus analysts are constantly urged to provide one summary number one poverty index that will fill all expectations on which reforms can be based or investments be targeted The 1$/person/day" is a good example of such one-dimensional yet extremely influential indicator One may agree on such a number by default because it is too complicated (or takes too much time) to define and compute a poverty measure tailored to diverse needs and share it with other players We showed that it is not difficult to quickly derive complex in a flexible way as long as highly disaggregated data is accessible

On the other hand poor farmers which are living with another reality of poverty than the one of policy makers may not see some social investments such as latrines as a way to end their poverty This has been realized by Cornell University and the McArthur Foundation who brought together poverty analysts with different backgrounds from the social sciences to neoclassical economics to examine the complementarities and divergences of quantitative and qualitative approaches to poverty appraisal (Kanbur *et al* 2001) The work that we have presented here that links a measure of locally relevant indicators to nationwide databases is one way to achieve this synergy It may contribute to bridge the knowledge gap between decision-makers and poor farmers because it provides quantifiable means for the necessary self critical epistemological awareness (Chambers 1997) in developing a common language for poverty In order to fully achieve this potential poverty appraisal has to be part of a development process where alternative legitimate knowledge is embedded in the policy making process

It must be clear that we do not pretend that the UBNs or the local *well being* indicators presented here are right or ' better they are other representations of the same reality and are as biased as others However all representations acquire their best value when contrasted socialized and shared between all players In other words poverty measurement representation policy and action issues are inseparable In the second part of this paper we address in more detail the issue of representation of poverty indicators and provide some methodological clues to help contrast and harmonize them

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Appendıx 1 Indıcators of the partıcıpatory *well-beıng* ındex

The ındıcators of the *well-beıng* ındex (WBI) obtaıned from partıcıpatory exercıses ın Honduras departments Atlantıda Yoro and El Paraıso (Ravnborg 1999) are gıven ın Table 7

Table 7 Summary of Indıcators of local perceptıons of *well-beıng*

Varıable	**Score**	**Condıtıon**
Land Ownershıp	33	The household owns 4 *manzanas* (2 8 ha) or more or has land ın pasture or gıves land ın rent to other farmers
	67	Household owns land but fewer than 4 *manzanas* (2 8 ha) and doesn t have land ın pasture nor land ın rent to other farmers
	100	Household doesn t own land or only owns the house and land upon whıch ıt stands
Sell Day Labor	33	Nobody ın the household works as a day laborer and the housewıfe does not do housework for other famılıes nor prepare food to sell
	67	Someone ın the household works as a day laborer but eıther for fewer than 9 months or for more than 9 months but fewer than 3 tımes a week

	100	Someone in the household works full-time for more than 9 months a year as a day laborer or if the housewife does house work for other families or sells prepared food
Income	33	Someone in the household is a professional a businessman or a merchant or if children or other relatives send remittances
	67	Someone in the household is a skilled worker but no one in the household is a professional businessman or merchant and the household receives no remittances
	100	No one in the household is a professional businessman merchant or skilled laborer and the household receives no remittances
Hire Day Labor	33	Household contracts day labor
	67	Household does not contract day labor
Cattle ownership	33	The household has cattle
	67	The household does not have cattle
Animals ownership	33	The household owns horses pigs or oxen
	67	Household owns chickens but not horses pigs nor oxen
	100	Household owns no animals
Housing	33	If the household owns its own house and the house is of good quality
	67	Household owns its own house but it is not of good quality
	100	Household owns its own house but it is of very poor quality or does not own its own house

Market participation	33	Household grows coffee or cacao or if household does not buy basic grains and sells half or more of its production of basic grains
	67	Household does not grow coffee but buys both buys and sells basic grains or if the household does not but basic grains and sells less than half of its production
	100	Household does not grow coffee or cacao and it buys basic grains in addition to using all of its production for home consumption
Money	33	Household has a savings account or makes loans to others
	67	Household does not save nor make loans
Health	67	No one in the house was sick or if someone were sick he/she paid for adequate health care either with own money or by selling assets
	100	Someone in the household has health problems and they were treated by asking relatives for money borrowing money or by going to the herbalist or they were untreated for lack of money
Food Security	67	Household has not experienced a food shortage, or did for less than a week and solved it without having to ask others for food or money to reduce number of meals or to send the wife or children out to work

	100	Household experienced a food shortage for more than a week or of less than a week but had to solve it by asking for food by borrowing money or by sending wife and children out to work

Appendix 2 Determining the area of influence of a village

We will define the area of influence of a village (AOI) as the neighborhood in interaction with a village center Schematically a village consists in private and public land with buildings (homes industries) and roads arranged in a more or less dense core (the village center) which spreads out as we move away Houses and buildings roughly follow the road pattern but in rural Honduras agricultural fields (and often poor households) may be located quite far from a road accessible by foot or donkey through a series of paths that do not appear on official maps

In a GIS context the question is now to see how from the village point coverage which corresponds to the location of village centers it is possible to create a polygon coverage representing the area of influence of a village in order to dispose of a similar representation as for municipalities and departments Thiessen polygons have proven to be quite useful but it is possible to construct a much more accurate representation provided we have a DEM a road map and land use map The hypothesis we make is that the AOI of a village is determined by the accessibility to the village center i e the time it takes to travel to the village center from a given location The travel time is determined by the transportation network the terrain slope and land use along the path to the village center

We used ArcView accessibility tool (Farrow and Nelson 2001) to produce a travel time surface a raster grid where each pixel receives the value of the time it takes to travel to the nearest village center Then village catchment regions are generated from the accessibility surface just like a series of watersheds can be generated from a DEM (figure 10) We used a 50m resolution DEM and road network coverage (from 1 50 000 scale topographic maps) and a land use map at 1 250 000 scale

To validate our AOI coverage we used georeferenced interview data for 768 Honduran farmers (Ravnborg 2002) Each farmer of the random sample located their main field for agricultural production on orthophotos or maps The coordinates were digitized and linked to the database of questionnaire information Incidentally the questionnaire contains information on the hamlet and on the village to which the farmer claims he belongs to

The zoom areas of Figure 10 show for the three watersheds covered by the sample how coincident (spatially) are the villages as stated by farmers (small square dots) and the AOI of the villages (colored polygons) as computed from the village centers coverage (large square dots) To help visualize the spatial accuracy we use a different color for each village which we assign to the village center and AOI and to the farmer field location according to their claim We can see that our AOI reflects very accurately the farmer s perceptions except in flatter relief (top left of Figure 10) This may be caused by a greater confusion in the sense of place because of better accessıbılıty ı e farmers are more mobıle Another possıbılıty whıch ıs also lınked to ıncreased mobılıty ıs that the farmer's maın field may be located far from ıts house

[Fıgure 10 around here]

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Figure Captions

Figure 1 Schematic representation of the hierarchy of our Unsatisfied Basic Needs Index (UBN) UBN4 is essentially the same as UBN3 but includes an additional indicator related to Education

Figure 2 Map of Honduras showing departments sampled (shaded) the 90 villages where *well-being* indicators have been obtained (large squares) and the 12 villages where the *well being* questionnaire has been used (stars)

Figure 3 Q Q plots to verify condition of distribution normality quantiles of the *well being* index (vertical axis) vs quantiles of a standard normal distribution

Figure 4 Homogeneity plots (from Ravnborg *et al* 1999) showing the contribution of indicators to *well being* levels High (H) Medium (M) and Low (L) The thick line represent an approximate boundary to separate the H M and L categories The dashed line is the approximate boundary between the higher and lower *well being* (WB)

Figure 5 Maps of the Proportion of poor which UBN3 (and UBN4) is greater than 0 4 at Village Municipality and Department levels Legend categories are defined as quantiles of the distributions

Figure 6 Scatter plot of the census based P_{UBN3} and P_{UBN4} with respect to the proportion of households classified by informants in the poorest *well being* category

Figure 7 Scatterplots and boxplots of average values of indicators from the census (vertical scale) vs values obtained with a *well-being* questionnaire in 12 communities (a) (i) <Ic> vs <Iq> (j)-(l) <WBIc> vs <WBIq>

Figure 8 (a) first 5 rows simulated proportion of households which WBI (P_{WBI}) is greater than *Threshold* (*T*) in function of <WBI> for distributions of width Standard Deviation (*S*) last row actual $P_{WBIq}(T)$ vs <WBIq> for data collected in 12 communities for various *T* (b) 2D maps of slope and intercept of regression line between simulated $P_{WBI}(T)$ and <WBI> showing the variation in function of *T* and *S*

Figure 9 Left Maps of the <WBI> (average household WBI) at Village Municipality and Department levels legend categories are chosen as quantiles of the distributions Right star plots in a geographical context of average values of household-level Ic each branch of the star correspond to one of the 9 local dimension of poverty found in the census

Figure 10 Area of influence (AOI) of Honduras villages as computed based on a surface of travel time to village center On the zoomed areas the farm symbols are colored according to the village that farmers perceive they belong to (Ravnborg 2002) The solid lines in cyan represent the boundary of CIAT's pilot watersheds in Honduras Cohen s Kappa index of agreement (Cohen 1960) between the farmer s perception and AOI are given for each region

Title

A spatial model of accessibility Linking population and infrastructure to land use patterns in the Honduran hillsides

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Abstract

This paper presents two applications of a simple spatial model that can estimate potential accessibility and thus delineate market catchment areas The model is closely related to von Thünen s theory of the isolated state

One study compares the access to market model to a traditional crow-flies distance model and their relationship to the underlying land use patterns The second compares to market catchment areas to administrative units at a similar local level to assess their ability to represent the perceived boundaries of local communities

The results show that market catchments are consistent with perceptions of local boundaries and performed better than the official boundaries From the second study land use patterns are more closely and more consistently related to travel time than distance over two time periods and over two scales of analysis

1 Introduction

The last 20 years has seen dramatic changes in local rural development and planning Greater emphasis on economic liberalisation has seen many national governments cease to be the major providers of services infrastructure and facilities Regional and local levels of government as well as state institutions have become more important seeing themselves increasingly vested with the responsibility for economic development and employment creation-though not necessarily with the means to carry this out (Dixon Fyle 98)

Our interpretation of rural development and rural economies stems from Von Thunen's model of land use even though the real world is much more complex (Hite 98) However if the simplicity of the Von Thunen model is a problem it is also a great advantage in helping to isolate essential relationships and generalise about the fundamental nature of rural economies Given that local (demand-driven) development is accepted as the means to make the most efficient use of scarce resources then Von Thünen s theory might be a suitable starting point for grasping local realities and understanding rural economies and their movements But we first need to define what is a rural economy and what factors affect its development

A basic problem facing the analysis of geographic data is the choice of units or boundaries for representing the data The choice of measurement unit is usually limited to two options digitised administrative/political units or watershed boundaries that have been generated from elevation and watercourse datasets Neither is entirely suitable for modelling rural economies

The first recourse is to political boundaries hierarchical units such as states counties and enumeration unit (in Honduras these are departments *departmentos* municipalities *municipios* towns - *aldeas* and villages *caserios*) Although census data is available at one or more of these levels their relationship to the underlying distribution of the rural population is often poor since the boundaries are determined a by a confusing mixture of historical and political decisions that often bear little resemblance to the underlying demographic pattern This is especially true of the aggregate levels where any inferences about individual characteristics from the aggregate data are subject to the ecological fallacy (Robinson 1950)

On the other hand watersheds are derived directly from the lay of the land and have a direct relationship to local geography water resources and agriculture Management and modelling at the watershed level usually addresses issues such as

- On site loss of land productivity and the welfare of the people who rely on that land
- Peak (storm) flow of water and the implications for floods in lowland areas

- Dry season base flow especially for people animals or industries that abstract water directly from streams
- Sedimentation of lowlands reservoirs and lakes

(Van Noordwijk *et al* 1998 p 224)

But as Rhoades (1998) points out people do not live or manage resources simply by how surface water flows The problems of focusing on hydrologically defined units in sustainable development projects are well documented (Jinapala *et al* 1996) as they have little direct significance for the degree to which a given community is involved in economic activities

Rural economies are characterised by a spectrum of social physical and agricultural factors and constraints and neither watersheds nor political units can claim to represent all of these dimensions People s mobility is critical yet this dimension has been systematically overlooked by the development process or in the best cases has been oversimplified It is here that the Von Thunen model can play an important role in defining in a rigorous and reproducible way the regional extent of rural economies

1 1 Von Thunen

Early in the 19th century amateur economist Von Thunen developed a model of land use that showed how market processes could determine how land in different locations would be used The model is based on the following assumptions

- The city is a self sufficient Isolated State hence there are no other cities
- The city is surrounded by a flat featureless wilderness hence no roads
- Market price is the same for all producers of a given product
- Yield is invariant of location hence climate and soil are constant
- Transportation costs are proportional to distance and invariant to direction
- Farmers act to maximise profits

(Von Thunen 1926)

In an isolated state with the foregoing statements being true Von Thunen hypothesised that a pattern of concentric circles would develop with intensive farming nearest followed by forested areas and timber production then extensive field crops and finally ranching (figure 1) The Von Thunen model is an excellent illustration of the balance between land cost and transportation costs As one gets closer to a city the price of land increases The farmers of the isolated state balance the cost of transportation land and profit and produce the most cost effective product for market

1 2 Reality

But few regions are self sufficient the terrain in the Honduran hillsides is anything but flat and featureless soil quality is possibly the most heterogeneous of all biophysical variables and there is a complex road network permeating the landscape Von Thunen s neat concentric circles are continuously being disturbed erased and redrawn Rural development is about a process of change in time and the Von Thunen model taken by itself offers only limited insight into the dynamics of change in remote economies

If we interpret the concentric rings as rings of economic distance rather then Euclidean distance then we can replace distance with some measure of economic cost If such a definition is to be accepted however it must follow that since some places are more remote than others some places are also more rural than others However measured there are degrees of remoteness and degree of rurality Since economic distance refers to the costs of overcoming the friction of space being rural means operating under the economic disadvantage of having to overcome costs that are lower in other places that are less rural And since the costs of overcoming distance are not forever fixed and indeed are radically altered by innovations in transport and communications the degree of remoteness i e rurality shifts through time in ways that dictate the economic opportunity of a particular location

This economic cost and its inequity amongst the population can be termed accessibility the ease in terms of time effort and cost with which a need can be satisfied

1 3 Accessibility

Accessibility has been defined as the ability for interaction or contact with sites of economic or social opportunity (Deichmann 1997a) however there are a multitude of ways in which this intuitive concept has been expressed in the literature Goodall (1987) defines accessibility as the ease with which a location may be reached from other locations and Geertman (1995) states that the concept of accessibility can be used in rural development policy as an indicator or rural deprivation and as a variable on location analysis

Access is a precondition for the satisfaction of almost any need and certainly for all physical needs hence accessibility provides a central integrating concept with which to grasp the complex interactions between the subsistence economic and social needs of any population (Dixon Fyle 98)

If the level of accessibility can be estimated then boundaries of the potential catchment areas of each market can be drawn, providing a spatial unit that is related to

- social and economic aspects such as population pressure infrastructure and services provision
- physical aspects such as topography rivers or barriers and
- agricultural aspects such as land use and land use change

Geographical information systems (GIS) lend themselves naturally to the computation of accessibility indicators GIS can represent networks villages or facilities and provide functions to compute distances and to define relationships among spatial objects Consequently certain accessibility measures can be computed using packages such as IDRISI GRASS and ArcView

This chapter argues that

- Accessibility can be modeled easily in a GIS environment
- Market accessibility is closely related to land use
- Market catchments are a useful unit of analysis for rural development

What follows are two case studies of the accessibility model applied in the Honduran hillsides

2 Methodology and data

2 1 Data

The transport network is represented by a *friction surface* that consists of a regular two-dimensional grid (raster) where each cell in the raster represents either a transport route such as roads railway lines tracks or navigable rivers or relatively inaccessible land and water bodies The transport network was generated from 1 50 000 topographic sheets containing high detail road and river information including road type and river width Travel speeds were taken from the literature (Chesher and Harrison 1987 Archondo Callao and Faiz 1994 Barwell 1996) and from surveys and driving times within

Honduras Slope data were similarly derived from the 1 50 000 map sheets using 100m contour intervals (and 20m intervals for coastal areas) that were interpolated into digital elevation model Slope was used as a factor to decrease the maximum speed on steep inclines assuming that travel speed is reduced for both uphill and downhill travel

The markets (towns and villages) are usually located on the transport network and are represented by a *target* raster The target data is represented by aldea centres (figure 2)

Additional datasets include official aldea boundaries that were digitised by *Secretaria de Recursos Naturales y Ambiente de Honduras* (SERNA) and 30m resolution land cover data, based on classified LandSat TM images from 1986 and 1994

To validate our village market catchments we used georeferenced interview from an independent study (Ravnborg 2002) aiming at understanding the linkages between well being and natural resources management In this study data was collected for 12 villages and a total of 768 Honduran farmers located in three distinct regions

- Rio Saco in the north coast (208 households)
- Tascalapa in the central highlands (270 households)
- Cuscateca in the south (290 households)

For each village farmers were selected randomly from a list of inhabitants and were asked to fill a questionnaire In addition each farmer had to locate on orthophotos and maps, the field that they used for their main agricultural production The coordinates of these fields were digitized and linked to the database of questionnaire information Incidentally the questionnaire contains information on the hamlet and on the village to which the farmer claims he belongs to which we can use for validation

2 2 The accessibility model

The accessibility model is based on a GIS costdistance algorithm that calculates for least-accumulative cost-distance to each market across the transport network and determines the catchment area of each market The model has been developed by CIAT into a publicly available GIS tool called the Accessibility Analyst This software a user manual example applications and technical notes can be downloaded from the CIAT website (figure 3)

2 2 1 Calibration

An accessibility maps was generated for the CIAT benchmark site of Tascalapa (figure 4) with the following assumptions

Dry Season	Velocity per transport type (km/hr)			
Surface type	**Car**	**Truck**	**Bus**	**Walking**
Paved road	100	80	60	6
Packed earth road	60	40	30	6

Track or footpath	20	10	NA	5
Forested	NA	NA	NA	4
Croplands	NA	NA	NA	4
Bare soil	NA	NA	NA	4

Wet Season	**Velocity per transport type (km/hr)**			
Surface type	**Car**	**Truck**	**Bus**	**Walking**
Paved road	80	50	40	5
Packed earth road	40	30	20	5
Track or footpath	NA	NA	NA	4
Forested	NA	NA	NA	3
Croplands	NA	NA	NA	3
Bare soil	NA	NA	NA	3

These values were validated by fieldwork in the study site by compiling travel time information for both vehicle and foot based travel An example travel-time matrix is shown in Table 1 The figures in bold are journeys that were made as part of the verification Additionally farmers were asked to estimate the time it took to walk to markets and this too was compared to the model although sometimes the responses were vague and we acknowledge that it is difficult to verify these results

The model corresponds very well to the observed data Over 60 routes were travelled and the average error per route was less than 10% with the lowest errors being on routes with flat good quality roads and the greatest errors on steep sinuous paths and trails Most errors were attributed to inaccurate and old road quality data for example the main road passing north sough through the area has been recently re paved with compacted earth and gravel producing far quicker travel times than the model had predicted After changes were made to the road database to reflect the current situation an almost perfect fit was achieved

2 3 Methodology

2 3 1 Study 1

The test site for the first study surrounds Tascalapa The main road runs north south through the two municipios passing through Yorito and other aldeas Two land use/land cover images were available for this region from 1986 and 1994 as was a 50m resolution slope map (figure 5)

We compared the relationship between land use with distance to markets (Von Thunen) with travel time to markets (accessibility) With accessibility we define bands of land used based on time to market thus changing the symmetrical nature of the model

With both models we should expect to see that amount agricultural land decreases steadily with increased distance from the market and the amount of forested land should increase Additionally urban or degraded land should decrease with distance from market

2 3 2 Study 2

The second study compares farmer s perception of location to official aldea boundaries and then to the accessibility model market boundaries We ran the costdistance algorithm for each of the three sites surveyed by Ravenborg using the aldea centres as the markets and computed catchments around each aldea The household locations were compared to the aldea boundaries and the computed catchments by generating a classification matrix

We should expect a close correlation between the farmers perceived location and both sets of boundaries

3 Results

3 1 Study 1, Land cover patterns and distance/access to markets

The road network and slope map were combined to create a friction surface and along with the aldea centres an accessibility map of travel time to the nearest aldea was generated (figure 6a) This time travel map was combined with the two land cover images to determine the percentage of land use within each time band For ease of visualisation the land classes have been reduced to farmland forested and *other* where *other* can be urban area, degraded land or bare soil These percentages are represented as histograms in figure 6b for both dates As we would expect there are definite trends for each class in each image

The percentage of the *farmland* class decreases with travel time from the aldea

The percentage of the *other class* decreases with travel time from the aldea

The percentage of the *forested* class increases with travel time from the aldea

Also the change from forested to agricultural land is evident between the two time periods with the land that is between two and three hours distant from the aldeas seeing the greatest degree of change

Similarly distance from each aldea (figure 7a) was combined with the two land cover images and percentage land cover per distance band was calculated These percentages are represented in figure 7b for both dates The same strong trends are evident for all three land-classes in both time periods

Again the change from forested to agricultural land is evident between the two time periods with the land that is between four and eight kilometres distant from the aldeas seeing the greatest degree of change

The town of Yorito is recognised as being the major local market for this area and so the experiment was repeated but using one target Yorito Figure 8a shows the travel time in hours around Yorito and figure 8b the corresponding land cover percentages per time band

We see the same trends for Yorito as we did when we considered all the aldeas decreasing agricultural land and increasing forested land with increasing time from Yorito

Similarly the process is repeated for Euclidean distance from Yorito (figure 9a) and figures 9b reflect the corresponding land cover percentages per distance band The majority of forested land appears to be nearer to Yorito than the majority of agricultural land which exhibits a U shaped histogram The same patterns are visible in both years

3 1 Study 2, Market catchments and administrative boundaries

The farm location datasets are compared with the official boundaries and catchment boundaries in figure 10 ?? with the data arranged in one column per site (Rio Saco, Cuscateca and Tascalapa) The points which correspond to the farmer s main production field are colored based on their location and are overlayed on the official boundaries (a to c) and then on the generated market boundaries (d to f)

The relationships are presented as confusion matrices in Table 2 The upper section shows the congruencies between the official boundaries (columns) and the farmers perception (rows) and the lower section shows the congruencies between market catchment boundaries and the farmers perception The user s accuracy which is the percentage of farms falling in the corresponding village zone is given in parenthesis It represents the accuracy of the zoning from the viewpoint of the farmer Table 3 gives for each region the Overall accuracy as measured as number of villages assigned correctly to a catchment and Cohen's Kappa index of agreement (Cohen 1960) which is the overall accuracy corrected for chance (there is always a possibility that some villages may be classified correctly even if they are distributed randomly)

A test aimed to measure the significance of agreement is *Press s Q* statistic which is defined in equation 1

$$Q = \frac{[N-(nK)]^2}{N(K-1)}$$

Where *N* is the sample size *n* is the number of correctly classified observations and *K* is the number of groups Significance is given by the value of the chi square distribution XXX for n=K(K 1) degrees of freedom Results for each region are given in Table 3

Table 3 Overall accuracy between farmer's perceptions of their village and village boundaries

	Rio Saco				Cuscateca				Tascalapa			
	User s	Kappa	Q	P (n=XX)	User s	Kappa	Q	P (n=XX)	User s	Kappa	Q	P (n=XX)
Official	0 52	0 23			0 79	0 65			0 65	0 57		
Catchment	0 53	0 26			0 94	0 90			0 75	0 70		

The catchment method gives market boundaries that are systematically more accurate than the official ones

In Rio Saco (table 2a) the overall classification accuracy is low for both boundaries but still significantly good The low accuracy here can be partially explained by aldea number 10806 (coloured yellow in figure 10) since only one household identified itself as belonging to this aldea In Cuscateca (table 2b) and Tascalapa accuracy is particularly high Rio Saco is also in flatter terrain and this may be caused by a greater confusion in the sense of place because of better accessibility i e farmers are more mobile Another possibility which is also linked to increased mobility is that the farmer s main field may be located far from its house

4 Discussion

4 1 The model

For a spatial model the data requirements for accessibility modelling are minimal a road coverage and a market location would be sufficient However as can be seen the framework is flexible and many other data sources such as rivers international borders and topography can be included if required

There are several key issues surrounding the market catchments

1 Each catchment is focused on a resource or market commonly referred to as a target Although administrative units are also based around a population centre there are no consistent guidelines or rules that describe their creation from region to region

2 Each catchment can be divided into hierarchical bands of accessibility This makes the catchment a unique type of areal unit since it is now possible to control the disaggregation process as we move to a finer level of detail

3. They are user defined in that the analyst has full control over the boundary generation process data can be represented in a controlled and specific manner unlike using pre generated administrative units This is an important concept for addressing MAUP (Modifiable Areal Unit Problem) issues

4. They are defined by local physical agricultural and economic factors relating to accessibility

5. The units are dynamic in that they are able to adapt with time as the underlying factors influencing them change Road networks are expanded in some places and become degraded in others Land cover undergoes dramatic changes as population pressure increases Crop prices fluctuate farmers adopt new crops markets change

6. Accessibility is important at local regional and national levels and is an inherently scaleable framework Catchments for local products can be generated as can catchments for agricultural processing plants for large scale production and finally commodities such as exported crops can be related to access to ports and major cities

7. It can be applied to a range of issues Access to agricultural markets is but one application Health care provision via mid wives rural health care

centres of general hospitals can be assessed and compared to infant mortality rates for example Access to education can be determined and its effect as a constraint on local development Gender issues could be addressed by focusing on infrastructure and facility siting improvements to minimise the load carrying work and effort where women bear the larger part of the transport burden

4 2 Accessibility

It is clear that the availability of transport means and services determines the movement of goods agricultural and otherwise into and out of communities Inaccessibility has the immediate effect of causing isolation but it also has medium and long-term implications as a constraint on agricultural productivity Transport is in reality a means to an end and that end is simply to gain access

It can be argued that access is a precondition for the satisfaction of almost any need and that accessibility provides a central integrating concept with which to grasp the complex interactions between the spectrum of subsistence economic and social needs of any population

With the concept of accessibility it becomes possible to investigate the degree to which a given community is involved in economic activities Recognition of the actual accessibility needs of the rural population could lead to an identification of the factors that affect their satisfaction Using accessibility as an entry point gives us a better idea of what is actually happening from the point of view of socio-economic development in many critical areas of rural life and what can be done to improve the situation

4 3 Conclusions

We have presented a new concept for defining and developing ecoregions with roots in the Von Thunen model of agricultural economies and land patterns By exchanging distance for time we can incorporate a further degree of realism

From the first study land use patterns were more closely and more consistently related to travel time than distance over two time periods and over two scales of analysis

From the second study the market catchments were seen to be consistent with perceptions of local boundaries particularly in hilly terrain and performed much better than the official boundaries derived for the 1988 population census

Accessibility combines biophysical (land cover and terrain) social (population and infrastructure) with economic (market forces supply and demand) factors These factors naturally change with time both long term and short and the units adapt with them Therefore it is a unique spatial unit suited to development planning monitoring and modelling

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