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USING GIS FOR SPATIAL AUTOCORRELATION IN CHILDHOOD VULNERABILITY ASSESSMENT: CENTRAL AMERICAN COMPARISONS

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Abstract (english)

According to UN ECLAC in the last four years period (2003-2007), Latin America has shown important growth in its GPD that even with the current crisis confirms a trend that will continue. Nevertheless, several social and economic problems persist and Latin American countries lag behind other regions in many areas. Socioeconomic inequality and social exclusion is still very high. Children and adolescents deserve special attention because they are "over-represented" within the poorest population and have a high degree of dependency on adults and their families. In addition, children have a greater vulnerability to poverty because of their living and dwelling conditions and other negative factors that prevent them from exercising their rights. This study presents. (1) the spatial distribution of infant poverty in Central America at a sub national level of disaggregation (municipal) (2) an exploratory analysis in order to detect local spatial autocorrelation of infant poverty indicators in Central America (LISA) and therefore identify clusters at the municipal level that crosscut country boundaries. Poverty is measured using the Unmet Basic Needs- UBN approach using three components, namely: i) household privation, ii) accessibility to piped water, and iii) sewerage connection. The analysis will provide useful information for decision makers and governments seeking to focus public policies effectively and to promote a more equitable development.

Introduction

In the last four years period (2003-2007), the highest GDP per capita growth since the '70 has been registered; this might represent the best social and economic performance in Latin America in the last 25 years. Latin America has managed to move forward in poverty reduction, the unemployment has decreased and in some countries the income distribution has gotten better according to UN ECLAC Social Panorama 2007 (Panorama Social 2007). Nevertheless, several social and economic problems persist and lags with regard to other regions of the world remain. Socioeconomic inequality is still very high. There are still high levels of social exclusion. The social expense – measured as a percentage of GDP, ostensibly increased during the last decade, but since then has been leveling off and it is not enough to meet social needs. Likewise, migratory flows continue to be spurred by uneven levels of development in within the countries.

According to geographic areas, poverty and extreme poverty show a clear difference in their composition. From the population in poverty situation, a 34% live in rural areas, while 50% of the extreme poverty population lives there. Even though this composition has presented very few changes since the end of the 1990's, it is possible to notice an increasing tendency to the urbanization of both poverty groups (CEPAL, Panorama Social 2008). Among the poor population living in Latin America, 14% lives in Central America, including Dominican Republic. These figures represent closely the relative difference in terms of participation, being Central America and the Andean Community the most noticeable since they have a higher percentage of poor population than total population, and being MERCOSUR the opposite. As for indigence, Central America represents the 20% of Latin American total.

On the other hand, poverty goes hand in hand with the collective feeling of social inclusion or exclusion in a way that reflects people desire of accomplishing autonomy and material welfare, and count on the essential competences to perform in information and knowledge-based societies. The poorest people are the ones that feel the most excluded, and this perception is not only linked to the material precariousness. Being part of ethnic minorities is perceived as a discrimination factor, living in rural areas as well, lack of participation in conventional institutions and social isolation is also related to higher degrees of perceived exclusion (CEPAL, Panorama Social 2008). Moreover, kids and teenagers that live in poverty conditions are perceived as a group susceptible to social exclusion.

In Latin America, child poverty studies have generally followed a macro approach. The poverty indicators used are aggregated by country or even regions, which doesn't allow us to observe real differences in the geographic distribution of poverty in the region. Decisions around public policies directed to the reduction of poverty require even more disaggregated information to allow allocation of resources directly to the areas showing higher levels of child poverty. Although several studies about poverty have been done, in the whole region of Latin America (UNFPA, BID, Balk et al 2005, CEPAL), it is still seen as a strictly economic problem. Moreover, after carrying out an important number of studies in the last few years, and after discussing a lot about the poverty that affects children and teenagers – its causes, consequences, and possible solutions, we think this is

a developing topic that requires new analytical approaches. Children and teenagers deserve special attention for reasons that goes from their weight inside the poorest population (Minujín, Delamónica y Davidziuk, 2006), and their dependency on the adults and family nucleus, to the highest vulnerability they present when facing the impacts of the aforementioned inequalities.

Thus, it is on such a specific group that we will focus our investigation: children who live in poverty. We should not forget that the levels of poverty are the result of a complex relationship, sometimes hard to understand, between government policies, every family efforts, labor market conditions, and social decisive factors. Furthermore, although in the last few decades there has been a regional tendency to poverty reduction, it is also true that those children who are born in poor or indigent homes are bound to inherit the poverty condition since it is transmitted from one generation to another settling itself down on the same homes and the same geographic area, condemning in that way the new generations to continue being poor. Child poverty seems to be a constant and catalytic element among the circumstances that generates it, perpetuating such life conditions from generation to generation.

This investigation will analyze child poverty in the Central America region from a sub-national level perspective focusing on finding clusters or spatial relationships that exist between those municipalities where children and teenagers who have lived in poverty for generations gather together. As ACNUR (2004) emphasizes, "Poverty is a specific, local and contextual experience," (page 3). As a consequence, the policies designated to face children and teenagers poverty require locally disaggregated information.

A material deprivation approach based on the dwellings' precarious conditions, on the unhealthy conditions of sanitary facilities, and limited access to drinking water, will be used to determine poverty clusters in Central America. For that, it is necessary to have the information adequate to allow a geographically disaggregated analysis. By definition, the measurement of material deprivation is multidimensional, which facilitates a multi-faceted view of infant and adolescent poverty. Moreover, this deprivation approach focuses on the material aspects of life that have a direct impact on children and teenagers development. As the material deprivation measurement includes aspects of houses and communities' infrastructure, this approach therefore recognizes the importance of services and public resources provision and quality in their lives.

Investigation Objective

The objective of this investigation is to determine if there exist territorial groups or sub-national clusters with similar concentration of children and adolescents (0 – 17 years old) living under poverty conditions in relation to material deprivation indicators – determined by i) housing deprivation, ii) drinking water access, and iii) sewer system connection, in Central America through spatial statistics, exploratory analysis and local indicators of spatial association (LISA). We also expect to present the territorial distribution of child poverty expressed through the same indicators.

With this analysis, we expect to present differentiated spatial patterns or municipalities clusters in the region of Central America, which we can relate to high and low concentrations of children population in poverty conditions. This investigation does not look for causality of this concentrations (open for consideration of a future research) but some determinant factors can be mentioned like being part of a community or native populations, residence in urban or rural areas, different geography, etc. which will be very useful for the persons in charge of taking decisions, creating policies and for the government to focus in a more effective way in public policies directed to specific groups of population and to promote in that way a more equitable development.

To achieve the objective it is required to count with vanguard analytic tools and methods for geospatial analysis as well as software tools such as Geographic Information Systems - GIS and GeoDa (Arizona State University), with the purpose of showing policy makers, civil people, professionals and the scientific community that it is necessary to focus the public policies so they can be more effective.

Methodology and Information

Spatial Analysis Method of Child poverty

The geographic information system (GIS), special software that analyzes spatial patterns in the information will allow us to take, in this investigation, a closer look towards the relation between poverty and territory. Likewise, statistical methods specifically developed for georeferenced data will be used to analyze estimators of spatial autocorrelation and determine if there exist spatial patterns presented in relation to child poverty. For the spatial statistical analysis, we use ArcGIS 9.2 software of ESRI and GeoDa (Geoda Center from Arizona State University).

Spatial data processing was done through software GeoDa that makes an exploratory analysis generating new information from spatial data. The define zones detection for clusters, where exists a high proportion of the child poverty indicator was generated through local indicator of spatial association or LISA indicators (Local Indicator of Spatial Association).

A basic concept of spatial statistics is the dependency or spatial autocorrelation that analyzes the lack of independence between the one variable cases for its different locations. It is the point where spatial statistics links to geography and introduce the space as a fundamental element of the analysis. In the direction of Tobler's work, his first law of geography, he states that, “Everything is related to everything else, but near things are more related than distant things,” (Tobler 1970, in Martori and Hoberg, 2008). It means that, a territorial unit that presents high index of child poverty is likely to have a relation with the poverty index of its neighbors too. With this concept as a base, we can talk about *spatial clustering* or spatial grouping of characteristics, in other words, the correlation degree existing between indicators is relative to the distance between territorial units.

This spatial clustering is many times studied just because it is a disconcerting factor in the traditional statistical probabilistic models, which assume that the variables are calculated based in independent observations distributed identically. However, spatial grouping itself – measured by spatial autocorrelation or spatial diversity that underneath it – is also a source of important information to explain the link between territory and the socio-demographic characteristics. The identification of these spatial clusters of child poverty and its cartographic representation integrating the systems of geographic information –GIS, allows the exploration of the causes, mechanisms and effects of poverty, which may not necessarily be obtained with a simple ranking of territorial units for its level of child poverty. Although child poverty spatial clustering is not a definite test of the territory effect in poverty experienced by children and teenagers, it does offer evidence of the possible causality between variables that should be studied in depth (Miller 2004).

The autocorrelation analysis allows us discover if the spatial distribution null hypothesis is real, that means if a variable has an random distribution or if on the other hand there is a connection of similar or not similar values between neighboring regions. In this way, the variable high and low values tend to focus in the space which is called a positive spatial autocorrelation, in other cases they are placed surrounded by neighboring units with different values which is called negative spatial autocorrelation.

A graphic instrument used in the spatial autocorrelation analysis is called Moran scatter plot. The four quadrants represent different types of spatial association. If the group of points is disperse in the four quadrants it is a sign of spatial autocorrelation absence. If, on the other hand, the values are focus on the diagonal that crosses the upper right and bottom left quadrants, there is a high positive autocorrelation. The autocorrelation is negative if the points are on the other two quadrants.

The first step in spatial distribution characterization in social science is the exploratory spatial data analysis – ESDA. Usually the tools related with ESDA process allow the calculation of only one indicator for the totality of a determined study area compound of several territorial units. These generic indicators of spatial autocorrelation, such as the I of Moran global, is one if the oldest indicators (Moran 1950), only offered one territory units spatial grouping intensity measurement, but they lack of indicator of which territorial units belonged to this or that spatial grouping and where are this groupings located. In brief, the global autocorrelation indicators even today only show the degree of spatial relation between territorial unit's values, but do not offer a pattern for this spatial relation.

On the other hand, the group of **local indicators of spatial association** – LISA, comes from the spatial autocorrelation global indicators usually calculated in ESDA exercises. According to Anselin (1995), in order to be considered as a LISA, an indicator needs to fulfill two conditions: the first is that the sum of the LISA values for each territorial unit must be proportional to a global indicator of spatial autocorrelation; and the second is that it has to identify the territorial units spatial groupings. Therefore, the additional

advantage of the LISA compared to the autocorrelation global indicators is its spatial diversity identification; a value is assigned to each territorial unit to indicate what kind of relation it has with its neighbor units. Consequently, the LISA indicators do not only identify spatial association patterns but also the spatial behavioral outliers of the variables – those territorial units with atypical data, where its spatial relation is out of the distribution of the other territorial units.

There are also indicators that identify spatial groupings, but without a corresponding global indicator of spatial association, as the G_i* of Getis-Ord (Getis and Ord 1992). For this investigation, the territorial units spatial grouping is measured through the I of Moran given the relevant information from the spatial autocorrelation global measurement and the autocorrelation pattern measurement when offering a autocorrelation measurement and spatial diversity.

An additional advantage of using the *I* of Moran is how easy it is to calculate this indicator and at the same time to execute descriptive spatial analysis with the software GeoDa, designed specifically for this purposes and that can be download for free in http://geodacenter.asu.edu.

The local and global Moran's I

As previously mentioned, the Moran's I can be presented in two different ways: global and local indexes. Both, the global and local Moran's I vary between -1 and 1, where the negative values indicate a spatial grouping of territorial units with values of different analysis (the values of the analyzed indicator will determine certain grouping of territorial units), and positive values indicate a spatial grouping of territorial units with values of similar analysis (high or low). The values close to zero indicate lack of spatial relation between the analysis values. Likewise, as mentioned in the previous section, global Moran's I represents a brief statistic that indicates the autocorrelation intensity between groups of territorial units, but does not identify the pattern of this spatial relations. Nonetheless, global Moran's I is really useful as the first step to identify the presence or absence of a spatial relation between analysis indicators in territorial units, allowing the rejection or not of the non existence null hypothesis of spatial autocorrelation.

The other way of presenting Moran's I is the local index, which represents the correlation degree of a territorial unit indicator with its neighbor's indicators.

The local Moran's I is estimated in the following way for each case *i*:

$$I_i = z_i \sum_j w_{ij} z_j \ ,$$

Where:
z_i, z_j correspond to the remarks average deviation, and w_{ij} is the neighbors matrix, which will be discuss later in a detailed way.

As a result, the local Moran' I identifies territorial units where the high or low analysis values are group spatially, as the territorial units with significant different values to the neighbors areas values. Therefore, the local Moran I indicates 5 different types of spatial groupings which are:

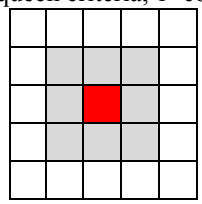
- High – High: group of areas with values above the average, surrounded significantly by neighbor areas that are as well over the average in comparison with interest variables. These areas correspond to the ***hot spots*** identified by the *Gi** de Getis-Ord index;
- Low-Low: group of areas with values under the average, surrounded by neighbors areas that are as well under the average compared to the interest variable. These areas correspond to the ***cold spots*** identified by the *Gi* de* Getis-Ord index;
- Low – High: represents an area with a low value, surrounded by neighbor areas with values significantly over the average interest variable;
- High – Low: represent an area with high value, surrounded by neighbors areas with values significantly under the average of the interest variable; and
- Not significant: represent areas where the interest variable value has not significant relation with the values presented by its neighbors.

When we talk about poverty indicators, where a value higher than the indicator indicates a territorial unit with a higher poverty incidence, is reasonably easy to think in cases where hot spots exits (groupings of poor territorial units) or cold spots (groupings of prosper territorial units), but the cases of groupings low - high and high -low are less intuitive. Examples of the last type of spatial autocorrelation could present in cases where exist in close condominiums of high incomes built in the middle of predominantly poor or vulnerable places (for the case of high-low autocorrelation), or for example where there are "shacks" or poor slum areas settle in the middle of high income neighborhoods (for the case of low- high autocorrelation). Moreover, in order to delimit the priority areas for child poverty, what produces more interest are the poverty hot spots, that is groups of adjoining territorial units with child poverty values significantly high.

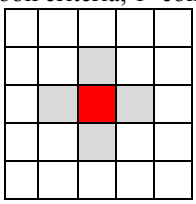
Final Methodological Considerations

Going back to Tobler's First Law, "Everything is related to everything else, but near things are more related than distant things"; but, what is consider near? In fact, the definition of neighbor used with the zones or territorial areas is very important because it influence a lot in the estimation of Moran's I. The estimation requires the creation of a spatial weight, generated with an adjacent matrix form and that takes values from 1 to adjacent territorial units and values from 0 in the opposite cases (these matrix can be standardized by lines to make easier its interpretation). For our objectives, neighbor between territorial areas is defined in contiguity first order by a criterion called queen, that is, if any of territorial units' borders or vertices touch each other, they are considered neighbors (fig.1). The rook criteria was discard as it demand that a whole side or border have to be common between both units to be considered neighbors.

A. Neighbor by queen criteria, 1ª contiguity order



B. Neighbor by rook criteria, 1ª contiguity order



Source: Own creation

There are another two methodological things to consider that can affect the estimation of the spatial analysis indicators in a territorial unit level (not for individual observations) these are the unit of analysis and the geographic scale. Indeed, it is about the potential distortion that exists by imposing a definition of the territorial limits about constant spatial phenomenon; since there is the possibility that the definition of the territorial unit and the scale in which the spatial group is measured introduce a statistic partiality. From one point, there is modifiable areal unit problem MAUP, very usual in the spatial analysis because of the arbitrariness by which the limits of the spatial units (census sector for example) have been defined. Generally, the spatial units used in geo-referenced data management are designed for methodological or operational simplicity when taking data in field (for example, in the case of census operatives) and the later aggregation of individual data, or correspond to a political-administrative division imposed on the territory, and for that reason does not necessarily reflect the living spaces of people, or does not represent either the spatial units with similar populations (for example, limits that divide native towns or indigenous populations). Another side of MAUP is related to the scale issue, where the data aggregation level used to certain extent, affects the results of the spatial clustering studies. For example, the level of spatial autocorrelation would vary if it is calculated in DAM (major administrative division for its Spanish abbreviation) versus the municipality level, due to a change in scale.

Keeping this statistical potential tramps in mind, it is reasonable to work, for this investigation, with the census data aggregated to minor administrative divisions (DAME for its Spanish abbreviation). As the objective of this investigation is to provide local level information, the DAME (that corresponds to the municipal level in most countries) is a political-administrative unit that is beneficiary of policies and social programs. And also for a practical matter, there are only a few countries where digital cartography of the national census exists and has been spread to a minor level of DAME.

This section concludes with some further considerations about the use of Moran's I for this investigation in particular. Even if in the estimation of Moran's I take as observations the average deviations of each territorial unit, for a regional level analysis (Latin America and the Caribbean), there is the necessity to prove the distributions of the calculated indicators by municipality for each country in order to compare percentages that come from different distributions. This homologation becomes necessary since the objective of the investigation is not to describe the national differences between each country, but to describe the sub-national differences across the region. Without this standardization, the

Moran's I would identify groups of child poverty hot spots that would cover most of the territory in the poor countries (or groups of child poverty cold spots that would cover most of the prosper countries territory), without identifying the differences in the child poverty incidence that certainly exist in a sub-national level.

Most of the times the standardization process only looks for a common scale, expecting the transformed distribution to be similar to the known distribution form (in the case of z-score method standardization, it corresponds to a normal distribution), that means that the standardization transform all the normal distributions in only one distribution which continue being normal. However, and especially for this investigation, it is necessary to homologize the set of regional distributions to be similar between them independently of whether or not they resemble to a normal distribution or a known one. For that reason, we are not speaking of standardization but of homologation.

When executing the mentioned homologation, we can observe the existence of an extended variety in each country distribution levels, especially in the lines of the distributions, for which it is necessary to eliminate the average lines in those distributions to be able to make regional level comparison. This could be made by using the winsorization method which consists in "stylizing" the lines to avoid having in the distribution extremes too dominant values that can cause problems in the estimation of Moran's I. The process of homologation considers two steps:

i) Center and scale (standardization). When centering, the distributions move to have a common average value. And when scaling, the distributions are adjusted to share a common variance. The standardization can be carried out with any known method, as the z-score or the maximums and minimums. In this investigation we have decided to use the maximums and minimums detailed later.

ii) Eliminate the outliers (winsorization). For each variable used in the investigation and strategy called winsorization was used with the distributions, which means "to cut them short" in a specific point, correspondent to a determined couple of percentiles, and all together they sum up a winsorization percentage. For example, if such percentage is 10% that means that the data under the 5th percentile moves up to the value of such percentile, and all the data above the 95^{th} percentile moves down to the value of such percentile.

Winsorization and standardization can be made in only one step, achieving in that way a confirmation methodology that considers the maximum and minimum replaced by the value of the respective percentiles (95 and 5) according to the data specific percentage with to avoid that the extreme values change the results.

The confirmation is estimated as:

$$Zs_i = \frac{X_i - Vp_5}{Vp_{95} - Vp_5}$$

Where:

Zs ¡ = Standardize variable value;
Xi = Variable value;
Vp 5 = Percentile reached value (5);
Vp 95 =Percentile reached value (95).

If the resulting value is minor than 0 it is recoded to 0, if it is higher than 1, it is recoded to 1, to obtain a level value of 0 to 1. Based in that transformation, the indicators are used to estimate the regional Moran's I.

This procedure allows the estimation of the Moran's I, which at the same time emphasized the sub-national differences in the child poverty incidence, but also allows the identification of child poverty hot spots that extend to more than one country in the border areas of the region.

Finally, the local Moran's I can identify child poverty spatial clusters formed by very different nature territories; some urban agglomerations in the region show a strong territorial bias in the distribution of poverty, but there's also the possibility that these areas of concentrated poverty are located in rural areas or extended beyond the national frontier, making possible the establishment of **priority action areas** to intervene in child poverty matter in the region, independently of the territory's urban/rural classification, or if it is extended to more than one country. Nevertheless, because of this territorial diversity that can assume the hot spots, poverty nature in the hot spots is not going to be similar and requires considering the geographical, social, political and national context. Although this clustering of territorial units with high child poverty can be of a varied nature, all indicate that these territories are characterized by a lack of presence of the Government and public services. Consequently, it is important to keep in mind the territory specifications and its characteristics that produced a concentration of high poverty on it. However, we can not take this second step without identifying first these areas for priority action, the hot spots of child poverty.

Methodology and Approaches for measuring poverty

Poverty is a complex and multidimensional phenomenon and that is why there is not only one point of view when measuring, defining and quantifying poverty. Most of governments, as well as local and international organizations assign important resources to the generation of statistical data about the level and characteristics of poverty, considering them as a very important input for the formulation of policies. The measurement and quantification of poverty is going to depend on the approach adopted. In that regard, there is a lot of information (Feres, 1997; Feres and Mancero, 2001a and 2001b; Kaztman, 1995; Rodriguez, 2001; Desafíos, 2005; Martinez, 2004) where as time passes by, at least four approaches have been defined, adopted and modified, approaches that we mention here and that use and focus its attention in the needs and deprivations, life standard, human rights, gender disparity and resources insufficiency.

The income approach is the most commonly used methodology in the region. Generally poverty has been defined under the perspective of material deprivation, of impossibility to reach a minimum of resources to accede to the goods and services available in the society, Measured by the income and expense of the person or the house. To decide which person or home is poor, a base line has to be established to be used as a threshold. From this point, come out two measurement choices: absolute poverty and relative poverty. Absolute poverty is defined as the lack of necessary income to satisfy the basic nutritional needs, given by a basket of goods and services that covers the primary needs of the person of home to live with dignity. The persons or houses that have incomes below this established point of reference are quantified. Additionally, there is the definition of relative poverty, where the threshold to decide if a person or house is poor or not is measured according to the distribution of income of all the society. An specific part of a society typical income level is the point of reference to measure if a person or house have low income in accordance with the rest. It means it relates the individual person with the rest of the society and placed the person close or far to the average of the society income, independently of whether the resources are enough to satisfy the basic needs.

The unsatisfied basic needs approach or UBN defines poverty as the incapacity of a person or house to satisfy a number of basic needs, measured in material goods and services required to live and function as a member of the society. It can be measured in direct and indirect way. In the direct measurement, it is evaluated if the house count or not with the goods and services defining a minimum threshold to satisfy the needs and the attention to specific products and services such housing, food, education and health is limited. The same consists in selecting a group of basic needs and qualify as poor those houses that do not satisfy one of them and as extremely poor those who do not satisfy more than one of them. In the indirect measurement, the resources that the house has (income or expense) are used to determine the ability to satisfy its basic needs and that can have an acceptable level of life in accordance with the standards of live. That means it relates the welfare with the potentiality of consumption. This method has as characteristic to allow a high geographical disaggregating level given that it uses the census information for the estimation; which can be useful at the moment of focusing policies that aim to improve these life conditions, especially those that follow a territorial approach.

The human rights Approach. Instead of emphasize the material goods (income), it focuses on the capacity of the individual of being able to live the kind of life he/she values. In other words, poverty is seen as individual limitation of liberty. Though by Amartya Sen (Martinez, 2004), it states that poverty should not be measured only according to access to material and social goods and services. It is necessary that the persons have the capacity of using them effectively, that it allows them to be free to reach welfare.

The gender approach. Given the women circumstances, associated with their biology (pregnancy, breastfeeding, etc.), their gender roles (wife, mother, etc.) and their subordination culturally constructed, they faced disadvantageous conditions that accumulate with other effects of poverty. This approach places poverty in a cultural and

social cultural frame of discriminatory sexual deference and expresses in the division per gender at work, and in the access to material and symbolic resources as well as the power in its different expressions (Batthyány et al, 2005).

Unsatisfied basic needs Approach

For this investigation the approach is used for measuring material deprivation poverty in which live children and teenagers. Given the information availability in the region of Central America, the proposal was adapted to moderate deprivation indicators of Bristol [1]methodology to the lack of unsatisfied basic needs –UBN that reflects the reality of the region and deprivation of this basic needs affecting in that way, the welfare and development of children and teenagers in a territorially broken down level with respect to life conditions and information availability. Moderate criteria were used in the determination of thresholds under the perspective that at these levels shows a situation that requires change in the region. We think it is relevant to reduce the level of analysis to determine clusters of municipalities that go through the national limits and cross frontiers inside the region of Central America showing a reality that affects the region more than affects each country as individuals.

When analyzing child poverty under the approach of unsatisfied basic needs that includes its territorial distribution, the reference unit is represented by the municipality, which is conceived as one of the spaces or scenarios where child poverty is more visible and at the same time, the local communities are recognized as the actors that unleash change and break the poverty cycle. It is in that way that poverty indicators, consumption levels, income levels and access to health and education are influenced by geographical and agro-climatic factors that give account of the reality of poverty in which children and teenagers live in and that should be studied in a more detailed way. In that manner, we could discover and identify different socioeconomic and cultural causes that will allow us to design every time more effective policies *ad hoc* for the surmounting of child poverty since it is not uniformly distributed in the territory.

For the estimation of the deprivations thresholds were defined for every indicator as follows:

Shelter. Percentage of children between 0-17 years that live in houses built with low quality materials with roofs and exterior walls of waste or houses that have overcrowding condition or houses without bedrooms.

Plumbing: Percentage of children between 0-17 years that live in houses that do not have toilet connected to a public or private sewage system.

Water: Percentage of children between 0-17 years that live in houses that are not supplied by public or private pipe system.

[1] Bristol methodology uses the deprivation components of housing, drinking water access, malnutrition levels, access to sewer system access, communication technology access and education access, classified in moderate and severe thresholds.

Education: Percentage of children and teenagers that are not currently going to school depending on the official age to be registered for country.

Used information: Population and Housing Census

Likewise, to obtain the indicators in a municipality level it is required a separation of information and for that reason we have to look in other sources of information since the traditional housing or health surveys are not representative in that level of territorial disaggregating. For that reason, we used the national population and housing census, which, for its universality, give information about each person, each home and each house located in an aggregated country in levels as small as a block, a district or a municipality.

For this investigation, we grouped the region of Central America: Belice, Costa Rica, Guatemala, Honduras, Mexico, Nicaragua, El Salvador and Panama. All these countries count on a population census from the year 2000. As a whole, they are 8 countries that represent the 30.9% of the total population of Latin America and the Caribbean and that for that reason, give account of the regional situation as regards child poverty at the beginning of the new millennium.

Specifically, for the versatility that present in the treatment of data, we have used the format available basis of REDATAM (Recuperation of data for small areas by Microcomputer), developed by CELADE (www.cepal.org/redatam).

Spatial Analysis results using GIS and spatial statistics with GeoDa

Spatial autocorrelation analysis

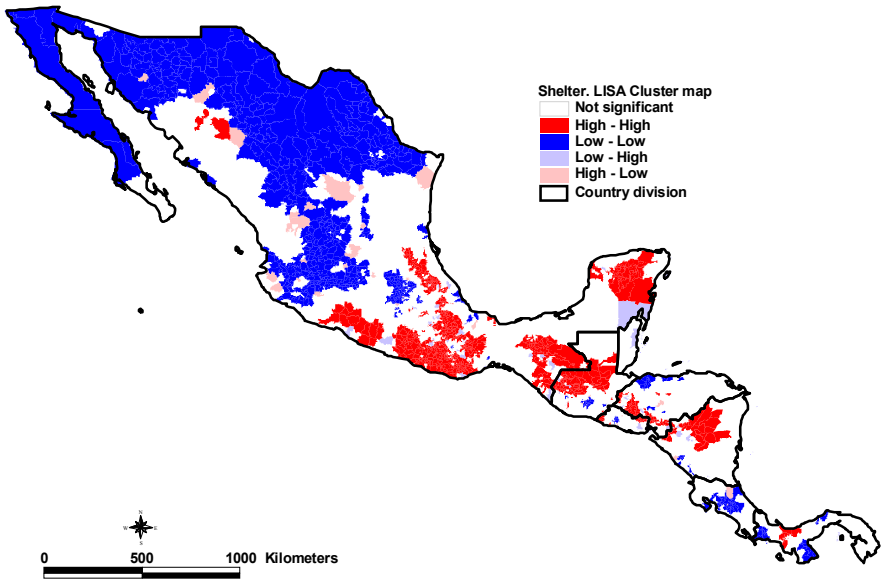
Then, we present the results of the existing spatial association between the municipalities of all countries of Central America, obtained by correlating the value of a certain deprivation indicator for each municipality with the value of the indicator in the neighboring municipalities, using the GeoDa software. The used indicators are three and correspond to the percentage of children between 0 and 17 years old who live in homes with a certain deprivation (shelter, no access to drinking water, lack of sewerage system) in respect of the total number of children living in the municipality.

In Central America there are more than 6 million of children and teenagers who live in 837 municipalities with high levels of child poverty deprived of shelter. The percentile distribution of municipalities and the percentile weight per country of the total number of child population in these spatial clusters is presented in table 1 and the map with the location of clusters in fig.1.

Table 1. Number of children and teenagers in municipalities forming hot spots of child poverty with moderate shelter deprivation in Central America.

País	Número de municipios Alto-Alto	Porcentaje	Poblacion de 0 a 17 años	Porcentaje
Guatemala	85	10.16	1,514,858	24.15
Honduras	76	9.08	336,176	5.36
México	599	71.57	3,671,390	58.52
Nicaragua	32	3.82	472,741	7.54
Panamá	5	0.60	45,517	0.73
El Salvador	40	4.78	232,575	3.71
Total	**837**		**6,273,257**	

Fig. 1. Spatial correlation for the variable 'Percentage of children between 0 and 17 years old with moderate shelter deprivation'.



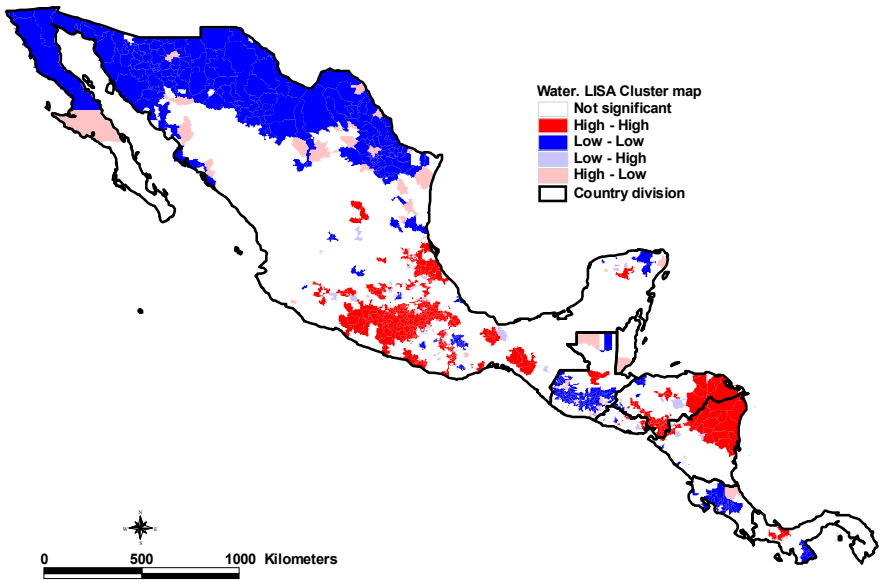
We can see the existence of positive autocorrelation clusters (red color for hot spots of type high-high); in other words, municipalities with high percentage of children between 0 - 17 years old living in homes with bad conditions in the southeast zone of Mexico, in the north of the Yucatan peninsula, and in the zone bordering on Guatemala. This zone is primarily occupied by native population of Middle America (according to what is shown in the map of Central America ethnic groups in fig. 4), then in the center of Nicaragua and part of Panama corresponding to the native region Ngöbe Buglé.

Regarding the component of moderate drinking water deprivation, in Central America can be found more than 6 million children and teenagers distributed in the 575 municipalities making up the high-high clusters who live in homes with no access to drinking water. The percentile distribution of municipalities and the percentile weight per country of the total number of child population that can be found in these spatial clusters are presented in table 2 and the map with the location of the clusters in fig. 2

Table 2. Number of children and teenagers in municipalities forming hot spots of child poverty with moderate water deprivation in Central America.

País	Número de municipios Alto-Alto	Porcentaje	Poblacion de 0 a 17 años	Porcentaje
Guatemala	3	0.52	142,444	2.15
Honduras	70	12.17	423,453	6.39
México	449	78.09	5,541,664	83.67
Nicaragua	30	5.22	372,014	5.62
Panamá	5	0.87	46,568	0.70
El Salvador	18	3.13	97,076	1.47
Total	**575**		**6,623,219**	

Fig 2. Spatial correlation for the variable Percentage of children between 0 - 17 years old with moderate drinking water deprivation.



We can see the existence of positive autocorrelation clusters, hot spot high-high with municipalities presenting high percentage of children between 0 - 17 years old living with no access to drinking water in the central zone of Mexico, in the north bordering zone

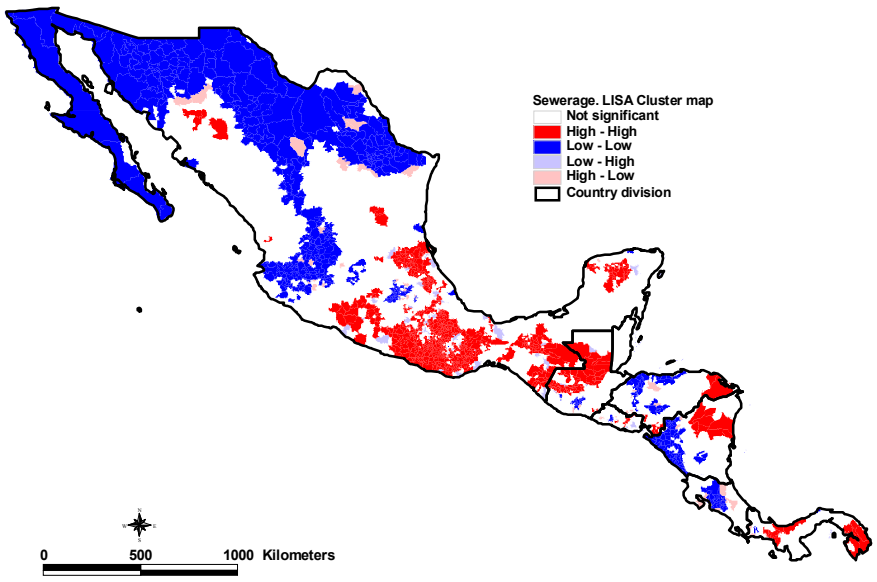
between Nicaragua and Honduras occupied by native people and ethnic communities of the community nation Moskitia, and a small part of Panama corresponding to the native region Ngöbe Buglé (according to fig.4)

Regarding the component of moderate sewerage system deprivation, in Central America there are more than 6 million children and teenagers distributed in the 854 municipalities making up the high-high clusters and who live in homes with no sewerage system. The percentile distribution of municipalities and the percentile weight per country of the total number of child population that can be found in these spatial clusters are presented in table 3 and the map with the location of the clusters in fig. 3

Table 3. Number of children and teenagers in municipalities forming hot spots of child poverty with moderate sewerage system deprivation in Central.

País	Número de municipios Alto-Alto	Porcentaje	Poblacion de 0 a 17 años	Porcentaje
Guatemala	71	8.31	1,314,084	21.06
Honduras	11	1.29	143,630	2.30
México	718	84.07	4,447,609	71.28
Nicaragua	9	1.05	155,686	2.50
Panamá	15	1.76	103,020	1.65
El Salvador	30	3.51	75,854	1.22
Total	**854**		**6,239,883**	

Fig 3. Spatial correlation for the variable Percentage of children between 0 and 17 years old with moderate sewerage system deprivation.



We can see the existence of positive autocorrelation clusters, hot spot high-high; in other words, municipalities with high percentage of children between 0- 17 years old living with no access to sewerage system in the central zone of Mexico expanding to the border with Guatemala where can be found native communities, in the north of Nicaragua where native people and ethnic communities of the community nation of Moskitia are located and in Panama, the zone corresponding to the native region Ngöbe Buglé and the region of Darién in the east of the country (according to fig.4)

Analyzing the three maps of spatial autocorrelation (according to shelter, drinking water Access and sewerage system) we can identify a similar pattern of clusters or groups of territorial units for the three indicators used here; in other words, we can detect a meaningful presence of children living in poverty conditions in zones where native communities are predominant, also these clusters go beyond national borders. We can clearly notice that there are marked groups of hot spots (high-high) in terms of child poverty in the southeast of Mexico and its border with Guatemala as well as in the north border between Honduras and Nicaragua and in the regions of Ngöbe Buglé, Veraguas, Emberá and Darién in Panama. In the south of Mexico we can also observe a great red spot covering the states of Guerrero and Oxaca and in the north of the Yucatan peninsula.

Likewise, there are clusters where there are not a significant presence of children living in poverty conditions (blue color for hot spots low-low), mainly in the northeast of Mexico and south of Nicaragua.

Fig. 4: Ethnic and cultural diversity of the people from Central America, 2000

Source: Héctor Pérez Brignoli

Analysis of Moran's scatterplot

As it was mentioned before, one of the common tools used in the spatial autocorrelation analysis is the scatterplot of Moran which allow us to have a global vision of the relationship between municipalities' spatial processes. The observations of the deprivation component (no shelter, no access to drinking water and sewerage system) for each municipality are represented in the axis of abscissas while in the axis of ordinates is represented the average value (weighted) of the same variable for the group of municipalities that shares at least one border in common. In this way, the four quadrants reproduce the different types of spatial association.

Right upper quadrant (AA): Municipalities with a high percentage of children living under deprivation and surrounded by municipalities that are also in the same condition.
Left upper quadrant (AB): Municipalities with a low percentage of children living under deprivation and surrounded y municipalities with a high percentage of children living under deprivation.

Bottom right quadrant (BA): Municipalities with a low percentage of children living under deprivation and surrounded by municipalities with a high percentage of children living under deprivation.

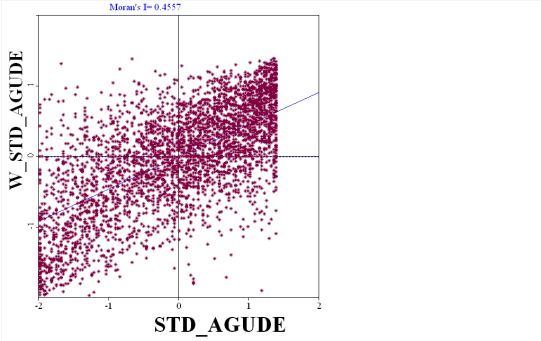
Bottom left quadrant (BB): Municipalities with a low percentage of children living under deprivation and surrounded by municipalities in the same condition.

If the cloud of points is scattered in the four quadrants then it is a sign of a spatial correlation absence. If, on the contrary, the cloud of points is assembled on the diagonal crossing the quadrants I-III then there are a high positive spatial autocorrelation (Martori and Hoberg, 2008). However, if the cloud is distributed between the quadrants II- IV there is a presence of a negative spatial autocorrelation.

We can see in the group of graphics (Figure 8) the predominance of a positive local spatial autocorrelation among the municipalities of Central America specially when considering the variables of shelter and sewerage system deprivation because most of the municipalities are located in quadrants I-III. In the scatterplot case of moderate water deprivation where the cloud of points is distributed in all quadrants which implies a absence of a local spatial autocorrelation with a global Moran's I of 0.4557 (Fig. 8)

Fig 8. Moran's Scatterplots for Water, sewage system and shelter deprivation

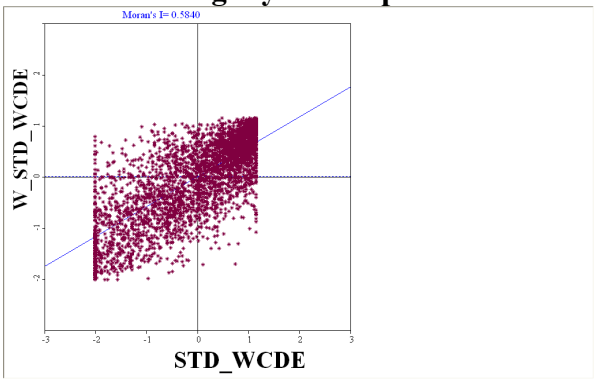
Moderate water deprivation



Comment

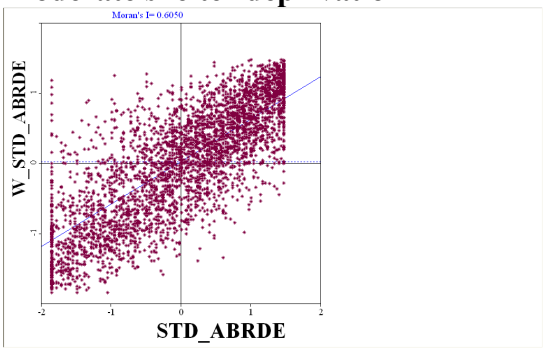
Component: Percentage of children between 0 – 17 living with no Access to drinking water. Result: I of Moran = 0.4557, there is no spatial autocorrelation.

Moderate sewage system deprivation



Component: Percentage of children between 0 – 17 living with no access to sewage system. Result: I of Moran = 0.5840, there is a positive spatial autocorrelation.

Moderate shelter deprivation



Component: Percentage of children between 0 – 17 living with shelter deprivation. Result: I of Moran = 0.6050, there is a positive spatial autocorrelation.

The global spatial autocorrelation can also be measure in the scatterplots because the value of the global rate of Moran is equivalent to the slope of the regression line. Constructed in this way, the scatterplots allow us to observe the differences in the global spatial association (slope to the line) as well as the own local spatial association (cloud of points) among the three components of deprivation. We can also observe the municipalities that have a negative spatial autocorrelation corresponding to the clusters low-high or high-low in the map; in other words, poor municipalities (with a significant presence of deprivation) surrounded by wealthy municipalities (without a significant presence of deprivation) or vice versa.

Final comment

The behavior/ performance of the deprivation components used in the analysis of the spatial autocorrelation allow us to localize groups of municipalities with the same conditions of poverty affecting a high percentage of children. The next step for future research is to look for some relations among the social factors that coexist and to look for ways to fight against social exclusion. We can state that these clusters high-high encourage residential segregation which leads to social exclusion and isolation of the poorest blocking the access to a better conditions of life (access to labor sources, better homes and infrastructure, access to education) strengthening poverty and encouraging its reproduction from generation to generation. The social cohesion is menaced because the possibilities of interaction within municipalities with different levels of life quality decrease, while the levels of poverty reproduce in these groups from one generation to another. Due to these phenomena it is required to pay more attention to changes in the territorial segregation, to exert a greater control on the determining factors of this process and to deeply check the state measures related to the territorial planning, local investment and social dwellings.

Poverty and marginalization are intergenerational problems related to children and teenagers who live in poverty conditions and inherit the conditions of their homes. For this reason, it is necessary to consider in the state policies the necessity to implement special programs that allow us to break this generational inheritance of poverty generating opportunities for children and teenagers who live under any deprivation.

The methodology used here tries to emphasize the strong geographical relation that exists in the components of poverty. The measurement of the spatial autocorrelation help us to understand that the poverty problem, specially the one that affects children and teenagers, studied in minor levels goes beyond the political limits and appoints territories that go beyond of the borders determined by countries. The areas with high incidence of child poverty involve groups of population that share common geographical residence, social networks, forms of organization and common culture and traditions.

Finally, we would like to mention the United Nations Development Program - UNDP's recommendations to overcome poverty using a multifaceted approach moving beyond the required policies in order to maintain stability, economic growth and a stable political environment:

1) To invest in human development; in other words, in nutrition, education, health, water to encourage the creation of a productive labor force.
2) To help the small farmers to increase their productivity.
3) To invest in infrastructure: electricity, roads, and harbors.
4) To implement policies of industrial development directed to small and medium-sized industries.
5) To promote social equity and the human rights so that poor and marginalized people, including women, can have freedom and voice to influence on the decisions that can affect their lives.
6) To promote the environment sustainability and the good management of cities to provide safe environments

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