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**Analysis on Relation between Natural Disaster Risks and Living
Conditions:
The Case of Bolivia[♦]**

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Octubre, 2008

[♦] Document prepared for the ISDR/RBLAC Research Project on Disaster Risk and Poverty. This document is part of the Latin American contribution to the Global Assessment Report on Disaster Risk Reduction, and the Regional Report on Disaster Risk and Poverty in Latin America. The terms natural disaster and climate-related events will be used interchangeably, understanding that socioeconomic conditions play a role to explain the intensity and consequences of such phenomena. Thus, no event is strictly or exclusively natural.

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Working paper prepared for the UNDP-ISDR Project

**Analysis on Relation Between Natural Disaster Risks and Living Conditions:
The Case of Bolivia¹**

FINAL DRAFT

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1. Background

The starting point of this document has been recognition of natural hazards importance and their risk on development processes. Research faces an outlook that goes beyond improving response capacities and designing mechanisms to deal with human aid or for emergency assistance in case of disaster. UNDP (2004) has determined that disaster must necessarily include study of impact on household living conditions, in order to thereby establish improved mechanisms to mitigate and prevent its effects, as well as to sustain people living conditions. Therefore, this is one of the main challenges in terms of learning, developing tools and administration of development processes, particularly in regions particularly exposed to natural hazards and their possible effect on human lives, on infrastructure and income generation means of most vulnerable homes.

From this approach, several tasks are necessary in order to develop a frame for analysis and management implied, both quantization of impact as well as aspects related to means of recuperating productivity conditions and infrastructure affecting or at least endangering living conditions of people exposed to them (De la Fuente, et. Al, 2008).

In the case of Bolivia, research on poverty and development conditions of households have been mainly focused on elaboration of tools allowing to identify geographic location of poverty – UBN² and poverty line maps (UDAPE, 2002, 2005), national, department and Municipal Human Development Indexes – as well as estimations of change in times of incidence, the gap and intensity of poverty allowing to determine well-being evolution patterns. That information has been used by several governmental administrations, which in turn have developed strategies for poverty reduction allowing the elaboration of public policy interventions in order to reduce poverty levels in the country.

From the point of view of estimation of determinants of well-being household conditions, most of the poverty surveys have been oriented towards aspects of income generation, or opportunities' development through productive resources, as well as to growing capacities such as education, health, understood as a human well-being requirements.

However, inclusion of weather hazards as determinants of poverty has not been studied in the country. Estimates of natural events shocks over household, or mechanisms allowing mitigating effects of climatic events, have not been part of surveys and research on poverty in Bolivia. The only approaches developed have been the quantification of damages by natural events such as inundation and drought, particularly during 2006 and 2007, when large natural disasters occurred in the eastern and Amazonia region of the country (CEPAL, 2007).

The objective of this document is assessment of natural disaster impacts on income and living conditions of exposed population, starting from available information from census and household surveys. The present document stands at two levels of analysis; the first involve the analysis of disaster risks at national and municipal level, while the second focus

² Unmet Basic Needs

its attention in regions that have been affected by disaster in the eastern regions of the country. In both cases it is intended to discover relations among natural events and changes in living conditions. Given limited information, results may not be translated into causality relations, and are simple estimates and benchmark to undertake future research containing more thorough disaggregated information.

The document has been divided into five sections. Section 2 contains a methodological background and information resources, while in section number 3, an approach has been made on effects of natural disasters within the country's municipalities. Section number 4 assesses household living in Trinidad city, the capital of Beni, which is the urban conglomeration that underwent large disaster in 2007. Section number 5 underlines final statements on study of Bolivia.

2. Methodology and information

Impact estimates of disaster on living conditions of the population can be approached from two levels of analysis. On the first approach, main sources of information were taken from population and housing³ census information, together with disaster information from the DESINVENTAR⁴ data base and from other sources. Information contained on this first part is referential and only takes into consideration municipal levels of disaggregation, since disintegration of natural events only refers to this geographic level.

On second approach, natural events assessment is measured from of household surveys. Nevertheless, limited information (see point 2.1) circumscribes the study to a particular geographical area – the capital city of Beni – flooded between December 2006 and January 2007. Information on this particular case before and after the event is available. Since there is no panel information, focus is made on the fact whether significant change is to be found on well-being conditions before and after the natural event.

2.1. Available Information

The Bolivian case shows some particular characteristics, particularly in terms of available information, which in turn prevent the use of several instruments for assessment of natural event impact on household well-being. Disaster and natural and events, as well as information on household surveys display characteristics that reduce precision of results as well their validity.

Information on Disaster Risk

Three types of sources are available with regards to natural events. The first one is data base made by the Civil Defence Vice-Ministry, in which natural phenomena are systematized according to their type, department of occurrence and period. However, problems deriving from this type of information are related to levels of disaggregation – solely departmental – and temporary covering of data – that is, from 2000 to 2006 – limiting global use of information with available well-being sources.

Second source is the DESIVENTAR data base, whose origin is written press news about natural event registered from 1970 to 2007. Evidently this type of information is limited since it is not supported by technical information - like registers from meteorological institutions or geological research centres-. In fact, this type of available information is strongly biased since there is an over reporting events of capital cities or regions with secular events such as large flooding or dry periods. Additionally, DESINVENTAR data base has a provincial scope. The mentioned geographical unit is in disuse at present, taking into account the decentralization process effected since 1994, since which, official

³ The National Statistics Institute of Bolivia carried through two last Censuses in years 1992 and 2001.

⁴ The DESINVENTAR data base is a result of regional initiative taken by the Andean Information System for Disaster Prevention and Attention.

information was systematized at municipal (corresponding to a section of a province) or at departmental level (the totality of provinces).

On this account, an additional systematization work was carried through on DESINVENTAR data base, with municipalities being identified according to event location within a province. This implied loss of part of data with no precise identification of municipalities involved.

Finally, there is information on climatic characteristics and probability of natural events on the maps from the National Territorial Information System (SNIOT by its acronym in Spanish) at the Ministry of Sustainable Development, which have been the basis for risk geo referenced information systematising. To this effect, World Food Program (PMA by its acronym in Spanish), enabled systematization of municipal occurrence probability of these events starting from weather information, as well as agro-ecological SNIOT scale of 1:1,000. 000.

With this set of information sources, the strategy in order to estimate risks in Bolivia have been as follows: it was determined that risks index need to be constructed from most significant events found in available SNIOT information on flood, drought, and freezing periods), assessed according to population exposed to them. Information contained at DESINVENTAR data base is analyzed in terms of limitations and only as indicative data on most important events identified by written press.

Information on Living Conditions

Living conditions of the population are available in two main sources of information: population censuses, and household surveys. In the case of population and household censuses, information has a nine year periodicity (1992 to 2001), and no information of income is available. However, UDAPE simulation exercises combining survey information on living conditions of the population (MECOVIs and EIH) and censuses provide income imputations, allowing having municipal disaggregation information.

In the case of household surveys, information limitations are related to lack of representativeness, which in turn implies the impossibility to infer results beyond urban-rural, capital cities and macro-region (highlands, valleys and tropics) levels. Likewise, available information is a repeated cross-section, with no panel data, which implies the presence of biased data when comparing data in time.

2.2 Non Causal Relations at Municipal Level

The first level of analysis, will focus on links between well-being indicators available from official sources (see annex) and exposition to natural events. Study unit in this case is the municipality and correlations will be esteemed from well-being changes, in order to obtain non causal relations between natural disasters and changes in living conditions, according to census data of 1992 and 2001.

UDAPE (2006) has calculated income imputations from household survey variable, explained through information obtained in the censuses. Through this imputation poverty lines for 1992 and 2001 years was obtained.

In the case of municipal risk assessment, risk events were obtained from SNIOT information, and it were weighted by proportion of exposed population in municipality. Hazard index is as follows:

$$riesgo_i = \sum_{k=1}^3 PRiesgo_k * EXPOSICION$$

Where risk index for i municipality (*riesgo*) is given by addition of the probability of k risk (inundation, drought and freezing), normalized to 1, multiplied by index of population exposed to risk. In the case of municipalities with a population below 50.000 inhabitants, population index exposed is proportionate to municipality's agricultural population, whereas in the case of municipalities with over 50.000 inhabitants total population is exposed to inundation (EXPOSITION=1), since usually whole municipality is exposed to this type of hazard.

On this basis, municipalities with higher incidence of each risk have been geographically referenced. Additionally, a pattern of municipalities was drawn with which to obtain a categorization of changes in living conditions and environment.

For estimation of risk disaster effects on well-being, following function is proposed:

$$p_{i,t} - p_{i,t-1} = \alpha + \beta riesgo_{i,t-1} + \gamma(x_{i,t} - x_{i,t-1}) + \delta(invar_i) + \varepsilon$$

Where the depending variable is (inter-census) change on p, representing municipality i well-being level. β represents well-being municipality risk indexes impact. γ show the effect of control variables within municipality, susceptible to change in time (schooling, migration, mortality, etc.). Finally, δ represents control effects on non-varying characteristics inside municipality (altitude, slope of the terrain, productive vocation, etc.).

On account to possibly endogenous of well being risk variables, estimation strategies were adopted starting from ordinary least squares, to simultaneous equations estimations (3SLS).

2.3. Impact of flood: the Case of Beni Department.

The second level of analysis of this document centres on estimation of changes on well-being indicators within a determined geographic area undergoing natural events of great intensity. The unit of analysis is the city of Trinidad, capital of the Beni department. This urban centre was chosen for two main reasons: first, Trinidad is the only recent case of a capital city – for which representativeness of household survey data is acceptable - greatly overflowed.

The second reason has to do with the fact that analysis of the event is currently important since need for public policy assessment instruments for future execution stands out. In fact, the Niño 2006-2007, generated impact with serious socio-economic policy implications in the country, affecting over 100.000 families and provoking nearly 443 million dollars loss (CEPAL, 2007). Characteristics of affectation in terms of territorial extension and intensity in terms of damage and loss indicate such harm may hardly be exclusively attributed to weather conditions in the country such as hydrological excess in the eastern region of the country and deficit in occidental areas. Available information shows, on the contrary, special relation between disaster and high degrees of vulnerability in physical, ecological, social, institutional and economical factors in the country. This correlation concretizes, therefore, in designing multiple risk and disaster scenarios particularly associated to inundation and drought.

Damage in Trinidad city is directly associated with El Niño phenomenon, registered from December 2006 to April 2007. Nonetheless, if state of emergency and disaster undergone by the country during the same period the previous year is considered, it is evident that effects of the latter are temporarily and territorially related to former disaster processes magnifying and rendering risk conditions more complex. Additionally, current information on meteorological and hydrological conditions foresees that extreme events in association with hydrological excess and deficit in the country will gain greater intensity within recurrent increasingly shorter periods.

Impact valuation strategy for the city of Trinidad was targeted on following exercises. Strictly descriptive character analysis was achieved first, focusing on demonstrating department socio-economic vulnerability, as well as relative change in living conditions after flood in the city of Trinidad. The above implied estimation of change in monetary poverty and extreme poverty, as well as intensity and severity.

On second term, proceedings went on to determine poverty patterns, according to **multi**-varying regressions for both years. Estimations are as follows:

$$\ln Y_i = \alpha + \beta \text{distrito}_i + \gamma(X_i) + \varepsilon$$

Where LnY is the head of family's income logarithm depending on "district" residence (*distrito*), whose own dichotomic scale of values are in accordance to district household exposure to inundation. X represents set of control variables (sex, experience, education).

From these estimations for years 2006 and 2007, structural change in β regressors will be tested to determine change in the way in which control variables at home and district levels were affected according to poverty conditions that might be attributed to shock during the

two years. Magnitude and change in coefficient β is of particular interest, since it represents a proxy of household exposition to risk.⁵

Thirdly, inequality indicators for both years were compared. Mentioned indicators will be chosen from generalized entropy family (GE). Absolute change on well-being conditions, as well as vulnerability differences among certain strata and population groups facing natural events, will be observed through exercise.

Finally, decomposition inequality on basis of regressions whose coefficients are used to evaluate *contributions relating to factorial inequality* developed by Fields (1997) will be calculated. These contributions are valid for several inequality measures, and various explicative regressions variables (see annex for description of method employed). On this particular case, Gini was used as inequality index.

Some authors also used methods based on regressions, but came short of number of explicative variables they were able to use. Some only included one explicative variable (Almeida and Barros (1991), Lam and Levison (1991)). Chiswick and Mincer (1972) only included schooling, labour experience and number of working weeks and used log-variable as inequality measure. On the other hand, Freeman (1980) used a large scale of variables but decomposition is, according to his own words, “an approximation” and an “incomplete decomposition”.

Therefore, the Fields method is particularly useful by the fact that it includes an unlimited number of explicative variables and because relative contributions to factorial inequality conditions thence deriving are valid for a large number of inequality measures. Particularly, main objective in applying this method is determining contributing changes toward inequality conditions deriving from shock inundation, whose proxy, will be the neighbourhood district in the city. Aim pursued is that following contribution may be statistically important, and that its relative importance in explaining inequality might be incremented along inter-annual period under study.

⁵ Lack of panel data or even a pseudo-panel construction – on account of reduced sample - two years – implies bias deriving from assessment of weather effects. Nevertheless, magnitude of event registered in Trinidad, is presumably large enough as to provide an idea of effect on living conditions.

3. Analysis at Municipal Level

3.1 Analysis on Risk Incidence in Bolivia

Disaster Data Systematization

DESINVENTAR data from an inter-census period (1992-2002), was systematized in order to assess an event's incidence on population well-being. There are well-being indicators⁶ (UBN, poverty line, IDH), that may be related to events occurred.

Still, available information is limited. From over more than 1.600 DESINVENTAR events registered between 1970 and 2007, only 289 belong to the 1992-2001 inter-census period, while solely 281 are relevant. In 84 from the 389 cases registered information does not correspond to one natural disaster event, while from remaining sample (305), 24 had no precise location. On the other hand, 158 from 314 municipalities register at least 1 from 281 events, which means that sample only represents 50,6 % of municipalities. Most extreme case belongs to Pando, where only one event was registered in the capital city of Cobija from 1992 to 2001, while it is generally known that this department undergoes yearly intensive rainfall and inundation.

On this account DESINVENTAR does not permit precise identification of municipalities demonstrating greater degree of hazard and natural disaster vulnerability, neither does it allow translating tendencies, on account of disproportionate bias of events registered in city capitals (142) and the rest (139). Over half the events took place in 9 municipalities (2,6%), La Paz being the one with highest registers (62).

This is, fundamentally, because DESINVENTAR data base identifies events only from one source, La Paz morning paper "El Diario", which, while being a country wide circulating newspaper, reflects most of its information on events happening in that city. Also, very often there is distorted information, on account of description of event's impact not often being assessable. This is often the case in rural zones, where (frequently due to absence or inadequate use or loss of information) direct impact on agriculture, forestry, education, health, etc. may not be assessed.

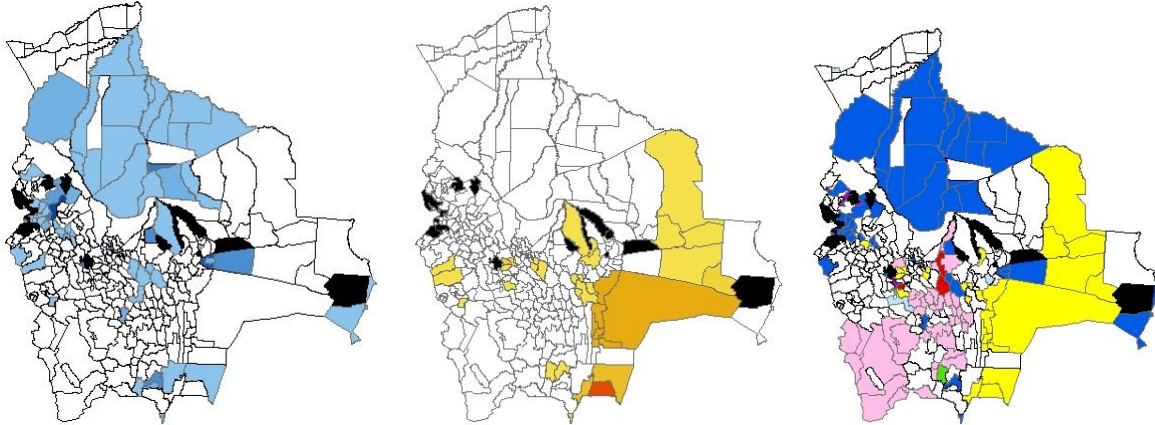
DESINVENTAR limitations

DESINVENTAR information was systematized into thematic maps showing the number of events per municipality for each type of disaster.⁷

⁶ On basis of official INE and UDAPE information.

⁷ See Maps on next page.

Following Maps Nos. 1, 2 and.3, were drawn on basis of DESINVENTAR Municipality Data Systematization corresponding to Inter-Census Period of 1992-2001.



Map No. 1. Floods

Map No. 2. Droughts

Map No. 3 Events of largest impact

Map No. 1 displays the number of Inundations Registered in Different Bolivian Municipalities As shown, most vulnerable regions in terms of inundation are located within the *Amazonas territory* (Beni, Santa Cruz and La Paz departments) as well as in that of Tarija. However, map information does not correspond to reality and there are some elements which might cause confusion and incorrect interpretation. Municipality of La Paz, (registering 23 inundation episodes, appears as the municipality in darker blue, while municipalities in the department of Beni (registering one only inundation event each one) appears in light blue. On a quick sight one could interpret that La Paz is by far the municipality with greater number of inundations, however, this is due to disproportionate biased available information between municipalities. Surprisingly, the department of Pando (north of the country) appears in white, meaning that none of its municipalities registered any inundation during that period.

Map No.2, shows Number of Dry Periods Registered in Different Bolivian Municipalities. Although information in this case may seem to be consistent, drought seem to affect only the oriental part of the country, corresponding to el *Chaco* and subtropical valleys of Santa Cruz and Tarija. The department of Potosí, on the contrary, presents only one municipality registering drought, while the Altiplano is one of the driest regions not only in the country, but in the whole continent. 80% of Potosí territory is located in the Altiplano and some of the municipalities in that zone have less than 15 days of rainfall a year.

Map No, 3, shows Greatest Impact Event in Different Bolivian Municipalities. In this case, inundations appear in blue, dry periods in yellow and freezing periods in light pink. Quick reading of this map permits visualizing geographic macro regions affected by different natural disasters. South-western municipalities in the country, corresponding essentially to the department of Potosí, show freezing impact; municipalities located to the

north of the country, show impact due to inundation, while municipalities situated to the east, display impact on account of drought.

Still, reading is relative since, for instance, in the case of Potosí, although drought seems to be the event of greatest impact, lack of information on droughts could make it be mistakenly interpreted, in that Potosí is a department with exclusively “freezing” periods.

However, given **DESINVENTAR** characteristics in the case of Bolivia, it is advisable to only keep register of mentioned events as chronological data, not to be used as tendency reference of municipality events towards future local public policy planning.

By above exposed, **DESINVENTAR** is unreliable for estimation of natural disaster behaviour tendencies in Bolivian municipalities. Information is incomplete, and interpretation of different results obtained through this source could generate confusion and lead to mistaken interpretation.

On Non Causal Relations at Different Geographic Scales

Under this context, information taken into account to determine municipality tendencies in terms of risk and natural disasters, will be one elaborated by World Food Program (PMA by its acronym in Spanish), based on systematization of agro-ecological maps from the Sistema Nacional de Informacion de Ordenamiento Territorial (SNIOT) elaborated by the Unidad de Ordenamiento Territorial from the former Ministry of Sustainable Development in year 1997.

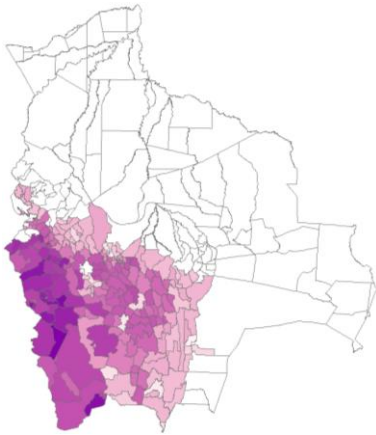
In this case, the PMA assessed yearly probability of existing natural risk. For instance, municipality of San Pedro de Quemes located to the south of Potosí and on the border with Chile (Andean Cordillera), with a freezing frequency of 270 days a year, permits creating a freezing risk index ponderable starting from interaction between (freezing) risk probability and municipality endangered population. Still, it must be said that this does not allow for evaluation of damage to infrastructure or agricultural plantations.

Once **index 1) freezing risk**, has been assessed it is proceeded to evaluate indexes **2) drought risk** and **3) inundation risk**. From calculations, assessment of, municipal vulnerability to **general** risk may be determined, by adding up values found in three indexes.

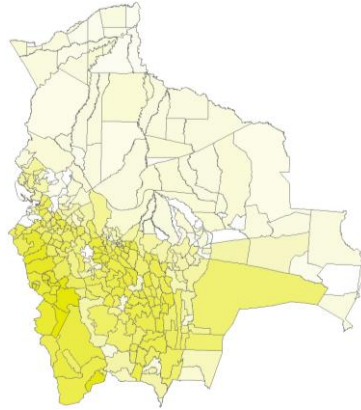
It is very important to point out that natural disaster events may be of different types and nature. Still, on account of source unreliability and scarce information, consideration of this paper will be three types of natural disaster events most recurrent in time and space, from which behaviour tendencies and risk indexes may be elaborated. These three disaster types are freezing periods, drought and inundation.

Behaviour and Tendency of Natural Disaster

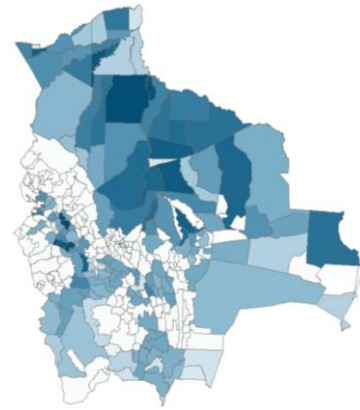
Maps Nos. 4, 5 and 6 displayed on next page, were based on PMA Systematization Data and on Different Municipality Risk Indexes Assessed.



Map No. 4 Freezing Risk



Map No. 5 Drought Risk



Map No. 6 Inundation risk

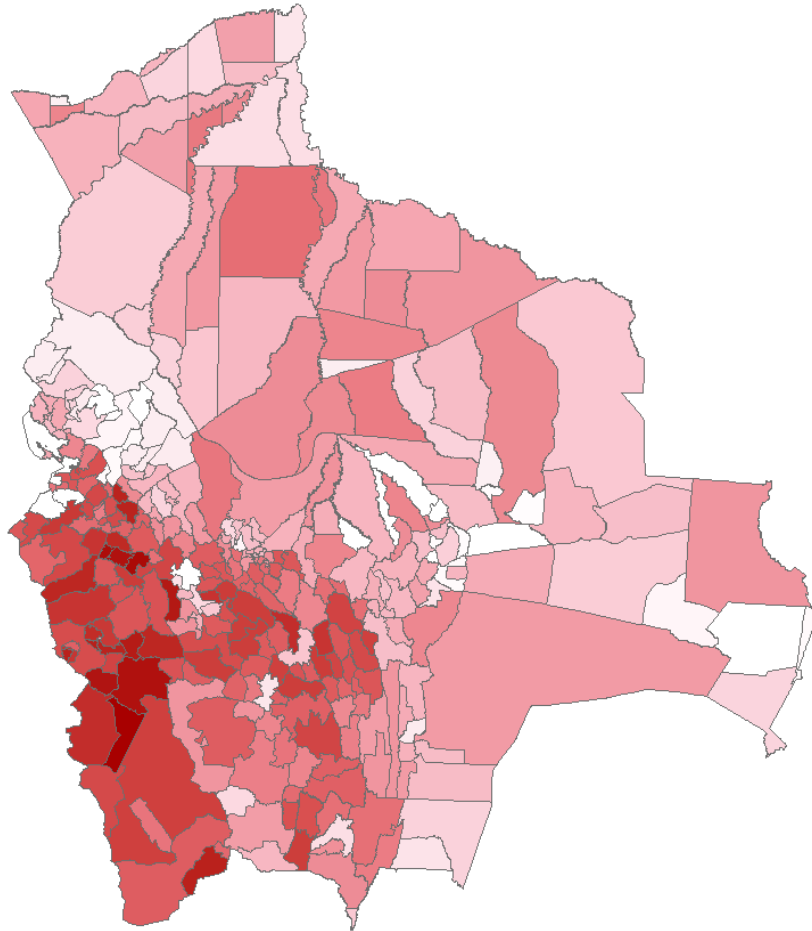
Map No. 4, shows Freezing Risk Present in Different Bolivian Municipalities. As may be seen, freezing affects two distinct regions in Bolivia. First one is Highlands comprising south of the La Paz department, while the other two are Oruro and Potosí, the second one being *Valles Altos* (High Valleys) which include most of the departments of Chuquisaca, Tarija and Cochabamba. Incidence of freezing risk strongly depends on altitude above sea level at which different municipalities struck are located. Thereby, definite “East-West” echeloning may be appreciated in relation to territory freezing risk. Municipalities appearing in white are located at an altitude below 2400 meters above sea level and do not run any risk. Freezing risk is increased at higher altitudes, and in municipalities on the border of Chile, located between 4000 and 6000 meters above sea level, risk becomes critical (dark purple).

Map No. 5, shows Drought Risk Present in Different Bolivian Municipalities. In this case it may be evidenced that drought mainly affects the south of territory and involves regions of *Altiplano* (*highlands*), *Valleys* (*High and Low*) and *El Chaco*. The *Altiplano* region characterizes for being arid due to scarce oxygen on account of altitude. The Valleys (High and Low) though they may be humid zones at some seasons of the year, during part of autumn and winter, are severely struck by drought, with negative effects on agriculture and cattle-raising.. Finally the Chaco region, located to the south of Santa Cruz department and to the east of Tarija, undergoes severe drought during most part of the year. Some *Chaco* regions have below 15 days of rainfall a year.

Map No. 6, shows Risk of Inundation Present in Different Bolivian Municipalities. Although risk is valid for all Bolivian departments, it is clear that *Amazona* departments of Pando, Beni, north of La Paz and Santa Cruz are most affected by this type of disaster. Absolutely all municipalities in Beni and Pando display inundation risk; and at some of these municipalities disaster, could be of considerable magnitude, since response capacities are almost non existent at some very isolated communities.

As may be observed from these three maps, almost all Bolivian municipalities are prone to some type of risk. *Amazona* municipalities are most affected by inundation, while municipalities to the south and those of the *Altiplano* are affected by drought, and municipalities in the *Altiplano* alone are mainly affected by freezing.

From former evaluation, vulnerability to natural risk disasters behaviour and tendencies may be assessed. Next, municipalities most vulnerable to overall risk will be assessed, according to freezing, drought and inundation periods normalized addition.



Map No. 7 General Index of Risk by Municipality

Final result displays that municipalities at the highlands, chiefly those located on the Chilean border, the interior of the Oruro and Potosí departments, are most vulnerable to natural risk from the whole territory. Likewise, that the south and centre of the country, where departments of Tarija and Sucre are located, has a somewhat high index of vulnerability. Vulnerability index is moderate within Beni department, while municipalities in La Paz, Cochabamba, Pando and Santa Cruz, mostly display low degrees of vulnerability.

Though results of these tendencies are real, risk impact is not the same on the whole territory. For instance, departments of Oruro and Potosí (appearing in darker red) are most vulnerable to all types of risk (there is a very high risk of drought and freezing within their municipalities, together with a moderate risk of inundation). However, more often, population exposed to those types of disasters is reduced, and economic activities are rare. Consequently, while these municipalities display high risk indexes, conclusions are relative since real impact on human activities may come to be almost none in least populated municipalities.

On the other hand, there are Beni and Pando municipalities displaying low and moderate risk, where disaster impact is nonetheless much higher than in other municipalities of the country. In such a case, municipalities at the Amazone region do not display freezing, or drought, but where magnitude of inundation is such that it sometimes reaches enormous proportions. During 2006 and 2007 rains in Beni department, over 15000 people were directly affected by El Niño, and economic loss in agricultural and cattle-raising areas, was of millions.

Assessment of natural disaster in Bolivia tendencies may be concluded by saying that over 70% municipalities in the country are exposed to some type of event. Main types of disaster having an effect on population are freezing, drought and inundation. The Altiplano is the most vulnerable region in Bolivia, while it not being most impacted. Amazone region, in change, while not being the most vulnerable one, is the one undergoing largest impact.

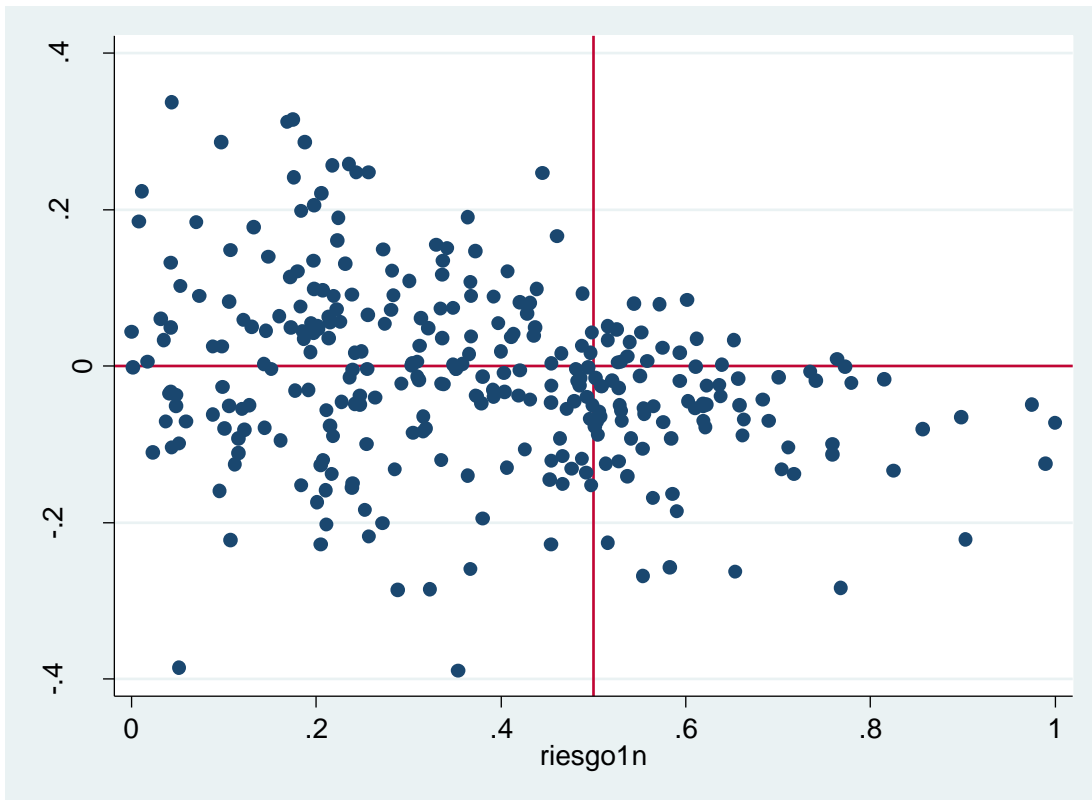
On Cross Sectioning Disaster and Well-Being Indicators

Once natural disaster incidence overall behaviour has been established in Bolivian municipalities, attempts have been made to identify whether there is direct relation between disaster incidence and well-being of population exposed to disaster. It is simply a matter of identifying existing correlation between disaster and living conditions of damaged population

In order to achieve this task, data on risk index (freezing, drought, inundation) from a determined municipality was cross-sectioned against population well-being indicators, such as IDH, Poverty Line or the NBI, registered in the inter-census period (1992-2001), by first considering overall conditions of the population on initial period (1992) to subsequently assess overall conditions at the end of inter-census period (2001).

Results from cross information shall display municipal general tendencies on people living conditions following disaster. Tendencies will display whether improvement of population living conditions followed after disaster, and if living conditions and habitat were deteriorated or not within affected municipalities.

Following graphic shows overall evolution tendency of living conditions in municipalities facing natural disaster. General parameters used to achieve this tendency are **1) Disaster Risk, and 2) Change in Poverty Line** following disaster.



Graph. No. 1. General pattern between change in poverty and risk index

Though it may seem there is a tendency indicating that to higher risk index, living conditions will be worsened, it is not always the case.

Synthetically reading this graphic, may result in classification of municipalities by types, according to evolution of living conditions opposed to natural disaster. To this effect, 4 types of municipalities may be identified displaying different degrees of evolution (of their living conditions) with regards to existing disaster risk.

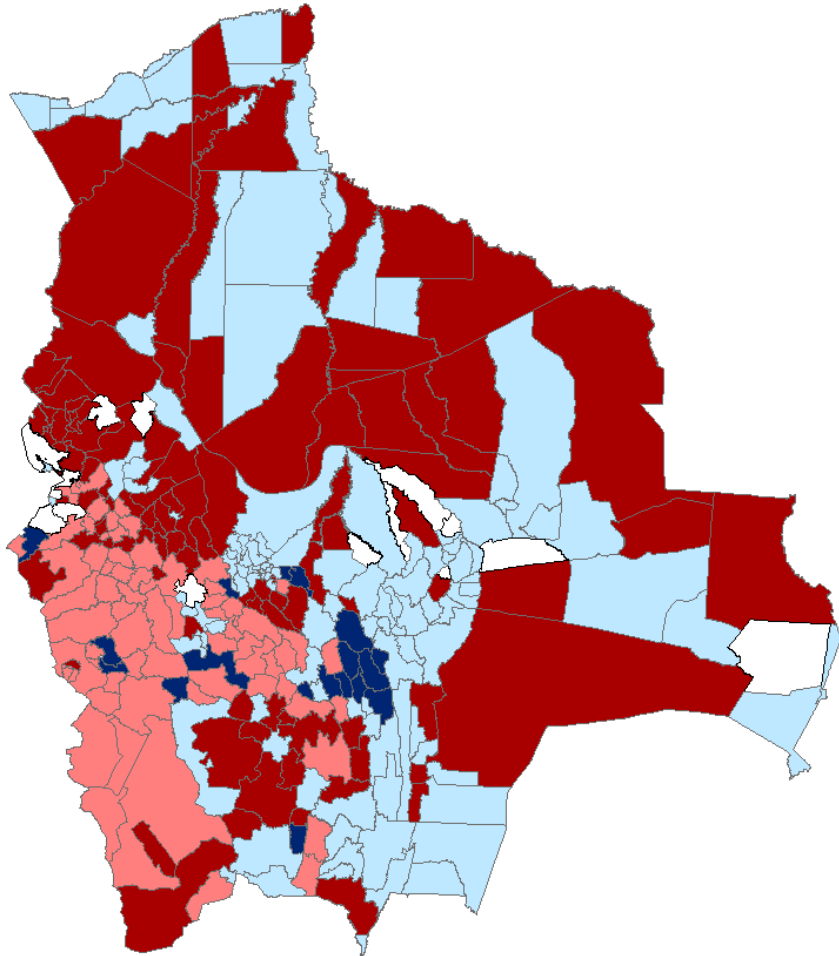
Previously 4 mentioned municipality types are:

- **High Risk Index Municipalities with Improved Living Conditions (Dark Blue)**
This is the group with least number of municipalities. Exceptional though this may seem with respect to general tendency, this may happen.
- **Low Risk Index Municipalities and Improved Living Conditions (Light Blue)**
This group responds to a logic. The least exposed to risk a municipality is, the more chance will it's population have to improve its living conditions.
- **High Risk Index Municipalities and Worsened Living Conditions (Light Red)**

This group of municipalities responds to a different logic. The more exposed municipality is to risk, the fewer chances will it's population have of improving living conditions.

• **Low Risk Index Municipalities and Worsened Living Conditions (Dark Red)**

These Municipalities also escape to general tendencies. In this case, they are lowest income municipalities and the most abandoned in the territory.



Map No. 8 Tipology of Municipalities under poverty change and risk criteria

As the Map shows, Municipalities which though having a high risk index improve their living conditions are to be found in La Paz, Oruro Cochabamba and Chuquisaca.

This may be explained by the fact that impact of event (in this case drought or freezing), is not as harsh in terms of population or produce affected.

Municipalities displaying low risk index and improvement of living conditions are chiefly located in Tarija, Chuquisaca, Cochabamba, Santa Cruz, Beni and Pando. In some cases this is on account of impact of event reaching very small towns.

Municipalities showing a high risk index with worsened living conditions are mainly located in the Altiplano. The reason for this is that risk indexes in these municipalities are extremely high.

Finally municipalities, that while not showing great vulnerability to risks, worsen their living conditions, are mainly located to the north of La Paz, Beni, Pando and Santa Cruz. It is the case of municipalities having dispersed population scarcely communicated, which explains reaction to disaster being slow, a fact worsening well-being conditions. Furthermore, there are other factors weighing on well-being conditions, such as migration rates, productivity possibilities and access to markets in different capital cities belonging to a municipality.

3.2 Living Conditions and Natural Invents Change Pattern

In order to design a pattern for natural event impact, change in municipal poverty incidence was assessed according to several specifications, including natural risk variable. Reduced scale expresses that:

$$p_{i,t} - p_{i,t-1} = \alpha + \beta_1 P92_i + \beta_2 \text{cambio NBI} + \beta_3 \text{TNM}_i + \beta_4 \text{Cambioeduca}_i + \beta_5 \text{riesgo}_i + \beta_6 \text{cambiomortalida}_i + \varepsilon$$

(3.1)

Where $P_t - P_{t-1}$ is change in poverty incidence (FTG(0)) in municipality i , depending on the following variables:

- $P92$, is municipal poverty incidence on initial year (1992).
- NBI Change, which is change of municipal unmet basic need indexes (non monetary) during inter-census period.
- TMN , which is municipality migration rate during inter-census period.
- $Cambioeduca$, is change of municipality average school years ended by population above 19 years of age.
- $Risk$, being municipality risk rate combined with drought, inundation and freezing, considered at the above section.
- $Mortality$ Change, is change in municipal child mortality rates.

There are some difficulties in estimation of equation 3.1. There may possibly be endogenous biases among some variables. There are particularly two regressors that may show this characteristic. First one is risk rate, since in model explained, exogenous quality is assumed with relation to poverty incidence. Nonetheless, according to conceptual frame developed by UNDP (2004), it is established that risks are reinforced by poverty, since the poorer population is, the more it will be exposed to natural risks. Therefore risks and poverty are increasing factors when they go together.

Other variable that may be endogenous is NBI. According to the model, it is presumed that improve on non monetary living conditions should lead to improved monetary poverty conditions. However, improvement in monetary conditions may also be a factor affecting non monetary well-being (especially that related to housing conditions and access to health services).

The following strategy was adopted in the attempt to correct these problems. On a first design, model was calculated from Ordinary Least Squares (MCO in Spanish) in order to adopt a *benchmark* model. On second stage, an estimation of Seemingly Unrelated Regression model was adopted (SURE) where system includes equations in which NBI variables on risk and change in UBN are also modelled. Third estimation used SURE corrected by degrees of freedom. (SLS) Two Stage Least Squares method was applied to fourth estimation based only on poverty change and risk. Finally at fifth estimation, simultaneous equations method (3SLS) was used.

The rest of equations of the model were proposed as follows:

$$NBI_{i,t} - NBI_{i,t-1}(\text{cambioNBI}) = \alpha + \delta_1 \text{riesgo}_i + \delta_2 \text{cambiopobreza}_i + \varepsilon \quad (3.2)$$

Equation 3.2 has UBN change (NBI) as dependent variable, which depends on:

- Risk index (*riesgo*) and
- Poverty change (*cambiopobreza*)

Finally risk equation is as follows:

$$\text{riesgo}_i = \alpha + \rho_1 \text{altura}_i + \rho_2 \text{precipitacion}_i + \rho_3 \text{pendiente}_i + \varepsilon \quad (3.3)$$

Equation No. 3.3 models risk as dependent variable as a function of exogenous variables related to climatic and geological aspects within the municipality.

- Altitude (*altura*)
- rain precipitation (*precipitacion*) and
- municipality average area with over 30 degrees gradient (*pendiente*).

In the case of equation 3.2, it is assumed that non-monetary well-being conditions are also related to change in monetary poverty and risk, while in equation 3.3 risk index is calculated through exogenous variables (non-varying in time) such as altitude, precipitation and gradient.

Results of these estimations are displayed on chart 3.1.

CHART 3.1.
ESTIMATIONS OF CHANGE IN POVERTY INCIDENCE AT MUNICIPALITY LEVEL

	MCO	SURE	SURE - AJUSTE GRAD. LIBER.	2SLS	SIM. EQ (3SLS)
Equation 1: $p_{it} - p_{it-1} = \alpha + \beta_1 P92_i + \beta_2 \text{cambio NBI} + \beta_3 \text{TNM}_i + \beta_4 \text{Cambioeduca}_i + \beta_5 \text{riesgo}_i + \beta_6 \text{cambiomortalida}_i + \varepsilon$					
P92	.0910804 (.0514194)	.059492 (.0459805)	.0593782 (.0465069)	.1227646 (.1136482)	.0200725 (.0309786)
Cambio-NBI	.0219261 (.0026578)	.0366192 (.002413)	.0367365 (.0024406)	.0727613 (.0166978)	.0774851 (.010643)
TNM	.0002364 (.0003314)	.0001365 (.0002962)	.0001361 (.0002996)	-.0002555 (.0210075)	-.0000197 (.000133)
Cambio-educa	.0360562 (.0120107)	.0260058 (.0107553)	.0259728 (.0108785)	.0024577 (.0005596)	.0003079 (.0048315)
Riesgo	-.1169673 (.0189808)	-.1106567 (.0181587)	-.1106353 (.0183666)	-.0415988 (.00529006)	-.030789 (.00320285)
Cambio-Mort.	-.0004538 (.0002466)	-.0003248 (.0002206)	-.0003244 (.0002231)	-.0012642 (.0004555)	-.0001284 (.0002017)
Constante	-.0551276 (.0400289)	-.0215602 (.036121)	-.0214425 (.0365345)	.0913149 (.0784839)	.0222874 (.0278203)
R2	0.3107	0.2349	0.2337	0.3459	0.2133
F/Chi2	22.84	303.18	49.65	6.19	333.02
Obs.	311	311	311	311	311
Equation 2: $NBI_{i,t} - NBI_{i,t-1} (\text{cambio NBI}) = \alpha + \delta_1 \text{riesgo}_i + \delta_2 \text{cambio pobreza}_i + \varepsilon$					
Riesgo	-	-.9827519 (.3154544)	-.9791202 (.316987)	-	-.3830289 (.442533)
Cambio pobreza	-	14.0645 (.9130939)	14.02038 (.91753)	-	12.7839 (1.948239)
Constante	-	-.4569783 (.2210351)	-.4552053 (.2221089)	-	-.1014442 (.2897237)
R2	-	0.1105	0.1118	-	0.1274
F/Chi2	-	238.67	117.45	-	44.83
Obs.	-	311	311	-	311
Equation 3: $\text{riesgo}_i = \alpha + \rho_1 \text{altura}_i + \rho_2 \text{precipitacion}_i + \rho_3 \text{pendiente}_i + \varepsilon$					
Altura	-	.0000875 (.0000195)	.0000875 (.0000197)	.0000854 (.0000197)	.0000847 (.0000195)
Precipitación	-	-.0018668 (.0005188)	-.0018668 (.0005222)	-.0019011 (.0005241)	-.0019263 (.0005173)
Pendiente	-	-.0026111 (.0005507)	-.0026112 (.0005542)	-.0025139 (.0005563)	-.0026382 (.0005478)
Constante	-	.654643 (.0869502)	.654641 (.0875148)	.6589137 (.0878268)	.6675938 (.0868109)
R2	-	0.3275	0.3275	0.3276	0.3275
F/Chi2	-	154.38	50.80	49.85	153.68
Obs.	-	311	311	311	311

Note: values in parenthesis stand for standard errors.

Without assuming causal relations, given limited information, grade of aggregation and temporary timing of analysis, in a general way, it is evident that in equation 1, different methods of estimation reveal that variables establish expected results. In terms of statistical significance, both risk variable as well as schooling change are statistically significant in any of the models. From regressions, it is clear that:

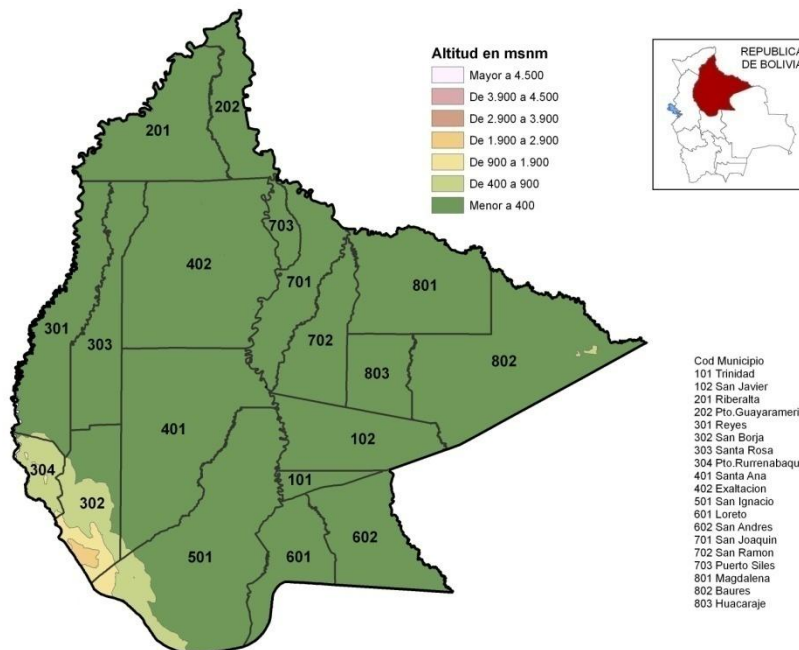
- Schooling level shows increasing contribution to improve poverty incidence.

- The fact of an initially higher municipal poverty incidence has a positive effect on change of same with time. However this result may only be interpreted as an effect of been initially situated at a disadvantageous position, and not as an index of municipality convergence.
- Negative change in infantile mortality rate (interpreted as improvement) together with positive migration rates (immigration) positively influence poverty incidence. However direction of sign at both variables changes with simultaneous calculation and two stages estimation, though significance also falls.
- In the case NBI change, improvement of municipal poverty conditions has positively relation to NBI change, significance remaining unaltered in any of two models.
- Finally risk variable, shows expected results from theory, meaning that, to greater municipality risk, correspond lesser improvement of living and monetary conditions. Variable shows negative and statistically significant values upon five estimations, though in the case of two stage method, and in that of simultaneous equations, magnitude of the effect measured by the coefficient, falls in more than 50%, situating itself between 4% and 3% respectively.
- Lastly, it must be said that results of equations 3.2. and 3.3. are qualitatively consistent in their different estimations, emphasizing the fact that risk index has a negative incidence on NBI improvement.

4. WELL-BEING CHANGES IN TRINIDAD AFTER THE EL NIÑO 2006-2007 PHENOMENON

4.1 Socio Economic Context in Beni

Department of Beni located to the north of the Republic of Bolivia, has an extension of 231.264 Km². With a projected population of 422.434 inhabitants for year 2007, it concentrates 4.3% of national population. Beni department is an “expulsing” department, with a negative migration rate of 8,4 for each thousand inhabitants. Political distribution divides the department into 8 provinces and 19 municipality sections.



Map No. 9 Beni: Political Division

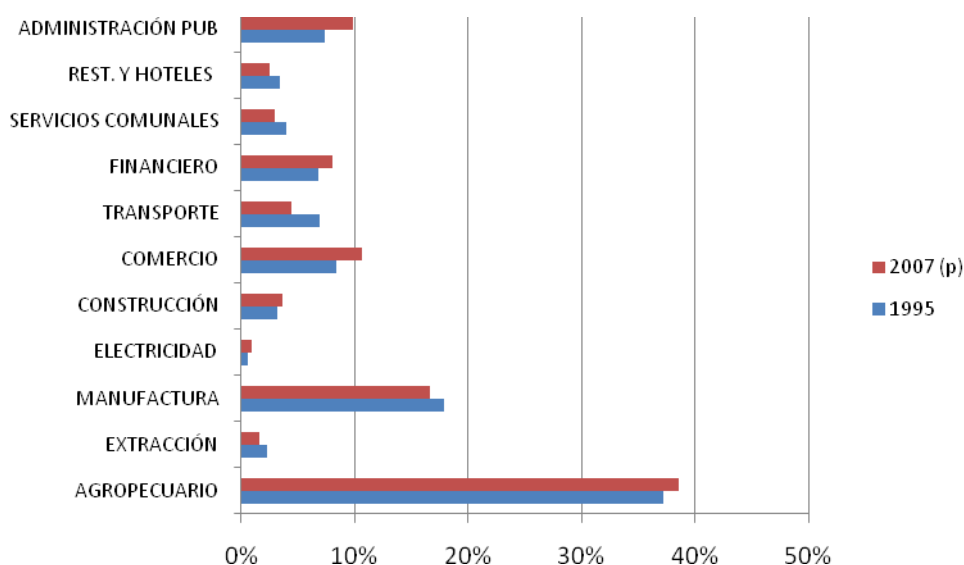
Demographic and economic profile of the department is characterized by a young, urban agricultural, cattle raising population with high migration rates. High economic dependency on agricultural and cattle raising activities makes economy in Beni highly vulnerable to climatic risks, mainly, inundations and drought. To this characteristic, population composition mainly belonging to younger generations must be added, a factor accelerating impact of natural disaster.

Natural disaster impact in this department, specially that derived from the El Niño phenomenon in 2006-2007 reveals necessity of orienting public policy toward actions of risk prevention, as effective instruments for poverty reduction. Additionally risk and natural disaster prevention might constitute an effective instrument for growth of economic capacity by reducing impact of infrastructure and basic services loss – particularly water supply and drainage systems – and consequent serious diseases.

An Agricultural and Cattle-Raising Economy

Economy in Beni is based on agricultural and cattle-raising activities. Contribution of these activities represented 38,5% of the departmental produce for year 2007. During the last two decades this sector was first contributing to departmental GDP; in year 1988 this sector's contribution already represented 37% of produce. Second economic sector in Beni is manufacturing industry contributing with 17% to department PIB. Following activities are commerce with 11%, and public administration with 10%. Economic dependence of agricultural and cattle-raising sector transcends the field of produce generation: 18 Agricultural and Cattle Raising Peasant Economic Organizations (OECAS) are registered in the rural areas in agriculture and cattle-raising, handicrafts, and forestry activities. Additionally agriculture and cattle-raising constitute the chief source of income from exports in the department; chestnut exports alone represent more than 50% of department exports.

Graphic No.4.1
Contribution to GDP According to Economic Activity (%)



Department contribution to national product in 19 years oscillated between 4,2% and (1988) and 3,5% (2007). Along this period, economic activity in Beni kept development rates below national averages. Under high dependency circumstances on agricultural and cattle-breeding and raising, natural disaster affecting Beni inhabitants year by year, may constitute, on the short term, in important drawbacks for department development.

An example of such vulnerability is impact registered by the El Niño phenomenon 2006-2007. Loss of cattle raising sector was quantified in US\$ 31 million dollars, owing to loss of 178.000 livestock from 3 million registered in Livestock Cadastre in year 2006.

Productivity vocation of the department shows large diversification potential of economic activities towards activities transcending economic insertion in merely extractive activities. Sectors that may be mentioned for their great potentiality to generate department surplus, are forestry exploitation other than for wooden purposes (e.g. chestnut), expansion of organic goods production and tourism infrastructure. Target of political policies in the department should be supporting these activities which combine sustainable environmental and labour strategies with strategies for risk and disaster prevention.

Young population

Beni population is characterized by a young demographic profile. Population composition shows that it mainly concentrates in the range below 5 years, corresponding to 15% of department population. Previously mentioned is important in terms of population vulnerable to natural disaster impact. According to several surveys on impact of natural disaster, infantile population results in one of the groups particularly vulnerable to environmental impact. There are several factors determining identification of this group as part of the population particularly vulnerable: death during disaster, disease proliferation and larger malnutrition risk, and death of people at their charge (UNDP, 2007; UNDP, 2004).

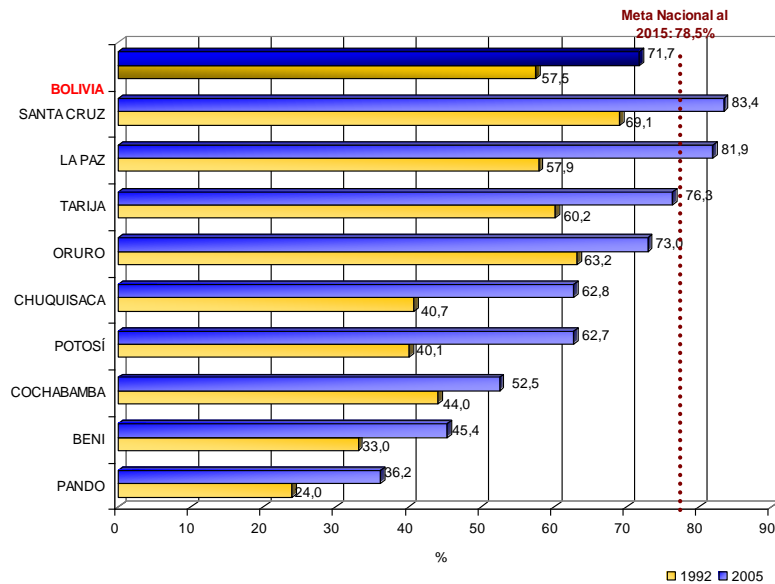
Contributing to this young age composition characteristic, delay in compliance of ODM related to development and living conditions of population may be added. Chronic malnutrition and maternal mortality are above national averages. Last data registered on 2003 reported 28% chronic malnutrition, 4% above national average; something similar happens with registers on maternal mortality which reported the third highest index for year 2005, with 259 deaths for every 100,000 live newborn, compared to national average of 234. Despite these indicators, department infantile mortality stays below national average.

Important data in terms of effect of natural disaster is, no doubt, high incidence of serious diseases: malaria, which despite of having favourably diminished since 2001, still highly affects Beni inhabitants, and is seven times above national levels. Propagation of serious disease in disaster seasons is a fact; according to the Malaria Prevention National Program, levels of infestation grew during the last months of 2006 and first of 2007, as a consequence of the El Niño Phenomenon. Dengue Propagation is another example of risk in disaster seasons.

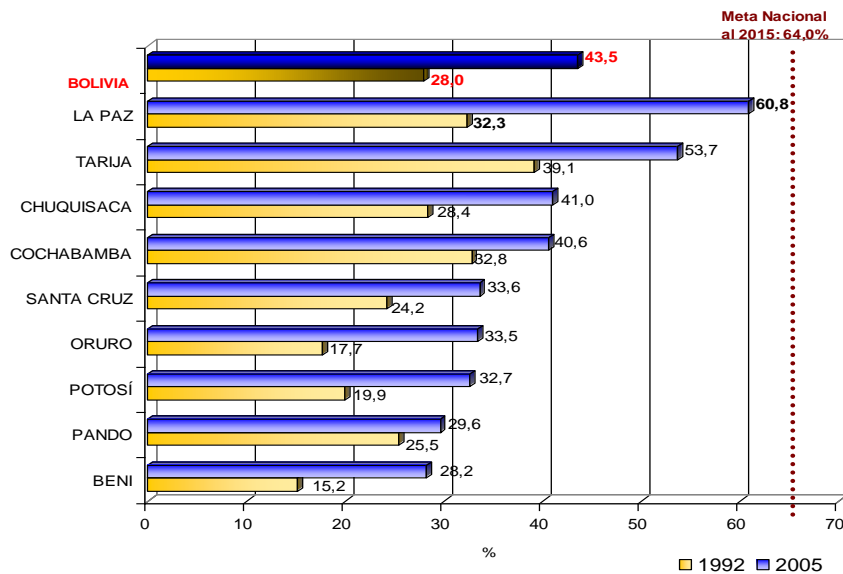
Basic Sanitation and Drinking Water Access Deficit

Living conditions of Beni population is typified by the lowest coverage rates with regards to sanitation system and potable water, together with the department of Pando. Compliance with seventh ODM for year 2005, situated Beni in the penultimate place in drinking water coverage and at the last place in draining system coverage. Only 45% of population has access to drinking water and only 15% has access to sanitation. Access opportunities to both services in Beni department are far below national average.

Graphic 4.2
Potable Water Coverage Rate (%)



Graphic 4.3
Sanitation Coverage (%)



It is not only that there is shortage in potable water provision, but its distribution also displays important inequality rates. From 19 municipalities in Beni, only 5, that is between 52% to 72%, have coverage, 3, San Borja, San Ignacio and San Ramón) have between 34% to 52% coverage, while the rest is unable to cover 34% of municipal population. Between 1992 and 2001, potable water coverage rose in all departments, however there are persistent uneven regional opportunities of access to this service: Santa Cruz and La Paz have

coverage surpassing 80%, while in Beni and Pando departments it only reaches 50% of the population. These differences could be attributed to population low demographic density and dispersion in two departments with lowest coverage.

During year 2005 Beni department had a sanitation service coverage of 28,2%, having positively evolved since 1992. Between 1992 and 2005, department basic sanitation coverage only grew in 13%, being below last national average observed (43%) and almost 36% from national goal (64%).

Natural Disaster and Contingency Plan

Most important regional impact from climatic drought and inundations phenomenon occurs in Beni. With the objective of creating response capacities to emergencies, through collaboration from the Vice Ministry of Civil Defence and Integral Development, together with World Food Program (PMA by its acronym in Spanish) have developed the national contingency plan as well as department contingency plans in order to identify hypothetic scenarios of expected disaster in next five years.

Joint effort by national and departmental planning offices has developed a method for qualification of alimentary crisis, by taking into account resources and response capacities to emergency situations in the Beni department. Plan's main objective is providing alimentary assistance during climatic event and at recuperating stage; and safeguarding nutritional level of most vulnerable groups.

Chart 4.1
Drought Probability and Impact

Provincia	Municipality	Probability	Impact
Iténez	Magdalena	3	B
	Baures	3	B
	Huacareja	3	B
Mamoré	San Joaquín	3	B
	San Ramón	3	B
	Puerto Siles	3	B
Cercado	Trinidad	3	B
	San Javier	3	B
Marbán	San Andrés	3	B
	Loreto	3	B
Moxos	San Ignacio e Moxos	3	B
	Territorio Indígena Parque Nacional Isiboro-Sécure	1	C
Yacuma	Santa Ana de Yacuma	3	B
	Exaltación	2	B
José Ballivián	San Borja	3	B
	Reyes	3	B
	Rurrenabaque	2	C
	Santa Rosa	3	B
Vaca Díez	Riberalta	3	B
	Guayaramerín	2	C

Source: PMA (2008)

1: improbable; 2: probable; 3: very probable

B: large impact, C: moderate impact

Impact on 98,183 (19,637 families) has been foreseen in case of drought. Distribution of food will reach 9,428 metric tons. In the case of Beni, beneficiaries of the contingency plan for inundation amount to 31,428 people (6,286 families). 1,520 metric tons of food will be delivered during recovery.

Previous table shows probability of occurrence and drought impact in Beni provinces and municipalities. Scale employed reveals high probability of drought occurrence, as well as greater impact, in terms of density. It is evident that vulnerability scenario affects all municipalities in this department. To this high probability of drought occurrence, inundation probability menacing department municipalities may be added, though with increasingly varied occurrence and impact intensity.

Chart 4.2.
Inundation Probability and Impact

River	Province	Municipality	Probability	Impact	
Mamoré e Ichilo	Marban	San Andrés	3	A	
		Loreto	3	B	
	Moxos	San Ignacio de Moxos	3	A	
		Cercado	Trinidad	3	A
	Mamoré	San Javier	San Javier	3	B
			Puerto Siles	3	A
		Mamoré	San Joaquín	3	B
			San Ramón	3	B
		Vaca Diez	Santa Ana de Yacuma	3	A
			Exaltación	3	A
	Iténez	Vaca Diez	Guayaramerín	3	C
			Baures	3	B
			Huacaraje	3	C
	Beni	José Ballivián	Magdalena	3	B
Rurrenabaque			2	A	
Reyes			2	B	
Santa Rosa			2	B	
Vaca Diez		San Borja	2	A	
		Riberalta	2	B	
Iténez		Iténez	Baures	2	A
	Huacaraje		2	B	
	Magdalena		2	A	
	Mamoré	San Ramón	2	B	
		San Joaquín	2	B	
	Vaca Diez	Baures	2	C	
		Guayaramerín	2	C	

Source: PMA (2008)

1: improbable; 2: probable; 3: very probable

B: large impact, C: moderate impact

Department regions more prone to disaster correspond to productive spaces found on the banks of Mamoré, Iténez and Beni rivers. Worst prognosticated scenery in simulations is the one corresponding to the Mamoré delta. Main consequences of inundation is worsened availability and access to food products with consequent loss of income source: in this setting most vulnerable groups are inhabitants whose income and/or jobs depend on agricultural, cattle and fish breeding.

Contingency plan for the department foresees that 31,428 people from 6,286 families benefit. On first stage, 1,031 metric tons of food will be distributed along 60 days: On second stage, foreseen for a period of 120 days, 488 metric tons will be delivered.

Above table displays probability of inundation occurrence and impact in provinces and municipalities, mainly in basins of Ichilo and Mamoré rivers. Impact intensity is varying.

4.2. Estimation of Impact of Inundation on Trinidad

Data used in the analysis comes from 2006-2007 Survey on Improvement of Living Conditions (MECOVI, by its acronym in Spanish). These surveys were applied by the National Statistics Institute in large Bolivian cities, including Trinidad. As mentioned in the methodological section of this work, survey has the necessary statistical representation with regards to this city.

For purposes of this paper, household labour as well as non-labour income was selected from surveys. Size of sample varies from 373 observations in 2006 to 333 individuals in 2007.

Descriptive Statistics

Population. In year 2006, 135,551 people lived in Trinidad (373 were interviewed). There were 55.27% men and 44.73% women. Inhabitants were grouped in 32,103 households, with an average number of 5.3 members. According to language spoken, nobody living in Trinidad is, or might be considered indigenous. According to self-identification parameters, 25.09% from total population might consider themselves belonging to some indigenous or native people. In year 2007, 131,140 people lived in Trinidad (333 people were interviewed); 50.75% men and 49.25% women.

Poverty. Following are displayed poverty levels according to poverty rates according to Foster-Greer-Thorbecke (FGT(a)) poverty rates.

Chart 4.3.
INCIDENCE, GAP AND INTENSITY
POVERTY INDEXES IN THE CITY OF TRINIDAD

Año	a=0	a=1	a=2
2001	0.54906	0.18757	0.08512
2005	0.35121	0.11862	0.04898
2006	0.3775	0.15133	0.07315
2007	0.4932	0.21601	0.12455

Where: FGT(0) = headcount ratio (proportion of poor)

FGT(1) = average normalised poverty gap

FGT(2) = average squared normalised poverty gap

According to previous chart, poverty levels between years 2006 and 2007 increased in almost 12 points, accounting for large shock on people of Trinidad. Similar situation may be observed in the case of poverty gap, with inter-annual increase above 6 points. Finally, poverty severity, expressed by FGT(2) index has also undergone an increase between years assessed.

These results reveal enormous affectation in Trinidad living conditions, supposedly derived from natural disaster effects. Increase of poverty incidence in almost six times above Bolivian average may be observed, when comparing these figures with national average.⁸ Therefore attempts should be made to separate effect of inundation on population living conditions from assessment of household income.⁹

Income Patterns

Following methodology described in section 2, first step should be estimating income regressions, taking the log of income per hour per person coming from their working activity during month previous to survey as dependent variable

$$\ln Y_i = \alpha + \beta_1 \text{Educa}_i + \beta_2 \text{exp}_i + \beta_3 \text{exp2}_i + \beta_4 \text{sexo}_i + \beta_5 \text{distrito}_i + \varepsilon$$

Available independent variables for both years are¹⁰:

- *EDUCA* individual highest grade of finished studies
- *Exp and exp2* which is a proxy of potential working years experience of a person, calculated as age minus number of years of finished studies, minus six. Linear as well as a quadratic form are included.
- *Sex*, a dichotomic variable identifying person sex.
- *District*. Which is equal to one, if household lives within city's first protection ring against inundation (artificial barrier constructed to prevent water advance) and zero in any other case.¹¹ This is the variable that allow to capture, at least partially, the effects of inundation on individual well-being.

Results of regression are displayed in Chart 4.4. As is has been explained, estimations do not represent individual follow up in time, since this is not panel data. However, results are consistent.

⁸ FGT(0) increase for the whole of Bolivia was only two points in the reference period.

⁹ According to theory (Borjas,1997), the district of residence is an endogenous variable to the household income, because we are in presence of double causality problem. On the one hand, income determines the place of residence of a household, according money possibilities to choose a better or worse location. On the other hand, there are effects of district residence determining household outcome in education and income achievement. Though, this case is a cuasi-experiment situation deriving from the fact that we are in presence of exogenous shock. Accordingly to this, it is expected that, explaining power of this variable may mainly come from event affectation on household living conditions,.

¹⁰ Language variable is not included since household survey does not report indigenous tongue. Besides, self identification question report that only 1.5% of surveyed declared themselves belonging to an indigenous group.

¹¹ Census zones within protection ring against inundations are 9, while remaining 8 are outside and were most affected by 2006-2007 inundation.

CHART 4.4.
INCOME FUNCTIONS
Dependent Variable: Labour Income Logarithm

	2006	2007
Education	.0879574 (.0120931)	.0667194 (.0171117)
Sex	-.3877122 (.0959541)	-.6491378 (.1165754)
Experience	.0440748 (.0078642)	.040709 (.011347)
experience Sqr.	-.0004251 (.0001388)	-.0004794 (.0002152)
District	.0500732 (.01407258)	.0719007 (.01196048)
Constant	5.925533 (.2244203)	6.68306 (.2877115)
R ² adjusted	0.3255	0.2614
F	18.47	10.63
Obs.	182	137

Regression results displayed in Chart 4.4 indicate that for every year of schooling, there is an average income increase between 6.6% and 8.7%. It should be noted that return to school was significantly lower in year 2007. This situation might be due to the fact that disaster affected city productivity negatively, and consequently also affected return of education on income generation.¹²

Similar situation may be found in the case of sex variable. In fact, it is observed that income earned by men is above that of women's in those two years. Additionally, this negative effect on women increased between 2006 and 2007, implying that changes in the city's conditions along that period – including inundation event – have had a clearer effect on feminine population.

With regards to working experience, we can note that increases in experience have a positive return on income at decreasing rate. Changes in both years are not statistically different for the case of Trinidad.

Finally, it may be observed that the fact of living in a district protected from inundation (least exposed to risk) has a positive income return. Although, nothing may be concluded about the mechanisms that produce such extraordinary return, it is evident that this coefficient grew from 5% to 7% between 2006 and 2007.

¹²Results for this and other variables are valid as long as regression and decomposition are specified in terms of monthly incomes instead of hourly income, or whenever depending variable is expressed in terms of levels, instead of logarithms.

Income Inequality and Decomposition

Once returns from several income determinants have been assessed, identifying their meaning in terms of functionality is of interest. It has to do with decomposing income inequalities to determine main factors differentiating high income, from low income workers. To this effect, Fields decomposition discussed on section 2 was used.

First step for this type of analysis was Gini (GE(1)) coefficient calculation for both years. In the reference period, this inequality measure varies between 0.37 and 0.43, situating Trinidad within an intermediate range in terms of inequality, with respect to national average, as well as in comparison to all other capital cities.¹³ Nonetheless, the extraordinary growth of this index – almost five points – induce to consider that natural event registered in this city, did not only lead to an increase in poverty incidence, but it also affected population in term of inequality. It is presumed that most vulnerable workers to event were those that got the greater inundation impact.

Results from decomposition are shown in Chart 4.5

CHART 4.5.
FACTOR'S CONTRIBUTION TO LABOR INCOME INEQUALITY IN TRINIDAD

	2006	2007
GINI	0.3781	0.4381
Variable		
• Education	0.774	0.755
• Experience	0.079	0.067
• Sex	0.073	0.079
• District	0.074	0.096

Decomposition exercise shows that schooling (education) is the most important variable in order to explain income inequality in Trinidad. Schooling accounts for between 75% and 77% of inequality. This factor, that is over 9 times greater than other factors, including district of residence. All other variables together explain only one fraction of what has been explained by education.

Nevertheless, registered changes in all other factors between 2006 and 2007 should be noted. In the first place, second important factor in inequality decomposition for year 2006 is working experience, accounting for 7.9 % of inequality. District residence and sex take third and fourth places this year, with 7.4% and 7.3% of contribution to inequality respectively. The magnitude of factors contribution for 2007 registered an important change. Though education still being the main factor in order to explain inequality in that year, district factor takes the second place now, with a 9.6% of contribution to inequality.

¹³ This is consistent with previous surveys: Urquiola (1993) shows Gini coefficients around 0.5 % for urban areas in Bolivia and World Bank (2005) and Hernani (2005) believe this value nears 60% for all of Bolivia.

Both education as well as experience decrease their contribution to inequality, and only sex displays an increase, which is though, less significant than district residence.

These results allow inferring that district residence contribution to inequality could be partly due to effect of natural disaster impact on the city of Trinidad. Additionally, increased sex contribution reveals that women's conditions are not only worse than men's in absolute terms, (lower return) but also that inequality affects women more than men after natural events.

5. Conclusions

The objective of this document has been to clarify relation between Bolivian well-being measures and natural disaster risks. However, limited data lead to circumscribe the analysis to relatively general conclusions and estimations.

Municipal analysis of the city of Trinidad does not permit answering all questions related neither how to attenuate impact on individual well-being exposed to disaster risk. Still, information and analysis indicate that effect on income and inequality is important.

From results obtained by the present work, some important conclusions may be inferred.

Municipal changes on population well-being are negatively correlated to natural disaster events. Though causal relations may not be establish between natural events and change in poverty levels, it is quite clear that municipalities more exposed to natural disaster are most prone to worsen off well-being conditions. The same conclusion can be observed from results of typologies of municipalities under natural events exposition criteria, that is, those municipalities most affected by intense events (even without having data on impacts and damages) are the most affected in their well-being.

In Bolivia, analysis on natural disaster tendencies shows us that over 70% of the country's population is exposed to some type of event. The most important disasters that affect population are freezing, drought and inundation. The *Altiplano* is Bolivia's most affected region, though it is not one undergoing greatest impact. *Amazona* region, instead, though not being most affected in number of events, is the one undergoing greatest impact, on account of events extent.

Assessment of poverty indicators at 1992-2001 inter-census periods reveals that municipality hazard incidence is correlated to increases on poverty. Although is not possible to isolate the effects; estimations show that poverty increased about 3% (at the most conservative estimations) in regions exposed to natural events. Statistical data also shows that hazards do not have a negative effect on economic well-being indicators alone, but also on non economic ones (UBN). These conclusions on well-being indicators should be considered by policy making officials, since issues like schooling assistance, housing improvement indexes and access to basic services – the main components of UBN – undergo as strong or stronger impact than economic matters like productive infrastructure and physical capital.

With regards to case study on the city of Trinidad, it may be established that change in population well-being conditions, was so deep after 2006-2007 inundation that it is unlikely that an additional determinant might be found besides magnitude of disaster. In effect, changes in well-being conditions of the city of Trinidad are statistically different to those observed in urban zones of the rest of the country. Even more important is the fact that poverty incidence in this period grew in 12 points in the city of Trinidad, notably higher than national average.

It is not only that poverty levels display important increase, but it is also that income distribution statistics rise significantly. Gini index for labour income in Trinidad rose from 0.38 % to 0.43 % during the mentioned period, showing a presumable outstanding impact of natural event on lower income population.

In term of inequality, it is evident that although education is the main component to explain inequality, exposition to risk - approached in this document through Trinidad district of residence – are relatively important, once natural events have occurred.

Assessment of relations between well-being levels and disaster hazards reveals that there are still many questions to be answered: which issue of well-being conditions should be first approached for hazard prevention and recuperation? How to choose suitable insurance mechanism of disaster hazard in order to minimize impact? Which should be the most important action after emergency situation? Careful evaluation of development and emergency response policies should be face at the light of indicative results displayed in this paper.

Finally, limited analysis in the case of Bolivia, shows the need for improved information, both on natural events and hazards as well as on aspects related to disaggregation of well-being data.

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ANNEX 1. WELL-BEING MEASURES

Following several well-being measures were undertaken – both at municipal as well as at household levels – based on available official information:

Dimension	Indicator	Definition	Source
Income	Poverty incidence (poverty line)	Households Unable to have Access to Basic Set of Good “Typical Consumption Set” according to Family Budgets and Family Surveys	Income Variable obtained from INE Household Surveys and 1992, 2001 CENSUSES Income Imputations.
	Poverty gap	Household Distance from Poverty Line.	Income Variable obtained from INE Household Surveys and Income Imputations on 1992 and 2001 CENSUSES.
	Inequality	Household Income / Consumption Distribution.	Income Variable Obtained from INE Household Surveys and Income Imputations on 1992 and 2001 CENSUSES.
Basic Needs	Unmet Basic Needs Index	Poverty Indicator Constructed by Normative Criteria on Education, Health, Housing Quality and Access to Basic Services.	1992 and 2001 Population CENSUSES.
Human Development	Development Index	Composed Index Assessment According to Life Expectancy, Per Capita Income, and Education Issues (Adequacy and Illiteracy) Variables.	Consumption and Income Imputation from National Accounts, CENSUSES Data, Administrative Registers from the Ministry of Education and from Household Surveys on Education Issues. Demography and Health Surveys towards Life Expectancy Estimations.
Malnutrition	Global Malnutrition Rates	Weight /	CENSUSES and Health Surveys

		Height Relation Among Children Between 2 and 5 Years When Compared to Normative Values.	Index Imputations
Life Expectancy	Life Expectancy at Birth Indicator	Life Expectancy Elaborated from Living Normative Tables	Population CENSUSES.

ANNEX 2: DESCRIPTION OF PRODUCTIVE AND CLIMATIC VARIABLES

1. Agricultural Potential

Agricultural potential indicator refers to soil aptitude for agricultural activities development. It may be divided into four categories, according to the following Chart:

Agricultural Potential Categories

Meaning	Categories
Optimal (unlimited)	1
Moderate (moderate limitations)	2
Very low (severe limitations)	3
Limited (very severe limitations)	4

Source: Planning and Sustainable Development Ministry, 1997.

PMA information was used for VAM 2002 assessment based on Agricultural Potential Map by the Planning and Sustainable Development Ministry on 1997. This map was digitalized and superposed on map incorporating municipal political and administrative division.

2. Forestry Potential

This indicator refers to determining apt soil for forestry activities, by means of quantifying number of cubic meters of forestry produce per hectare and per year. It is divided into the following categories:

Forestry Potential Categories

Meaning	Categories	M3 Hectare Produce
Poor Potential	1	1-5
Low Potential	2	5-7
Limited Potential	3	7-9
Medium Potential	4	9-11
High Potential	5	11-14

Source: Ministry of Planning and Sustainable Development, 1997.

Data source and assessment procedures are similar to those of Agricultural Potential.

3. Geographic and Climatic Characteristics

Indicators detailed in following Chart were obtained from INESAD data base:

Geographic and Climatic Characteristics

Indicator	Definition
Altitude	It Refers to Average Meters Above Sea Level a Municipality is Located. It is Expected that to Greater Altitude, Increased Vulnerability to Alimentary Insecurity Follows
Fluvial Precipitation	It is the Quantity and Amount of Municipal Rainfall Measured in Centimetres Per Year. It is Expected that More Frequent Rains, While These Do Not Turn into Inundation, will be Help Reduce Alimentary Insecurity Vulnerability.
Road Density	It refers to the Amount of Kilometres of Main Roads in Territorial Area. It is Expected that Municipalities with Better Connections to Roads be Least Vulnerable to Alimentary Insecurity.

Following indicators were obtained from same source as Agricultural and Forestry Potential. Classification and Categories are detailed as follows:

Climatic Indicators

Indicator	Category	Meaning
Drought Frequency in Years	Low	1 Every 10 Years
	Medium	1 Every 5 Years
	High	1 Every 2 Years
	Very High	4 Every 5 Years
Freezing Days per Year	Very Low	No freezing
	Low	30 to 90 days Freezing per Year
	Medium	90 to 180 days Freezing per Year
	High	180 to 270 days Freezing per Year
Area under Inundation Hazards	Very High	270 to 330 days Freezing per Year
	Low	No Inundations Problems
	Medium	Less than 30% Inundated Surface
	High	Between 30% to 50% Inundated Surface
	Very High	Over 50% Surface

ANNEX 3: INEQUALITY DECOMPOSITION METHODOLOGY

Fields 1997 and Fields et. Al (1997) proposes a method for decomposing sources of income inequality. His method is based on *an income generation function* and concludes with following answers: “x% inequality income is explained by education and % by area residence, z% by gender of the individual, etc”.¹⁴

From an income generation function, based on human capital theory, or some other theoretical model sustaining it, in which i logarithm of an individual’s income in period t is specified as a function of a series of explaining variables (identified by sub-index j),

$$\ln(Y_{it}) = \alpha_t + \sum_j \beta_{jt} w_{ijt} + \varepsilon_t \quad (1)$$

$$\text{which may be rewritten as } \ln(Y_{it}) = \sum_j a_{jt} z_{ijt} = a'Z \quad (2a)$$

$$\text{Where } a = (\alpha \ \beta_1 \ \beta_2 \dots \beta_J \ 1) \quad (2b) \text{ and}$$

$$Z = (1 \ x_1 \ x_2 \dots x_j \ \varepsilon) \quad (2c)$$

Strategy for obtaining a useful decomposition equation consists in decomposing an inequality measure, income log-variation in this case, to further explain that same decomposition may be also applied to other inequality measures.¹⁵

By using inequality functions in (2a) and (2c), variant is taken from both sides. To the left income log-variant is obtained, while right side variant may be manipulated to obtain following result:

Result N1. Since income generation function (2^a – 2c), is s_j (ln Y) and proportion of income log-variant attributed to explaining factor j , covariant will be called $\text{cov}(\cdot)$ and variant $\sigma^2(\cdot)$. Income log-variable may then be decomposed as:

$$s_j(\ln Y) = \text{cov}(a_j z_j, \ln Y) / \sigma^2(\ln Y) \quad (3a)$$

$$\text{where, } \sum_{(j=1, J+1)} s_j(\ln Y) = 100\% \quad (3b) \text{ and}$$

$$\sum_{(j=1, J)} \text{cov}(a_j z_j, \ln Y) / \sigma^2(\ln Y) = R^2(\ln Y) \quad (3c)$$

If p_j (ln Y) is fraction of log-variable applied to j explaining factor, it is concluded that

$$p_j(\ln Y) \equiv s_j(\ln Y) / R^2(\ln Y) \quad (3d)$$

¹⁴ *Income Generation Function* Term is used instead of *Income Functions* or *Salary Equations* owing to Methodology being Sufficiently Ample for Non Labour Income to be Included together with Labour Income in Regression, if Researcher Considers it Appropriate.

¹⁵ Log Variant is Income Logarithm Variant, Not Variant of Income Logarithm, as is sometimes wrongly interpreted.

Furthermore, other inequality measures other than log-variant may be decomposed. To this purpose, result belonging to inequality decomposition literature through factorial components may be used. On this literature, total income Y_i , from i -ism receptor unit is represented as income addition resulting from each different factorial component, i.e., labour income, INCOME PER CAPITA, income from transferences, etc. This is as follows:

$$Y_i = \sum_k Y_{ik} \quad (4),$$

Then, it must be determined which fraction from total inequality, represented by an inequality measure $(Y_1 \dots Y_n)$, may be explained by labour produced income, capital income, income from transferences, etc.

Sk Relative contribution to factorial inequality is established, as income inequality percentage explained by k -ism factor, u is $E_i(Y_i/n)$, average income.)Shorrocks, 1982) an important theorem on factorial component decomposition, displays following:

Result N 2. Under six axioms enumerated in appendix, s_k , relative contributions to factorial inequality are given by:

$$s_k = \text{cov}(Y_k, Y) / \sigma^2(Y)$$

de manera que $\sum_k s_k = 1$

for any $l(Y_1 \dots Y_n)$ inequality index defined on income vector $(Y_1 \dots Y_n)$ as long as index is continuous and symmetric, and satisfies condition $l(u, u, \dots, u) = 0$.

Above decomposition may be applied to almost all inequality measures, including Gini coefficient, Atkinson index, generalized entropy indexes family, log-variant and several measures based on percentiles.

Shorrocks theorem may now used to decompose labour income inequality, from income generation functions. These functions are:

$$\ln(Y_{it}) = \sum_j a_{jt} Z_{ijt} = a'Z \quad (2a)$$

while function expressing total income as income addition of each component is,

$$Y_i = \sum_k Y_{ik} \quad (4);$$

both are simple additions. It must also be noted that on decomposing inequality of (4), Schorrocks obtains

$$s_k = \text{cov}(Y_k, Y) / \sigma^2(Y), \text{ así como } \sum_k s_k = 1,$$

which is the same as (3) with Y_k replacing $a_j z_j$ and with Y instead of $\ln(Y)$. Through this homeomorphism and applying Shorrocks theorem following result is achieved:

Result No. 3. Given (2^a 2c) income generation , $I(\ln Y)$ inequality index is established on income logarithm vector, $\ln Y = (\ln Y_1, \dots, \ln Y_n)$.

Under six enumerated axioms in appendix, income inequality decomposition given by:

$$s_j(\ln Y) = \text{cov}(a_j z_j, \ln Y) / \sigma^2(\ln Y) \quad (3a)$$

$$\text{where } \sum_{(j=1, J+1)} s_j(\ln Y) = 100\% \quad (3b)$$

$$\sum_{(j=1, J)} \text{cov}(a_j z_j, \ln Y) / \sigma^2(\ln Y) = R^2(\ln Y) \quad (3c)$$

$$\text{And where } p_j(\ln Y) \equiv s_j(\ln Y) / R^2(\ln Y) \quad (3d)$$

is maintained not for log-variant alone, but for almost any $(\ln Y_1, \dots, \ln Y_n)$ inequality index that is continuous and symmetric, and as long as long as it meets condition that $l(u, u, \dots, u) = 0$.

Measures subject to this decomposition include Gini-log and Atkinson-log, generalized entropy log-family and log-percentiles.¹⁶

Result 3 states that if decomposition conditions are accepted and if inequality measure decomposition based on income logarithm vector is also accepted, then it is not compulsory to restrict oneself to a specific inequality measure for decomposition. This is due to the fact that all UNDERLINE ALL inequality measures that might be considered useful would have same j ism explaining factors percentage effects, when measure is applied to income logarithms.

In order to prevent violation of transference principle expressed in the usual way, human capital theory may be abandoned to use income levels instead of logarithms for the function of income generation. When this is the case, regression coefficients as well as percentage contributions will change. Following result is obtained when using b to denote this proceeding's coefficient:

Result N. 4. Given income generation

$$Y_{it} = \sum_j b_j z_{ijt} = b' Z \quad (2a')$$

$$\text{Where } b = (\alpha \beta_1 \beta_2 \dots \beta_J 1) \quad (2b') \quad \text{and}$$

$$Z = (1 \ x_1 \ x_2 \dots x_j \ \varepsilon) \quad (2c'),$$

$L(Y)$ inequality index is determined on $Y = (y_1 \dots y_n)$ inequality vector on six enumerated axioms in appendix, income inequality decomposition given

¹⁶ In all cases, where "log-l" Measures are mentioned, reference is made to Income Logarithms.

$$s_j(Y) = \text{cov}(b_j z_j, Y) / \sigma^2(Y) \quad (3a')$$

$$\text{en donde } \sum_{(j=1, J+1)} s_j(Y) = 100\% \quad (3b')$$

$$\sum_{(j=1, J)} \text{cov}(b_j z_j, Y) / \sigma^2(Y) = R^2(Y) \quad (3c')$$

$$\text{y en donde } p_j(Y) \equiv s_j(Y) / R^2(Y) \quad (3d')$$

is maintained for any continuous and symmetric inequality index $l(Y_1, \dots, Y_n)$, as long as $l(u, u, \dots, u) = 0$.

Measures that may be decomposed this way include Gini coefficient, Atkinson index, generalized entropy index family and measures based on percentiles.

Results 3 and 4 together explain that: i) log-variance, Gini log, Theil log, etc., all provide same j-ism explaining factor percentage contributions factor to income inequality logarithm, ii) Gini coefficient, Theil index, etc variances, at their ordinary form, provide same percentage contributions to j-ism explaining factor to income inequality, however, iii) – percentage contributions – answers in i) and ii) are not the same.

ANNEX 4: UNMET BASIC NEEDS ESTIMATION

Unmet Basic Needs Index (NBI by its acronym in spanish) is assessed through lack of various needs. These needs are: education, access to health services, housing materials, overcrowding, and basic draining and energy services.

Lack Indexes. (NBI) lack indexes were assessed according to NBI and INE qualification methodology. According to same

$$nbi(x) = \frac{Nx - Cx}{Nx}$$

Where:

Nbi(x)	component lack index
Nx	component normative value
Cx	household x observed component

NBI (x) might be rewritten as follows:

$$nbi(x) = 1 - \frac{Cx}{Nx}$$

For practical purposes Lx will be called Observed Goal Coefficient divided by Norm will be called)Lx) **Achievement Goal:**

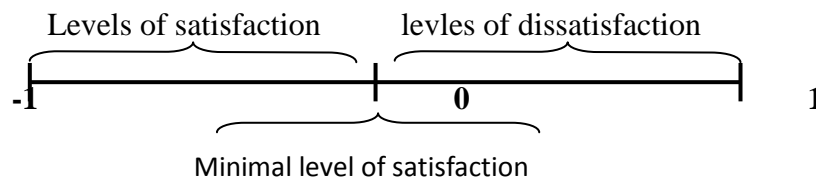
$$Lx = \frac{Cx}{Nx}$$

Then

$$Nbi(x) = 1 - Lx$$

Lack Index displays dissatisfaction level or degree with regards to normative values. By definition it may take a value from (-1, 1) range, where:

Lack Indicator



Positive values denote dissatisfaction levels while those nearing unity indicate greater lack, on the contrary, **negative values** reflect **over minimal satisfaction level**, and the more they tend to -1, greater satisfaction will be met.