Issues and concepts for the Norway-funded project "Improving Methods for Poverty and Food Insecurity Mapping and Its Use at Country Level"

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Table of contents

1. Introduction[1]

The objective of the Issues paper is to provide a framework with which to guide the activities of the Norway-funded project "Improving Methods for Poverty and Food Insecurity Mapping and Its Use at Country Level," which is jointly administered by the FAO, CIAT-CGIAR, and GRID-Arendal. Over a three year period the project is expected to result in the following outputs:

a) the establishment of a global GIS database geared towards poverty and food insecurity which will be available to interested users/network members
b) a synthesis of the state-of-the-art GIS technology and standardized formats for mapping food insecurity, poverty and vulnerability in various contexts
c) the carrying out of national and subnational mapping of food insecurity and poverty variables and indices, based on available data in six countries or ecosystems, equitably spread across the different regions of the developing world
d) an active and functional web-based network of individuals and institutions exchanging information and jointly improving the techniques and practical utility of food insecurity and poverty mapping systems for improved the effectiveness of policies and actions aimed at reducing poverty and food insecurity at national, regional and global levels.

The Issues paper focuses on outputs a) and c), and will propose a few key questions/issues which the project can address in the context of poverty and food security mapping, as well as the appropriate methodologies to answer these questions. These should serve as the point of departure for the discussion of key questions and methodologies by the April, 2001 expert consultation. This discussion and resulting conclusions will then shape the actions taken by the project regarding the construction of global data bases and the design of case studies. Some funding may also be available for smaller complementary studies, which should be kept in mind as we review the current state of poverty mapping.

In this context the paper will be organized in six sections. In Section 2 we define poverty and food security mapping and discuss current issues and applications in the context of reviewing alternative poverty and food security mapping methodologies. In Section 3, we present a discussion of the types of indicators and information issues in both poverty and food security mapping. In Section 4 we review the responses to a user needs survey, and in Section V we explore possible research questions that could be addressed by the project. We finish in Section VI with a series of proposals regarding research questions, complementary methodological studies, and priority subnational poverty and food security mapping methods.

2. Definitions, methodologies, and current applications

2.1 What is poverty mapping

Poverty and food security[2] in most countries are highly heterogeneous phenomena; wide spatial variability at the local level is common but is difficult to measure quantitatively with

[1] We would like to thank Leslie Lipper, Barbara Huddleston, Claudia Heberlein, Ergin Ataman, Glenn Hyman, Changchui He, Freddy Nachtergale, and Tim Kelley for detailed comments and suggestions.

conventional tools. Both types and depth of poverty, measured in a variety of ways, vary between and within countries, regions or other geographic and administrative units. Heterogeneity can develop for a variety of reasons, including differences in geography, history, ethnicity, and access to markets and public services, infrastructure, and other facets of public policy (see, for example, Bloom and Sachs, 1998, Jalan and Ravallion, 2000, or de Janvry and Sadoulet, 1997).

Poverty and food security mapping can take place at a variety of levels ranging from the world to continents and regions, to subnational analysis and even specific areas within countries. Global or regional mapping typically uses country level or broad geographic based variables. At the subnational level, poverty mapping in all its various forms involves techniques which permit sufficient disaggregation of a poverty measure to local administrative levels, or small geographical units based on a variety of possible criteria (e.g. agroecological, land use, livelihood or production system parameters), in order to accurately gauge this spatial heterogeneity.

Most types of poverty mapping increasingly depend on GIS generated data. The spatial location of the poor facilitates integration of data from various sources such as satellites, census, household surveys, sectoral surveys, and models and simulations for the analysis of the determinants and impacts of poverty. GIS techniques provide five functions in poverty mapping (see, for example discussion in Bigman and Deichmann, 2000a):

- The integration of multiple databases from different sources
- Analysis of spatial association between variables
- The inclusion of spatially generated explanatory variables into the multivariate analysis of the determinants of poverty, including natural capital, infrastructure, and access to public services, and product and labor markets
- Scenario analysis and projections development through modeling
- Policy comparison and formulation through dynamic mapping or monitoring.

2.2 Key issues in poverty mapping

Spatial determinants are important for understanding the distribution of assets key to poverty alleviation, including human capital (health and education, technology) and social capital (ability to cooperate, social networks). It is particularly in the area of natural resources, however, where GIS has most promise, as natural capital asset holdings (including natural resource stocks and environmental quality) are difficult to characterize with conventional variables, and by definition are spatially distributed.

At the subnational level progress is still lacking on the environmental side in terms of the feasible micro analysis of poverty and other related issues. In terms of socioeconomic data, which is more widely available, only recently has the importance of georeferencing been realized. Also still in early stages is the understanding of the statistical problems that must be taken into account when using spatial variables.

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[2] In this paper we do not advocate a specific definition of poverty or food insecurity. See discussion of alternative indicators in Section III.

The lack of subnational poverty and food security data that is not comparable across countries hampers the development of global and regional poverty mapping. This is particularly true for the study of regional or global issues which require consistent subnational data across countries. The real challenge lies in the continued development of subnational environmental and socioeconomic GIS datasets, as well as the creative use of existing data, an issue which this project hopes to at least partly advance.

Poverty mapping is, at essence, a tool, and thus its functionality must be seen and evaluated in light of the objectives for which it is put to use, that is, the research and policy questions and hypotheses upon which it can shed light. Poverty mapping should be initiated with clear objectives in mind, which will help guide interpretation of the output and determine the appropriate methodology to utilize. While poverty mapping can serve as a useful exploratory or directed tool in establishing and presenting the spatial relationship between a pair or series of indicators, it can also lead to serious misinterpretation of causal relationships between variables. In general poverty maps do not represent causal linkages but rather visual correlations, and interpreting causality can lead to serious policy and analytical mistakes. In a multivariate regression framework, however, using appropriate econometric analysis techniques variables derived from poverty mapping exercises can serve as determinants—or outcomes—of causal relationships.

2.3 Subnational poverty mapping methodologies and current applications

In this light, the spatial analysis of poverty has been utilized in a number of policy and research applications. Beyond a visual representation of spatial relationships between variables, these range from the targeting of emergency food aid and anti-poverty programs to assessments of the determinants of poverty and food insecurity. These applications have been used by organizations ranging from NGOs and multilateral development organizations to national governments (see Henninger, 1998, for a review of many of these applications).[3] The methodologies utilized are diverse, from participatory poverty profiles to sophisticated econometric techniques, and most are under continuing development. Each has different data requirements and implementation costs, and different advantages and disadvantages in their use. Below we look at the principal subnational methodologies and applications currently in use.

2.3.1 Small area estimation

Small area estimation is a statistical technique which combines survey and census data to estimate welfare or other indicators for disaggregated geographic units such as municipalities or rural communities. Small area estimation applies parameters from a predictive model to identical variables in a census or auxiliary database, assuming that the relationship defined by the model holds for the larger population as well as from the original sample. This technique has been used by the U.S. government for planning and targeting purposes (Riely and Anselin, 1995; Ghosh and Rao, 1994).

[3] We do not include mapping efforts which are not directly tied to poverty or food security, such as the FAO farming system and agro ecological typologies or the many environmental and production applications among the CG centers, though these may be relevant to combining with poverty mapping exercises.

More recently, small area estimation has been extended to use in developing countries for poverty mapping. Two principal methods have emerged. The first, using household unit level data from a census has been developed principally by staff at the World Bank and is the principal methodology utilized by the Bank's new poverty mapping group (World Bank, 2000). The second uses community level averages instead of household unit level data, and has been employed by researchers at both the World Bank and the CG system.

a) Household unit level method

This method has been developed in Hentschel, *et al*, 2000 and Elbers, *et al*, 2001, and is also presented in World Bank, 2000 and Deichmann, 1999. The following discussion is derived from these sources. The method requires two sets of data at a minimum: household level census data and a representative household survey corresponding approximately to the same time period as the census. For example, in Nicaragua poverty maps have been built using 1995 population census data and a 1998 LSMS survey, and in Ecuador 1990 population census with 1994 survey data. The maximum allowable time difference will vary by the rate of economic change in a given country. Most efforts have used a population census with household unit data, but an agricultural census, which includes basic demographic information, such as the 1997 Chinese agricultural census, could also be used.

The first step is to estimate a model of consumption based household welfare[4] using the household survey data. This model should be estimated by statistically representative regions or areas (such as urban/rural), with explanatory variables limited to those found in both data sets. The second step of this process involves applying the parameter estimates to the census data. For each household, the estimated parameters from the regression are used to compute the probability of each household in the census living in poverty. Household-level results can then be aggregated by the geographical region of interest by taking the mean of the probabilities for the chosen geographical entities.

This permits the construction of maps illustrating different levels of poverty disaggregated across geographic units. The size of standard errors in these estimates depends on the degree of disaggregation. The optimal degree of disaggregation will depend on

- The purpose of the map
- The level at which the household data is estimated
- Tradeoffs between the size of standard error and policy needs.

The Nicaraguan government, and in particular the Fondo de Inversión Social de Emergencia (FISE), has adopted the household level unit data method (Hentschel, *et al*, 2000), with support from the World Bank, for creating poverty maps for planning purposes and future targeted programs, such as the Red de Protección Social (Social Protection Network) anti-poverty program. This method has also been used to create poverty maps for targeting and policy making in Panama (World Bank, 2000) and South Africa (Alderman, et al. 2000), and efforts are under way in a number of other countries.

[4] Other well-being or food security indicators may also be used. See, for example, discussion in Carletto and Davis (2000).

b) Community level data method

An alternative method involves using average values from disaggregated geographical units, such as communities or small towns, instead of household unit level data. Besides the difference in scale of the predictive model, the two small area estimation methods follow essentially the same steps. Minot (1998) utilizes Vietnam's 1994 Agricultural Census to create a national poverty map, though again relies on district-level averages to predict district-level poverty rates. Bigman, et al, (2000) use a population census and household survey to similar ends in Burkina Faso. Bigman and Srinivasan (2001) likewise use a population census and household survey in India. Bigman and Huang (2000) have proposed a similar approach using the 1997 China Agriculture Census data. Using data from Kenya, Bigman and Loevinsohn (1999) show how the community level data method can be used in targeting agricultural research and development for poverty reduction.

2.3.2 Multivariate weighted index

a) Principal components

An alternative method of disaggregated poverty measures by community level is that in use by the Mexican government. This methodology was first utilized to create a marginality index for policy planning purposes, and then specifically as part of the targeting mechanism of the PROGRESA anti-poverty program (see PROGRESA, 1998; CONAPO-PROGRESA, 1998; and Skoufias, Davis, and Behrman, 1999). This $700 million program provides bimonthly cash transfers to over three million rural households. The marginality index was developed using the method of principal components, based on seven community level variables from a combination of the 1990 and 1995 population census. Communities with missing data were brought in using regression techniques. The marginality index was then divided into five groups based on the degree of marginality. The cutoff points were determined by the Dalenious-Hodges statistical procedure (for details of this application, see de la Vega, 1994).

This index was then crossed with other spatially based criteria—geographic location, distance between localities, and access to health and school infrastructure. Combining data from the Public Health and Education Secretariats with computerized geographical information, service zones were established, whereby localities were characterized by their access to these required services, taking into account the availability and quality of roads when the services were not located in the same community.

b) OLS

The Nicaraguan Red de Protección Social anti-poverty program also used poverty mapping to target intervention census segments. In the first phase, which began operations in August, 2000, the program used population census data to build a regression weighted marginality index to rank countries (Arcia, 1999) This program reaches approximately 10,000 rural households located in two departments of northern Nicaragua targeted by census segments.

2.3.3 Assessments of determinants of poverty and food insecurity vulnerability

Mapping has also been used to analyze the determinants and status of household poverty and food insecurity vulnerability. Almost all of these revolve around the concept of livelihood strategies, but collect and utilize data in different ways. At least five different approaches can be identified: primary data, secondary data, mapping of DHS survey data, extrapolation of participatory approaches, and multivariate analysis.

a) Primary data

Two different variants of the livelihood approach are employed using primary data in field vulnerability assessments. First, the Household Economy Approach developed by Save the Children Fund (Seaman, et al, 2000) define food economy zones for a given region and then use rapid appraisal techniques and key informants to group and quantify households by livelihood strategies within these zones. This analysis is supplemented by secondary data. Livelihood strategies are linked to geographical areas, from which vulnerability maps are then constructed.

Second, the vulnerable group profiles developed by FAO (FAO-ESAF, 2000) identify mutually exclusive livelihood strategy groups first, through brainstorming sessions with experts. These groups are further refined through participatory fieldwork techniques and secondary data, and linked with geographical areas. Calculations are made as to the size of the groups, when possible using population census data linked through occupation codes. Vulnerability maps are then constructed.

b) Secondary data

The methodology employed by the Famine Early Warning System (FEWS) of USAID, also geared to vulnerability assessment, is based primarily on secondary evidence, with less direct field work (FEWS, 1999a). Stratification is by administrative unit, and within administrative units, in some cases by household production strategies. These may derive from NGOs, key informants, or livelihood system approaches. Food access and availability per person is then calculated at the administrative or group level (see FEWS, 1999b and 2000). The collection of this secondary data ranges from tables to statistical procedures to qualitative information when data is missing. This information is linked to geographic area and thus is commonly put into vulnerability maps.

c) Mapping of DHS survey data

Georeferenced, standardized Demographic and Health Surveys (DHS) on health and nutrition have been carried out in a number of African countries. This data has been used to create poverty maps. Henninger (1998) for example describes how the survey data was aggregated to new units of analysis—aridity zones—within which the distribution of anthropometric indicators was analyzed. GRID Arendal (1996) studied the relationship of rural poverty and land use potential using DHS data from West Africa. Macro International, the firm that carries out the DHS, is also beginning efforts to map a wealth index using data from the survey in Egypt (Montana, 2001). Rogers (2000) describes the use of DHS in the spatial analysis of program impact evaluation in

West Africa, and McGuire (2000) uses DHS data to build food insecurity indices in the Sahel for subsequent mapping.

d) Extrapolation of participatory approaches

Participatory poverty assessments measure poverty based on local perceptions of poverty. These local perceptions are identified and then extrapolated and quantified in order to construct regional poverty measures. Local perceptions are gathered from community informants who provide definitions of poverty and rank neighbors in terms of well being.[5] In Ravnborg (1999a), a well being index is created and extrapolated to other communities in a region using a questionnaire applied to a random sample of communities. At this point it resembles a proxy means analysis (Grosh and Baker, 1995), but instead of key variables identified by multivariate regression, they are identified by local informants. Leclerc, et al (2000) further this extrapolation to the whole country using neural nets and proxy indicators found in population census data. They compare these results to a more traditional Basic Needs index, and find large differences in results.

e) Multivariate analysis of the determinants of poverty and food insecurity

One important application of GIS in poverty mapping is the use of spatially generated variables as explanatory variables in multivariate regression analysis of poverty and inequality. Similarly, poverty and inequality variables generated through mapping techniques can be used to analyze a wide variety of issues, including the determinants of education, individual health outcomes, and crime (World Bank, 2000). Bigman, et al. (2000), for example, use in part GIS generated variables to model the determinants of consumption-based poverty in Burkina Faso. One of the most common applications is the analysis of the causal relationship between poverty and the environment, where to date few links have been found, often due to technical, estimation, or data limitations (see review in Lipper, 2000).

2.3.4 Direct measurement of census data

The Hunger Map of Brazil is based on the direct measurement of household income reported in the 1991 population census. Household level income was compared to both a food-based extreme poverty line, and a food-non food moderate poverty line. The headcount index was then calculated for each municipality. Regional and state level measures were based on a 1990 household survey (Peliano, 1993). This municipality map is problematic as income figures from census data are not generally considered reliable due to underestimation of non wage labor sources of income.[6]

2.3.5 Composite indices

A later map in Brazil instead used 38 georeferenced variables from the 1970, 1980, and 1991 population census to build two indices following UNDP methodology: the Human Development Index, and the Life Conditions Index. The resultant Atlas of Human Development has been used

[5] See Ravnborg (1999a) for an application in Honduras, Narayan (1997) in Tanzania, and Turk (2000) in Vietnam.
[6] See, for example, the analysis in Alderman, et al, (2000).

for public investment decision making and targeting of social programs (UNDP-IPEA-IBGE, 1998).

Another project developed and mapped, by municipality in Honduras, a series of disaster vulnerability indices with the following dimensions:

1. environmental (flood and landslide risk area),
2. population (total population at risk of flooding and landslide),
3. social (percent of very poor at risk), and
4. infrastructure (roads and electricity lines at risk)

In turn these indices were weighted and aggregated into an overall vulnerability index which allowed identification of municipalities for priority intervention (Segnestam, et al, 2000).

Finally, McGuire (2000) using DHS data, also combines indices into an overall food insecurity vulnerability index.

2.3.6 Correlation and spatial analysis of poverty and the environment

A number of studies have begun linking subnational well being and environmental variables in correlation and visual spatial analysis. Godilano, et al, (2000) have done preliminary work in linking disaggregated poverty incidence to environmental risk (flooding) and suitability for rice production in Bangladesh. Osgood and Lipper (2000) link subnational proxies for poverty with soil degradation measures in Ghana as well as by country for Africa. The Segnestam, et al, (2000) study cited above links municipal poverty indicators with environmental and infrastructure risk indices.

GRID-Arendal (1997) looks at the correlation between poverty and degree of aridity and land degradation. Nelson, et al (1997) reject the hypothesis that a spatial correlation exists between poverty and a strictly bio-physically defined measure of environmental fragility. Ravnborg (1999a) uses household survey data from 3 watersheds in Honduras and finds a similar result for soil quality and poverty.

2.3.7 Regional maps

An ongoing effort in the Andean region of Latin America provides a good example of the possibilities for regional mapping. The Andean Network of Spatial Data (REDANDA) has brought together statistical agencies and universities in five countries (Bolivia, Columbia, Ecuador, Peru, and Venezuela) who have created disaggregated regional maps, at the municipal level, of development indicators from population census data. This network achieved homogenization of standards between the five countries for the 2000 census, which will be analyzed in a coordinated fashion in 2002-2003 (REDANDA, 2001). An example of a first effort in terms of natural resource and infrastructure variables can be found in Segnestam, et al, (2000) for Central America.

3. Indicator and information issues in poverty mapping

3.1 Alternative indicators

While few dispute the multidimensional nature of poverty and food security, poverty mapping, by definition, is about summarizing information in a few indicators, whether these be indices or single variables. Thus a decision must be made in each poverty mapping application on how to aggregate or how to best proxy both "well-being" in the case of poverty and food insecurity. While poverty and food insecurity are not necessarily the same phenomena, much overlap exists in terms of indicators.

Multiple indicators exist for both poverty and food insecurity, as well as a long and storied literature on their respective strength and weaknesses.[7] As such we will keep our discussion here to a minimum and focus on household measures. The choice of indicator may respond to philosophical preconceptions (beliefs that self chosen, participatory or basic needs indices are inherently better then economic indicators), to data limitations, or as the result of analysis. Analytical procedures range from statistical techniques to participatory studies where poverty indicators are revealed by the population being studied. Similarly, information on most of these measures may be generated either through surveys, secondary data, key informants/experts, or a combination of these.

Poverty measures can be grouped into four major categories:

Economic. These include monetary indicators of household well being, particularly food and non food consumption or expenditure and income. These measures are primarily used by economists, but many NGO and development agencies also use a variety of consumption and or income measures. These also include non monetary proxies of household well being, such ownership of productive assets or durables.

Social. These include other non monetary indicators of household well being, such as quality and access to education, health, other basic services, nutrition, and social capital. These measures are sometimes grouped into composite development indices by such agencies as UNDP.

Demographic: these indicators focus on the gender and age structure of households, as well as household size.

Vulnerability. These indicators focus on the level of exposure of households to shocks which can affect poverty status, such as environmental endowment and hazard, physical insecurity, and the diversification and riskiness of alternative livelihood strategies.

Similarly, food insecurity measures can be grouped into four categories.

National balance sheet. This indicator measures whether adequate food production or supply is available for a given national or regional population.

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[7] See, for example, Ravallion (1992) and Maxwell (1999) for two among many on poverty measures; Maxwell and Frankenberger (1992), D. Maxwell (1996); S. Maxwell (1996), and Carletto (1997) for food security; and Henninger (1998) for a good review in the context of poverty mapping.

Direct measures of consumption. Household or individual food intake, total and food expenditures, and caloric acquisition.

Outcome indicators of nutritional status. Anthropometric and micronutrient indicators.

Vulnerability. Encompasses notions of access and availability, as well as risk and uncertainty. Indicators include household access to assets, household size and composition, asset liquidity, crop and income diversification, and food production at a household level.

3.2 The choice of indicator matters

For both poverty and food insecurity, the choice of indicator matters. Numerous studies have shown that at the subnational level different indicators can lead to alternative poverty or food insecurity rankings.[8] Thus the choice of indicator has very practical indications for results, in terms of determining who the poor are, and where they are located. The key organizing principal of this project should not be to a priori assert that one variable is better than another, but rather to explore the tradeoffs inherent in the choice of indicators: what assumptions must we make, and what are the practical implications in terms of costs, technical requirements, errors of exclusion and inclusion, and the characteristics of the chosen population. While a full scale comparison of the impact of alternative indicators in each case study may not be feasible, at the very least each case study should justify its choice of poverty or food security indicator.

3.3 Types, scales, and availability of data

Different questions will require different kinds of data, including census, household, survey, and GIS based facility, infrastructure, and natural resource information. Bringing together these different kinds of data is a key challenge in poverty mapping. Integration problems include missing position information, inconsistent classification and methodologies across datasets, different spatial units, different levels of resolution, and data gaps (Gerland, 1995).

Many global data sets may not be appropriate for use in subnational studies, particularly in medium or smaller sized countries, as they do not capture in country variation and thus are insufficient for establishing relations between these variables and the outcomes of interest. These include, for example, the FAO farming systems typology and the GLASOD soil degradation database. However, they can be used for other applications such as monitoring global food insecurity trends and in certain cases for cross-country comparisons.

One key problem in spatial analysis is known as the Modifiable Areal Unit Problem (MAUP). Areal units, whether administrative or political boundaries, agroecological zones, or image pixels are essentially arbitrary groupings and the data within can be aggregated in an infinite number of ways (Nelson, 2001 and Bigman and Deichmann, 2000a). This includes not only GIS constructed data, but any kind of spatially aggregated data, such as census or household surveys. The practical implication is that, for example, alternative aggregations of the data may lead to

[8] See, for example, Glewwe and Gaag (1988), Baker and Grosh (1994), Carletto and Davis (2000), Hentschel, et al (2000), Skoufias, Davis, and Behrman (1999), and Leclerc, et al (2000).

different and conflicting results. In terms of multivariate analysis, the relationship between dependent and independent variables may change over space in a manner that the analyst may not be able to determine *a priori*. Thus results can be modified purposely—or errors made inadvertently—through the process of aggregating data.

Nelson (2001) discusses a number of tools to minimize these effects. These include convolution filtering, in which a window moves over the data to produce a new data value, and different methods of zonification, including extending the concept of areal units beyond preset administrative boundaries or Euclidean distance to other measures such as time, accessibility, cost or energy, which have more social or economic meaning. Nelson also explores a multivariate analytical technique, geographically weighted regression (GWR), which in combination with clustering techniques permits mapping of regression parameters and goodness of fit measures.[9] Rogers (2000) describes the process of reasoning in avoiding MAUP for the WASAP Project in rural West Africa and impact evaluation in Zaire.

Many countries do not have contemporaneous census and household survey data, which is a major problem for small area estimation methodologies. Since most of the databases involved in poverty mapping are relatively expensive to collect, they are not repeated very frequently. When combining databases, practitioners are thus faced with problems of timing between databases—at some point, after a certain number of years, the databases become no longer compatible.

Subnational accessibility data, such as access to health and education facility location and infrastructure, as well as transport and travel time, for example, have proven very useful in Mexico (PROGRESA, 1998) and Burkina Faso (Bigman, et al, 2000), as inputs into the targeting of anti-poverty programs and in the visual correlation with poverty and food insecurity (see Henninger, 1998 for many examples). They also can play a very important role as explanatory variables in the multivariate analysis of the determinants of poverty and food insecurity, though this has yet to catch on as common practice. The availability of this type of data varies widely by country, however, and must be taken into consideration in terms of the design and selection of case studies. In some instances it may be worthwhile to collect this data as part of a case study.[10]

A key problem is that data is still weak on the environmental side, particularly for single country subnational poverty studies. Few in depth environmental surveys collect information typically found in household surveys (though we must search for those notable exceptions), and while some kind of subnational poverty data is usually available, it is often not comparable with the environmental surveys, or is not georeferenced.

On the other hand, while many countries collect a wide variety of subnational poverty data, no subnational poverty data has been systematically collected at a global level. Beside problems of compatibility, the task of simply gathering this data from different countries has proved formidable. An FAO effort to receive subnational nutrition data from 36 countries took over three years to complete. In this context surveys such as the DHS, by applying a relatively standard methodology, can be considered as valuable source of compatible data. Furthermore, a

[9] The model and examples are discussed in detail in Nelson, 2000a.
[10] See Nelson (2000b) for a description of constructing these types of variables in Honduras, and Bigman and Deichmann (2000b) for discussion and examples on Madagascar.

more modest effort focusing on published sources may take substantially less time. This question is crucial as a number of suggested research questions rely on the existence of a global subnational poverty map. A regional study may constitute an appropriate first step, as suggested in the case studies. The issue whether to build a global or semi-global subnational poverty map should be discussed.

4. Assessment of user needs

4.1 Methodology

The assessment covered the following categories of potential users: bilateral aid organizations, international NGOs, UN organizations and international financial institutions, the CG system, and national institutions. About 140 persons were contacted or interviewed.[11] While national institutions were asked to fill out a country form[12] the following questions were asked to all other potential users contacted:

- What they would need food insecurity and poverty mapping for?
- What would be the key questions/issues they would like to elucidate/address through the use of those tools/products?
- What were their specific concerns/needs with regard to conceptual, technical issues related to food insecurity and poverty mapping.

Inputs from users were gathered and are presented in the next section under the following categories: a) use of food insecurity and poverty mapping tools/products; b) main concerns regarding the use of food insecurity and poverty mapping tools/products; c) key research questions and d) most common needs and interests.

4.2 Results

The results presented here reflect the opinions of only part of the potential users contacted. No inputs were provided from bilateral aid organizations and UN agencies (except from FAO, UNEP and WFP). Only four centers and the TAC provided contributions from the CG system.

4.2.1 Use of food insecurity and poverty mapping tools/products

The following applications of the spatial display of food insecurity and poverty information were identified among the users queried, having as an ultimate goal to contribute to policy-making, strategic-planning, emergency management and preparedness, resource allocation decision-making process and public awareness.

– Analysis of food insecurity vulnerability / characterization of food insecurity at subnational level: this includes spatial relation-ship between geo-physical and socio-economic data or any other type of combination of variables. (FAO-ESAF; SCF; FAO-ESNA; UNEP; CIAT; TAC; Brazil; Mozambique; WFP-VAM; FAO-RLC)

[11] For details and contact information see Annex 1 – List of Potential Users Contacted.
[12] See Annex 2 – Country Form.

- Cross-country and/or in-country comparisons (SCF; FAO-ESAF; FAO-ESNA; UNEP; Brazil; Mozambique)
- Monitoring of food insecurity /poverty trends / time series of development indicators (FIVIMS; FAO-ESAF; TAC; Brazil)
- Disaster vulnerability mapping (Mozambique)
- Compare different food insecurity and poverty measure methods (UNEP)
- Impact assessment (programs / technologies) (TAC; CIMMYT)
- Perspective studies (modeling) (FIVIMS; ESAF; TAC; UNEP; Brazil)
- Targeting - agricultural research and development programs at the vulnerable/poor. (ISNAR; Brazil – Ministry of Education; India - Indira Gandhi Institute of Development Research; CIAT; ISNAR; CIMMYT)

4.2.2 Main concerns regarding the use of food insecurity and poverty mapping tools/products

- Data quality (SCF - in particular with routinely collected statistical data)
- Limitation of descriptive definitions of poverty in giving an indication of the cause (SCF)
- Data availability limitations (in particular referred to small geographical areas and to certain variables) (SCF; ISNAR; FAO-RLC)
- Difficulties in characterizing poverty with quantifiable measures which do not always accurately convey welfare (CIMMYT)
- Missinterpretation of data (FAO-ESNA; FAO-ESAF; FIVIMS; CIAT)
- Variation in the definition of poverty and food insecurity (SCF; CIAT; Brazil)
- Need of having comparable poverty and food insecurity measures but at the same time keeping local specificity (CIAT; Brazil) tool should allow users to calculate their own (custom) indices of poverty, welfare, marginalization.
- Donors and stakeholders advocacy - linking information to the improvement of action programs (Mozambique; Brazil)
- Little communication between users and producers of information (FAO-RLC)
- Little coordination in the production of information products leading to duplication of efforts (FAO-RLC)
- Information infrastructure present but few useful products (FAO-RLC)
- Information not linked directly to problem solving (FAO-RLC)
- Sense of using information not prevalent (FAO-RLC)
- Need for more timely information (FAO-RLC)
- The understanding by users of the conceptual framework which lays behind the production of GIS maps to understand how the generation of information would need to be linked to decision-making (Mozambique)
- List of indicators to be included in the database, which should be based on the development of a clear analytical framework by all members of the data users group (Mozambique)
- The level of understanding of food insecurity, poverty and vulnerability concepts and of their underlying causes, to be able to relate the message contained in the information to their sphere of institutional and professional responsibilities (Mozambique).
- Limitations of aggregated information (CIAT; Brazil)
- Accuracy of poverty mapping measures (CIAT)

4.2.3 Key research questions

- Whom the food insecure and vulnerable are, where they are located at subnational level and why they are food insecure and vulnerable? (FAO-ESAF; FIVIMS; CIAT; TAC; Mozambique; WFP-VAM)
- Where are the poverty hotspots within the continent? (IPGRI; CIMMYT)
- What are the components of poverty and their spatial distribution within the hotspots? (IPGRI)
- What the progress has been made towards the WFS goal of reducing the number of undernourished by half by 2015? (FIVIMS)
- How does the spatial distribution of poverty change when applying different poverty definitions? (UNEP)
- What types of producers (in terms of poverty, food security, production systems) would be vulnerable to different types of global environmental change? (UNEP)
- Where are the poor in relation to agricultural production systems / agro-climatic zones / access to infrastructure / natural hazards? (UNEP; CIAT; TAC; IPGRI)
- Where are the poor located in urban and rural areas and how to compare measurements based on different conceptual framework? (Brazil)
- What agricultural products would better contribute to nutritional improvement in a specific agro-ecological, economic and social context? (TAC; CIAT)
- What kinds of crops are associated with various levels of poverty and malnutrition? Data should include both crop species and area of coverage, if possible, by representative farm size. (IPGRI)
- What are the crops and thematic research areas (soil, water) that are most relevant in the geographical areas where the poor concentrate (ISNAR)?
- Which land use planning, which crops, which cropping patterns should be favored in the geographical areas where the poor concentrate? (TAC; CIAT)
- Where have different approaches to reducing the PFV been tried? (FAO-RLC)
- Where have particular approaches helped/not helped? (FAO-RLC)
- How to verify the accuracy of poverty mapping measures? (CIAT)
- What is the nutrition profile, in terms of food adequacy/inadequacy in the municipalities of Campinas, Bagé, Erexim and Santa Rosa? (Brazil)
- Who are the nutritionally vulnerable children and family in the poorest areas of the municipality of Campinas? (Brazil)
- Who are the nutritionally at risk elder people in the city of Curitiba? (Brazil)
- How to effectively turn mapping products into valuable, easily understandable and useful tools for use by policy-makers and planners? (Brazil)
- How to better complement and integrate information from early warning information systems with more structural food security information (Mozambique).
- Where are the poorest family to which should be targeted the Bolsa Escola National Programme? (Brazil)
- What are the costs and benefits associated with different poverty mapping methodologies in terms of data, technical expertise, and the precision and content of outcomes? (FAO-ESAE)
- To what extent do natural endowments determine people's choice of production system (land use system) and how does this in turn affect their income levels, and on the other hand, to

what extent does people's land use choices result in negative environmental effects which generate private or social costs? (FAO-ESAE)
- What will be the areas of future poverty, food insecurity and vulnerability? (SDRN; IPGRI)
- How is the World population distributed by agroecological zones, and how will the situation change over the next 15 years? (SDRN)
- How does the distribution of poverty over nations match up with a variety of other national indicators? (UNEP)
- What is the impact on poverty alleviation of the adoption of specific technology development activities? (CIMMYT)
- What are the geographical areas and/or socio-economic groups on which technology development activities should be targeted? (CIMMYT)
- Where are the areas where deployment of plant genetic resources in agroecosystems and/or on-farm conservation interventions would have the most significant effect on poverty/food insecurity? (IPGRI)
- What is the spatial relationship between nutrition/health and food security/poverty? (IPGRI)
- What is the spatial relationship between poverty/food insecurity and current levels of genetic diversity in staple crops or neglected and underutilized species, or indeed species-level crop diversity? (IPGRI)
- What is the spatial relationship between poverty/insecurity on one side and genetic erosion on the other? (IPGRI)
- What is the spatial relationship between poverty/insecurity and current protected area systems? (IPGRI)

4.2.4 Most common needs and interests

- Access to information on poverty, food insecurity and geo-physical parameters, as spatially desegregated as possible.
- Methods to explore causal relationships between various food insecurity related indicators.
- Characterization of food insecure and vulnerable groups.
- Common format, reliable, disaggregated and updated data on food insecurity and vulnerability.
- Information on which methodology is best.

5. Research Tasks

In this section we discuss possible tasks that could be undertaken by the project to address broad research issues that emerged from the user needs analysis. These tasks are summarized in the Table below, together with the specific research questions to which they refer. We also establish a set of criteria for choosing between candidate case studies and global datasets.

A few research questions identified as priorities in the user needs survey are not considered appropriate for a poverty mapping approach. One set of questions relates to the composition and nutrient value of the diet of the poor and the identification of the nutritionally vulnerable children, families and elderly in the poorest areas of various municipalities. Answers to these questions are best obtained directly from surveys. Another set of questions relates to the

identification of agricultural products that would contribute to nutritional improvement in a specific agro-ecological, economic and social context. In this case, farming system models would need to be used to obtain the answers, although the results could be displayed in map form.

The project calls for two separate levels of analysis, conceived of as, on the one hand, the collection of global data bases, and on the other hand, poverty mapping case studies in specific countries. The project document does not specify when or whether these two levels of analysis should come together, and no money is specifically allocated to the analysis of data gathered into the global GIS database, though provision is made for the modeling and creation of new maps if necessary.

The two levels of the project could come together, however, in the analysis of those topics where it is feasible to combine global and regional GIS databases with subnational data on poverty and food insecurity. We will look at this possibility in the context of the tasks that could be undertaken by the country case studies.

5.1 Country Case Studies

The project document calls for six cases studies distributed over different regions. We list below a series of possible key research tasks that could be tackled in the case studies. As shown in the Table, these are grouped into three categories: locating and characterizing poverty spatially within countries and regions, investigating poverty causality and correlation, and methodology development.

User Needs	Research Issues	Research Questions	Research Tasks
▪ Access to information on poverty, food insecurity and geo-physical parameters, as spatially disaggregated as possible. ▪ Maps showing locations and characteristics of food insecure and vulnerable groups. ▪ Expanding the frontiers of poverty mapping.	Locating and characterizing poverty spatially within countries and regions	▪ Who are the food insecure and vulnerable, where are they located, and why are they food insecure and vulnerable? ▪ How does spatial distribution of poverty change when applying different poverty definitions? ▪ Where are the poor located in urban and rural areas and how compare measurements based on different conceptual frameworks? ▪ What is the spatial distribution of the poor over major farming systems, agro-ecological zones, or food self-sufficiency zones? What are the poverty implications of non optimization of agricultural land use? ▪ How does the incorporation of spatial variables affect the analysis of the determinants of poverty or food insecurity?	▪ Locating the poor within countries and regions, using different definitions of poverty; ▪ Mapping assets to which the poor have access and livelihood strategies that they pursue;
▪ Methods to explore causal relationships between various food insecurity-related indicators.	Investigating poverty causality and correlations	▪ To what extent do natural endowments determine people's choice of production systems, and how does this affect their income levels, and vice versa? ▪ Are poverty and environmental degradation correlated? ▪ What are the poverty implications of non optimization of agricultural land use? ▪ What types of producers would be vulnerable to different types of global environmental change? ▪ What are the crops and thematic research areas (soil, water) that are most relevant in the geographical areas where the poor concentrate? ▪ Which land use planning, which crops, which cropping patterns should be favored in the geographical areas where the poor concentrate? ▪ What is the correlation between poverty and agriculture? ▪ To what extent does public investment mitigate/change people's production choices for a given natural [socio-economic] environment?	▪ Comparison of different map-based methodologies for evaluating the determinants of poverty and food insecurity ▪ Investigating causal relationships and correlations between poverty and spatial variables ▪ Investigating possible impacts of climate change upon the poor and food insecure
▪ Solutions to methodological challenges. ▪ Information on which methodology is best. ▪ Common format, reliable and updated data on food insecurity and vulnerability.	Methodology development	▪ How can the accuracy of poverty mapping measures be verified? ▪ How can qualitative information about food insecurity and vulnerability be integrated with statistical poverty mapping methodologies? ▪ How can early warning information be better integrated with more structural food security information? ▪ How can mapping products be turned into valuable, easily understandable and useful tools for use by policy-makers and planners? ▪ What are the implications of spatial analysis for poverty and food security mapping ▪ What are the costs and benefits associated with (i) different poverty mapping methodologies and (ii) different methodologies for evaluating the determinants of poverty and food insecurity, in terms of data, technical expertise and the precision and content of outcomes?	▪ Evaluation of the costs and benefits associated with different poverty mapping methodologies ▪ Integrating qualitative information about food insecurity and vulnerability with statistical poverty mapping methodologies ▪ Investigating the implications of spatial analysis for poverty and food security mapping

5.1.1 Locating the poor within countries and regions, using different definitions of poverty

Perhaps the most immediate and practical application of poverty mapping is to spatially locate the poor in a given country, and subsequently target an intervention or motivate political debate. Poverty maps have been used in such a fashion in a number of countries including Mexico, Nicaragua, Panama, Honduras, and South Africa. Other countries have carried out poverty mapping exercises, or have expressed interest in doing so (World Bank, 2000).

An option for one of the case studies would be to carry out a poverty mapping exercise in a given country, using one of the methodologies discussed in Section 2. To make this case study approach worthwhile in the context of the project, the chosen country or countries should not be located in Latin America, where poverty mapping has been applied in a number of countries but in a region where it could serve as a test and example for neighboring countries, such as Asia or sub Saharan Africa. Two recent CG system proposals seek funding for carrying out national poverty mapping exercises in Mozambique and Malawi (IFPRI) and Kenya, Tanzania, and Uganda (ILRI) (IFPRI, 2000, and ILRI, 2000). This effort could be carried out in conjunction with the new World Bank poverty mapping group or another institution providing similar efforts but with different methodologies.

The construction of one or more regional poverty maps may also be of interest. While regional maps may be less useful to individual national governments in terms of policy formulation, they have a number of important potential uses.

- Assisting multilateral and bilateral aid agencies in planning budgets or specific interventions
- For use with regional policy instruments, such as regional common market agricultural tariffs or commodity flows
- Cross border phenomena, such as migration, natural disasters, environmental issues, and agroecological zones. Specific environmental issues include problems such as river basin management, deforestation and erosion linkages, land use change and impacts on greenhouse gas emissions and biodiversity.

Initial efforts in regional poverty mapping are underway and Central and South America. A proposal to do regional poverty mapping in Africa has been prepared by researchers at both IFPRI and ILRI. In terms of the regional component, however, both proposals need strengthening in their formulation before being considered as case study options for this project.

5.1.2 Mapping assets to which the poor have access and livelihood strategies that they pursue

Investigating the spatial distribution of the poor over major farming systems, agroecological zones, or food self sufficiency maps and mapping natural and physical assets where they are found would involve the combining of subnational or regional poverty maps with a farming systems, agricultural producers typology map, genetic diversity map, current protected area systems, etc and georeferenced information about natural resources and physical infrastructure. Such a map or map series would not imply causality, but could be helpful for

multilateral and bilateral aid institutions in designing and planning agricultural technology interventions whose goals include poverty alleviation.

One possible database would be the FAO farming systems study, a detailed georeferenced typology of farm production systems for the developing world, commissioned by the World Bank. This would be combined with a global or semi-global subnational poverty map.

A second possibility, at a subnational level, would be to combine an agricultural census—or large-scale producer surveys, such as the georeferenced Basic Grains surveys in Nicaragua, which permit sufficient disaggregation—with a household survey including both detailed agricultural production data and consumption. The household survey could be used to determine the relationship of agricultural and livestock assets and production decisions on consumption. These parameters could then be applied to the agricultural census data or basic grains survey, using small area estimation techniques.

A third possibility would be to use an agricultural census or large-scale producer survey, as above, but in combination with an already existing subnational poverty map.

Global maps giving details of the natural resource base and the network of physical infrastructures in different parts of the world can be provided from the Global GIS Dataset (see below).

Another case study could involve the IIASA-FAO Global Agroecological Zones (AEZ) study (described in more detail below) which indicates the parameters under which different crops are at an optimum for every region in the world. Comparison with actual sub national land use statistics where available would possibly lead to insights in terms of the poverty implications of the non optimization of land use. Alternatively, this comparison could serve to ground truth the Global AEZ study. The candidate countries would need to have georeferenced land use data for comparison with the Global AEZ study parameters. One possibility could be Nicaragua, which has collected georeferenced national land use and production data continually since 1994.

5.1.3 Comparison of different map-based methodologies for evaluating the determinants of poverty and food insecurity

This task involves the comparison of three different methodologies for evaluating the determinants of poverty and food insecurity (e.g. econometric models, livelihood systems analysis, and participatory appraisal). In each case, poverty mapping is used to reveal the locational aspects of the identified determinants of poverty and food insecurity. Within the more econometrics-based methodologies, this assessment generally takes place within a multivariate regression framework (though it can and should be complemented with other types of information). The livelihood approach uses in-country expert opinions to categorize households by asset structures and livelihood strategies, thus uncovering the determinants of poverty. The participatory approach elicits self-generated definitions of poverty—and with it the determinants—from respondents in the population under study. The objective of this case study would be to compare these methodologies in terms of outcomes and policy implications.

5.1.4 Investigating causal relationships and correlations between poverty and spatial variables

Recent studies have stressed the importance of geography and spatial variables as determinants of poverty. But surprisingly, most of the recent voluminous research on poverty and food insecurity has not gone beyond only very rudimentary and one dimensional characterizations of the role of regions and access to different types of infrastructure, public services, and product and labor markets. One case study could use GIS techniques to incorporate spatial analysis into the determinants of rural poverty or food insecurity, or into issues which are important for alleviating poverty and food insecurity. This could include the determinants of migration, participation in off farm labor activities, product market participation, crop choice, or technology adoption.

In terms of the link between poverty and natural resource endowments, most recent studies have found little correlation.[13] This ambiguity in the macro and micro level research results on the spatial correlation of poverty and natural resource endowments may be due to the lack of data availability at the spatial and temporal scales necessary to measure the relationships in question, as well as the fact that the two outcomes are jointly determined, which creates problems in sorting out causal directions. It is difficult to find time series data and/or proper instruments to control for endogeneity.[14] The poverty—environmental relationship is also altered by government intervention and migration patterns, which can change natural resource endowments (as well as poverty status).

Separating out these causal relationships at the micro level in order to understand the impacts of natural resource endowments on poverty and the way in which the dynamic of poverty is manifested in natural resource endowments is crucial for effective policy-making for both poverty alleviation and improved environmental management. This question is also extremely relevant from a policy perspective in terms of whether and how farmers should be provided with incentives to use more environmental friendly farming practices.

One case study would thus involve examining this issue in a country using estimation techniques which would allow poverty and environmental variables to influence each other in a dynamic feedback system, based on georeferenced data.

As discussed in Section 2.3.6, a number of studies have tried to find a correlation between a variety of well being and environmental indicators. The poor results thus far may be due to inadequate data and estimation problems, or the fact that governments can alter the environment and the poor can migrate. This topic is still an important area of research as new global and subnational datasets become available. One case study could explore these relationships in a country with appropriate data. Collaboration could be explored with other initiatives with similar objectives, such as the recent IUCN-WWF-UNEP proposal (IUCN-WWF-UNEP, 2001).

5.1.5 Investigating possible impacts of climate change upon the poor and food insecure

There is a growing consensus that climate change will have major impacts on world agriculture as well as on a number of large metropolises in both developed and developing

[13] See, for example, Kelley and Rao (1995), Fan and Hazell (1997), Kirschke, et. al. (1999), and the review in Lipper, 2000.
[14] See discussion in Lipper (2000), Scherr (2000), and Osgood and Lipper (2000).

countries. However, the distribution of these impacts between the poor and non-poor is still a subject for debate.

One or more case studies in a country or agro-ecological zone could be undertaken that would group and locate producers by poverty level and by type of farming system, and create scenarios for the effects of climate change on the production and market access potential of the farming systems under study. The case study could then assess possible response strategies under varying policy scenarios, as well as assess the environmental and socioeconomic impact associated with these strategies. This would serve as a natural extension of recent studies of the impact of global environmental change such as Gommes, et al (1998) analysis of the impact of sea level rise on a national vulnerability index.

5.1.6 Evaluation of the costs and benefits associated with different poverty mapping methodologies in terms of data, technical expertise, and the precision and content of outcomes

A variety of methods for the spatial location of the poor have been put forward in the literature and in practice, and most are under continuing development. Each of these methods has different data requirements and implementation costs. Few formal comparisons have been made, however, among the different methodologies. In this case study, we would compare the best practice methodologies in use in terms of outcomes, data requirements, and costs. The output of this case study would be a set of guidelines for policymakers and practitioners as to the implications and tradeoffs of using a particular poverty mapping methodology in policy development and targeting.

The five methodologies chosen for the comparison include:

- Small area estimation—household level unit data method
- Small area estimation—community level data method
- Principal components—PROGRESA method
- Basic Needs index
- Livelihood or participatory

All five methodologies would be employed in one country. Possible candidates include Nicaragua, Ecuador or Malawi. The two most important criteria for country selection include availability of data for the most data intensive method (the household level unit method) and the interest of the national statistical agency or other government agency in participating. The comparison criteria would include:

- Calculation of FGT (Foster, Greer, and Thorbecke, 1984) poverty indicators
- Rank correlation between FGT poverty indicators
- Calculation of standard errors of FGT poverty indicators, and comparison of precision of alternate methods
- Analysis of bottom 25 percent (most marginal) of households, as counted through town population. How different are the classifications? On what characteristics of these households/towns do the classifications turn?
- Compare different classifications with different financial costs and statistical requirements

5.1.7 Integrating qualitative information about, poverty food insecurity and vulnerability with statistical poverty mapping methodologies

Food insecurity and vulnerability assessments which rely on participatory approaches can generate a wealth of useful information that is not captured by statistical measures. Much of this information is currently lost because it is not transformed into georeferenced data that can be manipulated, extrapolated and mapped. The objective of this case study would be to explore the possibilities of linking qualitative, location-specific information generated by these approaches with large national datasets, such as the census, for extrapolation of results to the national level and subsequent mapping. A preliminary effort has been attempted in terms of linking results of participatory assessments and census data (Leclerc, et al, 2000).

If successful, the results could enrich the locational poverty maps with information about the characteristics of different groups of poor or food insecure people, and provide useful guidance for programming decisions.

5.1.8 Investigating the implications of spatial analysis for poverty and food security mapping

GIS opens the door not only to the integration of new types of data and the visualization of the heterogeneity of poverty and food insecurity, it also adds a new analytical dimension to the analysis of poverty and food insecurity. The purpose of this case study is to evaluate the importance of taking into account the spatial dimension in the construction of poverty and food security maps. In one country, two subnational poverty mapping methodologies will be implemented with and without taking into account the spatial dimension. Three types of spatial factors will be considered:

- The implication of MAUP in terms of outcomes
- The trade off between spatially generated and traditionally reported information for such variables as access to public services and infrastructure
- The use of regression techniques explicitly incorporating the spatial dimension versus traditional regression techniques

5.1.9 Criteria for selection of subnational case studies

First, each case study must conform to the following criteria.

- Does the case study push back the frontier of subnational poverty or food security mapping applications?
- Does the case study use spatial analysis to resolve pending points of inquiry which have poverty alleviation policy implications
- Is the data required for the proposed case study currently available?
- If new data collection is required, has additional funding been obtained?
- Is the proposed methodology feasible?

- Is the proposed methodology the most appropriate for this application?
- Does the proposal justify adequately the choice of indicators?
- Is the proposed budget feasible?
- Does the case study respond to at least one of the user needs described in Section 4?

Second, the overall selection of case studies should reflect the following two considerations:

- Regional variation among the case studies
- Overall selection should include both poverty and food security applications
- Overall selection should cover a mix of the different categories of potential research questions

5.2 FIVIMS Global GIS Database

The Project Document calls for the development of a FIVIMS Global GIS Database, or FGGD, which will include subnational boundaries, various geo-physical thematic maps, as well as population, population density, and their projections. The FGGD will be developed using maps in the public domain, though if key maps are found to be missing, and if funding is available, the construction of these maps may be commissioned. The FAO has already begun researching the availability of databases on the web and is developing a working list of possible databases for inclusion. The FGGD is intended mainly for global or continental level studies.

The key question for this paper is therefore which maps should be given priority. With this in mind we propose a series of research questions.

5.2.1 How is the World population distributed by agroecological zones, and how will the situation change over the next 15 years?

The Rome Declaration of the World Food Summit pledged to cut in half the present number of undernourished people in the World by 2015. In order to improve planning and budgeting of efforts to reach this goal, the development of a global database incorporating information on Agro-ecological zones together with current and projected population densities is critical. This feasibility of carrying out this effort is high due to the fact that datasets with global coverage of agro-ecological zones and population densities are already available: the IIASA-FAO Global AEZ and Population Density datasets.

The AEZ is a model which generates simulations of the potential for agricultural crop production across ecological zones which are defined by various biophysical characteristics such as climate, soils, terrain etc. The AEZ model also allows for an adjustment of the maximum attainable yield to reflect varying levels of technology (low, medium and high) as well as the impact of agro-climatic factors such as length of growing period, water stress, presence of disease, pests etc. There are also at least two Population Density datasets available globally. Combining these two datasets, together with projections of future population growth and greater refinements on the potential for technology changes and other

improvements in the AEZ model, as well as the availability of water resources maps can yield a very useful tool for identifying areas of future food insecurity and vulnerability. This will include, based on the AEZ and population density projection maps and using various models, making potential food self sufficiency maps for high and low input levels.

5.2.2 What progress has been made towards the WFS goal?

Mapping of the number and proportion undernourished, and the depth of their hunger has already been introduced by FAO for global monitoring of the progress being made towards the WFS goal. If poverty and food insecurity mapping at national and subnational level produces refinements in the estimates, comparisons of these with the results obtain when using the standard FAO method, could provide greater insight into the progress being made.

5.2.3 How does the global distribution of poverty change when applying different poverty definitions?

This question seeks to compare how the application of alternative national poverty indicators affects the global ranking of poverty among nations. Different indicators may include GDP per capita, basic needs indices, and a variety of other proxies of national well being. The result would provide practical information as to the tradeoffs implicit among alternative indicators in the creation of global poverty maps.

5.2.4 How does the distribution of poverty over nations match up with a variety of other national indicators?

This exercise would match a global map of poverty at the national level with a variety of other national indicators including the prevalence of war/conflicts, debt ratio, political system, population density, and changes in GNP.

5.2.5 How can information on potential agricultural productivity help identify the food insecure?

Scenarios on potential agricultural productivity under various levels of inputs and/or management can be compared to population density and transformed into a GIS database and map indicating potential food production kg/ha/person/year. This would help identify areas where the local population is particularly vulnerable and food insecure. An example worked out with provisional data for Africa indicates that in certain areas this local food insecurity can be alleviated by increasing inputs and management level, while in other areas the capacity of the land is already exceeded at the highest input level (e.g. Rwanda and parts of Nigeria). This kind of study can as well be expanded globally as updated using new datasets on the environment as well as on population. Moreover this approach can be made dynamic by incorporating population dynamics in the simulation.

5.2.6 Criteria for selection of global maps

The above research questions, as well as those developed for some of the subnational case studies, imply the incorporation of specific maps into the FGGD at 1:5,000,000 or higher scales (or for raster maps 5 arcminute or 30 arcsecond resolution). Each of these maps should be evaluated in terms of the amount of work required to incorporate into the FGGD, which may range from a few days to a few months, versus its usefulness. This has not been done yet,

so the recommendations on global maps simply reflect suggestions made by different participants in the Project.

6. Recommendations

The following Recommendations are not meant to be the last word, but in fact to provoke discussion and debate. They reflect what we think are the most interesting possibilities for the project to focus on, while following the criteria described in Section 5.1.9. we have noted below any doubts regarding the feasibility of these recommendations.

6.1 Recommendations on subnational case studies

- What are the costs and benefits associated with different poverty mapping methodologies in terms of data, technical expertise, and the precision and content of outcomes?

- How can vulnerability profiling and assessment tools be integrated with statistical poverty mapping methodologies?

- What is the spatial distribution of the poor over major farming systems, agro-ecological zones, or food self-sufficiency zones?

(Feasibility requires global or semi-global subnational poverty map, or appropriate individual country data.)

- To what extent do natural endowments determine people's choice of production system (land use system) and how does this in turn affect their income levels, and on the other hand, to what extent does people's land use choices result in negative environmental effects which generate private or social costs?

(Feasibility requires spetial datasets that will permit estimation.)

- What are the implications of spatial analysis for poverty and food security mapping?

- How does the incorporation of spatial variables affect the analysis of the determinants of poverty or food insecurity, or the analysis of issues which are important for alleviating poverty and food insecurity?

6.2 Recommendations on global studies

- How is the World population distributed by agroecological zones, and how will the situation change over the next 15 years?

- What progress has been made towards the WFS goal?

6.3 Recommendations on global maps

(in order of importance)

- Global subnational poverty map

- Standard global coastline and international boundaries
- Subnational administrative units with a standard administrative codes
- FAO-IIASA Global Agro-ecological Zones
- CIESIN and LandScan Population Density
- Variety of global national poverty maps
- Updating of food self sufficiency map

The following have been suggested by FAO for possible incorporation into the FGGD dataset as individual data layers (not all of these maps may be available globally at the scales/resolution noted above and some of them are already part of the AEZ maps.)

- Topography/Elevation
- Infrastructure (roads, railways, communications, towns and settlements)
- Hydrology (rivers/water bodies)
- Soils
- Physiography
- Geomorphology (landforms)
- Land degradation
- Precipitation/drought risk
- Temperature
- Evapotranspiration (moisture regime)
- Hydrological Basins (watersheds)
- Irrigated Areas/water resources
- Land Cover/Land Use

6.4 Recommendations on subnational poverty mapping methodologies

- Small area estimation—household level unit data

Advantages: statistically rigorous; proven feasible in a number of countries; resources are available to continue its development

Disadvantages: significant data requirements, in terms of amount of data, timing between data sources, and access to household unit level census data; requires high level of technical expertise

- Small area estimation—community level data

Advantages: statistically rigorous; proven feasible in a number of countries; somewhat less onerous data requirements (community level averages instead of household unit data)

Disadvantages: significant data requirements, in terms of amount of data and timing between data sources; requires high level of technical expertise; unclear how use of more aggregate data effects outcomes and precision of statistical estimates in comparison with household unit level data method.

- Multivariate weighted indices—principal components

Advantages: statistically rigorous; proven feasible in Mexico; less data requirements then small area estimation, only requires community level averages from a census.

Disadvantages: requires high level of technical expertise; unclear how use of more aggregate data effects precision of statistical estimates in comparison with small area estimation.

- Vulnerability profiling

Advantages: permits incorporation of qualitative information; proven feasible in a number of countries; less data requirements that statistical methods; requires lower level of technical expertise and instead more field experience.

Disadvantages: not statistically rigorous; unclear how use of qualitative information effects outcomes and precision of statistical estimates in comparison with statistical methods; extrapolation procedures to whole country undeveloped.

- Participatory poverty assessment

Advantages: allows the target population to define poverty in its own words; permits incorporation of qualitative information; proven feasible in a number of countries; less data requirements that statistical methods; requires certain level of technical expertise.

Disadvantages: statistical rigorous unclear; unclear how use of qualitative information effects outcomes and precision of statistical estimates in comparison with statistical methods; poverty definition may not be comparable across villages; extrapolation procedures to whole country undeveloped.

6.5 Recommendations on complementary studies

- Further development of GWR
- Further development of zoning techniques
- Updating of Henninger (1998) review

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