SOLAW TR14

Where are the poor and where are the land and water resources?

SOLAW Background Thematic Report – TR14

Geodata Institute, UK
University of Southampton, UK

John S. Latham, FAO
Renato Cumani, FAO
Barbara Huddleston, FAO

FAO
FIAT PANIS

Table of contents

List of figures

List of tables

[1] Poor areas are defined as areas in the bottom quintile (20 percent) of poverty globally as derived from prevalence of stunting among children under 5 years of age

List of maps

Abbreviations and acronyms

A	Area
CIESIN	Centre for International Earth Science Information Network
DFID	United Kingdom Department for International Development
DHS	Demographic and Health Surveys
FAO	Food and Agriculture Organization of the United Nations
FIVIMS	Food Insecurity and Vulnerability Information and Mapping Systems
GIS	Global Information Systems
GLCN	Global Land Cover Network
GLCN	Global Land Cover Network
GMFS	Global Monitoring for Food Security
GTOS	Global Terrestrial Observing System
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IWMI	International Water Management Institute
IWRM	Integrated water resources management
MDG	Millennium Development Goals
mm	Millimeter
P	Population
PC	Principal Components
PCA	Principal Component Analysis
PCS	Per capita share
UNEP	United Nations Environment Programme
UNPD	United Nations Population Division
WHO	World Health Organization
WWF	World Wildlife Fund

Contributors to this report

John S. Latham – Senior Geospatial Land and Water Officer and leader of the Environmental Monitoring Unit of the Food and Agriculture Organization of United Nations (FAO), Natural Resources and Environment Department, Land and Water Division. Programme director of the Global Terrestrial Observing System (GTOS) and of the Global Land Cover Network (GLCN). Member of the Global Monitoring for Food Security (GMFS) User Advisory Board. He has more than 25 years of involvement in research, development, application, technology transfer and capacity development programmes in the field of Remote Sensing and Geographical Information Systems in developing and developed countries in Africa, NearEast, Asia, Latin America and Europe. The focus of the work is the integral use of information systems, geographical information systems and remotely sensed data from earth observation satellites to support environmental and natural resources management, crop acreage estimation procedures using Remote Sensing data and spatial data infrastructure programmes.

Renato Cumani – Has more than 15 years experience in application of Geographic Information Systems (GIS) and Remote Sensing technologies to natural resources management, environmental monitoring and assessment, sustainable agriculture development, decision support tools, vulnerability assessment, and environmental services. The focus of the work is use of earth observation data combined with spatial and tabular data to support environmental and natural resources management programmes.

Barbara Huddleston – Has spent most of her professional career in the international arena, first with the United States Departments of Commerce and Agriculture, and subsequently at the International Food Policy Research Institute (IFPRI) and the Food and Agriculture Organization of the United Nations (FAO). While at IFPRI from 1976 to 1984, she established her credentials as a food security expert, specializing in issues related to food trade, food reserves and food aid. Following her move to FAO she served as Secretary to the Committee on World Food Security and Chief of the Food Security Service until her retirement in 2002. In this capacity, she promoted FAO's work programmes in the field of early warning, food security information, vulnerability assessment, vulnerable livelihood profiling and participatory extension. Barbara continues to make her home in Rome and remains active professionally, as a consultant to the Rome-based food agencies, focusing in particular on use of geospatial information for analysing environment, poverty and food insecurity relationships and impacts of climate change on food security, and on tracking and mapping food security actions as a decision-support tool for developing countries and their development partners. She holds an MA in International Relations from The Johns Hopkins School of Advanced International Studies and an M.Phil. in Economic History from The George Washington University. She is the author or editor of several books and articles in her fields of expertise, and has served on various editorial boards and public service commissions through the years.

Key messages:

- At a global scale there are inverse relationships between occurrence of poverty, as measured by the prevalence of stunting amongst children under five, and both access to land suitable for agricul tural production, and access to easily available water.

- A bivariate analysis revealed that poverty levels vary substantially between the regions of the world. However, when the effect of land, water resources and farming systems are taken into account, the regional differences become less important. This indicates that there is no independent effect of region on poverty as measured by prevalence of stunting among children under five years of age. Land, water resources and farming systems do, however, account for some of the differ ences in poverty between the regions of the world.

- Farming systems and their associated land management practices modify the inverse relationship between poverty and land resources (agricultural and arable land). This is an indication that using appropriate farming systems may improve livelihood in areas with limited land resources.

- When a 'resource management' index, which accounts for the combined effects of access to land, water and the type of farming method on the prevalence of stunting is developed, a statistically significant relationship between resource management and poverty is indicated.

- It is recognized that reducing poverty and food insecurity in an area with constrained land and water resources will require a good understanding of the possibilities for utilizing virtual water and land resources through imports as well as an understanding of national export strategies in the face of domestic food demand. It is further recognized that people in poor areas (both urban and rural), may experience issues in accessing food owing to economic and supply issues as opposed to access to land and water. Additionally, there will need to be an understanding of exogenous poverty factors (war, political instability, etc.) as well as hazard and disease burden.

Nevertheless, the results of this study have clearly demonstrated that:

- poor resource management is a predictor of poverty; and

- improving resource management in a poor area with land and water constraints is a viable option for reducing poverty and food insecurity.

Results of this analysis are significant only at a global scale. Comparable analyses could be carried out to help guide decision-making at national and local levels, using higher resolution datasets, where available.

1. INTRODUCTION

Who are the poor, where they are and what resources are available to them are questions that have been asked for decades by policy-makers, researchers, planners and organizations interested in the well-being of the poor (Henninger and Snel, 2002; Muller, Epprecht, and Sunderlin, 2006; CIESIN, 2006; Sachs, 2005; Chen and Ravallion, 2004). These questions have been at the heart of several policy initiatives and strategies designed to reach targets set for the Millennium Development Goals (MDGs). Organizations and researchers have carried out extensive work to identify the poor and the resources that are available to them (Muller, Epprecht, and Sunderlin, 2006; CIESIN, 2006; Sachs, 2005; Chen and Ravallion, 2004; Henninger and Snel, 2002). Knowing who the poor are, their geographical location, the land and water resources available to them, and the farming systems they currently practice, is important for implementing strategies aimed at alleviating poverty and sustaining the environment.

It is important to emphasize that the literature is sated with differing definitions of poverty and numerous indicators for its measurement according to each of these definitions (Akindola, 2009; O'Boyle, 1999; Hagenaars and de Vos, 1988). The importance of a consistent definition of poverty and the indicators used to measure it cannot be over-emphasized. The emphasis on consistency does not however preclude a diverse range of indicators for poverty, which is a multifaceted phenomenon. Where a poverty indicator is limited to one facet, it is important to recognize the limited focus that the specific indicator may give to an analysis of poverty (e.g. stunting – the indicator used in this study – will provide a focus for the analysis of food insecurity).

Population, poverty and the environment are issues that are often discussed in unison (Dasgupta, Deichmann, Meisner and Wheeler, 2005; United Nations, 2001; Vosti, 1995; Ehrlich, Ehrlich and Daily, 1993; The World Bank, 1990). The world's poor have a high dependence on the environment and its natural resources including land and water, which are the rudiments of their livelihood and survival. The pressure of rapidly expanding population means that many of the poor live in areas of acute environmental degradation (The World Bank, 1990). The world's poor do not wilfully degrade the environment and its natural resources, but their circumstances and the lack of resources often drive them to do so (The World Bank 1992).

The MDGs, which have been the measurement for progress in development and human well-being recognize the importance of the environment and its resources in eradicating poverty. For example, land and water resources are essential for producing the food needed to eradicate hunger, secure livelihoods, and reduce the number of children dying of malnutrition; for combating major diseases such as malaria and for ensuring the sustainability of the environment (FAO, 2005).

As the world's population continues to grow and the earth's climate to warm, there is growing concern whether there will be enough resources, particularly suitable agricultural land and water to secure a better quality of life for the world's population and future generations, particularly the poor. The growing population is already degrading suitable land for agriculture and driving up demand for agricultural products, while the warming climate is increasing the demand for the water required for their production (Scherr and Yadav, 1996; Ruttan, 1993; The World Bank, 1992; The World Bank, 1990).

Historical projections show that the human population is growing exponentially (United Nations Population Division [UNPD], 2009), whereas food production only increases linearly. With more than 99 percent of the world's food supply coming from the land and 70 percent of the world's surface and groundwater supplies being used for agricultural production (IWM, 2007; Pimentel *et al*., 1998; Ongley, 1996), continued degradation of land and water resources will pose a serious threat to food security and rural livelihood (UNEP, 2008; Henao and Baanante, 2006), a threat that is likely to be compounded for many of the poor by the effects of climate change.

1.1 Poverty mapping

Poverty mapping is the spatial representation and analysis of indicators of human well-being and poverty. Poverty maps are powerful visualization tools for illustrating of spatial heterogeneity in poverty within and between areas. The demand for poverty maps has grown tremendously in recent years especially in the context of decentralized approaches to planning and resources allocation. This is particularly the case in countries where there are considerable spatial inequalities concerning the distribution and use of resources. Poverty maps have become important tools in implementation of poverty reduction strategies, targeting of public expenditure and ensuring transparency in public decision-making (Henninger and Snel, 2002).

Over time, different methods, indicators, measures and resolutions of poverty maps have evolved. Each method, indicator, measure and resolution has its own strengths and weaknesses. Data needs differ, as do the sets of analytical skills required to assess implications of mapped information for policy. Poverty indicators can be grouped into two main categories – monetary and non-monetary. Monetary measures focus mainly on income and consumption indicators, while non-monetary measures focus on health, nutrition, literacy, deficient social relations, insecurity, low self esteem and powerlessness. The proportion of the population with less than three years of education is an example of a non-monetary indicator (Coudouel, Hentschel and Wodon, 2002). Ownership of non-monetary assets, e.g. cattle or jewels, is another indicator of poverty that is widely used.

In recent times, there has been much emphasis on self-reported measures of poverty, both at the individual and aggregate levels. These include questions on income and consumption; for example, do you have enough money to afford basic needs? Do you get enough food? Do you consider yourself poor? What is the least amount of money a family of two adults and two children would need to stay out of poverty in a particular community and many others.

These indicators have been used to measure the incidence of poverty, the poverty gap (depth of poverty) and poverty severity. Poverty incidence considers the share of the population, whose income is below the national poverty line or who cannot afford to buy sufficient food. The depth of poverty shows how far removed households are from the poverty line, while poverty severity shows the distance separating the poor from the non-poor and the inequality among the poor.

Poverty lines are used to characterize varying degrees of poverty – extreme (or absolute) poverty; moderate poverty; and relative poverty (DFID, 2009). Extreme poverty has often been used to describe households that cannot afford basic needs for survival – food, health care, clothing, safe drinking water and sanitation and education among others. Moderate poverty is generally used to refer to households where basic needs are met but just barely. Relative poverty is generally construed based on household income.

Households with income levels below a given proportion of average national income are usually referred to be in relative poverty.

The World Bank uses an income of US$1.25 and below per day per household measured at purchasing power parity to measure extreme poverty. Using this poverty line, the World Bank reported that there were 1.4 billion poor people living in the developing world in 2005 (Chen and Ravallion, 2008). The choice of poverty line is, however, often arbitrary. Different countries use different poverty measure and lines (Muller, Epprecht, Sunderlin, 2006; DeNavas-Walt, Proctor, Smith, and United States Census Bureau, 2009. For a chosen poverty line to be meaningful it has to resonate with social norms or what is understood to be a minimum living standard of the chosen area, e.g. minimum income or what is deemed necessary to achieve an adequate standard of living.

1.2 Land cover, land use change and poverty

The term 'land use' refers to how land is being used by human beings (as well as the inputs to land e.g. quantity of water, land tenure, farming system, etc.) and the term 'land cover' refers to the biophysical materials found on the land including vegetation, construction, bare rock, bare soil and inland water surfaces (Herold, Latham, Di Gregorio and Schmullius, 2006). Land cover characteristics, and the uses of land, are key issues in climate change (Herold, Latham, Di Gregorio and Schmullius, 2006) and so are their implications for poverty and poverty alleviation (Grootaert, Kanbur and Oh, 1997; Carter and May, 1999; Scott, 2000; Gunning, Hoddinott, Kinsey and Owens, 2000; Finan, Sadoule, de Janvry, 2005; Herold, Latham, Di Gregorio and Schmullius, 2006).

Over 70 percent of the world's population are rural inhabitants with land use as the major source of livelihood (IFAD, 2010). Of the 1.4 billion poor people living in the developing world (Chen and Ravallion, 2008) most of them are dependent on the land and its resources for their livelihood (DFID, 2009).

Land use and land cover change directly affect the lives of the people. Land cover change affects biodiversity, soil degradation and deforestation altering the earth's ecosystems services. These changes adversely affect the ability of biophysical systems to support human needs e.g. increased floods and droughts, increased food insecurity and loss of essential medicinal plants among others. The poor suffer most from environmental damage because they are the least able to avoid the consequences as they depend upon natural resources for their livelihoods (DFID, 2009).

1.3 Study questions

This study assesses the relationship between the poor are and the land and water resources available to them focusing on three perspectives: distribution of the rural poor in relation to land suitable for agricultural production; threats to livelihoods posed by land and water constraints in relation to farming systems practiced; opportunities for reducing poverty in areas with natural resource constraints through improved resource management practices.

This is done by first analysing geo-referenced data to examine the degree of human access to different types of land, easily available water, and distribution of farming systems, to graphically illustrate the association of these variables with the prevalence of poverty, as measured by stunting (low height-for-age) amongst children under five. Next, it assesses the extent to which these variables individually, or in various combinations, are good predictors of the prevalence of poverty. Finally, it generates a resource management index to investigate the significance of the relationship between resource management and poverty. The data and methods used to conduct the study are described in Section 2 and the results obtained are described in Section 3.

2. Data and method

2.1 Data

The data for the analysis is from the Food and Agriculture Organization of the United Nation's (FAO) GeoNetwork metadata portal (Available at: http://www.fao.org/geonetwork). The GeoNetwork database is a standardized and decentralized spatial information management environment hosted by the FAO. It is designed to enable access to geo-referenced data, cartographic products and their metadata. The database was developed to enhance access to spatial data and thematic maps that could support informed decision-making, promote multidisciplinary approaches to sustainable development and enhance understanding of the benefits of geographic information.

All the geospatial layers used in this study are converted into a uniform and standardized geospatial format according to the FAO guidelines. The data layers used for the analysis are categorized into five groups:

- (1) stunting amongst children under five;
- (2) population distribution;
- (3) land use and land cover;
- (4) surface and groundwater data and
- (5) farming systems data.

Groups 1, 2 and 3 above are documented at Food insecurity, poverty and environment (FAO, 2007). The data cover 825 170 grid cells (783 961 rural and 41 209 urban), mostly in developing countries, where a stunting observation for the most recent available year during the period 2002–2010 has been recorded. The population data coverage for this study is 3 708 797 723 (49 percent rural and 51 percent urban), this represents 57 percent of the world population as of 2005. The spatial resolution of the main datasets is 5 arc-minutes. The size of the grid cells range from 9.7 km^2 to 85.5 km^2. The reader is referred to FAO and the Food Insecurity and Vulnerability Information and Mapping Systems (FIVIMS, 2003), Salvatore *et al*. (2005), Wint and Robinson (2007) and van Velthuizen *et al*. (2007) for detailed discussions on the data.

2.2 Methods

Land cover / population ratios (per capita shares)

The relationship between population and land cover can be presented in two ways – per capita share or population density. Population density is used where the focus is on population distribution, whereas per capita share is used when the focus is on distribution of land and water. In this study, the focus is on land and water distribution; therefore per capita share is adopted.

The advantage of using per capita share in this case is that it is a measure of development potential, which demonstrates the current capacity for food security and potential development of additional productivity, particularly in areas where mechanized farming is limited. Per capita share also enables identification of where people are in relation to resources (agricultural, arable, irrigated, barren and agriculturally suitable land, water). Per capita share can be expressed mathematically as:

$$PCS_a = (A_a/P_a) * 1\,000$$

Where PCS_a in this case, is the per capita share of land or water resource expressed in km^2 per 1 000 people or mm/month per 1 000 people, respectively for a given area *a*, A_a is the amount of land or water resource in area *a* and P_a is the total population in area *a*. The land and water resources considered in this study are described below. All definitions follow FAOSTAT definitions (Available at: http://faostat.fao.org/site/291/default.aspx).

- **Land area** is the total of a given area, excluding the area under inland water bodies. The data comes from the FAO GeoNetwork data archive and was published on the 29th of May 2007. Per capita share of land is measured as the ratio of total area to the total population in the area expressed in km^2 per 1 000 people.

- **Agricultural land** is the sum of areas under arable land, permanent crops and permanent meadows and pastures. Permanent crop land is land cultivated with long-term crops that do not have to be replanted for several years (such as cocoa and coffee); land under trees and shrubs producing flowers and nurseries (except those for forest trees). Permanent meadow and pasture are lands used permanently (five years or more) to grow herbaceous forage crops, either cultivated or growing wild. The data for the analysis comes from the FAO GeoNetwork data archive and was published on the 29th of May 2007. Per capita share of agricultural land is measured as the ratio of total agricultural area to the total population expressed in km^2 per 1 000 people.

- **Arable land** is land under temporary agricultural crops, temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years). Abandoned land resulting from shifting cultivation is not included in this category. Arable land does not indicate the amount of land that is potentially cultivable. The data for the analysis was extracted from the FAO GeoNetwork data archive and was published on the 11th of June 2007. Per capita share of arable land is measured as the ratio of the total amount of arable land in an area to the number of people in the area expressed in km^2 per 1 000 people.

- **Irrigated land** refers to areas where water is artificially supplied to land to produce food crops. The data for the analysis comes from the FAO GeoNetwork data archive. The data was published on the 12th of June 2007. Per capita share of irrigated land is measured as the ratio of total agricultural area that is irrigated in an area to the number of people in the area expressed in km^2 per 1 000 people.

- **Barren land** in this study refers to land without vegetation or sparse vegetation. This is land that is not suitable for crop production, e.g. desert, stony and rocky lands. The data was extracted from the FAO GeoNetwork data archive, published on the 29th of May 2007. Per capita share of barren land is measured as the ratio of the total area of barren land in an area to the number of people in the area expressed in km^2 per 1 000 people.

- **Easily available water** refers to the amount of stored soil moisture readily available to crops. The data on easily available water was extracted from the FAO GeoNetwork data archive. The data was published by the FAO on the 13th of February 2007. Per capita share of easily available water is measured as the ratio of the amount of easily available water in an area the number of people in the area expressed in mm/month per 1 000 people.

Poverty measure

As indicated earlier in the report, there are several indicators (monetary and non-monetary) that have been used in the literature to assess poverty level. For this study, a non-monetary indicator of poverty is adopted – prevalence of stunting amongst children below five years of age (proportion of under-five years falling below minus two and minus three standard deviations from the median height-for-age of reference population recognized by World Health Organization).

The data represent various years during the period 2002–2010, and were compiled by the FAO from different sources, Demographic and Health Surveys (DHS), Multiple Indicator Cluster Survey, the World Health Organization (WHO) Global Database on Child Growth and Malnutrition and national surveys. There is substantial evidence that most indicators of poverty related chronic undernourishment are related to stunting in young children (Gross, Schultink and Sastroamidjojo, 1996; FAO and FIVIMS, 2003). Indeed where a single indicator of poverty is sought, "stunting prevalence is one of the most reliable and most suitable indicators for monitoring and assessing poverty" (Simondon, 2010). Stunting reflects chronic restriction of potential growth, inadequate food intake and poor health conditions, resulting from endemic poverty (FAO, 1999).

The approach differs from that used by the World Bank in its analysis of poverty, which is based on an absolute monetary indicator. As a result, the population figures that fall within the definition of poverty are different for the two studies. In the developed world prevalence of stunting is not considered to be highly indicative of poverty, whereas a monetary analysis would highlight poor areas. In developing countries, however, it is advisable not to rely on a purely monetary approach, which by its nature precludes barter-trade and other non-monetary transactions. Indeed, according to Simondon (2010), in the monetary approach to measuring poverty, "wealth at the national level is not always translated into better living conditions for all citizens, notably women and young children in poor households".

Typically, non-monetary poverty indicators are summarized in terms of quintiles. In this study, prevalence of stunting amongst children below five years of age is categorized into quintiles to identify poor areas. The richest quintile refers to the 20 percent of areas with the lowest prevalence of stunting, while the poorest quintile refers to the 20 percent of the areas with the highest prevalence of stunting. Poor areas are those belonging to the poorest quintile.

Suitability of land for agricultural production

Land suitability refers to the natural ability of given land to support a specific purpose (FAO, 1976). FAO (1976) relates this to land qualities (e.g. erosion resistance, water availability and flood hazard) and land characteristics (e.g. slope angle and length, rainfall and soil texture). The land suitability index used in this study is adopted from van Velthuizen *et al*. (2007). The study derived suitability indices for nine crop types (cereals, fibre crops, oil crops, pulses, roots and tubers, stimulants, sugar crops, tree fruits and vegetables) at three input levels, and a separate suitability index for pasture. The resulting output was then used to derive a combined suitability index which reflects the suitability of a given area for crop production.

The suitability index is classified into eight classes: 0 – not suitable; 1 – 10 very low; 10 – 20 low; 20 – 35 medium low; 35 – 50 medium; 50 – 65 medium high; 65 – 80 high and 80 – 100 very high. The data for suitability of global land area for rainfed crops, 2007 was extracted from the FAO GeoNetwork data archive. The reader is referred to van Velthuizen *et al.* (2007) for a detailed discussion of the land suitability index.

Farming system database

The farming system database used in this study is taken from the classification of farming systems in developing and transition countries, 2000 published in Dixon, Gulliver, Gibbon and Hall, 2001 and used in van Velthuizen *et al.,* 2007. A farming system is defined as a population of individual farm systems that have broadly similar resource bases, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate. Depending on the scale of the analysis, a farming system can encompass a few dozen or many millions of households.

Farming systems are classified based on availability of resource, enterprise patterns, household livelihoods, constraints and development strategies and interventions. Seven major farming system classes are identified; and within each of these a number of more specialized farming systems are distinguished. The seven classes and the farming systems belonging to each class, as defined in van Velthuizen *et al*. (2007) are reproduced in the table below.

Farming system classes and farming systems of developing and transition countries

Farming system class	Farming systems	Where found
Smallholder irrigated*	Smallholders in large-scale irrigation schemes	Africa, Western Asia, Latin America and Caribbean
Wetland rice-based	Rice, rice-wheat, lowland rice Lowland rice	South Asia East Asia and Pacific
Smallholder rainfed humid	Forest based, rice-tree crop, root crop, cereal-root crop mixed, maize mixed Tree crop, root-tuber, temperate mixed Forest based, intensive mixed, maize-beans	Africa South Asia, East Asia Latin America and Caribbean
Smallholder rainfed highland	Highland perennial, highland temperate mixed Highland mixed, sparse mountain Upland intensive mixed, highland extensive mixed Intensive highland mixed, high altitude mixed, moist temperate mixed forest-livestock	Africa Western Asia, South Asia East Asia, and Pacific Latin America and Caribbean
Smallholder rainfed dry/cold	Agropastoral millet/sorghum Pastoral, sparse arid, small scale cereal-livestock Rainfed mixed, dryland mixed Rainfed mixed, dry rainfed, pastoral, sparse arid Pastoral, sparse arid, sparse forest Dryland mixed, pastoral, sparse forest	Africa Africa, Western Asia Western Asia South Asia East Asia and Pacific Latin America and Caribbean
Dualistic	Tree crop, large commercial and smallholder Irrigated, mixed, forest based livestock, horticulture mixed, large scale cereal-vegetable, extensive cereal-livestock, pastoral, sparse cold Tree crop mixed Coastal plantation and mixed, extensive mixed, cereal-livestock, temperate mixed, extensive dryland-mixed	Africa European and Central Asian countries in transition East Asia and Pacific Latin America and Caribbean
Coastal artisanal fishing	Coastal artisanal fishing	Africa, Western Asia, South Asia, East Asia and Pacific

* In this farming system category, which represents a small but important class of agriculture, smallholders in large-scale irrigation schemes grow most or all of their crops under irrigation. However, various forms of small-scale irrigation and moisture management techniques are found in most farming systems dominated by rainfed cropping.

Source: van Velthuizen et al. (2007)

Rural-urban localities

Data for all variables analysed in this study are distributed across all grid cells in the population distribution database. Grid cells classified as urban on the 2005 Global Population Distribution database by FAO, are denoted in this study as urban localities, and those classified as rural are denoted as rural localities, based on the methodology described in Salvatore, M., Pozzi, F., Ataman, E., Huddleston, B. and Bloise, M. (2005). This data structure enables identification of poor areas (grid cells in the quintile with highest prevalence of stunting) according to whether they are rural or urban and to make a similar distinction for the other variables whose association with poor areas is examined.

Multivariate analysis

The factors that constrain livelihoods are multidimensional and act inter-dependently. To investigate the inter-dependencies between land, water resources and farming systems as factors that constrain livelihood, a multivariate statistical technique, which involves observation and analysis of more than one variable at a time, is adopted. This technique allows the use of one set of variables (explanatory variables) to predict another, to optimize and to identify important variables in the relationship.

The response variable in this analysis is prevalence of stunting in children under five, which is used as an indicator of poverty. As this variable is dichotomous, a logistic regression technique is used to examine the association between poverty (*the response variable*) and per capita share of land and water resources, suitability of land for agricultural production, and farming systems (*the explanatory variables*), accounting for confounding factors such as region of the world and rural-urban localities.

The analysis aims to identify areas where land, water resources and farming systems pose potential threats to livelihoods. The response variable is coded 1 if the area is in the poorest quintile and 0 otherwise. The explanatory variables considered in the analysis are per capita share of:

- total land area;
- agricultural land;
- arable land;
- irrigated land;
- barren land, all expressed in km^2 per 1 000 people;
- suitability of land for crop production;
- easily available water expressed in mm/month per 1 000 people and
- farming system classes.

The confounding factors considered for the analysis are region of the world and rural-urban location.

Three models are considered in the analysis. Model 1 controls for per capita share of land and water resources only. Model 2 controls for land suitability besides all the variables in Model 1 and Model 3 controls for farming systems besides all the variables in Model 2. This sequential model building process is adopted to investigate how the variables modify the relationships.

The main hypotheses set in the analysis are:

- land and water resources have a significant association with poverty;
- land suitability and farming systems could modify that relationship.

The results are presented as odds ratios along with their corresponding 95 percent confidence intervals. The odds ratio is a relative measure of how likely it is that an area will be poor, given its land, water resources and farming systems, compared to a reference group.

Principal component analysis

Principal Component Analysis (PCA) is used to derive a single resource management index based on land and water resources, land suitability and farming systems. PCA involves a mathematical procedure that transforms a number of correlated variables into a smaller number of uncorrelated variables called Principal Components (PC). The new sets of variables (PCs) are a linear combination of the original variables which are derived in decreasing order of importance, with the first principal component accounting for as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variability. The first PC, which is a measure of variability in access to land and water resources and in farming systems, is chosen as the resource management index.

3. Results

The results from the analysis are presented as graphs and maps that answer the following questions:

- Where are the rural poor concentrated?
- Where are the poor in relation to land and water resources and farming systems?
- To what extent do access to land and water resources and current farming systems constrain livelihoods for the poor?
- Can changes in resource management modify poverty outcomes in resource-constrained areas?

3.1 Where are the rural poor concentrated?

Table 1 shows the share of the population living in poor areas (areas characterized by a high prevalence of stunting among children less than five years old, by region and rural-urban localities. The table shows that poverty, as measured by this indicator, is endemic in Africa and Asia. In Africa, nearly 45 percent of the rural population and about 18 percent of the urban population are resident in poor areas. In Asia these figures are

29.5 percent and 18 percent, respectively. In contrast, in the Americas the shares are 4.3 percent and 0.9 percent. Map 1 shows the study area and regions considered in this study; while Map 2 shows where the rural poor are mainly concentrated. Unsurprisingly, the majority of the rural poor are concentrated in Africa and Asia.

MAP 1: STUDY AREA COVERAGE AND REGIONS

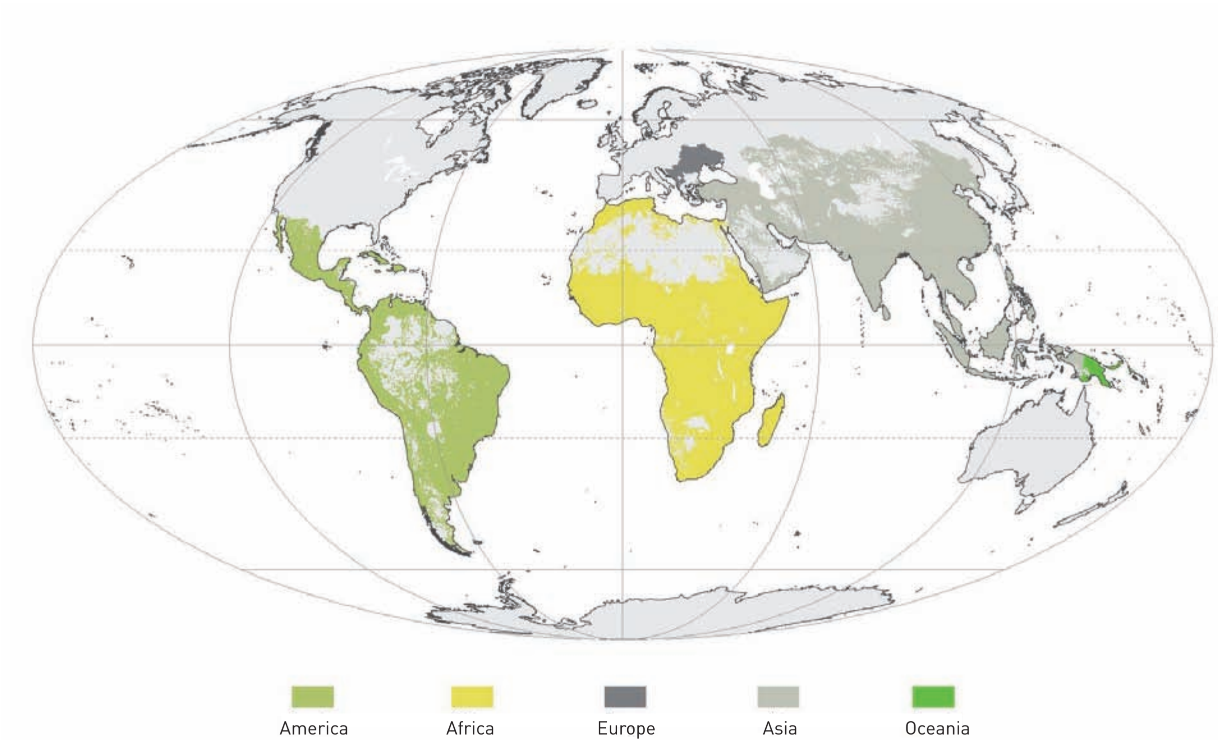
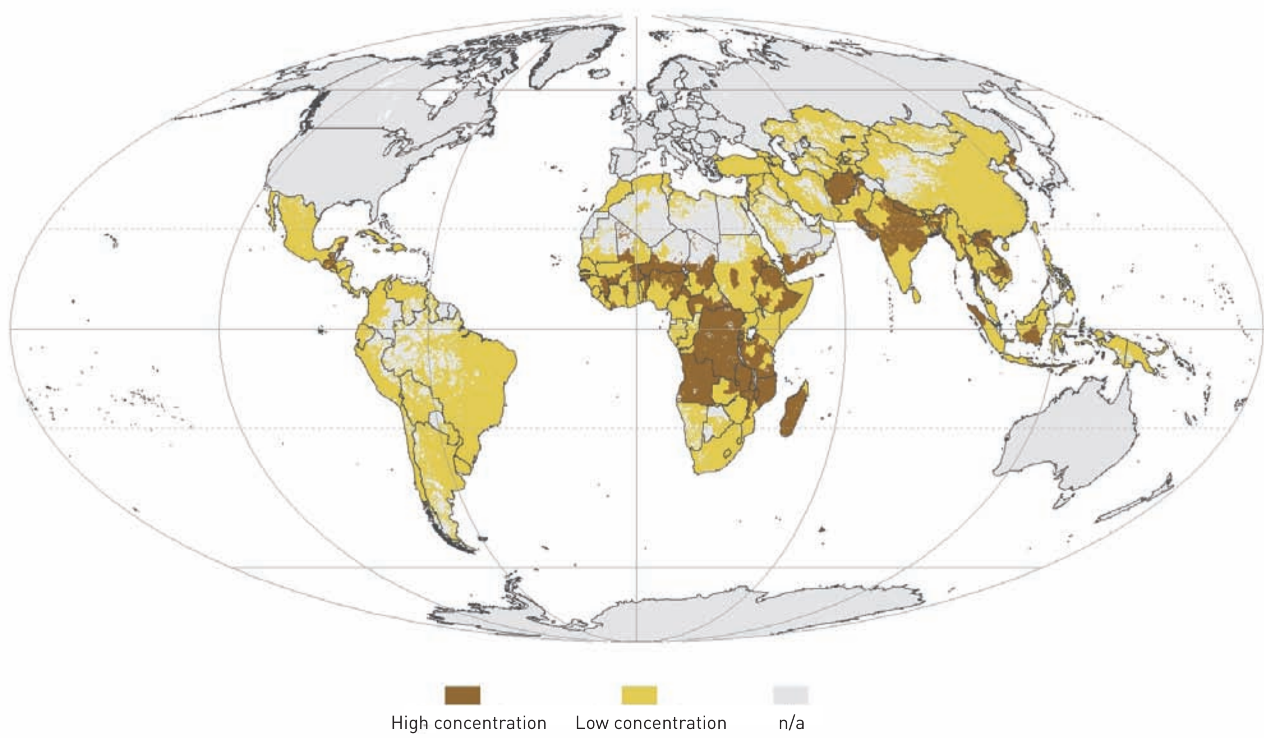


TABLE 1: SHARE OF POPULATION LIVING IN POOR[2] AREAS BY REGION AND RURAL-URBAN LOCALITIES WITHIN THE STUDY AREA

	Percentage of the population in poor areas	Total population (millions)	Number of gridcells
Rural			
Africa	44.9	438.8	259 134
America	4.3	118.2	176 167
Asia	29.4	1 238.7	327 646
Europe	0.0	35.3	17 146
Oceania	0.0	3.3	4 665
Urban			
Africa	17.7	262.5	6 504
America	0.9	340.9	14 224
Asia	18.0	1 221.8	18 051
Europe	0.0	65.6	2 588
Oceania	0.0	0.53	40

[2] Poor areas are defined as areas in the bottom quintile (20 percent) of poverty globally as derived from prevalence of stunting among children under 5 years of age

MAP 2: WHERE THE RURAL POOR ARE CONCENTRATED



3.2 Where are the poor in relation to land and water resources and farming systems?

Share of land by region and poverty quintile

Figure 1 shows the per capita share of land by region and rural-urban localities. There are substantial variations in per capita share of land across the regions of the world. The per capita share of land in Asia is only 10 km^2 per 1 000 people, in Europe it is 11.4 km^2, in Africa it is 31.3 km^2, 33.3 km^2 in America and 105.2 km^2 in Oceania. Per capita share of land is higher in rural areas than urban areas in all regions of the world. In Africa for example, the per capita share of land in urban areas is 2 km^2 per 1 000 people compared to 48.5 km^2 in rural areas. In America, it is 3.4 km^2 per 1 000 people in urban areas compared to 119 km^2 in rural areas. The trend is similar for Asia, Europe and Oceania.

Figure 2, shows the per capita share of land (km^2/1 000 people) by poverty quintiles and rural-urban localities. There is a clear indication that rich rural areas have higher per capita share of land than poor rural areas. The per capita share of land for the rural rich is estimated at 100.1 km^2 per 1 000 people compared to only 23.8 km^2 for the rural poor. For urban areas, the per capita share of land for the rich is 3.1 km^2 compared to 1.2 km^2 for the poor. This is clear indication that the poor, both in rural and urban areas have less access to land.

FIGURE 1: PER CAPITA SHARE OF LAND BY REGION AND RURAL-URBAN LOCALITIES

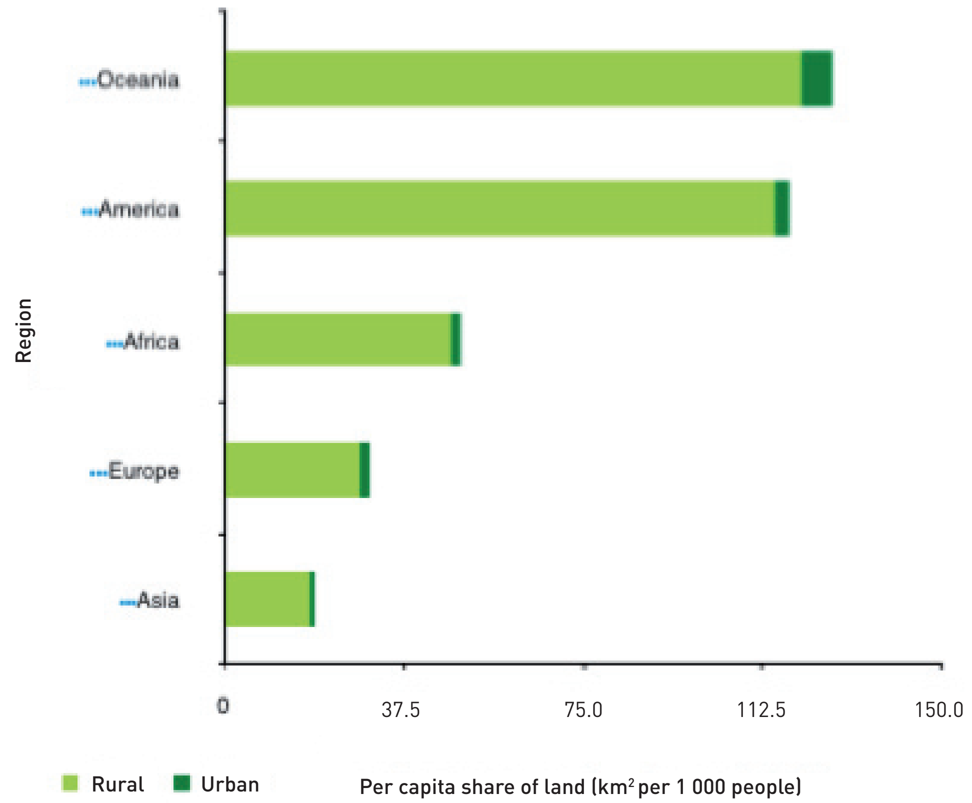
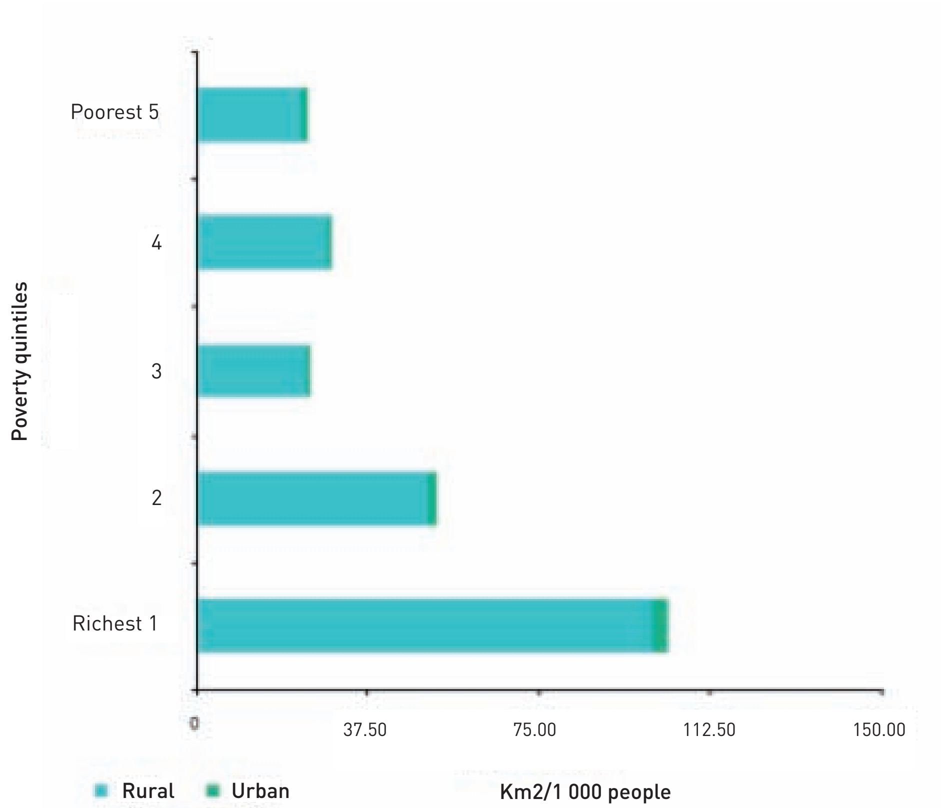


FIGURE 2: PER CAPITA SHARE OF LAND BY POVERTY QUINTILES AND RURAL-URBAN LOCALITIES



Share of agricultural, arable, irrigated and barren land by region and poverty quintile

Asia has the lowest per capita share of agricultural land (5.2 km² per 1 000 people). In Africa, the per capita share of agricultural land is 18.6 km² per 1 000 people. In America it is 17.7 km², per 1 000 people, 8.3 km² per 1 000 people in Europe and 33.5 km² per 1 000 people in Oceania. With regards arable land, Asia has 2.2 km² of arable land per 1 000 people, 2 km² per 1 000 people in Oceania, 3.5 km² per 1 000 people in Africa, 4.3 km² per 1 000 people in America and 5.4 km² per 1 000 people in Europe.

Considering irrigated land, per capita share of irrigated land is generally low across all regions of the world. Asia has the highest per capita share of irrigated land, 0.73 km² per 1 000 people, followed by Europe, 0.60 km² per 1 000 people, America, 0.35 km² per 1 000 people and Africa 0.17 km² per 1 000 people. Africa has the highest estimated per capita share of barren and sparse land, 4.9 km² per 1 000 people; in Asia it is estimated at 2.6 km² per 1 000 people, 2.4 km² per 1 000 people in America and 0.9 km² and 0.1 km² per 1 000 people in Oceania and Europe, respectively.

Figure 3 shows the per capita share of agricultural, arable, irrigated and barren land by region. In Asia, per capita share of agricultural and arable land in rural areas is 8.9 km² and 3.8 km² per 1 000 people, respectively compared to 0.7 km² and 0.4 km² per 1 000 people in urban areas. Figure 4 shows per capita share of agricultural, arable, irrigated and barren land by poverty quintiles and rural-urban localities. The pattern is similar across all regions in the study area.

It is found that generally richer areas have higher per capita share of agricultural and arable land than poor areas. This is particularly the case for rural areas. For example, the per capita share of agricultural land is 57.3 km² per 1 000 people in rich rural areas compared to only 13.2 km² per 1 000 people in poor rural areas. The trend is similar for urban areas, but less pronounced.

FIGURE 3: PER CAPITAL SHARE OF AGRICULTURAL, ARABLE, IRRIGATED AND BARREN LAND BY REGION

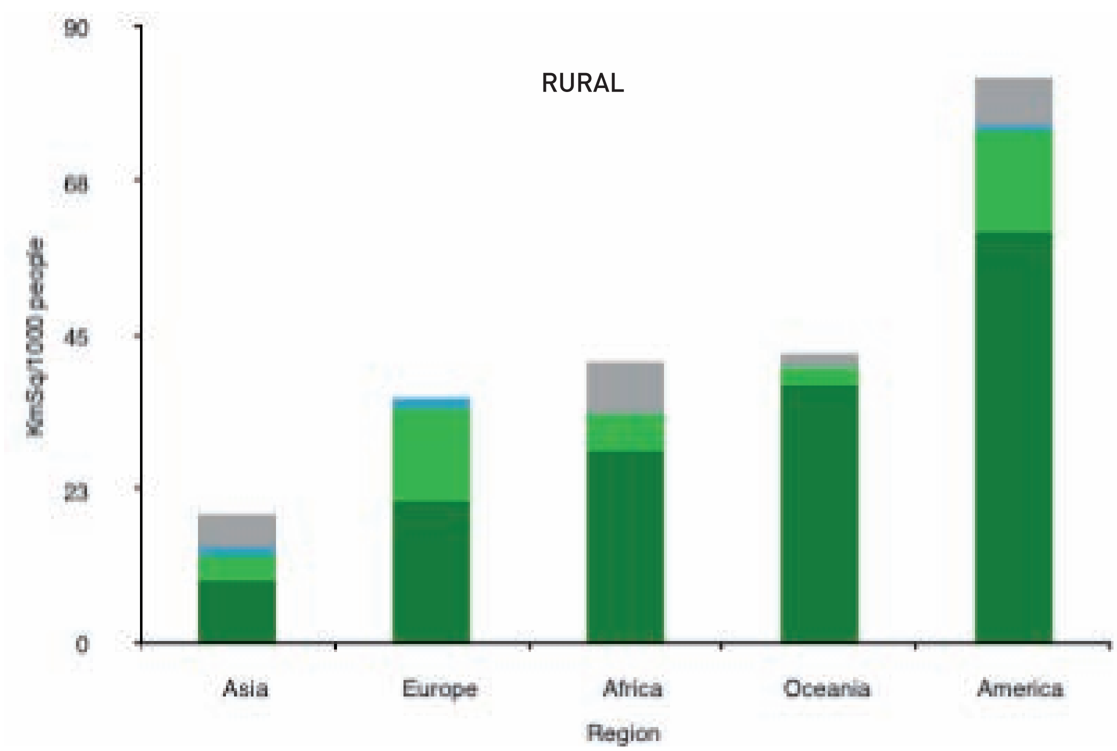


FIGURE 3: PER CAPITAL SHARE OF AGRICULTURAL, ARABLE, IRRIGATED AND BARREN LAND BY REGION

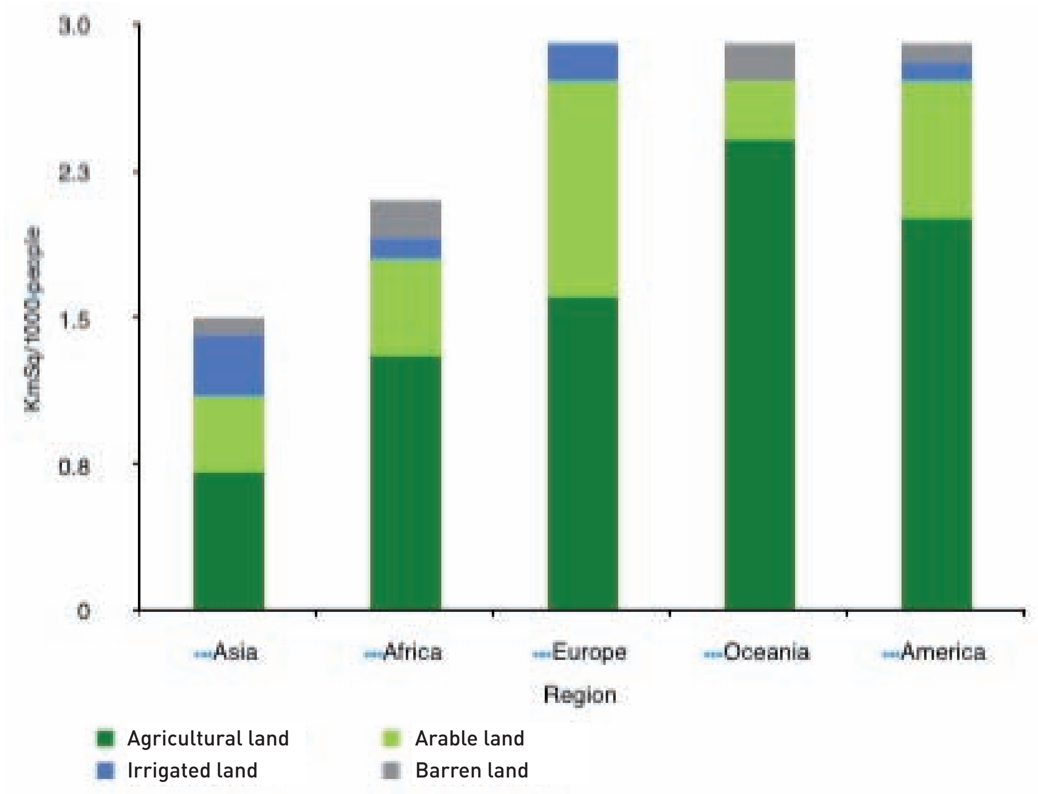


FIGURE 4: PER CAPITA SHARE OF AGRICULTURAL, ARABLE, IRRIGATED AND BARREN LAND BY POVERTY QUINTILES AND RURAL-URBAN LOCALITIES

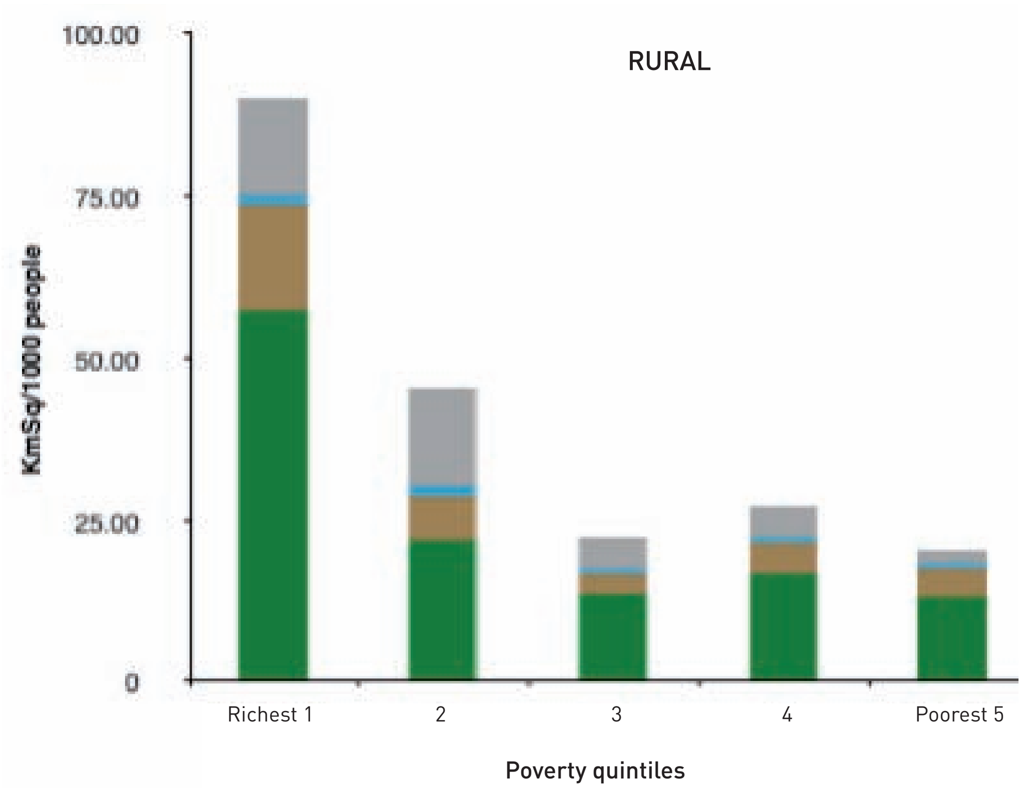
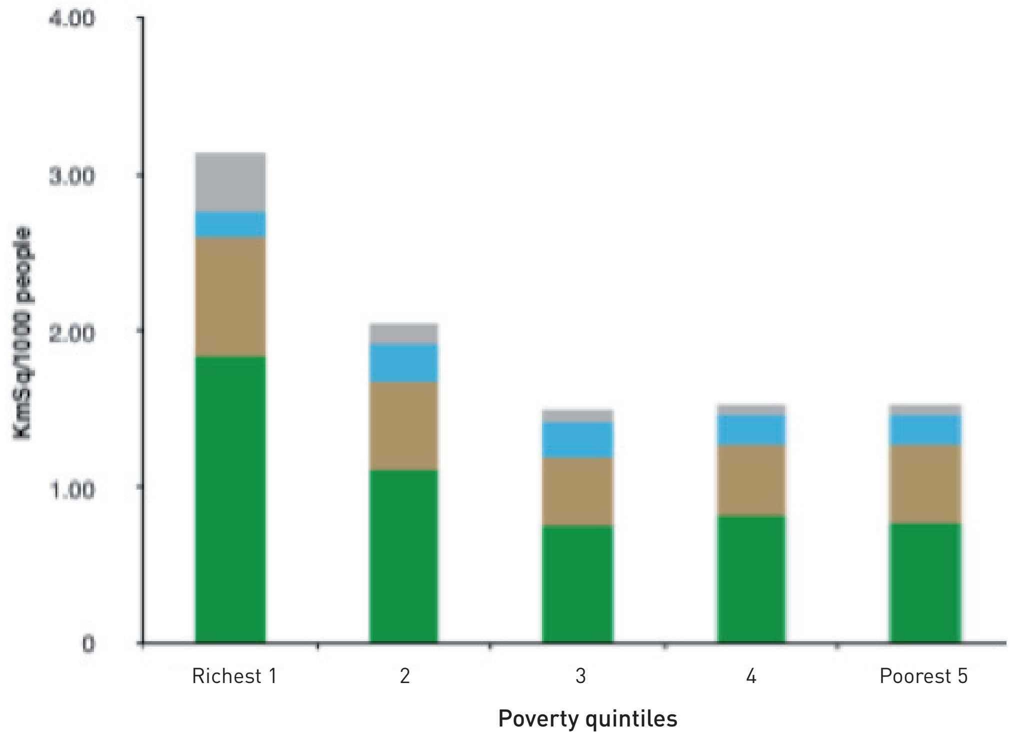


FIGURE 4: PER CAPITA SHARE OF AGRICULTURAL, ARABLE, IRRIGATED AND BARREN LAND BY POVERTY QUINTILES AND RURAL-URBAN LOCALITIES



Share of easily available water by region and poverty quintile

People are highly dependent on water for domestic use, irrigation, industrial, hydroelectric, fishing and recreation among others. However, with 70 percent of global surface and groundwater draws (in some countries it is 90 percent) being used for production of food and other agricultural products, agriculture sector is the biggest single use of water (International Water Management Institute, 2007). The high dependence on water for agricultural production contributes immensely to degradation of the world's freshwater ecosystems (WWF, 2008). Given the world's growing population, increasing demand for food and rapid degradation of freshwater resources, could pose a stern challenge to food production.

Figure 5 shows per capita share of easily available water by region and rural-urban localities. Per capita share of easily available water is lowest in Asia, 5.8 mm/month per 1 000 people. In Europe, America and Africa it is 6.2, 14.8 and 15.2 mm/month per 1 000 people, respectively compared to 37.7 mm/month per 1 000 in Oceania. Substantial rural-urban differentials exist for per capita share of easily available water. In rural areas of Asia, per capita share of easily available water is only 0.46 mm/month per 1 000 people compare to 10.2 in urban areas of Asia.

Figure 6 shows per capita share of easily available water by poverty quintiles. The figure shows that rich areas have higher per capita share of easily available water than poor areas. In rural areas, per capita share of easily available water for the rich is 48.6 mm/month per 1 000 people compared to 11.0 mm/month per 1 000 people for the poor. For urban areas, the per capita share of easily available for the rich is 1.4 mm/month per 1 000 people compared to only 0.5 mm/month per 1 000 people for their poor urban counterparts.

FIGURE 5: PER CAPITA SHARE OF EASILY ACCESSIBLE WATER BY REGION AND RURAL-URBAN LOCALITIES (MM/MONTH PER 1 000 PEOPLE)

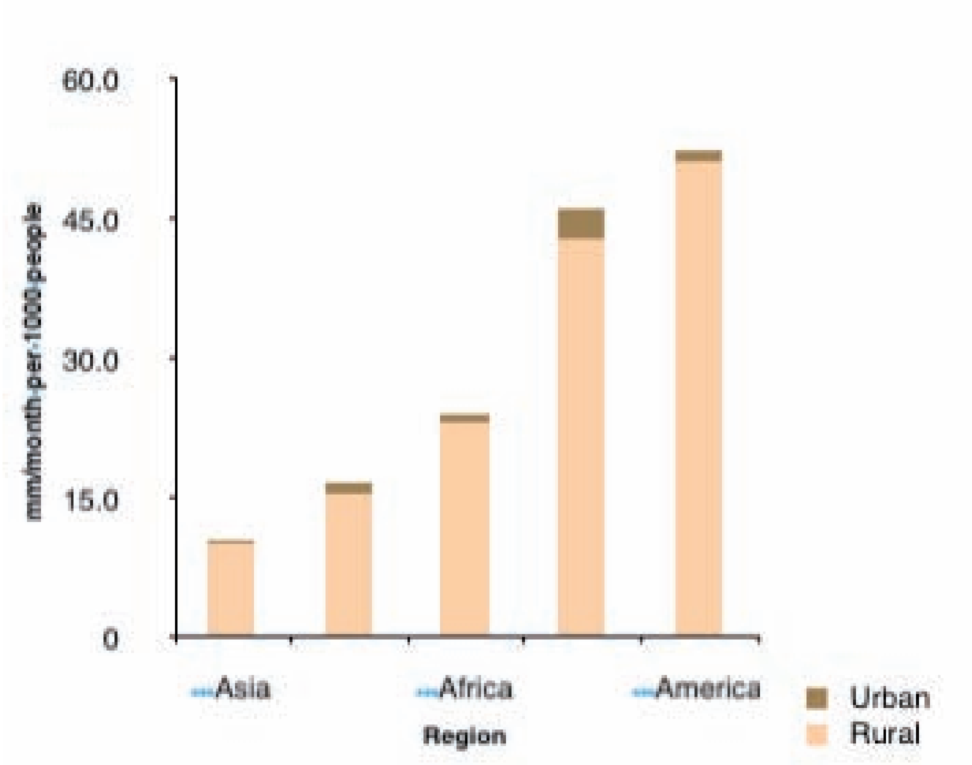
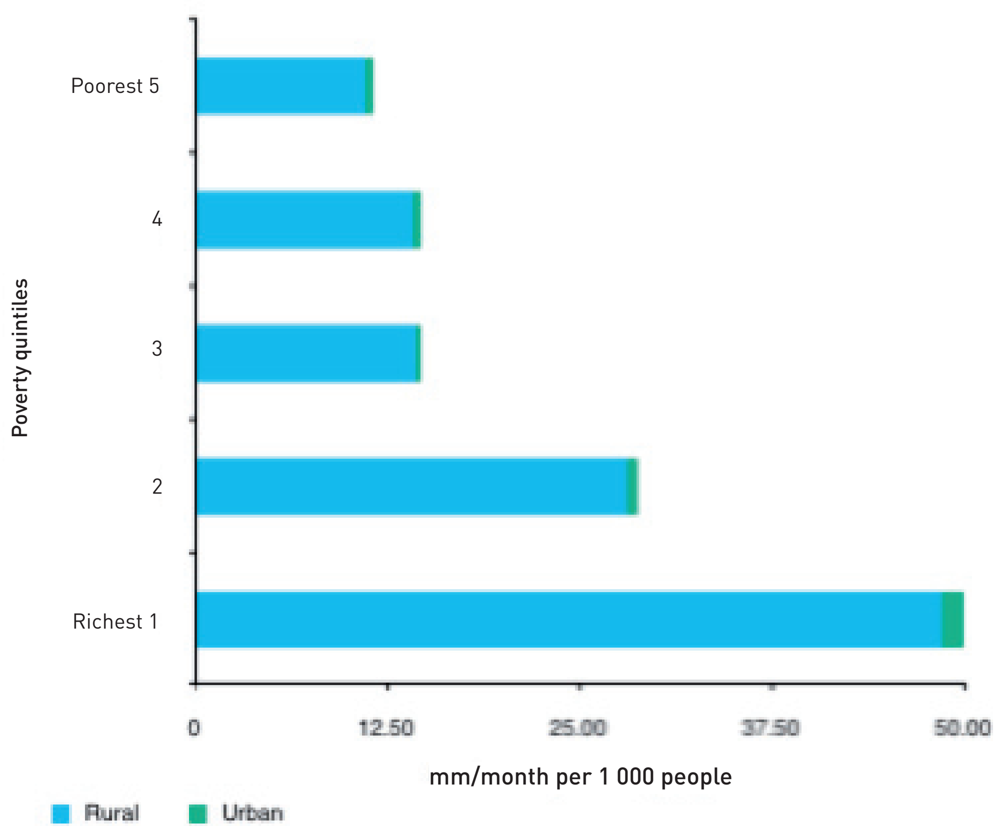


FIGURE 6: PER CAPITA SHARE OF EASILY AVAILABLE WATER BY POVERTY QUINTILES AND RURAL-URBAN LOCALITIES



Farming systems

Farming systems by regions of the world are shown in Figure 7. Farming systems vary substantially by region. In Europe, almost all farms are dualistic. In Africa, they are mainly smallholder rainfed humid and smallholder rainfed dry or cold farms. In Asia, farming systems are mainly smallholder rainfed dry/cold. Wetland rice-based farms in Asia comprise only 13 percent. Farming systems in Oceania are dominated by smallholder rainfed humid and smallholder dry or cold. Smallholder irrigated farms and coastal artisanal fishing are limited in most parts of the world.

Figure 8 shows farming systems by rural-urban localities. Farming systems in both rural and urban localities are mainly dominated by dualistic farms, smallholder rainfed humid and smallholder rainfed humid farms. Smallholder irrigated farms and coastal artisanal fishing are limited in both rural and urban areas.

Figure 9 shows farming systems by poverty quintiles. It clearly shows that rich areas are predominantly engaged in dualistic farming. About half of all farms in rich areas are dualistic farms, compared to only 3 percent in the poorest areas. Poor areas are mainly engaged in smallholder rainfed humid farming (46.8 percent of areas) and smallholder rainfed dry/cold farming (28.7 percent of areas).

FIGURE 7: FARMING SYSTEMS BY REGION

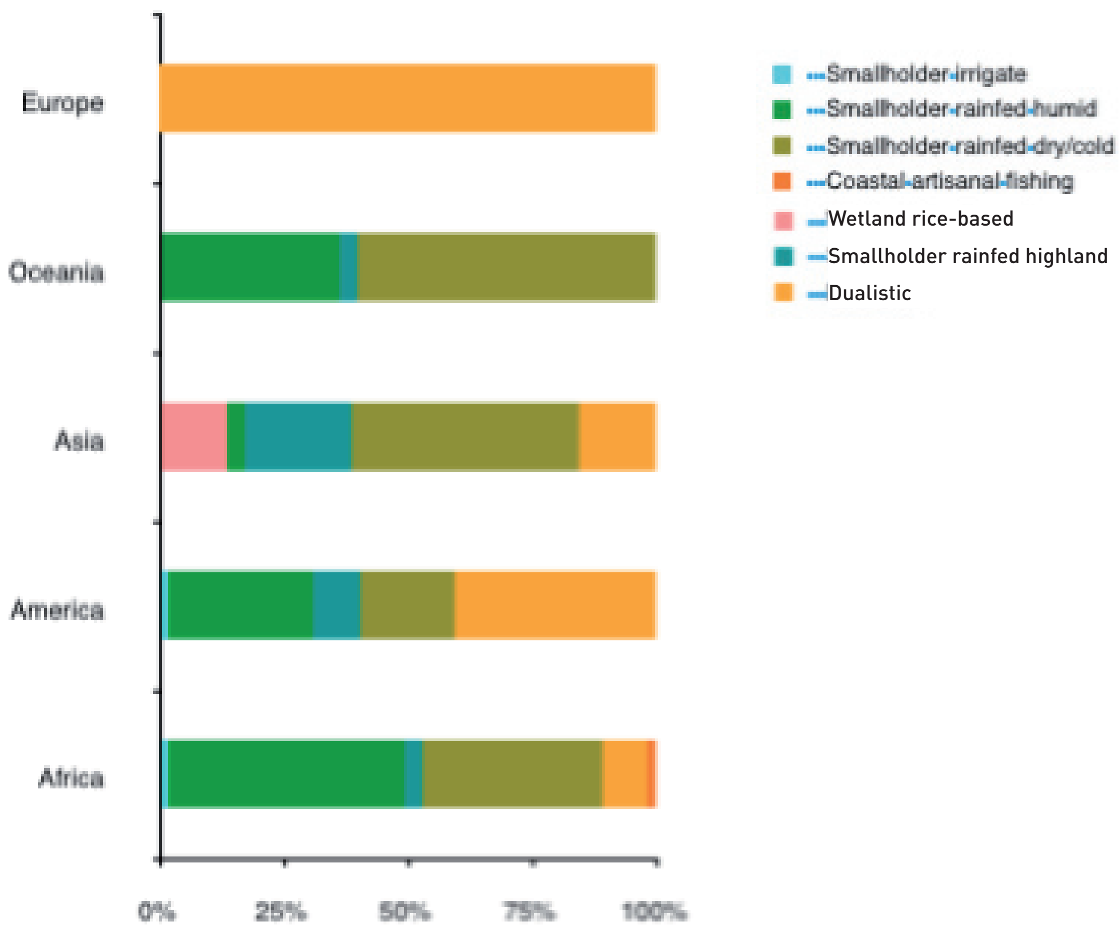


FIGURE 8: FARMING SYSTEMS BY RURAL AND URBAN LOCALITIES

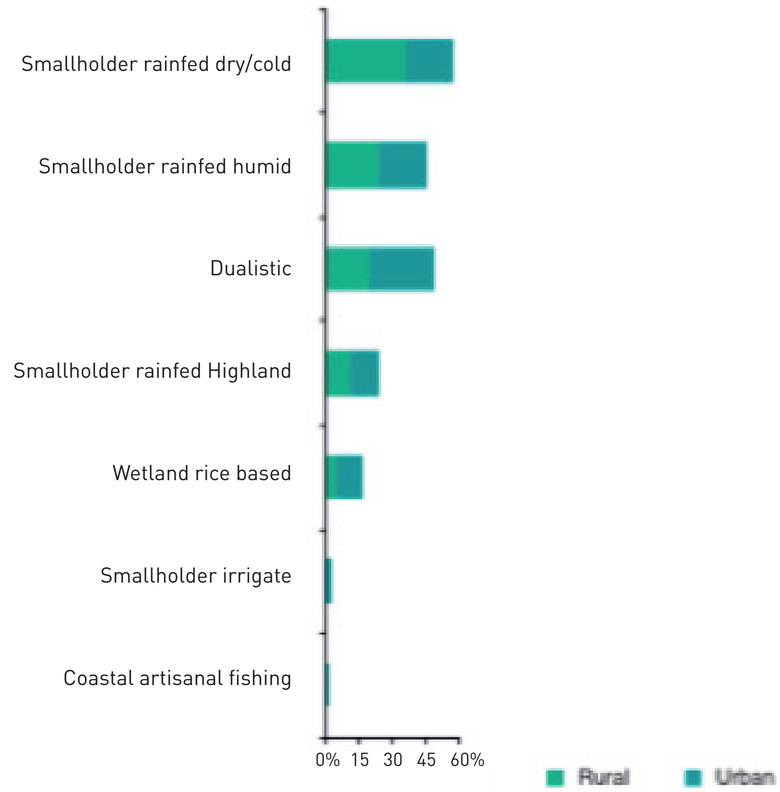
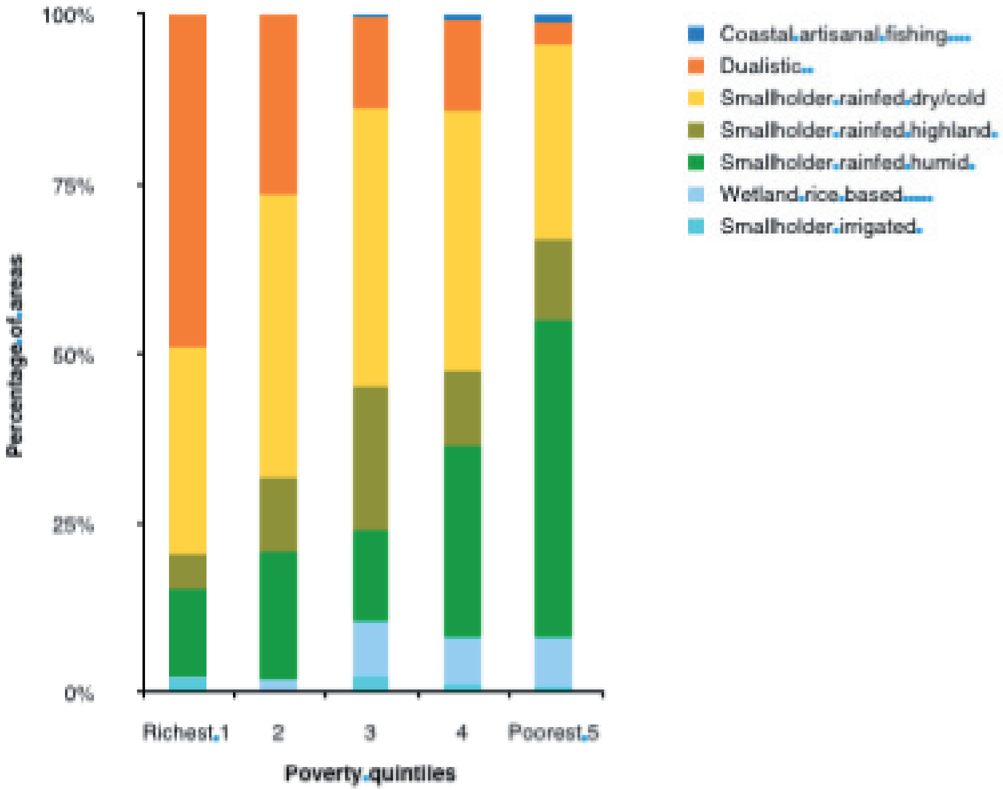


FIGURE 9: FARMING SYSTEMS BY POVERTY QUINTILES



3.3 To what extent do access to land and water resources and current farming systems constrain livelihoods of the poor?

Where the effect of land suitability and farming systems is not accounted for (Model 1), the results show that areas with limited per capita share of land (including agriculture and arable land) and water resources are more likely to be poor when compared with areas with high per capita share of land and water resources. In Model 2 where the effect of land suitability is controlled for, the effects do not change much. However, if we account for the effect of farming systems (Model 3), the pattern of the estimated effect of per capita share of agriculture, arable land and land suitability changes substantially.

The estimated effect of per capita share of agricultural land and land suitability becomes less important (compared to Models 1 and 2) and the direction of the estimated effect of per capita share of arable land changes, with areas having limited per capita share of arable land being less likely to be poor when compared with areas with high per capita share of arable land. This clearly reveals that farming systems modify the relationship between land resources and poverty. It is important to note that the effect of irrigated land and easily available water remained significant even when the effect of farming systems was introduced. These findings indicate that although land resources are important, constraints to livelihood due to limited land resources could be managed more appropriately with more suitable farming systems and possibly irrigation.

Figure 10 shows the estimated odds ratio of being poor before and after accounting for the effect of farming systems. It shows that the odds of being poor for all categories of per capita share of agricultural land is not very different from one when the effect of farming systems is accounted for in the model. Also, it is found that when the effect of farming systems is accounted for, the odds of being poor reduces substantially for all categories of per capita share of arable land.

Table 2 shows the estimated odds ratios and their corresponding 95 percent confidence intervals of the covariates from the logistic regression models showing the association between per capita share of land, water resources, farming systems and poverty. After accounting for the effect of per capita share of land and water resources, land suitability and farming systems, the regional effect was not significant at the 5 percent level, indicating that there is no independent effect of region on poverty as measured by prevalence of stunting among children under five years of age. Nonetheless, there is an independent effect of rural-urban location, with rural areas of the world being about two and half times more likely to be poor compared to urban areas (*Model 3*).

From Model 3, the estimated odds ratio shows that areas with less than 50 km^2 of land per 1 000 people are more than three times more likely to be poor compared with areas with 2 000 km^2 or more of land per 1 000 people. Also, areas with low irrigated land per capita are more likely to be poor. Areas with less than 1 km^2 of irrigated land per 1 000 people are more than twice as likely to be poor compared to areas with 100 km^2 or more of irrigated land per 1 000 people. The estimated odds shown in Table 2 reveal that areas with extensive barren land are more likely to be poor. Per capita share of easily available water is also significantly associated with poverty, with increasing per capita share of easily available water showing decreasing odds of being poor (Table 2). Considering farming systems, the estimated odds ratios show that areas involved in dualistic farming are more than six time less likely to be poor compared to areas involved in smallholder irrigated farming. Areas involved in coastal artisanal fishing are four and half times more likely to be poor compared to areas involved in smallholder irrigated farming.

FIGURE 10: ESTIMATED ODDS RATIO OF BEING POOR IN RELATION TO PER CAPITA SHARE OF AGRICULTURAL AND ARABLE LAND

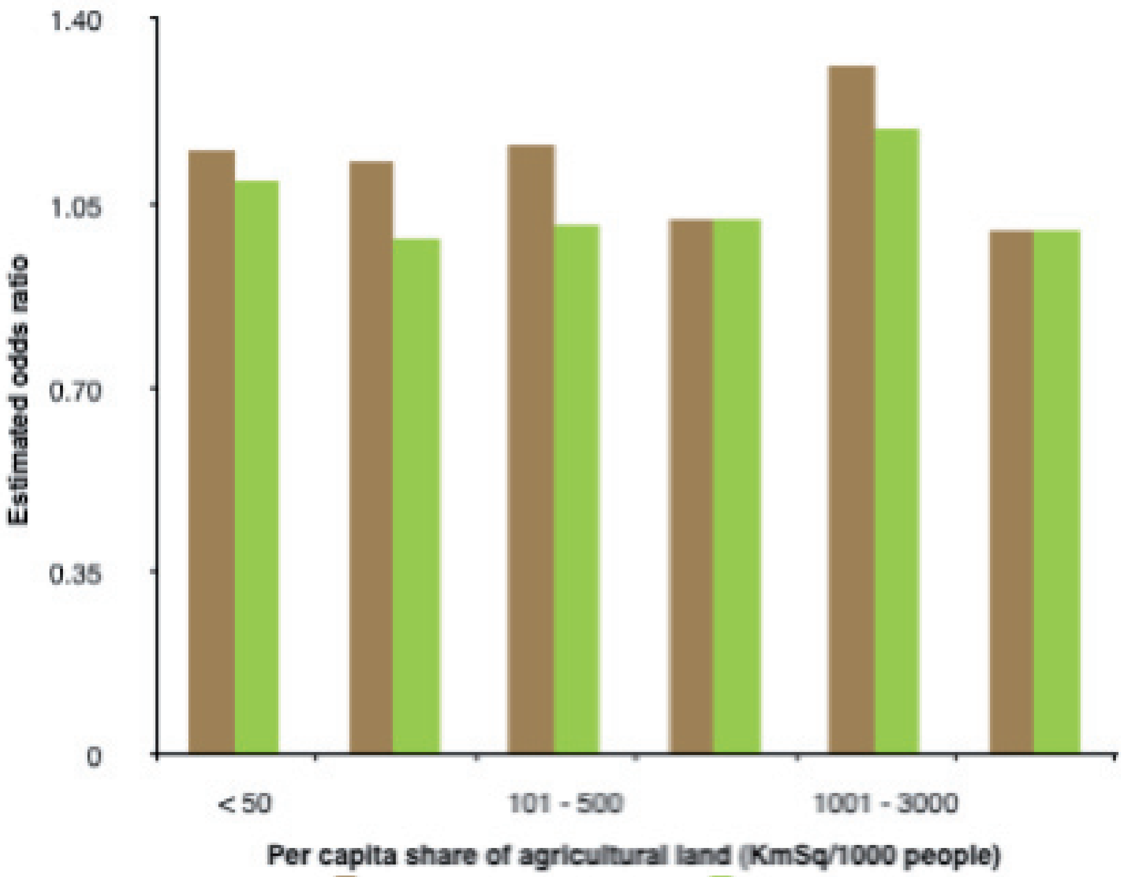


TABLE 2: ESTIMATED COEFFICIENTS FROM A LOGISTIC REGRESSION MODEL SHOWING THE EFFECT OF PER CAPITA SHARE OF LAND AND WATER RESOURCES, LAND SUITABILITY AND FARMING SYSTEMS ON POVERTY

	Model 1			Model 2			Model 3		
	Odds	95% CI for odds		Odds	95% CI for odds		Odds	95% CI for odds	
		Lower	Upper		Lower	Upper		Lower	Upper
Land (km²/1000 people)									
< 50	3.31**	3.11	3.52	2.55**	2.39	2.71	3.08**	2.88	3.29
50 - 100	2.95**	2.78	3.12	2.43**	2.29	2.58	2.92**	2.75	3.10
101 - 500	2.68**	2.55	2.83	2.42**	2.30	2.55	2.81**	2.66	2.96
501 - 1 000	1.93**	1.84	2.03	1.86**	1.78	1.96	2.14**	2.04	2.25
1 001 - 2 000	1.39**	1.33	1.44	1.38**	1.32	1.43	1.48**	1.42	1.54
> 2 000	1.00			1.00			1.00		
Agricultural land (Km²/1000 people)									
< 50	1.15**	1.09	1.21	1.26**	1.19	1.33	1.09*	1.03	1.15
50 - 100	1.13**	1.07	1.19	1.15**	1.09	1.22	0.98	0.92	1.03
101 - 500	1.16**	1.10	1.23	1.13**	1.07	1.19	1.01	0.96	1.07
501 - 1 000	1.02	0.95	1.08	0.98	0.92	1.04	1.02	0.96	1.09
1 001 - 3 000	1.31**	1.23	1.39	1.29**	1.22	1.37	1.19*	1.10	1.41

	Model 1			Model 2			Model 3		
	Odds	95% CI for odds		Odds	95% CI for odds		Odds	95% CI for odds	
		Lower	Upper		Lower	Upper		Lower	Upper
> 3 000	1.00			1.00			1.00		
Arable land (km²/1 000 people)									
< 5	2.42**	2.21	2.65	2.53**	2.31	2.78	0.91*	0.83	1.00
5 - 10	1.94**	1.77	2.13	1.98**	1.80	2.17	0.82**	0.74	0.90
11 - 20	1.32**	1.20	1.45	1.35**	1.23	1.48	0.63**	0.57	0.70
21 - 50	1.12*	1.02	1.24	1.15**	1.04	1.26	0.61**	0.55	0.67
51 - 500	0.96	0.88	1.06	0.97	0.88	1.07	0.68**	0.62	0.75
> 500	1.00			1.00			1.00		
Irrigated land (km2/1 000 people)									
< 1	2.32**	1.94	2.78	2.24**	1.87	2.69	2.24**	1.87	2.69
1 - 10	2.75**	2.30	3.29	2.67**	2.23	3.20	2.63**	2.20	3.16
11 - 20	1.85**	1.53	2.24	1.84**	1.52	2.23	2.07**	1.71	2.52
21 - 50	1.67**	1.37	2.04	1.67**	1.37	2.04	1.90**	1.55	2.33
51 - 100	1.22	0.95	1.56	1.23	0.96	1.58	1.39**	1.09	1.79
> 100	1.00			1.00			1.00		
Barren land (km2/1 000 people)									
< 5	0.79**	0.77	0.81	1.08**	1.05	1.11	1.05**	1.02	1.09
5 - 10	0.63**	0.60	0.66	0.76**	0.73	0.80	0.75**	0.71	0.79
11 - 20	0.70**	0.66	0.73	0.83**	0.79	0.87	0.84**	0.80	0.88
21 - 50	0.76**	0.73	0.79	0.87**	0.84	0.91	0.89**	0.86	0.93
51 - 100	0.77**	0.74	0.80	0.85**	0.81	0.88	0.84**	0.81	0.88
> 100	1.00			1.00			1.00		
Easily accesible water (mm/month per 1 000 people)									
< 10	1.96**	1.85	2.08	2.11**	1.99	2.25	1.94**	1.83	2.07
10 - 20	1.22**	1.15	1.29	1.30**	1.22	1.38	1.28**	1.20	1.36
21 - 50	1.32**	1.25	1.39	1.38**	1.30	1.45	1.33**	1.26	1.40
51 - 100	1.38**	1.31	1.45	1.41**	1.34	1.48	1.34**	1.28	1.41
101 - 500	1.05*	1.00	1.09	1.09**	1.05	1.14	1.06**	1.02	1.11
> 500	1.00			1.00			1.00		
Land suitability									
Not suitable				1.05*	1.01	1.09	0.71**	0.68	0.74
Very low				1.59**	1.51	1.68	0.97	0.91	1.02
Low				1.81**	1.74	1.88	1.03	0.99	1.07
Medium low				1.55**	1.49	1.61	0.98	0.94	1.02
Medium				1.16**	1.12	1.21	0.84**	0.81	0.88
Medium high				1.57**	1.52	1.63	1.04	1.00	1.08
High				1.41**	1.36	1.46	1.01	0.97	1.05
Very high				1.00			1.00		

**p<0.01; *p<0.05

TABLE 2: ESTIMATED COEFFICIENTS FROM A LOGISTIC REGRESSION MODEL SHOWING THE EFFECT OF PER CAPITA SHARE OF LAND AND WATER RESOURCES, LAND SUITABILITY AND FARMING SYSTEMS ON POVERTY

	Model 1			Model 2			Model 3		
	Odds	95% CI for odds		Odds	95% CI for odds		Odds	95% CI for odds	
		Lower	Upper		Lower	Upper		Lower	Upper
Farming system classes									
Smallholder irrigated							1.00		
Wetland rice-based							2.72**	2.54	2.91
Smallholder rainfed humid							2.45**	2.29	2.62
Smallholder rainfed highland							2.41**	2.26	2.58
Smallholder rainfed dry/cold							3.03**	2.83	3.23
Dualistic							0.16**	0.15	0.17
Coastal artisanal fishing							4.58**	4.20	5.00
Rural-urban location									
Rural	3.52**	3.41	3.63	3.09**	2.99	3.19	2.51**	2.43	2.59
Urban	1.00			1.00			1.00		

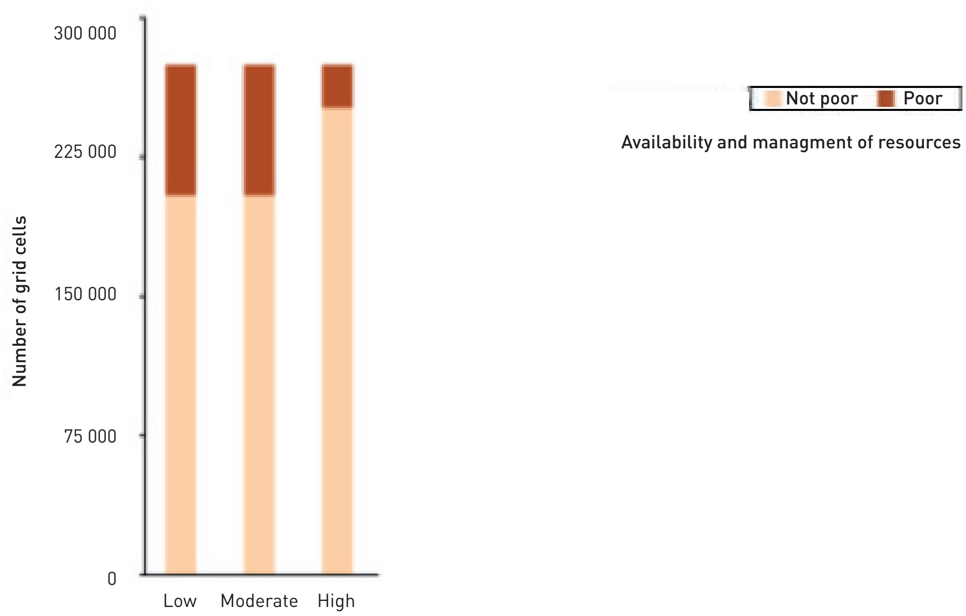
**p<0.01; *p<0.05

3.4 Can changes in resource management modify poverty outcomes in resource-constrained areas?

The results of the Principal Components Analysis are shown in Figure 11.

The resource management index (Figure 11) provides a clear indication of the existence of a relationship between the poor and low-to-moderate access to land and water resources.

FIGURE 11: RESOURCE MANAGEMENT INDEX IN POOR AND NON-POOR GRID CELLS OF STUDY AREA



When the index is applied to the gridded database, results show that this relationship is particularly prevalent in the sub-Saharan and in parts of the South Asian regions. The counter to this is where we have the least poor with access to high to moderate resources in central Asia and Russia, regions of South America and parts of West and South Africa.

The regions that show 'not poor' and low access to resources may indicate areas with interventions that reduce direct or localized reliance on resources such as urban areas or areas where food security is not reliant upon local production such as the San Paulo/Rio region of Brazil, southern India and eastern China.

The results show some anomalies that might require explanation based upon further examination of the nature and quality of the data or upon specific country profiles. This analysis of poverty might be reflective of limitations in accessing data in some regions.

4. Limitations of the study

Data for some of the indicators considered essential for this type of analysis (e.g. rate of land degradation) were unavailable at the required geographical level. The study itself is global in scope. However, the analysis covers only that part of global land area for which stunting data were available.

Projections of potential future land and water degradation are vital for enacting policies and strategies to ensure sustainable agricultural development, sustaining the environment and its natural resources and alleviating poverty. Data for such analysis is not available.

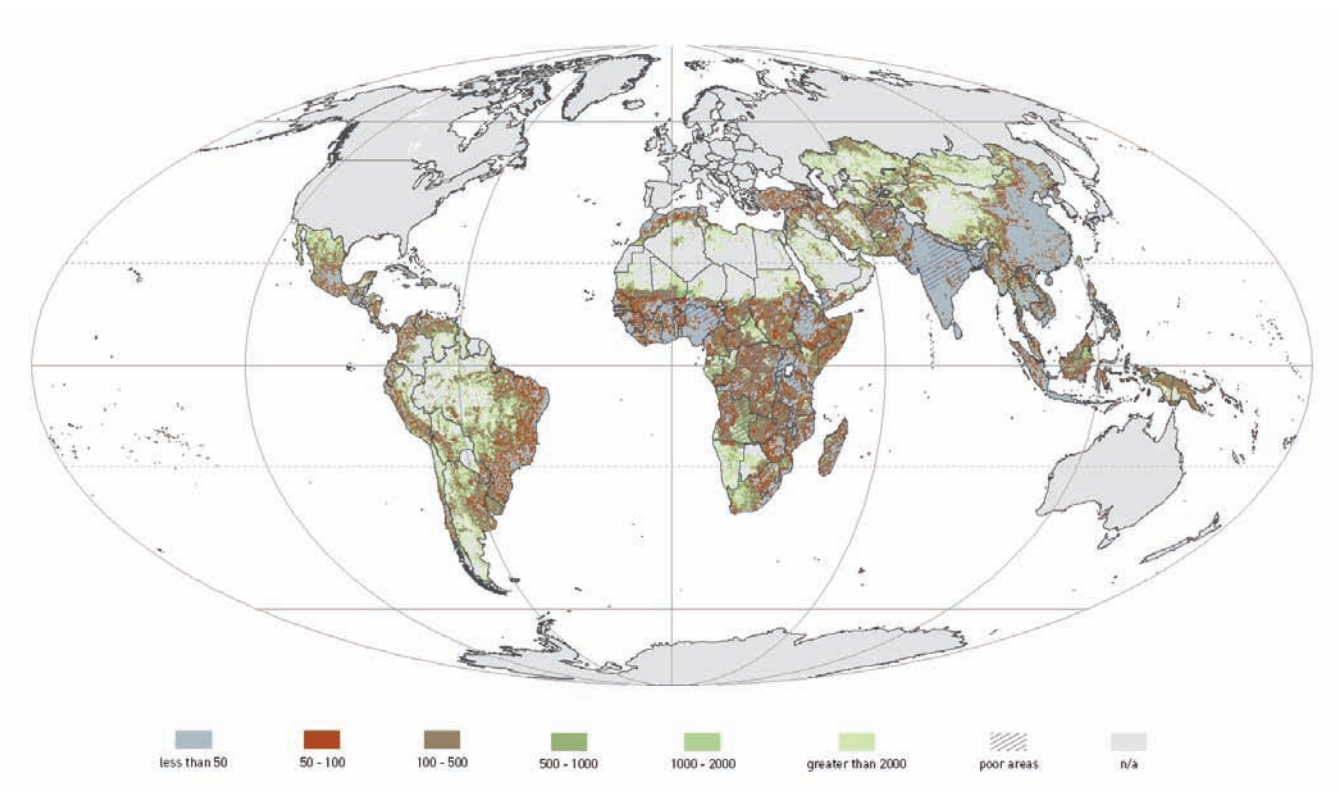
Consistent definition of indicators is another limitation worth noting. For example, the definition of poverty and the indicator used to assess poverty levels (prevalence of stunting among children below five years of age) reflects FAO's concept of poverty, which relates poverty to chronic under nutrition. This indicator is internationally accepted as a proxy for measuring poverty; however, it can bias occurrence of poverty towards some regions.

In this regard, it is recognized that there is a need to establish a strategic framework and standards that are accepted worldwide and can be used to consistently assess the relationships between land-water scarcity and poverty. Also, other factors such as trade regulations, access to markets, import-exports, exposure to hazards and diseases and political commitments and policies that could constrain earnings from agriculture and could therefore modify the effects of land and water resources and farming systems on well-being, were not available at the time of the study.

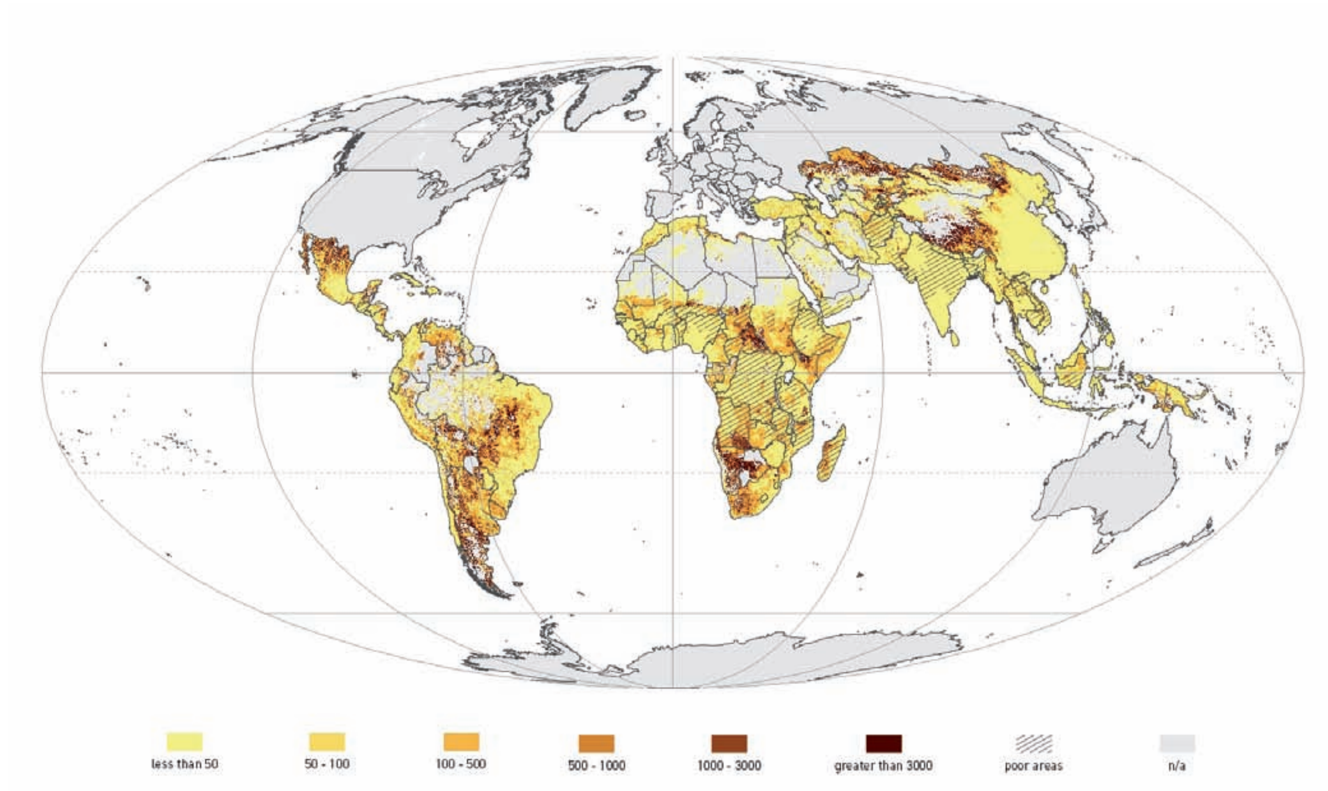
5. Maps

All maps included in this report display data only for poor areas that fall within the study area, as defined in Section 2. Poor areas are defined as areas in the bottom quintile (20 percent) of poverty globally as derived from prevalence of stunting among children below five years of age.

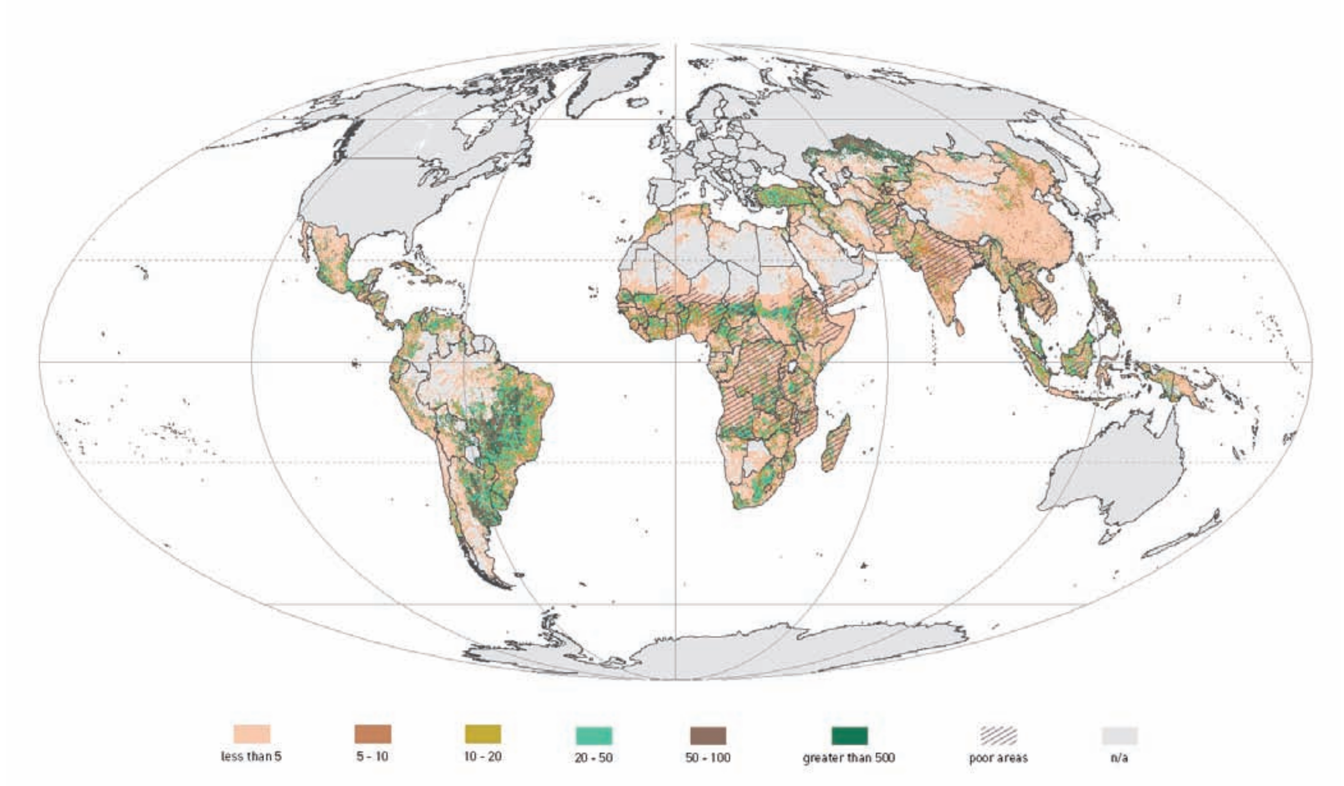
MAP 3: PER CAPITA SHARE OF LAND IN POOR AREAS



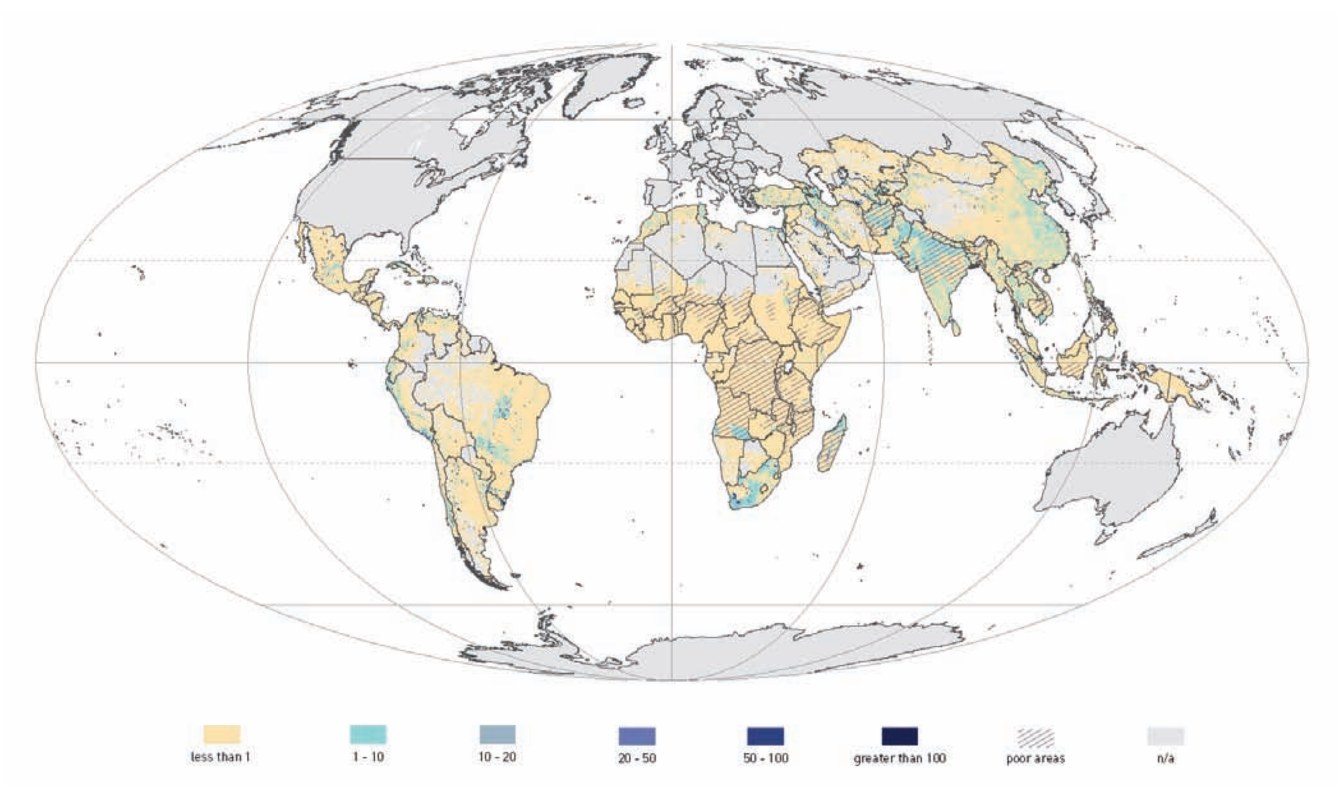
MAP 4: PER CAPITA SHARE OF AGRICULTURAL LAND IN POOR AREAS



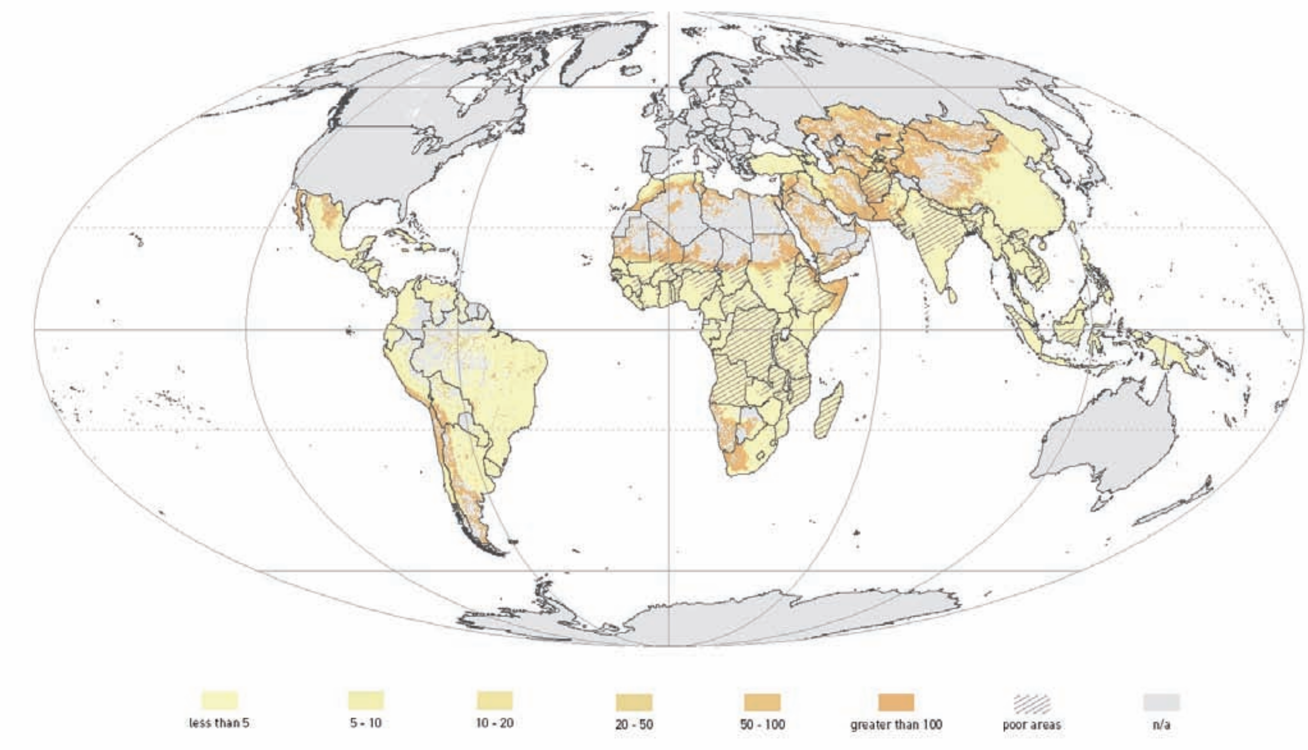
MAP 5: PER CAPITA SHARE OF ARABLE LAND IN POOR AREAS



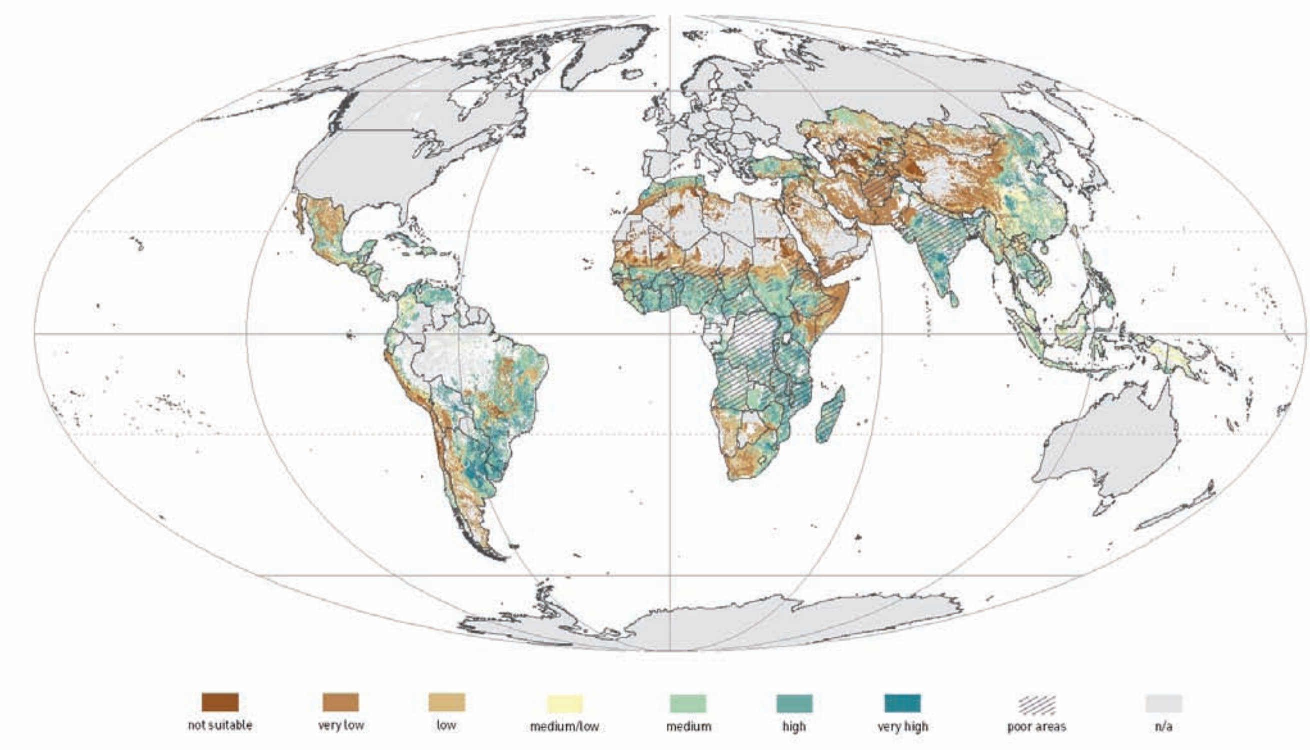
MAP 6: PER CAPITA SHARE OF IRRIGATED LAND IN POOR AREAS



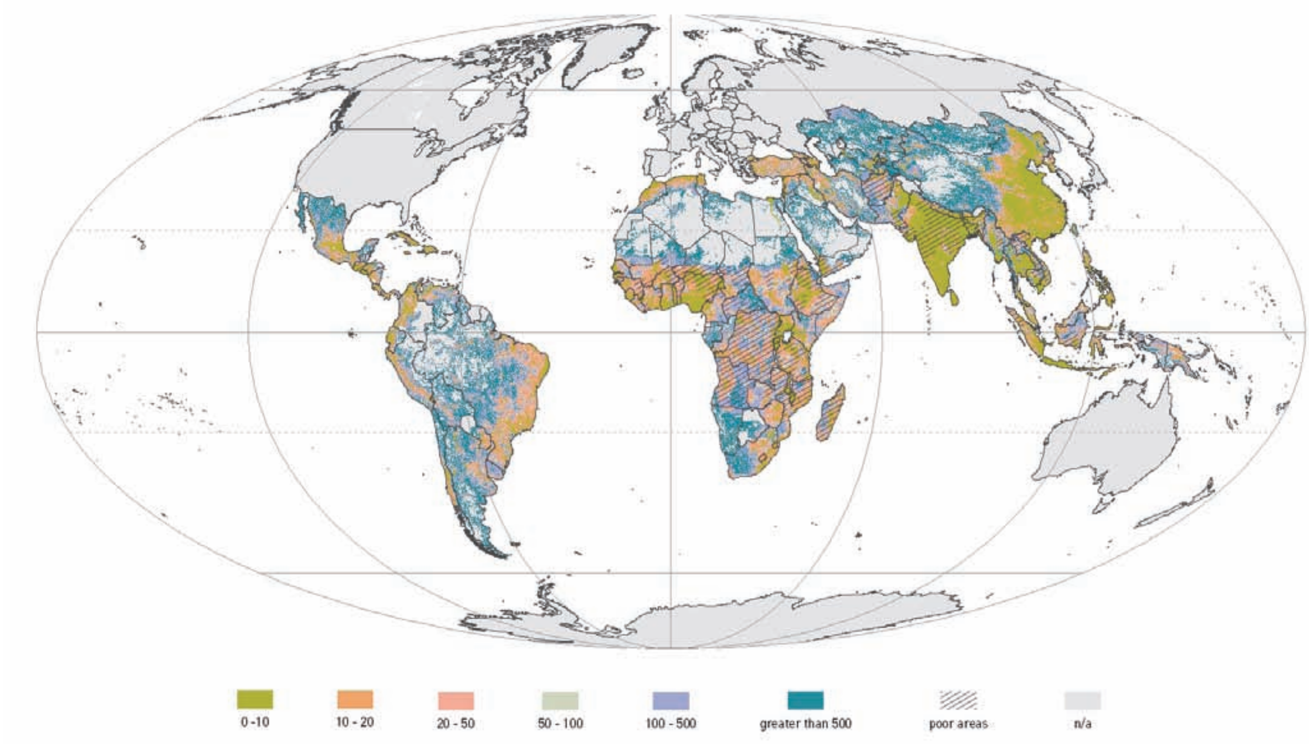
MAP 7: PER CAPITA SHARE OF BARREN AND SPARSE LAND IN POOR AREAS



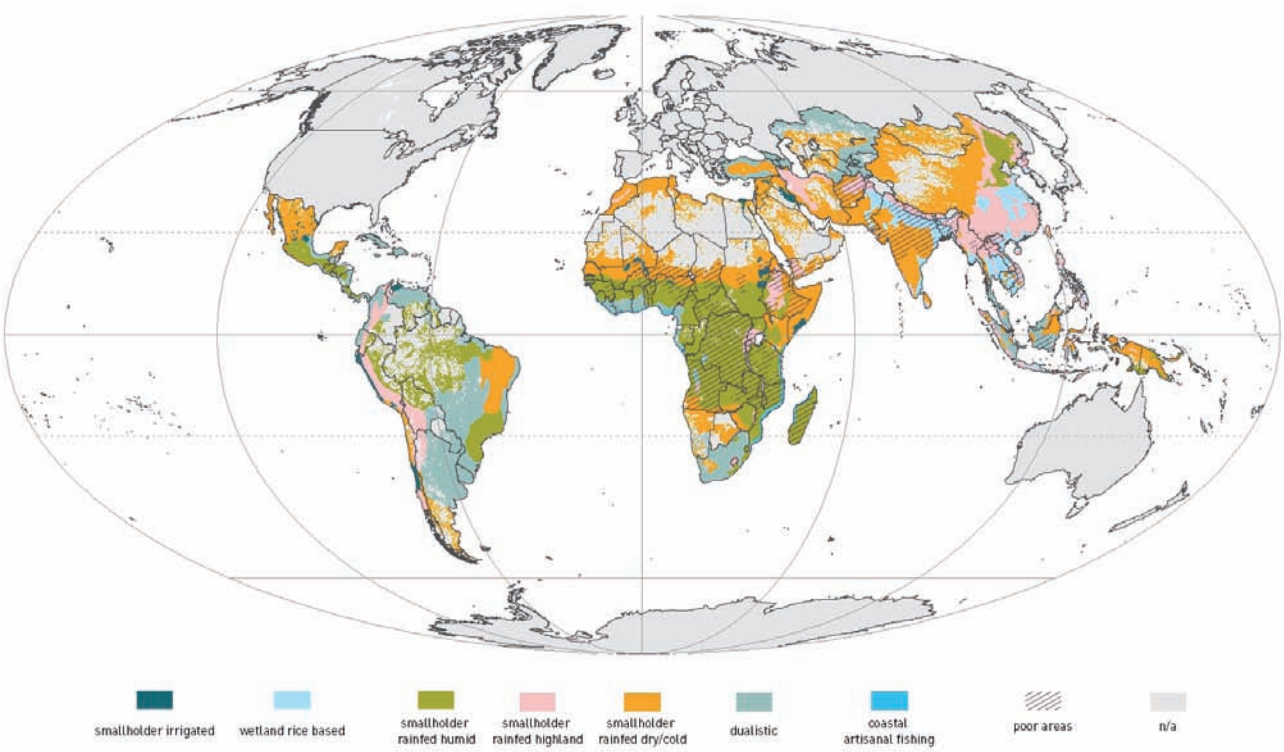
MAP 8: SUITABILITY OF LAND FOR AGRICULTURAL PRODUCTION IN POOR AREAS



MAP 9: PER CAPITA SHARE OF EASILY AVAILABLE WATER IN POOR AREAS



MAP 10: FARMING SYSTEMS IN POOR AREAS



6. REFERENCES

Akindola, R.B. 2009. Towards a definition of poverty: poor people's perspectives and implications for poverty reduction. *Journal of Developing Societies* 25(2): 121-150.

Carter, M. & May, J. 1999. Poverty, livelihood and class in rural South Africa. *World Development, Volume 27, Issue 1,* January 1999, pp 1-20.

Chen, S. & Ravallion, M. 2004. How have the world's poorest fared since the early 1980s? *The World bank Research Observer* 19(2): 141-169.

CIESIN. 2006. Centre for International Earth Science Information Network, I. Palisades, NY, Columbia University. (Available at: http://www.ciesin.columbia.edu/povmap/). Accessed 11.01.10.

Coudouel, A., Hentschel, J. & Wodon, Q. 2002. Poverty measurement and analysis. In Jeni Klugman (ed) *A sourcebook for poverty reduction strategies, Volume 1: Core techniques and cross-cutting issues*, Washington, DC, World Bank.

Dasgupta, S., Deichmann, U., Meisner, C. & Wheeler, D. 2005. Where is the poverty – environment nexus? Evidence from Cambodia, Lao PDR, and Vietnam. *World Development* 33(4):617-638.

DeNavas-Walt, C., Proctor, B.D., Smith, J.C. & the United States Census Bureau. 2009. Current population reports, pp 60-236. *Income, Poverty, and Health Insurance Coverage in the United States: 2008*. Washington, DC, United States Government Printing Office.

Development 27 (7), 1 –20.

DFID. 2009. *Eliminating world poverty: building our common future.* United Kingdom, Department for International Development. Accessed: 20.01.2010 (Available at http://www.dfid.gov.uk/Documents/whitepaper/building-our-common-future.pdf).

Ehrlich, P.R., Ehrlich, A.H. & Daily, G.G. 1993. Food security, population and environment. *Population and Development Review* 19(1):1-32.

FAO. 1976. *A framework for land evaluation*. Soils Bulletin No.32. Rome.

FAO. 1999. *Food insecurity: when people must live with hunger and fear of starvation*. Rome.

FAO. 2005. *The state of food insecurity in the world 2005: eradicating world hunger –key to achieving the Millennium Development Goals*. Food and Agriculture Organization of the United Nations, Rome.

FAO. 2007. *Food insecurity, poverty and environment*. Global GIS Database, Environment and Natural Resources Working Paper, 26, Rome.

FAO & FIVIMS. 2003. *Poverty mapping, chronic undernutrition among children: an indicator of poverty*. Food

Insecurity and Vulnerability Information and Mapping and the Food and Agriculture Organization of the United Nations. Rome, Italy.

Finan, F., Sadoulet, E. & de Janvry, A. 2005. Measuring the poverty reduction potential of land in rural Mexico. *Journal of Development Economics* 77: pp 27– 51.

Grootaert, C., Kanbur, R. & Oh, G. 1997. The dynamic of welfare gains and losses: an African case study. J*ournal of Development Studies* 33 (5), 635– 657.

Gross, R., Schultink, W. & Sastroamidjojo, S. 1996. Stunting as an indicator for health and wealth: An Indonesian application. *Nutrition Research*, 16(11-12):1829-1837.

Gunning, J., W., Hoddinott, J., Kinsey, B., Owens, T. (2000). Revisiting forever gained: income dynamics in the resettlement areas of Zimbabwe, 1983–96. *Journal of Development Studies* 36 (6), 131– 154

Hagenaars, A & de Vos, K. 1988. The Definition and Measurement of Poverty. *The Journal of Human Resources* 23(2):211-221

Henao, J. & Baanante, C. 2006. Agricultural production and soil nutrient mining in Africa: Implication for resource conservation and policy development. IFDC *Tech. Bull. International Fertilizer Development*

Henninger, N. & Snel, M. 2002. *Where are the Poor? Experiences with the Development and Use of Poverty Maps*. Washinton, DC, Kenya and Arendal, Norway, the World Resources Institute, United Nations Environment Programme and GRID-Arendal.

Herold, M., Latham, J.S., Di Gregorio, A. & Schmullius, C.C. 2006. Evolving standards in land cover characterization. *Journal of Land Use Science*, 1(2-4): 157–168.

IFAD. (2010) Rural Poverty Report. Update of 2001 report. (Available at: http://www.ifad.org/rural/rpr2010/index.htm).

International Water Management Institute. 2007. Water for food, water for life: A comprehensive assessment of water management in agriculture. London and Colombo, Earthscan and the International Water Management Institute.

Muller, D., Epprecht, M. & Sunderlin, W.D. 2006. Where are the poor and where are the trees? Targeting of poverty reduction and forest conservation in Vietnam. Indonesia, Centre for International Forestry Research.

O'Boyle, E.J. 1999. Toward an improved definition of poverty. *Review of Social Economy* 57 (3): 281–301.

Ongley, E.D. 1996. *Control of water pollution from agriculture*. FAO Irrigation and Drainage Paper 55.

Ruttan, V.W. 1993. Population growth, environmental change, and innovation: implications for sustainable growth in agriculture. In :*Population and Land Use in Developing Countries* (eds) Jolly, C.L. & Torrey, B.B. Washington, DC, National Academy Press.

Sachs, J. 2005. *The end of poverty: How we can make it happen in our lifetime*. London, Penguin Books.

Salvatore, M., Pozzi, F., Ataman, E., Huddleston, B. & Bloise, M. 2005. *Mapping global urban and rural population distributions*. Rome, Food and Agriculture Organization of the United Nations.

Scherr, S.J. & Yadav, S. 1996. *Land degradation in the developing world: Implications for food, agriculture, and the environment to 2020*. Food, Agriculture, and the Environment Discussion Paper 14, Washington, DC, International Food Policy Research Institute. (Available at: http://pdf.usaid.gov/pdf_docs/PNABY622.pdf).

Scott, C.D. 2000. Mixed fortunes: a study of poverty mobility among small farm households in Chile, 1968–86. *Journal of Development Studies* 36 (6), 155– 180.

Simondon, K.B. 2010. *Review on stunting: Clarification and use of the indicator for the assessment of poverty*. United Nations System Standing Committee on Nutrition, Task Force on Assessment, Monitoring and Evaluation. (Draft)

United Nations. 2001. *Population, environment and development – The concise report*. Department of Economic and Social Affairs, New York. Accessed: 07.06.2010. (Available at: http://www.un.org/esa/population/publications/concise2001/C2001English.pdf).

UNEP. 2008. *The environmental food crisis: The environment's role in averting future food crises*. Kenya, United Nations Environment Programme.

UNPD. 2009. *World population prospects: The 2008 Revision Population Database*. New York, United Nations Populations Division. (Also available at: http://esa.un.org/unpd/wpp2008/xls_2008/WPP2008_LOCATIONS.XLS).

van Velthuizen, H., Huddleston, B., Fischer, G., Salvatore, M., Ataman, E., Nachtergaele, F.O., Zanetti, M. & Bloise, M. 2007. *Mapping biophysical factors that influence agricultural production and rural vulnerability*. Food and Agriculture Organization of the United Nations and International Institute for Applied Systems Analysis, Rome.

Vosti, S.A. 1995. Links between rural poverty and the environment in developing countries: Asset categories and investment poverty. *World Development* 23(9): 1495-1506.

Wint, W. & Robinson, T. 2007. Gridded livestock of the world. Food and Agriculture Organization of the United Nations, Rome.

World Bank. 1990. *World development report 1990 – poverty*. New York, Oxford University Press.

World Bank. 1992. *World development report*. New York, Oxford University Press.