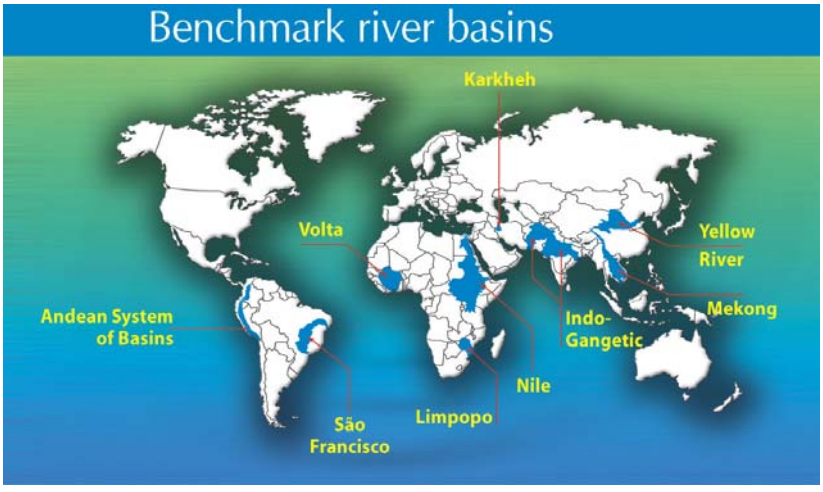
ANALYZING WATER POVERTY:
Water, Agriculture and Poverty in Basins

Basin Focal Project Working Paper No. 3

CGIAR Challenge Program on WATER & FOOD

WORKING WITH PARTNERS TO ENHANCE AGRICULTURAL WATER PRODUCTIVITY SUSTAINABLY IN BENCHMARK RIVER BASINS



DISCLAIMER

This is an advance edition of *Analyzing Water Poverty: Water, Agriculture and Poverty in Basins* and is a **draft version** of a working paper to be published formally by the Challenge Program on Water and Food. This report contains less than fully polished material. Some of the works may not be properly referenced. The purpose is to disseminate the findings quickly so as to invigorate debate.

The findings, interpretations, and conclusions expressed here are those of the author(s) and do not necessarily reflect the views of the Challenge Program.
Comments and additional inputs that could contribute to improving the quality of this work are highly welcomed.

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Analyzing Water Poverty:
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Contents

1 Introduction: Why analyze poverty in basins?

The purpose of analyzing poverty data within basins is to identify:

a) How many people are affected adversely by poor availability or access to water, to what extent, and how this can be modified through improved agricultural water management, and
b) Where low water productivity appears to induce poverty, and to what extent this is modifiable.

The analysable relationship between water, agriculture and poverty can be explained as follows: The total gain that people derive from water used by agriculture is a product of the amount of water they take and the productivity they achieve per volume consumed. In some cases the total gain is limited by water availability, through either problems of availability or distribution. Otherwise the total gain is limited by water productivity, and poverty will be related to other problems such as land degradagtion, lack of land tenure, poor access to markets, inadequate labour or capital.

All the above factors can be estimated at a range of scales within basins and used to analyze the existence of water-related causes of poverty. Such analysis is required within each basin to answer the following types of questions:

- How many people are affected by drought, and to what degree?
- How many could benefit from improved governance and infrastructure within a given irrigation domain?
- What are the consequences of soil erosion within an area on water productivity in the basin as a whole? How will this impact on livelihoods?
- What are the potential gains in water productivity within the basin?

Analysis is required to identify the incidence and depth of poverty associated with attributes of agricultural water management, and to provide a richer understanding of the nature of poverty and the degree to which it can be alleviated through improved agricultural water management. This is a necessary step for devising evidence-based, targeted interventions.

According to Black and Hall (2003) the water poor comprise[1]:

- Those whose livelihood base is persistently threatened by severe drought or flood;
- Herders, fishers and farmers whose livelihood depends on environmental services of water that are not dependable because of upstream factors beyond their control;
- Those whose livelihood base is subject to erosion, degradation, or confiscation (e.g. for construction of major infrastructure) without due compensation;
- Farmers who cannot improve agricultural productivity because of the high risk and uncertainties of markets and rainfall, which could be reduced by a little water at the right time,
- Subsistence farmers who are constrained from higher value products such as fruit, vegetables or meat because of lack of access to water and
- Those living in areas with high levels of water-associated disease (bilharzia, malaria, trachoma, cholera, typhoid, etc.) without means of protection.

Water-related poverty occurs because people are either denied dependable water resources or because they lack the capacity to use them, because they have insufficient land, degraded land, poor access to market, capital or other factor known to constrain development. Improvements in agricultural water management that offer poverty alleviation include:

- Provision of water resources to people who require it to sustain food production,
- Increases in water productivity at the field or farm level through removal of production constraints,
- Protection of environmental flows to increase dependability of supply and
- Protection from water-related health hazards.

An important factor to consider is the collective vs. individual gains. Water is distributed within basins by surface and groundwater flows and irrigation infrastructure. Options to modify distribution include modification of the irrigation infrastructure and conservation of the soil and water resources. Other aspects of the water balance may be modified by changes in vegetation type as in converting native savanna to more productive sown pasture and/or increasing its growth rate as by correcting nutrient deficiencies. Net gain occurs when the benefit acquired by recipients exceeds the losses suffered by alternative users, where these exist.

Section 2 of this working paper clarifies the concepts that link poverty and agricultural water management. Section 3 outlines a methodology to analyze poverty at basin scale to determine the effects of agricultural water management.

2 Conceptual relationship between water, agriculture and poverty

2.1 Concepts that link water, agriculture and poverty

The linkage between water, agriculture and poverty is complex and non-linear; not all poor people lack adequate water resources. On the other hand, not all people who live in dry areas are poor. Water resource endowment alone does not explain the state of poverty within basins; it is a necessary, but of itself not sufficient basis for explanation (Castillo *et al.* 2006). The purpose of analysis is to determine to what extent agricultural water management explains poverty, in relation to other factors, and to what extent it can be improved.

Water is used in a variety of both productive and consumptive activities and contributes to rural and urban livelihoods in many different ways. Lack of access to drinking water is itself an indicator of poverty, but the role of water in human well-being is far more complex than simply access to drinking water. Food crop production, fishing, agro-processing, and health can all influence and are influenced by the quantity and quality of available water. Rural upper catchments largely contribute to livelihoods by providing valued primarily ecosystem services to downstream urban, agricultural, and industrial users. As the principal water user, agriculture

[1]Black and Hall (2003) also include those who are impoverished by lack of provision of water for drinking and sanitation, which are potentially indirect consequences of poor agrciultural water management.

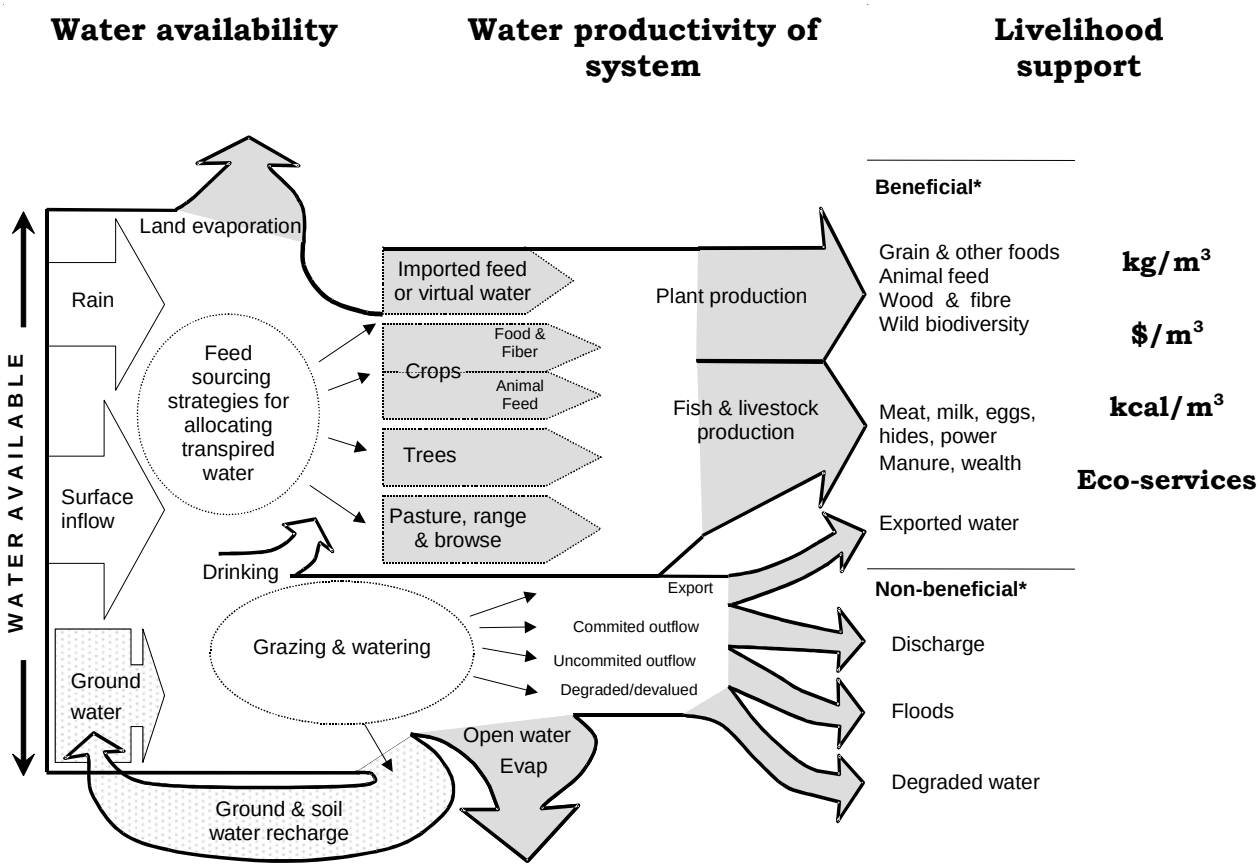

Figure 1. Framework for improving water productivity of livestock. (Modified from Peden *et al.*, 2002.)

offers important, if complex, opportunities for improvement of livelihoods for both consumers and 'producers' of water. Many of these issues are detailed by Castillo *et al* (2006).

The complexity can be simplified. For example, Figure 1 shows the complex pathways of water within a livestock management system in sub-Saharan Africa (Peden *et al.*, 2002). It seems reasonable to simplify this concept and see it as flow through three systems: a hydrologic system; an agricultural system and a livelihood support system. The well-being that people derive from water therefore depends on the interaction between:

(a) The water system, that determines availability and reliability;
(b) The agricultural system that converts the water into livelihood support, through food, income or other attribute – this is defined by water productivity; and
(c) The livelihood system that modifies access according to social relations, institutions or organizations (Allison and Ellis, 2001).

The constraint that water places on well-being is attributable to two factors: its availability to people (as individuals or groups) and the agricultural system in which they use it. People will derive well-being through the interaction between the resource and the agricultural production system.

The objective of analysis, therefore, is to determine evidence for relationships within a three-variable system in which *poverty* (which we define for now as the lack of 'water wealth'), is a function of the *water availability* and the *water productivity* of the agricultural water management system that enables people to derive livelihood from it. We represent this in Figure 2.

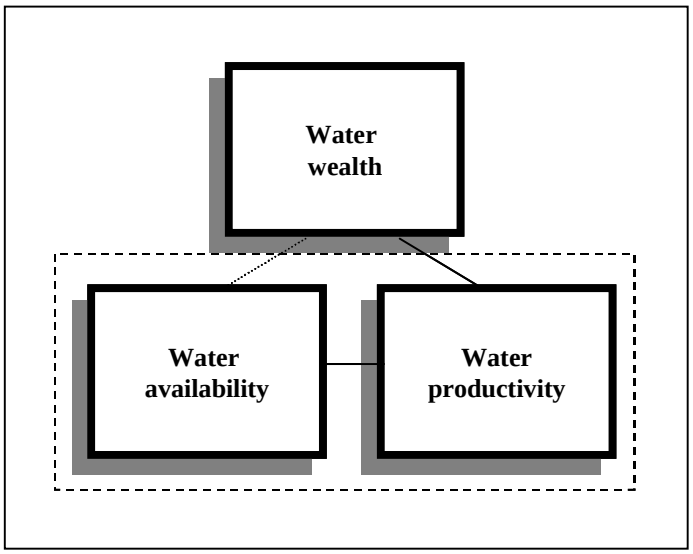

Figure 2. Representation of the components of water wealth.

The remainder of Section 2 provides information about the functional significance of different agricultural systems to poverty alleviation, indicating the ways in which productivity can be modified through agricultural water management.

2.2 Significance of agricultural water management to poverty alleviation

While water is the component that we seek to change, the reality is that change is effected through the agricultural system on which most of the world's poor depend. Nash (2005) reported that 63 percent of global population (and 73 percent of poor) live in rural areas. He further noted that even with rapid urbanization, more than 50% of the poor will remain in rural areas by 2035. For these rural poor, agriculture[2] is their main source of livelihood. For most poor countries, agriculture is a major economic sectors accounting for 30-60 percent of GDP. Agriculture growth contributes to poverty reduction through four main pathways:

- Household food self sufficiency for subsistence farmers, fishers and pastoralists;
- Low food prices, particularly for the urban poor for whom the cost of food accounts for a large percentage of their income;
- Employment opportunities and high wages; and
- Foreign exchange earnings that make it possible for governments to import goods at prices the poor can afford.

Water is one of the main factors that constrain their agricultural output, income and profitability. According to UNDP (1997), about half of the poorest people in the world earn their livelihood in areas where water constrains agricultural production.

2.2.1 Importance of crop production to the poor

Crop production is the main agricultural sub-sector in most countries. In most developing countries, crop production is carried out by smallholder farmers and is generally labor intensive. Low producer prices, low yields and high cost of inputs constraints its potential for getting farmers out of poverty. Agricultural laborers are amongst the most poorly-paid workers and are generally under-employed due to the seasonal nature of labor demand for crop production. Nevertheless, for lack of alternatives, it continues to be the main source of livelihood for most poor people.

[2] In this paper, agriculture includes crop, forestry (plantation and tree crops), livestock and fisheries production.

Analysis of major farming systems in Sub-Saharan Africa illustrates the importance of crop production to the poor, as follows (IFAD, 2002):

- Cereal-root crop mixed and irrigated systems have low incidences of poverty mainly attributed to the higher yields and favorable prices for produce;
- Agropastoral and forest-based crop production systems have the highest incidences of poverty mainly attributed to low yield and remoteness of the farms;
- Mixed maize and agropastoral farming systems have high potential for poverty reduction mainly due to the high demand and the potential for yield increases; and
- Approximately 43 percent of the population in the region depends on maize mixed (16%), cereal-root crop (15%) and root crop (12%) farming systems, which occupy 10, 13 and 12% of the total land area in the region.

Crop production is constrained by biophysical, technological, socio-economic and institutional factors, water being one of the most critical factors. It is generally observed that crop yields are low in areas:

- Where soil nutrients are depleted by erosion and/or nutrient leaching;
- With low, erratic and unreliable rainfall;
- That are water-logged and/or have high levels of salinity.

In contrast, crop yields are high:

- Even in semi-arid areas so long as runoff is minimized and rainfall is well distributed; and
- In adequately irrigated land as compared to that receiving inadequate irrigation or none at all.

2.2.2 Importance of forest (tree) products to the poor

Forest products include timber products (sawn wood, building material, wood-based fibres, fuel wood and charcoal) and non-timber products (food-stuffs and medicine). Harvesting and processing these products is labour-intensive and is a significant source of employment. Forest and trees can also provide valuable ecosystem services.

Forest products are important sources of cash income and employment at certain times of the year and for certain groups of people. Forest values related to subsistence use, environmental services and other indirect benefits are generally not accounted for. World Bank forest strategy and policy document highlights the critical role that forests play:

(a) 1.6 billion rural people are dependent upon forests to some extent;
(b) 1 billion out of 1.2 billion extremely poor depend on forest resources for part of their livelihoods;
(c) 350 million people are highly dependent on forests;
(d) 60 million indigenous people are almost wholly dependent on forests;
(e) production of wood and manufactured forest products contribute more than US$450 billion to the world market economy;
(f) the annual value of internationally traded forest products totals US$150-200 billion; and
(g) globally, forest based industries provide about 47 million full time jobs (Nash, 2005).

Forests make a major contribution in the provisioning of water services, particularly to the poor. Forests buffer the effect of rainfall on stream flows reducing flood peaks and increasing dry season flows. This service is very beneficial to the poor who have limited water storage facilities and who live in flood plains.

2.2.3 Importance of fish to the poor

For poor communities with good access to aquatic resources, fisheries offer complementary livelihood strategies as illustrated below:

- High national importance as evidenced by (a) global trade of US$55-66 billion annually, with 50 per cent of the trade from developing countries; (b) national income from license fees; and (c) multiplier effect to the national economy; and

- Benefits to the poor as evidenced by: (a) the livelihood support for 30 million poor fishers and their families, employing an additional 150 million people in developing countries in associated sectors, e.g. marketing, boat-building; (b) main source of food security for 400 million poor people; and (c) high potential source of alternative employment for rural poor through aquaculture.

The poor engaged in fisheries comprise artisanal fishers and aquaculturalists. Artisanal fishers comprise approximately 8 million people of which more than half are engaged in sea fishing activities. They generally use un-motorized boats without decks and their activities are centered around landing sites from where they set out each day for sea or lake fishing. The following factors contribute to making them one of the weakest livelihood groups:

- Lack of control over the water resource on which their fisheries depend and of capital.
- Dangerous working conditions, which lead to high mortality rates. A profile of artisanal fishers in Benin indicated that malaria is endemic and diarrhea and respiratory infections are common, especially in the rainy season when people are weakened by food shortages (FAO, 2000);
- Lack of investment capital and low profit margins hence low labor productivity. The southern Lake Volta fishing communities reported that increasing cost of production and transportation is eroding their profit margins. Their profit margins fell by 10-25% over a 10 year period (Pittaluga *et a.l*, 2003);
- Seasonal variation in fish availability and consequently uncertainty of income and food availability. The southern Lake Volta fishing communities reported that fishing contributes on average 70% of the household revenue and during the lean season (November-May) a large proportion of the families are unable to meet daily food needs (Pittaluga *et al.*, 2003);
- Poor fisheries management, which can result in over-fishing and eventual loss of fish stock and
- Water pollution that degrades the aquatic ecosystem and reduces productivity.

2.2.4 Importance of livestock to the poor

Keeping livestock is one of the main livelihood strategies of the poor and food insecure and directly affects the livelihood of approximately 987 million poor people (Table 1). Livestock contributes to the livelihoods of the poor in many and diverse ways. The relative importance of these different ways varies between households, time of year and prevailing biophysical and socio-economic conditions. The main ones include:

- Livestock is the main source of income for the poor in semi-arid and arid areas. Most of the income in semi-arid areas is derived from small animals – goats and poultry. In Mali, it is estimated that 78% of the cash income on small-scale mixed farms comes from livestock (Sissoko *et. al.*, 1992 quoted by Livestock in Development, 1999). A study in Bangladesh reported that 40% of the landless households owned cattle and a Pakistan study reported more than 50% of the landless households' income was derived from livestock (Subrahmanyam and Rao, 1995; Kurosaki, 1995, both quoted by Livestock in Development, 1999). The landless supported their livestock production through the use of crop residues, other waste material and feed resource found in communal land and roadsides.
- Livestock is a cherished way of storing cash as livestock can be accumulated in good times and sold off when the need arises. A study in Lesotho reported that in investing in livestock earned farmers the equivalent of 10% interest rate while a bank account lost 10% due to inflation (Swallow and Brokken, 1987, quoted by Livestock in Development, 1999). This is also a good strategy in remote areas where banking services are not readily available.
- In mixed crop-livestock farming systems, livestock plays a key role in enhancing productivity of the farming system of the poor households through provision of draught power and manure. Draft animal power reduces drudgery associated with land preparation and transportation of water and other farm inputs and outputs, while manure returns soil nutrients for maintaining soil fertility.
- Livestock enhances livelihood security through diversification of the farming system. A diversified farming systems buffers the poor against shocks associated with drought, floods, diseases and

Table 1. Distribution of the poor livestock keepers by agroecological zones. Source: Livestock in Development (1999).

Agroecological zone	Category of livestock producers		
	Extensive graziers	Poor rainfed mixed graziers	Landless livestock keepers
		(millions)	
Arid and semi-arid	87	336	
Temperate (including tropical highlands)	107	158	107
Humid, sub-humid and sub-tropical		192	
Total	194	686	107

market failures. A study in Nepal reported that the introduction of dairy buffalo into a village reduced the period of food deficit from eight to two months in a year. It also contributed to a reduction of the proportion of people in the village with inadequate food intake from 50 to 18% (Thomas-Slayter and Bhatt, 1994 quoted by Livestock in Development, 1999).

- Livestock production enhances nutrition status as it is a source of high-quality protein and energy as well as essential micronutrients.

Assessing the contribution of water-related benefits through livestock is complicated by the multiple pathways, stores and products that link water to benefits through multiple uses (feed, direct consumption) and multiple benefits (meat, milk, eggs, hides, power etc). Quantifying the flow of water through intermediate benefits shown in Figure 1 can be extremely difficult, as can assessing the benefits of the products. Additionally, there are numerous constraints and livestock related hazards that obstruct the poor from benefitting from livestock. The main ones include:

- Regulations restricting the keeping of livestock production in urban areas;
- High cost of livestock and lack of credit facilities;
- High risk of diseases and drought;
- Availability of feed resources; and
- Low prices offered for livestock products.

3 Analyzing the linkage between poverty and agricultural water management in basins

This section lays out a framework in which to analyze the linkage between poverty and agricultural water management within basins.

The analytical framework has three components:

(a) Measurement of poverty within the basin. This process includes mapping at best resolution feasible to improve analysis against biophysical and socio-economic attributes.
(b) Analysis of poverty variation against measurable attributes of agricultural water management within basins, and
(c Modeling the current and future status of agricultural water management in basins with respect to poverty alleviation.

3.1 Measuring poverty within basins

3.1.1 Concepts of poverty

Lok-Dessalien (1998) provides an exhaustive review of poverty concepts and indicators. She argues that the distinction between different poverty indicators was important because poverty measurement and subsequent policy and program implications depend on the facets of poverty being addressed. For example, to address both temporary and chronic poverty, two sets of policies and programs would be required along with their indicators for establishing baseline conditions and monitoring progress. Likewise the definition of poverty determined the appropriate poverty measures, policies and programs to address it and corresponding indicators. She highlights the following poverty concepts:

- **Absolute poverty** refers to inability to meet (food, shelter, education and health) needs that enable a person to enjoy a minimum acceptable standard of living. The needs define the required goods and services and the value of these goods and services used to define the minimum income needed to acquire them – the income poverty line.
- **Relative poverty** focuses on the inequality and uses income quintiles or deciles to compares the lowest and upper segment of the population.
- **Objective poverty** involves normative judgment of what constitutes poverty and what is required to lift people out of their impoverished state.
- **Subjective poverty** puts emphasis on individual utility in terms of how much people value goods and services. The subjective poverty approach has led to the development of participatory poverty assessment methodologies.
- **Physiological deprivations** concept is linked to the basic needs concept. Under this concept, people are poor because they lack income, food, clothing and shelter. Poverty-reduction strategies emerging from this approach focus on increasing income/consumption of the poor and their attainment of the acceptable levels of basic needs.
- **Sociological deprivation** perspective argues that people are poor because of the underlying structural inequalities, inherent disadvantages and other factors that constrain access of the poor to credit, water, common property resources and information. These structural inequalities thereby hamper them from using the resources at their disposal to climb out of poverty. Hence, poverty is not just low consumption but also the lack of opportunities to lead valuable and valued lives.

Poverty assessment

Poverty measurement exists for all countries. The nature and source of poverty data affects its ease of analysis and is detailed in Appendix II. Analysis against water-related variables is constrained by two further factors: date of sampling and spatial resolution.

The date of sampling may cause problems of analysis if the data are out of date and do not provide an accurate current view or are asynchronous with the data with which they are to be compared. Within trans-boundary river basins, data of different age (and probably different character) will need to be combined in a single data-set. Effects of droughts or flooding are likely to be partially date-variable, and so may not be visible if poverty is measured at a time when effects were minimal. Conversely, poverty measurement immediately after a crisis may over-emphasize an effect which is only of short-medium term.

The spatial resolution and definition of location may limit the quality of analysis against other factors that are highly variable spatially. Significant effects of localized biophysical factors, such floods, land-use potential, and groundwater availability or socio-economic factors, such as access to markets will be obscured if the resolution of poverty measures is at a regional level.

Poverty Mapping

Poverty maps (normally of absolute poverty measures) improve analysis with respect to water-related attributes within the basin, which are difficult to understand without acknowledging spatial variability. Poverty mapping has been developed in many countries and used to:

(a) Target public interventions by identifying where the neediest population live,
(b) Target emergency response and food aid programs, and
(c) Improve transparency of public decision making. Henninger and Snel (2002) highlight the value of spatial analysis to provide basin information on which to decide where, how, when to intervene.

A very important factor with respect to basin analysis is that maps provide a common data-framework on which to model socio-economic, agricultural and hydrological processes. Since many hydrological processes can *only* be represented effectively in spatial form, GIS provides a logical analytical platform to which other analyses relate.

Davis (2003) provides a comprehensive review of techniques of mapping poverty and food security, pointing out that at the time of writing there existed no gold standard of poverty mapping because of the wide array of applications. He groups the different methods according to:

- Small-area estimation of
    - Household level data
    - Community level data (Bigman *et al.,* 2000)
- Weighted basic-needs index, using
    - Principal components analysis
    - Factor analysis
    - Ordinary least-squares
- Combined qualitative-plus-secondary data (detailed in section 3.3)
    - Primarily based on qualitative assessment, (WFP, 2006)
    - Primarily based on secondary data
- Extrapolated participatory approach
    - Calibrated participatory assessment (Ravnborg, 1999; Kristjanson *et al.*, 2005)
- Direct measurement
    - Household survey data
    - Census data

3.2 Analyzing poverty variation with respect to agricultural water management.

The general process of analysis comprises the following:

- Definition of the hypothetical 'model' that links poverty variation with agricultural water management within the basin, on the basis of a theoretical and contextual understanding of the problem and an awareness of the data that are likely to be available. This step should also outline the method of analysis.
- Acquisition of poverty data for the basin, where possible using spatial analysis to improve the resolution and reliability of the data using methods of small-area estimation. Detail is provided above about the rationale and methodology of poverty mapping.
- In consultation with collaborators, assemble data of candidate explanatory variables.
- Analyze the general and site-specific relationship between the two variables. Coudouel *et al.* (2002) provides many useful suggestions (and cautions) to guide analysis, which commonly employs regression of poverty measures against 'explanatory' variables.

Conventional Poverty Analysis

Coudouel *et al.* (2002) provide a comprehensive review of conventional methods of poverty analysis. Analysis is intended to identify correlates against a range of poverty measures (e.g. income, consumption, inequality)

that may help understand the general nature of poverty. Analysis normally uses a form of regression analysis to identify poverty effects for specific groups, by disaggregating data according to geographical region, age, gender, employment or other factor contained in the data.

Vulnerability analysis presents a special type of analysis, which looks at a measured decline in well-being that results from specific shocks.

Analysis is confounded by geographical variables that are not accounted for in the regression model. This could be reduced by including dummy variables of location, or map-derived variables of access to water, drought or flood incidence, market access etc., where these are considered to be candidate variables.

Analysis of poverty maps:

Why map? The effort to map poverty and its explanatory variables can be justified by the following:

(a) Improved data resolution by interpolation and small area estimation techniques
(b) Improved coincidence of socio-economic and hydrologic data on a common GIS data platform. These variables are generated through different sampling and estimation techniques.
(c) Visual representation of geographical patterns.

Experience in generation and use of poverty maps has demonstrated the potential value of looking at both spatial and temporal dimensions of poverty. (Table 2) Poverty mapping at high spatial resolution has identified pockets of poverty amidst areas of prosperity. More importantly, it has enabled explanation of variations in poverty incidence by comparison with other spatial attributes such as drought incidence. This last feature can be crucial because the effects of agricultural water management are unlikely to be constant throughout an

Table 2. Explanatory variables from poverty mapping in seven case studies. Source: Hyman and Imminck (2003).

Mexico	**Malawi**
Indigenous groups	Educational attainment
Education	Non-agricultural activities
Accessibility	Dependency ratio
Population density	**Kenya**
Ecuador	Soil resources
Accessibility	Rainfall and climate
Water availability	NDVI (vegetation growth rate)
El Niño	Access to education
Land tenure	Accessibility to towns
Nigeria	**Bangladesh**
Rainfall	Educational attainment
Vegetation (more analysis needed)	Availability of infrastructure
Sri Lanka	Land tenure
Access to land and water	Flood-prone lands
	Soil suitability for rice cultivation

area and will require geographically localized analysis. Several other examples of spatial analysis of poverty against factors which include water-related attributes can be found in Hyman *et al.* (2005).

Trend or change analysis, that is, comparing data from two of more sampling periods, enables the dynamics of poverty to be assessed, for example where people have moved out of poverty or have been hit by natural or human-induced shocks. Figure 3 from Farrow *et al.* (2005) shows how poverty in Ecuador changed over the period 1991 to 2001. Areas in the Andes improved, in the face of drought stress (see Farrow *et al.*, 2005), as a result of concerted action by organizations to ameliorate problems of isolation. Conversely, areas on the Pacific coast deteriorated as a consequence of El Niño damage to income-generating plantation crops.

Pinpointing these variations enables us to interpret poverty within the basin-specific bio-physical, socio-economic and institutional settings and therefore get a better understanding of the causes and appropriate interventions.

Hazards that confront the unwary analyst include:

- Assumed correlation between measured and non-measured well-being variables, e.g. consumption vs. income measures (Coudouel *et al.*, 2002).
- Use of the same information in explanatory and dependent variables, for example, if land quality is used in small-area estimation of poverty, it should not be used in analysis as an 'explanatory' variable.
- Complex variance structures may be hidden within data covering large areas: Geostatistical analysis by Farrow *et al.* (2005) revealed complex non-random patterns in poverty data that, if undetected, would have reduced the value of 'conventional' regression techniques. Analysis by Leclerc (2002) at department, municipality or village level shows that the level of disaggregation can significantly modify the advice coming from analysis.
- Non-stationarity of models: Conventional analysis of poverty may unjustifiably assume stationarity – leading to significant error (Coudouel *et al*, 2002). Analysis by Farrow *et al.* (2005) show strong geographically variation, with both positive *and* negative regression coefficients for the same explanatory variable at different locations. This may cause particular difficulties when ascertaining the geographical variation of significance of household level influences such as gender and age, which are unlikely to be analyzed at basin scale.

Explanatory variables from poverty mapping in seven case studies (Hyman and Imminck, 2003)

3.3 Modelling the effects of changes in agricultural water management on poverty

The converse process is to predict poverty distribution on the basis of variation of attributes that represent the effects of agricultural water management. Davis (2003) provides a useful characterization of the two principal methods as used to map poverty:

- Combined qualitative-plus-secondary data (detailed below)
    - Primarily based on qualitative assessment
    - Primarily based on secondary data

3.3.1 Primarily qualitative information approach:

This method uses qualitative information such as a land-use map as a basis for 'first-cut' categorization of explanatory factors. Davis (2003) describes two examples. The first has been used successfully by the World Food Program Vulnerability and Mapping system (VAM) to target emergency aid. The method of Seaman *et al.* (2000) could be modified to map impacts of water-related interventions as follows:

(a) Define agricultural system zones for each basin (Dixon *et al.*, 2001). System zones define areas containing similar combinations of agricultural activities.
(b) In each zone, define major categories of livelihood support.
(c) For each of these categories, determine information of the impacts of livelihood support of attributes of water-availability and water productivity known to be significant from analysis.

(d) Use the above as a baseline from which to estimate the possible impacts of changes in water availability and /or productivity resulting from detailed study of individual factors.

A second variant may be useful to focus on particular groups who are vulnerable within basins (e.g. fishers). In this method, mutually-exclusive, livelihood-strategy groups are defined by workshops of experts, following which the impact of changes in water availability and productivity would be estimated from institutional attributes.

Water poverty index

The water poverty index (WPI, Sullivan *et al.*, 2003), subsequently modified to the water wealth index (WWI) attempts to define poverty that includes all factors relevant to the livelihood support provided to the poor by water resources in five dimensions:

- Per capita resource availability
- Access to water;
- Capacity to benefit;
- Water uses; and
- Environmental impact.

Maps have been produced at national scale and sub-national scale. The WPI has also been applied to analyse community-level characteristics, but the feasibility of more detailed mapping may be limited. This concept has undoubtedly broadened the scope of examination, but the rigid definition of relative weights reduces its value as an analytical tool, especially since some of the factors that could be used to help explain poverty variation are used within the index itself. WPI/WWI may provide greater value as a diagnostic indicator for subsequent analysis.

Falkenmark water stress index

The Falkenmark water stress index provides easily quantifiable measures that assume no direct association between poverty and water (Falkenmark and Widstrand, 1992). This was modified by Ohlsson and Appelgren (1998) to include measures of social capital – that is, the ability and willingness of people to engage in activities that provide collective benefit - that seem likely to modify the ability to cope with stress. Useful as a broadscale indicator of the imperative for action, this makes no distinction between impact and condition.

Vulnerability

Several definitions on vulnerability exist. IFAD defines vulnerability as the probability of an acute decline in access to food or consumption, which leads to "inability to meet minimum survival needs". This definition captures two main elements that need to be present simultaneously: the exposure to risk, and the inability to cope with it. Kasperson *et al.*, 2001 defined vulnerability as "the differential susceptibility to loss from a given insult". They argued that vulnerability has three dimensions:

- **Exposure** is a measure of the probability that a certain risk will occur. It is related to both the presence of the risk in a given location and to people being in that location.
- **Sensitivity** is influenced by both socioeconomic and ecological conditions, which together determines the degree to which a group will be affected by environmental stress. For example, people in poorer health condition are more sensitive to a health-affecting environmental stress than people in good health.
- **Resilience** is the extent to which an individual or a community utilize coping and adaptation strategies to help them retain their basic properties under stress, recover from damage, and enact change to prevent future damage.

The risk of severe poverty increases with membership in certain identifiable social and age groups that also suffer a higher risk of perpetuating poverty into the next generation. The strongest predictor of poverty is

inability to perform or lack of access to paid work or lack of access to productive resources. The groups mostly affected by poverty are:

- Children, youth, and families with many children: The young face the highest risk of poverty and moreover the risk of poverty increases with the number of children in a family. Families with three or more children have a higher rate of poverty than those with fewer children, significantly affecting their long-term life prospects;
- Single parent families, particularly female-headed households in rural areas;
- Families with unemployed members;
- Agricultural families, particularly in areas of low productivity;
- Pensioner;s
- Homeless families; and
- Abused, neglected or abandoned children

3.3.2 Primarily secondary data:

The other hybrid method described by Davis (2003) is based on 'indicators' and is typified by the famine early warning system (FEWS) promoted by the USAID. The method (modified form Davis, 2003) comprises the following steps:

(a) Determination of the principal water-related 'drivers' for which information exists over the basin;
(b) Selection and transformation of indicators over the basin;
(c) Weighting of indicators, based on analysis, expert judgment;
(d) Ranking according to summed scores of indicators; and
(e) Mapping of indicator scores.

3.4 Comparison of analytical and modeling activities

The analytical and modeling components contrast in the ways in which poverty is inferred to be related to agricultural water management:

- Identify the incidence of poverty and *infer* how much variation is associated with water management. This is called backward chaining: (*from* analysis of ***Y***, *infer* the influence of ***X)*** and is useful to help explain the causes of poverty. An example is the analysis of poverty in relation to the intensity of drought in Ecuador (see Farrow *et al.* 2005).
- From information about biophysical and socio-economic characteristics in the basin *infer,* from modeling, the impact on poverty. This is forward chaining: (from ***X***, *infer* the likely status of ***Y)***. This is useful to represent targetable problems on the basis of prior understanding. The approach is used to predict poverty effects of vulnerability (see the Vulnerability and Analysis Mapping reports of the World Food Program, WFP, 2006).

It is helpful to clarify the complementary use of these two processes. The first process helps to understand the causes of poverty that are related to agricultural water management, and to quantify, as far as the data allow, the relationship between the two. The result is a model that can be used – within limits of plausibility – to link explicitly the relationship between poverty and other measurable attributes in the basin. The second process takes the best current understanding of causes to portray where water-related poverty, and changes to it, is likely to occur within the basin, given data about the basin.

4 Summary:

The complete analysis and representation of *agricultural water management*-related poverty in basins depends on four assumptions.

The first is that poverty can be measured in sufficient detail to identify the effects of variations in agricultural water management, should these exist. In some areas, data are likely to be of insufficient spatial

resolution to compare with short-range hydrologic features. Temporal resolution may be insufficient to define the effect of changes or extreme events.

The second is that agricultural water management is a major controlling factor on poverty. Logically, a wealth of evidence exists from case studies to support this view: agricultural production systems support the poor and agricultural production systems are influenced significantly by water availability and use. It seems crucial to separate the constraint of water availability on agriculture from the effects of other factors that influence the benefit people acquire from it.

The third assumption is that analysis of data from basins will reveal significant effects of agricultural water management on poverty within different parts of the basin. Many factors may confound such analysis: lack of high-resolution poverty measurement; spatial and temporal confusion of different data; poor quality data of 'explanatory' variables.

The fourth assumption is that the basin system can be modeled to represent the current condition of people living in the basin, together with the likely impact of changes targeted by the analysis. Analysis will be required to provide maps and tabular data to support assessment of the state of water-related poverty, and the degree to which it is modifiable.

5 References:

Allison, E.H. and Ellis, F. 2001. The livelihoods approach and management of small-scale fisheries. *Marine Policy* 25:377-388.

Bigman, D., Dercon, S., Guillaume, D. and Lambotte, M. 2000. Community targeting for poverty reduction in Burkina Faso. *The World Bank Economic* Review 14: 167-194.

Black, M. and Hall, A. 2003. *Pro-Poor Water Governance.* Asian Development Bank.

Castillo, G., Namara, R., Hussein, M.H., Ravnborg, H., and Smith, L. 2006. *Improving Agricultural Water Management for Poverty Reduction: Challenges and Pathways.* Comprehensive Assessment for Water in Agriculture. Draft report. IWMI, Colombo, Sri Lanka.

Coudouel A., Hentschel J. S., and Wodon Q.T., 2002: *Poverty Measurement and Analysis*. PRSP Sourcebook, World Bank, Washington. URL: http://povlibrary.worldbank.org/files/5467_chap1.pdf. Accessed 19 June, 2006

Davis, B. 2003. *Choosing a Method for Poverty Mapping*. FAO, Rome. 48pp.

Dixon, J., Gulliver, A. and Gibbon, D. 2001. *Farming Systems and Poverty: Improving Farmers' Livelihoods in a Changing World*. FAO Rome. 412 pp.

Dzenovska D., 2001: *Thematic review of NHDRs: Poverty,* UNDP report.

Falkenmark, M. and Widstrand, C.. 1992. *Population and Water Resources: A Delicate Balance*. Population Bulletin. Population Reference Bureau

FAO, 2000. *The State of Food Insecurity in the World – 2000*. FAO, Rome. 31 pp. URL: http://www.fao.org/documents/show_cdr.asp?url_file=/docrep/x8200e/x8200e00.htm. Accessed 19 June, 2006

Farrow, A., Larrea, C., Hyman, G. and Lema, G. 2005. Exploring the spatial variation of food poverty in Ecuador. *Food Policy*. 30: 510-531.

Henninger N, Snel M. 2002. Where Are the Poor? Experiences with the Development and Use of Poverty Maps. World Resources Institute and UNEP/GRIDArendal, Washington. URL: http://www.povertymap.net/publications/wherearethepoor/where_are_the_poor.pdf. Accessed 19 June, 2006.

Hyman, G. and Imminck, M. 2003. *Results of CGIAR/FAO/UNEP Poverty Mapping Case studies*. Presentation to ESRI Users' Conference, San Diego, 7-11 July, 2003.

Hyman, G., Larrea, C. and Farrow, A. 2005. Methods, results and policy implications of poverty and food security mapping assessments. *Food Policy* 30: 453-460

IFAD. 2002. Assessment of rural poverty: Eastern and Southern Africa. International Fund for Agricultural Development, Rome. URL: http://www.ifad.org/poverty/region/pf/index.htm. Accessed 22 June, 2006.

Kasperson, R.E., Kasperson, J.X., Dow, K., Ezcurra, E., Liverman, D.M., Mitchell, J.K., Ratick, S.J., O'Riordan, T. and Timmerman, P. 2001. Introduction: Global environmental risk and society. In: Kasperson, J.X. and Kasperson, R.E. (Eds.). *Global Environmental Risk*. United Nations University Press, New York.

Kristjanson, P., Radeny, M., Baltenweck, I., Opgutu, J. and Notenbaert, A. 2005. Livelihood mapping and poverty correlates at a meso-level in Kenya. *Food Policy* 30:568-583.

Leclerc, G. 2002. *Poverty targeting with local and classic indicators: An attempt to integrate multiple perspectives*. Land Use Project, CIAT, Cali, Colombia.

Livestock in Development. 1999. *Livestock in Poverty-Focused Development*. Livestock in Development, Crewkerne, United Kingdom. 96pp. URL: http://www.theidlgroup.com/downloads/livestock.pdf. Accessed 19 June, 2006.

Lok-Dessallien, R. 1998. *Review of Poverty Concepts and Indicators*. SEPED Poverty Reduction Series. URL: http://www.undp.org/poverty/publications/pov_red/Review_of_Poverty_Concepts.pdf. Accessed 19 June, 2006.

Nash, J. 2005. Sustainable development strategies in agriculture and rural development: A paper presented during the WTO Symposium on Trade and Sustainable Development held in Geneva, 10- 11 October, 2005. URL: http://www.wto.org/English/tratop_e/envir_e/sym_oct05_e/nash_session2_e.ppt . Accessed 19 June, 2006.

Ohlsson, L. and Appelgren, B. 1998. Water and social resourcescarcity: Alternative socially based approaches to assessment and management of water scarcity. URL: http://www.thewaterpage.com/SoicalResourceScarcity.htm. Accessed 19 June, 2006.

Peden, D., Tadesse, G. and Mammo, M. 2002. Improving the Water Productivity of Livestock: An Opportunity for Poverty Reduction. URL: http://www.ilri.org/publications/cdrom/integratedwater/iwmi/Documents/Papers/Don.htm. Accessed 18 May, 2006.

Pittaluga., F., Braimah, L.I., Bortey, A., Wadzah, N., Cromwell, A., Dacosta, M., Seghieri, C. and Salvati, N., 2003. Poverty Profile of Riverine Communities of Southern Lake Volta., Sustainable Fisheries Livelihoods Programme in West Africa, Cotonou, Bénin. 70 pp. URL: http://www.sflp.org/ftp/dload/fr18.pdf. Accessed 19 June, 2006.

Ravnborg, H. 1999. Poverty and soil management- evidence of relationships from three Hounduran watersheds. In: Workshop: Assessing the Impact of Agricultural Research on Poverty. Costa Rica, September 1999.

Seaman, J., Clarke, P., Boudreau, T. and Holt, J. 2000. *The Household Economy Approach: A Resource Manual for Practitioners*. Save the Children Fund, London.

Sullivan, C.A., Meigh, J.R., Giacomello, A.M., Fediw, T., Lawrence, P., Samad, M., Mlote, S., Callan, J.A., Schulze, R.E., Dlamini, D.J.M., Cosgrove, W., Delli Priscoli, J., Gleick, P., Smout, I., Cobbing, J., Calow, R., Hunt, C., Hussain, A., Acreman, M.C., King, J., Malomo, S., Tate, E.L., O'Regan, D., Milner S. and Steyl, I. 2003. The Water Poverty Index: Development and application at a community scale. *Natural Resources Forum* 27:189-199.

UNDP, 1997. *Human Development Report 1997*. Oxford university Press, Oxford. 134 pp. URL: http://hdr.undp.org/reports/global/1997/en/. Accessed 19 June, 2006.

WFP, 2006. Vulnerability Analysis and Mapping. World Food Programme. URL: http://www.wfp.org/operations/vam/. Accessed 10 June 2006.

Appendix I: Types and sources of poverty data

Data for poverty analysis can be obtained from two major sources: service records and surveys.

Service record data sets are the data collected by various government organizations such as: health service data on nutrition status, disease incidence, inpatient and outpatient visits; education data on school enrolment and performance; agricultural statistics on agricultural produce, prices and wages. Some of the limitation of these data sets include: limited coverage, questionable quality, not generally disaggregated and in most cases they are in a raw form requiring a lot of time to pre-process.

Household surveys are the basis for poverty data collection. Survey data contain information collected based on the needs of the study objectives and includes both quantitative and qualitative data. A poverty-study survey will in most cases yield a more comprehensive dataset than will other types of survey. Quantitative methods tend to define poverty in external terms such as need deprivation and focus on measurable and observable parameters. Qualitative methods tend to use an interactive process to understand both the constituents and their sources of well being. The surveys include:

- **Living Standard Measurement Survey (LSMS)** a large, multi-topic household survey comprising three sections: household, community and prices
- **Integrated Survey (IS)** is similar to LSMS and was designed to collect data for analyzing impacts of structural adjustment on household.
- P**riority Survey (PS)** collects data for identifying and monitoring population groups most affected by structural adjustment policies.
- **Household Income and Expenditure Surveys (HIES)** core data sets include: household characteristics (size, structure, composition and activities of its members); household income (both individual and collective, in-kind, in-cash, paid and self employment); and household expenditure (purchased goods and services, consumption of self-production). Depending on the coverage, the survey may also include: consumer prices, income distribution, inequality, poverty, savings, taxation, elasticity of demand for goods and services, and nutritional data.
- **Demographic and Health Surveys (DHS)** that focuses on maternal and child health, fertility and family planning, but also include education, occupation and knowledge data.
- **Consumer Price Surveys (CPS)** carried out to assess the comparative costs at current prices of the same basic basket of goods and services over time.
- **Labour Force and Employment Surveys (LFES)** that focus on the relationships between poverty and occupation and livelihoods.
- **Food Consumption and Nutrition Surveys (FCNS)** that collect information on:
    (a) type and severity of nutritional deprivation;
    (b) consumption and production of certain foods; and
    (c) consumption expenditure and effects of subsidy programs.
- **Agricultural Surveys (AS)** that cover:
    (a) comprehensive statistics of agricultural land, crops cultivated, irrigation, number and types of livestock;
    (b) benchmarks for improvements in crop and livestock production;
    (c) agricultural structure attributes such as size and distribution of holdings, extent of various forms of tenancy, agricultural resources, production facilities and practices;
    (d) agricultural machinery and inputs; and
    (e) food.
- **Other specialized household surveys** such as gender equity, education and literacy, housing, access to markets, schools and hospitals.

Poverty indicators and their derivation

Single indicators

Poverty line: The poverty line defines who are poor and who are not poor by establishing individual or household incomes or expenditures levels below which they are considered poor. Poverty lines are usually established using one of the following methods:

- The food energy method determines the consumption of a bundle of food items required to reach a minimum agreed caloric intake. Regression of caloric intakes with income or expenditure levels then determines the income at which the minimum energy intake is realized. This becomes the poverty line income or expenditure level. The method implicitly takes into account non-food expenditures.
- The US$1 per day per person poverty line was set up to facilitate comparison of poverty situations of different countries or of different areas in the same country in a uniform manner. The US$1 is converted to local currency using purchasing power parity (PPP) indices, which are derived from the costs in constant US dollars of a national average consumption bundle. The index therefore does not reflect the composition or the relative prices of typical consumption items of poor households but rather national averages compared to a world average. International comparisons are thus made on a fairly inadequate basis, and their results should be used with much caution.

Poverty incidence of a given area is computed as the percentage of the total population that is poor. This measure is intuitively understandable but fails to indicate the depth of poverty for different groups of people.

Poverty gap: Poverty gap captures the depth of poverty by assessing the income shortfall if all the poor had to have incomes equal to the poverty line. The poverty gap is defined as the income transfer required to lift the incomes of all poor exactly up to the poverty line and is expressed as the percentage of total income that needs to be redistributed.

Composite Indicators

Indices of human development: From a human development perspective, poverty is defined as deprivation of capabilities and opportunities essential for human development, which include material welfare, education, health, freedom of choice, and participation (Dzenovska, 2001). According to the 1997 Human Development Report, human poverty is the denial of choices and opportunities most basic to human development – to lead a long, healthy, creative life and to enjoy a decent standard of living, freedom, dignity, self-esteem and the respect of others. Lack of any or all of these capabilities and opportunities constitutes poverty because provision of these capabilities is a desired end of human development process. Hence, from measures of human development, poverty is pinned on two primary indicators – the human development index (HDI) and the human poverty index (HPI). HDI measures the conditions of human development and its fluctuations while HPI measures deprivation of human development and its fluctuations.

HDI encompasses: life expectancy at birth; literacy rates and combined primary, secondary and tertiary enrollment; and adjusted income. HPI for developing countries encompasses indicators for the percentage of people not expected to survive the age of 40; percentage adult literacy; and economic provisioning in terms of the percentage of people who do not have access to health services, safe water, and the number of malnourished children under the age of 5. These indices do not measure all aspect of development and poverty and are aimed at identifying potential problem areas and for comparing general trends among countries, regions or population groups at a very aggregated level. These indices therefore fail to capture the distribution of the deprivation across income groups, social and ethnic groups and regions. They also fail to provide information needed to interpret the data more broadly. For example these indices fail to illuminate the political and historical context, which may be imperative for understanding the trends of development or deprivation as well as devising policy solutions.

Human development approach challenges the assumption that economic growth is the primary vehicle for poverty reduction and asks what kind of economic growth is conducive to poverty reduction for all with a focus on quality and equity rather than quantity of economic growth. Technology-driven economic growth tends to favor the rich and increases income inequality among countries and within countries.