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ASSESSING THE CONTRIBUTION OF AQUACULTURE TO FOOD SECURITY: A SURVEY OF METHODOLOGIES

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ASSESSING THE CONTRIBUTION OF AQUACULTURE TO FOOD SECURITY: A SURVEY OF METHODOLOGIES

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PREPARATION OF THIS DOCUMENT

This document was prepared within the framework of the FAO Fisheries Department's efforts to promote aquaculture as a financially self-sustained business, or commercial aquaculture, as one of the means of eradicating hunger and alleviating poverty in developing countries. The document surveys some of the methodologies available in the literature for assessing the contribution of a given sector, such as commercial aquaculture, to food security and economic growth and development. The document was produced through a desk study.

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ABSTRACT

Poverty, hunger and malnutrition affect millions of people across the globe; of these, 25 percent live in sub-Saharan Africa. The challenge is to find suitable and sustainable technologies which ensure them physical, social and economic access to sufficient, safe and nutritious food at all times: a situation referred to as food security.

Many scholars, researchers, development agencies and policy-makers argue that aquaculture, the farming of marine organisms including fish, contributes to food security in many parts of the world including sub-Saharan Africa. A range of methodologies exist which assess the prevalence and extent of food insecurity. However, little is known about the extent to which aquaculture contributes to alleviating poverty and hunger.

This study surveys different methods which could be used to determine the contribution of aquaculture to improving food security. It focuses on four main essential components of food security, namely: stability of food supply, increased availability of food, improved access to supplies and more effective food utilization.

Findings indicate that physical, dietary and economic indicators are widely used to achieve this goal. However, because of the complexity and extent of global food insecurity, it is unlikely that, of the methodologies surveyed, a single one can ever accurately quantify the contribution of a given technology, such as aquaculture, to food security.

Further research is needed to address this issue. Perhaps a combination of indicators currently used into a methodology could be a starting point.

CONTENTS

1. INTRODUCTION

An estimated 840 million people lack adequate access to food (FAO, 2002); of these about 25 percent are in sub-Saharan Africa (Pinstrup-Anderson, Pandya-Lorch and Rosegrant, 1999). As the population grows and puts more pressure on natural resources more people will probably become food insecure, lacking access to sufficient amounts of safe and nutritious food for normal growth, development and an active and healthy life (Pretty, 1999). The hungry are the poorest of the poor. Hence reducing hunger must be one of the first steps towards reducing poverty (NEPAD, 2003). Poverty in sub-Saharan Africa is becoming more widespread with nearly half the population living below the international poverty line[1] (Clover, 2003). Although many local successes have taken place, the food situation in sub-Saharan Africa is still extremely unstable (Pinstrup-Anderson, Pandya-Lorch and Rosegrant, 1999). Agricultural production in the African continent is low, economic stagnation widespread, political instability persistent and environmental damage increasing (Pretty, 1999). The challenge is therefore to provide the poor and hungry with a low cost and readily available technology to increase food production using less land per caput and less water without further damage to the environment (Pretty, Morison and Hine, 2003).

Aquaculture, the farming of aquatic organisms, including fish, molluscs, crustaceans and aquatic plants, is often cited as one of the means of efficiently increasing food production. Fish provides a good source of protein and essential micronutrients and thus plays an important role in the prevention of many human diseases (Williams and Poh-Sze, 2003). About nine million people are employed in the aquaculture industry, which provides them with supplementary income during lean seasons (FAO, 2003a). Aquaculture could increase the availability of low-cost fish in local markets bringing poor households above poverty threshold levels relatively quickly (Edwards, 1999). Larger scale commercial aquaculture, practised in many developing countries, can enhance the production for domestic and export markets bringing much needed foreign exchange, revenue and employment, thereby contributing to food security (Ridler and Hishamunda, 2001; Subasinghe, 2003).

Although aquaculture could theoretically bring numerous benefits to the quality of life of millions throughout the world, until the effects of this technology can be measured and quantified, the true benefits cannot be fully understood. There is a need for a direct, simple and rigorous method to measure the potential contribution of aquaculture towards improving food security. Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (SPFS, 2003). This study examines some of the aspects that could be included in any such measure. Particular reference is made to fish farming in sub-Saharan Africa where the need to improve food security is greatest.

2. AQUACULTURE: PAST DEVELOPMENT AND FUTURE POTENTIAL

Fish has been an important source of food for centuries and contributes around 50 percent of total animal protein in the diets of many Africans (FAO, 2003b). However, as the industrialized world's fish stocks depleted, the fish trade increasingly turned to developing

[1] The poverty line provides a measure of the minimum income or consumption level necessary to meet basic needs. Information is obtained through surveys and global comparisons are made using a reference line, set at US$1 per day in Purchasing Power Parity (PPP) terms (where PPP measures the relative purchasing power of currencies across countries).

countries for fish (Wilson, 1997). Although marine and inland capture fisheries play a significant role in African economies, the situation appears unsustainable as resources are already fully exploited and so increasing fishing effort will not increase catches (Cushing, 1988; FAO, 1991; NEPAD, 2003). People are threatened with food insecurity when overall supplies dwindle and prices increase. During the last decade, African fish production stagnated, the import surplus did not keep pace with population growth and the per caput availability of fish in Africa fell from about 9 kg/caput/year to 7 kg/caput/year (NEPAD, 2003). At the global level, aquaculture helps to fill the gap between the rising demands for fishery products and the current capture fisheries production and it could therefore make a significant contribution to food security in sub-Saharan Africa.

Although the practice of aquaculture in sub-Saharan Africa is relatively recent, it is not new to the majority of countries (Vincke, 1995; see Box 1). The development and wide adoption of the technology can therefore be seen as an important step towards improving household food security. Aquaculture is one of the fastest growing food-producing sub-sectors (Subasinghe, 2003; see Figure 1) but, although nearly 85 percent of world aquaculture production comes from developing countries (Ahmed and Lorica, 2002), sub-Saharan Africa currently contributes less than one percent of total aquaculture production by weight (FAO, 2003b). African aquaculture is still essentially a rural, secondary and part-time activity, taking place in small farms with small freshwater ponds (Coche, Haight and Vincke, 1994; Aguilar-Manjarrez and Nath, 1998). However the sector is expected to continue to expand into the next century (Li, 1999) with the industry responding to the growing demand for fish by improving production efficiency and product quality, domesticating additional species and using biotechnology to improve stock performance (Sverdrup-Jensen, 1999). Estimates suggest that 31 percent of sub-Saharan Africa is suitable for smallholder fish farming (Kapetsky, 1994) and so clearly the availability of land is not a constraint for aquaculture development in this region (Aguilar-Manjarrez and Nath, 1998). Nevertheless, although rapid commercialization may produce more fish in less time, there are inevitably a number of constraints limiting the expansion of aquaculture and questioning its sustainability in the long run. Current factors impeding aquaculture development in sub-Saharan Africa include: limited direct investment, which will only occur if potential profits exceed an acceptable risk level (Ridler and Hishamunda, 2001); undefined or poorly defined land and water rights (Hishamunda and Manning, 2002); and a limited availability of feed, the provision of which can have substantial negative environmental impacts (Naylor *et al.*, 2000; Bruinsma, 2003). Fortunately as awareness of these limitations increases, many of the constraints that were previously inextricably linked to aquaculture are surmountable and therefore no longer common (FAO, 2003a).

The lack of tradition of fish and water husbandry in sub-Saharan Africa and the past socio-economic, environmental and political constraints have limited investment and slowed the expansion of African aquaculture leaving sub-Saharan countries in an extremely difficult food situation (Pinstrup-Anderson, Pandya-Lorch and Rosegrant, 1999); Brummett and Williams, 2000). Future aquaculture is working towards a product that is not only acceptable to consumers in terms of price, quality and safety, but also in terms of environmental cost (Jia *et al.,* 2001). Predictions also suggest an improvement in the future economic state of sub-Saharan Africa (Bruinsma, 2003), which may therefore reduce the prevalence of food insecurity and widespread poverty. The extent of the contribution of fish and fisheries in ensuring food security is still not fully known. However, despite providing a low calorie diet, fish is often the most important source of dietary protein especially in less developed areas of the world where other sources of animal protein are scarce or expensive (FAO 2001). Studies in various developing countries show that 80–100 percent of aquaculture products from rural farm households are marketed, suggesting that aquaculture can also be considered as a cash-generating activity and thus an important indirect source of food security (FAO, 2003a). Thus, in addition to the nutritional advantages of increased fish production, aquaculture may bring the diversification necessary to provide a source of livelihood and foreign exchange essential for household and national food security (Sverdrup-Jensen, 1999; Williams, 1999; DFID, 2003).

Box 1: Aquaculture development in sub-Saharan Africa

Trout breeding in high altitude cold water was introduced in South Africa between 1859–1896 and in Kenya and Madagascar towards the end of the 1920s (Vincke, 1995). The first successful production of tilapia in ponds (mainly *Oreochromis niloticus*) occurred in the Democratic Republic of Congo in 1946 (Vincke, 1995). Pisciculture techniques were introduced subsequently from Europe to a number of African countries and fish farming therefore developed rapidly such that by the end of the 1950s there were about 300 000 ponds in production (Satia, 1989; Machena and Moehl, 2001). Aquaculture development slowed dramatically at the end of the colonial era when resources became scarce (Aguilar-Manjarrez and Nath, 1998) and most ponds were abandoned because of low yield or as a result of political disturbances (Vincke, 1995). Aquaculture began to develop again in the late 1960s through increased technical assistance financed by multilateral and bilateral donors (Vincke, 1995; Aguilar-Manjarrez and Nath, 1998). The 1970s and 1980s witnessed numerous aquaculture development projects (Machena and Moehl, 2001) and in the 1990s commercial development and diversification allowed production to increase (Brummett and Williams, 2000). Aquaculture has become well established in a number of countries including Côte d'Ivoire, Madagascar, Malawi, Nigeria and Zambia (Machena and Moehl, 2001). More than 60 species of fish were farmed in sub-Saharan Africa in 2001, producing 62.4 thousand metric tonnes of aquaculture products valued at US$138 million (Fishstat, 2001).

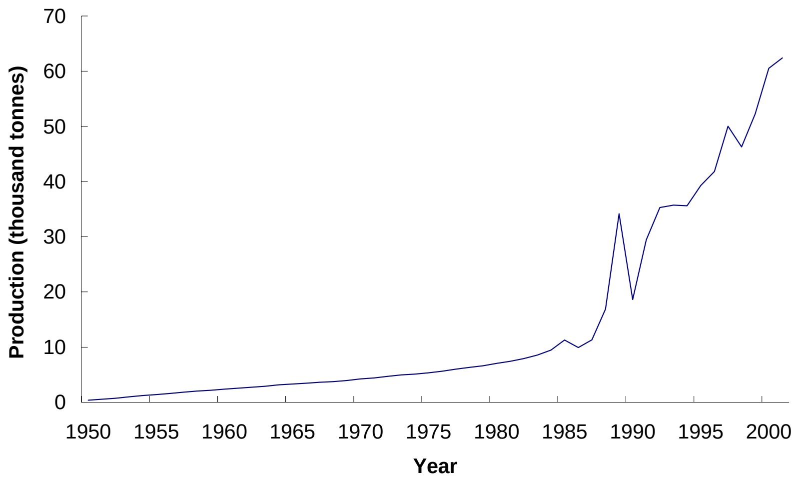

Figure 1: **Evolution of the total aquaculture production in the sub-Saharan Africa region (Fishstat 2001).**

3. FOOD SECURITY

The roots of concern about food security can be traced back to the Universal Declaration of Human Rights which recognized that "everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food" (United Nations, 1948). Despite technological improvements to increase global food energy per person, regional differences in productivity and distribution problems mean that while some areas have an excess of food, others are lacking (Welch and Graham, 2000). Food secure households should not be at risk of losing access to food, which should be acquired in socially acceptable ways without resorting to emergency food supplies, scavenging, stealing or other coping strategies (FIVIMS, 2003). Purchasing power is therefore essential to guarantee access to sufficient food at the household level (World Bank, 1986; Clover, 2003). Although food security is defined at the level of the individual, it is brought about by a combination of individual, household, community, national and international factors. There is sufficient food at the world level yet distribution and access problems result in millions of people not having enough food (FAO, 2001). The mere presence of food does not entitle a person to consume it. Thus, achieving food security requires four components:

- *stability* of food supply throughout natural, political and/or economic crises;
- sufficient *availability* of food;
- sustainable *access* to affordable food by all; and
- effective *biological utilization* of safe, nutritious food so that every person can lead a healthy and productive life (Pinstrup-Andersen and Pandya-Lorch, 1999).

4. MEASURING FOOD INSECURITY

Food insecurity is a complex phenomenon attributable to a range of temporally and spatially varying factors, such as the socio-economic and political environment, the performance of the food economy and the health and sanitation situation (FIVIMS, 2003). Food-insecure people are those whose food intake falls below their minimum energetic requirements. They are also those who exhibit physical symptoms caused by energy and nutrient deficiencies resulting from an inadequate or unbalanced diet or from the body's inability to use food effectively because of infection, disease or poor sanitation (DFID, 2003; FIVIMS, 2003). In addition to the numerous physical and psychological costs associated with food insecurity there are a number of economic costs, such as the costs of lost productivity or additional health care (Chung *et al.*, 1997). Attempting to ensure food security can be seen as an investment in human capital. A properly fed, healthy and active population contributes more effectively to economic development than one which is physically and mentally weakened by an inadequate diet and poor health (World Bank, 1986).

The definition of food insecurity encompasses many elements and therefore no single indicator can measure its prevalence or extent. Five main types of method are currently used for assessing the extent of hunger and malnutrition, each with different applications, advantages and disadvantages. Qualitative methods assess the perceptions of hunger and behavioural responses while also measuring the stability of supply (FIVIMS, 2002). The FAO method estimates dietary intake and its relation to energy needs thus providing an indication of the availability of food supply (FSIEWS, 2001). The individual dietary survey and the household income and expenditure survey methods measure access to food supplies (Ferro-Luzzi, 2002; Smith, 2002). Finally, anthropometry determines the physical effects of malnutrition on growth and thinness thus indicating the extent of the biological utilization of food (Gibson, 1990; Cogill 2003). These methods assess the effects of hunger on health, suffering, behaviour and economics and are compared in Table 1 and outlined below.

4.1 Qualitative method

The qualitative method of assessing food security examines people's perceptions about energy inadequacy and food deprivation and provides a simple, direct measure of food insecurity and hunger that is country- and context-specific (Kennedy, 2002). The method targets those who have experienced food insecure conditions directly and examines experiential dimensions including emotional effects and behavioural changes (FIVIMS, 2002). Interviewers look for evidence of an alteration in food type consumption through substitution for cheaper foods, the physical sensation of hunger or weight loss, the experience of running out of food without money to obtain more and the perception that consumed food was inadequate in quality or quantity (Bickel *et al.*, 2000). This method has mostly been used in developed countries, although efforts are under way to extend its use to developing countries (FIVIMS, 2002). It could easily be adapted to looking at the introduction of aquaculture and the consequent impact on food security. Nevertheless, due to the highly context-specific and linguistically dependent nature of qualitative methods it may never be possible to develop a universal measure to capture the successive stages of severity in food insecurity across diverse regions and peoples (Kennedy, 2002).

4.2 FAO method

The FAO method for measuring food deprivation is based on a comparison of energy requirement norms with usual food consumption, expressed in terms of dietary energy (see Box 2). A minimum amount of dietary energy intake is essential to maintain body weight and so the individual energy requirement is defined as the level of energy intake from food that will balance energy expenditure when an individual has a body size, composition and level of physical activity consistent with long-term good health (Naiken, 2002). The FAO method measures the distribution of dietary energy consumption on a per person basis from the daily dietary energy supply (DES) per caput for a country, which is derived from food balance sheets, averaged over three years. DES therefore relates food availability to a theoretical energy allowance, which varies between 2 000 and 2 350 kcal/day/person depending on the age, sex, health status and physical activity of the individual (FSIEWS, 2001). National DES gives a good indication of the extent of poverty (Mason, 2002) and those countries with food supply problems (Naiken, 2002).

The per caput DES refers to food acquired by households rather than the actual food intake of individual household members (Naiken, 2002) and it therefore does not show the inequitable distribution of available supplies within countries. This method may overstate prevalence of undernourishment in some regions and understate it in others by placing too much stress on mean energy consumption and not enough on energy distribution (FIVIMS, 2002). In addition, there are serious inaccuracies in the food balance sheet data arising from flawed production and trade data in countries with relaxed borders and thus may provide an unreliable indicator of the scope of the undernutrition problem (Svedberg, 1999; FIVIMS, 2002).

Box 2: FAO method calculations

The basal metabolic rate (BMR) is the energy expended for the functioning of an individual in a state of complete rest and is derived from the Schofield equations, a set of sex-age-specific regression equations based on body weight. The total energy expenditure of an individual can be expressed as multiples of the predicted basal metabolic rate BMR. This ratio of the total energy expended to the BMR has been termed the physical activity level (PAL) index and reflects both the body weight and the level of physical activity of the individual (Shetty and James, 1994). A PAL value of 1.4 corresponds to the maintenance requirement, which is the minimum level of energy expenditure compatible with health, and so a value of 1.4 times the BMR may be used as a cut-off point for assessing the prevalence of chronic energy deficiency (Shetty and James, 1994). The body mass index is used to determine the height to weight relationship and by exposing underweight individuals gives an indication of the extent of food insecurity in a population. The body mass index (BMI) can be used as a reflection of the body energy stores and is calculated as:

$$\frac{\text{weight in kilogrammes}}{(\text{height in metres})^2}$$

Individuals with a BMI >18.5 are considered to have adequate energy reserves, as are those with a BMI between 17 and 18.5 and a PAL >1.4. However those with a PAL index value <1.4 may be suffering from chronic energy deficiency (Shetty and James, 1994).

4.3 Individual dietary survey methods

Individual dietary survey methods measure actual food intake at the individual level by taking a dietary history, administering a food frequency questionnaire, recording weights of foods consumed, asking respondents to recall what they ate in the previous 24 hours or analysing the chemical and nutrient content of diets (Wiehl and Reed, 1960; Ferro-Luzzi, 2002). This information is then compared with dietary energy requirements to determine the proportion of the population with deficient energy intakes (FIVIMS, 2002). The methods are flexible and can be adapted to fit the purpose of the study. Individual intake surveys therefore assess food patterns, provide estimates of intake of particular foods and are the only existing method to reveal intra-household distribution of food (FIVIMS, 2002). In addition to providing data on energy availability, food intake surveys give estimates of micronutrient intakes (Mason, 2002).

One unique strength of the individual dietary survey method is that the results can be validated using the doubly labelled water method which measures energy expenditure (Ferro-Luzzi, 2002). Large-scale individual dietary intake surveys may not be the best way to monitor trends of food security over time because of the associated costs and logistical difficulties (Ferro-Luzzi, 2002), and so this technique may be a useful validation tool for other food security measurement approaches that are routinely used. Constraints encountered in conducting a dietary survey in developing countries include cultural reluctance to allow strangers to handle foods destined for home consumption, local taboos or rules that cause embarrassment and limit cooperation, and the culturally specific ways of purchasing, storing and cooking food (Kigutha, 1997). Some studies have shown that fat and carbohydrate intakes are under-reported to a larger extent than protein (FIVIMS, 2002), while fish and other non-staple foods consumed in small quantities may be missed in surveys, leading to an underestimate of levels of micronutrient intake (Mason, 2002). Indeed under-reporting is common in dietary assessment surveys causing a potentially significant source of error.

4.4 Household income and expenditure surveys

Food insecurity is increasingly concentrated in particular regions or groups within countries and thus there is a great need for sub-national information. Household income and expenditure surveys (HIES) obtain information on a variety of specific conditions, experiences and behaviours indicating the severity of the condition (FIVIMS, 2002). The set of food security questions (see Box 3) can be combined into a single overall measure called the food security scale which is a continuous, linear scale measuring the degree of severity of food insecurity experienced by a household. The statistical procedure depends on the number of affirmative responses to the increasingly severe sequence of survey questions which examine three key measures of food insecurity (Smith, 2002):

The *household food energy deficiency* measure indicates whether a household falls below a certain energy intake requirement by comparing energy availability with a requirement based on age and sex composition (Smith, 2002). The depth of energy deficiency can therefore also be determined.

Dietary diversity, the number of different foods or food groups consumed by a household, is considered to be a good summary measure of diet quality (Hoddinott and Yohannes, 2002). The quality of food is a complex characteristic that determines its safety, nutritional value, acceptability to the consumer and functional properties (FSIEWS, 2001). There is some debate as to whether dietary diversity can be considered as an indicator of food security rather than just dietary quality, but recent work has shown that increased dietary diversity is associated with increased birth weight, child anthropometric status and haemoglobin concentrations (Allen *et al*., 1991; Bhargava, Bounis and Scrimshaw, 2001; Rao *et al.,* 2001).

The *percentage of a household's total expenditure on food* gives an indication of their vulnerability to food insecurity in the future. In the case of a job loss, natural disaster, disease onset or price policy reform, a household will be particularly at risk if over 70 percent of their income is spent on food (Smith, 2002).

Household income and expenditure surveys (HIES) are a source of policy relevant measures allowing monitoring and targeting of regional or national prevalence of food insecurity. However data collection and computation costs are high in terms of time, financial resources and technical skill required and cannot determine inequalities of access to food between individuals within a household (Smith, 2002). The household is only examined at the time of interview so changes may well occur, and estimates may be biased through systematic non-sampling errors. In addition, social desirability problems may occur when respondents do not want to look bad in front of interviewers (FIVIMS, 2002).

Box 3: **Specimen core food security module where all questions below are answered: often true, sometimes true, never true or don't know/refused**.

1. I worried whether my food would run out before I got money to buy more.
2. The food that I bought just didn't last and I didn't have money to get more.
3. I couldn't afford to eat balanced meals.
4. I relied on only a few kinds of low-cost food to feed the children because I was running out of money to buy food.
5. I couldn't feed my children a balanced meal because I couldn't afford that.
6. My children were not eating enough because I just couldn't afford enough food.
7. In the last 12 months, since last (name of current month), did you ever cut the size of your meals or skip meals because there wasn't enough money for food?
8. How often did this happen – almost every month, some months but not every month, or in only one or two months?
9. In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money to buy food?
10. In the last 12 months, were you very hungry but didn't eat because you couldn't afford enough food?
11. In the last 12 months, did you lose weight because you didn't have enough money for food?
    If affirmative response to any one of these questions, continue, otherwise skip to end.
12. In the last 12 months did you ever not eat for a whole day because there wasn't enough money for food?
    If affirmative response to above:
13. How often did this happen – almost every month, some months but not every month, or in only one or two months?
    If there are children under 18 years old in the household, ask the next questions, otherwise skip to end.
14. The next questions are about children living in the household who are under 18 years old. In the last 12 months, since (current month) of last year, did you ever cut the size of your child's meals because there wasn't enough money for food?
15. In the last 12 months did (child's name) ever skip meals because there wasn't enough money for food?
    If affirmative response to above
16. How often did this happen- almost every month, some months but not every month, or in only one or two months?
17. In the last 12 months, was your child ever hungry but you just couldn't afford more food?
18. In the last 12 months, did your child ever not eat for a whole day because there wasn't enough money for food?

Table 1: **Current methods for assessing food insecurity**

Method	Main indicator(s)	Data acquisition	Level of indicator	Potential problems	Advantages	Sources
Qualitative	Percentage reporting experience of food insecurity and hunger.	Interviews looking for perceptions of energy inadequacy.	Individual, population subgroups and national.	Analysis does not include information on prices and quantities in markets or the functioning of the transport system. Perception of deprivation is influenced by person's relative position in society.	Quick to administer, well understood by policy-makers and specific to country and context.	Bickel *et al.* 2000; Kennedy 2002; Mason 2002.
FAO	Comparison of energy requirement norms with usual food consumption, expressed in terms of daily dietary energy supply (DES).	DES per capita for a country, derived from food balance sheets.	National.	Roots and tubers are not included in food balance sheets, which may also have flawed production and trade data. Only energy intakes are considered, but not that of micronutrients.	DES gives good indication of where individuals are suffering and correlates with income to indicate extent of poverty.	Svedburg 1999; FIVIMS 2002; Mason 2002; Naiken 2002.
Individual dietary survey	Individual intake related to requirement.	Dietary history, food frequency questionnaire, record of food consumed, chemical and nutrient analyses.	Individuals or population subgroups.	Activity levels are largely unknown for assessing requirements and potential cultural constraints where strangers handle food. Fat and carbohydrate may be underreported while micronutrients are missed.	Flexible, reveals intra-household distribution of food and estimates micronutrient intake. Results can be validated with doubly-labelled water technique.	Kigutha 1997; FIVIMS 2002; Mason 2002.
Household income & expenditure survey	Depth of deficiency, dietary diversity and percentage of household's total expenditure on food.	Food security questions combined into overall scale.	Population subgroups or national.	Often fails to determine accurate account of food eaten outside home. Data collection and computation costs high and households may change after interview.	Valid, policy relevant, multilevel measure.	Hoddinott & Yohannes 2002; Smith 2002.
Anthropo-metry	Percentage of underweight or stunted children; adults with low body mass index (BMI).	Human body measurements compared with international reference standards.	National or population subgroups.	Children's ages must be accurately reported. Poor results may reflect past history of undernutrition rather than current problem. Risk of food insecurity may still be high and temporal changes not indicated.	Simple, non- invasive, precise method that can be carried out by relatively unskilled personnel using inexpensive equipment.	Gibson 1990; Maxwell & Frankenberger 1992; FIVIMS 2002; Cogill 2003.

4.5 Anthropometry

Anthropometry is the use of human body measurements to obtain information about nutritional status. It is a simple, safe and non-invasive procedure giving precise quantification of the degree of undernutrition (Gibson, 1990). Nationally representative anthropometric surveys have now been carried out for most developing countries which allow estimates to be made of the proportion of the population lying below established cut-offs and who are therefore considered to be undernourished (FIVIMS, 2002). Undernutition is diagnosed when individuals' anthropometric measurements in terms of weight and height fall below international reference standards (Cogill, 2003). Anthropometric indicators used for assessing the nutritional status of children now have a degree of international acceptance but due to the varying effect of puberty there are currently no accepted indicators for undernutrition in adolescents. The status of adults is determined using the body mass index (see Box 2) thus indicating the extent of food insecurity in a population by exposing underweight individuals. Those individuals with a BMI <18.5 are considered to have inadequate energy reserves which, evidence suggests, increases morbidity and mortality, decreases work productivity and lowers birth weight in offspring (FIVIMS, 2002). Poor growth in children as well as underweight in adults may be the consequence of both inadequate food intake and poor absorption of food caused by environmental factors such as infections which can lead to the impairment of physical and cognitive functions (Shetty, 2002).

Information is generated on past nutritional history and relatively unskilled personnel can perform measurement procedures using inexpensive equipment. The methods used are therefore suitable for large, representative population samples and can be used to monitor and evaluate changes in nutritional status over time (Gibson, 1990). Country trends are particularly useful for determining the rate and slope of progress or regress and anthropometry can also be used to track individual status, for example monitoring a child's weight over time is a powerful tool to look at the impact of introducing a new crop or technology such as aquaculture (FIVIMS, 2002). However, there is some debate as to whether undernutrition is an adequate measure of food insecurity as poor anthropometric results, especially stunting, reflect a past history of undernutrition rather than a current problem (FSIEWS, 2001). Anthropometric indicators are status indicators and therefore do not indicate changes in the nutritional status of population or the most vulnerable groups. In addition, acceptable anthropometric results do not necessarily demonstrate adequate food security as risk levels may be high (Maxwell and Frankenberger, 1992).

5. MEASURING AQUACULTURE'S CONTRIBUTION

Although food security is not generally a major objective of present-day aquaculture production, aquaculture does contribute to overall food supply by increasing the production of popular fish, thus reducing prices and by broadening the opportunities for income and food access (McKinsey, 1998; Sverdrup-Jensen, 1999). Thus aquaculture is thought to be an important mechanism for local food security through reduced vulnerability to uncontrollable natural crashes in aquatic production, improved food availability, improved access to food and more effective food utilization (see Figure 2). At present there is no standard method of measuring and quantifying the contribution of aquaculture to food security. Instead the role of aquaculture can be assessed by looking at its impact on a variety of different aspects of food security using several core indicators, some of which are briefly discussed below.

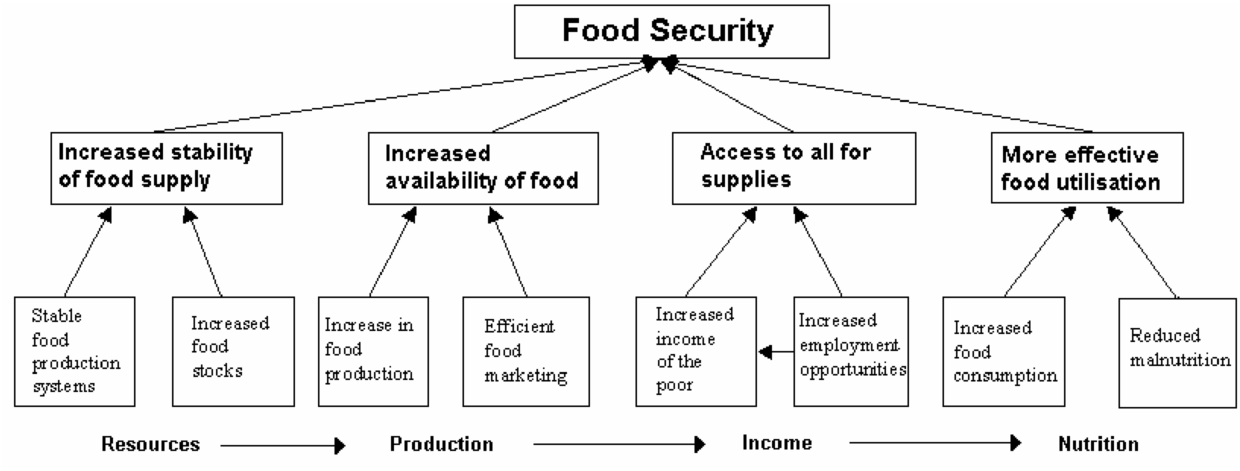

Figure 2: The interrelation of generic indicators of food security
(adapted from Saad, 1999; Metz, 2002; Webb *et al.*, 2002)

5.1 Stability of food supply

To be food secure, a population, household, or individual must have access to adequate food at all times. Thus food should be accessible all year round, irrespective of the political or economic situation. Agriculture is particularly vulnerable to environmental shocks such as droughts and floods, and so assessing the reduced susceptibility of aquaculture to natural catastrophes would give an indication of its importance to food security. This could be done by comparing trends in traditional agricultural food production with those from aquaculture under different environmental conditions. Quantifying the cost of losses in the case of inevitable disaster is another way of comparing aquaculture with traditional farming methods. Aquaculture is often a more predictable use of available resources than alternative types of farming (Williams, 1999). Thus the general trends in availability of aquaculture products could also give an indication of the stability of food supply.

The percentage of fish farmer's total income received from aquaculture could also be an important measurement of its role in alleviating hunger and poverty, particularly if the amount remains relatively constant throughout the year. If on the contrary fish are only sold during times of economic need, such as when school fees are due, then aquaculture would appear to be more important for financial security than for food security. Coping strategies, such as the foods which are stored or consumed in times of crisis, indicate those foods which are most important for the poor. If these foods are primarily aquaculture products then one could infer that aquaculture is important not only in providing food during the most critical periods, but also in providing cheap and accessible food to those most in need (Ali and Delisle, 1999; Maxwell *et al.,* 1999). The stability of food supply relies on fish production changing in parallel with the human population density in the region, thus this comparison determines whether per caput production is stable and maintains constant food availability.

5.2 Availability of food

Individuals require sufficient quantities of appropriate food to be available from domestic production or commercial imports. The relative importance of an increase in aquaculture production could be determined by comparing the per caput food fish supply from aquaculture with that from capture fisheries (Pillay, 1999). The amount of land and water required per quantity of food produced in aquaculture could also be compared to that achieved on land, although species diversity, levels of intensification and the range of products produced may make this evaluation hard. In terms of availability of food supply, the direct contribution of aquaculture to food security could be measured by comparing consumption of aquaculture products to total food consumption measured in terms of energy (kcal/person/year) or protein.

Trade contributes to food availability by reducing supply variability, fostering economic growth and eliminating the gap between production and consumption needs (World Bank, 2003). Data on imports and exports of aquaculture products from sub-Saharan Africa are currently limited but measuring the quantities and value of products traded would be a good indirect indicator of food security. Statistics of products bought and sold at markets could give an indication of aquaculture trade, although some small-scale farmers may not trade at markets. Price fluctuations appear to increase local production, thus assisting rural livelihoods and food security (FAO, 2003a). Thus prices of traded aquaculture products as well as input costs, such as the price of fingerlings, fishmeal and fertilizers, could be used as indicators of the contribution of the technology to food security.

5.3 Access for all to supplies

Increasing the supply of fisheries products is not sufficient to improve food security without the assurance of economic, physical and social access to adequate and nutritious food (Kent, 1997; FSIEWS, 2001). Economic access to food occurs when households generate sufficient income to buy food and nations generate foreign exchange to pay for food imports (Sigot, 1998; Williams, 1999). Consumption of fish, often a non-staple food, rises rapidly with income on a percentage basis (Bouis, 2000). One could infer that the higher the proportion of income spent on aquaculture products, the greater the importance of aquaculture in relieving food insecurity since the very poor will buy the most nutritional and calorific food that they can afford. Therefore one method of measuring the relative contribution of aquaculture to food security could be to compare the proportion of income spent on aquaculture products to those spent on other food items as well as on food in general.

Poverty is measured by the percentage of people living in households consuming less than US$1 a day at purchasing power parity (CFS, 2001). The distribution of poverty could be compared with that of aquaculture over time in order to determine whether the extent of poverty decreases in the presence of aquaculture. Aquaculture may provide a primary source of income to many farmers thus ensuring economic access to food (Williams, 1999; Ahmed and Lorica, 2002). The extent of employment revenues, which could be determined through individual surveys, can be used as an indirect measurement of the contribution of aquaculture to food security. A comparison of direct revenues generated from aquaculture to the value of items in the consumption basket can also give an indication of the relative indirect contribution of aquaculture products to food security.

Individuals must be able to get to food supplies and so increasing the physical access of the poor to productive resources may be a more reliable guarantee of food security than increasing purchasing power (Ahmed, 1999). The supply of fish in landlocked nations may be limited by poor infrastructure or storage facilities and so the accessibility of dried fish may be important in areas where fresh and frozen products are not easily available (Thilstead and Roos, 1999). Important aspects therefore include the distance from food distribution sites and the types of products available in nearby markets (FSIEWS, 2001). Commercial aquaculture may primarily respond to the market demand of the rich rather than improving food security (Kent, 1987) and so indirect indicators, such as the literacy level, dependency ratio and gender of fish farmers, could be used to determine what type of household benefits from aquaculture (Webb, Coates and Houser, 2002).

Social access to food requires supplies to be equitably available to people of all cultures and beliefs. Thus studies on the attitude towards aquaculture would be useful to assess the acceptability of the technology by different classes and religions (Pérez-Sánchez and Muir, 2003). Equitable social access to aquaculture could also be determined by assessing which aquaculture products are acceptable in different societies and whether there are any gender differences.

5.4 Effective biological utilization of food

The effective utilization of food is an important aspect of food security and relies on sufficient energy consumption and a varied diet to provide required micronutrients. Inadequate diets are likely to occur primarily in terms of quality rather than quantity as poor people will initially strive to fill their stomachs to meet their energy needs and the cheapest foods have the poorest quality (Allen, 1994). At a global level there has been significant progress in raising food consumption per person, and diets have shifted away from staples such as roots and tubers towards livestock products and vegetable oils (Bruinsma, 2003). The energetic contribution of aquaculture products could be assessed in terms of calorific importance (Christiaensen and Boisvert, 2000). However people do not live on carbohydrate sources alone and a high percentage of energy derived from starchy staples, such as cereals, roots and tubers, indicates a relatively poor diet in terms of diversity. Low dietary diversity suggests that people are deficient in many of the micronutrients needed for good health (CFS, 2001). Which species of fish is farmed is therefore a potentially useful indication of aquaculture’s role in alleviating hunger, as fish have different amounts of flesh, calcium-rich bones, vitamins and fatty acids (Prein and Ahmed, 2000). Protein should provide between 10 and 12 percent of energy intake while the recommended amount of fats is between 15 and 30 percent (FSIEWS, 2001). Thus in addition to assessing the percentage of energy in the diet derived from cereals, the proportion of protein derived from aquaculture products should also be considered. Animal protein supply could also be determined across different regions to indicate where aquaculture gives the greatest benefit (Tacon, 2003).

Several studies have used anthropometry, the use of human body measurements to obtain information about nutritional status, to show that improved nutrition is linked to increased productivity and wages (Strauss, 1986; Strauss and Thomas, 1998; Croppenstedt and Muller, 2000; Bruinsma, 2003). Life expectancy is lowest in countries with the highest prevalence of undernourishment because hunger and malnutrition shorten lives. A high incidence of under-five mortality, wasting, undernourishment and stunting can also indicate food insecurity, although other factors such as disease prevalence and health care are also important (Maxwell *et al.*, 1999; Bruinsma, 2003). Although improved life expectancy, growth, fertility and reduced mortality rates are useful indicators of an improving food situation, neither these statistics nor those derived from anthropometry can be attributed solely to the presence or absence of aquaculture.

6. THE OUTLOOK

It may seem ironic that despite many major technological achievements, ranging from sequencing the human genome to exploring planet Mars, the international community has still not succeeded in solving the global issues of poverty and feeding the hungry. Recent years have seen substantial problems with the safety of farmed food due to Bovine Spongiform Encephalopathy (BSE), dioxin poisoning and the Foot and Mouth crisis which has led to predominantly negative feelings amongst the general public towards intensive farming methods such as aquaculture (Burbridge *et al.,* 2001). Aquaculture often focuses more on increasing production rather than system security, stability or sustainability and thus has the potential to become another high risk technology. Nevertheless the sustainability of aquaculture has been assessed in the past (Thompson *et al.,* 2000) and should continue to be monitored in different parts of the world as it has the potential of reducing poverty and food insecurity which are the most crucial and persistent problems facing humanity, especially in sub-Saharan Africa where the overall picture remains bleak (see Table 2).

The main threats to ensuring stable access to food in sub-Saharan Africa are economic variability, drought and civil strife (FAO, 2003c). In addition HIV/AIDS is expected to have a substantial negative impact on a number of countries in sub-Saharan Africa, which has about 70 percent of the 34 million existing cases worldwide (CFS, 2001). It is predicted that by 2010 the world's population will have reached 6.8 billion, with 205 million people living in sub-Saharan Africa (Bruinsma, 2003). Per caput food consumption in sub-Saharan Africa will probably remain at around 2 360 kcal/person/day, though with substantial regional variations (Bruinsma, 2003). Problematic soils limit agriculture from expanding in sub-Saharan Africa and only 21 percent of the population lives within 100 km of a navigable river or the coast compared to 89 percent in high-income countries (Bruinsma, 2003). Maintaining the present rate of consumption in the face of human population growth will require a global increase of 19 million tonnes of fish every year from 2010 (Safina, 1998). Due to Africa's low per caput fish consumption there is ample scope for an increase in demand.

Although currently important in only a few countries in sub-Saharan Africa, aquaculture may supply much of the future increase in fish production provided the technology remains economically feasible and socially acceptable (Satia, 1989). Africa has the natural resources to support an aquaculture evolution and as a significant contributor to employment and income generation it is likely to contribute to alleviating poverty (Brummett and Williams, 2000; De Silva 2001). Aquaculture is also an important domestic provider of much needed, high quality, animal protein, generally at prices affordable to the poorer segments of society (Ahmed and Lorica, 2002; Subasinghe, 2003). Worldwide, aquaculture has expanded, diversified, intensified and advanced technologically; as a result, its contribution to aquatic food production has also increased significantly (Jia *et al*., 2001). The extent to which this increase has contributed to improving food security remains to be assessed.

Table 2: Sub-Saharan African countries with threatened food supplies (FAO/GIEWS, 2003)

Country	Reason for emergency
Angola	Internally displaced persons (IDPs)
Burundi	Dry weather, civil strife and IDPs
Cape Verde	Drought
Central African Republic	Dry weather, civil strife and IDPs
Congo, Democratic Republic of	Civil strife, IDPs and refugees
Congo, Republic of	Civil strife and IDPs
Côte d'Ivoire	Dry weather, civil strife and IDPs
Eritrea	Drought, IDPs and returnees
Ethiopia	Drought and IDPs
Guinea	Population displacement and refugees
Kenya	Drought
Lesotho	Adverse weather
Liberia	Civil strife, IDPs and shortage of inputs
Madagascar	Drought, cyclones and economic
Malawi	Adverse weather, especially floods
Mauritania	Drought
Mozambique	Drought and floods
Rwanda	Drought
Sierra Leone	Civil strife and population displacement
Somalia	Drought and civil strife
Sudan	Drought and civil strife in the South
Swaziland	Drought in parts
Tanzania	Drought in parts and refugees
Uganda	Drought, civil strife and IDPs
Zambia	Drought in parts
Zimbabwe	Drought, economic disruption

7. CONCLUSION

Eliminating hunger and malnutrition can save millions of lives every year. It is generally recognized that aquaculture could make a substantial contribution to achieving this goal, especially in sub-Saharan Africa. If socially acceptable, economically viable and environmentally friendly, aquaculture could also play an essential role in reducing poverty. However although methods are in place for identifying those affected by food insecurity, the methodologies of assessing the contribution of technologies, such as aquaculture, to food security and poverty reduction are poorly documented. Because of the complexity and extent of food insecurity, it may be difficult to devise a single method for assessing aquaculture's contribution to alleviating poverty and hunger. There are a number of biological and socio-economic indicators that give a good indication of whether a technology is beneficial to global, national and local food security. Assessing and quantifying even small benefits is essential for improving food security as it allows the advantages of one type of food production to be compared with the advantages of others. Further work should combine the indicators outlined in this study to form a single methodology to assess the contribution level of both small-scale and commercial aquaculture to alleviating hunger and poverty in different parts of sub-Saharan Africa. The outcome would determine the extent to which the promotion of this sub-sector should be encouraged in the many food insecure regions of the world where its sustainable development is possible.

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APPENDIX

Some indicators of malnutrition, poverty and hunger as mentioned in the text above

(Source: CFS, 2001; CIA, 2002; BWI, 2003; CIDA, 2003; FAO/GIEWS, 2003; Fishstat, 2001; UNICEF, 2003).

GENERAL DATA ON SUB-SAHARAN AFRICA

Country *(* aquaculture prod.; LIFDCs in bold)*	Area 1000 km²	Population millions mid 2002	Projected pop. change % 2002-2050	Fertility rate 2000	Life expectancy at birth male 2002	female 2002	Child rate of mortality (% age <5) 2000	Aquaculture Production tonnes 2001
Angola	1247	12.7	319	7.2	44	47	29.5	0
Benin	112.6	6.6	173	5.9	53	56	15.4	0
Botswana	600	1.6	-27	4.2	39	40	10.1	0
Burkina Faso*	274	12.6	172	6.9	46	47	19.8	5
Burundi*	27.8	6.7	202	6.8	46	41	19	100
Cameroon*	475.4	16.2	114	4.9	54	56	15.4	50
Cape Verde	4	0.5	81	3.4	66	72	4	0
Central Afr. Rep.*	623	3.6	75	5.1	42	46	18	125
Chad	1300	9	270	6.7	49	53	19.8	0
Comoros	2230	0.6	199	5.2	54	59	8.2	0
Congo, Dem. Rep.*	2300	55.2	229	6.7	47	51	20.7	400
Congo, Rep.*	342	3.2	235	6.3	49	53	10.8	200
Côte d'Ivoire*	322.5	16.8	112	4.9	44	47	17.3	1025
Dijbouti	23.2	0.7	64	6	42	44	14.6	0
Equatorial Guinea	28.1	0.5	185	5.9	49	53	15.6	0
Eritrea	117.6	4.5	198	5.5	53	58	11.4	0
Ethiopia*	1100	67.7	155	6.8	51	53	17.4	5
Gabon*	267.7	1.2	47	5.4	49	51	9	102
Gambia*	11.3	1.5	186	5	51	55	12.8	1
Ghana*	238.5	20.2	58	4.4	56	59	10.2	6000
Guinea*	245.9	8.4	147	6.1	47	48	17.5	5
Guinea-Bissau	36.1	1.3	161	6	43	46	21.5	0
Kenya*	580.4	31.1	20	4.4	47	49	12	1009
Lesotho*	30	2.2	29	4.7	50	52	13.3	8
Liberia*	111.4	3.3	204	6.8	49	52	23.5	14
Madagascar*	587	16.9	178	5.9	53	57	13.9	7749
Malawi*	118	10.9	38	6.6	37	38	18.8	568
Mali*	1200	11.3	221	7	46	48	23.3	35
Mauritania	1000	2.6	175	6	53	55	18.3	0
Mauritius*	2	1.2	22	2	68	75	2	59
Mozambique*	802	19.6	17	6.1	38	37	20	5
Namibia*	824.3	1.8	35	5.1	44	41	6.9	70
Niger*	1300	11.6	346	8	45	46	27	21
Nigeria*	923.8	129.9	134	5.7	52	52	18.4	24398
Rwanda*	26.3	7.4	20	6	39	40	18.7	435
Senegal*	196.7	9.9	129	5.4	52	55	13.9	151
Sierra Leone*	71.7	5.6	166	6.5	38	40	31.6	30
Somalia	637.7	7.8	229	7.3	45	48	22.5	0
South Africa*	1221	43.6	-25	3	50	52	7	4329
Sudan*	2500	32.6	95	4.7	55	57	10.8	1000
Swaziland*	17	1.1	80	4.6	40	41	14.2	72
Tanzania*	945	37.2	137	5.3	51	53	16.5	7300
Togo*	56.8	5.3	84	5.6	53	57	14.2	120
Uganda*	241	24.7	241	7.1	42	44	12.7	2360
Zambia*	753	10	104	5.9	37	37	20.2	4200
Zimbabwe *	391	12.3	-18	4.8	39	36	11.7	200
Sub-Saharan Africa	24300	693	132	5.7	52	54	17.5	62151
UK (for comparison)*	*242.9*	*60.2*	*9*	*1.7*	*75*	*80*	*0.6*	*170516*

CURRENT FOOD SUPPLY AND EFFECTS OF HUNGER IN SUB-SAHARAN AFRICA

Country *(*aquaculture prod.; LIFDCs in bold)*	Per capita food supply DES kcal/day 2000	Food production 2000	Cereal share of total calories % 2003	Undernourished population % 1998-2000	Undernourished population millions 1998-2000	Proportion of children underweight (% age <5) 1995-2000	stunted	wasting
Angola	1.9	103.8	32	50	6.3	-	-	-
Benin	2.6	123.1	36	13	0.8	29	25	14
Botswana	2.3	76.9	51	25	0.4	13	23	5
Burkina Faso*	2.3	106.2	75	23	2.6	34	37	13
Burundi*	1.6	82.2	16	69	4.3	45	57	8
Cameroon*	2.3	100.4	43	25	3.6	21	35	5
Cape Verde	3.3	105.8	50	-	-	14	16	6
Central Afr. Rep.*	1.9	107.2	22	44	1.6	24	39	9
Chad	2.0	94.7	54	32	2.5	28	28	12
Comoros	1.8	87.1	44	-	-	25	42	12
Congo, Dem. Rep.*	1.5	57.7	18	73	36.4	34	45	10
Congo, Rep.*	2.2	92.6	30	32	0.9	14	19	4
Côte d'Ivoire*	2.6	100.6	41	15	2.3	21	22	10
Dijbouti	2.1	69.7	53	-	-	18	26	13
Equatorial Guinea	-	74.5	15	-	-	-	-	-
Eritrea	1.7	102.2	79	58	2	44	38	16
Ethiopia*	2.0	102.5	68	44	27.1	47	51	11
Gabon*	2.6	88.7	26	8	0.1	-	-	-
Gambia*	2.5	104.1	55	21	0.3	17	19	9
Ghana*	2.7	134.5	28	12	2.2	25	26	10
Guinea*	2.4	119	44	32	2.6	23	26	9
Guinea-Bissau	2.3	111.3	58	-	-	23	28	10
Kenya*	2.0	80.4	50	44	13.2	23	37	6
Lesotho*	2.3	102.2	78	26	0.5	16	44	5
Liberia*	2.1	92.9	39	39	1	20	37	3
Madagascar*	2.0	76.7	53	40	6.2	33	49	14
Malawi*	2.2	119.2	58	33	3.7	25	49	6
Mali*	2.4	102.1	73	20	2.3	43	-	-
Mauritania	2.6	81	54	12	0.3	23	44	7
Mauritius*	3.0	96.4	45	5	0.1	16	10	15
Mozambique*	1.9	92	43	55	9.8	26	36	8
Namibia*	2.6	88.5	64	9	0.2	26	28	9
Niger*	2.1	101.1	69	36	3.8	40	40	14
Nigeria*	2.9	115.4	45	7	7.3	27	46	12
Rwanda*	2.1	91.2	17	40	2.8	29	43	7
Senegal*	2.3	103.2	61	25	2.3	18	19	8
Sierra Leone*	1.9	69	54	47	2	27	34	10
Somalia	1.6	81.7	34	71	6	26	23	17
South Africa*	2.9	84.5	54	-	-	-	25	-
Sudan*	2.3	128.7	56	21	6.5	17	-	-
Swaziland*	2.6	69.2	44	12	0.1	10	30	1
Tanzania*	1.9	76.8	51	47	16.2	29	44	5
Togo*	2.3	100.3	47	23	1	25	22	12
Uganda*	2.4	100.1	21	21	4.7	26	38	5
Zambia*	1.9	82.3	65	50	5.1	25	59	4
Zimbabwe *	2.1	92.4	58	38	4.7	13	27	6
Sub-Saharan Africa	2.2	98.4	47.2	33	195.9	30	41	10
UK (for comparison)*	*3.3*	*86.2*	-	-	-	-	-	-

ECONOMIC AND DEVELOPMENT SITUATION IN SUB-SAHARAN AFRICA

Country *(*aquaculture prod.;* *LIFDCs in bold)*	Adult literacy rate (% age >15) male 2000	 female 2000	Population below poverty line % 1984-2000	GNP per capita US$ 2000	GDP per capita % growth 1999-2000	External debt (US$) millions 2000
Angola	56	29	-	290	-0.8	10146
Benin	52.1	23.6	33	370	3.1	1598
Botswana	74.5	79.8	33.3	370	2.5	413
Burkina Faso*	33.9	14.1	61.2	3300	-0.4	1332
Burundi*	56.2	40.4	61.2	210	-1.6	1100
Cameroon*	82.4	69.5	40	110	2	9241
Cape Verde	84.5	65.7	-	580	-	-
Central Afr. Rep.*	59.7	34.9	66.6	-	1.1	872
Chad	51.6	34	64	280	-2.1	1116
Comoros	63.2	48.7	-	200	-	-
Congo, Dem. Rep.*	73.1	50.2	-	-	-	11645
Congo, Rep.*	87.5	74.4	-	570	4.9	4887
Côte d'Ivoire*	54.5	38.6	36.8	600	-4.9	12138
Dijbouti	75.6	54.4	-	-	-	-
Equatorial Guinea	92.5	74.4	-	-	-	-
Eritrea	67.3	44.5	53	170	-10.6	311
Ethiopia*	47.2	30.9	31.3	100	3	5481
Gabon*	80	62	-	3190	-0.6	3995
Gambia*	44	29.4	64	340	2.3	471
Ghana*	80.3	62.9	31.4	340	1.3	6657
Guinea*	50	22	40	450	-0.3	3388
Guinea-Bissau	54.4	23.3	48.7	180	5.2	942
Kenya*	88.9	76	42	350	-2.5	6295
Lesotho*	72.5	93.6	49.2	580	2.5	716
Liberia*	36	18	-	-	-	2032
Madagascar*	73.6	59.7	70	250	1.6	4701
Malawi*	74.5	46.5	54	170	-0.4	2716
Mali*	48.9	34.4	72.8	240	2.1	2956
Mauritania	50.7	30.1	57	370	1.7	2500
Mauritius*	87.8	81.3	10.6	3750	6.9	2374
Mozambique*	60.1	28.7	37.9	210	-0.7	7135
Namibia*	82.8	81.2	34.9	2030	1.6	-
Niger*	23.8	8.4	63	180	-3.2	1638
Nigeria*	72.4	55.7	34.1	260	1.3	34134
Rwanda*	73.7	60.2	51.2	230	3.1	1271
Senegal*	47.3	27.6	33.4	490	2.9	3372
Sierra Leone*	45.4	18.2	68	130	4.9	1273
Somalia	36	14	-	-	-	2561
South Africa*	86	84.6	11.5	3020	1.4	24861
Sudan*	69.5	46.3	-	310	6.4	15741
Swaziland*	80.8	78.6	40	1390	0	262
Tanzania*	83.9	66.5	41.6	270	2.7	7445
Togo*	72.4	42.5	32.3	290	-3.7	1435
Uganda*	77.5	56.8	55	300	0.8	3408
Zambia*	85.2	71.5	86	300	1.3	5730
Zimbabwe *	92.8	84.7	25.5	460	-6.7	4002
Sub-Saharan Africa	66.2	49.4	46.7	470	0.6	215794
UK (for comparison)*	*99*	*99*	-	*24430*	*2.7*	-