NARROWING THE NUTRITION GAP: INVESTING IN AGRICULTURE TO IMPROVE DIETARY DIVERSITY

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ABSTRACT

This paper presents an overview of how agriculture can contribute to improving dietary diversity and nutrition outcomes in developing countries. Following a discussion on why increasing production of staple crops is not enough to accelerate reductions in malnutrition, the concept of the "nutrition gap" is introduced - the gap between what foods are grown and available and what foods are needed for a healthy diet. This term helps to differentiate nutrition security from food security and to articulate the concept of dietary diversity, which requires increasing availability and access to the foods necessary for a healthy diet, and increasing the actual intake of such foods. Various food typologies or consumption patterns from developing countries are used to illustrate how dietary diversity and quality is often insufficient in a variety of contexts, including those where total dietary energy supply is adequate. Sample agriculture-based interventions are presented, each aiming to improve dietary diversity and quality with the long-term objective of accelerating reductions in malnutrition. Finally, a series of policy recommendations are made. These range from proposals for ways to raise nutrition's profile on national development agendas to recommendations for successful implementation of agriculture-based nutrition programmes to promotion of nutrition security within international contexts

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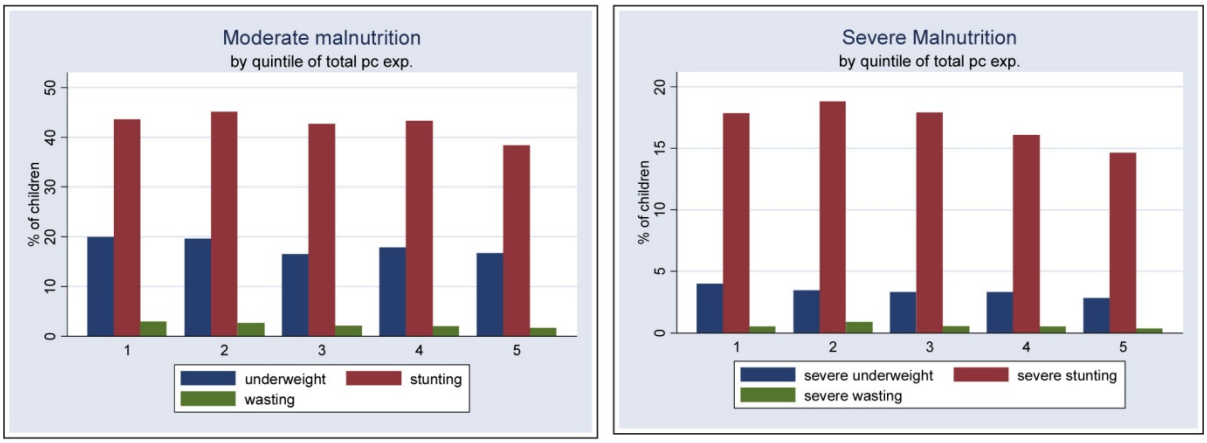
1. Agriculture's Role in Reducing Hunger and Malnutrition

1.1) Increasing production of staple crops is not enough to accelerate reductions in malnutrition

Agricultural development programmes that aim to address food security by increasing production of staple crops are, by themselves, often not enough to accelerate reductions in hunger and malnutrition. Increased staple crop production may result in increased energy availability but it does *not* guarantee comparable improvements in nutrition outcomes. Similarly, direct reductions in income poverty and improved purchasing power do not generally result in proportional reductions in malnutrition.

The current consensus is that although higher incomes do improve nutrition outcomes, they tend to do so at unacceptably slow rates (FAO 2012, Ruel et al. 2013). Momentum for this perspective has been building for the last decade. For example, a doubling of GNP per capita in developing countries was shown to reduce child underweight rates by only 9 percent in 2003 (Haddad et al. 2003). Further, data from many countries have shown persistent high undernutrition rates in regions and households where staple crop production is high and food availability is good. For instance, both the Arsi region in Ethiopia and the Iringa region in Tanzania have high production rates *and* very high stunting rates[1] (62 and 66 percent, respectively [World Bank 2006a]).[1] Another example is Malawi, a country with very high malnutrition rates. Per Figure 1, malnutrition does occur less frequently in children from upper income quintiles in Malawi, but the difference between the richest and poorest households is minimal (5 percent) and does not decline consistently across quintiles (World Bank 2006b).

Figure 1. Child malnutrition and household wealth in Malawi



Source: World Bank (2006b)

Malnutrition can occur despite increased food availability and higher incomes for a number of reasons, including poor maternal and child feeding practices as well as inequitable food allocation within households. Other causes of malnutrition include inadequate sanitation, poor or non-existent health services, and lack of access to safe, potable water.[2]

[1] Based on the WHO classification for assessing severity of malnutrition in children 0 to 5 years of age where stunting <20 percent low, 20-29 percent medium, 30-39 percent high, ≥ 40 percent very high

[2] While not obviously associated with poor nutrition outcomes, these problems contribute to high levels of infection and disease which compromise the immune system, increasing susceptibility to malnutrition.

In addition to these explanations, a leading cause of persistent malnutrition is *poor dietary diversity,* that is, poor quality and variety of food in the diet. Poor dietary diversity can occur in a variety of contexts, including those where food availability is good and purchasing power is sufficient. It is typically expressed as a monotonous diet that is too high in carbohydrates and too low in nutrient-rich foods. This intake pattern is common in many parts of the developing world, even among households who can afford to eat better. This type of diet, which is high in starch but low in protein, fat and micronutrients, will result in malnutrition even if dietary energy supply (DES) is adequate. Stunting, nutrition-related anaemias, and iron, zinc and Vitamin A deficiencies are just a few examples of the types of "hidden" malnutrition that can occur in individuals who are consuming enough total energy but not enough macro and micro nutrient-rich foods such as meat, fish, eggs, dairy, legumes, fruits and vegetables. In less secure households where income and DES are low, malnutrition resulting from inadequate caloric intake will be exacerbated by poor dietary diversity. In both cases, increasing consumption of nutrient-rich foods is key to improved nutrition outcomes.

1.2) Agriculture-based interventions to improve nutrition security and narrow the "nutrition gap"

To improve the probability that increases in production or purchasing power do lead to accelerated reductions in malnutrition, agricultural development programmes must include *nutrition security* (in addition to food security) in their objectives. In an agricultural context, nutrition security refers to the "quality" aspect of food production, consumption and utilization by all individuals in a household[3]. While food security may increase the total *quantity* of energy available for consumption, only nutrition security can guarantee the *quality* and *diversity* of food necessary for protecting and promoting good nutritional status and health (Thompson et al. 2009)

Just as improving food security can be thought of in terms of narrowing the gap between current and potential production yields, improving nutrition security can be thought of in terms of narrowing the "nutrition gap" between current food intake patterns and intake patterns that are optimal in terms of macro and micronutrient content (Figure 2). Narrowing the nutrition gap means improving dietary diversity through increasing availability and access to the foods necessary for a healthy diet, and increasing the actual intake of those foods.

The example of optimised food intake shown in Figure 2 shows how various food groups can be combined to ensure both food security (adequate energy intake)and nutrition security (adequate macro and micro nutrient intake). In contrast, the DES data for Ghana and Ethiopia indicate monotonous diets low in animal source foods, fats and micronutrients. Increasing the contribution of nutrient-rich foods to correct this imbalance is what we mean by narrowing the nutrition gap.

Agriculture can narrow the nutrition gap in a number of ways. Some of the most important are:

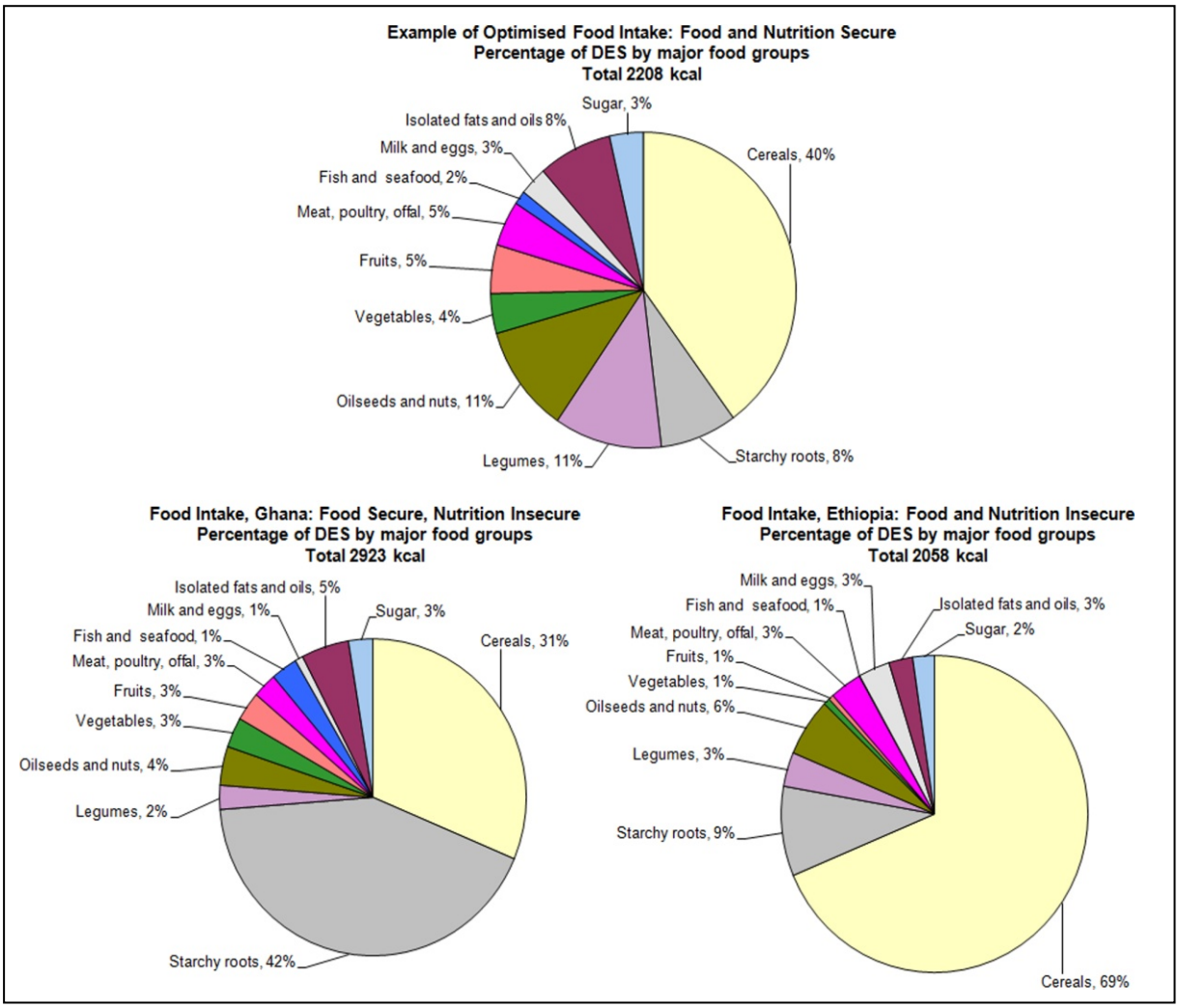
- Increasing small-scale production of nutrient-rich foods
- Increasing commercial production of nutrient-rich foods
- Reduction of post-harvest losses to maintain nutrient levels in commonly eaten foods
- Plant selection and breeding to increase nutrient levels

[3] A full definition of nutrition security is as follows: **Nutrition security** exists when food security is combined with a sanitary environment, adequate health services, and proper care and feeding practices to ensure a healthy life for all household members. In addition to proper hygiene, health and care, nutrition security also requires consumption of a diet that is adequately diversified in terms of macro and micronutrients. (Adapted from World Bank, 2006a.)

- Extension-based (or supported) education and social marketing strategies that increase consumption of nutrient-rich foods
  (Thompson and Amoroso 2011, Herforth et al. 2012, SCN 2013a)

The food typology examples below illustrate how these strategies translate into interventions in the field. Each focuses on ways to boost production and/or consumption of high quality foods in one of a series of "typical" agriculture-based food typologies based on geographical area (selected countries from FAO's regional classification system). It is important to note that within each of the areas described, intake patterns differ according to a host of factors (e.g. livelihood, purchasing power, degree of urbanization, region, and consumer preference). Hence the following examples should be qualified as only broadly representative of commonly consumed diets in a given region. Their primary purpose is not to catalogue all of the intake patterns in a particular area, but rather to illustrate how poor dietary diversity occurs in a wide variety of contexts.

Figure 2. Nutrition Gap Example: DES by major food groups in Ethiopia and Ghana compared to a model of optimized intake[4]



Source: Authors own

[4] This example should not be taken as a prescriptive "model diet" as dietary requirements exist only in terms of nutrients which can be sourced from a range of food, leading to a potentially wide variety of very different dietary patterns, many of which are adequate in terms of total energy supply as well as nutrient requirements.

2. NARROWING THE NUTRITION GAP FOR SPECIFIC FOOD TYPOLOGIES

Each food typology includes a number of specific country examples:

- Rain-fed roots and tubers in West Africa
- Irrigated/rain-fed rice in South and Southeast Asia
- Rain-fed cereals in Central and East Africa
- Irrigated/rain-fed maize and beans in Central America

While framed according to specific food typologies, many of the interventions discussed below can be applied to a range of countries, agro-ecological zones and dietary patterns.

2.1) Rain-fed roots and tubers in West Africa

(Burkina Faso, Cote d'Ivoire, Ghana, Nigeria)

One of the most important staple food crops in West Africa is cassava. Cassava is hardy, drought resistant, maintains acceptable yields on low-fertility soils and is of great importance for subsistence farmers throughout the region. Yam, sweet and Irish potatoes, and taro are other foods grown in this area. All these staples are high in carbohydrate. Diets in this region may also include bananas, plantains, rice, maize, sorghum, peanuts, and a variety of vegetables. Meals typically consist of a starchy staple (e.g. cassava–based *gari or foufou,*) and sauce; the latter can include a variety of ingredients, most commonly peanuts and/or vegetables. Consumption of animal source foods (ASFs) in western Africa may be low, especially among the rural poor. Bushmeat and insects, small livestock and poultry for both meat and dairy, and fish are eaten, but quantities are often inadequate to ensure nutrition security.

Protein intake may be low in many root and tuber-based West African diets, especially when cassava is the main food source. Cassava roots are very low in protein with 1.2 grams protein/100 raw edible grams as compared to 6.1 grams for rice (Stadlmayr et al. 2012). And while yams and most other roots and tubers have higher protein contents than cassava, their nutritional composition is also inadequate to ensure nutrition security if not accompanied by sufficient protein-rich foods such as ASFs and legumes. In addition to low protein intake, this food typology may also be lacking in adequate amounts of fat and essential micronutrients, including Vitamin A, iodine, zinc and iron. For instance, twelve countries from the region either had Vitamin A deficiency of 10 percent or more, and/or iron deficiency anaemia of 20 percent or more in 2007 (World Bank 2006a). Moreover, even in West African countries where DES is adequate, macro and micronutrient deficiencies may persist. In Ghana, for instance, dietary energy supply meets population requirements, but contributions to DES made by protein and fats are lower than recommended (FAO 2009a). This situation clearly illustrates the difference between food and nutrition security (see Figure 2). Without sufficient diversification, adequate calories at the household level, (and certainly not in aggregate, which is how food security is often measured), rarely result in acceptable rates of declines in malnutrition.

Selectively breed cassava; introduce cassava leaves as a nutrient rich food; boost red palm oil production

Improving the nutrient content of cassava would be one very important way agriculture could narrow the nutrition gap in West Africa, as this crop is one of the most commonly consumed staples in the region. To date, high protein genotypes have been identified and the current challenge is to increase endogenous proteins containing adequate levels of the desired amino acids within common

cultivars (Beach 2009). Biofortification of cassava with provitamin A is also an option. To date, Harvest Plus (a member of the CGIAR consortium) has released varieties in Nigeria and DRC. A number of "spillover countries" in West Africa are also expected to benefit (Harvest Plus, 2013).

In addition to selective breeding of cassava to increase nutrient content and quality, encouraging consumption of cooked cassava leaves has potential for improving dietary diversity, this is especially true in areas of West Africa where they are not considered a conventional food source (Nweke 2004) In addition to protein, cassava leaves are also high in Vitamins A and C as well as calcium (Latham 1979). Especially noteworthy is the combination of Vitamin C and calcium, as the former increases bioavailability of the latter. Cassava leaves are available year-round, unlike a number of other vegetables that are commonly consumed in West Africa. As such, encouraging cassava leaf consumption in this region could reduce seasonal food insecurity and be extremely cost-effective, as it uses an existing resource which is already widely available, even in remote and resource poor areas, and that can be harvested at weekly intervals from plants that are as young as five months old (Nweke 2004). However, a communication strategy to increase awareness of the leaves as a potential food source, combined with education regarding the procedure required to eliminate toxicity (a three step process of soaking, pounding and boiling to remove cyanogens from the leaves) would be essential.

Per the above, Vitamin A deficiency (VAD) rates are high in many West African countries. Stimulating production and consumption of red palm oil (RPO), which is extremely high in Vitamin A, is one way to reduce VAD and at the same time generate income in the region. A pilot study in Burkina Faso showed that school children whose lunches were supplemented with 15 ml of RPO three times per week showed significant improvements in serum retinol (Vitamin A) levels (Zeba 2006). From a nutrition and public health perspective, meals supplemented with RPO are a sustainable, food-based alternative to Vitamin A supplements. From an agricultural perspective, palm oil plantations and the extraction and commercial distribution of RPO have income generating potential, especially for women, who are typically the ones involved in this industry (Zeba 2006). Increasing women's purchasing power is fundamental to improving nutrition as the resources and income flows that women control have been shown to have disproportionately positive impacts on health and food and nutrition security (World Bank 2007). A national strategy that combined a public health campaign to increase consumption of RPO, in conjunction with incentives based in the agricultural sector to increase RPO production[5] could narrow the nutrition gap through direct changes in intake and potential increased purchasing power.

2.2) Irrigated/ rain-fed rice in South and Southeast Asia

Bangladesh, Cambodia, Indonesia, Laos, Sri Lanka, Vietnam

Rice-based food typologies are the norm throughout South and Southeast Asia. Consumption patterns do vary between and within countries, but most diets consist primarily of rice supplemented to varying degrees with vegetables, pulses, ASFs, and some fruits. Fat and oil intake is often low, especially among low income groups. As a result, for many households, DES is predominantly derived from carbohydrates. For example, based on data from FAO's Food Balance Sheets, 63 percent of total

[5] It is important to note that job schemes which target women can backfire because employment affects time allocation in ways that can have a negative impact on nutrition. For example, breastfeeding - critically important during the first six months of life – can become very difficult either because employment takes the lactating mother away from the baby for long periods or because the employment activities are otherwise incompatible with breastfeeding. Given these potentially high opportunity costs, employment schemes aiming to increase women's purchasing power should also consider their net effect on women's time allocation, as introducing new demands for women's work may actually increase poor nutrition outcomes.

DES in Lao PDR came from rice in 2009. In Cambodia, the number was 64 and in Bangladesh it was 70. For Sri Lanka (where total DES is fairly high at 2416 kcals/per capita/day) it was 53 percent (2002). Although these are aggregate figures and intake patterns vary substantially within and between countries, such statistics are indicative of monotonous diets that are too high in carbohydrates and too low in ASFs and micronutrient rich fruits and vegetables. This may be especially true among rural households, where access to a diversified diet is constrained by both lack of purchasing power and limited availability.

Although malnutrition in Asia as a whole is decreasing (led in large part by China), South Asia still has some of the highest prevalence rates of malnutrition in the world and serious challenges also remain in South East Asia (UNICEF, WHO, World Bank, 2012, FAO 2013a). For instance, stunting prevalence rates in Cambodia and Indonesia were estimated at 41 and 54 percent in 2010 (WHO, 2013).[1] Estimated prevalence of iron deficiency anaemia for women and children is also high throughout South and Southeast Asia (FAO 2013a). The monotonous diets described above are one of the reasons for these persistent high rates of malnutrition.

Increase cultivation of nutritious dry season crops; agricultural extension-based nutrition education; integrated horticulture/aquaculture

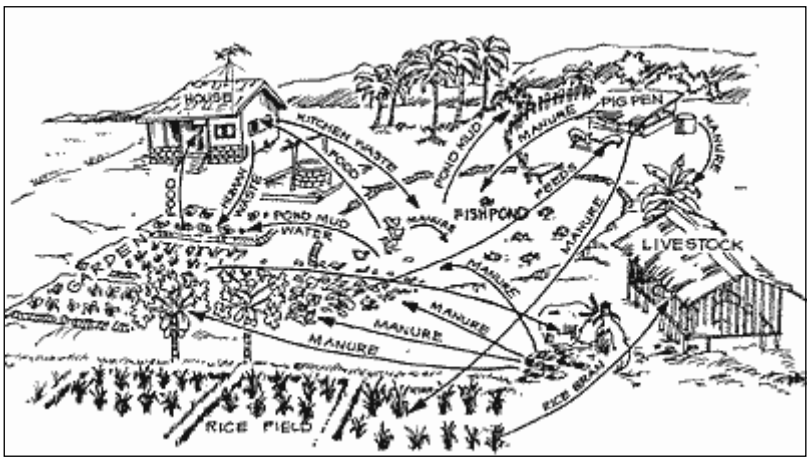
Although rice production cycles vary according to country and region, most areas where rice is grown have dry seasons during which non-paddy rice crops can be harvested. Facilitating cultivation of dry season crops can be especially important in areas where rice mono-cropping is common, as mono-cropping can increase vulnerability to production-based, cyclical patterns of food insecurity. For example, in Bangladesh, cultivation of lentils, peas and other pulses has declined, partly because rice is more lucrative, but also because the growing season of pulse crops is longer than that of rice, and because many pulses require more input and maintenance than do rice crops (Kennedy et al. 2005). Introduction or re-introduction of nutritious, low-input, short duration crops might thus be appropriate to improve availability and access to a more diversified diet. Mung bean, for example, is high in protein, iron, B Vitamins, folate, Vitamin C and a number of other nutrients. Mung beans have traditionally been grown by the poor but have become less popular due to the reasons cited above. From an agricultural perspective, mung beans have a short production cycle (approximately 60 days), minimal moisture requirements and improve soil fertility via nitrogen fixation. (Nono-Womdim 2010). Moreover, recent improvements in mung beans' nutritional content, pest and disease resistance, and maturation cycle (Spielman and Pandya-Lorch 2009) could facilitate their re-introduction. Soybean production for local consumption is another option. Although often promoted as a commodity crop for global markets, soybean cultivation can also be encouraged among smallholders to diversify production and capture positive rotation effects. Soybeans are high in protein and are a good source of poly- and monounsaturated fats as well omega-3 fatty acids. Another option is mustard, this hardy oil seed could also increase fat intake and is appropriate for many rice-based food typologies, particularly those that are rain-fed and subsequently drought prone (FAO 2009b).

Interventions that increase availability of nutritious crops are an important first step in improving nutrition security, but do not, in and of themselves, guarantee improved outcomes at the individual or household level. The cassava-based interventions described in the previous section focused on a staple food that is already commonly consumed in West Africa. In contrast, introduction of a food that may not be especially popular or common (e.g. soy beans in Bangladesh) must be accompanied by social marketing and education efforts to encourage consumption. This is because the target population may not be open to introduction of new foods, even those that are nutritious and practical from a production perspective. Furthermore, traditional dietary habits may work against good nutritional advice and/or may further reduce the nutritional value of foods (e.g. food taboos or cooking rice in excessive water as opposed to using absorption methods). In these situations,

extension-based social marketing and education services play a crucial role in creating awareness and promoting behavioural change. However, in many countries, agricultural extension, especially nutrition education services, are underfunded or nonextant. Investing in these services is imperative to the second step in narrowing the nutrition gap - increasing the actual intake of foods necessary for a healthy and balanced diet. In South and Southeast Asia, where preferences for polished rice, cooking habits, and cultural beliefs may exacerbate malnutrition, extension-based nutrition services are badly needed to both improve existing habits and promote healthy new ones.

Integrated horticulture/aquaculture projects are one way to improve households' access to ASFs, fruits and vegetables. In many areas of South and Southeast Asia, they fit into traditional production strategies. In Vietnam, for example, the VAC (Vegetation, Aquaculture, Cages for Animal Husbandry) system has been officially promoted since 1989 as part of a more general policy to improve crop diversification and nutrition security (Hop 2003). VAC farms typically include a pond stocked with fish placed close to the home, livestock or poultry pens situated near or over the pond to provide an immediate source of organic fertilization, and gardens that include both annual and perennial crops for year-round food provision as well as products for market (garden waste may also be used for pond fertilization).

Figure 3. Integrated Horticulture/Aquaculture System (VAC), Vietnam



Source: FAO/FII (2001)

Although the VAC system is specific to Vietnam, integrated horticulture/aquaculture projects are appropriate for a wide array of agro-ecological zones and have great potential throughout South and Southeast Asia (FAO 2001). Fruit and vegetable farming on fish pond embankments, cultivation of short cycle species in seasonal ponds and ditches, integrated fish-duck, fish-chicken, or fish-pig farming, and rice-fish farming are all examples. From a nutrition perspective, these strategies are exemplary in that they address deficits in ASFs and fruits and vegetables simultaneously. For example, even a small amount of haem iron (found only in ASFs) consumed with a meal where most of the iron is non-haem, (i.e. plant derived), will enhance absorption of all the iron in the meal. If this meal contains Vitamin C-rich fruits or vegetables, iron absorption will be further enhanced. In all regions, integrated horticulture/aquaculture projects increase the probability of these sorts of meals being consumed on a regular basis. In South and Southeast Asia, where iron deficiency anaemia (IDA) is especially pronounced, they present culturally viable opportunities to increase availability of iron and other essential micro-nutrients.

2.3) Rain-fed cereals in Central and East Africa

Central African Republic, Chad, Democratic Republic of Congo, Kenya, Malawi, Tanzania

The most common cereals used as staples in many areas of Central and East Africa include sorghum, millet, rice and maize. Other foods grown and consumed in this region include cassava, other starchy roots, and pulses. Fruits and vegetables are also cultivated, but production may be limited due to little or no access to water, seeds and other inputs, time constraints, and lack of knowledge regarding horticultural techniques. Livestock production in Central Africa is low, due in part to endemic trypanosomiasis, which causes anaemia, emaciation, decreased milk yields and death in non-resistant breeds of cattle and other livestock. Although livestock production in parts of East Africa may be high relative to Central Africa, it remains underdeveloped, especially in terms of low-input small ruminants and other options that do not require economies of scale (Mack 2009).

Typical diets in Central and East Africa consist primarily of a cereal-based porridge or paste (e.g. *nsima* in Malawi, *ugali* in Kenya) complemented by a meat or fish-based sauce, or by a relish which could include meat, fish and/or a variety of vegetables or legumes. Such meals are usually eaten twice a day. Fruits may also be consumed but intakes are highly seasonal and may also be limited in terms of access (e.g. budget constraints, poor market infrastructure). Like the other food typologies described above, diets are often lacking in micro and macronutrients and may also be inadequate in terms of energy. Intake patterns may be especially deficient in areas where conflict and political unrest have weakened infrastructure and reduced production. For example, based on data from FAO's food balance sheets, total energy intake in the Democratic Republic of Congo (DRC) was 1,605 kcals in 2003. Using the same food balance sheets from 2003, as much as 76 percent of DES came from cereals and starchy roots. It is unlikely that these very poor diets will have improved much in recent years. Even in more politically stable states, dietary diversity can be extremely poor. In Malawi, for example, cereals and starchy roots represented more than three-quarters of DES in 2008. Further, the DES provided by ASFs and fruits and vegetables were 3 and 4 percent, respectively. The lack of diversity in the Malawian diet is especially pronounced and most certainly contributes to its very high rates of stunting: 53 percent in 2006 (WHO 2013). However, stunting rates are high or very high throughout Central and East Africa ; micronutrient deficiencies are also common in these subregions, both VAD and anaemia prevalence rates are some of the highest in the world (Meerman et al. 2012).

Keyhole gardens; increase production of small ruminants and poultry; reduce post-harvest losses

Increasing small-scale production of micronutrient-rich foods at the community or household level is one way to improve crop diversity and increase availability of fruits and vegetables. However, implementation is contingent on, *inter alia,* water availability, soil quality, and seed availability. In many parts of Central and East Africa, these factors are of limited supply. Keyhole gardens, which are simple to implement and require minimal inputs, are one solution in such contexts. A keyhole garden is a raised mound of soil contained by stones. They have a simple drip-irrigation system based on a lined basket which is placed in the centre of the garden, and which disperses water throughout (Figure 4) allowing these gardens to use significantly less water than larger gardens do. Keyhole gardens can be built in places where it is difficult to plant conventional gardens (rocky areas, shallow arid/or compacted soils, etc), and are often placed near the entrance of dwellings to facilitate their watering with household waste water. As keyhole gardens are self-contained and can be built close to the home, they are good options where violence restricts travel. They maintain their soil fertility for 5 to 7 years, produce food all year round even under harsh temperatures and are prolific, supporting production of at least 5 varieties of vegetables at a time (FAO 2009).

Figure 4. Keyhole Gardens: Initial construction including (unlined) irrigation basket, and after planting

Source: FAO 2009c

As mentioned above, trypanosomiasis constrains livestock production in Central Africa, and, while production is higher in East Africa, many smallholders in this region could still increase outputs of poultry and small ruminants. Cross-breeding to improve hybrid vigor, increase resistance to trypanosomiasis, and increase meat and dairy yields is one way to do this. However, sustainability of this strategy is an issue as it requires constant maintenance of breeding stock as well as regular and costly re-introduction of non-indigenous species. A solution better-suited to smallholders, especially those who are facing budget constraints, is to increase productivity of existing local animals. Introducing improved housing and supplementary feeding through improved extension services can go a long way in reducing what are often extremely high losses among small ruminants and poultry (Mack 2009). For example, in areas where mortality rates for poultry are high, chickens and their eggs are rarely raised for home consumption. Farmers often allow the majority of their eggs to hatch in order to maintain the flock as an asset base, thus reducing opportunities to improve intake via direct egg consumption. If mortality rates can be reduced through improved housing and supplementary feeding as opposed to simply letting chickens forage, the risk to the farmer in letting eggs hatch will be reduced, and the probability of increased egg intake will increase (Mack 2009). From a nutrition perspective, supplementing central and east African diets with regular egg consumption could increase intake of protein, fat, and Vitamin A.

In addition to chickens, small ruminants like sheep and goats are well-suited to smallholders with limited resources. Like chickens, these livestock can survive on a combination of foraged foods and household scraps, and may not require much more than a simple, low-cost shed for housing. Furthermore, in Central Africa where trypanosomiasis is endemic, cattle are the main species affected. Goats and sheep are somewhat shielded from the disease and hence represent good options for smallholders who may not be able to afford antiparasitics or have no cattle to begin with. From a nutrition perspective, mutton and goat are excellent sources of Vitamin A, haem iron (as mentioned above, haem iron is iron in a highly bioavailable form), protein and essential amino acids. Sheep and goat milk provide calcium, fat, Vitamin A, and protein. Extension efforts to educate smallholders regarding the value of small ruminants and poultry and to provide simple, cost-effective solutions such as improved housing are well suited to Central and East Africa where small livestock ventures are underdeveloped. When combined with extension packages that provide farmers with the means to begin their own flock or herd, these types of interventions could plausibly improve dietary diversity through both direct consumption and increased purchasing power.

Poor harvesting practices and lack of adequate processing, packaging, storage and preservation techniques can lead to post-harvest losses for a variety of crops. Losses can be especially high for micronutrient-rich foods, which have a very short shelf life (Thompson and Amoroso 2011). Although post-harvest losses of perishables are high throughout the developing world, they are especially high in sub-Saharan Africa (Aworh 2008). Large scale reductions in post harvest losses require improvements in infrastructure (e.g. cold chain refrigeration, road construction and repairs) that are beyond the scope of this paper. However, strategies to reduce post-harvest losses can also be rudimentary, low cost, and appropriate for smallholders. For example, solar drying of beta-carotene rich fruits and vegetables (e.g. mangoes, pumpkins, and orange fleshed sweet potatoes) can preserve Vitamin A levels for up to six months. Simple solar dryers can also be used for green leafy vegetables such as amaranth, which are common in both east and central Africa and are high in iron, folic acid and Vitamin C. Even more basic techniques, such as growing root crops on raised beds or mounds to avoid damaging the root during harvest, can make a difference, especially among cereal-based food typologies who may store roots and tubers to eat as supplementary staples in lean seasons between grain harvests (FAO 1989).

2.4) Irrigated/ rain-fed maize and beans in Central America

El Salvador, Guatemala, Honduras and Nicaragua

Maize and beans are grown and eaten throughout Central America. Together with sugar, these staples provide the bulk of DES for most households. Maize may be eaten in the form of tortillas, beans are typically mashed into a paste or cooked as a soup or stew, and copious amounts of sugar are added to weak coffee or sometimes a thin, corn gruel (*atol*). These may be complemented by a variety of items including a cow's milk cheese (*queso blanco*), eggs, plantains, avocadoes, bananas, carrots, chilis, onions, tomatoes and/or leafy greens. However, in many cases, meals are lacking in diversity and inadequate in terms of fat, ASF-based protein and micronutrients. Meat is often too expensive for regular consumption, especially among low-income and indigenous groups, and fruits and vegetables may be consumed in insufficient amounts to ensure nutrition security (Mazar 2009). This lack of dietary diversity contributes to high rates of malnutrition in much of Central America, namely El Salvador, Guatemala, Honduras and Nicaragua. Although prevalence of stunting and underweight has decreased since the nineties, it still remains high relative to both South America and the Caribbean. In some cases, malnutrition rates are comparable to those found in sub-Saharan Africa and South Asia. For example, in Guatemala, almost half of all children under five years of age were stunted in 2008-2009 (WHO 2013).

Increase consumption of "trash fish"; intercrop using the Milpa System; greenhouses; integrate agro-forestry to increase fruit production; extension-based nutrition education

Fish farming throughout the developing world is increasing. However, fish are raised primarily for export and are not typically consumed by the local population. Since many aquaculture ventures displace indigenous species that may be a traditional food source for local populations, fish farming may actually reduce consumption of indigenous fish species with the end result being an overall decrease in ASF intake. Moreover, even when farmed species are consumed by local populations, net micronutrient intake can still decrease, as many small, indigenous fish are actually higher in micronutrients than popular farmed varieties (Figure 5). This is especially true when indigenous species are consumed whole, due to the high calcium content of the bones (Roos et al 2007). Encouraging continued consumption of these indigenous species, which are sometimes considered "trash" in comparison to farmed varieties, could increase micronutrient intake and may also galvanize efforts to design ecologically friendly, polyculture fish farms that include both commercial and indigenous species. This intervention is of relevance to many areas of Central America, where the majority of fish farms raise tilapia and other species for export (Toppe 2009, Karunasagar 2009).

Figure 5. Nutrient Content of Darkina, a "Trash Fish," Compared to Commonly Farmed Varieties

Selected micronutrients per 100 g edible portion of Darkina (*Esomus danricus*)

		Carp	Tilapia	Darkina	RDI
Calcium, Ca	mg	41	10	800	1000
Iron, Fe	mg	1.24	0.56	12.0	12
Zinc, Zn	mg	1.48	0.33	4.0	9
Vitamin A	mcg RAE	9	0	890	900

Source: Toppe 2009

Currently, many areas of Central America are primarily engaged in maize monocropping. Reintroduction of the *milpa* system, which promotes the intercropping of maize, beans and vegetables is a traditional way to increase crop diversity and can also improve dietary diversity, especially if accompanied by extension-based nutrition education services that promote healthy diets (FAO 2013c). Similarly, the use of greenhouses to increase production of cabbages, sweet potatoes, tomatoes and fruit has been successful in Guatemala and could be introduced to other countries in the area. Again, a nutrition education component would be essential to increase actual consumption of fruits and vegetables (Gavotti 2009; FAO 2013c).

Slash and burn cultivation is common in many parts of Central America. Poor yields, environmental degradation, and high rates of food and nutrition insecurity are negative spillovers typically associated with this type of agriculture. Introduction of the *Quesungual* system in Honduras has mitigated many of these problems. *Quesungual* is an integrated agro-forestry system which promotes maintenance of part of the forest canopy in conjunction to crop cultivation (FAO 2013c). From a nutrition perspective, many of the trees that are allowed to remain provide fruit for consumption. Dietary diversity is hence potentially increased. Moreover, no investment is required on the part of the farmer to increase fruit production and consumption. Introducing the *Quesungual* system to other areas of Central America, especially in concert with *milpa* intercropping techniques and greenhouse cultivation of fruits and vegetables, could significantly increase the availability of fruits and vegetables in the region (Gavotti 2009). Again, extension-based nutrition education is often necessary to increase awareness of the benefits of increased fruit and vegetable intake and would hence be an important component in these interventions.

3. POLICY RECOMMENDATIONS FOR AGRICULTURE-BASED APPROACHES TO NARROW THE NUTRITION GAP

Key policy recommendations[6] for narrowing the nutrition gap include (1) incorporating explicit nutrition objectives into agricultural research agendas, development policies and programmes, (2) building institutional and technical capacity at national and decentralized level, and (3) promoting the concept of "nutrition sensitive" or "nutrition enhancing" agriculture regionally and globally.

3.1) Incorporate explicit nutrition objectives into agriculture development policies (ADPs)

The formulation of an overarching development policy that addresses food and nutrition security is the first step to narrowing the nutrition gap. This process is often referred to as "mainstreaming," as its primary purpose is to mainstream food and nutrition security considerations into a country's broader development agenda. Poverty Reduction Strategy Papers (PRSPs), United Nations Development Assistance Frameworks (UNDAFS) and Five or Ten Year Plans are all examples of national policy frameworks into which food and nutrition security objectives need to be incorporated. Mainstreaming requires convincing policy makers that reductions in income poverty do not guarantee proportional reductions in malnutrition and that specific policies and targeted interventions for improving nutrition outcomes are necessary. As discussed in the initial section of this paper, a growing body of evidence exists to support this concept. However, many government officials as well as actors in the international development community continue to see the relationship between income poverty and malnutrition as simple and direct. Convincing decision makers that reductions in malnutrition will *not* occur at the same rate as reductions in income poverty is integral to building political commitment for nutrition.

The second step in narrowing the nutrition gap is to incorporate nutrition objectives into the mandate of the Ministry of Agriculture as well as Health, Education, Social Protection and other sectors that influence a country's food and nutrition situation. Convincing each of these agencies to address nutrition is essential;[7] however for the purposes of this paper we have focused only on the former.

Successful incorporation of nutrition objectives into an Agricultural Development Plan (ADP) requires a series of related activities. These include creating stakeholder ownership to increase the probability of sustained action, conducting a situation analysis and needs assessment to fully capture opportunities and risks, and designing policies, strategies and action plans in concert, as opposed to sequentially. Formulating policy and programme documents in tandem achieves three distinct goals. First and foremost, it grounds the ADP's objectives in reality. Second, it creates a direct link between those objectives and explicit budget allocations. Third, it creates opportunities for development partners to identify programmes they would like to support early in the process, further expediting funding for implementation. Throughout the process, improving nutrition outcomes, as opposed to simply increasing production to achieve national self-sufficiency, must be emphasized (Immink 2009).

[6] For a recent (June 2013) consensus document providing guidelines for "Improving nutrition through agriculture", please see http://www.unscn.org/files/Annual_Sessions/UNSCN_Meetings_2013/Agriculture-Nutrition_Key_recommendations.pdf. This document is cited in Sections 1.2 and 3.1 and discussed in Section 3.3.

[7] A number of sources on mainstreaming and working multisectorally have been published in recent years. In addition to Benson 2004, see for example Garrett and Natalicchio, 2011 and World Bank 2013.

The distinction between an ADP focused primarily on maximizing yields and an ADP that also aims to improve nutrition outcomes via improved dietary diversity is a crucial one. Just as "mainstreaming" requires convincing decision makers that income growth does not necessarily lead to proportional reductions in malnutrition, creating a nutrition-sensitive ADP requires convincing policy makers that improved food security must occur in conjunction with improved nutrition security, and that maximising production of staple foods and commodities is insufficient in and of itself to reduce malnutrition. For instance, although some of the country examples cited above focus on total energy deficiency, others (e.g. Ghana) illustrate how, if dietary diversity is insufficient, micronutrient malnutrition can persist even within a context of relative food security. Communicating this concept to agriculture-based decision makers is absolutely crucial to narrowing the nutrition gap.

The following explicit nutrition objectives may be incorporated into ADPs:

- Select crops based on nutritional content in addition to yield potential and market value
- Sensitize extension workers to food and nutrition security issues
- Promote simple technologies to guard against seasonal food insecurity
- Monitor and evaluate consumption and access to safe, diverse and nutritious foods (Knowles 2009, SCN 2013a)

Taken together, these objectives can be used to guide the sorts of interventions described in the sections above, namely increasing production of micronutrient-rich foods, reducing post-harvest losses to maintain micronutrient levels in commonly eaten foods, plant selection and breeding to increase micronutrient levels, and communication strategies to increase consumption of micronutrient-rich foods. The ultimate goal of these objectives and the subsequent interventions is to improve nutrition. ADPs that include strategies to achieve this goal through increasing dietary diversity are a crucial step in narrowing the nutrition gap at country level. An example of an ADP that incorporated nutrition initiatives is provided in Annex 1.

3.2) Build institutional and technical capacity at national and decentralized level

After mainstreaming nutrition objectives into broad national policy frameworks and incorporating nutrition objectives into the ADP and other sectoral policies and programmes, countries are faced with the challenge of implementation. Lack of technical and institutional capacity in assessing the situation, prioritizing needs, designing intervention strategies and providing operational and managerial support is a serious constraint (World Bank 2007, Natalicchio et al. 2009, Gillespie et al. 2013). In some countries, there may be a dearth of qualified personnel at every level - national, district, municipal and local. Community nutrition workers are often limited or non-existent. Agricultural extension workers and health staff receive either basic or no training in nutrition, and have poor skills in communicating nutrition information to specific population groups. (Moreover extension services are themselves often weak.) Funding for training nutrition specialists at all levels of government should thus be a priority. In addition, nutrition curriculae are frequently outdated. Aligning both academic and field materials with current scientific knowledge (e.g. plant selection and breeding to improve micronutrient levels) is integral to the application of nutrition policy objectives for maximum impact at community levels. Finally, resources for laboratory equipment, transportation to and from the field, computers and other materials which are often in short supply need to be mobilized. The cost of such equipment can be minimal (e.g. using SMS to collect and disseminate nutrition surveillance data) and should be a priority, even for departments with budget constraints.

At the institutional level, technical support is needed to identify and formulate appropriate policies and interventions, assess nutrition security situations, monitor trends, and evaluate their impact.

Awareness-raising and policy guidance regarding the concept of nutrition security and its practical application in the field can sharpen the focus of policy-makers and practitioners and improve capacity for effective action. One important example concerns monitoring and evaluation (M&E): In many countries, routine collection of food and nutrition security data does not occur. Few national surveys collect food consumption data at household (let alone individual) level with the needed periodicity (World Bank, 2012, FAO, 2013b). The same is true of child growth and micronutrient status. This lack of quality data presents a fundamental challenge to monitoring and evaluating nutrition security. Solving the problem requires administration of multipurpose, nationally representative household surveys that capture dietary diversity and other nutrition-related information (FAO 2013b). However, these types of M&E initiatives may be hamstrung by lack of capacity and/or reluctance on the part of project managers and planners to incorporate nutrition considerations into their management information systems. In situations where these constraints are present, one alternative approach is the use of an external team who carries out M&E for food security and nutrition at geographically representative sentinel sites. This option will certainly generate much needed nutrition data, it may also encourage collaboration efforts and capture information that is of interest to project managers whose primary focus is on agricultural growth (Levinson in SCN 2013b).

3.3) Promote "nutrition sensitive agriculture" within international contexts

While traditional food security models have historically fallen short in their efforts to reduce malnutrition, momentum is now building to better align agriculture and nutrition agendas to benefit from mutual synergies and to improve nutrition through agriculture (World Bank, 2012, SCN 2013a). To date, a general consensus has been reached on a series of recommendations (formerly "Guiding Principles") which are well-aligned with the objectives and intervention options presented above. These include programme and investment recommendations such as facilitating production diversification and increasing production of nutrient dense crops and small-scale livestock, as well as policy recommendations such as providing support to multi-sectoral nutrition strategies and developing capacity in human resources and institutions (SCN 2013a)

Ideally, these recommendations will galvanize regional and international policies, regulatory frameworks and agreements to support standard-setting processes in agriculture that promote nutrition security, as well as the related concepts of biodiversity and sustainable diets. Relevant examples from the interventions discussed in this paper include integrated agro-forestry (*Quesungual* in Central America*),* reintroduction of traditional plant species (mung beans in South and Southeast Asia) and responsible aquaculture (maintenance of aquatic biodiversity in Central America). Additional relevant strategies include adaptation measures for climate change, promotion of pro-poor food and agricultural trade policies that are conducive to nutrition security and encourage positive spillovers into local markets, and promotion of social safety nets that reduce harmful coping mechanisms among the most vulnerable.

The recognition that nutrition remains trapped in a "low priority cycle" (Nattalicchio et al. 2009) in many countries is also gaining traction. Findings from political economy analyses of how to create an enabling environment to break this vicious circle (Gillespie et al. 2013) are sharpening international interest to incentivize and deliver multisectoral coordination, and are an important recent addition to the discourse on promoting nutrition sensitivity in agriculture as well as other sectors.

4. CONCLUSION

Nutrition security refers to the quality aspects of food production, access and consumption, without which sustained and significant improvements in nutrition outcomes will remain elusive. If we are to reduce the unacceptably high levels of malnutrition which currently affect much of the developing world, achieving nutrition security must be given equal standing alongside the goals of poverty reduction and improved food security. This is especially crucial in contexts where dietary diversity is inadequate and where food security is a challenge.

Achieving nutrition security requires that development policies, strategies and plans include specific nutrition objectives and considerations. Given the role of agriculture in food-based approaches to malnutrition, investing in nutrition in this sector is especially important. Doing so requires that household and individual-focused nutrition initiatives to increase production and consumption of nutrient rich foods are incorporated into agricultural development policies and programmes.

In conclusion, narrowing the nutrition gap – the gap between what foods are grown and available and what foods are needed for a healthy diet – can only occur when national policy makers and members of the international development community recognize that attempts to reduce malnutrition solely via increased production of staple crops are not enough. ADPs and agricultural development programmes that address food *and* nutrition security are an essential step in reducing malnutrition; they enhance national prospects for improved labour productivity and economic growth, and increase the chances of long, healthy lives for even the most vulnerable.

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ANNEX 1

Nutrition Initiatives Recommended for Incorporation into Malawi's 2008-2012 Agricultural Development Programme (ADP)/ AgSWAP

(Source: 2008 consultative meeting on the incorporation of food and nutrition security in Malawi's agriculture development programme)

Sub Program 1.1. Promote production of diversified high nutritive value foods at household level. (Entry points for interventions include clusters, green belts, model villages and commercial estates.)

Objectives	Outcome Indictors	Action
Increase pulses productivity (beans, soy beans, pigeon peas, cow peas) and ground nuts	Yield increased from 0.5 to 3 metric tons per hectare (MT/ha)	▪ Facilitate multiplication (breeders and basic seed) and distribution of improved seeds ▪ Promote development of new varietals, conduct seed quality control, promote community seed banks, popularize improved seed technologies and agronomic practices
Increase root & tuber crop productivity (Yellow flesh potato, cassava, Irish potato)	Average yield increased for cassava from 20 to 25 MT/ha, sweet potato from 13 to 20 MT/ha *(Yield estimates from revised ADP)*	▪ Facilitate multiplication and distribution of disease free improved planting material of cassava, sweet potato, and Irish potato ▪ Develop mother nurseries for supply of cassava cuttings and sweet potato vines *(Action items from revised ADP)*
Increase plantain productivity	Increase MT/h *(No yield estimates provided.)*	▪ Introduce improved varieties of plantains
Increase vegetable productivity (amaranthus, kamganje, okra, carrots, pumpkin, moringa, tomato,)	Increase productivity for horticultural crops. *(No yield estimates provided.)*	▪ Improve existing systems from distribution of high quality vegetable seeds ▪ Promote adoption of integrated production and protection technologies for vegetables ▪ Promote establishment of gardens (backyard, communal, school)

Increase fruit productivity (pawpaws, avocado pear, mango, citrus, banana, masawu, masuku)	Increase productivity for horticultural crops. *(No yield estimates provided.)*	▪ Improve existing production and distribution systems of high quality fruit tree seedlings ▪ Promote adoption of integrated production and protection technologies for fruits ▪ Improve provision of vaccines/ vaccination services for poultry diseases
Increase household poultry population	▪ Chicken population increased from 13 to 18 million at national level ▪ Mortality rate reduced from 60 percent to 20 percent ▪ Chickens increased from 7 to 30 per household ▪ Egg production increased from 2,291 to 4,685 metric tons per year Guinea fowl population increased from 900,000 to 2,000,000 at national level *(Yield estimates from revised ADP)*	▪ Improve provision of vaccines/ vaccination services for poultry diseases ▪ Promote increased production of high quality feed, including development of local feed formulations ▪ Monitor and certify quality of poultry feeds ▪ Increase capacity of regional hatcheries and number of mini-hatcheries for rapid multiplication of chickens and guinea fowl.
Increase in small stock herd	▪ Goat herd size increased from 3 to 5.4 million ▪ Goat milk production increased from 0.5 liters to 1.5 liters per goat ▪ Rabbit herd size increased from 600,000 to 1.2 million per year. ▪ Pig herd size increased from 1 to2 million pigs per year. *(Yield estimates from revised ADP)*	▪ Promote goat re-stocking and farmer-to-farmer transfer (pass on) systems for meat and milk production. ▪ Introduce improved dairy goat breeds for milk production ▪ Improve provision of Swine Fever vaccines and vaccination services ▪ Disseminate information and technologies on rabbit management and meat processing *(Action items from revised ADP)*
Increase household aquaculture production	Household pond fish production increased from 700kg to 2,000kg per hectare	*(No actions items cited)*

Sub programme 1.2: Promote consumption & utilization of diversified high nutritive value foods at household level

Strategic Objective	Final Outcome Indicator	Action
Increase consumption of diversified high nutritive value foods	Proportion of household consuming diversified diet increased and measured by the household dietary diversity score (HDDS)	▪ Develop standardized messages covering production to utilization ▪ Produce information, education and communication (IEC) materials ▪ Train extension staff (via training of trainers) and households in processing, preservation, storage and utilization. ▪ Conduct staff and farmer training in food budgeting (e.g. 300kg maize + 50kg groundnuts + 50kgs soyabeans + 50kgs beans, per person per year) ▪ Conduct demonstrations on processing and utilization of a diversified diet. ▪ Conduct multi-media campaigns on dietary diversification ▪ Develop local recipes (with emphasis on the multi-mix approach) ▪ Conduct regular dietary monitoring and assessments ▪ Baseline study on the promotion of the six food groups approach and post-promotion evaluation (in year 3) ▪ Conduct joint staff and farmer training with the Ministry of Women and Child Development and Local Government and promote coordinated approaches
Increase consumption of micronutrient rich foods	Number of households consuming Vitamin A and iron rich foods increased	▪ Train extension workers on prevention of micronutrient deficiencies ▪ Conduct multi-media campaigns on consumption of Vitamin A and Iron rich foods ▪ Conduct consumer education on fortified foods
Improve quality of diets for the most vulnerable groups (Intensify nutrition education)	Number of vulnerable people accessing quality diets	▪ Promote consumption of enriched foods (soya, groundnuts, beans, pigeon peas, cow peas) in complementary feeding, maternal nutrition, and prevention for people living with HIV programmes ▪ Develop IEC materials on consumption, processing, preparation and utilization of enriched foods ▪ Conduct demonstrations on preparation of enriched phala in communities and at nutrition rehabilitation units and community therapeutic care sites

Sub programme 1.3: Capacity Building and Institutional Strengthening in the Food and Nutrition Security Programme

Strategic Objective	Final Outcome Indicator	Action
Improve the knowledge and skills of existing nutrition staff	Number of staff trained increased	▪ Conduct short courses on Nutrition ▪ Train nutrition officers to a higher academic level (Diploma, BSc, Masters and PhD level)
Increase staffing at all levels	Number of vacancies filled	▪ Fill vacant positions ▪ Conduct orientation of newly recruited staff in nutrition policies and programmes ▪ Coordinate recruitment with the Dept of Nutrition and HIV and AIDS
Improve resource allocation for nutrition programmes	Adequate resources provided, e.g. motorbikes, vehicles, bicycles, computers, lab equipment	▪ Procure equipment, facilities and vehicles for frontline staff
Strengthen institutional capacity	Number of institutions and systems developed and strengthened for nutrition	▪ Establish and strengthen Public/Private Partnerships ▪ Develop effective lobbying and advocacy strategies in nutrition at all levels ▪ Strengthen nutrition surveillance