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An Introduction to Nutrition-Agriculture Linkages

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Série de Relatórios de Pesquisa

A Direcção de Economia do Ministério da Agricultura apoia a publicação de duas séries derelatórios dos resultados de pesquisa na área de segurança alimentar. As publicações da série*Flash* são relatórios breves (3-4 páginas), cuidadosamente focalizados, visando fornecer resultados de pesquisa portunos em questões de grande interesse. As publicações da série de *Relatórios de Pesquisa* visam proporcionar análises mais detalhadas e profundas sobre questões de segurança de alimentar. A preparação de *Flash* e *Relatórios de Pesquisa* e sua discussão com os que desenham e influenciam programas e políticas em Moçambique é um passo importante para a missão geral de análise e planificação da Direcção. Os comentários e sugestões de utilizadores interessados sobre os relatórios publicados em cada uma dessas séries ajudam a identificar questões adicionais a serem consideradas emfuturas análises de dados e preparação de relatórios, bem como no desenho de actividades de pesquisa adicional. Os utilizadores destes relatórios são incentivados a submeter seus comentários e informar os autores sobre as suas necessidades contínuas de informação e análise.

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About Dr. Kim Chung (the contributor)

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ABSTRACT

Agricultural development is now expected to proceed in a way that maximizes opportunities to improve health and nutrition. Accordingly, the term “nutrition-agriculture linkages” describes the set of relationships that shows the mutual dependence of nutrition, health and agriculture. Changes in nutrition or health status are expected to affect agricultural production; conversely changes in the agricultural sector can have significant effects on individual health and nutritional status. Most development professionals, however, are sectoral specialists. Some are trained in nutrition or agriculture, but very few will be trained in both. It is therefore difficult to begin discussions on nutrition-focused agricultural programs and policies. How do we begin to identify these linked outcomes? And how do we begin to think about ways to impact factors that are outside of our sector of expertise?

This paper provides a simple framework for thinking critically about nutrition-agriculture linkages. The purpose is to help readers identify the linkages of greatest importance to their goals and to begin thinking about how to take steps toward integrating programs more effectively. Five different approaches are discussed and when possible examples are given from the Mozambique context. The framework illustrates the complexity of effecting nutritional changes through agricultural interventions, and underscores the importance of understanding the various mediating relationships in the nutrition-agriculture loop. Changes should be monitored at each link within the chain, with the understanding that changes to nutritional status will be the last to be affected. Given the complexity of these linkages it is important to think beyond advocating for a single approach and to instead think about building a larger, coherent strategy that comprises many varied approaches.

1. INTRODUCTION

Recently there have been renewed calls for greater integration of nutrition and agriculture policy (USAID 2010, IFPRI 2011). The reasons are many, but in general, good nutrition, and by extension, good health, are no longer seen as only outcomes of successful development. Rather, health and nutrition are increasingly framed as critical inputs to achieving economic growth and poverty reduction (WHO 2001, World Bank 2006). The World Bank, for example, speaks of repositioning nutrition within the development agenda. Stating that malnutrition "slows economic growth and perpetuates poverty" the World Bank presents improved nutrition as "essential to reducing extreme poverty" (World Bank 2006).

An accumulating body of evidence supports these claims (Fogel 1999, Sahn 2010). At the micro level, economic and nutrition studies maintain that better nutrition and health lead to greater labor productivity (Strauss 1986, Haddad and Bouis 1991, Thomas and Strauss 1997, Hoddinott et al 2008). The effects of poor nutrition are thought to be long-term, with poor nutritional status in early childhood affecting productivity in adolescence and adulthood (Haas et al 1995, Hoddinott et al 2008). In addition, some argue that poor health and nutrition create poverty traps for those who comprise the world's "ultra-poor" (Barrett 2010; Pinstrup-Andersen 2011). Too poor to invest in themselves or other productive assets, the poor fall into persistent states of poverty as they experience adverse shocks, such as serious illness or loss of livelihood assets. With only weak safety nets at their disposal, they are caught in a trap that reinforces poor health and nutritional status and weakens their ability to climb out of long-term poverty.

Intervention is needed to break out of this poverty trap. Agriculture remains an important focus for pro-poor interventions in countries such as Mozambique. Agriculture is the primary sector of employment for the poor (Barrett 2010) and food expenditures occupy the largest budget share of the poor (Ahmed et al. 2007); as such, agriculture has great potential to impact the food security of poor, rural households.

Since malnutrition, poor health, and low-productivity agriculture are recognized as mutually reinforcing states, there is heightened interest in addressing these problems jointly (von Braun et al 2010, Barrett 2010). Agricultural development is now expected to proceed in a way that maximizes opportunities to improve health and nutrition, while health and nutrition programs are expected to do the same for agriculture. The difficulty is that governments and donors tend to separate these responsibilities by sector. In addition, most development professionals are sectoral specialists and are not well-equipped to program for outcomes that lie outside their field of expertise (Benson 2011). As a result, it is difficult to initiate programs and policies that integrate the goals of two diverse sectors.

How do we begin to identify these linked outcomes? And how do we begin to think about ways to impact factors that are outside of our sector of expertise?

The purpose of this paper is to help with this process. The paper is written for our partners in government and the PVO community and is meant to provide a simple framework for thinking critically about nutrition-agriculture linkages. When possible the paper illustrates key linkages with examples from Mozambique. These examples are meant to help readers identify the linkages of greatest importance to their goals and to begin thinking about how to take steps toward integrating programs more effectively.

2. A PRACTICAL FRAMEWORK FOR ILLUSTRATING AGRICULTURE-NUTRITION LINKAGES

The term “nutrition-agriculture linkages” describes the set of relationships that shows the mutual dependence of nutrition, health and agriculture. Nutrition-agriculture frameworks usually feature looping relationships that illustrate the bi-directional causality, and thus interdependence, among their key components. Changes in nutrition or health status are expected to affect agricultural production; conversely changes in the agricultural sector can have significant effects on individual health and nutritional status (Sahn 2010). Agricultural interventions that are intended to lead to improvements in nutritional have also been called ‘nutrition-focused agriculture’ (Haddad 2011).

The renewed interest in nutrition-agriculture linkages in policy circles has led to the release of many frameworks that describe the relationship of health and nutrition to agriculture (Pinstrup-Andersen 2011, Herforth 2010, Deckelbaum et al 2006). Perhaps the most complete and conceptually tight framework is by Hoddinott (2011). Hoddinott’s framework identifies three basic components of the agricultural sector, each of which is a potential target for policy and programing. He then describes the channels through which changes to agriculture (through policy) can affect nutrition and health, and vice versa.

Hoddinott (2011) identifies three aspects of the agricultural sector that policymakers may target: the resources available to households, the context surrounding agricultural decision-making, and the processes that are used in agricultural activities. In doing so, he captures almost all ways in which agriculture may impact health and nutrition, and vice versa. The Hoddinott framework is extremely comprehensive, but it is not an easy place to begin thinking about nutrition-agriculture linkages.

This paper takes a more simplified approach. We start by focusing on rural households and intuiting the relationships that connect nutrition, agriculture and health at the household and individual levels (Figure 1). We then use this framework to present various approaches in which nutrition and agriculture goals have been integrated in the Mozambican context. Our focus is on nutritional outcomes, and as result, we do not detail the ways in which agriculture affects health status, and indirectly, nutritional status. For this topic we refer the reader to Hoddinott (2011).

Beginning on the left-hand side of Figure 1, household food production is expected to improve individual food intake by either 1) increasing consumption from own-production or 2) contributing to household income for the purchase of food. In turn, improved food intake provides energy that is needed for bodily growth, maintenance and activity. A high quality diet also provides protein and various micronutrients (vitamins and minerals) that are essential for optimum growth and functioning (Task Force for Child Survival and Development 1991). As such the term “diet quality” refers to the idea that an adequate diet will provide more than just energy, but also other essential nutrients needed by the body.

The linkages among agriculture and consumption are expected to be strong and direct for agricultural households since agricultural activity determines the amount, type, stability, control, and distribution of income. In addition, agriculture affects the food available for consumption by the household, including its diversity, quality and price (von Braun et al 2010).

Figure 1 also shows that adequate food intake is a necessary but not sufficient condition to produce good nutritional status. At the right side of the figure, we see that nutritional status is dependent upon health status, which is itself a function of health care behavior and the health environment (e.g. access to water, sanitation, health services, and healthy work conditions). Increased expenditures on education and health services are shown to have beneficial effects on nutritional status by supporting healthy behaviors and individual health status. The important point here is that nutritional status is

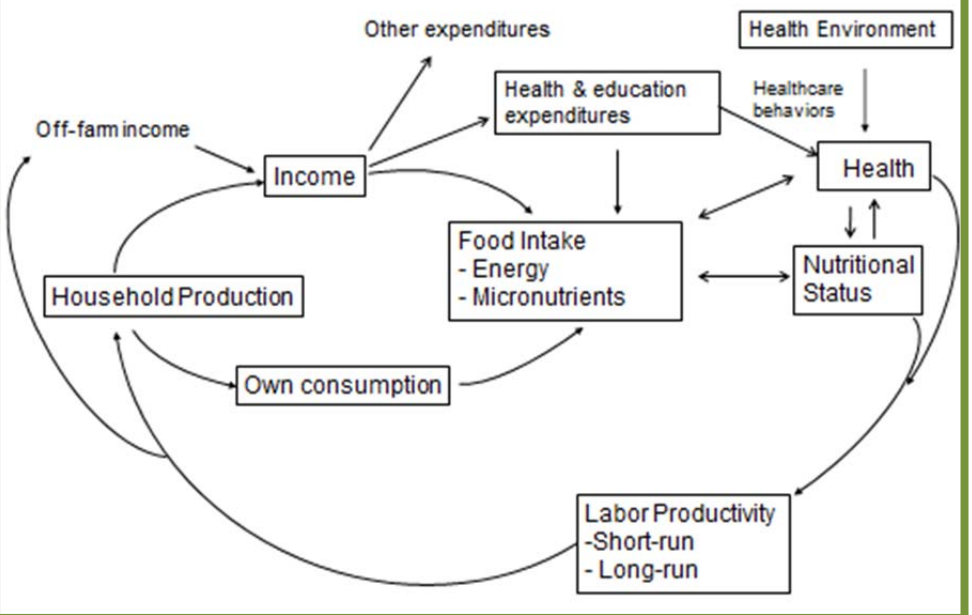
inseparable from health status and that any discussion of nutrition must take into account health care behaviors and the health environment (UNICEF 1990).

In addition, improved nutritional status and health status are expected to increase individual productivity in the short run (particularly in areas where manual labor is common) and in the long run, thereby improving household production and income. The set of agricultural-nutrition relationships at the household level is therefore bi-directional and suggests how vulnerable households can be locked in a vicious cycle of poverty and chronic under-nutrition (Sahn 2010). Exogenous shocks to production systems, or health, market or other conditions can start a downward spiral for vulnerable households.

In countries such as Mozambique the onset of HIV/AIDS in an individual can initiate a downward spiral in households. Since HIV/AIDS often strikes adults during the most productive years of their lives, it reduces the ability of individuals to work, forces the reallocation of household resources, and endangers the food security of all members of the household. As with other illnesses, HIV/AIDS and nutritional status are strongly interdependent. HIV/AIDS often leads to nutritional deficiencies due to reduced food intake, malabsorption, and increased nutrient use and excretion (Gillespie 2010). Because HIV/AIDS is so widely prevalent in rural areas it is an important threat to nutrition security among rural households (Pinstrup-Andersen 2010).

In sum, there are multiple links that connect agricultural production to nutritional status and projects must be clear about the links they intend to influence. Accordingly, achieving changes in household income, food consumption, or individual nutritional status through agricultural intervention requires a conscious effort to understand and monitor these links.

Fig 1: Ag-Nutrition Linkages at the Household and Intra-Household Levels



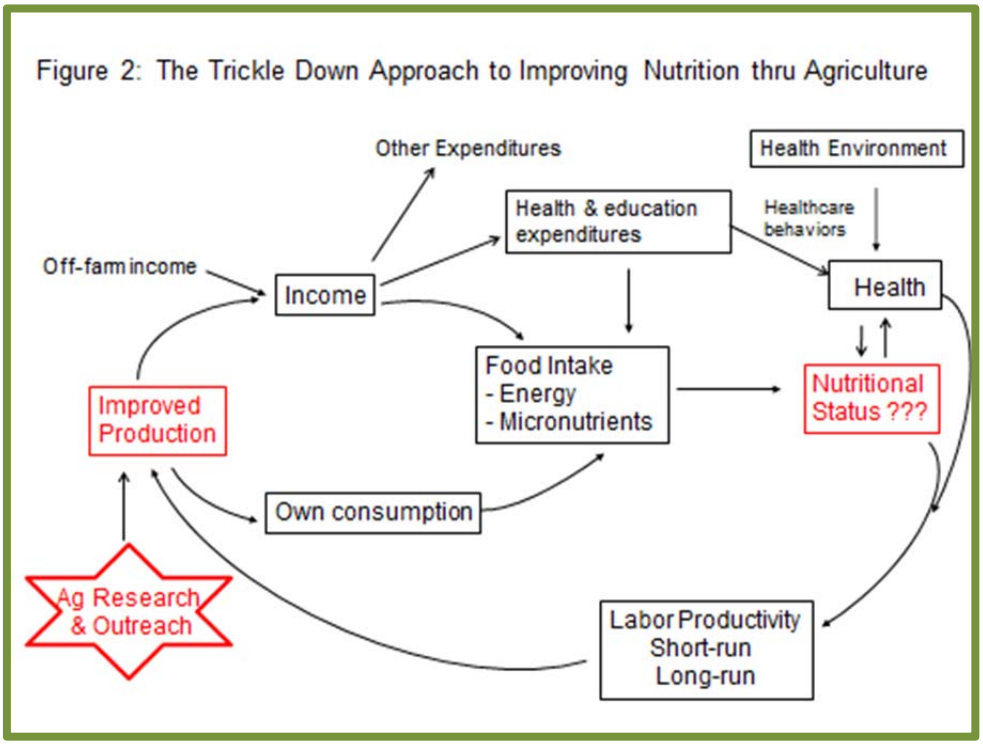
3. APPROACHES TO INTEGRATING NUTRITION-AND AGRICULTURE PROGRAMMING IN MOZAMBIQUE

Using the framework presented above, this section presents five models or approaches in which agriculture and nutrition programming are often integrated, 1) The Trickle-Down Approach; 2) The Biofortification Approach; 3) Fortification; 4) An Ag-Based Diet Diversity Approach; and 5) Gendered Approaches.

3.1. The Trickle-Down Approach (Figure 2)

In this approach, the focus is on improving production, usually through some sort of technical change at the farm level. Typically this involves some combination of research and outreach to develop and disseminate the new technology. Examples of such interventions include developing new varieties or management techniques that are expected to increase yields, farm output, and total income.

We call this the trickle-down approach because it assumes that an increase in output will elicit changes in nutritional status within the target households. In Figure 2, the intervention is marked by a red star and has its primary effect on improving household production.[1] Nutritional status is presumed to improve as a result of increases in own consumption or income. The trickle-down strategy can also benefit net consumers if aggregate production changes are large enough to reduce the price of crops that are nutritionally important.



[1] For visual clarity, all remaining Figures omit the link between individual labor productivity and non-farm income. Increased labor productivity is assumed to increase both farm and non-farm income as shown in Figure 1.

As an agricultural development strategy this is often a successful approach to improve household income. However, as a pro-nutrition agricultural strategy it is not easy to anticipate the final effects on individual nutritional status. There are, for example, many linkages that mediate the effect of improved production on nutritional status. It is possible that a technology increases yield or income from the target crop but does not increase total income or improve food consumption or nutritional status (Masset et. al. 2011). Households may sell their crop but not direct the new income to improved consumption or health (Kennedy 1994). Some household members may benefit disproportionately. A large literature explores these mediating relationships and makes it clear that it is an empirical question whether adoption of a new technology or management practice will result in increased income, food intake, or nutritional status (von Braun and Kennedy 1994; Quisumbing and McClafferty 2006). The end effect may be positive, negative or neutral on nutritional status.

As such, programs that take this approach must consider the mechanisms by which production changes are expected to affect nutrition or consumption indicators. Changes in total income should be tracked as well as diet composition. Program design should involve personnel that are familiar with the relationships that govern the production-income-consumption loop and with the literature documenting previous work in this genre. The body of work concerning agricultural commercialization and nutrition at IFPRI provides excellent examples of the complexity of these relationships (von Braun et al 1994), as does MSU's earlier work on the effects of cash cropping on household consumption and nutrition (Tefft and Kelly 2004; Kelly, et al. 2004). Masset et. al. (2011) provides an excellent review of the evidenciary base on each of these links.

Typically the weak link in doing this work is the ability to frame nutrition and agriculture questions in an interdisciplinary fashion. Many agricultural scientists, for example, will identify their work as having nutritional outcomes if the crop or animal they study is important to the livelihoods of the poor. But often their work will focus only on the technical aspects of a production problem. As agricultural scientists cannot be expected to examine nutrition-agriculture effects on their own, interdisciplinary partnerships are key to this work.

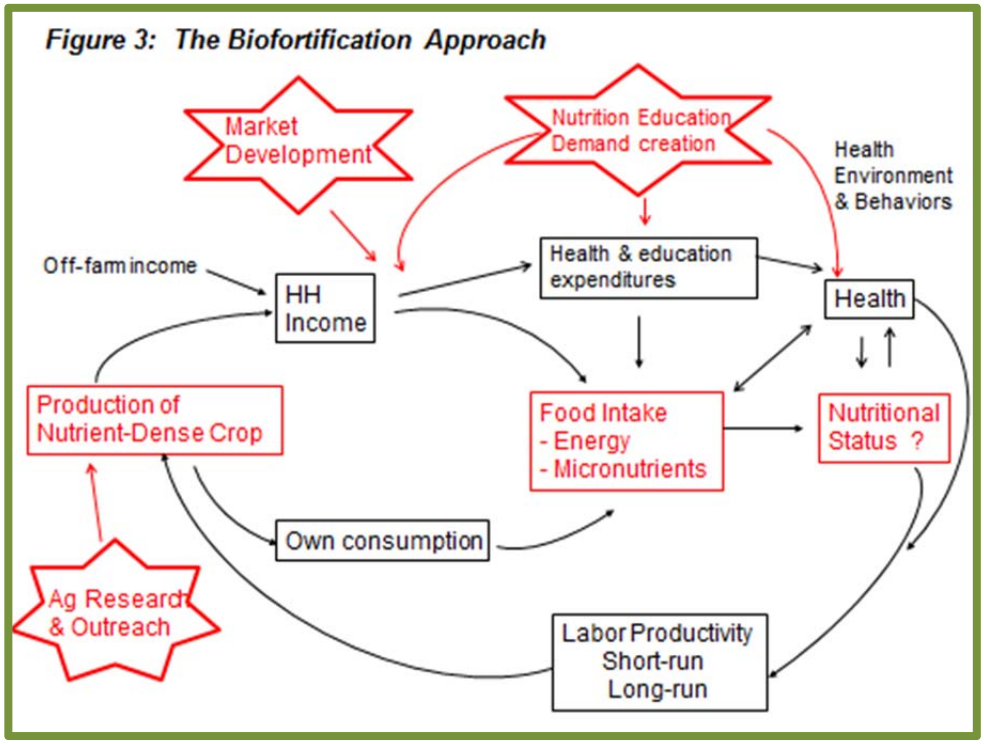
In Mozambique the most obvious place to start might be to expose agricultural researchers to these frameworks, followed by brainstorming and prioritizing of the most pressing nutrition-agriculture research questions. For this approach to be effective, agricultural researchers must be paired with scientists (social or otherwise) that are familiar with these issues.

3.2. The Biofortification Approach

The biofortification approach (Figure 3) focuses on tightening the relationship between production and improved consumption by promoting new cultivars that are rich in nutrients lacking in the diet. Typically, this approach focuses on staple crops that are widely consumed by the target population. The biofortification approach aims to improve nutritional status by introducing a single, nutrient-dense food. In doing so, it creates a stronger connection, or follow-through, between the production and consumption linkages shown in Figure 2. In doing so, it aims to improve access to nutrients that are under-consumed (such as iron or vitamin A) and to improve nutritional status by improving diet quality (Bouis and Welch 2010).

The biofortification approach requires research on the production side to develop appropriate plant materials as well as effective outreach to support farmers in their adoption (See starred interventions in Figure 3). A good strategy, however, will not focus solely on technical production issues. Consumer preferences must also be taken into account to ensure that new varieties have the characteristics desired by consumers. In addition, once a new variety passes consumer acceptance tests, there must be efforts to ensure that consumers are aware of its healthful attributes. This approach should

therefore include nutrition and health education to help the target population understand the benefits of the new food. Finally, there is also a need to offset some of the risk that traders perceive when dealing with products that are unknown to consumers.



Thus far there have been few biofortified foods that are highly successful as nutrition interventions. Part of the problem has been to identify appropriate vehicles that satisfy the various requirements. Ideally, the target crop must be a poor people's food that is readily accepted by the food insecure population. It must have all the functional attributes of the conventional/unfortified food. It must also be affordable and storable and provide a stable source of the target nutrient. Finally, to develop and field test such a variety takes years of research and funding.

In Mozambique, the best-known example of the biofortification approach is the work on the Orange Flesh Sweet Potato (OFSP). OFSP has been under study for almost two decades as a biosource for pro-vitamin A in Sub-Sahara Africa. The project has shown significant impacts on the vitamin A intake and nutritional status of young children in Mozambique (Low et al 2007).

There are at least two reasons for the success of the OFSP work (Harvest Plus 2010). First, sweet potato is an excellent candidate for biofortification. Women traditionally cultivate and sell white-fleshed versions of the crop. It is affordable and widely consumed in areas of Mozambique where nutritional status and vitamin A intake is poor. Although the orange-flesh variety was not traditionally consumed, with successful outreach it is now recognized as a variety with important nutritional advantages.

Second, work on OFSP has consistently included diverse forms of expertise, including disciplinary diversity (e.g. agronomists, plant breeders, applied economists, nutritionists, and health communicators) as well as organizational diversity. Researchers have partnered with NGOs and community-based organizations, local government, and local and national media to carry out the production,

marketing and educational outreach that have been needed to develop the interest and capacity to produce, market, and consume the new “vitamin potato.”

A large impact evaluation conducted by the Harvest Plus consortium recently reported positive effects of OFSP on vitamin A status (Harvest Plus 2010). Nevertheless, applied research and outreach continues on OFSP. New varieties are needed that will be more successful in drought-prone areas. In addition, systems are needed to maintain and distribute OFSP vines locally. Finally, more research is needed to understand the location and gender-specific production, marketing, and consumption behaviors associated with OFSP in high-malnutrition, high-vulnerability areas.

Although OFSP garners much of the biofortification attention in Mozambique, IIAM, SETSAN, and partnering NGOs have great interest in developing biofortification programs for other important staple crops. At IIAM, for example, researchers have released high protein maize varieties that are being grown by farmers. Certainly, more needs to be known about the status of these efforts and the extent to which companion studies have explored the demand for such crops. The OFSP case has demonstrated the level of investment (in terms of time and resources) that is needed to produce a successful product. Clearly not all products will merit such a long program of work.

Having a successful OFSP program in Mozambique, however, provides a useful model of how other biofortification research might proceed. In particular, the early interdisciplinary work on OFSP that determined 1) the appropriateness of the sweet potato as a biofortification vehicle, 2) the potential demand for the new product, and 3) the multi-pronged efforts needed to support the production, marketing, and consumption of OFSP can provide a template for planning research on other crops.

3.3. Fortification: An Agribusiness-Corollary to the Biofortification Approach

Ostensibly, food processors can also play a role in nutrition-agriculture strategies by developing food products that are fortified with important micronutrients. This strategy could affect both rural and urban households and would focus on improving the availability of a micronutrient-rich food that could be purchased by poor households. In Figure 3 the new products would be introduced through the red market development star and would help to improve micronutrient status through increased consumption of nutrients that are not available in the market or not financially accessible to poor households. USAID-Mozambique showed a particular interest in including small and medium-scale agribusiness in a strategy to integrate agriculture and nutrition programming. Under this approach, as with biofortification, the challenge is to find food vehicles that are appropriate and affordable for the target population.

In theory, fortification can be approached in a number of ways. Mass fortification may be appropriate when there is a large public health risk and the capacity for regulation is high. Targeted fortification may be a better approach when specific populations are at particular risk for nutrient deficiency, for example young children who are receiving complementary foods or refugees who are at risk of severe macro- and micronutrient deficiency (Allen et al 2006).

Fortification can also take a market-driven approach in which private firms develop food products that are fortified with various nutrients. In Figure 3 the effect would be to increase the availability of nutrient-dense foods that can be purchased by households, thereby improving nutritional status and health. Market-driven strategies can have important public health effects, but success generally depends upon an educated population of consumers as well as a reliable system of regulation. It is for these reasons that nutrition and public health experts have raised concerns about the growth of market-driven fortification in developing countries. Specifically, if government institutions are weak

and oversight is poor, this approach could cause harm (Allen et al 2006). Unnecessarily high levels of nutrients can be delivered to individuals of different ages who have different requirements. Conversely, products could be under-fortified, leaving consumers with a false sense of security that they are getting essential nutrients. A major concern, therefore, is the combined circumstances of an unregulated fortification process and an uneducated, nutritionally-vulnerable consumer population.

In addition, based on the experience from developed countries, public health specialists worry that fortified foods, particularly those that are tasty but poorly composed in terms of nutrient content, can subvert healthy dietary patterns and encourage increased consumption of sugars and decreased consumption of fiber.

Given these concerns, can agri-business make a contribution to improved nutrition? Is it possible to encourage the growth of an industry that can effectively provide healthful, fortified, affordable food products?

At present there is great interest in food fortification among the food security community in Maputo. Recently, the National Food Fortification Committee of Mozambique has been formed. The Committee is a coordinating body that includes representatives of the Ministries of Health and of Industry and Commerce, as well as industry and many NGOs. As of late 2010 they lacked a consumer representative. Would it be possible for this group to lobby for appropriate food laws and industry codes of practice? Is it possible to ensure that market promotion does not conflict with national food and nutrition policies, particularly as they concern the vulnerable populations? There is an excellent literature on this topic and many good models to follow if there is interest (Allen et al 2006). Some options include permitting only certain foods to be fortified (thus limiting the oversight that must occur) and/or providing health education campaigns that make it clear how these products can be used in healthful and not harmful ways.

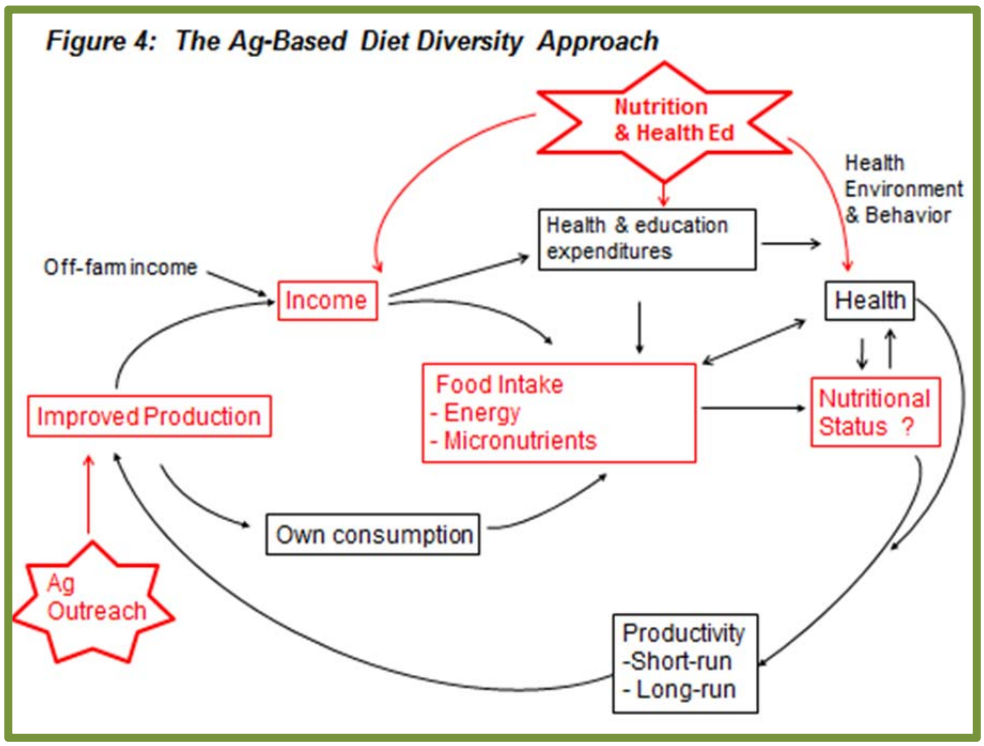
3.4. An Ag-Based Diet Diversity Approach

Like the biofortification approach, the diet diversity approach focuses on improvements to the quality of the diet. However, it does so by different means. Instead of promoting the nutritional benefits of a single crop (such as OFSP) it encourages the production and consumption of varied sources of micronutrients, usually through small-scale home production that improves access to a diverse, high quality diet (See Figure 4). Second, in contrast to the biofortification approach, it relies on community-based programming that emphasizes nutrition, health, and agricultural education. NGOs work intensively with small learner groups to support the practice of better nutritional, health and agricultural practices. Third, this approach makes use of simple messages to improve health practices as well as low-tech approaches to increase access to and utilization of locally-produced foods. Such techniques are more likely to be practical and ground-tested rather than the result of high-end science. Finally, programming efforts tend to be tailored to the circumstances of each locale, taking into account the livelihood structure within a village.

An example of work that employs this strategy is the Homestead Food Production projects carried out by Helen Keller International in Asia (HKI 2001). HKI focuses on developing local food production through gardens and small animals and livestock. As suggested by Figure 4, nutritional status of family members is expected to improve through the consumption of home-produced vegetables and animal products as well as the income generated from the sales. Like the biofortification approach, agricultural extension and nutrition and health education are major components of this approach. However in contrast to that approach, outreach efforts tend to include a wider variety of activities and focus on practices that are customized to the existing context.

Another example of such work might include programming around a school garden. Like the above example programming would be developed for a specific setting and context and would take into account the existing dietary patterns, as well as production and food preparation practices.

In Mozambique, the Multi-Year Assistance Programs (MYAP) supported by USAID employ a diet diversity approach to integrating nutrition concerns into agricultural programming. Most appear to deliver the same basic outreach messages at the community level, but differ slightly in the design of their programs.



One MYAP program, Save The Children's SANA Project (Food Security through Nutrition and Agriculture Programming, abbreviated as SANA in Portuguese) uses community-based nutrition/health education as well as agricultural education aimed at increasing income through the adoption of new production and marketing practices. The program delivers educational programming through small groups of mothers and farmers in each village. The groups function as collaborative learning circles in which new knowledge is brought into practice through a public (i.e. social) space. Local health promoters, called animadoras, hold learning sessions with mothers groups that include food preparation, child care, health nd hygiene demonstrations. Educational songs and dramas are used to spread important health messages and provide a simple means by which they may be remembered.

Similarly, the agricultural outreach focuses on small farmer groups to pass-on knowledge that can be put into immediate practice. Programming emphasizes practical endeavors, such as experimenting on demonstration plots or learning to develop business plans or market analyses for new agricultural products. Special emphasis is placed on how to work in groups or associations to undertake new entrepreneurial activities.

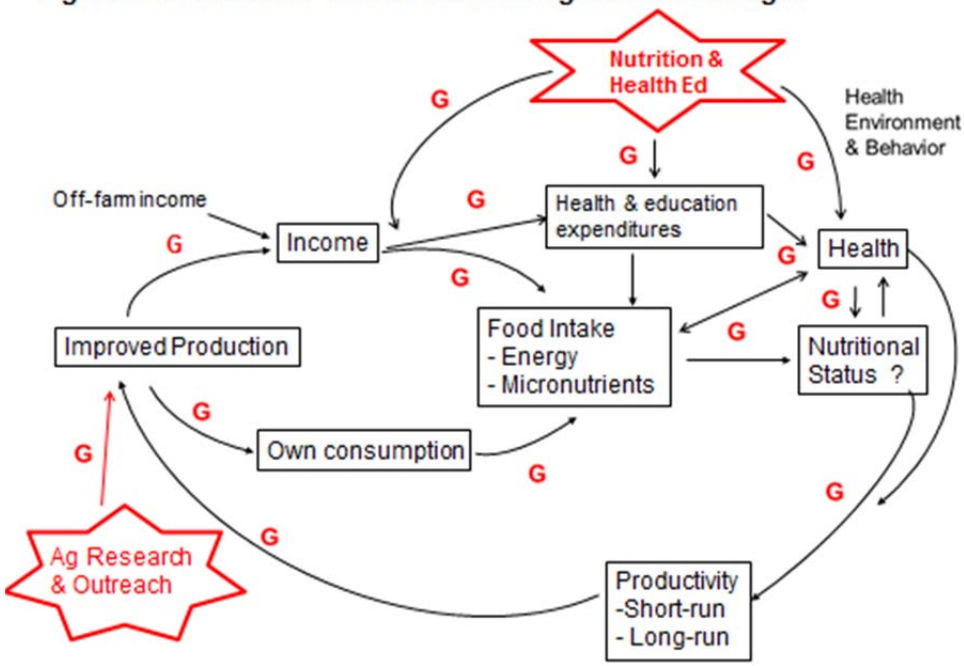
The educational efforts on the nutrition and health side are often carried out separately from those on the agriculture and entrepreneurship side. The programs, however, are integrated in at least three ways. First, households are often involved in multiple groups. Thus, Save the Children claims there is a "natural integration" at the level of the household. Second, programs are based on the same model of outreach---using small voluntary groups to develop capacity for collective learning and action. In this sense Save the Children aims to do more than just pass-on technical information; they are also developing capacity for problem identification and action at the local level. Learning becomes a shared, public process in which new practices become part of the public discourse. This ongoing discourse provides support for the learners and has the effect of changing the culture surrounding health behaviors, experimentation and entrepreneurship. Finally, programming efforts are adapted to the particular circumstances of the locale, taking into account local food and production practices, health behaviors and beliefs, and social structures. This is one of the major advantages of a community-based approach, as program activities can be tailored for the circumstances of the site.

3.5. Gendered Approaches (Figure 5)

The literature shows clearly that males and females play different roles in household activities, including the feeding and provision of care for children (Quisumbing and Pandolfelli 2009). As such, the relationships shown in Figure 1 are likely to be affected by gender norms (Fig 5). For example, a household's decision whether a crop should be sold or stored for future consumption may differ according to the gender of the individual who makes these decisions.

Similarly, control over household income and decisions about spending on food or health care are expected to differ by gender. Health and nutritional requirements will differ by gender (as well as other attributes, such as age). The point is that programs that involve any of these relationships must be cognizant of the gendered aspects of each one of these links.

Figure 5: A Gendered View of Nutrition-Agriculture Linkages



A gendered approach to nutrition-agriculture linkages advocates for understanding how programs or policies will affect males and females differently and in turn, what effect this will have on the health and nutritional status on males and females within the household. The literature suggests that some of these links are more generalizable than others (Quisumbing and MacClafferty 2006). For example, increasing women's control over household resources is expected to improve child nutrition. However, how a new agricultural program or policy changes women's' control over such resources is likely to be location-specific. Cultural factors can limit women's participation in programs or the adoption of new technologies or practices. They can also lead to changes in time allocation which can have adverse effects on maternal and child health.

It is therefore important to understand the sets of behaviors that programs or interventions are expected to change. Assumptions about gender roles and gendered behaviors need to be verified before intervening as patterns of behavior can differ by location. Tefft and Kelly (2004), for example, found that fathers of young children spent more than mothers on child health, but that overall control of discretionary income remained in the hands of elderly heads of households. These effects were strong in cotton-growing areas of Mali where production units involved large extended families. The same effects were less prevalent in rice and coarse-grain growing areas. Kelly et. al. (2004) therefore argued that in this area more attention was needed on the intra-household distribution of income to ensure that both mothers and fathers could gain access to income to care for their children.

Women are often assumed to be the most natural targets of health and nutrition education programs. However, a gendered approach to nutrition and health education also seeks ways in which men may act as advocates for better health and nutrition outcomes. Save the Children's SANA project incorporates this philosophy by including men in health support groups and by making health and nutrition issues part of the public dialogue within communities. For example, community dramas are often used to relay messages about desirable or undesirable behaviors that are important to child health, reproductive and public health. Performances include men and highlight the role they play in perpetuating or changing specific behaviors. By featuring local men in these productions it allows men to represent their own behaviors, play them to male and female audiences, and underscore the role that men can play in bringing about new health behaviors.

In Mozambique it appears there is very little analytical work that focuses on understanding (and acting upon) the different roles that men and women play within these nutrition-agriculture relationships. As a result, most programs are built upon assumptions about gender roles that are not explicitly stated. In some circumstances, assumptions are probably reasonable (eg. that women are the primary caregivers of young children). But there are many areas where we may not know the gendered aspects of a particular program, especially when such relationships are expected to be location-specific. What, for example, has been the effect of the OFSP program on women's control of income? Is it the same across regions where the use of OFSP differs? Has women's control over the crop remained stable, or has it been changing as OFSP becomes more important as a cash crop? These are only examples of the kinds of questions that should be considered, but certainly the answer to each would affect program and outreach strategies.

4. NUTRITION-AGRICULTURE LINKAGES MEDIATED THROUGH HEALTH

The previous section focuses on agriculture-nutrition linkages that work primarily through the production-consumption loop at the center of Figure 1. It is important to note that agriculture can also affect nutritional status through its effect on health. Hoddinott (2011) and Pinstrup Anderson (2010) identify various examples by which agriculture may affect human health. In these circumstances adverse changes to health are the result of a poor health environment (either at home or at work) and are brought about by agricultural activity; nutritional status is impacted through agriculture's effect on health.

Torrey (2010), for example, maintains that changes to animal production and processing systems can have important effects on disease transmission between animals and humans. He cites examples in which households have begun to keep animals closer to the family quarters to avoid cattle raids. In such situations, households face higher risk of contracting animal-borne diseases as flies may carry them from animal feces to water or foods meant for human consumption. In addition, as animal processing systems become larger and more centralized in urban areas, Torrey expects the possibility for widespread illness to rise as mass processing overtakes smaller-scale production.

Another example of agriculture-health linkages involves the use of chemical pesticides for crop protection. Although pesticide use is relatively low in Africa, Nelson (2010) maintains that pesticides use is on the rise and is used intensively in the production of crops such as cotton and vegetables. The use of chemical pesticides presents health risks to those working in agriculture as well as the possibility of groundwater contamination, harm to livestock and associated food products. (Pimentel et al 1991, Pimentel et al. 1997; Pingali et al 1994)

Finally, the spread of HIV/AIDS is especially important to strength of the agricultural sector. Households struggling with the disease show lower agricultural productivity and income (von Braun et al 2010) and are thus likely to be vulnerable and food insecure. Conversely, low-productivity agriculture can encourage migration and thus greater exposure to risk of infection. HIV/AIDS and nutritional status are strongly interdependent. HIV/AIDS often leads to nutritional deficiencies due to reduced food intake, malabsorption, and increased nutrient use and excretion (Gillespie 2010).

5. CONCLUSION

The purpose of this paper has been to present a simple exposition of nutrition-agriculture linkages. In contrast to the Hoddinott (2011) model, which details the ways in which agriculture may affect health, and indirectly nutrition, this paper focuses on the primary overlaps between nutritional status and agriculture. In doing so, it considers changes to nutritional status that come about from changes to income and the quantity and types of foods that are available and accessible to poor households.

Policymakers, donors and development practitioners in Mozambique can take a number of steps to advance the integration of agriculture and nutrition programming. The framework and examples presented in Section 3 demonstrate that multiple and varied efforts will be needed to affect nutritional outcomes through agriculture (e.g. research and outreach in multiple fields, plant breeding, production, marketing, health and nutrition education, gendered analyses of relationships). In general, keen attention needs to be placed on understanding the complexity of the production-consumption-nutrition loop and on identifying outcomes that are appropriate for a given agricultural intervention. Changes should be monitored at each link within the chain, with the understanding that changes to nutritional status will be the last to be affected.

Given the complexity of these linkages it is important to think beyond advocating for a single approach and to instead think about building a larger, coherent strategy that comprises many varied approaches. Understandably, any given government agency or development organization has its own strengths and areas of interest. But finding ways to cut across these experiential bases is important if we aim to affect nutritional status through agriculture.

The remainder of this paper discusses elements of a strategy that links agriculture and nutrition. It is important to keep in mind that even as a more comprehensive strategy is designed and implemented, there is ample room for opportunistic, ad hoc efforts to strengthen nutrition-agricultural linkages through existing channels.

Building Capacity

Mozambique lacks a critical mass of people with university-level training in nutrition and/or public health. Government staff are limited, with the result that professionals are stretched very thin. Not surprisingly, three of the six strategies in the Multisectoral Action Plan for the Reduction of Chronic Undernutrition (MAP 2010) involve building capacity to enable nutrition programing and planning. Many partners have stated that think that these capacity building strategies are the most crucial identified in the MAP.

For Mozambicans to lead in this area it is important for partners to help support and train local professionals to recognize nutrition-agriculture linkages and develop programs that consider the various mediating linkages. This needs to occur at all levels of the government.

Mozambique, however, is doing an impressive amount with the few people it has. International NGOs bring important resources and manpower for cross-cutting nutrition-agriculture work, and many fruitful collaborations between government and NGOs are in place. Most cross-over work between sectors, however, is not initiated by government, but by donors and NGOs, with government as a partner.

Working with Agricultural Scientists to Improve Trickle Down and Biofortification Approaches

Many breeding programs want to address nutritional concerns by working to improve crops that are consumed by the poor. Many projects, however, begin without consideration of the social science relationships that are outlined in Section 3. How do households in vulnerable areas currently use the target crop? What attributes are consumers seeking? Is there a market for these improved varieties and are there financial incentives to market these varieties? What are associated marketing con-

straints? Who will benefit? This information is necessary for any breeding program as there is no advantage to pursuing nutritional improvements if the target population will not consume the new variety.

By now, there is a significant body of experience from the success of the OFSP that can be helpful to breeding programs as they consider pro-nutrition projects. It may be useful for scientists to review the process and partners involved in the development of OFSP as they contemplate new variety development. Reviewing the many and varied steps involved in the interdisciplinary development of OFSP can provide a useful template for the types of skills, activities and partnerships that are required for success.

What might social scientists in Mozambique do to further this collaboration? Useful contributions might include working with IIAM (and other CGIAR breeding programs) to (1) assess the potential of select improved varieties to improve the nutritional status of vulnerable populations; and (2) develop a protocol for making decisions about continued research on varieties that are promising for improving nutritional status. The basis of this work would be the application of social science methods (including participatory approaches) to assess consumer interest and farmer reactions to new materials as well as other constraints to success (e.g. market conditions, existing policies, etc.). Participatory approaches can be an important way to determine whether breeding products are on the right track to acceptability by farmers and consumers.

Expanding the reach of OFSP

While work on OFSP has been very successful, much more can be done to fulfill its potential. It is important to explore the current gaps in knowledge and areas of opportunity in terms of OFSP use. For example, there has been little adoption of OFSP in drought-prone areas – essentially the areas where people are most vulnerable to food insecurity. In addition, sweet potato use varies by region. Consequently, it would be beneficial to expand our understanding of the role that sweet potato plays in the diet, how its use varies within the household, and the potential for it to make a contribution to improved vitamin A status among those most vulnerable.

There has also been discussion of introducing more nutrition and health messages through current outreach efforts for OFSP. OFSP project staff have aimed to keep educational messages clear and simple, but it may be possible to develop further health messages that can be piggybacked to OFSP outreach, especially as OFSP (and its original messages) becomes more established in each area.

Identifying important nutrition-agriculture relationships that are gendered

Nutrition-agriculture linkages are likely to be gendered. Recognizing this and exploring these factors is important for understanding who stands to gain from changes in agricultural policies and programming.

At present, it appears there is little work in Mozambique that addresses the gendered nature of nutrition-agriculture relationships. I found little evidence of systematic efforts to understand the effects of agricultural programs by gender, nor to understand the dynamics that determine a woman's control of resources, her bargaining power within the household or their ultimate effects on nutrition security. Experience from elsewhere in Africa shows that when women's crops are commercialized, men often take control of them (Schroeder 1997, Grey and Kavane 1999). As a result, all agricultural projects can benefit from attention to how interventions may alter existing patterns of responsibility and entitlement and thus food security and nutritional status within the household.

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