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Table of Contents

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The Negative Side of the Agricultural–Nutrition Impact Pathways: A Literature Review

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Agricultural development interventions and policies have an impact on the nutrition of individuals through changes in food availability, in food diversity, in food prices, and changes in farmers' income. Less straightforward, they also entail many changes in health environment and in time availability for care activities. They finally have impacts on the balance of power both at the intra-household, community, and global levels. The impact pathways are complex and interlinked, and many recent studies have primarily focused on their positive effects. However, some agricultural interventions might have a negative impact on nutrition in certain cases. This article sets out to identify them, through a review of the scientific and institutional literature, along with expert interviews. Six risk categories are proposed, relative to incomes, prices, types of products, women's social status and workload, the health environment, and inequalities. This review underlines the necessity to have an ex ante *analysis of the nutrition impacts of any food or agricultural policy or intervention with "do not harm approach" regarding the nutrition outcomes. It gives clues to identify and mitigate the main negative outcome and advocate for more applied and well-documented research on that topic.*

Keywords*: nutrition, agriculture, pathways, impact, development*

I - Introduction

There is a quite large and global consensus concerning the necessity to reinforce investments and interventions in farming and animal husbandry to achieve food and nutrition security. Agricultural policies, particularly those designed to support small farmers, play a fundamental role in the fight against undernutrition. Following the 2008 food price crisis and the series of articles on maternal and child undernutrition published in *The Lancet* in 2008 and in 2013, there has been renewed interest in how agriculture affects nutrition. Ruel, Alderman, and Maternal and Child Nutrition Study Group (2013) showed that it is necessary to develop the so-called "nutrition-sensitive" interventions, as specific interventions are insufficient. Recent reviews of the literature (such as those of Masset et al. 2012) have endeavored to identify the effects of agricultural development interventions (ADI) on nutrition, and put forward recommendations to make them nutrition sensitive.

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It is interesting to underline the fact that these studies sought the positive effects of interventions, while agricultural interventions may also have negative effects, as the impact pathways are complex and interlocking. Taking a "do no harm" lens, based on the existing literature and interviews with experts, this article proposes to shed some light on the risks that ADIs might entail for nutrition. The article sets out to inventory potential risks, without assessing neither the reality of the threats nor their relative weight, which greatly depends on the intervention contexts. It proposes conceptual guidelines for agricultural policy or project designers to assess *ex ante* likely impacts and to mitigate the possible drawbacks of their actions.

The followed methodology of data collection and analysis is detailed in Section II. Section III illustrates the different pathways from agriculture to nutrition. Six different risks are identified and developed in section IV. Discussion and conclusion are the last two sections.

II - Methodology

Starting from the different recent reports (Webb 2013; World Bank 2007, 2013; du Vachat and ACF 2013), conference presentations (Headey 2013; Hoddinott 2012), books (Fan and Pandya-Lorch 2012), and scientific papers (Masset et al. 2012; Ruel, Alderman, and Maternal and Child Nutrition Study Group 2013; Berti, Krasevec, and FitzGerald 2004) concerning the effect of agriculture on nutrition, we followed a backward snowball methodology, identifying each paper or author, who was quoted about a possible negative causality. In addition, we interviewed 15 colleagues, from different backgrounds: history, human nutrition and epidemiology, agricultural economics or agronomy from Food and Agriculture Organization - FAO, Action Against Hunger (Action Contre la Faim in French – ACF), Institut de Recherche pour le Développement - IRD, and Centre de coopération Internationale en Recherche Agronomique pour le Développement - Cirad about their knowledge of existing literature or empirical evidences concerning a possible negative effect of certain types of projects or policies on nutrition.

Altogether, we gathered 171 different documents, in English and in French, all written between 1980 and 2013. We excluded from this stock of documents all references presenting neutral impacts of ADIs on nutrition or stating impacts are not necessarily positive but without specifying impacts are negative. It appears that studies documenting specifically the negative impacts of ADIs on nutrition were scarce and relatively old (e.g. those published by Von Braun and Kennedy 1986; 1994). For example, despite a number of studies highlighting the limitations of biofortification and questioning its relevance as a "silver bullet solution" compared to dietary diversity (e.g., Keatinge et al. 2011; Brooks 2010, Kimura 2013), it has been difficult to find references clearly showing negative impacts on nutrition. Consequently, articles revealing negative links between agriculture and certain key variables for nutrition were also taken into consideration, even though the impact pathways did not extend all the way to nutrition. We then included references presenting negative impacts of ADIs on

key determinants for nutrition but not nutrition per se. In the end, based on these exclusion and inclusion criteria, we use here 81 different references. There is no claim to be exhaustive and when the same idea is found in different papers, we do not quote all of them. We know the methodological weakness of most of these papers which have been already highlighted, notably by Arimond et al. (2011): lack of control groups, reference situations, and randomization. We ought to underline the fact that, "in one case, one observer has report in a written form a specific risk." With the existing material, it is impossible to draw conclusions regarding the probability of the occurrence of neither the identified risks nor their severity. The message here is qualitative for practitioners: to have a guideline in their impact assessments; and for scholars: a claim for conducting more serious research on this issue.

The existing work has mostly dealt with the people directly concerned by ADIs, yet they can have effects on other populations, whether they live in a rural or urban environment. In addition, most of the work focused on protein-energy undernutrition responsible for stunting, while other forms of malnutrition such as micronutrient deficiencies (vitamin A, zinc, iron, iodine, etc.) or "overnutrition" is a major issue. These two forms of malnutrition (by deficiency or excess) also often go hand in hand in the same countries, or even within the same households (Maire et al. 2002). The range of ADIs is wide and covers as much technical dimensions (development of production basins for example) as it does institutional dimensions (producer capacity building or policy support). In the field, ADIs usually comprise several components combining technical and institutional aspects. Some ADIs correspond more to rural development projects taking on regional dimensions, while others focus on agricultural products. Here, the ADI perimeter is mainly confined to localized projects since it is the majority of the literature. Agriculture is covered in its broad sense (plant and animal production, rural development, natural resource management, etc.), but for easier reading the examples of ADIs are intentionally schematic (irrigation, food crop production, cash crop production, livestock, land, plant health, etc.). This presentation is consistent with that undertaken by the *French Development Agency*, one example of development organizations targeted by this work. In its 2013–2016 sectorial intervention framework, the Agency distinguishes interventions between food and cash crops or land issues but in a wider perspective, considering also transformation activities, territorial governance, and public policies (AFD 2013).

III - Links between agriculture and nutrition: what impact pathways?

There are several schematic and conceptual representations of the effects of agricultural activities on nutrition (Randolph et al. 2007; Headey, Chiu, and Kadiyala 2011, 5). The different stakeholders of the agri-food system are more or less well taken into account according to the different authors: relations are especially represented for individual scales but rarely at larger scales. Most authors emphasize the complexity of those relations. However,

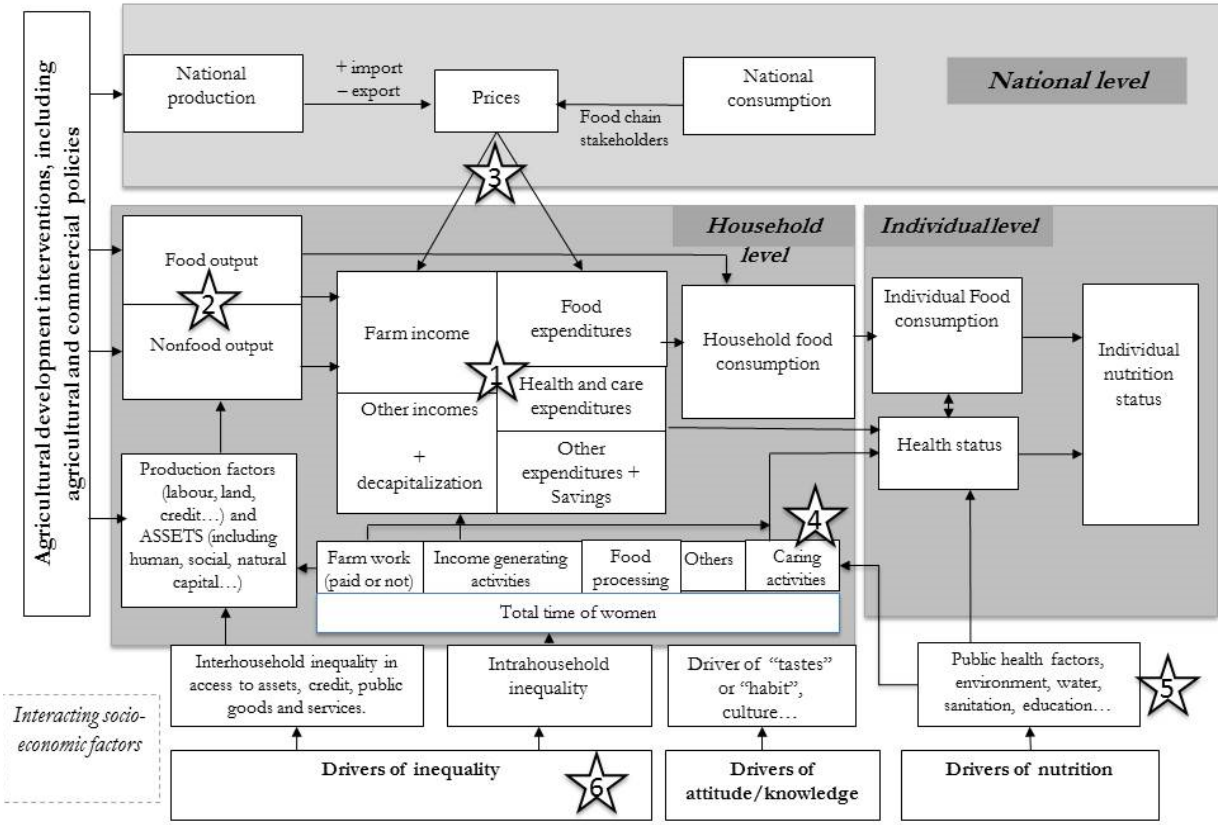
most of these representations are based on the UNICEF causal model of malnutrition (1990). In that sense, the starting point is the "individual" and its health/nutrition status. The different causes/factors affecting its nutrition are organized in different levels from household, community, supply chain, country, and the world. These specific models disentangle the drivers linked to food, food systems, and agriculture. That is, on the basis proposed by Headey, Chiu, and Kadiyala (2011, 5) that we propose our own model: the nutritional status of individuals (on the right-hand side in Figure 1) results from the quality and amount of food intake, and their health status. These two factors are highly dependent on two drivers at the level of the household: most of the care time[1] and household food consumption, and on many drivers at the level of the general health environment (natural surroundings, hygiene, health services, etc.) that are not on the scope of this study. In addition to minor changes brought to Headey et al.'s model to make it more reader friendly and less specific to the case of India which was studied by the authors, we introduced two main changes: the total time of women detailed by the types of activities, and the production factors at the household level.

The important factors at the level of the household depend on variables that are analyzed in classical agricultural household and food consumption micro-economic literature: i.e., during one period of time the household has to decide to spend its money and affects its time in a specific way according to its "preferences" and resources (income, savings). In the model we propose, we represent a simplified budget of a household (central rectangle) to illustrate the choice between food expenditures, health and care expenditures, and other expenditures. Of course, one can imagine a more detailed model where the household affects its money between beans or meat, cereals, beers or cigarettes, school or shampoo, smartphone or radio, etc., the list can be infinite and worth to be discussed. By drawing a different arrow from the production of food to the household food consumption box, we stress the possibility of self-consumption in the household. We also chose to disaggregate the time of women who are the main caregivers and whose health depends on their activities. Most of the women have to deal with different kinds of income generating activities as well as "home" activities such as food and meal processing. They also have to take care of themselves and of their children. Last, but not least, in most agricultural families, they have to work on the family farm with no immediate wage, but in advance of a share of the harvest. The nature (money, products) and the amount of this share depends on the local social rules of sharing in-between the families. And, as we are dealing with agriculture activity, the harvest as well as this share are highly risky.

At the left side in the household level box, we drew two boxes concerning the production side of the agricultural households (though this figure does not

[1] Child care practices encompass food, health care, stimulation, and emotional support required for the development of the child. They are ensured by a care provider (usually the mother).

Figure 1:
Identification of the main risks along the agriculture/nutrition impact pathways
Click on the image to enlarge.



Note: The stars indicate the main risks presented in the article.
Source: Authors adapted from Headey, Chiu, and Kadiyala. (2011)

represent only farmers; for nonfarmers one just has to imagine that these two boxes are empty). These boxes represent the production factors and assets, taken in a broad sense (labor, land, financial capital, but also human, and social, natural capital) and the farm outputs, subdivided into two categories: food and nonfood.

Surrounding these two individual and household levels, on the top of the figure the agri-food market at a "national" level is represented in a very schematic way, while at the bottom, the socioeconomic/cultural drivers are also represented. At the left side of the figure, the different food and agricultural policies and interventions are finally represented. We will now start from this left side and propose different pathways through which these interventions may affect, actually in a positive or negative way, the nutrition outcome of the individual. One has to underline the fact that pathways may be the same for different types of interventions and/or different for a single intervention.

IV - The main agricultural risks for nutrition

The topic of this paper is to identify potential risks of agriculture interventions or policies. Using the schematic figure we just explained the different pathways from agriculture toward nutrition of individuals, we chose to present six families of risks corresponding to six impact pathways and to present them separately, though they are interconnected. Each risk/pathways is represented by a star in Figure 1 that corresponds to the numbering of the title.

1. Nutritional risk despite an increase in real incomes (relative to prices): the level of the households, including farm and nonfarm household.

The rise in income linked to an ADI usually enables households to increase their food expenditure, as well as their health expenses, both of which are positive for nutrition. Some studies have shown that agriculture is a powerful lever in lifting people out of poverty, which is itself correlated to an improvement in nutritional indicators (World Bank 2007; 2013). The growth in real incomes (relative to price) derived from agriculture generally enables a reduction in malnutrition (Webb and Block 2012), but it is not automatic. It depends on:

1. *Modalities of change in other sources of income*: An increase in the income derived from marketing a product may be counteracted by a drop in other incomes derived from other farming or nonfarming activities (Masset et al. 2012).
2. *Modalities of change in source of food access*: The impact of ADIs encouraging commercial crops was studied in the 1980–1990s (Fleuret and Fleuret 1980; Von Braun and Kennedy 1994). They may be negative, from a nutritional viewpoint, when the income derived by converting from a subsistence system to cash crop farming does not compensate for the loss of self-consumed products. For example, the sale of milk, whose consumption reduces the risk of chronic malnutrition, may have a negative impact on the nutrition of

dairy farmers, as has been shown in India (Bhagowalia, Headey, and Kadiyala 2012), Rwanda (Pimkina et al. 2013), or Ethiopia (Hoddinott, Headey, and Dereje 2013). In addition, specializing in a commercial crop entails an income risk. An adverse event affecting the commercial crop may lead to a drop in household income and potentially a drop in food purchases. For example, in Kenya, in 1984, it was found that farming households living in irrigated areas had an income based on commercial rice and had poorer nutritional indicators (stunting) than households not living there with more diversified sources of incomes (Niemeijer and Hoorweg 1994).

3. *Income uses*: For example, extra income may be used for purposes other than buying food. In some countries and under different circumstances, it has been shown that the income elasticity of food consumption, or calorie consumption or nutriment intake might be null or even negative in certain cases. For example, Skoufias et al. (2009) found in Mexico, that "for the poorest households, the deficiency of total energy, protein, and zinc is not accompanied by a positive income elasticity."
4. *The person controlling the income*: Income controlled by women is used more for food expenditure and has positive impacts on child nutrition (Marek 1992). Interventions that tend to reduce income controlled by women (even if the men get more income) therefore run the risk of producing negative impacts on nutrition (see risk 4).
5. *Change in income regularity*: A regular income, even small one, is used more for food than a larger but less regular one (Von Braun and Kennedy 1986; IYCN 2011). Strong income seasonality prevents households, who buy when prices are highest, from covering their annual needs. The period of higher prices also corresponds with peaks in the prevalence of water-related illnesses and workload peaks (Devereux and Longhurst 2010).

Altogether, the ADIs whose main objective is to raise income of the poor/farmers might not always end with the improvement in nutrition. One has to be aware that the additional income might be gained at the expenses of other sources of income (nonagricultural income) or resources (food) which might not be properly replaced. And that the use of additional income is not always directed to food expenditures nor adequate food, nor for the ones who are in deficit.

2. Risk of a mismatch in food availabilities and diversity: macro and "meso" (market chain, regional development) levels.

By focusing on certain specific products, ADIs affect the nature and quantity of available foods. They may have negative impacts on energy quantities (too much or not enough) and on available nutrients. This may be the case when agricultural policies encourage specialization at the expense of the availability and diversity of foodstuffs.

During the green revolution in India, a policy package (fertilizer and seed subsidies, infrastructures, price support, etc.) led to a very large increase in per capita wheat and rice production between 1960 and 1990. That increase in availability helped India escape the famine that had marked the country up to then. Be that as it may, the prevalence of undernutrition among women and children remained among the highest in the world. One hypothesis, albeit difficult to verify due to the multiplicity of causes of malnutrition and wide disparities between regions (Gillepsie and Kadiyala 2012), corresponds to the crop and food specialization brought about by these policies which were centered almost exclusively on cereals. The case of legumes is particularly striking: their availability fell from 23 kg in 1961 to 12 kg/year/inhabitant in 2003 (Dorin and Landy 2009). Likewise, for Southeast Asia, the calorie supply rose from 2,050 to 2,250 kcal/person between 1970 and 1990, while the iron density in food fell from 6.2 to 5.75 mg/kcal and the prevalence of anemia (iron deficit) in women rose from 57% to 73% over the same period (Welch and Graham 1999). Francesco Burchi, Jessica Fanzo, and Emile Frison (2011, 362) insist on that opinion "this push to concentrate on a few staple crops may be a contributory factor to the simplified diets, the continued undernutrition in South Asia and widespread hunger". Even Peter Hazell (2009, 12), who is a strong supporter of the green revolution, admits "However, since deficiencies in iron and the B vitamins are common amongst the poor the increase in micronutrient-rich foods must not always have been high enough to offset the decline from cereals" consumption that has followed the green revolution. Finally, the availability of other foodstuffs (animal products, fats, fruits, and vegetables) remained well below world averages and their consumption was very unequally distributed (Dorin and Landy 2009).

Sometimes the development of commercial products may go hand in hand with: (i) a change in natural ecosystems, the disappearance of wild species—an integral part of local diets and (ii) a reduction in resources devoted to subsistence crops (Fleuret and Fleuret 1980). Such changes lead to simplification of diets and risks of micronutrient deficiencies. The promotion of maize in Mali was associated with cotton supported by development companies though the distribution of maize seeds, promotion of cereal crop standards, in order to secure the food supply of cotton farmers. It is thus possible to cover the calorie requirements of certain households (not all), but it has also led to more monotonous diets than in other regions, along with a risk of deficiencies and chronic malnutrition (Dury and Bocoum 2012).

The introduction of improved varieties can lead, though not always, to a simplification of cropping systems (Bellon and Hellin 2011) and diets (Johns and Eyzaguirre 2007). The substitution and reduction in the number of accessible traditional varieties may also be accompanied by an erosion of the variety of recipes and dishes consumed. An example involving the industrial white-fleshed banana, which has replaced a local, orange-fleshed banana rich in carotenoids, has been described in Micronesia (Englberger 2003).

3. Risk of price ratios detrimental to nutrition

ADIs may lead to an increase in the agricultural production and to a drop in prices for certain food products. However, the link between agricultural prices and food prices tends to slacken with the lengthening of the value chain and with the fact that agriculture accounts for an increasingly small share of food product end-prices.

The effect of a price drop on nutrition depends on the products involved and the nutritional status of consumers. It may be positive in a situation of deficiency-related malnutrition (e.g., consumption of animal products in poor countries), or negative if thresholds are exceeded (e.g., overconsumption of fatty and sugary products). The gain in purchasing power resulting from a drop in prices may lead to more diversified food intake and/or better household access to healthcare, hence a better nutritional status (Headey 2013). It should also be noted that the effects differ depending on whether households are urban or rural, hence whether they purchase part or all of their consumption (Ruel et al. 2010) and depending on whether farming households are net buyers or sellers: a drop in food prices may correspond to a drop in income for the latter.

Policies intended to support the targeted agricultural products may therefore produce complex effects on nutrition. For example, the focus on cereals, oil palm, sugarcane, or livestock farming has led to a relative drop in their prices, while products that have not benefited from the support see their relative prices increase. In India, relative price changes are very pronounced between cereals—having benefited from strong agricultural support—and noncereal products. The rise in prices of the latter (legumes) might explain the weak improvement in nutritional status, or even its deterioration (Webb 2013), despite an increase in incomes over the last 20 years (Deaton and Drèze 2009).

Price subsidy policies targeting staple food products may have perverse effects on diet and nutrition. For example, in Tunisia, subsidies for staples (cereal products, oil, and sugar) make them highly accessible, but a wide-scale occurrence of excess weight and obesity problems is being seen. It is difficult to blame subsidy policies for the increase in chronic illnesses, as many factors are involved in nutritional transition (urbanization, changes in lifestyle, higher living standards, etc.) (Beltaifa et al. 2002), but it seems necessary to raise the question of their relevance for public health.

The three previous pathways are dealing with the left and upper part of Figure 1, i.e., the production/income/price sides of the figure, both at household, market, and macro-economic levels. Hence, one has to look at intra-household level, at socio-cultural framing, at the health environment and finally at the specific effect of inequalities.

V - Risk of a deteriorating role of women

The abundant literature on the role of women in farming (e.g. Quisumbing and Maluccio 2000; Kurz and Johnson-Welch 2007) is often used to show that ADIs that empower

women in managing production factors and incomes, or which free up some of their time, help to improve the nutrition. Conversely, a reduction in decision-making power or an increase in workload carries risks for nutrition. Few references enable us to gauge the size of those risks, but the fact that they are reported many times indicates that particular attention needs to be paid to them.

• *Increased marginalization of women in decision making*

As certain commercial crops are often in the hands of men, ADIs that encourage them may lead to women being marginalized in decisions relative to production and income use, and may therefore entail risks for nutrition. Agricultural extension projects are often targeted at men and tend to side-line women, who are penalized due to a lack of sufficient capacities (education, access to credit, etc.). For example, the introduction of irrigated rice production unbalanced gender relations in favor of men in the twentieth century in Senegambia (Carney and Watts 1991). The exclusion of women from management of the fields and crops for which they were previously in charge of, while remaining responsible for children and food, carried risks for family nutrition. In East Zambia, the adoption of hybrid maize was accompanied by a reduction in the power of women to make production decisions, and by a nutritional risk (Kumar and Siandwazi 1994). However, the fact that commercial crops are mainly managed more by men does not systematically mean that the decision-making power of women is reduced. The introduction of irrigated rice production in northern Cameroon, for example, obliged women to work in plots managed by their husbands, but they were able to negotiate an income at a rate based on the opportunity cost of their labor (Jones 1986).

• *Increased workload for women*

Some ADIs entail a much greater workload for women, to the detriment of the time devoted to child care, breast feeding, and food preparation: faster preparation methods, less nutritional meals, or even fewer meals (Masset et al. 2012; Jones et al. 2012). For example, vegetable-based meals that can provide vitamin A often take time to prepare. For example, in Burkina Faso, in the large hydro-agricultural schemes of the Sourou region, female labor is one of the factors that explains why wasting is more frequent in households depending on those schemes than in other households (see also risk 5). In the Bagré region, women practicing market gardening—primarily a female activity—have one hour and thirty minutes less to take care of their children and two hours less to rest than those not involved in market gardening (Parent et al. 2002).

The workload of mothers is also a risk for their own health and nutrition, and those of their children, particularly during pregnancy or breast feeding. For example, Lima et al. (1999) showed that an excessive agricultural workload throughout pregnancy had a direct impact on infant birth weights.

Mechanization can have ambivalent effects on work sharing within households and on nutrition: a positive impact by lessening the workload

of farmers, notably women (FAO 2012), but also sometimes a deepening of gender inequalities within the household. On some cotton farms in Mali, without any strong land tenure constraints, motorization led to an increase in the area farmed, and consequently to the amount of labor needed for sowing, weeding, crop thinning, and harvesting, largely provided by women (Girard and Dugué 2009).

However, very obviously female labor also has some positive effects in terms of autonomy (Ukwuani and Suchindran 2003; Arimond et al. 2011; Leroy and Frongillo 2007). What matters is that, a balance is found so that women's involvement in ADIs does not result in a workload that is harmful to their health and to that of their children. A balance must also be found between agricultural, other productive, and care activities. When women have little control over the income of a farm, care has to be taken to guarantee they have enough time for their productive activities ensuring them an income or their own crops.

VI - Health risks and environmental degradation

Some farming practices may entail risks for the environment (air, water, soil, biodiversity) term and/or the health quality of foods, thereby affecting the health of individuals and their nutritional status.

• *Risks of zoonosis associated with livestock farming*

While livestock farming is a strategy for alleviating poverty and malnutrition (quality foodstuffs, income from the sale of animal products or animal rental, manure and draught power, savings, social status afforded by the ownership of animals, etc.), it may also generate risks for nutrition (Randolph et al. 2007). Diarrheal diseases, which are closely associated with malnutrition, are linked in half the cases to animal pathogens or foodstuffs of animal origin in poor countries (Grace 2011). In addition, given population growth and increased demand from the urban population, there is a tendency for the number of livestock animals to increase, especially monogastric animals which are more at risk of transmitting pathogens in countries without operational veterinary services. The gradual intensification of animal production is also accompanied by a longer and more complex food chain, and an increased risk of gastro-intestinal zoonosis responsible for diarrhea (ILRI 2012).

• *Risks linked to aflatoxin in maize–groundnut systems*

In tropical zones, where the diet is largely maize and groundnut dependent, chronic exposure of the population to aflatoxin is massive. It involves 85%–100% of children in African countries of the Gulf of Guinea (Khlangwiset, Shepard, and Wu 2011). Many studies have shown a link between chronic malnutrition and the exposure of unborn children to aflatoxin, or subsequently through breast feeding or weaning foods. The biochemical mechanism involved remains to be identified, but the strong and regular links observed between the level of exposure to aflatoxins and the prevalence of chronic malnutrition argues

in favor of a direct causality (Gong et al. 2003; 2004). Contamination occurs right from the field, before the crop mature, amplified by drought, and heat, then after ripening, favored by moisture in the fields, and during drying, storage, and transport (Zakhia-Rozis and Schorr-Galindo 2013).

• *Risks associated with exposure to pesticides*

The risks of pesticide use for the health of those applying them are known in the short term and suspected over the medium and long terms (INSERM 2013). Those health risks affect nutrition. They are particularly significant in developing countries where, even if the use of pesticides is low (25% of world consumption, 4% for Africa), they account for 99% of deaths due to poisoning (75% in Africa) (Thiam and Sagna 2009). In Africa, the regions most affected by the impacts of pesticide applications are the zones with large farms, irrigated zones, and cash crop areas, where pollution can contaminate the environment and the food chain (Thima and Sagna 2009).

• *Risks associated with irrigation*

Irrigation is a way of improving productivity, alleviating poverty in rural zones (Mc Cartney et al. 2007) and breaking away from the seasonality of hunger (Devereux and Longhurst 2010). However, it may also be propitious to the development of water-borne diseases, such as schistosomiasis and malaria (Mc Cartney et al. *op cit.*), major scourges in Africa. It may also be conducive to the spread of zoonosis such as Rift Valley Fever (FAO–WHO 2008). The existence of surface water near villages may also lead to a deterioration of drinking water quality and a multiplication of diarrheal diseases (Van der Hoek et al. 2001). Such links are not systematic: despite a high density of *Anopheles* mosquitoes throughout the year associated with irrigation, the prevalence of malaria in people living near irrigated zones is often less than in control groups, for immunological and socioeconomic reasons (WHO 2005).

• *Market gardening and diarrheal diseases in urban areas*

Urban agriculture, practiced in a polluted environment, generates health risks for producers and consumers. However, studies often consider that the benefits of the activity (income and supplies for towns, development of urban space, a better living environment and conditions) outweigh the risks entailed. Waste water use by urban agriculture has particularly attracted the attention of numerous studies. This practice offers the merits of using water rich in nutrients and available throughout the year for several cropping cycles, while helping to make use of urban waste. However, it greatly exposes the populations to pathogens (Blumenthal and Peasey 2002) and to chemicals—heavy metals, hydrocarbons, and pesticides—which entail health risks.

VII - Risk of worsening inequalities

The risks described here refer to partial or total exclusions, created or amplified by ADIs. They concern producers not directly targeted by an intervention and who lose some

or all of their access to certain resources (land, forest, water, work, or sale opportunities, etc.). They may concern an entire category of the population, often the most socially and politically fragile: for example, rural versus urban, nomadic versus sedentary, employees versus owners, poor households versus wealthy households.

• *Land inequalities*

In the 1980–1990s, many authors described the negative effects of agricultural policies on land inequalities, in favor of large farms to the detriment of smallholders. For example, in Malawi, the size of farms was reduced and farmers who were net purchasers had to work on other farms, usually at the tiding-over period. As many small farms were also managed by women, it fell to them to work on the farms of others and young children, entrusted to their older brothers and sisters, had to wait until the mother returned to eat (Millard, Ferguson, and Khaila 1990). The current phenomenon of land grabbing seen in developing countries may offer economic opportunities for some, but results in greater poverty, food insecurity, and potential malnutrition for others (Ansoms 2013).

• *Unequal negotiating powers for contracts*

Agricultural investments by foreign investors or local elites, which lead to contracts with smallholders, are a strong trend in the future of farming (Karsenty and Ongolo 2012). There is a debate under way as to the effects on the well-being indicators of farming households, but the power relationships are very unbalanced between enterprises and farmers and, in that sense, there exists a risk for farming families under contract.

• *Inequalities linked to salaried work*

A national survey in South Africa revealed that it was on commercial farms that chronic malnutrition in children was the most prevalent in the country (Labadarios 2000). In the United States (Nichols, Stein, and Wold 2014) and Turkey (Simseka and Korukb 2011), the nutritional status among the children of seasonal agricultural workers is less good than in the rest of the population. In Chile, fruit and vegetable exports, and the standardization accompanying them, have led to a structural modification in the wage earners in this sector (Bain 2010). Some relatively protected wage earners under permanent contract work alongside unprotected seasonal wage earners (mostly women) who are without contracts. The export policy adopted by Chile has been accompanied by deterioration in working conditions for most wage earners. The development of hired labor-intensive farming therefore potentially increases the risks of malnutrition.

• *Inequalities linked to targeting*

The question of targeting interventions is a recurrent debate in agricultural development: should farmers with capacities, capital, etc. be targeted or should the poorest farmers be targeted? It is not a question here of choosing but of considering whether there exists

a risk of worsening inequalities when agricultural interventions benefit the largest producers to the detriment of the most vulnerable (FAO 2012). For example, in Malawi, the auctioning system introduced for tobacco led to a lower price being paid to small farmers than to large producers, who were the only ones allowed to sell directly via that system (Millard, Ferguson, and Khaila 1990). The example of the green revolution in Uganda also showed that small farmers did not have the means of using new technologies and were unable to take advantage, like the others, of the economic gains generated and of the improvement to their food and nutritional security (Munyonyo 1998).

VIII - Discussion

This review of the literature shows that certain agricultural interventions that are successful for certain aspects (production, income, etc.) may have unexpected negative effects on nutrition. The relations between agriculture and nutrition are eminently complex, the risks vary depending on the nature and context of the intervention, with economic growth and development (Dorward 2013). No recommendation can be made in absolute terms. Recommendations below can be applied to all scenarios, but must be specified and tailored to each context. Nevertheless, a few precautionary principles can be applied: (i) identify and keep track of nutritional risks at the ADI design stage and throughout the life span of the intervention; (ii) promote diversification to prevent risks linked to specialization of farming systems and incomes; (iii) encourage practices with low labor requirements and activities enabling women to increase their autonomy; (iv) set in place good practices known to enable a reduction in health risks; and (v) anticipate potential exclusion effects of interventions, and pay specific attention to vulnerable groups. Overall, by ensuring coordination between sectors when designing and implementing interventions, it is possible to identify and manage some aspects that the agricultural sector can hardly tackle alone. This set of precautionary principles we proposed is intended to avoid any harmful aspect of ADIs on nutrition. This "do no harm" perspective can be considered as a minimal definition of what could be nutrition-sensitive agricultural interventions. However, this also gives us indirect insights on what could be done to reinforce the positive impacts of ADIs on nutrition, thus shaping a more ambitious definition of nutrition-sensitive agricultural interventions. It seems that agricultural diversification, women-focused agricultural interventions, agroecology or the targeting of the most vulnerable groups are some of the key areas for such a definition.

We can wrap up the different insights of our study to propose a larger and more precise definition of what nutrition-sensitive agricultural policies or programs (NSAP) should be: they should promote the positive linkages and at the same time, avoid the drawbacks. It is an issue to, at least, not harm people when implementing a project. Some operational recommendations can be drawn. First of all, NSAP must recognize international human rights agreements and endeavor to implement them (Pascal 2014). NSAP

promoters should assess the nutritional situation of the population they might have a direct impact on: the farmers/cattle or raisers themselves and the members of their families. In addition, and depending on the scope of the policy, promoters should assess the nutritional situation of other populations, nonfarmers' families from the intervention area, and populations who might be affected by the outputs but who are living in other places: urban dwellers for instance who might be impacted by changes in relative prices. Diagnoses which must be carried out prior to designing the project must endeavor to identify the different impact pathways, including potential risks in order to avoid or alleviate them upstream. As already said, many times NSAP must be gender sensitive. Agricultural policies and programs geared toward the development of cash crops must be offset by measures to ensure the preservation of sufficient subsistence farming for farmers to be able to feed themselves and supply local markets. They must promote environmental and health-friendly practices. To achieve NSAP, health officials and agricultural extension practitioners should be involved, with clearly attributed roles in the definition of preventive measures (e.g. good agricultural practices, information, home visits during pregnancy, anti-mosquito measures, etc.) and measures to tackle these risks (human and animal healthcare services). Tools and methodologies must be put in place to allow project managers to monitor the potential negative impacts of their projects and to target them with adequate corrective measures. Many development actors already have similar tools at their disposal. In this case, they might, for example, include tools to track the price of essential foodstuffs (detecting the negative impacts of agricultural programs on the availability of food resources and access thereto) or to monitor the schedule and workload of women. Existing project matrices must take into account positive and negative impacts on nutrition. Most donors require the use of tools to monitor the environmental impact of agricultural projects. The integration of both positive and negative impacts on food and nutrition security could, for instance, allow for a link between agriculture, environment, and nutrition to be established. Nutritional education should be included in interventions, particularly with the objective of allowing the resulting new agricultural resources (products, income, reduction in certain prices, new time if diffusion of time-saving technologies, etc.) to contribute to better nutrition.

IX - Conclusion

While highlighting the potential negative impacts on nutrition of agricultural interventions through various pathways and suggesting operational recommendations to address these risks, the literature review has helped to identify several research gaps.

It is necessary to give further thought to defining how agricultural public policies could be nutrition sensitive. At this level of intervention, it is not easy to design agricultural and agri-food policies supporting the diversity of foodstuffs, since those policies have usually targeted priority products or supply chains.

Therefore, there is an urgent need to develop conceptual framework, methodologies, and operational tools to think food system(s) as systems and not only as separated food market chains providing each certain kinds of "healthy foods" (such as fortified single staple food). The food systems should provide *all* people (including poor and rich) *at all time* with many different kinds of affordable food products. Food systems do not only encompass producers and markets but the whole realm of eating and food practices, including provisioning, cuisine, cooking and recipes, places and different "table manners", companionship, … (see Poulain, 2002). These multiple knowledge and know-how, which are gendered are invisible, while women are the very cornerstone of food security. We believe that precise theoretical and applied research in those areas are lacking and would be most fruitful. It will nourish new conception of agricultural policies and interventions where people, especially women, would be seen as both beneficiaries and actors with real agency.

It is thus important to update explicit empirical studies on linkages between agriculture and nutrition. It was not possible to identify any recent empirical work directly showing negative impacts on nutrition. Intermediate variables were used (income, status of women, food diversity, health, etc.), but the full impact pathways have not been developed. The few recent studies of this type tend to concentrate on localized projects and on positive effects, particularly of small-scale livestock farming or family gardens. It is therefore necessary to (i) reposition the question of the links between agriculture and nutrition in the current context, taking into account the different forms of agriculture (see Wiggins and Keats 2013), the double malnutrition burden (excess weight and undernutrition), the lengthening of the supply chains (see Hawkes and Ruel 2012), the role played by private processing and distribution macro-stakeholders, etc., and (ii) extend deliberations to the scale of agricultural and food policies.

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