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PARI

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About this study

In 12 African countries and India Green Innovation Centers (GICs) have been established under the ‘‘One World, No Hunger’’ Initiative (SEWOH) of the German government and other investors. The aim of the GICs is to promote agricultural innovation, improve food and nutrition security and build sustainable value chains in the agri-food sector of these countries. The Program of Accompanying Research for Agricultural Innovation (PARI) has been providing independent research to the SEWOH since 2015. PARI is led by the Center for Development Research (ZEF) at the University of Bonn in close collaboration with the Forum for Agricultural Research in Africa (FARA) and its network of national and regional partners in Africa, the African Growth and Development Policy Modeling Consortium (AGRODEP) facilitated by the International Food Policy Research Institute (IFPRI, Africa Office) and other partners in Germany and India. This country dossier offers a situation analysis of the current state of the agri-food sector, related policies and existing agricultural innovations. It thereby provides basic background knowledge necessary to make fruitful investments in line with the country‘s policies and its potentials, and to find promising partners for development cooperation.

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Acronyms/Abbreviations

AMAPAD	Association Mawouro-bi pour la Promotion de l'Agriculture Durable/ Mawouro-bi Association for the Promotion of Sustainable Agriculture
APESS	Association pour la Promotion de l'Elevage en Savane et au Sahel/ Association for the Promotion of Livestock in the Savannah and the Sahel
Bt	Bacillus thuringiensis
CAADP	Comprehensive Africa Agriculture Development Programme
CEFCOD	Centre d'Etude, de Formation et de Conseil en Développement/ Centre for Development Studies, Training and Consulting
CORAF/WECARD	Conseil Ouest et Centre African pour la Recherche et le Développement Agricoles/ West and Central African Council for Agricultural Research and Development
DGEP	Direction Générale de l'Économie et de la Planification/ General Directorate of the Economy and Planning
DGPER	Direction Générale pour la Promotion de l'Economie Rurale/ General Directorate for the Advancement of the Rural Economy
DHS	Demographic and Health Surveys
DONATA	Dissemination of New Agricultural Technologies in Africa
DPAM	Direction de la prévision et des analyses macro-économiques/ Directorate for Macroeconomic Forecasting and Analysis
ECOWAP	ECOWAS Agricultural Policy
ECOWAS	Economic Community of West African States
FAO	Food and Agriculture Organization
FARA	Forum for Agricultural Research in Africa
FMI	Fonds Monétaire International/ International Monetary Fund
GDP	Gross Domestic Product
GHI	Global Hunger Index
GIC	Green Innovation Center
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit/ German Agency for International Cooperation
GNI	Gross National Income
IFPRI	International Food Policy Research Institute
INERA	Institut de l'Environnement et des Recherches Agricoles/ National Institute for the Environment and Agricultural Research
IP	Innovation Platform
IRSAT	Institut de Recherche en Sciences Appliquées et de Technologies/ Institute for Research in Applied Sciences and Technologies
NGO	Non-Governmental Organization
PABSO	Projet d'aménagement des bas-fonds dans le Sud-Ouest et la Sissili/ Lowland Development Project in the South-West and Sissili
PARI	Program of Accompanying Research for Agricultural Innovation
PNSR	Programme national du secteur rural National Rural Sector Program
PPAAO/WAAP	Programme de Productivité Agricole en Afrique de l'Ouest/ West Africa Agricultural Productivity Program
PPP	Purchasing Power Parity
PRP	Projet de Riz Pluvial/ Rain Fed Rice Project
R&D	Research and Development
RCA	Revealed Comparative Advantage
SCADD	Stratégie de Croissance Accélérée et de Développement Durable/ Strategy for Accelerated Growth and Sustainable Development
SEWOH	"One World, No Hunger" initiative

SONAGESS	Société nationale de gestion du stock de sécurité alimentaire/ National Cereal Bank
SRI	System of Rice Intensification
TFP	Total Factor Productivity
UNICEF	United Nations International Children's Emergency Fund
USAID	United States Agency for International Development
WHO	World Health Organization
ZEF	Zentrum für Entwicklungsforschung/ Center for Development Research

1 General background information on the agricultural and food sectors

Burkina Faso is a landlocked country in West Africa. The economy has seen considerable growth over the past decade, with an annual average growth rate of over 6% between 2000 and 2012 (Food and Agriculture Organization (FAO), 2014). Agriculture, livestock, forestry and mining are the dominant economic activities. The agriculture sector employs the largest share of the workforce and accounted for 30% of Gross Domestic Product in 2012 (ibid). The cotton sector in particular has benefitted from the modernization measures implemented by the government, although insufficient water supply and poor soil continue to hamper the growth of the sector. Cereal output has also been on the rise, but part of the demand still needs to be met with imports. Other important crops are cassava, cowpeas, sweet potatoes, and tobacco. Sugarcane has recently been introduced on a large scale and is becoming an important cash crop.

In twelve African countries, including Burkina Faso, Green Innovation Centers (GICs) have been established in selected regions under the ‘‘One World, No Hunger’’ Initiative (SEWOH) of the German government and other investors. The aim of the GICs is to promote agricultural innovation, improve food and nutrition security and build sustainable value chains in the agri-food sector. The selected value chains in Burkina Faso are rice and vegetables in the rainy season, rice and sesame in Southwest region, and sesame production (including also post-harvest and processing) in the Eastern Region.

1.1 Pan-African policies and strategies

Burkina Faso was the 20th African country to sign the Comprehensive Africa Agriculture Development Programme (CAADP) compact in 2010. Between 2005 and 2015, Burkina Faso has reached or exceeded the CAADP 10% budget allocation target six years out eleven years. It has also exceeded the annual 6% growth rate target four years during the same period. Burkina Faso is one of the West African countries that adopted the **Economic Community of West African States (ECOWAS) Agricultural Policy (ECOWAP)** in 2005 to ensure food security, economic and social development, and poverty reduction in the region. Another objective of ECOWAP is to operationalize the CAADP process in West Africa. In 2012, Burkina Faso joined the **New Alliance for Food Security and Nutrition** with the commitment to achieve sustained inclusive, agriculture-led growth in the country. It seeks to facilitate greater private investment in agricultural development, scale innovation, achieve sustainable food security outcomes, reduce poverty, and end hunger. Burkina Faso is also part of the **Grow Africa Partnership,** with the goal of increasing private sector investment in agriculture, and accelerating the execution and impact of investment commitments. In 2013-2014, US$ 36 million investments were made, 172,000 smallholders were reached, and 1,751 jobs were created in Burkina Faso by international and national companies through the Grow Africa Partnership and New Alliance for Food Security and Nutrition initiatives.

1.2 National (and regional) policies and strategies

The Government of Burkina Faso adopted a new development strategy in 2010, the five-year Strategy for Accelerated Growth and Sustainable Development (SCADD). The SCADD is centered on promising areas and value chains for the acceleration of growth and job creation through private investments and diversified high value production. SCADD emphasizes: (i) promoting growth poles, (ii) developing promising value chains, business niches and clusters and (iii) encouraging a pro-poor growth to effectively alleviate poverty. It is notable that SCADD was replaced by the *Plan national du développement économique et* social, the National Program for Socioeconomic Development.

Under ECOWAP and SCADD, the government developed a National Rural Sector Program (PNSR I) in 2012 which has the objective of contributing to ensuring food and nutrition security, sustained

economic growth and poverty reduction. Phase II of the National Rural Sector Program (PNSR II) is now under implementation.

Some key agricultural and food sector policy decisions by the Burkinabe government in recent years include:

- Input subsidies, which accounts for a large share of agricultural expenditure;
- Provision of price support to cotton farmers;
- Increased investments in irrigation systems;
- Adoption of new legislation to enhance land tenure security;
- School feeding as one of the main social safety nets;
- Use of food security stock for emergency purpose;
- Suspension of import tariffs to respond to the food crisis.

1.3 Data on food and nutrition security in Burkina Faso and GIC region

The following section includes information about important socio-economic and agricultural indicators and data on diet quantity, diet quality and nutrition status.

1.3.1 Socio-economic and agricultural data

Table 1: Selected national economic and health-related data

Indicator	Value	Year
Population, total	17,419,615	2014
Population growth (annual %)	1.6	2014
Rural population (% of total population)	71	2014
GDP per capita, PPP (constant 2011 international $)	1,606	2014
GNI per capita, PPP (constant 2011 international $)	1,591	2014
Poverty headcount ratio at $2 a day (PPP) (% of population)	72	2009
Poverty headcount ratio at $1.25 a day (PPP) (% of population)	44	2009
Poverty headcount ratio at national poverty lines (% of population)	47	2009
Rural poverty headcount ratio at national poverty lines (% of rural population)	53	2009
Agricultural land (% of land area)	44	2012
Agricultural irrigated land (% of total agricultural land)	no data	
Agriculture value added per worker (constant 2005 US$)	190	2014
Agriculture, value added (% of GDP)	22	2014
Access to electricity, rural (% of rural population)	1.4	2012
Employees, agriculture, female (% of female employment)	87	2005
Employees, agriculture, male (% of male employment)	82	2005
Employment in agriculture (% of total employment)	85	2005
Literacy rate, adult total (% of people ages 15 and above)	29	2007
Ratio of female to male secondary enrolment (%)	85	2013
Mortality rate, under-5 (per 1,000 live births)	98	2013
Maternal mortality ratio (modeled estimate, per 100,000 live births)	340	2010

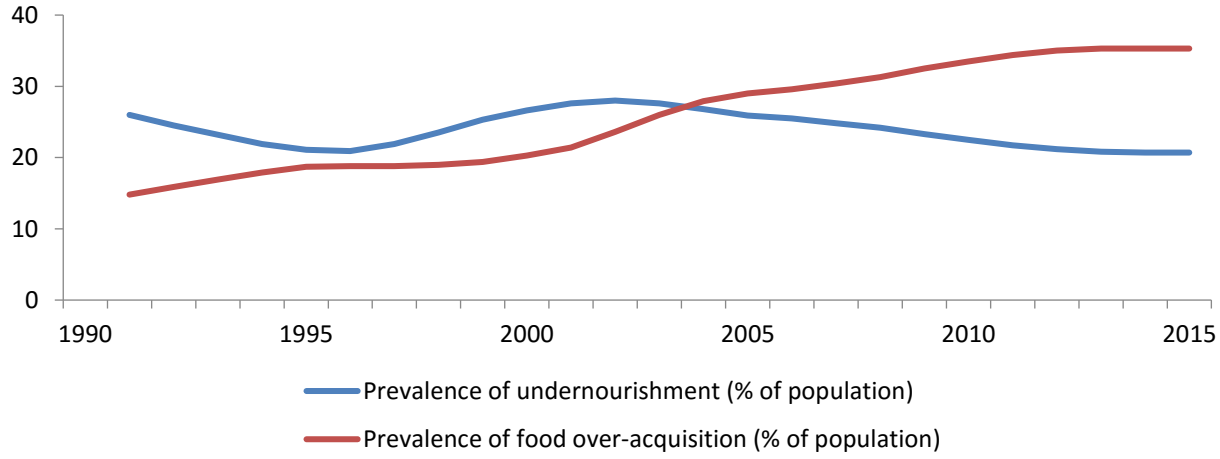
Source: World Bank, data.worldbank.org/country

Note: GDP refers to Gross Domestic Product; GNI refers to Gross National Income; PPP refers to Purchasing Power Parity

1.3.2 Consumption and nutrition status

Overall, dietary energy supply per capita – a measure of diet quantity – is sufficient in Burkina Faso, exceeding the average dietary energy requirement of the population by about 20% (Table 2). Nevertheless, about one fifth of the population is unable to meet their minimum dietary energy requirements and suffers from chronic undernourishment. The prevalence of undernourishment has decreased very little since 1990-92 – by only five percentage points – and has even seen a transient increase between the mid-1990s and 2002 (Figure 1). The prevalence of food-over acquisition has risen more steadily in the past 25 years. The Food and Agriculture Organization of the United Nations (FAO) estimates that about one third of the Burkinabe population regularly acquires food in excess of their dietary energy needs (Table 2).

Figure 1: Prevalence of undernourishment and food over-acquisition (1990-92 to 2014-16)



Source: Authors' presentation based on data from FAO (2016)

The diet in Burkina Faso is predominantly based on starchy staples (mainly maize, sorghum, millet, and rice) that provide about two thirds of dietary energy supply (Table 2). The shares of dietary energy supply from carbohydrates, protein, and fat are well within the recommended ranges of 55-75%, 10-15%, and 15-30%, respectively (WHO, 2003). This means that the diet is balanced in terms of its macronutrient composition. Judged against protein requirements, average protein supply is more than sufficient (Table 2; see Annex A for further explanation).

The consumption of sufficient quantities of non-staple foods such as fruits and vegetables and animal-source foods is essential for the diet to provide adequate micronutrients. Meat and fish supply amounts to only about 50 g/caput/day in Burkina Faso, despite increases in supply after the turn of the millennium (Figure 2). Milk supply has remained low overall, and eggs play only a minor role in the Burkinabe diet. Pulses and nuts are supplied in moderate amounts, providing roughly one fifth of protein supply in Burkina Faso.[1] The supply of fruits and vegetables is dismally low and has even declined after 2005. Amounting to little more than 60 g/caput/day in recent years, it falls way below the recommended intake of 400 g of fruits and vegetables per day (WHO, 2003).

[1] Source: Food balance sheet for Burkina Faso, 2013, from FAOSTAT, accessed 20 Oct, 2016.

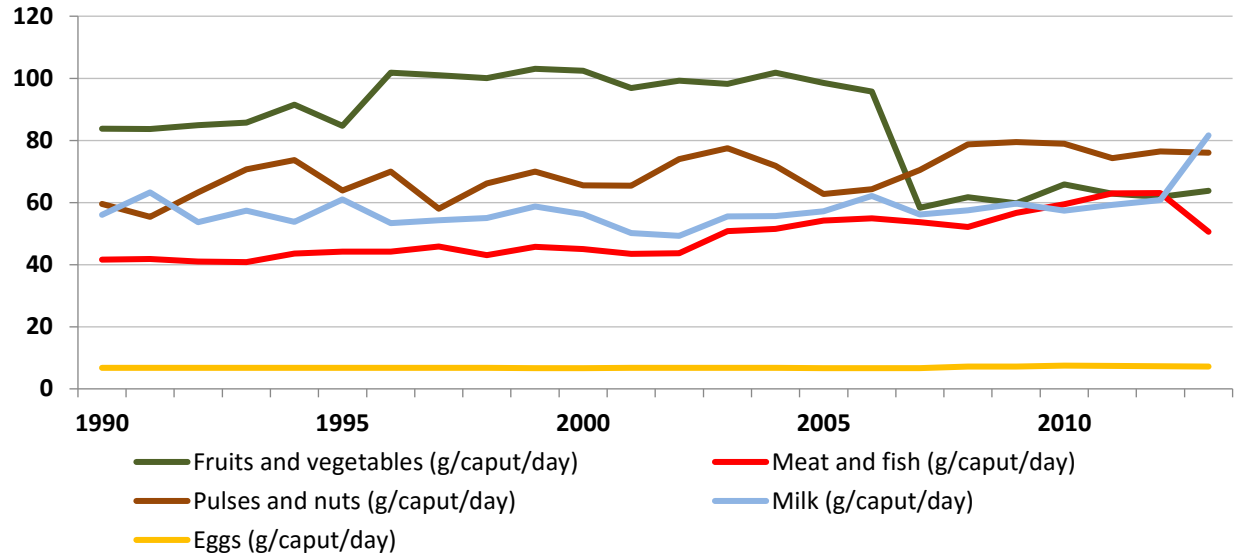
Table 2: Food and nutrition security indicators

Indicator	Value	Year
Diet quantity		
Dietary energy supply (kcal/caput/day)	2712	2014-16
Average dietary energy supply adequacy (% of average requirement)	123	2014-16
Prevalence of undernourishment (% of population)	21	2014-16
Prevalence of food over-acquisition (% of population)	35	2014-16
Diet quality		
Dietary energy supply from cereals, roots and tubers (% of total dietary energy supply)	65	2009-11
Dietary energy supply from carbohydrate (% of total dietary energy supply)	67	2009-11
Dietary energy supply from protein (% of total dietary energy supply)	12	2009-11
Dietary energy supply from fat (% of total dietary energy supply)	21	2009-11
Average protein supply (g/caput/day)	80	2009-11
Average fat supply (g/caput/day)	61	2009-11
Child feeding practices		
Minimum dietary diversity: consumption of 4+ food groups (% of children 6-23 months)	6	2010
Consumption of foods rich in vitamin A (% of children 6-23 months)	35	2010
Consumption of foods rich in iron (% of children 6-23 months)	23	2010
Nutrition status		
Child wasting (% of children under five)	11	2012
Child stunting (% of children under five)	33	2012
Child overweight (% of children under five)	2	2010
Adult overweight and obesity (% of adults 18+ years)	24	2014
Adult obesity (% of adults 18+ years)	6	2014
Vitamin A deficiency (% of children 6-59 months)	52	2013
Anemia in children (% of children 6-59 months)	86	2014
Anemia in women (% of women 15-49 years)	49	2010

Source: FAO (2016), and authors' calculations based on FAO (2016); Institut National de la Statistique et de la Démographie and ICF International (2012); Institut National de la Statistique et de la Démographie, Programme National de Lutte contre le Paludisme and ICF International (2015); Ministère de la Santé, Direction de la Nutrition (2012); Stevens et al. (2015), quoted in International Food Policy Research Institute (IFPRI) (2015); World Health Organization (WHO) (2015a)

Note: See Annex A for definitions of the indicators.

Figure 2: Supply of non-staple foods (1990-2013)

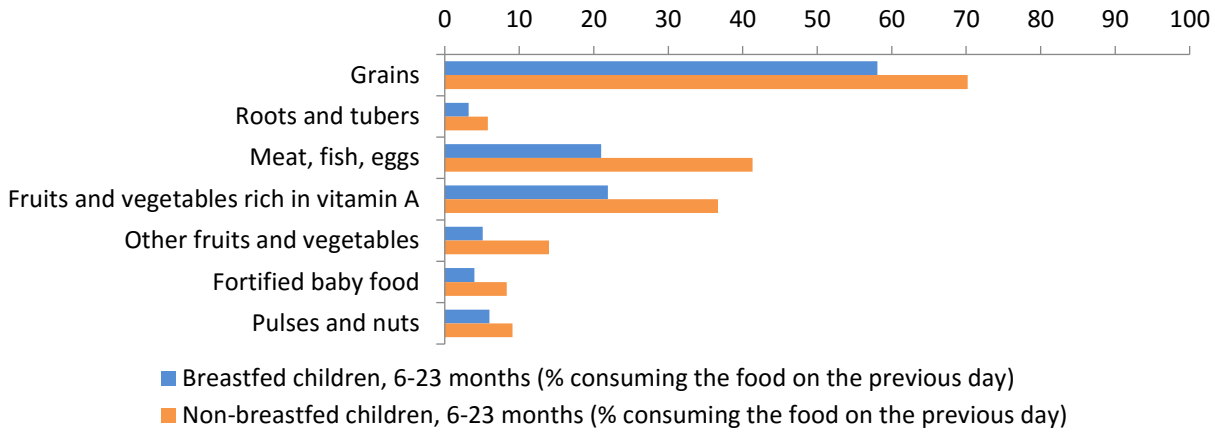


Source: Authors' presentation based on data from FAOSTAT, accessed 07 Oct 2016
Note: Based on their nutrient profiles, pulses and nuts include groundnuts and soybeans, although these foods are classified by FAO as oil crops. Coconuts are not included among pulses and nuts because they have low protein content

Two dietary intake studies among women of reproductive age in Burkina Faso, one in the capital city Ouagadougou and one in two rural provinces in the Nord and Nord-Ouest regions, found that their diets were lacking in multiple micronutrients. The women's intakes of vitamin B12 (a micronutrient found only in animal-source foods) and calcium were highly inadequate. The diets of the women in Ouagadougou were also highly deficient in iron and most other B-vitamins, whereas the women in the rural areas had very low intakes of vitamin A, vitamin C and folate (Martin-Prével et al., 2015).

Infant and young child feeding practices are crucial for children's nutrition and health status and long-term development. Children 6-23 months should consume at least 4 out of 7 food groups (minimum dietary diversity) and receive iron-rich foods and foods rich in vitamin A daily. In Burkina Faso, infants' and young children's diets are sorely lacking with regard to these recommendations: only 6% achieved minimum dietary diversity, roughly one third consumed foods rich in Vitamin A, and less than one fourth had foods rich in vitamin A on the previous day (Table 2). Both breastfed and non-breastfed children aged 6-23 months were most frequently fed foods made from grains; other, more micronutrient-rich foods such as meat, fish and eggs, fruits and vegetables, and pulses and nuts, were given much more rarely (Figure 3). Fortified baby foods, which can compensate for a lack of micronutrients in the diet, were consumed by less than 10% of breastfed and non-breastfed children.

Figure 3: Percentage of infants & young children consuming foods from selected food groups (2010)

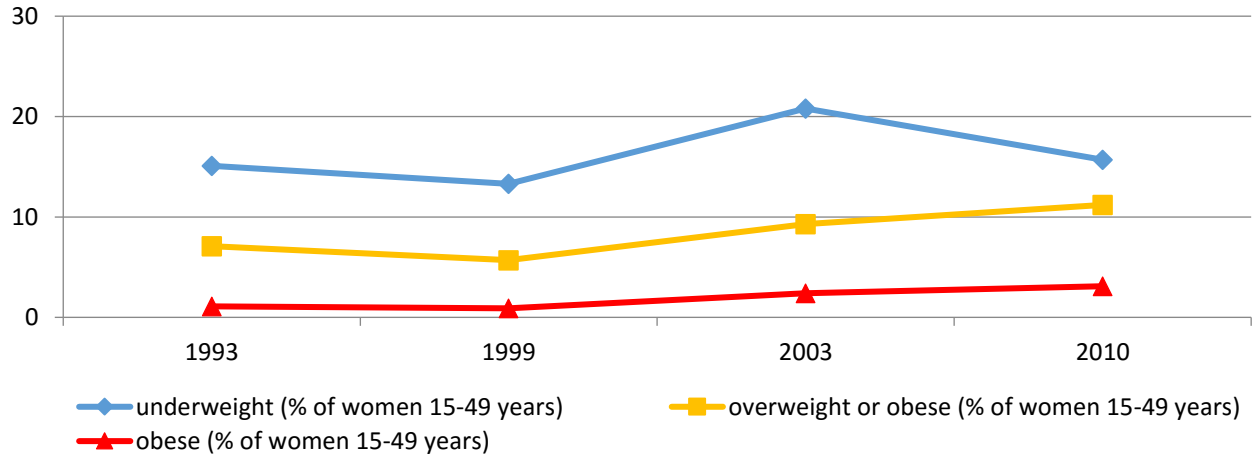


Source: Authors' presentation based on data from Institut National de la Statistique et de la Démographie and ICF International (2012)

Stunting and wasting are indicators of chronic and acute child undernutrition, respectively. With 33% of children under five in Burkina Faso being stunted and 11% being wasted, the public health significance of these forms of undernutrition is moderate (Table 2). Wasting has fluctuated greatly in Burkina Faso since the early 1990s – with prevalence rates varying between 10% and 24% – and was cut by less than one third overall (UNICEF[2]/WHO/World Bank, 2016). Progress was even slower for stunting, which was reduced by less than one fifth since 1992-93. According to the latest available data, overweight in children is at a low level (Table 2).

Overweight and obesity are risk factors of chronic diseases such as diabetes (Must and McKeown 2012). About one fourth of adults in Burkina Faso are overweight or obese (Table 2). According to data from the Demographic and Health Surveys (DHS), the combined prevalence of overweight and obesity has increased relatively slowly among women of reproductive age, barely exceeding 10% by 2010 (Figure 4). The prevalence of underweight, however, is still unacceptably high: 16% of women were underweight in 2010, down from a peak of 21% a few years earlier.[3]

Figure 4: Underweight, overweight and obesity among women of reproductive age (1993-2010)



Source: Authors' presentation based on data from ICF International (2015), The DHS Program STATcompiler, funded by the United States Agency for International Development (USAID), accessed 12 Sept 2016

[2] UNICEF = United Nations International Children's Emergency Fund

[3] See Annex A for definitions of overweight, obesity, and underweight.

Vitamin A deficiency is a risk factor for blindness and for mortality from measles and diarrhea in children aged 6–59 months (Imdad et al. 2010; Imdad et al. 2011). In Burkina Faso, more than half of all children in this age group are estimated to be vitamin A deficient (Table 2). A staggering 86% of children aged 6-59 months and close to 50% of all women of reproductive age suffer from anemia (Table 2). About half of the global burden of anemia can be attributed to iron deficiency (WHO, 2015b). Anemia is also caused by malaria, which is prevalent in Burkina Faso and constitutes a major risk factor of severe anemia among preschool children (Institut National de la Statistique et de la Démographie, Programme National de Lutte contre le Paludisme and ICF International, 2015).

Regionally disaggregated data are available for indicators of nutrition status and child feeding. The diversity of infants' and young children's diets is very low throughout the country. Only the Centre region, which includes the capital Ouagadougou, and the neighbouring Centre-Sud region exceed the national average of 6% of children having minimum dietary diversity by a mentionable margin (Table 3). In the more remote Centre-Ouest, Centre-Est, Centre-Nord, and Sahel regions, however, only 1% of children aged 6-23 months achieved minimum dietary diversity. The Centre-Est, Centre-Nord, and Sahel regions also rank at the bottom in terms of the shares of children consuming foods rich in iron and vitamin A, whereas the Centre and Hauts Bassins regions do best on these indicators. In the Centre, Sud-Ouest and Hauts Bassins regions, children have the lowest rates of anemia, whereas the highest anemia prevalence is found in the Sahel region (Table 4). The adjacent Est region has the highest proportion of stunted children, almost three times as high as in the Centre region. The Centre-Nord and Est regions have the worst wasting rates.

Regarding overweight and obesity in women, they are most prevalent in the Centre, Hauts Bassins, and Cascades regions (Table 5). Concurrently, these regions have the lowest underweight prevalence in women, whereas the Est and Sahel regions are most affected by underweight in women. Anemia prevalence among women is highest in the Sahel region, and lowest in the Centre and Sud-Ouest regions.

Table 3: Child feeding practices by region, 2010

Share of children 6-23 months consuming:					
4+ food groups		Foods rich in vitamin A		Foods rich in iron	
Region	**(%)**	**Region**	**(%)**	**Region**	**(%)**
Centre	19	Centre	55	Centre	43
Centre-Sud	16	Hauts Bassins	51	Hauts Bassins	36
Boucle de Mouhoun	8	Sud-Ouest	47	Centre-Sud	35
Hauts Bassins	7	Centre-Sud	46	Boucle de Mouhoun	28
Cascades	6	Boucle de Mouhoun	41	Sud-Ouest	23
Est	6	Plateau Central	35	Cascades	23
Sud-Ouest	3	Est	35	Centre-Ouest	20
Plateau Central	3	Cascades	35	Est	19
Nord	2	Nord	27	Nord	17
Centre-Est	1	Centre-Ouest	27	Plateau Central	16
Centre-Ouest	1	Centre-Nord	22	Centre-Nord	12
Centre-Nord	1	Centre-Est	20	Centre-Est	12
Sahel	1	Sahel	9	Sahel	4

Source: Institut National de la Statistique et de la Démographie and ICF International (2012)
Notes: GIC regions are highlighted in red. See Annex A for definitions of the indicators.

Table 4: Child nutrition status by region, 2010/2012/2014

Prevalence among children under five:						Prevalence among children 6-59 months:	
Stunting		**Wasting**		**Overweight**		**Anemia**	
Region	(%)	**Region**	(%)	**Region**	(%)	**Region**	(%)
Centre	16	Cascades	6	Nord	1	Centre	80
Centre-Ouest	30	Hauts Bassins	8	Centre-Est	1	Sud-Ouest	80
Nord	31	Centre-Sud	9	Hauts Bassins	1	Hauts Bassins	81
Boucle de Mouhoun	31	Centre-Est	10	Centre-Ouest	2	Centre-Sud	82
Hauts Bassins	32	Sahel	10	Sahel	2	Centre-Nord	83
Centre-Est	33	Sud-Ouest	10	Boucle de Mouhoun	2	Centre-Ouest	86
Centre-Sud	33	Centre-Ouest	11	Sud-Ouest	2	Centre-Est	86
Plateau Central	34	Plateau Central	11	Plateau Central	2	Plateau Central	87
Centre-Nord	34	Boucle de Mouhoun	11	Est	3	Est	87
Sud-Ouest	34	Centre	12	Centre	4	Nord	88
Cascades	40	Nord	12	Centre-Nord	4	Boucle de Mouhoun	91
Sahel	41	Est	13	Cascades	6	Cascades	93
Est	45	Centre-Nord	14	Centre-Sud	6	Sahel	95

Source: Institut National de la Statistique et de la Démographie and ICF International (2012); Institut National de la Statistique et de la Démographie, Programme National de Lutte contre le Paludisme and ICF International (2015); Ministère de la Santé, Direction de la Nutrition (2012)
Notes: GIC regions are highlighted in red. Data on wasting and stunting were collected in 2012, data on overweight in 2010, and data on anemia in 2014. See Annex A for definitions of the indicators.

Table 5: Women's nutrition status by region, 2010

Prevalence among women of reproductive age (15-49 years):							
Underweight		**Overweight + obesity**		**Obesity**		**Anemia**	
Region	(%)	**Region**	(%)	**Region**	(%)	**Region**	(%)
Centre	8	Centre-Sud	4	Nord	0	Sud-Ouest	40
Cascades	9	Centre-Nord	5	Centre-Nord	1	Centre	42
Hauts Bassins	12	Nord	5	Est	1	Nord	44
Plateau Central	13	Est	5	Centre-Sud	1	Plateau Central	45
Boucle de Mouhoun	13	Plateau Central	6	Sud-Ouest	2	Hauts Bassins	45
Centre-Nord	15	Centre-Est	6	Centre-Ouest	2	Centre-Sud	46
Sud-Ouest	15	Sud-Ouest	7	Plateau Central	2	Boucle de Mouhoun	49
Centre-Est	17	Centre-Ouest	7	Centre-Est	2	Centre-Est	50
Centre-Ouest	18	Sahel	8	Boucle de Mouhoun	2	Centre-Ouest	51
Centre-Sud	20	Boucle de Mouhoun	9	Sahel	2	Centre-Nord	51
Nord	20	Cascades	14	Cascades	3	Est	53
Sahel	23	Hauts Bassins	17	Hauts Bassins	4	Cascades	57
Est	31	Centre	27	Centre	10	Sahel	69

Source: Institut National de la Statistique et de la Démographie and ICF International (2012)
Notes: GIC regions are highlighted in red. See Annex A for definitions of the indicators.

Among indicators of children's nutrition status that are available at the regional level, anemia dominates the picture in terms of prevalence rates, followed by stunting (Table 4). Under the assumption that half of all anemia is due to iron deficiency, iron deficiency anemia among children is of moderate public health significance in the Centre and Sud-Ouest regions, and of severe public health significance in all other regions.[4] Stunting has mild public health significance in the Centre-Ouest region, severe significance in the Cascades, Sahel, and Est regions, and moderate significance in all other regions. Wasting levels are a mild concern in the Cascades, Hauts Bassins, Centre-Sud and Centre-Est regions, and moderately high in the remaining regions. Overweight in children has mild public health significance the Est, Centre, and Centre-Nord regions, and moderate significance in the Cascades and Centre-Sud regions.

Considering indicators of women's nutrition status that are available at the regional level, anemia has the highest prevalence rates in all regions, followed by underweight in 10 regions, and overweight and obesity (combined) in the remaining 3 regions (Table 5). In the Est region, more than 30% of the women are underweight, and close to one quarter are underweight in the Sahel region.

In summary, over- and undernutrition coexist in Burkina Faso and micronutrient deficiencies are widespread. Dietary energy supply needs to be increased in disadvantaged regions, ideally without spurring further increases in overweight and obesity. Dietary diversity and the supply of micronutrient-rich foods such as fruits and vegetables and animal-source foods are very low in Burkina Faso, and there is an urgent need to improve diet quality by developing value chains for vegetables, fruits, animal-source foods, and possibly also red palm oil (rich in vitamin A). Value chains for pulses, nuts and seeds are also relevant because these foods are already an integral part of the Burkinabe diet and they are good sources of micronutrients, protein, and dietary energy. The fortification of staple foods and the production of fortified baby foods could be addressed at the processing stage of the value chain. Promoting biofortified staple foods, such as the orange-fleshed sweet potato and maize rich in Vitamin A developed by HarvestPlus, could also be considered for Burkina Faso.[5]

In addition, reducing aflatoxin contamination of foods is necessary to improve food safety in Burkina Faso. Aflatoxins are highly toxic substances that are produced by certain types of fungi and can cause acute poisoning, liver cancer, and stunted growth in children (Bhat and Vasanthi, 2003; Gong et al., 2004). In Burkina Faso, aflatoxins and other mycotoxins were found in maize, sorghum, groundnuts, infant foods, and animal feed (Warth et al., 2012; Partnership for Aflatoxin Control in Africa, 2013).
A look at the regions reveals that nutritional deficiencies are particularly severe in the Sahel region. This suggests prioritizing the Sahel region for interventions and agricultural innovations, yet climatic and other factors may be limiting factors. In the Centre region, which hosts the capital city, infants and young children have better diets, child stunting and underweight in women are lower, and anemia rates are more favorable than in other regions. At the same time, the Centre region has the highest proportions of overweight and obesity among women. Burkina Faso is a member of the Scaling Up Nutrition[6] network, a global movement led by 57 countries that aims to end malnutrition in all its forms.

[4] About half of the global burden of anemia is attributable to iron deficiency (WHO, 2015b). Since the prevalence of anemia among children in Burkina Faso is in the range of 79.6-95.3% at the regional level, the prevalence of iron deficiency anemia can be estimated to be 39.8-47.7%. This means that all except for two regions reach or exceed the threshold of 40% established to classify iron deficiency anemia a severe public health problem (see Annex A). However, it is possible that less than half of all anemia in Burkina Faso is caused by iron deficiency because malaria is widespread in the country.

[5] See www.harvestplus.org/what-we-do/crops.

[6] see scalingupnutrition.org/ for more information

1.4 Data on most relevant crops and value chains

The most relevant crops in Burkina Faso include sorghum and millets, maize, sesame, legumes (groundnuts, Bambara beans, and cowpeas), rice, sweet potatoes and vegetables. Cotton production is also an important sector.

1.4.1 Production

Table 6: Top 10 crops produced by area, volume and value

Area harvested (ha)		**Production volume (tons)**		**Production value***	
Top 10	Share of Total	Top 10	Share of Total	Top 10	Share of Total
Sorghum	25.2	Sorghum	21.4	Sorghum	22.8
Millet	18.6	Maize	17.8	Maize	18.8
Cow peas, dry	18.0	Millet	12.2	Seed cotton	14.5
Maize	12.3	Seed cotton	8.8	Millet	12.7
Seed cotton	8.9	Cow peas, dry	6.8	Cow peas, dry	11.3
Groundnuts	6.0	Sugar cane	5.6	Rice, paddy	6.8
Sesame seed	4.3	Cottonseed	4.9	Groundnuts	4.2
Rice, paddy	2.1	Groundnuts	3.9	Sesame seed	3.5
Cashew nuts	1.4	Rice, paddy	3.8	Sweet potatoes	1.1
Bambara beans	0.8	cotton lint	2.9	Yams	1.1
		Rank 12: Sesame seed	2.2		

Data: average 2012-2014, FAOSTAT, accessed 17 January, 2017
* Gross Production Value (constant 2004-2006 million US$), data: average 2011-2013, FAOSTAT, accessed 17 January, 2017
Note: GIC value chains marked in red; nes refers to Not elsewhere specified

1.4.2 Trade

Table 7 below shows that gold and cotton are the most traded products of Burkina Faso's exports. Until 2008, cotton was the main export product, but gold overtook cotton in the recent decade with sharp increases in the export of the product. In 2015, gold represented almost 62% of the total value of the top 5 export commodities (Table 7). The fluctuations in cotton exports reflect a crisis in that sector. The seeds and oil fruits, coconuts, and zinc are also important export products, but their share of the total exports remains low and variable. When considering only agricultural products, table 11 shows that Burkina Faso's top exports include cotton, oilseeds and beans.

Table 7: Changes in the share of export of five main products in total exports (in %)

Product	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Gold	25.74	47.74	68.63	77.42	65.64	55.98	51.41	61.74
Cotton	41.7	31.28	17.31	11.42	12.19	16.56	17.39	13.09
Oilseeds and oleaginous fruit	8.72	7.54	5.51	3.85	4.52	7.81	6.82	10.01
Coconuts	0.85	0.38	0.62	2.68	1.37	1.96	1.51	3.95
Unwrought zinc	-	-	-	-	-	0.94	3.06	2.53

Source: Adapted from African Statistical Yearbook (2017).

France has historically been the first destination for Burkina Faso's exports. However, exports to Switzerland have surpassed exports to France since 2004, and they increased from 40% to almost 51% between 2008 and 2015. The primary export products to Switzerland include gold and cotton. In the past decade, other partners rose to the trade scene, namely India, Singapore, South Africa and Côte d'Ivoire, becoming part of the top 5 export destinations.

Table 8: Burkina Faso's five main export countries

Country	Export to country as a share of total exports (in %)							
	2008	2009	2010	2011	2012	2013	2014	2015
Switzerland	40.21	55.40	63.43	69.2	58.4	52.21	49.96	50.62
India	0.21	0.5	0.08	0.39	0.29	0.26	1.12	10.3
Singapore	11.28	11.68	4.89	4.67	4.69	5.17	6.81	10.01
South Africa	-	-	11.18	10.25	9.12	5.43	4.04	3.9
Côte d'Ivoire	5.32	2.01	1.48	1.04	1.95	2.3	5.24	3.54

Source: Adapted from African Statistical Yearbook (2017).

China became the largest import partner to Burkina Faso, supplying 11.07% of total imports in 2015, thus surpassing France. Imports from France decreased from almost 14% to 9% between 2008 and 2015. Imports from Côte d'Ivoire also fell from 15.40% to 8.36% in the same period. Other important import partners include the Netherlands and the United States. Table 10 shows that the main agricultural products imported in Burkina are rice, sugar, wheat, tobacco and other prepared foods. Non-agricultural products include petroleum, medicaments, cement, motor cars and motor vehicles (African statistical yearbook, 2017).

Table 9: Burkina Faso's five main imports countries

Country	Import from country as a share of total imports (in %)							
	2008	2009	2010	2011	2012	2013	2014	2015
China	9.68	9.84	9.67	9.81	8.88	9.71	9.03	11.07
France	13.85	12.83	10.3	12.14	8.41	8.57	11.1	9.03
Côte d'Ivoire	15.40	14.55	16.02	10.68	9.45	8.87	16.9	8.36
Netherlands	3.37	5.29	4.39	3.99	2.1	8.57	1.31	7.65
United States	5.72	4.87	4.05	4.32	6.98	6.21	2.32	6.44

Source: Adapted from African Statistical Yearbook (2017).

Table 10: Burkina Faso's imports

Import volume (tons)		Import value (US$)	
Top 10	**Share of Total**	**Top 10**	**Share of Total**
Rice – total (Rice milled equiv.)	43.8	Rice – total (Rice milled equiv.)	24.5
Sugar refined	10.8	Tobacco products nes	10.0
Wheat	7.8	Food prep nes	9.8
Flour, wheat	6.2	Sugar refined	8.1
Oil, palm	5.9	Wheat	6.6
Food prep nes	3.1	Flour, wheat	5.2
Macaroni	1.9	Oil, palm	5.5
Food wastes	1.9	Flour, wheat	4.5
Beverages, non-alcoholic	1.6	Milk, whole dried	3.2
Malt	1.4	Coffee, extracts	3.0
Sesame seed	0.0	Sesame seed	0.0

Data: average 2011-2013, FAOSTAT, accessed 17 January, 2017
Note: GIC value chains marked in red; nes refers to Not elsewhere specified

Table 11: Burkina Faso's exports

Export volume (tons)		Export value (US$)	
Top 10	**Share of Total**	**Top 10**	**Share of Total**
Cotton lint	41.0	Cotton lint	60.4
Sesame seed	18.0	Sesame seed	18.5
Cashew nuts, with shell	13.2	Cashew nuts, with shell	7.4
Beans, dry	4.6	Oilseeds nes	3.8
Maize	3.9	Cashew nuts, shelled	1.5
Cake, cottonseed	3.7	Fruit, tropical fresh nes	1.1
Tomatoes	2.2	Oil, vegetable origin nes	0.9
Onions, shallots, green	1.8	Maize	0.9
Cotton waste	1.6	Cake, cottonseed	0.8
Fruit, tropical fresh nes	1.5	Beans, dry	0.8
Rank 20: Rice – total (Rice milled equivalent)	0.2	Rice – total (Rice milled equivalent)	0.1

Data: average 2011-2013, FAOSTAT, accessed 17 January, 2017
Note: GIC value chains marked in red; nes refers to Not elsewhere specified

1.5 National (and regional) innovation system

1.5.1 Research system and organizations

The international and national agencies that are conducting research activities and their research areas are summarized in the tables below.

1.5.1.1 International

Table 12: International research organizations in Burkina Faso

Organization	Research focus
International Institute of Tropical Agriculture	Cowpea
International Livestock Research Institute	Livestock
International Water Management Institute	Water and land resources
Centre de Coopération Internationale en Recherche Agronomique pour le Développement	Crops, livestock, food and energy security, public policy
West African Science Service Center on Climate Change and Adapted Land Use	Crops, livestock, climate change
Institut de Recherche pour le Développement	Social, biophysical and medical sciences

Source: Authors' compilations

1.5.1.2 National

Table 13: National research organizations in Burkina Faso

Type	Organization	Research Focus
Government	Institut de l'Environnement et des Recherches Agricoles (INERA)	Crops, natural resources, forestry, socioeconomics, livestock
	Institut de Recherche en Sciences Appliquées et de Technologies (IRSAT)	Off-farm post-harvest, natural resources, agricultural engineering, socioeconomics
	Laboratoire National d'Élevage	Livestock, pastures and forages
	Centre National de Semences Forestières	Forestry, socioeconomics
	Bureau National des Sols	Soils
	Direction des Pêches	Fisheries
Higher Education	Institut du Développement Rural, Université Polytechnique de Bobo-Dioulasso	Natural resources, pastures and forages
	Unité de Formation et de Recherche - Sciences de la Vie et de la Terre, Université de Ouagadougou	Crops, livestock, natural resources
	Unité de Formation et de Recherche - Sciences Économiques et Gestion, Université de Ouagadougou	Crops, livestock, pasturages and forages, off-farm post-harvest, natural resources, socioeconomics
	Département de Biologie, Technologie et Informatique, Université Catholique de l'Afrique de l'Ouest	Livestock, socioeconomics
	Centre Agricole Polyvalent de Matourkou	Crops, livestock, natural resources, socioeconomics
Non-Governmental Organization (NGO)	Centre Ecologique Albert Schweitzer	Crops, livestock, off-farm post-harvest

Source: asti.cgiar; author

1.5.2 Innovation platforms

Before 2010, the main approach for the country's agricultural products development was based on the sectorial approach. The first experience with the value chain and innovation platforms (IPs) was implemented with the FARA project DONATA, which stands for Dissemination of New Agricultural Technologies in Africa, in the Burkinabe province of Sissili. Since then, the approach has been applied to several agricultural value chains in the country. Table 14 presents some of the IPs that have been implemented in the country.

Table 14: Example of IPs implemented in Burkina Faso at the regional or local level

IP Name	Location	Name of focal	Commodity of interest
Maize	Leo province	Dr Taonda J., INERA	Maize grain
Sesame	Nouna	Dr Minoungou A., INERA	White sesame
Yellow maize	Banfora/Comoe province,	Dr Wereme/ N'diaye A., INERA	Yellow maize
Maize and animal products	Koumbia/Houet province	Ouedraogo S., INERA	Maize and animal products
Maize	Dedougou/Mouhoun province	Dr Wereme/ N'diaye A., INERA	Yellow maize
Agricultural seed system	Pouni/Boulkiemde province	Gué J.	Improved seeds
Cowpea	Kongoussi/ Bam province	Siambo E., PPAAO/WAAP	Cowpea
Sweet potatoes	Orodara Kénédougou province	Dr SOME K., INERA	Yellow potatoes
Yam	Leo/Sissili province	Dr KIBA I., INERA	Yam tubers
Kilishi	Koupela/ Kouritenga province	Siambo E., PPAAO/WAAP Burkina	Kilishi (dried meat)
Rice	Bama/Houet province	Ouattara A D., INERA	Rice
Milk	Banfora/ Comoe province	Traore A. APESS	Milk
Fonio	Bomborokuy Kossi province in the Mouhoun river region	Mme Koncobo C. IRSAT/INERA	Processed fonio cereal
Small ruminants	Titao/Yatenga province	Traore A., APESS	Small ruminants
Shea nut	Leo/ Sissili province	Siambo E., PPAAO/WAAP Burkina	Shea nut
Mango	Bobo/ Houet province	Siambo E., PPAAO/WAAP Burkina	Cowpea
Tomato	Yako/ Passore province	Dr. Ouedraogo L., INERA	Tomato

Source: Ouédraogo, 2016.

Note: APESS refers to Association for the Promotion of Livestock in the Savannah and the Sahel; PPAAO/WAAP refers to Programme de Productivité Agricole en Afrique de l'Ouest/ West Africa Agricultural Productivity Program

Below is a brief description of some of the IPs in Burkina Faso.

1.5.2.1 Maize in Sissili province

The IP on maize production in Sissili province, the first IP in Burkina Faso, was set up in 2009 during the DONATA project. The strategy of the project was to use an IP based on the maize value chain to facilitate technology adoption by creating synergies between several actors: research, the departments in charge of extension, policy makers, farmers' organizations, private sector, agro-business and NGOs. One year after implementation (2010), the returns generated were the following: 5 tons/ha of the Bondofa hybrid maize variety, 3.5 tons/ha of the Barka and Wari open pollinated varieties and 2 tons/ha of certified seed. A total of 4,358 tons of maize grains were produced by the *Fédération des Professionnels Agricoles de la Sissili*, of which 500 tons were sold under contract to the National Cereal Bank (SONAGESS). As the maize grain production was reaching higher levels, the IP decided to promote processing of maize and to address the challenges in accessing markets. The

project helped generate income for farmers via maize production. The driver of success in that case was the presence of a strong farmers' organization that was able to mobilize farmers and ensure their commitment and active participation to the project.

1.5.2.2 Maize and animal products IP in Koumbia

In the same vein, maize and animal products in Koumbia were a success because of farmers' commitment to the project, and success was mainly ensured by contracting yellow maize between farmers and private actors in 2014. All the inputs (including improved seed) were provided by the private sector, and farmers delivered high quality yellow maize grain. Consequently, IP members' capacities were strengthened through contract negotiations and advocacy, and they were thus able to renew the contract in 2015.

1.5.2.3 Seed system IP in Pouni

This IP was able to bring together farmers, researchers, extension agents, private actors and local policy makers on the issue of access to quality seeds for farmers. Potential appropriate varieties were identified in a participatory field selection process, and actors were aware of their responsibilities to provide quality seed to poor farmers.

The Consultative Group International Agricultural Research Challenge Program on Water and Food's Volta2 project, which was implemented from October 2010 for 3 years, used IPs as its principal development tool to achieve integrated management of rainwater for crop-livestock agro-ecosystems in the Yatenga province in northern Burkina Faso. A study by Teno *et al.* (2013) shows that the two Volta2 IPs in the Yatenga province contributed to an increase in crop and livestock production in the region.

The West and Central African Council for Agricultural Research and Development (CORAF/WECARD) developed a maize value chain IP in Burkina Faso in 2008 through INERA facilitation. This IP inspired commercial production of certified seed maize among farmers within two years of its creation, and it also enhanced the adoption of improved maize technologies (CORAF/WECARD, 2012).

The Syprobio project is using IPs to test innovative practices in cotton production systems in Burkina Faso. An impact so far is that the IPs have helped farmers to gain self-confidence in self-organized processes, and it has also increased farmers' trust in research.

In conclusion, most of earlier agricultural research innovations were not adopted by farmers because of insufficient market linkages. The pilot IPs demonstrated that there is potential to develop efficient value chain-based IPs either at the local, regional and national levels, but they need to be well-designed and well-mentored in order to get the expected impacts in terms of social innovation. There is a need to develop and provide local agricultural services that could help IPs to be more efficient in job creation. The IPs' functioning also needs to be documented for future learning.

1.5.3 Extension system and organizations

There is a pluralistic extension system in Burkina Faso with different stakeholders (public, private sector, non-governmental organizations (NGOs) and farmer organizations) providing extension services. Four ministries under the Government of Burkina Faso provide extension and advisory services in the areas of agriculture, livestock and natural resources. These ministries are: Ministère de l'Agriculture, de l'Hydraulique et des Ressources Halieutiques (Ministry of Agriculture, Water and Fishery Resources), Ministère des Enseignements Secondaire, Supérieur et de la Recherche

Scientifique (Ministry of Higher Education and Scientific Research), Ministère des Ressources Animales (Ministry of Animal Resources) and Ministère de l'Environnement et du Cadre de Vie (Ministry of Environment). These ministries provide extension services through the following departments and institutes:

Ministry of Agriculture and Fisheries:

- Regional Directorate for Agriculture, Water and Fisheries;
- National system for agricultural extension and advisory services.

Ministry of animal resources:

- National livestock Laboratory;
- National system for livestock extension services

Ministry of the Environment, Green Economy and Climate Change

- General Directorate for the improvement of the living environment.

Ministry of Higher Education, Scientific Research and Innovation:

- National Center for Scientific and Technological Research.

The following public research institutions also have extension units:

- INERA;
- International center for development research in livestock breeding in the Subhumid Zone;
- Agency for the Promotion of Small and Medium-sized Agricultural Enterprises and Handicrafts.

University-based extension services include:

- Technical University of Bobo-Dioulasso;
    - Rural Development Institute.

Some NGOs are involved in the delivery of advisory extension services to farmers in Burkina Faso.

Examples include:

- Sasakawa Africa Fund for Extension Education;
- African Institute for Social and Economic development, African Center for Training, National Office of Burkina Faso;
- Long Live the Farmer Association;
- Delwende Development Association;
- Catholic Relief Service;
- SOS Sahel International;
- Groupements Naam;
- Tree Aid etc.

1.5.4 Private research and development activities

The private sector, which comprises agro-dealers, banks, and input supply companies, works closely with farmers and livestock producers in Burkina Faso. Its members facilitate access to inputs and credit and also finance the agricultural sector. Through the Grow Africa Partnership, a number of private companies are investing in the agricultural sector of Burkina Faso. Among the companies are: Ecobank, Sarepta, Global Shea Alliance, Union Conannet des Etuveuses de Riz de Bagre, Yara International ASA, the Confederation of Farmers of Burkina Faso, Réseau des Caisses Populaires du Burkina, the Association of Agricultural Input Wholesalers and Retailers, National Union of Seed Producers of Burkina Faso, the National Union of Cotton Growers of Burkina Faso, the Centre for Processing Agricultural Products, the National Federation of Agri-food and Processing Industries of Burkina Faso, etc.

1.6 Key challenges, emerging needs and potentials in the agricultural sector

Key challenges include a variety of socio-economic and environmental issues:

- Population growth;
- Climate change (low and irregular rainfall);
- Labor migration;
- Child labor;
- Land tenure insecurity;
- Limited knowledge and capacity of producers;
- Poor transportation infrastructure (poor roads);
- Transport challenges (e.g., lack of coastline);
- Limited access to credit for farmers;
- Fragmented value chain;
- Low productivity of crop production systems (pests, fertility, no respect of technical itineraries)
- Low productivity / value of forest products (ecosystem knowledge deficiency, erosion of biodiversity, etc.)
- Low livestock productivity (health, food, genetics)
- Degradation of natural resources
- Volatility of prices of agricultural products (warehouse receipt)
- Low level of training of producers (assistance)
- Low level of producers' organization (credit, inputs and equipment)
- Low professionalization
- Low utilization of research results
- Difficulty of access to information

1.7 Potential areas for investment in Burkina Faso

Based on the general approach presented in chapter 4 of Husmann et al (2015) and in pursuit of efficiency and effectiveness, investment by Germany into the agricultural and food sector are suggested in those African countries, which:

- Show actual progress in sustainable agricultural productivity driven by related innovations, as indicated by comprehensive productivity measurement and innovation actions on the ground;
- Have a track record of political commitment to foster sustainable agricultural growth, as indicated by performance under CAADP; and
- Prioritize actions for hunger and malnutrition reduction and show progress, but where agricultural and rural development and nutrition interventions are likely to make a significant difference, as indicated by public policy and civil society actions.

Results of the assessment for Burkina Faso[7]:

Expected agricultural growth performance:

- Burkina Faso has increased its agricultural growth by more than the annual 6% agricultural growth target defined by CAADP, for only four of the years between 2005 and 2014 (www.resakss.org);
- Total Factor Productivity (TFP) in Burkina Faso had declined by 16% between 2001 and 2008 (Fuglie and Rada, 2011), which is the worst innovation performance record compared to the sub Saharan Africa standard.

[7] Details on the data sources and methodology used in the assessment can be found in Husmann et al. (2015)

Government commitment:

- Burkina Faso has a track record of political commitment to foster sustainable agricultural growth by being active in the CAADP process and having completed seven out of the eight steps in the CAADP process (www.resakss.org);
- However, the Burkina Faso government has shown a below-average willingness to invest in the agricultural sector by investing more than 10% of total government expenditures (CAADP target)in the agriculture for only four years between 2005 and 2014 (www.resakss.org);
- In addition, Burkina Faso had spent only 0.4 % of its agricultural GDP on agricultural R&D, which is much lower than the Sub-Saharan Africa average (www.asti.cgiar.org/) and the African Union's target value of 1% spent on R&D. This indicates that Burkina Faso´s investment in agricultural innovation is not yet sufficient.

Food and nutrition security progress and need:

- Burkina Faso is only modestly prioritizing actions for hunger and malnutrition reduction and shows a less than 6% improvement in undernourishment between 2001 and 2011, which is lower than the 10% threshold level (FAO, 2014);
- In addition, Burkina Faso has a Global Hunger Index (GHI) score value of 19.9, reflecting a serious level of hunger (von Grebmer *et al.,* 2014)[8]. This makes investment into the agricultural and food sector in Burkina Faso urgent in order to fight the high level of food insecurity.

Table 15: Burkina Faso Performance Indicators

Indicator	Indicator score	Overall score
1. Number of years with more than 6% agricultural growth (2005 to 2014)	4	40
2. Percentage point change in TFP index between 2001 and 2008	-16	0
3. Number of years with more than 10% government expenditure (2005 to 2014)	4	40
4. Average share of agricultural GDP spent on R&D (2005 to 2011) in %	0.4	39
5. Steps in CAADP completed	7	88
6. Percentage point improvement in undernourishment between 2001 and 2011	6	60
7. Global Hunger Index (2014)	19.9	60
Total score (weighted)		45

Data source: Husmann et al (2015)
Note: TFP refers to Total Factor Productivity

However, the overall economic, political and social/nutrition framework in Burkina Faso does not seem to suggest accelerated investment into the agricultural and food sector of the country. Investments are possible for agroforestry products, vegetables and cash crops, such as rice, sesame and maize (and not for staple food crops; sorghum and millet). Thus, even small scale farmers are ready to take out loans and grow their own business.

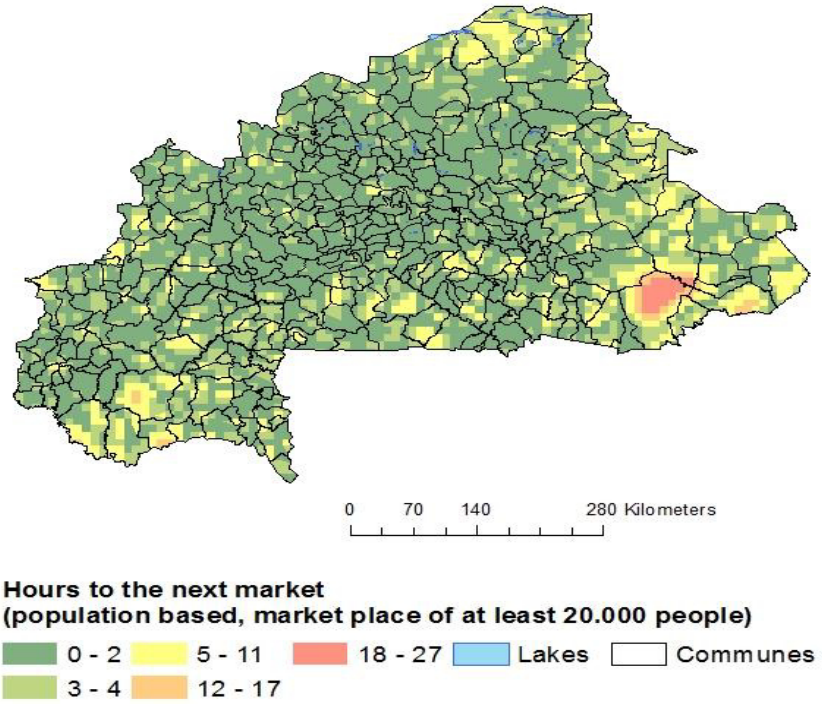
Nonetheless, there are areas of potential in the country's agricultural sector. For instance, Burkina Faso has significant land resources, with only a third of total farmland and 12% of irrigable land currently under cultivation. In addition, there is unexploited potential for rice cultivation: less than

[8]GHI score Values less than 5.0 reflect low hunger, values from 5.0 to 9.9 reflect "moderate" hunger, values from 10.0 to 19.9 indicate a "serious" level of hunger, values from 20.0 to 29.9 are "alarming," and values of 30.0 or greater are "extremely alarming" (von Grebmer, 2014).

10% of the 500,000 ha of lowland has been brought into production, and the irrigation potential for rice is significant. Potential investments include the rain fed rice project (PRP) throughout the country, or the lowland management project by the German cooperation in the south-western region. Burkina Faso also has a comparative advantage in cotton production and is well-placed to develop fruit and vegetable value chains as a source of export diversification.

The selection of which value chain to focus on is also determined by market access, i.e. transport intensive products should be promoted in areas that are well connected to markets, whereas the remote areas should focus on low volume and livestock value chain segments. Figure 5 presents the average number of hours it takes to reach the nearest market place of at least 20,000 people in Burkina Faso.

Figure 5: Distance to markets



Data sources: Hours to next market- HarvestChoice, 2015;
Administrative areas: www.gadm.org/, accessed 20 September, 2015
Inland water bodies: www.diva-gis.org/gData (water bodies), accessed 20 September, 2015

2 Most relevant value chains Burkina Faso

2.1 GIC-Value Chains

Rice and sesame were chosen as the value chains by the GIC.

2.1.1 Rice

Rice production is a major development priority for the Government of Burkina Faso in its food security strategy. The National Strategy for the Development of the Rice Value Chain (2011-2018) has the aim of intensifying and increasing rice production, improving the quality of the finished product reaching the market, and strengthening stakeholder capacity in the rice sector. There are about 100,000

smallholder rice producers in Burkina Faso, with average plot sizes from 0.5 to 1 ha, spread across three main producing areas: Bagré hydropower dam, Western and Sourou area (north-western). Bagré is the most attractive production region due to the good transport links to the national capital (Ouagadougou), the planned expansion of its irrigated land (from 1,800 ha today to 15,000 ha in 2015), and the importance of rice as a cash and staple crop in the region. Rice consumption in Burkina Faso is constantly increasing, but national rice production covers only about 47% of the population's needs. Rice consumption in the country is satisfied mainly by low quality imported rice, local parboiled rice and to a limited extent, local white rice. There are no commercial rice producers and millers in the country.

2.1.2 Sesame

Sesame was cultivated for consumption or sold on a small scale in Burkina Faso, but since 2010, it has developed from a marginal crop to a major agricultural export commodity. The volumes exported have increased more than ten-fold, and the area dedicated to sesame production is now five times larger. Sesame production is attractive for producers compared to cotton, as it provides higher profits per hectare, requires less investment, is not as labor intensive, is more drought tolerant, and is paid in cash at the farm gate. The sesame sector is entirely export-oriented, and there is hardly any local market. Due to the recent importance of sesame in Burkina Faso's economy, the government, producers and NGOs are showing interest in organizing the sesame chain and supporting producers. The major sesame producing regions are Boucle de Mouhoun (40% of national production), Est (20%), Cascades (13%) and Hauts-Bassins (9%) (Oudendijk, n.d.). A large share of sesame is exported to Asian markets, while the European market is the main destination for organic sesame (Oudendijk, n.d.)

2.1.3 Other relevant value chains

The other relevant value chains besides those selected for the GICs are discussed in this subsection. The relevance in this case is based on, among other things, the extensive review of available literature on the crop, the importance of the crop in relation to share of area cultivated (harvested), production volume, and trade importance (import and export).

2.1.4 Cotton

The cotton value chain is the most structured value chain in Burkina Faso. An organic cotton value chain program was promoted in Burkina Faso by an NGO, Helvetas Swiss Intercooperation, between 2004 and 2011. The value chain led to an important increase in employment: the number of producers increased from about 1,800 in the production years 2007/2008 to about 6,600 in 2011/2012. It has also led to an increase in the incomes of the producers involved, who receive a price which is, in average, 50% higher than that received by traditional farmers (Oxfam Italia, 2013).

2.1.5 Millet/Sorghum

Millet is grown in all regions and agro-climatic zones receiving between 400 mm and over 900 mm of rainfall every year. Sorghum, however, is produced in the Western, North Central, and Eastern regions. Millet accounted for 39% of all land on which cereals are cultivated and 32% of total cereal production for the 2010-2011 season, while sorghum production accounted for 64% of the cultivated land on which cereals are produced and more than 40% of total cereal production for that same year. Output in 2014 exceeded 1.7 million tons for sorghum and over 972,000 tons for millet, with yields of 11,028 Hg/Ha and 8,159 Hg/ha for sorghum and millet respectively. Despite being the two largest crops in terms of production in the country, representing an increasing cultivated land area, yields remain low and surplus for commercialization are only about 7% for millet and 10% for sorghum. Marketing channels between producers and urban centers are mainly informal, with irregular supply to meet the

weak demand. Production systems are extensive and based on subsistence. Fertilization rates and modern technology adoption rates also remain low (Badolo and Ilboudo, 2015).

2.1.6 Maize

Maize is an important crop for food and nutrition security in Burkina Faso and is the third most produced commodity in the country. Its cultivation has been increasing for the past 20 years, with output rising from over 270, 000 tons in 1993 to over 1.43 million tons in 2014 (FAOSTAT, 2016). As one of the key producers of maize in the West African region, the country seeks to move maize from subsistence farming to a cash crop in order to meet both domestic and international demands. Since 2005, maize imports have been declining and market penetration has increased to 75% of production in 2008 (Elbehri and Benali, 2013). Maize is mainly produced under rain-fed conditions, but there has been a recent development of irrigated maize. At the national level, the results of the first phase of the General Census of Agriculture showed that corn is produced by 78.6% of farm households in the rainy season. The main areas with a high proportion of producers for this crop during the rainy season are the Southwest (93.3%), the Eastern (91.7%), the North Central (89.2%) and the Cascades region (89.2%). The two regions with low numbers of maize producers during the rainy season are the Centre and the Sahel with 42.9% and 61.0% of farm households, respectively. In terms of production, the main areas are the Hauts-Basins, Boucle du Mouhoun, and Cascades with respectively 346,500 tons, 199,000 tons, 123,188 tons out of a total production of 1.2 million tons in 2010. Only 0.8% of total farm households produce maize during the dry season. The main producing areas of irrigated maize are the Mouhoun, Hauts-Bassins and Cascades with respectively 7,482 tons, 2,488 tons and 1,894 tons with a total production of 13,430 tons according to 2010 General Directorate for the Advancement of the Rural Economy (DGPER) estimates (Ouédraogo et. al., 2011).

2.1.7 Shea

The shea (*Vitellaria paradoxa*) value chain in Burkina Faso provides a source of income for nearly 500,000 women involved in the collection of kernels and the production of shea butter with direct jobs in processing and marketing. Women account for about 90% of those associated with the shea value chain. The shea value chain plays an essential role in food security for participants by providing fruit and cooking oil, and by generating income that can be used to purchase basic food.

2.1.8 Sugar cane

Sugar cane is mainly produced by la Nouvelle Société Sucrière de la Comoé, a public-private sugar company located in Banfora in the south-western part of the country. The farm is situated on a compound of 10,000 ha, 4,000 of which are used for cane planting. It employs over 3,000 workers and supplies the company with over 300,000 tons of sugar cane per year. Production is rain fed, but is also irrigated by a vast system pivot front-mounted spray booms and micro irrigation. The company's activities have direct economic impact on the region (Industrial Promotion Services West Africa, 2016).

2.1.9 Cashew nuts

Cashew trees were introduced in the country around 1960. Cashew nuts have increasingly become an important commercial crop, and the government launched a program in 1997 for the development of the sector, with the objective to plant a million trees. 45,000 households are involved in the production of the crop, 97% of which are located in the Cascades, South-Western, Hauts-Bassins and Ouest Central, with respectively 17,500, 14,220, 10,000 and 2,200 growers. Plantations vary in size from 0.5 to 50 ha, with most being between 2-5 ha and 5-10 ha. Most growers are members of village associations or cooperatives. Production in 2013 reached 115,000 t and roughly 90% of total output is exported (Bila et. al., 2010).

2.2 Promising agricultural products and value chains

In addition to assessing the returns on investments into institutional innovations in Burkina Faso, analyses are also undertaken in order to choose the most promising value chains in the country. This analysis is important because it provides an objective indicator for priority value chains that would have the highest returns on investments into technological and institutional innovations. The trio objectives of PARI (to promote and support the scaling of proven innovations in the agri-food sector; to support and enhance investments in the GICs through research; and to contribute to the development of the agri-food sector in Africa and India through the identification, assessment and up-scaling of innovations) guide the selection of indicators. The indicators should thus focus on improving the food and nutrition security, reducing poverty and improving the market participation of the small holder farmers. Taking into account the availability of data and the purpose of the study, four indicators that focus on poverty and market potential are used to select the five most promising agricultural products from the long list of agricultural products that the country produces and sells. These indicators are:

1. Trade potential (Revealed Comparative Advantage (RCA) index): computed to identify value chains over which the country has revealed, albeit may not necessarily potential, comparative advantage in the export market. The revealed comparative advantage is an index used in international economics for calculating the relative advantage or disadvantage of a certain country in the production and export of a certain class of goods or services as evidenced by trade flows. It is based on the Ricardian comparative advantage concept. We use Balassa's measure of RCA to determine the competitiveness of selected agricultural products in overseas export markets. In the present case, the RCA index compares the share of a given agricultural product in the country's export basket with that of the same product in total world exports.

2. Yield gap: used to assess the expected return of the envisaged investment on the given country value chains. The yield gap of a crop grown in a certain location and cropping system is defined as the difference between the yield under optimum management and the average yield achieved by farmers. A standard protocol for assessing yield potential and yield gaps is applied for some crops based on best available data, robust crop simulation models. It is a powerful method to reveal and understand the biophysical opportunities to meet the projected increase in demand for agricultural products.

3. Average yield growth: used to examine the potential of the product for poverty reduction. The most widely used indicator of crop productivity is production per unit of land (also referred to as crop yield). Average yield growth may reduce poverty in the following ways: (1) higher yield implies higher surplus product that could be sold in the market and thereby increase farmers income, (2) higher surplus product mean large quantity of food supplied to urban and rural market at a relatively lower price which in turn reduces urban and rural food poverty, (3) higher agricultural productivity will stimulate growth in the non-agricultural sector through its strong backward and forward linkage. For example, it boosts growth in the industry sector by freeing agricultural labor and reducing urban wage pressure (Lewis, 1962), and (4) agriculture's fundamental role in stimulating and sustaining economic transition, as countries (and poor people's livelihoods) shift away from being primarily agricultural towards a broader base of manufacturing and services (DFID, 2004).

4. Total production of the crop as a share of total supply (production + imports) is also used to assess the relevance of investing on that crop .Because it signals whether the agro-ecological system is suitable for the production of that crop in meeting the global demand for that particular crop. The ratio of production to total supply also illuminates the degree of integration of the producers that particular crop, small holder farmers in most African countries cases, into markets. The extent to which small holder farmers are able to participate in both input and output markets, and the functionality of those markets, are key determinants of their willingness and ability to increase

marketable surpluses (Arias, 2013). Across the developing world, smallholders farm in diverse agro-climatic systems which together with their assets and skills, shape their economic lives. Markets and the extent to which they are functioning well, also play a determining role.

Note: The share of production of that particular crop over the total crop production is another key indicator considered in this study while assessing the relevance of investing on a particular crop in a country. This indicator is used as an eliminating criteria. If the share of a given crop out of total crop production is less than 0.5 %, we consider it as less relevant and exclude from the list of most promising value chains.

The summary of the five most promising value chains based on the RCA index, average yield growth and relevance of crop is reported in Table 16 below. The production share, RCA index, actual yield growth and relative yield gap for the GIC value chain(s) is also reported at the bottom of the table, when they are not included in the list of the first five most promising value chains.

Table 16: Selection of the most promising agricultural product /value chain

	Rank by RCA		**Rank by Yield progress*** **		**Rank by yield gap**		**Rank by relevance of crop**	
Rank	**Name of agricultural product**	**RCA index (2012)**	**Name of the crop**	**Average annual yield growth (2005 - 2012)**	**Name of staple crop**	**Relative yield gap (%)****	**Name of agricultural product**	**Production share of supply (2012)***
1	Sesame seed	54	Sweet potatoes	10	Rainfed maize	85.6	Maize and products	126
2	Oilseeds	45	Rice, paddy	8	Rainfed rice	84.8	Cottonseed	121
3	Cake, cotton seed	40	Cashew nuts, with shell	5	Rainfed sorghum	85.2	Sorghum and products	105
4	Cashew nuts, with shell	19	Yams	5	Irrigated rice	63.8	Yams	100
5	Goats	18	Sesame seed	5	Rainfed millet	82.4	Sugar cane	100
GIC selected							Sesame seed	85
							rice	50

Source: * Own computation based on FAO 2015 data, ** from Van Bussel *et al.* (2015).
Note: *** a minimum of 0.5% production (volume) share threshold is used as a screening (crop relevance) criteria

Results of assessment (Table 16):

- The trade potential (RCA index) is very high for sesame seed (selected by the GIC), the German development aid agency), oilseeds, cottonseed cake, cashew nuts and goats. This indicates that Burkina Faso has comparative advantage (in the export) of these commodities. The country does not have comparative advantage (in the export) of the other GIC value chains;
- The yield performance indicating progress suggests that over the CAADP period (2005 to 2012) sweet potatoes, the two GIC selected value chains (rice and sesame), cashew nuts and yams are the five most promising crops;

- Yield gaps indicate potential from another angle, and is observed to be high for rain-fed maize, rain-fed and irrigated rice (GIC selected), rain-fed sorghum and rain-fed millet, indicating the high potential return on investing in these value chains;
- The leadings products in terms of relevance (production share of supply) are maize, cotton seed, sorghum, yams and sugar cane. The total production of the first three products exceeds the total supply. About 85% of the total supply of sesame (GIC selected value chain) and 50% of rice (the other GIC selected crop) is also domestically produced.

2.3 Summary on selection of agricultural products and value chains

This chapter (chapter 2) has presented different relevant and important value chains in Burkina Faso based on different criteria, resulting in different value chains. In summary, the three top value chains – GIC selected value chains, other relevant value chains, and those identified through the analysis of promising agricultural products and value chains – are presented in Table 17. The summary table shows that both GIC-selected value chains are identified as promising by the analysis of promising agricultural products and value chains. Furthermore, four out of the seven value chains based on the literature review (other chains) are also suggested by the promising agricultural products analysis. These are cotton, sorghum, maize and cashew nuts.

Table 17: Summary of all value chains

GIC value chains	Other value chains	Promising agricultural products and value chains (top 3)			
		RCA	Yield progress	Yield gap	Relevance of crop
Rice	Cotton	Sesame seed	Sweet potatoes	Rainfed maize	Maize & products
Sesame	Millet/ Sorghum	Oilseeds	Rice, paddy	Rainfed rice	Cottonseed
	Maize	Cake, cottonseed	Cashew nuts, yams, sesame seed	Rainfed sorghum	Sorghum & products
	Shea				
	Sugar cane				
	Cashew nuts				

Source: Authors' compilation

3 Innovations in value chains in the past 20 years

3.1 Main limiting factors

A key factor has been sustained underinvestment in agricultural research and development, since covering operating costs and capital investments for research are largely dependent on volatile donor funding. The number of agricultural researchers has steadily declined since 2006. Additionally, producers have limited knowledge and capacity, transportation infrastructure is inadequate (poor roads) and the land tenure is rather insecure.

In the rice sector, producers are faced with several constraints such as constant increases in cost of production, which are related to stagnating prices of rice paddy, lack of suitable funding mechanisms and equipment (insufficient drying areas, insufficient threshing floors and threshers, etc.). In addition, the lack of organization within the value chain, coupled with stiff competition from imported rice (often subsidized), causes low yields. Consequently, poor rice quality is supplied to the local market, and there is little activity from local processing industries, which absorb only a small part of the production (EASYPol, 2009; Centre d'Etude, de Formation et de Conseil en Développement (CEFCOD), 2013).

In the sesame value chain, upstream activities are hindered by issues related to climate and natural conditions such as rainfall variability and the harmful effects of pests. Furthermore, issues of theft, which especially occurs when sesame bunches are drying in the field, is a major problem. Constraints on downstream activities include the lack of processing industries, unstructured markets and value chain actors, high fluctuations in supply due to contract violations, low access to credit to buy inputs, etc. (Gildemacher et. al., 2015; CEFCOD, 2013).

3.2 Important value-chain related and cross-cutting innovations

In this section, we describe some of the key innovations that have been initiated in selected value chains in Burkina Faso in the last 20 years. The described innovations are considered significant or beneficial because of widespread adoption, proven positive impact on increasing productivity, increasing incomes, adapting to the environmental challenges (such as drought), creating employment etc.

3.2.1 GIC value chains

a. Rice

Trials of the System of Rice Intensification (SRI) started in 2006 in the Vallée du Kou by a graduate student (Tim Krupnik) from the University of California, Santa Cruz who worked with 6 farmers. After a reported yield of 7 tons/ha by one of the farmers, a Japanese funded FAO project carried out additional trials in the same region, and soon after, other NGOs, local and international actors (French NGO CODEGAZ, USAID's Expanded Agribusiness and Trade Promotion), rice producers' organizations, research institutions, development agencies, etc.) Increasingly fostered collaboration in the light of their growing interest in SRI. The project "Improving and Scaling up the System of Rice Intensification in West Africa", a World Bank-financed project to increase rice productivity through 13 countries in the ECOWAS area, was launched in 2014.

One of the success stories of SRI in Burkina Faso comes from the cooperation between CODEGAZ and its local partner organization Mawouro-bi Association for the Promotion of Sustainable Agriculture (AMAPAD). These organizations aimed to train farmers from the Bama region (Hauts-Bassins) on SRI and ecological gardening. In 2014, the program reached 524 farmers who cultivated 576 hectares of rice with an average yield of 8 t/ha. The SRI methods implemented therefore doubled the output for the producers. Furthermore, 72 relay farmers received extensive training to become references and advisors for other farmers. The program also planned scaling-up activities in 2015 to include more regions such as Sangouléma, Samandéni and Badara, and to build biodigesters for biogas and bio-slurry production, the latter which is to be used as fertilizer for soil restoration and further SRI yields improvement (CODEGAZ, 2014).

b. Sesame

A project for the development of the sesame sector was initiated in 2009 by sector stakeholders in Burkina Faso, namely a private organization (Burkinature), a farmer organization (Association Piéla-Bilanga), an international NGO (Helvetas) and the Ministry of Industry, Commerce and Crafts. The project was funded by the Common Fund for Commodities, the Organization of the Petroleum Exporting Countries Fund for International Development, the Netherlands Directorate General for International Cooperation and Helvetas Swiss Intercooperation. The objectives and work of the project were centered on yield improvement through soil fertility management, seed quality and farmer training. The results obtained from farmer managed trials during the four-year implementation of the program showed that modest doses of fertilizer (75 kg of NPK fertilizer per hectare) increased yields by 75%, providing a return on investment of 320%. Furthermore, the addition of organic manure or compost was also advised. The use of quality seed gave a return on investment of 1,900%, compared to recycled local seed. Farmer field schools were a very effective capacity building tool to improve

sesame crop husbandry and to demonstrate the use of fertilizer and high quality seed. As a result, yield increases of 30 to 60% were estimated. The project was able to involve many grassroots organizations and development partners, which continued to implement the farmer field schools even after the end of the project (Gildemacher et. al., 2015).

3.2.2 Other value chains and cross-cutting innovations

Several value chains and cross-cutting innovations are implemented in Burkina Faso:

a. Zai pit technology for land rehabilitation and restoration of soil fertility

The Zai technique is a traditional land rehabilitation technique invented by farmers in Burkina Faso to effectively rehabilitate degraded drylands and to restore soil fertility in these drylands. Small pits, 20-30 cm wide and 10-20 cm deep, are dug into degraded soils, often hardpans. At the bottom of the pits, farmers place about two handfuls of organic material (animal dung or crop residues). Pearl millet or sorghum seeds are planted in these pits as soon as the rainfall starts. The technology has several advantages. First, the poorly available organic matter is placed at the bottom of the pit and not broadcast over the whole field. In addition, the Zai pits collect and concentrate water for the plant. This reduces the risk of water stress in a region of low and erratic rainfall. The Zai technique therefore combines water and nutrient management into a technology that requires little external inputs and is financially accessible to and manageable by farmers. Tests conducted by ZEF on two experimental on-farm sites in Niger showed that a grain yield far above average is possible when using the Zai technique in the Sahel, particularly on highly degraded sandy soils. An additional 500 kg grains ha^{-1} were obtained by digging the pits, which is an important gain for the farmer. Crop yield also increased due to manure being added into the pit. As animal dung is scarce, this might be a constraint to the use of the technology. However, farmers are able to prepare good quality compost using home wastes, weeds and leguminous residues before and during the onset of the rainy season. Zai is a simple technique, but it is labor intensive. However, the pits are dug during the off-season when farmers do not engage in other field activities. The Zai technique is an effective technology with the potential to improve the livelihood of the rural populations in the Sahel while fighting desertification at the same time (Fatondji *et al.*, 2001).

b. Bacillus thuringiensis (Bt) Cotton

Burkina Faso adopted Bt cotton and began trials in 2003. The country became the first to introduce the genetically modified cotton variety in Africa through a partnership with Monsanto. Bt is a toxin that kills bollworm, one of the world's most common and pernicious cotton pests. Bt Cotton was approved for planting in 2008 and it boosted total cotton production. Output increased by 57.5%, rising from 400,000 tons in 2011-2012 to 630,000 by the end of January 2013 (Anon., 2013). Bt cotton also increased yields and profits. The average Bt cotton farming family gained 50% more profit than from conventional cotton, despite the very high cost of Bt cotton seed. Furthermore, Bt cotton growers used significantly less pesticide, reducing the number of sprayings from six to two (Dowd-Uribe and Schnurr, 2016). However, the adoption of Bt cotton resulted in some negative impacts. First, Bt cotton produces shorter, less desirable lint. This trait of the variety led to a poorer cotton quality, which in turn meant that the crop was bought at a lower price on the international market. Furthermore, despite higher yields, extraction machines extracted lower amounts of lint from Bt picked cotton than from conventional cotton. Therefore, the combination of shorter staples and lower lint qualities substantially undermined profits of the local cotton companies (Dowd-Uribe and Schnurr, 2016). As a result, Bt cotton was completely abandoned in 2016. Nonetheless, the national cotton company is willing to reintroduce Bt cotton provided that Monsanto undertakes further research and tests to address the two shortcomings of Bt cotton.

c. Contract farming

Contract farming was introduced in the cotton value chain. As the most organized and structured value chain, contract farming is more applicable in that chain. The cotton sector in Burkina Faso has been liberalized, but "regulations give local monopolies to the private cotton gins." (Minot, 2011, p. 17). Cotton farmers receive seed and fertilizer on credit from the cotton companies, and they sign contracts to sell their output to the companies providing the inputs. The local monopoly system "makes it easier to ensure repayment, thus facilitating contract farming and the provision of inputs on credit." (Ibid).

d. Weather-index drought insurance

Delavallade *et al.* conducted research on insurance index and other savings devices provided to farmers in Burkina Faso in 2013. The research tested the impact of the weather insurance and savings devices on farm inputs, agricultural output, household welfare and the demand for the different products. The insurance index provided protection against insufficient rainfall for maize growers, while the savings packages prompted farmers to set aside money for agricultural inputs or emergency expenses. The savings were kept by farmer association treasurers with accrued interests. The results of the study showed that demand for insurance by farmers was significantly higher, particularly for men,[9] than for the savings devices. Furthermore, farmers who purchased insurance invested more in agricultural inputs than those who did not. This resulted in higher yields for insured farmers; and additional investment of 1000 CFA francs in weather insurance led to a 10% increase in yields. Household welfare also improved more for insured farmers because they were better able to use their own savings to handle shocks and emergencies (Delavallade *et al.*, 2015).

e. Organizing farmers

With the increasing organization of farmers into unions, they are able to tap into services and marketing opportunities such as:

- Bulk supply of agricultural inputs through access to credit from the Regional Solidarity Bank;
- Participation in tenders for high quantities of grain products (several hundreds of tons of rice, niébé beans, sorghum, maize requested by the national cereal bank SONAGESS, or the local bureau of the World Food Program);
- Participation in farm fairs, Business weeks, fairs promotional days, and access to warranting cereal stocks against short term credits.

f. Counters

Producers of fruits and vegetables are expressing more and more the need to better control the sale price of their products. Hence the need for setting up counters in major production sites in order to compensate for the inadequacy or absence of conservation infrastructure that does not promote regulation of product marketing. The counters are the result of producers organizing themselves to market their products. They are an interface between buyers and organized farmers. The counters are not points of sale; in this sense the financial transactions will be directly between the buyer and the producer. They will rather be a space and type of infrastructure that is managed by producer representatives. Feasibility studies were conducted, and seven counters are under construction with accompanying support services (DGPER, Programme d'Appui aux Filières Agro-Sylvo Pastorales, Projet d'appui aux filières agricoles, etc.) in the following cities: Yako, Koudougou, Banfora, Ouahigouya Korsimoro, Mogtédo and Sourou.
The counters' roles are as follows:

- To organize the marketing of vegetable products from different organizations/ associations of producers and individual producers through the provision of services;

[9] Women invested 30% less in weather insurance than in savings devices. One possible hypothesis is the fact that women face higher levels of health-related risks in childbirth, children sicknesses, etc. When the costs associated with these health issues are uninsured and fall primarily on women, the weather insurance has less value for women than for men (Delavallade *et al.* 2015)

- To enable growers to learn about the prices in the sub-region and consultation to determine the minimum price for their products to market;
- To provide information on the offer price and quantity of goods on the site concerned and on other sites;
- To allow buyers to establish secure contracts and obtain the administrative documents required to move their products to the final destination;
- To direct buyers to production sites and support them in their purchases in accordance with pre-established provisions;
- To provide a guarantee of product quality for the buyer;
- To ensure the application of legal metrology;
- To serve as a framework for consultations between the actors of a link (producers, traders) and inter-links (between representatives of producers and traders)
- To allow market research in the sub-region for the various producer organizations;
- To provide reliable statistics on product sales volume after each production season (Ndiaye and Sandwidi, 2011).

4 Suggestions for collaboration

Burkina Faso's agriculture is mainly rainfed. This heavy dependence on rainfall makes it very vulnerable to recurrent droughts and uncertain weather conditions. This situation therefore affects agricultural productivity and puts farmer families at risk of food insecurity and economic hardships. Furthermore, agricultural value chains (with the exception of cotton) remain relatively unstructured, causing weaker links for processing and commercialization of agricultural products. German collaboration could have an impact in the following areas:

(a) Mitigating the effect of climate change (integrated soil fertility management),
(b) Strengthening institutional and organizational support (access to input, processing, capacity building of actors, etc.)
(c) Working in line with the priorities determined by the national government in the agricultural sector.

As for climate change impact and rainfall variability, the experience of lowland valleys management through the PRP (founded by Taiwan) is promising. Similarly, vegetable production around big diameter wells or small dams through the country has registered a spectacular development, and is also a promising lucrative activity, especially in rural areas. However, environmental impacts have not been taken in account by farmers.

Lowland valleys and small scale irrigation schemes have high potential, and the initial results from the German collaboration in lowland valleys management for rice production (Lowland Development Project in the South-West and Sissili (PABSO) project in South-western region and Sissili province) are promising.

Burkina Faso, based on its dry tropical climate, has potential for quality legume and vegetable seed production in West Africa. The country is producing enough tomato for the local market and even for exportation to neighboring Ghana and Togo.

Improved seeds varieties research at INERA is very active, with substantial results in maize, rice, cotton, sorghum, millet, cowpeas, groundnuts, sesame, sweet potatoes, etc. However, there is a need for new breeding research with the objectives to improve yields while taking consumer preferences into account. Breeding research needs improvement in the form of new biotechnology and through the acquisition of gene analysis equipment to reduce time and cost of obtaining new varieties.

Important areas for future activities include:

- Funding R&D projects on targeted value chain at regional levels, based on the integrated agricultural research for development promoted by FARA, CORAF/WECARD and other partners;
- The generalization of such an approach at the national level, with a clear understanding of relations between such IPs on the same value chain from the local to the national level;
- Capacity building to facilitate IPs by building a training program that could be carried out by high school partners in the medium term;
- Capacity building in value chain analysis (mainly how to increase added value while considering social equity);
- Development of infrastructure that supports the IPs (e.g., storage, processing units, etc.);
- Building on business plan-based micro-projects that can provide intermediate services to the IP actors, mainly farmers;
- Development of the negotiation and marketing skills of farmers and their organizations that are involved in the value chain based IP.
- The production level has showed good results with national research or private sector actors. Processing local products will add value along the value chain. There is a need to sustain all segments of the value chain, especially at the processing level, as there is a real market. Collaboration is possible: (a) in developing best practices and hygiene of processed products; (b) in increasing the availability of good quality packaging; (c) in acquiring high-performing processing equipment; (d) in supporting the installation of Volunteer Trial industries for the processing agricultural products, etc.

Potential key partners for collaborative activities include:

- Ministries in charge of agriculture, animal resources, environment, higher education and scientific and innovation research and their representatives at any national levels;
- National agricultural research system actors (INERA, IRSAT, universities…);
- Farmers' organizations and their representatives at national, regional, provincial and local levels;
- Other policymakers at regional, provincial and communal levels, such as regional chambers of agriculture, regional councils, mayors…;
- Consulting institutions.

Most of the experience with value chain-based IPs is very recent and there are still a number of challenges that require more research attention:

- Developing resources persons in charge of IP management in order to ensure that participatory learning processes can be strong and lead to the expected results
- Determining the structure of IPs from local level, so that farmers can be heavily involved, to the regional and national levels, where policy makers and market actors are more relevant.
- Determining which mechanism can be implemented in order to increase the involvement of microfinance actors in order to facilitate access to inputs
- Balancing mechanization with sustainable production, e. g. in terms of soil fertility management
- Developing and managing innovative services to support the IPs and promote more added value to the targeted value chain (land preparation, post-harvest operations, rural transport, grain cleaning, crop residues packaging for animal feeding, …)Those services will help increase value chains' efficiency and provide jobs.
- Developing mechanisms to capture the global impact of the value chain-based IPs
- Using systemic research within value chain-based IPs to deal with sustainability, food security, poverty alleviation and resilience.

References

African Statistical Yearbook. 2017. Burkina Faso Data. Retrieved from: www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/African_Statistical_Yearbook_2017.pdf

Anon. 2013. Burkina Faso cotton output soars 57.5 pct due to GMOs-producers. *Reuters.* Accessed on August 1, 2017 from: www.reuters.com/article/burkina-cotton-production-idUSL5N0B0G2W20130131

Arias, P., Hallam, D., Krivonos, E., & Morrison, J. 2013. Smallholder integration in changing food markets. Food and Agriculture Organization of the United Nations, Rome.

ASTI. 2017. Homepage. Accessed from: www.asti.cgiar.org/

Badolo F. and Ilboudo D. 2015. Baseline Survey of Sorghum and Pearl Millet Production in Burkina Faso. Harnessing Opportunities for Productivity Enhancement of Sorghum and Millets in Sub-Saharan Africa and South Asia - HOPE Project.

Bila N. K.; Djibo O.; Constant P and Sanon B. 2010. Analysis of the Cashew Value Chain in Burkina Faso.

Bhat, R. V. and Vasanthi, S. 2003. Mycotoxin food safety risk in developing countries. In: Unnevehr, L. J. (ed.). 2020 Focus 10: Food safety in food security and food trade. IFPRI, Washington DC

Cafiero, C. 2014. The excessive (and wasteful) consumption of food. Technical note 3. In: IFPRI. Global Nutrition Report 2014: Actions and Accountability to Accelerate the World's Progress on Nutrition. IFPRI, Washington, DC

CEFCOD. 2013. Situation de référence des principales filières agricoles au Burkina Faso. Version finale. 208 pages.

CODEGAZ, 2014. Actions menées au Burkina Faso depuis 1999 par CODEGAZ. CODEGAZ, Saint Denis la Plaine, France.

CORAF/WECARD. 2012. Integrated Agricultural Research for Development (IAR4D) —Innovation Systems: Innovation Platforms (IP) of Agriculture Value Chains and Food Systems. CORAF/WECARD Executive Secretariat, Dakar, Senegal.

Delavallade, C.; Dizon, F.; Hill, R. V. and Petraud J. P. 2015. Managing Risk with Insurance and Savings: Experimental Evidence for Male and Female Farm Managers in West Africa. IFPRI Discussion Paper 01426. Accessed on August 1, 2017 from: www.poverty-action.org/sites/default/files/publications/129282.pdf

DFID. 2004. "Agriculture, Growth and Poverty Reduction",

www.dfid.gov.uk/Documents/publications/agri-poverty-reduction.pdf

Dowd-Uribe B. and Schnurr M. 2016. Lessons to be learnt from Burkina Faso's decision to drop GM cotton. *The Conversation.* Accessed on August 1, 2017 from: theconversation.com/lessons-to-be-learnt-from-burkina-fasos-decision-to-drop-gm-cotton-53906

EASYPol. 2009. Analyse de la compétivité de la filière riz local au Burkina Faso. Rapport provisoire. 89 pages.

Elbehri A. and Benali M. 2013. A historical comparative analysis of commodity development models in West Africa and implications for staple food value chains, In: Rebuilding West Africa's Food Potential, A. Elbehri (ed.), FAO/IFAD.

FAO. 2014. Country Factsheet on Food and Agriculture Policy Trends: Burkina Faso. UN Food and Agriculture Organization, Rome.

FAO. 2014. The State of Food Insecurity in the World 2014. Rome: FAO, WFP, IFAD.

FAO. 2016. Food security indicators. Retrieved June 17, 2016, from www.fao.org/economic/ess/ess-fs/ess-fadata/en/

FAOSTAT. 2017. Food and agriculture data. Last accessed on January 17, 2017 from: www.fao.org/faostat/en/#home

Fatondji D., Martius C., Vlek P. 2001. "Zai" - A Traditional Technique for Land Rehabilitation in Niger. *ZEF News,* No. 8, pp. 1 – 2. Accessed August 1, 2017 from: www.zef.de/fileadmin/webfiles/downloads/zefnews/No8-9-2001-engl.pdf

Fuglie K. and Rada N. 2011, „Policies and productivity growth in African agriculture", in Agricultural R&D: Investing in Africa's Future. Analyzing Trends, Challenges and Opportunities, Bd. 19 (ASTI/IFPRI-FARA Conference, Accra, Ghana: Citeseer, 2011), citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.371.9698&rep=rep1&type=pdf.

Gildemacher P.; Audet-Bélanger G., Mangnus E.; Van de PolF.; Tiombiano D. and Sanogo K. 2015. Sesame sector development; lessons learned in Burkina Faso and Mali. KIT & CFC, Amsterdam.

Gong, Y., Hounsa, A., Egal, S., Turner, P. C., Sutcliffe, A. E., Hall, A. J., Cardwell, K., Wild, C. P. 2004. Postweaning exposure to aflatoxin results in impaired child growth: a longitudinal study in Benin, West Africa. Environmental Health Perspectives, 112(13), 1334-1338

HarvestChoice. 2015. Travel time to nearest town over 20K (mean, hours, 2000). International Food Policy Research Institute, Washington, DC., and University of Minnesota, St. Paul, MN. Available online at harvestchoice.org/data/tt_20k.

HarvestPlus. 2017. What we do: crops. Accessed online at www.harvestplus.org/what-we-do/crops

Husmann C., von Braun J., Badiane O., Akinbamijo Y., Fatunbi A.O., Virchow D. 2015. Tapping Potentials of Innovation for Food Security and Sustainable Agricultural Growth – an Africa-wide Perspective. Program of Accompanying Research for Agricultural Innovation (PARI). Bonn: Center for Development Research.

ICF International. 2015. The DHS Program STATcompiler. Last accessed on September 12, 2016 from: www.statcompiler.com/en/

IFPRI. 2015. Global Nutrition Report 2015: Actions and Accountability to Advance Nutrition and Sustainable Development: Nutrition Country Profiles. IFPRI, Washington DC.

Imdad, A., Herzer, K., Mayo-Wilson, E., Yakoob, M. Y. and Bhutta, Z. A. 2010. Vitamin A supplementation for preventing morbidity and mortality in children from 6 months to 5 years of age. Cochrane Database of Systematic Reviews, 12, CD008524

Imdad, A., Yakoob, M. Y., Sudfeld, C., Haider, B. A., Black, R. E., Bhutta, Z. A. 2011. Impact of vitamin A supplementation on infant and childhood mortality. BMC Public Health, 11(Suppl 3), S20

Industrial Promotion Services (West Africa) S.A. 2016. SN SOSUCO. Accessed online on August 16, 2016 at: ips-wa.com/en/businesses/agribusiness/sn-sosuco.html.

Institut National de la Statistique et de la Démographie (INSD) and ICF International. 2012. Enquête Démographique et de Santé et à Indicateurs Multiples du Burkina Faso 2010. INSD and ICF International, Calverton, Maryland.

Institut National de la Statistique et de la Démographie (INSD), Programme National de Lutte contre le Paludisme (PNLP) and ICF International. 2015. Enquête sur les Indicateurs du Paludisme au Burkina Faso 2014. INSD, PNLP and ICF International, Rockville, Maryland.

Lewis, W. A. (1962). Education and economic development. Caribbean Quarterly, 7(4), 171-184.

Martin-Prével, Y., Allemand, P., Wiesmann, D., Arimond, M., Ballard, T., Deitchler, M., Dop, M.-C., Kennedy, G., Warren, T. K. L., and Mourad, M. 2015. Moving forward on choosing a standard operational indicator of women's dietary diversity. FAO, Rome.

Ministère de la Santé, Direction de la Nutrition. 2012. Enquête nutritionnelle nationale 2012. Rapport final. Ministère de la Santé, Ouagadougou, Burkina Faso.

Minot N. 2011. Contract Farming in sub-Saharan Africa: Opportunities and Challenges. Accessed on August 1, 2017 from: file:///C:/Users/ssougrynoma/Downloads/Contract_Farming_in_sub-Saharan_Africa_Opportuniti.pdf

Must, A. and McKeown, N. M. 2012. The disease burden associated with overweight and obesity. In: De Groot, L. J., Beck-Peccoz, P., Chrousos, G., Dungan, K., Grossman, A., Hershman, J. M., Koch, C., McLachlan, R., New, M., Rebar, R., Singer, F., Vinik, A., and Weickert, M. O. (editors). Endotext. MDText.com, Inc., South Dartmouth (MA). Retrieved October 10, 2016, from www.ncbi.nlm.nih.gov/books/NBK279095/

Ndiaye O. and Sandwidi M. 2011. Participation des organisations paysannes et de leur faîtières à la sécurité alimentaire et aux flux commerciaux dans les marchés des produits de base. Rapport Pays: Burkina Faso. Collectif Stratégies Alimentaires (CSA), Bruxelles, Belgique.

Oudendijk K. (n.d.). Pluralistic Service Systems: Sesame in Kossi province, Burkina Faso. KIT Case Study. KIT Sustainable Economic Development.

Ouédraogo S. (2016). (2016). Status of Agricultural Innovations, Innovation Platforms, and Innovations Investment. 2015 PARI project country report: Republic of Burkina Faso. Accra and Bonn: Forum for Agricultural Research in Africa (FARA) and Center for Development Research (ZEF), University of Bonn.

Ouédraogo M., Ouédraogo S. and Kaboré M. 2011. Analyse de la compétitivité de la filière maïs au Burkina Faso. Rapport final N°3. PRESAO.

Oxfam Italia. 2013. The value chain as a tool to fight against poverty: the analysis of two practices. Briefing paper. Oxfam Italia, Arezzo, Italy.

PACA (Partnership for Aflatoxin Control in Africa). 2013. Evaluation of the level of contamination of the sorghum produced in the regions of western Burkina Faso by aflatoxins. Retrieved November 11, 2016, from aflatoxinpartnership.org/?q=node/304

ReSAKSS. 2017. Homepage. Accessed from: resakss.org/

Scaling Up Nutrition. 2017. Homepage. Accessed from: scalingupnutrition.org/

Stevens, G. A., Bennett, J. E., Hennocq, Q. et al. 2015. Trends and Mortality Effects of Vitamin A Deficiency in Children in 138 Low- and Middle-Income Countries: Pooled Analysis of Population-Based Surveys. Lancet, 3(9), e528–e536

Teno G., Cadilhon J.J. and Some H. 2013. Impact of Volta2 innovation platforms on improvement and increase of crop and livestock production in four villages of Yatenga province, Northern Burkina Faso. Paper presented at the Volta Basin Development Challenge Final Scientific Workshop, Ouagadougou, Burkina Faso, 17-19 September, 2013.

Tradingeconomics.com, Central Bank of West African States. 2017. Burkina Faso GDP annual growth rate. Accessed on July 18, 2017 from: tradingeconomics.com/burkina-faso/gdp-growth-annual

UNICEF. 2013. Improving child nutrition: The achievable imperative for global progress. UNICEF, New York.

UNICEF/WHO/World Bank. 2016. Levels and Trends in Child Malnutrition: UNICEF-WHO-The World Bank: Joint Malnutrition Estimates, August 2016. New York, Geneva, and Washington, DC. Retrieved September 26, 2016, from who.int/nutgrowthdb/estimates2015/en/

USDA (US Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory). 2016. USDA National Nutrient Database for Standard Reference, Release 28 (Slightly revised). Retrieved October 5, 2016, from www.ars.usda.gov/ba/bhnrc/ndl.

Van Bussel L.G.J., Grassini P., van Wart J., Wolf J., Claessens L., Yang H., Boogaard H., de Groot H., Saito K., Cassman K.G., van Ittersum M.K. 2015. From field to atlas: Upscaling of location-specific yield gap estimates. Field Crops Research, 117, 98-108.

von Grebmer K., Saltzman A., Birol E., Wiesmann D., Prasai N., Yohannes Y., Menon P., Thompson J. and Sonntag A. 2014. 2014 Global Hunger Index: The Challenge of Hidden Hunger. Bonn/Washington D.C./Dublin: Welthungerhilfe, International Food Policy Research Institute (IFPRI), Concern Worldwide.

Warth, B., Parich, A., Atehnkeng, J., Bandyopadhyay, R., Schuhmacher, R., Sulyok, M. and Krska, R. 2012. Quantitation of mycotoxins in food and feed from Burkina Faso and Mozambique using a modern LC-MS/MS multitoxin method. Journal of Agricultural and Food Chemistry, 60(36), 9352-63

WHO. 1995. Physical Status: The Use and Interpretation of Anthropometry. Report of a WHO Expert Committee. Technical Report Series 845, WHO, Geneva.

WHO. 2000. The Management of Nutrition in Major Emergencies. WHO, Geneva.

WHO. 2003. Nutrition and the prevention of chronic diseases. Report of a Joint WHO/FAO Expert Consultation. Technical Report Series 916, WHO, Geneva.

WHO. 2005. Guiding principles for feeding non-breastfed children 6-24 months of age. WHO, Geneva.

WHO. 2010. Indicators for Assessing Infant and Young Child Feeding Practices, Part 1: Definitions. WHO, Geneva.

WHO. 2015a. Global Health Observatory Data Repository: Adult overweight and adult obesity. Retrieved September 15, 2016, from apps.who.int/gho/data/node.main.A897A?lang=en and apps.who.int/gho/data/node.main.A900A?lang=en

WHO. 2015b. The Global Prevalence of Anemia in 2011. WHO, Geneva.

WHO/FAO/UNU. 2007. Protein and amino acid requirements in human nutrition. Report of a joint FAO/WHO/UNU expert consultation. Technical Report Series 935, WHO, Geneva.

World Bank. 2006. Repositioning Nutrition as Central to Development: A Strategy for Large-Scale Action. World Bank, Washington DC.

World Bank.2017. Country data. Retrieved from data.worldbank.org/country

Annex A: Background Information on Nutrition

This annex provides background information on diet quantity and quality, child feeding practices and nutrition status (including micronutrient deficiencies) and definitions of the food and nutrition security indicators presented in Chapter 1.4.2.

Background on food and nutrition security

Diet quantity: Dietary energy supply per capita is an indicator of diet quantity that can be gauged against a population's average dietary energy requirement. The data are based on FAO's food balance sheets that estimate the quantity of each food item available for human consumption at the national level. It has to be emphasized that supply does not equal intake: Supply includes food that households feed to domestic animals or pets and food that they waste. Also, a sufficient average supply of dietary energy (or a nutrient such as protein) may leave those parts of the population deprived that have greater-than-average requirements or lower-than-average intakes. Indicators of undernourishment and food over-acquisition seek to consider the distribution of dietary energy consumption in the population and the minimum/maximum requirements of the average individual in a country (Cafiero, 2014).

Diet quality: Assessing diet quality requires a look at the composition of the diet. In the absence of national food consumption surveys for most countries, data from FAO's food balance sheets are used. The percentage of dietary energy supply from starchy staples (cereals, roots and tubers) is a rough indicator of diet quality: generally, the higher this percentage, the lower the micronutrient density of the diet; starchy staples are rich in carbohydrate and good sources of dietary energy, but they are usually not very micronutrient-rich. Non-staple foods are important for micronutrient and protein supply: Foods of animal origin are good sources of high-quality protein and vitamin A as well as highly bioavailable iron and zinc (meat, fish) and calcium (milk, small fish eaten whole with bones). Pulses and nuts are also good sources of protein and micronutrients. Fruits and vegetables provide a range of micronutrients while generally contributing little dietary energy (USDA, 2016).

The shares of dietary energy supply from carbohydrate, protein, and fat roughly indicate whether the diet is balanced in terms of its macronutrient composition. The recommended shares of dietary energy are 55-75% for carbohydrate, 10-15% for protein, and 15-30% for fat (WHO, 2003). It should be noted that these shares do not reveal whether dietary energy supply per capita and average protein supply are insufficient, sufficient, or excessive in absolute terms. A diet that meets the average dietary energy requirement for Africa as a whole (2200 kcal/day according to FAO, 2016) and provides 55-82.5 g protein per day and 36-73 g fat per day contains the recommended shares of 10-15% of dietary energy from protein and 15-30% of dietary energy from fat. For an adult weighing 60 kg, a protein intake of 50 g/day is considered sufficient, and 60 g/day for an adult weighing 75 kg. No safe upper limit of protein intake has been established, but it is unlikely that intakes of twice the recommended level pose any risk (WHO/FAO/UNU, 2007).

Child feeding practices: Feeding practices are determined by local food availability and household access to food, but also by maternal knowledge and care. Breastfed and non-breastfed children aged 6-23 months should eat foods rich in iron (meat, fish, or eggs) and fruits and vegetables rich in vitamin A daily, and consume at least 4 out of 7 food groups every day (PAHO/WHO, 2003; WHO, 2005; WHO, 2010).

Nutrition status: Household food security, the health environment, and mothers' caring capacity influence children's dietary intakes and the risk of infection, and thereby their nutrition and health status (UNICEF, 2013). Wasting, or acute undernutrition, is the result of recent rapid weight loss or the failure to gain weight that is caused by inadequate diets or infection. Stunting is the failure to grow adequately and results from chronic or recurrent undernutrition or infection (UNICEF/WHO/World Bank, 2016). Stunting in early childhood can have irreversible consequences, such as impaired motor and cognitive development, shorter adult height, lower attained schooling, and reduced adult income, whereas wasting carries a higher mortality risk (Victora et al. 2008; Black et al. 2013; Olofin et al. 2013). Overweight in children and overweight and obesity in adults occur when dietary energy intakes exceed

dietary energy requirements. Overweight and obesity increase the risk of noncommunicable diseases (UNICEF/WHO/World Bank, 2016).

Micronutrient deficiencies arise from insufficient intakes or absorption of essential vitamins and minerals. Major causes are poor diets, diseases, and increased requirements during life stages such as early childhood, pregnancy, and lactation. Micronutrient deficiencies are not limited to poor populations with inadequate dietary energy intakes, but may coexist with overweight and obesity in individuals and communities. Measuring micronutrient deficiencies poses challenges: There is often a need to resort to proxy indicators and large data gaps persist. Anemia, for example, is used as a proxy indicator for iron deficiency, although only about half of the global burden of anemia can be attributed to iron deficiency. Iron deficiency anemia impairs cognitive and motor development, causes fatigue and low productivity, and may result in low birth weight and increased maternal and perinatal mortality if pregnant women are affected (WHO 2015b). Whenever survey data on anemia prevalence are not available, modeled estimates from WHO (2015b) are used. Vitamin A deficiency increases the risk of vision problems, infectious diseases, and death among children (Imdad et al., 2010). Without exception, the data on vitamin A deficiency that are presented in this dossier are modeled estimates (Stevens et al., 2015, quoted in IFPRI, 2015).[10]

Table A1: Cutoffs to identify nutrition problems of public health significance in children

Category of public health significance	Stunting	Wasting	Overweight	Iron deficiency anemia
Severe	≥40	≥15	≥10	≥40
Moderate	30-39	10-14	5-9	20-39
Mild	20-29	5-9	3-4	5-19

Source: Adapted from World Bank (2006) and based on data from WHO (1995) and WHO (2000)

Notes: The cutoffs for public health significance were applied to prevalence rates of stunting, wasting, overweight and iron deficiency anemia (estimated from anemia prevalence) that were rounded to the first decimal. In the tables in Chapter 1.4.2, the data have been rounded to integers, which may lead to seeming contradictions: In a region where 29.8% of children under five were stunted (30% if rounded), stunting would be considered a mild public health problem, and in a region where 30.3% of children under five were stunted (also 30% if rounded), stunting would be considered a moderate public health problem.

Indicator definitions

Dietary energy supply: National average energy supply, expressed in kcal/caput/day (FAO, 2016).

Average dietary energy supply adequacy: Dietary energy supply expressed as a percentage of the average dietary energy requirement. Each country's average supply of calories for food consumption is divided by the average dietary energy requirement estimated for its population to provide an index of adequacy of the food supply in terms of calories (FAO, 2016).

Prevalence of undernourishment: Probability that a randomly selected individual from the population consumes an amount of calories that is insufficient to cover her/his energy requirement for an active and healthy life (FAO, 2016). This indicator seeks to estimate of the percentage of individuals in the population who are chronically undernourished because they fail to meet their minimum dietary energy requirements on a consistent basis.

Prevalence of food over-acquisition: Percentage of individuals in a population who tend, on a regular basis, to acquire food in excess of their maximum dietary energy requirements (FAO, 2016).

Dietary energy supply from cereals, roots and tubers: Percentage of dietary energy supply provided by cereals, roots and tubers (FAO, 2016). A higher share of dietary energy supply from cereals, roots and tubers is generally associated with a lower micronutrient density of the diet.

[10] Iodine deficiency disorders are an important public health problem in many countries. They are not discussed here because salt iodization, the main prevention and control strategy, is not related to agricultural value chains.

Dietary energy supply from carbohydrate: Percentage of dietary energy supply provided by carbohydrates, calculated by subtracting dietary energy supply from protein and dietary energy supply from fat from 100%.

Dietary energy supply from protein: Percentage of dietary energy supply provided by protein, calculated as average protein supply times 4 kcal/g divided by total dietary energy supply.

Dietary energy supply from fat: Percentage of dietary energy supply provided by fat, calculated as average fat supply times 9 kcal/g divided by total dietary energy supply.

Average protein/fat supply: National average protein/fat supply, expressed in g/caput/day (FAO, 2016).

Minimum dietary diversity: consumption of 4+ food groups: Percentage of children aged 6-23 months fed four or more food groups in the 24 hours preceding the survey. The food groups are 1) infant formula, milk other than breast milk, cheese or yogurt or other milk products; 2) foods made from grains, roots, and tubers, including porridge and fortified baby food from grains; 3) vitamin A-rich fruits and vegetables (and red palm oil); 4) other fruits and vegetables; 5) eggs; 6) meat, poultry, fish, and shellfish (and organ meats); 7) legumes and nuts (ICF International, 2015, The DHS Program STATcompiler).

Consumption of foods rich in vitamin A: Percentage of children aged 6-23 months who consumed foods rich in vitamin A in the 24 hours preceding the survey. Foods rich in vitamin A include meat (and organ meat), fish, poultry, eggs, pumpkin, red or yellow yams or squash, carrots, red sweet potatoes, dark green leafy vegetables (for example, cassava leaves, pumpkin leaves, kale or spinach), mango, papaya, and other locally grown fruits and vegetables that are rich in vitamin A (ICF International, 2015, The DHS Program STATcompiler).

Consumption of foods rich in iron: Percentage of children aged 6-23 months who consumed foods rich in iron in the 24 hours preceding the survey. Foods rich in iron include meat (and organ meat), fish, poultry, and eggs (ICF International, 2015, The DHS Program STATcompiler).

Child wasting: Percentage of children under five who are wasted, that is, have weight-for-height below minus 2 standard deviations of the median of the WHO Child Growth Standards. This means that they are too thin for their height (UNICEF/WHO/World Bank, 2016).

Child stunting: Percentage of children under five who are stunted, that is, have height-for-age below minus 2 standard deviations of the median of the WHO Child Growth Standards. This means that they are too short for their age (UNICEF/WHO/World Bank, 2016).

Child overweight: Percentage of children under five who are overweight, that is, have weight-for-height above 2 standard deviations of the median of the WHO Child Growth Standards. This means that they are too heavy for their height (UNICEF/WHO/World Bank, 2016).

Adult overweight and obesity/overweight and obesity among women of reproductive age: Percentage of adults aged 18 years or older/percentage of women of reproductive aged 15-49 years whose body mass index (BMI) is equal to or greater than 25 kg/m2 (WHO, 2015a; ICF International, 2015, The DHS Program STATcompiler). BMI is calculated by dividing body weight in kg by squared height in m.

Adult obesity/obesity among women of reproductive age: Percentage of adults aged 18 years or older/percentage of women aged 15-49 years whose body mass index (BMI) is equal to or greater than 30 kg/m^2 (WHO, 2015a; ICF International, 2015, The DHS Program STATcompiler).

Adult underweight/underweight among women of reproductive age: Percentage of adults aged 18 years or older/percentage of women aged 15-49 years whose body mass index (BMI) is below 18.5 kg/m^2 (ICF International, 2015, The DHS Program STATcompiler).

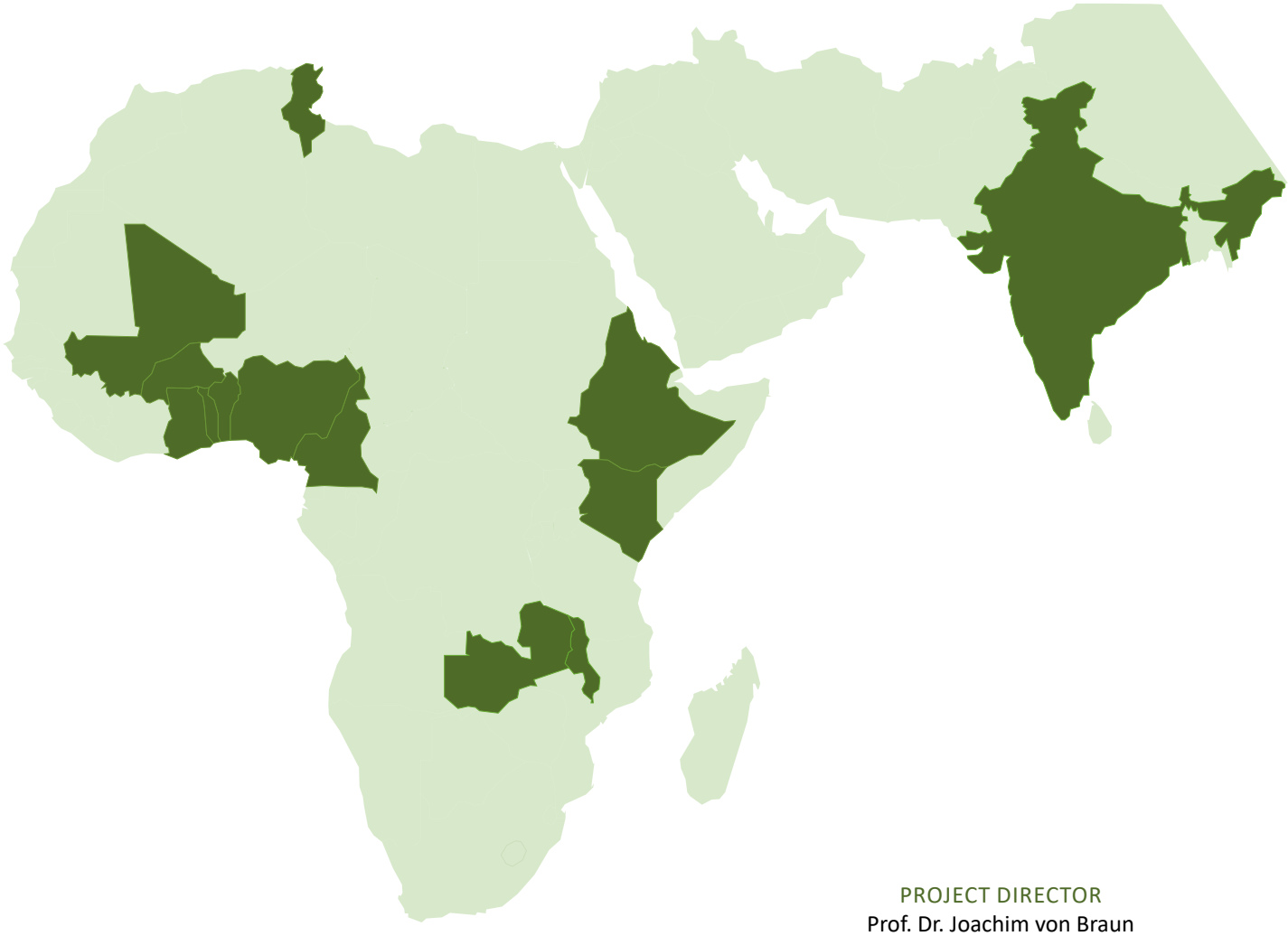
Vitamin A deficiency: Percentage of children aged 6-59 months with a serum retinol concentration below 0.7 µmol/l.

Anemia in children: Percentage of children aged 6-59 months with anemia, namely, a blood hemoglobin concentration below 11.0 g/dl.

Anemia in women: Percentage of women aged 15-49 years with anemia, namely, a blood hemoglobin concentration below 12.0 g/dl for non-pregnant women and below 11.0 g/dl for pregnant women.

ABOUT PARI

The Program of Accompanying Research for Agricultural Innovation (PARI) brings together partners from Africa, India and Germany to contribute to sustainable agricultural growth and food and nutrition security in Africa and India as part of the “One World, No Hunger” Initiative supported by the German government.



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