Income diversification and food security:evidence from Burkina Faso

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Income diversification and Food security: Empirical evidence from Burkina Faso

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Abstract

While food insecurity is a significant public health issue, addressing it is hampered by the fact that there exists substantial variation in food security across households conditional on economic resources. Food insecurity has attracted much attention from policy makers in developing world as well as in Burkina Faso, however it remains a veritable challenge. Accounting for potential endogeneity of income diversification, an IV Probit and IV Poisson models using control function approach explore the relationship of income diversification and food security status of households in Burkina Faso. We also state mean Decomposition to examine the differential of food consumption score by agro-ecological zones. We used nationally representative data from Harmonized Household Living Conditions Survey (HHLCS) over 6,010 households. The findings revealed that about 21% of households are food insecure. We find also that increases in income diversification is positively associated with household food consumption score, household dietary diversity and household food expenditure share meaning that household's livelihood diversification is considered as household 'resilience tool and is very relevant to improve the household's food security status. In addition, the age of the household head, the marital status and education level, the household size, the existence of permanent market, agricultural cooperative and women group in the community are important socio-economic variables in determining food security status in this study. According to findings, there exists differences in food consumption across the agro-ecological zones and between rural and urban households. These results suggest expanding income source opportunities is likely to enhance household diet diversity in Burkina Faso, while making progress towards other social and development goals. However, it is also necessary to push consumption patterns in some zones through climate resilience, infrastructures improvement (roads and transportation costs) and through commodities price control.

Key words: Food security; Household' livelihood sources; Instrumental Variable; Control Function approach; Mean Decomposition; Burkina Faso

JEL: Q18**,** Q12

1. Introduction

Food security is an important matter of concern for both the developed and developing countries. Interest in food security has been very strong most especially since the world food crisis of 1972–1974. The term food security has different aspects according to the level of focus from global, regional, national, community, and household to individual. Household food security, although complex, and a multi-dimensional phenomenon like poverty with approximately 200 definitions and 450 indicators (Hoddinott, 1999) is most important for the analyst since the household is the basic economic unit which determines the level of consumption by the individual. The importance of households' food security has become the concern of national governments as well as the international communities during the last few decades. A household is Food Secure (FS) when all people at all times in a household have sufficient physical and economic access to safe and nutritious food to meet their dietary needs including food preferences for an active and healthy life (FAO, 1996) revised by FAO, 2001. This definition integrates access to food, availability of food, and the biological utilization of food as well as the stability of all these. To the four dimensions, exist two additional dimensions: agency and sustainability (HLPE, 2020). Food insecurity, on the contrary, is known to be the absence of any of the conditions stated in the definition of food security at any level i.e. household, regional and national level. It is considered as severe food insecurity when individuals continuously take insufficient amounts of food to meet their daily dietary energy requirements. This may lead to hunger, the most severe stage of food insecurity (FAO, 2010).

Moreover, the situation of FS in developing countries become terrible. FAO (2021) reported that 264.2 million undernourished people lived in Sub-Saharan Africa out of the total 768 million undernourished people of the world in 2020. The situation is getting worse in West Africa where more than 75.2 million undernourished people do not have enough food to meet their basic nutritional needs unlike 50.6 million in 2019. Even though food supplies have increased substantially, constraints on access to food and continuing inadequacy of household and national income to purchase food, instability of supply and demand, as well as natural and man-made disasters prevent basic food needs from being fulfilled. The problems of hunger and food insecurity have global dimensions and are likely to persist and even increase dramatically in some regions, unless urgent, determined and concerted action is taken, given the anticipated increase in the world's population and the stress on natural resources. The persistence of hunger in the developing world means that ensuring adequate and nutritious food for the population

will remain the principal challenge facing policy makers in many developing countries in the years to come.

The problem of access to adequate and sufficient food for the population is a major concern in Burkina Faso. Indeed, due to its weather and soil conditions, Burkina Faso is an arid and poorly watered country. More than 40% of the population lives below the poverty line. With declining macroeconomic performance, the average growth rate for 2018, 2019 and 2020 being 6.0%, 5.7% and 2.0% respectively, due to the damaging effects of the COVID-19 pandemic on economic activity and the security situation, the live conditions of populations have worsened significantly.

The food security situations established at the end of each agro-pastoral season show that, despite an often surplus production at the national level, many populations are still faced with a situation of food insecurity of different degrees of severity. This situation is recurrent in many regions, which have remained chronically deficient. In addition, more than 45% of farm households are unable to cover their cereal needs with their own production only. In the projected situation, 13 provinces are "under pressure" and some could experience a crisis situation during the “lean period”. An estimated 257,238 people are in crisis with immediate and appropriate assistance needs in nutrition and health, food access and livelihood protection. These populations are mainly concentrated in the Sahel (38%), East (12%), and North (12%) regions respectively. According to FAO, (2021) the Burkina Faso was among the 20 countries hit by economic downturns, exhibit an increase in the prevalence of undernourishment (PoU), but oftentimes economic downturns occur simultaneously with food crisis (conflict) and climatic-related disasters.

Progressive increase in population without corresponding increases in livelihood sources diversification seems to have worsened the food security situation in Burkina Faso. One main reason concerns the livelihood systems of population who have lower purchase power. A key issue in poverty and food security is the livelihood diversification potential of households. In fact, it may be noted that treating the issue of food security without consideration of the resilience capacity may be inadequate to making appropriate policy recommendations. However, in keeping with the FAO, (1996) definition of food security, it is obvious that the actual problem of food security in Burkina Faso is that of “access” and appropriate use of food. In fact, food access is limited and inappropriate use, a major cause for malnourishment. Food access, one of the key dimensions of food security is the ability of the household/nation to obtain the food needed to maintain nutritional balance and is a function of income and

purchasing power of households. It encompasses physical access, economic access and sustainability access. Likewise, belonging to an agro-ecological zone regarding soil fragmentation and climatic conditions (rainfall), infrastructures as well as the ability to diversify their income sources may influence highly the livelihood stability and the accessibility to food by households.

Previous works have been done on food security in Burkina Faso among them; Sawadogo, (2021) examined the impact of soil degradation on agricultural production and food security in Burkina Faso using Computable General Equilibrium (CGE) model. Bougma et al., (2021) studied adoption of modernization practices of family farms and the sustainability of food security using Cox semi-parametric regression method.

However, the effect of income diversification on food security have received limited attention. The objective of this work is first, to determine the effect of income source diversity on food security and second, to state differences in food consumption by agro-ecological zone and between rural-urban areas. This paper presents new evidence in the relation between household' livelihoods source diversification and food security. First, the paper adds to the literature by examining the association between income diversification and different food security indicators using recent nationally representative survey collected in two complementary waves. The two round aspect helps to minimize potential seasonal bias and ensure comparability in the relationships observed across households. Second, this study deal with the potential endogeneity of income diversification through econometric methods. In addition, this paper uses a continuous definition of diversification and constructs a diversification index, a normalized Herfindahl-Simpson revenue diversification index (Di) that encompasses both the magnitude and the number of income sources and combine three variables, namely the Food Consumption Score, the Food Expenditure Share and the modified Household Dietary Diversity Score to explore the access dimension of food security. Finally, the paper apply Blinder-Oaxaca decomposition to examine the outcome differential by zone in terms of food consumption.

The remainder of the paper is organized as follows: Section 2 presents the literature review, Section 3 outlines the data used and empirical analysis. Section 4 discusses the empirical results, while the final section provides some concluding remarks.

2. Literature Review

The way food security is theorized, measured and finally analyzed affects the typology of policies that will be adopted. Different approaches exist, from food availability to capability approach that have drawn attention to different components of food security and, in turn, have contributed to modifying and extending the definition.

Food availability approach: it is undoubtedly the oldest and still the most influential. Although the core ideas of this approach can be traced back to the Venetian thinker Giovanni Botero (1588), it was Thomas Malthus (1789) who popularized it and hence it is also known as the Malthusian approach. The approach focuses on the balance or imbalance between population and food. In order to maintain this balance, the growth rate of food availability should not be lower than the growth rate of the population. Consequently, from this point of view, food security is merely a matter of aggregate (per capita) food availability.

Income-based approach: The long-lasting view of food security as a problem of food availability has been partly re-visited within a more macro-economic approach. The focus on the food sector, initially only agricultural production, but also food trading later on has been criticized by economists for being too concentrated on one single economic sector. Recognizing that the economy is composed of many interdependent sectors, food insecurity cannot be viewed as a problem that is exclusive to the agricultural/food sector.

Through household surveys providing information on income, it is theoretically possible to estimate the amount of food consumed, given the assumption that poorer households use a larger proportion of their income to buy food. Food is, then, converted into calories: if household calorie availability is lower than the ‘‘required’’ minimum, some or all the members of that household are food insecure.

The specific problem related to this method consists in the assumption of a given income-calorie elasticity. Taking, for example, an elasticity measured in the same country in previous studies, requires making very strong hypotheses.

Basic needs approach: This approach focuses directly on whether people eat enough food and has contributed to making a further step in shifting analysis from the macro level to the micro level. Food is seen as the priority (and probably the only) element of food security. With this framework, there are different ways of assessing food security coherently. The first one is a food frequency assessment, which can be performed by simply asking people the number of

meals eaten per day or even the frequency of consumption of different food items. These surveys are easy to conduct; however, focusing on the frequency and not on the quantity consumed makes calculating the calorie equivalent more complex.

The second method is based on a direct observation of food consumption. All household members are observed during meals in order to obtain direct information on all food consumed. The final calorie availability is obtained by weighting the food items according to their nutritional contents and aggregating them. More recently, some indicators based on the quality and diversification of diet have been developed, which are in line with the food first approach (Hoddinott and Yohannes, 2002)

The main advantage of the food first approach compared to the (micro) income-based approach to assess food security consists in the possibility of focusing directly on the commodity we are interested in (food), rather than on the income needed to buy it. This way we do not need information on current price per unit and, at the same time, we do not have to look at whether the person has physical or social problems in purchasing food. Finally, by concentrating on what is actually eaten, the food first approach implicitly recognizes (and does not underestimate) the food grown at home rather than purchased in the market.

As a conclusion of this brief review, this approach draws attention to short-term food security. It tells us whether households have enough food to feed all their members in a given time or in the past. However, it does not provide much information on potential food deprivations in the future.

Entitlement approach: In the 1980s Amartya Sen's entitlement approach contributed to challenging the Malthusian view of famine and hunger, and shifted the focus from national food availability to people's access to food.

'The entitlement approach concentrates on each person's entitlements to commodity bundles including food, and views starvation as resulting from a failure to be entitled to any bundle with enough food' (Sen, 1981). Entitlements depend on two elements: (1) personal endowments, which are the resources a person legally owns, such as house, livestock, land and non-tangible goods; (2) the set of commodities a person has access to through trade and production, i.e. the ''exchange entitlement. Given all the above considerations, employing this approach rather than the previous ones improves assessment from many points of view. The comparison with the food availability approach has already been made and there is plenty of evidence for the presence of major food insecurity and under-nutrition in countries with sufficient food per capita. The distance from the income-based approach is shorter, since income is an important

means of gaining access to food. As compared with the food first approach, the entitlement approach allows future food deprivations to be predicted: a smaller amount of assets, for example, means that the person may have more problems accessing enough food in the future.

Sustainable Livelihoods approach: The Sustainable Livelihoods (SL) framework is not just an approach to food security, but is a more general approach to development and poverty. Although the concept was certainly used previously, the ‘‘emphasis on livelihood’’ was given in the 1980s by Chambers (1983) who, in his seminal book, introduced the basic elements of this approach, with a focus on rural development and poverty. The SL framework has many communalities with the basic needs approach and the entitlement approach. Like the former, it focuses on ‘gaining a living’ (Chambers and Conway, 1992), that is ‘the necessities of life’ rather than on human development in a broader sense i.e. human flourishing. With the entitlement approach it shares the focus on the ‘‘means’’ of securing a living.

In fact, the SL framework is mainly concerned with the assets, tangible and intangible, at the disposal of a household which are very similar to the concept of ‘‘endowments’’ in the entitlement approach. The assets are classified in five categories: natural capital, physical capital, human capital, financial capital and social capital. Although the approach is presented as people-centred, the so-called ‘‘pentagon of assets’’ is actually the core concept of the SL framework. There are two distinctive features of the general SL framework that give it some advantages in the analysis of food security over previous approaches. The first is its long term perspective; the second is its focus on the context (political, economic, physical, social, cultural, etc.), although the latter is often confined to agricultural activities and rural areas, and seldom considers macroeconomic or economy-wide issues.

The combination of these two analytical features with the study of the household assets brings three interrelated concepts to the analysis of food security that are peculiar to the SL framework and neglected in previous approaches: Explicitly considering risks and shocks, adverse trends and seasonality leads to the concept of vulnerability, the idea of sustainability, strongly related to vulnerability and resilience, is one of the core principles of the SL framework and Coping strategies, that ‘represent a set of activities that are undertaken.

A human development and capability approach to food security: The capability approach to food security was primarily developed in 1989 by Jean Drèze and Amartya Sen in their pioneering book Hunger and Public Action. Although the authors do not make any reference to the concept of food security, they develop a general analytical framework for studying hunger,

chronic or transitory, and all related aspects, based both on the capability approach of (Sen, (1983, 1999), and his entitlement approach: undernourishment, malnutrition, famines, etc. In the beginning of the book, the authors explain why the entitlement approach is not sufficient for a general approach to hunger issues and why we therefore need to move beyond food entitlements towards nutritional capabilities: 'The focus on entitlements, which is concerned with the command over commodities, has to be seen as only instrumentally important, and the concentration has to be, ultimately, on basic human capabilities' (Drèze and Sen, 1991). This change of perspective derives from the crucial distinction between means and ends of development emphasized by Sen that also applies to the study of hunger: 'A more reasoned goal would be to make it possible to have the capability to avoid undernourishment and escape deprivations associated with hunger', i.e. the capability to be free from hunger. By switching the focus from ''command over food'' to ''nutritional capabilities,'' this approach goes beyond the ''access'' dimension of food security which is the main concern of the basic needs, entitlement and SL approaches and also includes the ''utilization'' dimension. This is one of the most important innovations of the capability approach to food security. Drèze and Sen explain why access is not sufficient and utilization is crucial: 'The object, in this view, is not so much to provide a particular amount of food for each. Indeed, the relationship between food intake and nutritional achievement can vary greatly depending not only on features such as age, sex, pregnancy, metabolic rates, climatic conditions, and activities, but also access to complementary inputs'. There are two recent developments that allow the framework proposed by Drèze and Sen in 1989 to be expanded and complemented. The first is about the role of another component of the capability approach: ''agency'', i.e. a person's ability to pursue and achieve goals. In the SL approach, the analysis is confined to ''livelihood strategies'', whereas in the capability approach, agency goes beyond the standard of living and personal well-being, and includes other valuable goals. The second development concerns security. The capability approach to food security should also include the fourth dimension of food security, as defined by the World Food Summit, which is stability that is much more than just food price stability. This dimension is explicitly considered in the SL framework, especially through the concept of vulnerability.

This paper ranges in the same order of the Capability and Sustainable Livelihood approaches to analyze food security seeing that household livelihood diversification is a household's ability to pursue and achieve the sustainability of food access.

However, empirical works are been done on household income diversification strategies and related it to household food security status. For small-holder farmers, income diversification may have both positive and negative impacts (Reardon, 1999), and also there is some controversy about the impact of income diversification on food access which are short run and long run effect. In the short run, participating in income diversification, raising the cash is important to fill the food deficit. However, the controversy comes from the long run effect of income diversification may reduce the availability of food and gradually it leads to food insecurity.

Mamabolo et al., (2021) examined Temporal and spatial variation of income diversification strategies among rural households in South Africa. The study applied Simpson Index of Diversity (SID) to panel data from National Income Dynamics Study from 2008 to 2017 to investigate these variations across four provinces of South Africa. Their findings pointed to the importance of disaggregating when analyzing household income diversification. They also looked at the differences by province and showed that, Limpopo, KwaZulu-Natal and North West had higher SID than the aggregated index, while Eastern Cape had lower degree of diversification. Contrary to other studies, this study found provinces with the highest and lowest income not having the highest degree of diversification.

In the same logic, Dev et al., (2016) using the Simpson Index of Diversity (SID) examined the impact of income diversification strategies on food security status of rural households in Bangladesh and found that the income diversification has significant implication on the food security status of the rural farming households in Bangladesh. Income diversification has been identified as essential strategy for raising income and reducing rural poverty. Food Security Index and Binary Logistic Regression model are also employed to analyze the data. The results of SID revealed that diversification of income sources (SID = 0.25) is very low implying that income diversification has positive but insignificant impact on household food security status in the study area.

In addition, Millimet et al., (2018) investigate a lack of financial capability as a potential salient determinant of household's food security status in extremely vulnerable households in US. They used two outcomes in the study. The first is a binary indicator denoting whether the household was food insecure. The second was a binary indicator denoting whether the household is very low food secure. Data were examine using OLS, GMM and IV Probit under control function approach. Their results indicate a strikingly significant effect, both

economically and statistically, of financial capability in general and financial behaviors in particular..

Dedehouanou and McPeak, (2020) used the same methodology as Millimet et al. to analyze household Income Generation Strategies and Food Security in Rural Nigeria using panel data. They apply the two-stage residual inclusion method for all regressions and the normalized Herfindahl-Simpson revenue diversification index (Di) to analyze the data. They used instead a composite indicators as Food Consumption score (FCS) and Reduced Coping Strategies Index (rCSI) as food security measures in addition to single indicators and found that income diversification favors food accessibility, food availability and food utilization and therefore, constitute resilience capacities overall.

With regard to Ilboudo Nébié et al., (2021), they combined three variables, namely the Food Consumption Score (FCS), the Food Expenditure Share (FES) and the Reduced Coping Strategies Index (rCSI) to explore the impact of climate shocks on the access dimension of food security in Senegal adopting cluster analysis. They used cluster analysis to find out who and where the most and least food secure households were. First of all they described household-level food security by varying the number of clusters retained. As such, the classification reveals a robust depiction of structural food insecurity. The least food secure are in the south and east, which is not where one would expect them to be, if climate were the dominant explanation.

Moreover, Flores-Lagunes et al, (2018) studied the differential incidence and severity of food insecurity by racial, ethnic, and immigrant groups over the great recession (GR) in the United States employing decomposition analysis to assess the contribution of compositional and structural factors to the observed differences in food insecurity incidence and severity for different demographic groups over time across groups defined by race/ethnicity and immigrant status before, during, and after the great recession. Their results show that during the great recession, the inequality in food insecurity incidence between Hispanics and whites and immigrants and nonimmigrants increased, but the inequality between blacks and whites fell.

The few studies on income diversification have focused on household calorie consumption or households' consumption expenditure (Bezu et al., 2012;Block and Webb, 2001) and little has account for endogeneity of explanatory variables in their works. This paper accounts for different dimensions of food security arguing that the empirical approach to the question of income diversification will help develop further insights into the interaction between livelihood diversification and household food security in sub-Saharan countries. The scarce literature on

food security and agro-ecological zones for sub-Saharan countries leaves the nature of this relationship as an open empirical question to be tested.

3. Methodological Approaches

3.1 Description of Study area

Burkina Faso is a Sub-Saharan country with a low income ($635 per capita in 2012 and $786.90 per capita in 2019) and limited natural resources. The population, which is growing at an average annual rate of 3.1%, is approximately 20 million according to the General Survey of Population and Housing (INSD, 2019) and is characterized by its youth (more than 77.9% of the population is under 35 years old) and 73.7% of the population lives in rural areas. The average household size is 5.2 individuals. However, the proportion of the population living in urban areas is increasing gradually over time, from 22.7% in 2006 to 26.3% in 2019. The economy is highly dominated by agriculture, which employs about 80% of the working population.

Burkina Faso has a Sudano-Sahelian climate characterized by an alternating dry season and rainy season that lasts three to six months depending on the agro-ecological zone. Seasons are determined by the movement of the inter-tropical front (ITF). The rains begin sporadically in the southwest in April and then progressively across the country from June. Average annual rainfall decreases from the southwest to the north, ranging from 1,200 mm to less than 400 mm, with the number of rainy days varying from 80 days to 40 days. Three agro-climatic zones can be distinguished: a sudanian zone with an average annual rainfall ranging from 900 to 1,200 mm with a six-month rainy season followed by the sudano-sahelian zone, with an average annual rainfall between 600 and 900 mm, spread over four to five months and finally, sahelian zone with an average annual rainfall of between 300 and 600 mm, spread over three months. Sahelian zone counts 10 provinces, sudanian zone counts 10 provinces and sudano-sahelian zone counts 25 provinces according to the administrative division. Agriculture is practically extensive and practiced on family farms. The family farm size set between 3 ha and 6 ha in average. The agricultural commodities farm in Burkina Faso are essentially: sorghum, millet, maize, rice, cotton, peas, bean, groundnut and sesame.

3.2 Sampling Methods and Data Collection

We use data from the 2018-2019 Survey implemented by the Burkina Faso National Institute of Statistics (INSD) in collaboration with the World Bank. These are survey carried out under the Harmonized Household Living Conditions Survey (HHLCS) project in WEAMU countries. About 7,010 households in rural and urban areas were interviewed over the six-month survey period. The sample is representative at the national level as well as at the urban and rural levels. After removing observations with missing values, we finally consider a total of 6,010 observations for the two survey rounds. The different modules of the questionnaire contain information on socio-demographic characteristics of the households, the different types of economic activities, and other information that allows calculation of the variables used in this study. Particularly relevant in this study are variables related to household income sources and indicators of food security. Information on household income allows us to investigate the degree of diversity in the income generation profile for each household interviewed.

The HHLCS employed a stratified two-stage sample design where in the primary sampling units were enumeration areas (EA). The EAs were selected with probability proportional to size within each province of the country and households were selected using random systematic sampling within each EA.

3.3 Multidimensionality of food security

No single indicator has been identified to comprehensively cover all four dimensions of food security at a time. The most successful studies have been those that incorporated diverse indicators to capture the complexity of food security (Cafiero, 2012; FAO., 2014). Previous studies have looked at two or more indicators to get a comprehensive understanding of the different dimensions of food security (FAO, 2019; Ike et al., 2017).

We explore the extent to which the access dimension of food security can be measured when data on dietary diversity and food frequency such as the Food Consumption Score (FCS) and adapted Household Dietary Diversity (HDDS) is triangulated with data on household food expenditure survey. Linking FCS and modified HDDS with Food Expenditure Share (FES) provides a better understanding of households' vulnerability to food security. FS focuses on cash expenditure on food and offers a good estimate of staple food price variations on household consumption quantity and quality (INDDEX PROJECT, 2018) in line with (Ilboudo Nébié et al., 2021) in analyzing food security and climate shocks in Senegal. Jones et al., (2014) in their study on farm production diversity associated with greater household dietary diversity in Malawi used the FCS and Household Dietary Diversity as food security indicators.

3.3.1 The Food Consumption Score (FCS)

The FCS is developed by World Food Program (WFP) that captures the quantity and quality of (household) food consumption. The Food Consumption Score (FCS) is the most commonly used food security indicator. It represents households' dietary diversity and nutrient intake. The FCS is calculated by inspecting how often households consume food items from the different food groups during a 7-day reference period. The FCS is a composite score based on the number of food groups (out of 8 possible food groups) that any household member has consumed over the previous 7 days, multiplied by the number of days that the food group was consumed, weighted by the nutritional importance of the food group, for a total possible score ranging from 0 to 112. Only foods consumed in the home are counted in this indicator. Broad food groups and associated FCS weights are: main staples weighted at 2, pulses weighted at 3, vegetables weighted at 1, fruit weighted at 1, meat and fish weighted at 4, milk weighted at 4, sugar weighted at 0.5, and oil weighted at 0.5. (Condiments can also be captured but are weighted at 0). Thresholds are imposed on the continuous score to differentiate households into one of three categories: acceptable (> 35, > 42 in areas where oil and sugar are consumed regularly), borderline (21–35; 28–42 in areas where oil and sugar are consumed regularly), and poor (< 21; < 28 in areas where oil and sugar are consumed regularly) (WFP, 2008).

Calculation steps:

- Using the consumption data group all the food items into specific food groups (see Appendix 2).
- Sum all the consumption frequencies of food items of the same group, and recode the value of each group above 7 as 7.
- Multiply the value obtained for each food group by its weight (see Appendix 2) and create new weighted food group scores.
- Sum the weighed food group scores, thus creating the food consumption score (FCS).
- Using the appropriate thresholds, recode the variable food consumption score, from a continuous variable to a categorical variable.

For the aim of this paper, poor and borderline food consumption score households are considered as food insecure and acceptable food consumption score households are food secure.

3.3.2 Modified Household Dietary Diversity Score (HDDS)

A modified Household Dietary Diversity Score (HDDS), (Swindale and Bilinsky, 2006) was calculated for each household using data on consumption of 138 food items. The HDDS is normally constructed using data on dietary intake in the previous 24 h. No dietary data were available in the HHLCS data set based on 24-h diet recalls. We therefore use a modified HDDS based on consumption of foods over the previous 7-d. Food items were categorized into 12 different food groups with each food group counting toward the household score if a food item from the group was consumed by anyone in the household in the previous seven days. The modified HDDS, then, is a continuous score from 0 to 12. The food groups used to calculate the modified HDDS included: cereals, roots and tubers, vegetables, fruits, meat, eggs, fish and seafood, pulses and nuts, milk and milk products, oils and fats, sugar, and condiments.

3.3.3 Food Expenditure Share (FES)

This indicator measures the percentage of each household's total expenditures devoted to food. It is an access measure based on the following premise: the greater the burden of food within a household's overall budget (relative to other consumed items/services), the more economically vulnerable the household. That is households that spend a large share on food are highly vulnerable to food insecurity regardless on their current consumption status.

The 'food expenditure share' indicator is essentially constructed by dividing the total household food expenditures by the total household expenditures**.** WFP analyses also capture food production in FES calculation. It should be noted that, an expenditure is not just a monetary purchase. Here, expenditure also refers to consumption of non-purchased items. The FES offers a good estimate of staple food price variations on household consumption quantity and quality (INDDEX Project, 2018). The percentage of cash spent on food is usually larger in poorer and more food insecure households (INDDEX Project, 2018; Smith and Subandoro, 2007)

3.4 Measurement of other variables

3.4.1 Income diversification index

Researchers have used different methods to measure the level of household income diversity. The Herfindahl–Hirschman index (HHI), Shannon's diversity index and Simpson's index of diversity (SID) are among the most commonly used measures.

We complement the analysis of the patterns and the dynamics of household's livelihood strategies in Burkina Faso by using an indicator that captures dimensions of both the distribution

of income from different sources and the number of income sources (Barrett and Reardon, 2000). We calculate a normalized Herfindahl-Simpson income diversification index (Di) that equals one minus the normalized Herfindahl–Simpson concentration index. Dependence on a single revenue source falls to the minimal value of zero and full diversification of revenue to the maximal value approaches one.

Four income sources are considered in this paper: the income from non-agricultural employment, the income from agriculture, rental income and income from remittances. The normalized Herfindahl–Simpson Index is expressed as:

$$Di = 1 - \frac{\sum_{i=1}^{N} p_i^2 - \frac{1}{N}}{1 - \frac{1}{N}},\ 0 \le Di \le 1$$

Where p_i represents the income share of the k-th income source for household i.

3.5 Empirical model

Food security is measured by either categorical variables or by a discrete non-negative integer variable. Hence, correspondingly, probit / logit and count data models are appropriate. This study employed the probit and poisson models with continuous endogenous explanatory variable to analyze income diversification effect on food security. The parameters of the probit and poisson regression models were estimated using the control function approach (CF). These approach was developed by Cameron and Trivedi, (2005), (Wooldridge, 2015); (Wooldridge, 2010)) and since our dependent variable (the household food security status) is binary (0, 1) or count data and ranked taking the values 0 to 12. This method is in line with previous work done examining effect causality on food security (Millimet et al, 2018; Sènakpon and McPeak, 2020). The coefficients show that for one unit increase in the predictor (independent variable), the response variable (dependent variable) is expected to change by its respective regression coefficient while the other variables in the model are held constant.

We are interested in the causal effect of income diversification on food security, controlling for economic and other attributes of the households. To that end, we first estimate:

$$y_i^* = \phi Di_i + X_i\beta + \mu_i, \quad i = 1,...,N \qquad (1)$$

One possibility is to estimate an LPM by 2SLS. This procedure is relatively easy and might provide a good estimate of the average effect.

In the model, y is equal to one if individual i is classified as either food secure and zero otherwise, Di is our scalar index of income diversification, X is a $1 \times K$ vector of covariates (including an intercept), ϕ is the coefficient of primary interest, and μ is a mean zero error term. We are assuming that income diversification is correlated with the error term in the latent variable model (model 1). Income diversification is suspected to be endogenous explanatory variable. The IV approach utilizes an instrument Z, for identification.

Prior to discussing identification, note that estimating equation (1) via 2SLS treats the dependent variable as continuous. Despite the popularity of this practice, strict conditions must hold to obtain consistent estimates if a binary outcome is treated as continuous (Horrace and Oaxaca, 2006). Thus, we also estimate an IV Probit model using control function approach. In particular, we estimate:

$$y_i = 1\left(y_i^* > 0\right), \quad i = 1,...,N \qquad (2)$$

$$Di_i = \delta Z_i + X_i\varphi + \nu_i \qquad (3)$$

Where (μ_i, ν_i) has a zero mean, bivariate normal distribution, and is independent of Z and $1(.)$ is the scalar function. Equation (1), along with equation (3), is the structural equation; equation (3) is a reduced form for Di, which is endogenous if μ_i and ν_i are correlated.

If μ_i and ν_i are independent, there is no endogeneity problem. Because ν_i is normally distributed, we are assuming that Di given Z is normal; thus Di should have features of a normal random variable.

The most useful two-step approach is a control function approach due to Rivers and Vuong, (1988) as it leads to a simple test for endogeneity of Di. To derive the procedure, we first state under joint normality of (μ_i, ν_i), with $Var(\nu_i) = 1$, we can write:

$$\mu_i = \theta\nu_i + e_i \qquad (4)$$

Where $\theta = \eta / \tau^2$, $\eta = Cov(\mu_i, \nu_i)$, $\tau^2 = V(\nu_i)$, and e_i is independent of Z and ν_i (and therefore of Di). Because of joint normality of (μ_i, ν_i), e_i is also normally distributed with $E(e_i) = 0$ and $V(e_i) = V(\mu_i) - \eta^2 / \tau^2 = 1 - \varphi^2$ where $\varphi = Corr(\mu_i, \nu_i)$

We can now write :

$$y_i^* = \phi Di_i + X_i\beta + \theta\nu_i + e_i, \quad i = 1,...,N \tag{5}$$

$$e_i | Z, Di, \nu_i \ \textit{follows a Normal}(0, 1-\varphi^2) \tag{6}$$

As such the estimation from the first stage regression where a household's borrowed money from informal source is used as an identifying instrumental variable. The logic behind this is that getting money may be considered as other income source of the household. Borrowing money is indeed correlated with income diversification in the estimation but is assumed to be exogenous by definition and not directly related to food security other than through the diversification of income sources.

4 Results and discussion

4.1 Descriptive Statistics

Descriptive analyses of key variables were performed for each location and total (pooled) respondents (Table 1).

The respondents' level of education, marital status, access to credit from informal source, dependency ratio, total annual income, level of income diversity (Di), food consumption score and household food expenditure share differed markedly between the two study areas. In most of the analysis, the urban households recorded better results than the rural households. In the pooled sample, the average age of the head of household is 47 years, with the youngest head of household being 16 years old and the oldest 100 years old. The average age is not varying much between rural and urban areas.

Table 1: Descriptive Statistic

Variables	Description	Rural (n = 3,529)	Urban (n = 2,578)	All (n = 6,107)	
		Mean (SD)	Mean (SD)	Mean (SD)	Min (Max)
Covariates					
Gender	Gender of household head (male = 1)	87.93 (0.33)	81.50 (0.39)	85.21 (0.35)	0 (1)
Age	Age of household head (years)	47.31 (14.94)	46.82 (14.39)	47.10 (14.1)	16 (100)
Marital status	Marital statut of household head (1 = married)	90.42 (0.29)	79.05 (0.41)	85.62 (0.35)	0 (1)
Household size	Number of household members in adult equivalent (AE)	5.38 (3.27)	4.36 (2.66)	4.95 (3.06)	0.66 (37.20)
Dependency ratio	The ratio of dependent household members to	1.41 (1.27)	0.91 (0.91)	1.20 (1.16)	0 (32)
Education	Education level of household head 0 = none ; 1 = primary ; 2 = secondary ; 3 = superior	 86.09 (0.35) 09.58 (0.29) 04.05 (0.20) 02.83 (0.05)	 48.60 (0.50) 18.35 (0.39) 23.74 (0.42) 09.31 (0.29)	 70.26 (0.46) 13.28 (0.34) 12.36 (0.33)	0 (4)
Community variables					
Agri. Cooperative	An agricultural cooperative exists in the community (1 =yes)			37.38 (0.48)	0 (1)
Women group	A women's group exists in the community (1 = yes)			79.08 (0.41)	0 (1)
Distance admin.	Distance in kilometres to the administrative capital			19.71 (24.58)	0 (145)
Instruments					
Credit	Any household's member borrowed money from informal credit source (1 = yes)	20.63 (0.59)	25.52 (0.56)	22.70 (0.57)	0 (1)
Permanent market	A permanent market exists in the community (1 = yes)	11.39 (0.32)	56.86 (0.49)	30.59 (0.46)	0 (1)
Income diversification					
Total incomes	Total household annual current income (CFAF "000")	722.44 (3232025)	1494.79 (3031379)	1048.48 (3171658)	800 (1.81e+08)
Di	Income diversification index	0.20 (0.27)	0.17 (0.25)	0.19 (0.26)	0 (.94)
Outcomes					
FCS	Food consumption score of household	53.73 (17.32)	62.17 (20.99)	57.30 (19.41)	0.5 (112)
HDDS	Dietary diversity score of household	8.24 (2.01)	8.75 (1.95)	8.46 (2)	1 (12)
FES	Food expenditure share of household	0.50 (0.12)	0.45 (0.12)	0.48 (0.13)	0.08 (0.87)

Source: Author's calculation from HHLCS data (2018). SD stands for standard deviation in parentheses.

Most of the households are headed by male in rural area as urban area. This result confirm that in Burkina Faso the households are most male-headed. The average household size in terms of AE in the sample is about 5 persons. However, we note the existence of individual households and the largest size of 37. Considering the dependency ratio, the table 1 shows that there are more inactive household members in rural area than urban area. In addition, in mean, rural households' head are most in none education level (86%), have very low access to credit from informal source and permanent market and save less total annual income compare to their urban counterparts. Total annual household income is approximately 1048.48 thousand CFAF in mean over all the sample. Hence, the income diversification index is very small in mean (0.19) corresponding to a very little income diversification among households in urban and rural areas. Furthermore, there is not much difference in household dietary diversity score among rural and urban households but in terms of food expenditure share and food consumption score, the urban households are more likely to access food than rural ones.

Table 2 shows food consumption score, household dietary diversity score and food expenditure share by number of income sources holding by the household. The average food consumption score 57.30, is slightly above 42 recommendation of acceptable food consumption. However, food consumption score is greater with greater income sources. Also, the household dietary diversity score in mean stands to 8.46 greater than 6 indicating a food secure status. From the food expenditure share the mean ratio is 0.48 < 50%. In mean the households are food secure. This result is in line with data available which find that 20% of households experience food insecurity in Burkina Faso (USAID, 2014). Disaggregating our sample by income sources show that more specialized households have smaller diet diversity score than more diversified households. These patterns underscore the importance of income for food security.

Furthermore, food expenditure revealed that the less diversified households are less economically vulnerable unlike the most diversified households. In the following, we analyze the role of agro-ecological zone belonging in this connection.

The table 2 presents also that the general trend stemming from the data shows that households were intensively involved in agricultural production, complemented mostly with off-farm activities such, remittances, non-agricultural wage employment, agricultural wage labor and rental wage. The maximum number of income sources observed in our sample was six. For the 6,010 households considered in the sample 11.27% relied on one source of income only, followed by 34.91% that relied on two income sources, 33.91% relied on three incomes sources and 19.91% that relied on more than three income sources. However, agriculture is the

dominant pattern for households in rural area and also the dominant source of income for all households (pooled sample). These results confirm previous works reporting that the agricultural sector employs more than 86.0% of the population in Burkina Faso (Monitoring and Analyzing Food and Agriculture Policies, MAFAP, 2013).

The descriptive statistics in table 3 show the food security access by ecological zone. According to the three indicators of food security, Ouaga performed better scores of diet quantity and household purchase power, followed by “Grand-ouest”, then “Grand-est”, “Grand-centre” and finally “Grand-sahel”. The total income per AE is highest in “Ouaga”. Comparing the others four agro-ecological zones, the total income per AE is more important in “Grand-ouest” zone and the lowest total income is recorded in “Grand-sahel” zone. In terms of income diversification index there is no large difference through agro-ecological zones. Hence, the average diversification seems low.

Table 2: Food security access by income sources

Variables	One income source (1)	Two income sources (2)	Three income sources (3)	More than three income sources (>3)
	Mean (standard deviation)			
FCS	54.39 (23.92)	56.46 (19.61)	57.75 (18.37)	59.63 (17.55)
HDDS	8.40 (2.05)	8.36 (1.96)	8.47 (2.03)	8.64 (1.96)
FES	0.45 (0.13)	0.47 (0.12)	0.48 (0.13)	0.50 (0.12)
Farmers				
All	33.57	64.68	78.75	86.92
Rural	79.56	94.67	97.17	98.45
Urban	11.23	27.37	44.47	66.66
Non-farmers	66.43	35.32	21.25	13.08

Note: SD stands for standard deviation in parentheses; FCS measures the food consumption score; HDDS represents the household dietary diversity score and FES is the food expenditure share
Source: Author's calculation from HHLCS data (2018).

Table 3: Food security access by ecological zone

Variables	Grand_ouest	Grand_est	Grand_centre	Grand-sahel	Ouaga
	Mean (SD)				
All	33.44	21.40	17.42	21.21	6.53
FCS	60.63 (19.79)	56.08 (17.64)	54.43 (18.09)	52.73 (18.43)	66.71 (22.99)
HDDS	8.89 (1.88)	8.35 (2.05)	8.46 (2.01)	7.73 (1.86)	9 (2.07)
FES	0.47 (0.12)	0.46 (0.12)	0.48 (0.12)	0.52 (0.13)	0.40 (0.11)
Total income per AE	270.96 (535901.71)	263.84 (591001.24)	246.95 (772161.23)	211.74 (487359.76)	896.63 (2123154.7)
Di	0.20 (0.27)	0.16 (0.25)	0.21 (0.26)	0.20 (0.26)	0.15 0.22)

Note: SD stands for standard deviation in parentheses; FCS measures the food consumption score; HDDS represents the household dietary diversity score and FES is the food expenditure share and Di= normalized Herfindahl-Simpson revenue diversification index
Source: Author's calculation from HHLCS data (2018).

4.2 Estimates results

Correlations across measures of dietary diversity and food expenditure share

The modified HDDS and FCS were strongly correlated with one another ($P < 0.000$). The Pearson product-moment correlation coefficient was 0.14. However, the correlations between FCS, HDDS and FES are not significant.

Associations between income diversity and food security

In probit and poisson models (table 4) controlling for the effects of several covariates on household food security, income diversification index is strongly and positively correlated with all measures of food security (food access) at 1% significance level. The estimated coefficients

reflect resilience capacities of rural livelihood diversification. The results also showed that an increase in income diversity increased the probability of households being food secure. According to FCS measure, a 1% increase in the value of the Di is associated with 116.105 and 4.137 increase household food consumption score in the 2SLS and the IV probit models, respectively.

Covariate relationships with food security

Several covariates in these models show consistent relationships with measures of food security. Table 4 shows that age of household head and distance to administrative town are negatively associated with FCS and modified HDDS in the models 2, 3 and 4 (1% and 5% significance level). Secondary and superior education level, permanent market and women group existence are positively related to FCS and HDDS at 1% level of significance in almost all models (e.g. P = 0.008 in models using the FCS).

However, age, gender and education level of household head, marital status of household head and household size are negative signicantly correlated with food expenditure share.

Belonging to other agro-ecological zone than "Grand-ouest" zone, is negatively correlated to the different measures of food access.

4.3 Discussion

The descriptive statistics, t-test, second-stage least square (2SLS), IV Probit and IV Poisson regressions presented resembling results from the study. The mean Di from the t-test indicates that the households of urban areas had a diversified income less than that of the rural area. But in general, the income diversification remain very low. By implication, urban households have a predisposition to specialization than diversification, while the rural households diversify their income moderately. This may be attributed to the seasonal character of agriculture exerted by the majority of rural households giving them time after harvest to undertake other activities compare to urban dwellers. In fact, much households in rural areas work in agriculture during the raining season and may do anything else during the lean season. Agriculture is contributing highly in household income (53.77%). With nearly 77% of the population living in rural areas and dependent on agriculture for their livelihoods, agriculture plays a leading role. However, the dominance of agriculture and its share in household's income is not surprising as it accounts for more than 37.0% of all exports in Burkina Faso (MAFAP, 2013).

Moreover, the average food consumption score and Household diet diversity score of households in urban area was comparatively higher than households in rural area. However, the

majority of households sampled were food secure in both study areas (Table 1). Additionally, the average food expenditure share is lower in urban zone than in rural location meaning that rural dwellers are more economically vulnerable than urban dwellers.

Results from our baseline model are presented in table 4. Models 2 and 3 define FCS as continuous and binary outcomes respectively. Model 1 defines FES as continuous outcome and model 4 specifies modified HDDS as count outcome.

Turning to the primary results for food security (table 4), we obtain key findings. First, borrowed credit from informal source instrument is not weak since Cragg-Donald Wald F statistic (23.658) is greater than Stock-Yogo weak ID test critical values: 16.38; 8.96; 6.66; 5.53. In all specifications, the underidentification test rejects the null hypothesis that the model is not identified ($p<0.01$). Second, addressing measurement error and/or unobserved heterogeneity matters. The IV regressions produce much larger effects of income diversification in absolute value as compared to the OLS and Probit regressions; exogeneity is always rejected ($p<0.01$ in all cases) Finally, we find that the 2SLS and IV Probit estimates are generally stable in coefficients for FCS models, the former gives slightly larger coefficients than the later. For example the coefficient of income diversification index is 116.153 in 2SLS model (model 2) and 4.195 in IV Probit model (model 3)

From model 2 and 3, income diversification index contributes positively to food security in the study area. An increase in the value of the Di increased the food security conditions of the households. Our results are in line with previous studies which have found that income diversification was associated with increased food consumption in Burkina Faso (Reardon et al., 1992) and Nigeria (Sènakpon and McPeak, 2020); Etea et al., (2019).

In model 4 our assessment of modified HDDS yields similar results as in FCS models. The IV Poisson estimate coefficients are statistically significant but not large (in absolute value). Moreover, the instrument continues to be strong (as the first-stage is identical) and we continue to reject exogeneity of income diversification index ($p<0.01$). Finally, we obtain the effect of income diversification on household diet diversity of roughly 0.761.

The results from model 1 are slightly different in signs compare to others, a positive coefficient meaning less food access while a negative coefficient means more food access. Hence, the instrument continues to be strong when using the food expenditure share.

Tableau 4: Results from the 2SLS, the IV Probit and the IV Poisson regressions

VARIABLES	FES	FCS		HDDS
	2SLS	2SLS	IV Probit	IV Poisson
	(1)	(2)	(3)	(4)
Di	0.352***	116.153***	4.195***	0.761***
Gender (Female)	-0.038***	-2.093	0.198	-0.058**
Age	-0.001***	-0.230***	-0.007**	-0.002**
Marital (Married)	-0.028***	8.377***	0.544***	-0.029
Household size	-0.001**	0.290***	0.031***	-0.002*
Dependency ratio	0.005***	0.158	0.025	-0.003
Primary level	-0.036***	-2.231**	-0.005	-0.020
Secondary level	-0.055***	10.667***	0.459***	0.028*
Superior level	-0.082***	19.857***	0.573***	0.039
Agr. Cooperative	-0.004	-0.988*	0.014	-0.009
Distance admin.	0.000***	-0.010	-0.003***	-0.000*
Permanent market	0.002	8.081***	0.348***	0.044***
Women group	-0.001	2.951***	0.168***	-0.012
Grand-est	-0.002	0.352	0.082	-0.042**
Grand-centre	0.003	-6.953***	-0.225***	-0.066***
Grand_sahel	0.040***	-8.603***	-0.406***	-0.150***
Ouaga	-0.035***	2.686**	0.106	-0.014
Residual from the first step	-0.330***	-114.182***	-3.953***	-0.743***
Constant	0.498***	33.890***	-0.509***	2.184***
Observations	6,010	6,010	6,010	5,965
R-squared	0.110	0.130		

Note: FCS measures the food consumption score; HDDS represents the household dietary diversity score and FES is the food expenditure share; Di= normalized Herfindahl-Simpson revenue diversification index; *** p<0.01, ** p<0.05, * p<0.1
Source: Author's calculation from HHLCS data (2018)

The agro-ecological zones are significantly related to food security variables in the four models. The Grand-ouest zone being considered as the base, the other agro-ecological zones are negatively associated to food security in model 2 to 4 except Ouaga zone. Belonging to Grand-centre, Grand-est or Grand-sahel zones decreases the probability of households to be food secure compare to their counterparts living in Grand-ouest zone and Ouaga. Moreover, households living in Ouaga are the most likely to be food secure. These results mean that some agro-ecological zones are more disadvantageous due to climate variability and extreme, soil conditions and economic slowdowns and downturns. The Grand-sahel is revealed to be the agro-ecological zone the most vulnerable vis-à-vis to food security measures in all models.

Table 5: Number of income sources and food security

VARIABLES	FES	FCS		HDDS
	2SLS	2SLS	IV Probit	IV Poisson
	(1)	(2)	(3)	(4)
Income sources	0.046***	15.062***	0.544***	0.099***
Gender (female)	-0.009*	7.357***	0.534***	0.004
Age	-0.001***	-0.046**	-0.000	-0.001
Marital status (married)	-0.026***	8.950***	0.566***	-0.025
Household size	-0.002***	-0.140	0.015*	-0.005***
Dependency ratio	0.005***	0.198	0.027	-0.003
Primary level	-0.027***	0.888	0.111*	0.001
Secondary level	-0.048***	12.879***	0.545***	0.042**
Superior level	-0.069***	23.970***	0.723***	0.066**
Agri. Cooperative (yes)	-0.003	-0.725	0.025	-0.008
Distance admin.	0.000***	-0.020*	-0.003***	-0.000**
Permanent market (yes)	-0.003	6.212***	0.285***	0.032***
Women group (yes)	-0.004	1.736***	0.124***	-0.020*
Residual	-0.041***	-12.771***	-0.369**	-0.083**
Grand-est	-0.010**	-2.286***	-0.013	-0.059***
Grand-centre	-0.000	-8.051***	-0.266***	-0.074***
Grand-sahel	0.049***	-5.582***	-0.299***	-0.131***
Ouaga	-0.030***	4.282***	0.161	-0.003
Constant	0.424***	9.397**	-1.388***	2.023***
Observations	6,010	6,010	6,010	5,965
R-squared	0.109	0.139		

Note: Standard error in parentheses; FCS measures the food consumption score; HDDS represents the household dietary diversity score and FES is the food expenditure share; *** p<0.01, ** p<0.05, * p<0.1
Source: Author's calculation from HHLCS data (2018)

In this section, we consider the number of income sources rather than the income diversification index. Table 5 presents the results of income sources in terms of number on food security status. As previously found in Table 4, the number of income sources is positively and significantly associated to food security indicators in the four models. Increasing livelihood sources thus leads to household's food security (food access) measured by the food expenditure share, the food consumption score and the modified household dietary diversity score. In general, the results show the same trend observed in Table 4 concerning the relationship between income diversification and food expenditure share, food consumption score and modified household dietary diversity score.

Consistent with the existing literature on human capital and household food security, the secondary and superior education level of the household head has a positive and significant relationship with both food consumption and dietary diversity while negatively associated to

food expenditure share. Household size has a significant negative impact on food expenditure share and dietary diversity, but has a positive and weakly significant correlation with food consumption. One possible explanation is since a household member may have access to food from a variety of sources (home production, purchased outside the house, received in exchange for labor, etc.), a larger household size may simply be a reflection of the greater variety in food consumption patterns as a result of having more people living in the household. Marital status and the existence in the community of permanent market are positively and significantly related to food consumption and negatively associated to food expenditure share (marital status only). Permanent market gives the possibility of more variety of food items available to afford by the household.

4.4 The Differential of Food Consumption Score by agro-ecological zone and rural-urban location

A decomposition mean differences is often used methodology to study group differences (sex, race, and so on) based on regression models in a counterfactual manner. The procedure is known in the literature as the Blinder-Oaxaca decomposition (Blinder, 1973; Oaxaca, 1973) and divides the outcome differential between two groups into a part that is "explained" by group differences such as commodity price, infrastructures, distance to administrative town, permanent market and agricultural cooperative existence, level of education, etc. (in this case) and a residual part that cannot be accounted for by such differences in food consumption determinants. This "unexplained" part is often used as a measure for discrimination, but it also subsumes the effects of group differences in unobserved predictors (rainfall, temperature or soil characteristics). Most applications of the technique can be found in the labor market and discrimination. However, the method may also be useful in other fields. In general, the technique can be employed to study group differences in any (continuous and unbounded) outcome variable. For example, O'Donnell et al., (2008) use it to analyze health inequalities by poverty status.

Using the agro-ecological zones and areas of residence, we conduct a decomposition analysis to assess the contribution of factors to the observed differences in the food consumption score. Those factors are an "endowment component" attributable to zone differences in observable characteristics, and a "structural component" attributable to zone differences in the structure linking the observable characteristics to food consumption (i.e., the regression coefficients).

Tableau 6. Mean Decomposition: Food Consumption Score

	Raw Difference	Endowment	Structure
Ouest-Est	4.279***	1.142**	4.984***
	(0.661)	(0.534)	(0.768)
Ouest-Centre	5.892***	0.464	6.696***
	(0.714)	(0.513)	(0.774)
Ouest-Sahel	7.876***	-0.560	8.275***
	(0.685)	(0.503)	(0.751)
Ouest-Ouaga	-6.239***	4.603***	9.478**
	(1.254)	(0.970)	(4.525)
Urban-rural	8.466***	3.531**	6.595***
	(1.615)	(1.454)	(2.295)

Note: Standard error in parentheses; Ouest, Est, Centre, Sahel represent Grand-ouest, Grand-est, Grand-centre and Grand-sahel agro-ecological zones respectively. *** p<0.01, ** p<0.05, * p<0.1
Source: Author's calculation from HHLCS data (2018)

For the decomposition we regard Grand-ouest as the reference zone, while we consider urban as the reference area in the analysis. We summarize the main findings here and make available in appendix the complete set of results. First, the decomposition of mean differences in food security shows that both the endowment and structural components contribute to Ouest-Est and Ouest-Ouaga differentials, with the structural component being somewhat more important for the Ouest-Ouaga difference. Meanwhile, the difference between Ouest-Centre and Ouest-Sahel is explained by the structure component.

Second, the decomposition analysis of differences in area of residence reveals that the urban-rural differential, which followed a similar pattern to food consumption for these groups, is primarily explained by the structural component. The endowment component is also relevant.

While coarse, the decomposition analysis is suggestive of the heterogeneity in the relative (importance of the factors endowments and structure) contributing to the observed differences in food consumption across these agro-ecological zones and location.

The observable characteristics differences reside in general in household's socio economic characteristics, commodity price differences, infrastructure quality (roads) capted here by the existence of permanent market and distance to administrative while structural component may be attributed to omitted variables such as the rainfall, storage conditions (temperature), soil fertility, household's productivity, adoption of agro-ecological practices.

5. Conclusion

While food insecurity is a significant public health issue, addressing it is hampered by the fact that there exists substantial variation in food security across households conditional on economic resources. This paper highlights the effect of income sources diversification on household's food security status in Burkina Faso. The study used three measures of food security (food access). Results of the assessment of households' food insecurity status in the considered sample revealed that 21.09% are food insecure. Among variables fitted into the model, income diversification index, agro-ecological zone, gender and age of household head, the marital status of household head, household size and community variables (distance from the community to administrative capital, agriculture cooperative existence, permanent market existence, women group existence) are important to explain households' food security status.

Different models findings revealed that income diversification contribute significantly to improve food security; we learn also that female-headed household are more food secure than their male counterparts (Table 5). In addition, households who live in other agro-ecological zone than "Grand-ouest" are likely to be food insecure except Ouaga dwellers. Higher education level increases the probability to be food secure of households (secondary and superior level).

In addition, the results present that there is differences in food consumption across agro-ecological zones and between urban and rural areas; Grand-sahel zone being the least in terms of food consumption. These differentials are explained by factors those are an "endowment component" attributable to zone differences in observable characteristics, and a "structural component" attributable to zone differences in the structure linking the observable characteristics to food consumption. Income diversification has larger effect in urban areas than rural areas

Income diversification and flexibility in income diversification strategies may be important contributors to dealing with climate variability and will play a growing role in confronting climate change. In that aspect, the importance of non-agricultural activities such as self-employment and salary work merits further attention in order to understand what factors allow or hinder movement into these activities. This is meaning that politics should encourage seasonality activities able to generate additional income for households. Moreover, additional training skills can allow households to develop other activities. The location of the household in an agro-ecological zone affects differently the food security status. Policies in favor of households belonging in Grand-sahel, Grand-est and Grand-centre as well as rural areas are necessary to dell with climate conditions, roads and high commodity prices. Promote the agro-

ecological practices and training in some zones where agricultural productivity is very low due to soil quality and low rainfall.

As shortcomings, this paper has used sectional data to analyze income diversification effect. New round of survey may analyze better this phenomena using panel data. Food consumption score (FCS), modified household dietary diversity (HDDS) and food expenditure share are used in this paper to examine the relationship between income diversification and household food security status. However, Food Consumption Score (FCS) is a survey based dietary diversity measure with subjective weights that are not applicable across all food consumption patterns in countries.

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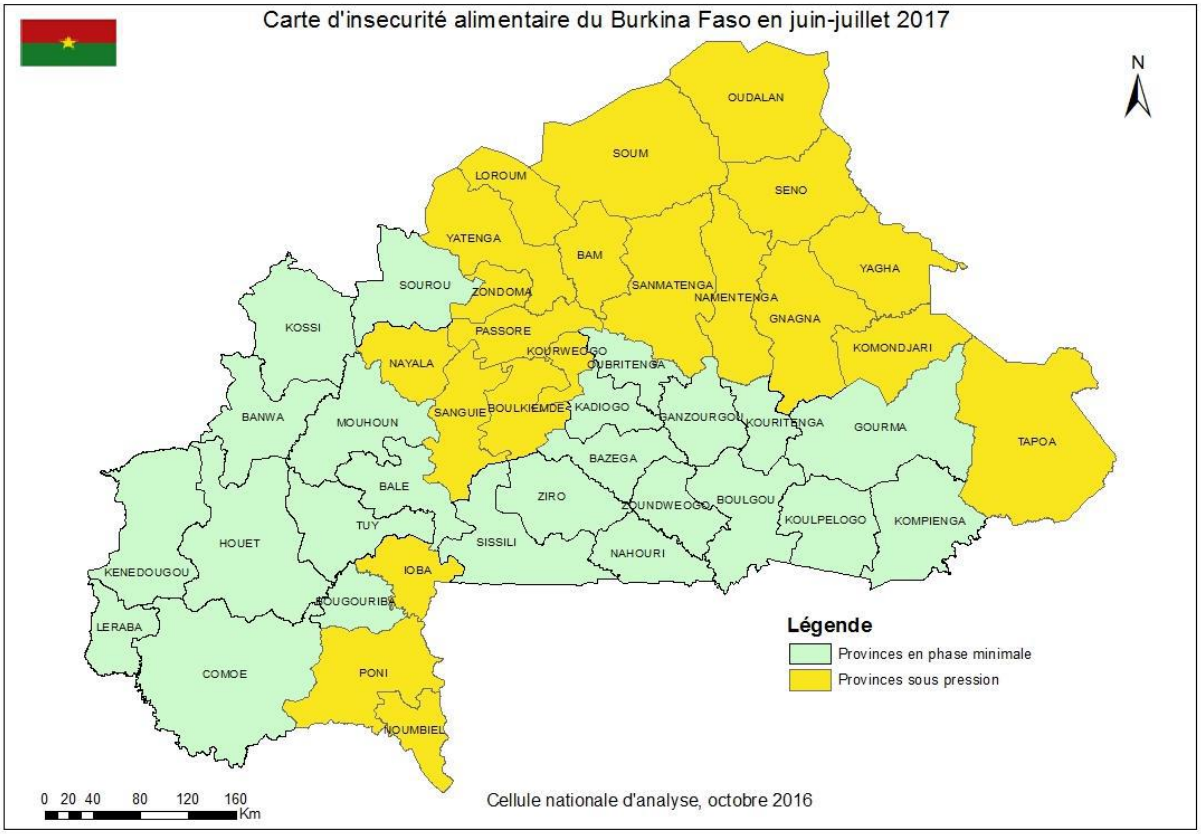
Appendix 1: Map of food insecurity in 2017



Source: EPA/DGESS/MAAH, 2017

Appendix 2: Food item groups and group weight

	Food items	Food group (definitive)	Weight (definitive)
Group 1	Maize, maize porridge, rice, sorghum, millet, pasta, bread and other cereals Cassava, potatoes and sweet potatoes, other tubers, plantains	Main staples	2
Group 2	Beans, peas, groundnuts and cashew nuts	Pulses	3
Group 3	Vegetables, carot, red pepper and leaves	Vegetables	1
Group 4	Fruits	Fruits	1
Group 5	Beef, goat, poultry, pork, chicken, snail, eggs, fish and see foods	Meat and Fish	4
Group 6	Milk, yogurt, cheese and other diary	Milk	4
Group 7	Sugar, honey, jam, candy, cake, biscuit and sugar products	Sugar	0.5
Group 8	Oils, fats and butter	Oil	0.5
Group 9	Spices, tea, coffee, salt, fish power, small amount of milk for tea.	Condiments	0

Source: Ndiaye. M, VAM officer (2008)

Appendix 3: First step regression of covariates and instrument on income diversification

VARIABLES	OLS	
	Coefficient	Standard error
Gender (female)	0.081***	0.012
Age	0.002***	0.000
Marital status (married)	0.026**	0.012
Household size	0.000	0.001
Dependency ratio	0.000	0.003
Primary educ. level	0.042***	0.010
Secondary educ. level	-0.012	0.011
Superior educ. level	-0.046**	0.018
Agri. Cooperative	0.005	0.007
Distance admin.	0.000	0.000
Permanent market	-0.036***	0.008
Women group	-0.012	0.009
Grand-est	-0.033***	0.010
Grang-centre	0.011	0.010
Grand-sahel	0.008	0.010
Ouaga	-0.012	0.016
Money borrowed from informal source	0.028***	0.006
Constant	0.058***	0.020
Observations	6,010	
R-squared	0.047	

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's calculation from HHLCS data (2018).

Appendix4: Determinant of Food Consumption Score by agro-ecological zones using 2SLS

VARIABLES	Grand-ouest (1)	Grand-est (2)	Grand-centre) (3)	Grand-sahel (4)	Ouaga (5)
Di	150.425***	169.946***	33.961*	148.599***	90.453
	(30.803)	(45.519)	(20.135)	(30.187)	(69.917)
Gender (female)	-9.718**	-10.612**	4.980**	-2.154	9.308*
	(4.310)	(4.241)	(2.193)	(2.269)	(5.048)
Age	-0.263***	-0.407***	-0.151**	-0.234***	-0.087
	(0.075)	(0.115)	(0.063)	(0.074)	(0.223)
Marital status (married)	5.645***	1.084	14.471***	-2.366	21.196***
	(1.967)	(2.313)	(1.918)	(2.491)	(2.942)
Household size	0.096	0.500***	0.329**	0.528***	0.641
	(0.115)	(0.138)	(0.162)	(0.138)	(0.628)
Dependency ratio	-1.205**	1.005*	-0.015	0.400	5.380*
	(0.505)	(0.522)	(0.687)	(0.404)	(2.885)
Primary level	-9.654***	5.917***	0.813	-3.067	3.749
	(2.554)	(1.484)	(2.036)	(2.106)	(3.780)
Secondary level	9.071***	16.164***	9.691***	8.773***	12.274***
	(1.342)	(2.388)	(1.940)	(1.926)	(2.746)
Superior level	19.290***	40.064***	12.627***	24.228***	17.871***
	(2.707)	(5.626)	(2.941)	(4.964)	(3.372)
Agri. Cooperative (yes)	-1.290	-4.114***	-1.591	3.577***	-13.974
	(0.900)	(1.318)	(1.200)	(1.162)	(12.323)
Distance admin.	0.009	0.029	0.015	-0.246***	
	(0.015)	(0.027)	(0.035)	(0.043)	
Permanent market (yes)	6.974***	3.897***	7.270***	11.976***	-4.718
	(1.508)	(1.048)	(1.959)	(1.910)	(3.608)
Women group (yes)	8.075***	-1.013	3.264**	2.503*	6.106**
	(2.611)	(1.614)	(1.348)	(1.404)	(2.573)
Residual 1	-147.152***				
	(30.845)				
Residual 2		-168.569***			
		(45.557)			
Residual 3			-32.352		
			(20.244)		
Residual 4				-147.643***	
				(30.248)	
Residual 5					-86.721
					(70.076)
Constant	31.695***	41.554***	33.991***	28.703***	25.181***
	(3.656)	(2.563)	(3.963)	(4.063)	(6.382)
Observations	2,014	1,289	1,047	1,263	397

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's calculation from HHLCS data (2018).

Appendix5: Determinant of Food Consumption Score by area of residence using 2SLS

VARIABLES	Rural (1)	Urban (2)
Di	88.154***	199.634***
	(14.445)	(42.019)
Gender (female)	-9.811***	1.275
	(1.948)	(2.533)
Age	-0.166***	-0.641***
	(0.030)	(0.157)
Marital status (married)	-1.527	15.375***
	(1.417)	(1.223)
Household size	0.324***	-0.236
	(0.070)	(0.234)
Dependency ratio	-0.054	2.846***
	(0.233)	(0.608)
Primary level	-4.784***	-3.368**
	(1.340)	(1.647)
Secondary level	3.004**	11.518***
	(1.455)	(1.086)
Superior level	23.240***	22.563***
	(5.328)	(2.125)
Agri. Cooperative (yes)	1.617***	-6.105***
	(0.613)	(1.287)
Distance admin.	0.045***	-0.024
	(0.012)	(0.025)
Permanent market (yes)	10.262***	4.252***
	(1.090)	(1.304)
Women group (yes)	1.682**	5.827***
	(0.719)	(1.425)
Residual urban		-198.561***
		(42.049)
Grand-est	-0.528	2.838*
	(1.102)	(1.544)
Grand-centre	-4.472***	-10.971***
	(0.839)	(1.536)
Grand-sahel	-11.120***	0.373
	(0.887)	(1.580)
Ouaga		4.879***
		(1.420)
Residual rural	-85.066***	
	(14.484)	
Observations	3,459	2,551
R-squared	0.089	0.166