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AGRONÓMICA, ALIMENTARIA Y DE BIOSISTEMAS**

***FOOD SECURITY MEASUREMENT IN RURAL
HOUSEHOLDS: THE CASE OF INDIGENOUS
COMMUNITIES IN SIERRA TARAHUMARA, MEXICO***

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Ph.D. THESIS

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HOUSEHOLDS: THE CASE OF INDIGENOUS
COMMUNITIES IN SIERRA TARAHUMARA, MEXICO***

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DEDICATION

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carry on.*

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RESUMEN

En la actualidad se utiliza una variedad de indicadores para el análisis, el seguimiento y la programación de la seguridad alimentaria. Por lo tanto, la medición exacta de la seguridad alimentaria de los hogares es esencial para generar información adecuada sobre la proporción de hogares con inseguridad alimentaria, especialmente en zonas o regiones vulnerables a la escasez de alimentos y hambre, como son las comunidades indígenas rurales. Se han llevado a cabo varios estudios para evaluar la inseguridad alimentaria en México. Sin embargo, la literatura es limitada en cuanto a las comunidades indígenas rurales. Teniendo todo esto en cuenta, la presente tesis doctoral se realizó con el objetivo de medir la seguridad alimentaria en hogares rurales entre las comunidades indígenas de Sierra Tarahumara, ubicada en el Estado de Chihuahua, México. La tesis proporciona una evaluación metodológica de tres indicadores de uso común para la medición de la seguridad alimentaria en el hogar, como son: la Escala Latinoamericana y del Caribe de medición de la seguridad alimentaria de los hogares (ELCSA), el puntaje de diversidad dietética en el hogar (HDDS, de las siglas del inglés) y los meses de aprovisionamiento adecuado de alimentos en el hogar (MAHFP, de las siglas del inglés). Asimismo, se examinaron algunas estrategias de afrontamiento empleadas por los hogares indígenas para combatir el hambre. La base empírica de la tesis doctoral emplea encuestas a hogares. La muestra representativa fue de 123 hogares de 38 comunidades, con una tasa de confianza del 95 por ciento y una tasa de precisión del 7 por ciento. Los datos fueron recolectados a través de entrevistas personales realizadas en sus hogares. Los autores fueron asistidos por traductores de la zona. Las encuestas se realizaron en febrero y marzo de 2015 (temporada de invierno), y se distribuyeron en diferentes días de la semana y diferentes horas del día para asegurar que todos los hogares tuvieran la misma probabilidad de ser encuestados.

En primer lugar, hemos analizado los determinantes de la inseguridad alimentaria entre las comunidades indígenas, y hemos explorado el problema en el ámbito familiar. Utilizamos la ELCSA, que se ha revelado como útil para medir los niveles de inseguridad alimentaria en los hogares. Se empleó el método basado en el alfa de Cronbach para medir la consistencia interna, que fue de 0,96. Además, estimamos los principales determinantes de la inseguridad alimentaria en los hogares utilizando tanto el modelo logit ordenado como el modelo logit binomial. Se encontró que aproximadamente 59,35% de los hogares vivían en una situación de inseguridad alimentaria severa. Los dos modelos predictivos aplicados sugieren que: i) el ingreso es el determinante más importante del acceso a los alimentos; ii) el aumento de la producción de maíz mejora la seguridad alimentaria; iii) los agricultores consumen sus reservas de semillas en tiempos de escasez de alimentos, y iv) los hogares se encuentran en situación de inseguridad alimentaria cuando el cabeza del hogar tiene trabajo temporal.

En segundo lugar, se analizó la diversidad dietética a través del HDDS en las comunidades indígenas. Se analizaron las características de los hogares, seguido de un análisis discriminante (DA) por inclusión de pasos, para determinar qué variables determinan mejor los niveles de la diversidad dietética. Los resultados muestran que el promedio de HDDS de consumo de alimentos fue de 6,89 alimentos. De los doce grupos de alimentos definidos en esta investigación, la mayoría de los encuestados consumen menos de ocho grupos de alimentos (50,41%). El grupo de alimentos más consumido por la muestra del estudio fueron los cereales (100%). La DA determinó que las variables que mejor explicaban la diversidad de la dieta eran el gasto de alimentos por habitante, el empleo ocasional, el programa Prospera y el estado civil del cabeza del hogar. El nivel de baja diversidad dietética fue el mejor para clasificar la DA.

Por último, se midió el acceso a los alimentos y se identificaron las estrategias empleadas por los hogares indígenas de las comunidades de Sierra Tarahumara en México para combatir la inseguridad alimentaria. Los resultados mostraron que el porcentaje de hogares que reportaron dificultades para obtener alimentos por tres meses o más en los 12 meses anteriores fue del 54,5% y sólo el 5,7% de los encuestados no tenían dificultades para obtener alimentos. Las principales estrategias utilizadas por los hogares fueron el racionamiento y el aumento de la disponibilidad de alimentos en el hogar a corto plazo. Algunas de las estrategias de afrontamiento se asociaron significativamente con el acceso a los alimentos. Concluimos que los hogares indígenas tuvieron dificultades para obtener alimentos.

SUMMARY

A variety of indicators is currently used for food security analyses, monitoring, and policy design. Hence, having accurate measurement of household food security is essential to generate adequate information on the proportion of households experiencing food insecurity, especially in areas or regions vulnerable to food shortages and famine, such as are rural indigenous communities. Several studies have been carried out to assess food insecurity in Mexico. Nevertheless, the literature is limited as far as rural indigenous communities are concerned. Taking all this into consideration, this doctoral thesis was conducted with the overall objective to measure the food security status in rural households among of indigenous communities in Sierra Tarahumara, located in the State of Chihuahua, Mexico. This thesis provides a methodological assessment of three commonly used indicators of household food security experience of hunger (ELCSA), dietary diversity (HDDS), and the months of adequate household food provisioning (MAHFP). Also, the main coping strategies employed by indigenous households to combat hunger were examined. The empirical basis of the thesis is founded on a households survey. The representative sample consists of 123 households from 38 communities, with a confidence rate of 95 percent and a precision rate of 7 percent. Data were collected through household-based face-to-face interviews. The author, and the team of researchers working with her in the fieldwork, were assisted by translators from the area. The surveys were conducted in February and March 2015 (winter season) and were distributed on different weekdays and different times of the day in order to ensure that every household had the same probability of being surveyed.

First, we have analyzed the determinants of food insecurity among the indigenous communities, and explored the problem at the household level. We used the Latin American and Caribbean Household Food Security Measurement Scale (ELCSA). This scale is useful for measuring food insecurity levels in households. We employed the method based on

Cronbach's alpha to measure internal consistency, which was 0.96. In addition, we estimated the main determinants of household food insecurity using both ordered logit model and binomial logit model. We found that approximately 59.35% of households were living in a situation of severe food insecurity. The two predictive models applied suggest that: i) income is the most important determinant of access to food; ii) increased maize production improves food security; iii) farmers consume their seed stocks in times of food scarcity, and iv) households are food insecure when the householders are in casual employment.

Second, we analyzed the dietary diversity through the Household Dietary Diversity Score (HDDS) in the indigenous communities. The households' characteristics were analyzed, followed by a discriminant analysis (DA) by steps inclusion to determine which variables determine best the levels of the dietary diversity. The results show that the average HDDS of food consumption was of 6.89 foods. From the twelve food groups defined in this research, most of the respondents consume less than eight food groups (50.41%). The food group most consumed by the sample of the study were the cereals (100%). The DA determined that the variables that best explained the dietary diversity were food spending per capita, casual employment, the Prospera program and the marital status of the head of household. The level of low dietary diversity was the best to classify the DA.

Lastly, we measured food access and to identify the coping strategies in indigenous households of the communities of Sierra Tarahumara in Mexico. The findings showed that the percentage of households reporting difficulties in obtaining food for three months or more in the previous 12 months was 54.5 % and only 5.7% of the respondents were not facing difficulties in obtaining food. The main coping strategies used by households were rationing and augmenting short-term household food availability. Some of the coping strategies were significantly associated with food access. We conclude that the indigenous households did experience difficulties in obtaining food.

ABBREVIATIONS

AIC	:	Akaike's information criterion
BIC	:	Bayesian information criterion
BLM	:	Binomial logit model
CCHIP	:	Community Childhood Hunger Identification Project
CEIR	:	Centro de Extensión e Innovación rural del Noroeste
CONEVAL	:	National Council to Evaluate Development
CCT	:	Conditional cash transfer program
DA	:	Discriminant analysis
ELCSA	:	Latin American and Caribbean Household Food Security Measurement Scale
FAO	:	Food and Agriculture Organization of the Geography
FI	:	Food insecurity
HDDS	:	Household Dietary Diversity Score
HDI	:	Human Development Index
HFSSM	:	Household Food Security Survey Module
INEGI	:	Instituto Nacional de Estadísticas y Geografía de México
MAHF	:	Months of Adequate Household Food Provisioning
OLM	:	Ordered logit model
SHCP	:	Secretariat of Finance and Public credit
WHO	:	World Health Organization

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CHAPTER 1.-

INTRODUCTION AND OBJECTIVES

1.1. THE CONTEXT OF FOOD AND NUTRITION SECURITY

In view of the alarming rates of prevalence of hunger and obesity affecting millions of people, policy initiatives in all countries have been developed towards improving the food and nutrition security status (Aliaga and Chaves-Dos-Santos, 2014). The concept of food security has evolved over the years, dates back to the 1940s with the Hot Springs Conference of Food and Agriculture in 1943. In this conference the concept of a “secure, adequate and suitable supply of food for everyone” was defined and was subsequently taken up at an international level (Gross et al. 2000; Napoli et al. 2011). The next step was in the 1950s, through the setting up of bilateral agencies by donor countries such as the USA and Canada, whereby their agricultural surpluses would be shipped overseas to countries in need (Gross et al. 2000; Napoli et al. 2011). By the 1960s there was a growing realization that food aid could actually hamper a country’s progress to self-sufficiency, and thus the concept of Food for Development was born, and with its realization expression, the World Food Programme (WFP) created in 1963.

However, the era of an abundance of food was coming to an end (Gross et al. 2000; Napoli et al. 2011). The issue of food security really came to the fore in the 1970s, the 1972-1974 food crisis marked the beginning of fluctuating food supplies and prices. At the 1974 World Food Conference in Rome the first explicit acknowledgement was made that this issue concerned the whole of mankind: “Every man, woman and child has the inalienable right to be free from hunger and malnutrition in order to develop fully and maintain their physical and mental faculties. Accordingly, the eradication of hunger is a common objective of all the countries of the international community, especially of the developed countries and others in a position to help” (United Nations, 1975; Maxwell and Smith, 1992; Gross et al. 2000; Napoli et al, 2011; Coates, 2013). In the 1980s, due to concerns about national, local and family availability, as a result of the African famine in 1984-1985, concern for physical and

economic access to food re-emerged, focusing the concept on the need for Humans well-being (Coates, 2013; Gross et al., 2000; Napoli et al., 2011). In the 1990s, the importance of the nutritional theme and the complexity of the concept were strengthened by their multidimensional nature. According to the World Food Summit of 1996, “Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (FAO, 1996). 186 countries signed the Rome Declaration, committing to assess and address Food and Nutrition Insecurity. Since then, the concept of food security has evolved to include the notion of nutrition security, including additional variables, like healthy dietary practices (Aliaga and Chaves-Dos-Santos, 2014; FAO, 1996).

In the first decade of the 2000s, the political importance of food security has intensified, even more so with the food crisis, which was complex, multifactorial and not cyclical, including natural disasters, and sudden increase in agricultural prices and food prices from 2007 to 2008 (Sanyal and Babu, 2009; Sumpshi, 2009). After that, significant price reductions in 2009 and part of 2010 occurred, followed by a new price increase sharply from August 2010 until July 2011. There is no doubt that structural causes of the high volatility and particularly strong and price spikes, particularly the supply-demand imbalance and climate change, mean that humanity faces a challenge of long-term food supply. This can only be solved through innovation and technology adoption, increased agricultural investment, design and implementation of appropriate agricultural policies and a new global governance for food and agriculture (Sanyal and Babu, 2009; Sumpshi, 2013; Garrido et al. 2016).

There are four pillars of food security, namely, (a) food availability addresses the supply side of food security and is determined by the level of food production, stock levels and net trade, taking into account food aid; (b) physical access to food in the market or

economic access to food, which depends on the purchasing power of households and the current level of food prices; (c) utilization refers to how the food consumed translates into nutritional benefits and to the health of individuals; and (d) stability, which seeks to guarantee access to food at all times and that can originate from political, economic or climatic causes (Coates, 2013; FAO, 2013a; Sanyal and Babu, 2009).

Determinants of food and nutrition security have been identified at different levels and vary from one region to another. While Africa is concerned about the variability of its agricultural production and the availability of food (Rosen et al. 2016a; 2016b; USDA, 2012), Latin America and the Caribbean are more concerned with issues related to access, especially income inequalities and rising food prices, while also facing growing rates of overweight and obesity (FAO, 2011; Willaarts et al. 2014; Aliaga and Chaves-Dos-Santos, 2014).

Across the globe, 75 per cent of the hungry poor live in rural areas. This fact reflects the continuing challenges facing rural areas linked to the social, economic and political marginalization of rural people (IFAD, 2016). In Latin American and the Caribbean, the state of food insecurity and poverty is higher in rural areas, especially among indigenous population. While food is produced in the rural areas, populations still have a high proportion of malnourished, compared to urban areas. The population living below the poverty line in rural areas is 52.8%, while in urban areas is 27.8%. The population in rural areas below the extreme poverty line is 30%, whereas in urban areas is 8.8% (FAO, 2015a).

Mexico has not been left out of the increase in the number of households and people being food insecure (FAO, 2013b). In 2014, 28.0 million people were affected by the lack of access to food (CONEVAL, 2015a). The strong deficiencies in access give rise to a mixed picture with significant gaps that require targeted interventions among certain population groups and in certain regions (FAO, 2015a).

Although the Mexican Constitution recognises indigenous people as an essential component of the nation, at present, the people who belong to indigenous communities suffer from various forms of social disadvantages that leave them behind the rest of the population (CONEVAL, 2014). With regard to the food security status, several studies have been conducted to assess food insecurity at the global and national level. However, the literature is limited with regard to the situation of indigenous communities and in particular the case of indigenous communities of the Sierra Tarahumara, which are known for being the Mexico's poorest citizens, with lower development and greater indigenous inequality (Fernández-Ham et al. 2006).

1.2. MEASUREMENT OF HOUSEHOLD FOOD SECURITY

Accurate measurement of household food security is essential to generate adequate information on the proportion of households experiencing food insecurity, especially in areas or regions vulnerable to food shortages and famine. This is why, during years, measures of food security have incorporated indicators to allow for the evaluation and monitoring of food and nutrition security at national, regional, community, household and individual levels (Babu et al. 2009; Chinnakali et al. 2014; Kirkland et al. 2013). In this doctoral thesis, the unit of analysis is the household since the direct observation of food insecurity probably suggests a high degree of vulnerability to a broad spectrum of consequences, including malnutrition in children, socio-familial problems, and overall poor health status. In other words, food scarcity is ultimately experienced at the household level (Kirkland et al. 2013; Chinnakali et al. 2014; Fuster et al. 2014). The analysis provides a methodological assessment of three commonly used indicators of household food security – experience of hunger (ELCSA), dietary diversity (HDDS), and the months of adequate household food provisioning (MAHFP). Also, some coping strategies employed by indigenous households were examined to combat hunger.

1.2.1. Household food insecurity access scale

Approaches to food security measurements based on subjective responses have recently received considerable attention. Latin American and Caribbean Household Food Security Measurement Scale (ELCSA) is based on the idea that there is a set of predictable reactions to the experience of food insecurity that can be summarized and quantified, allowing for measurement through household surveys. The ELCSA was adapted from various methodologies, including the one used in the United States (Carlson et al. 1999; FAO, 2012; Melgar-Quinónez and Hackett, 2008; Nord et al. 2007; Pérez-Escamilla, 2012; Wehler et al. 1992), or in Brazil (Segall-Corrêa et al. 2014), among others. Its classification system uses a set of fifteen questions used in surveys around the Latin American and the Caribbean that have been proved to be effective in distinguishing the food secure from the food insecure at the household level (Bezuneh et al. 2007; FAO, 2012; Melgar-Quinónez, 2010; Pérez-Escamilla et al. 2009; Shamah-Levy et al. 2014; Villagómez-Ornelas et al. 2014). The ELCSA questions thus represent universal aspects of the experience of food insecurity, capturing information on food shortage, food quantity and quality of diet to determine household food insecurity status (FAO, 2012).

1.2.2. Dietary diversity

One common dietary diversity indicator is the Household Dietary Diversity Score (HDDS), developed by the Food and Nutrition Technical Assistance (FANTA) project (Swindale and Bilinsky, 2006), which denotes the number of a total of 12 food groups consumed, the reference periods often varying from one to seven days. The HDDS separates main staples into two groups, disaggregates meat, fish, and eggs, and also includes a group for miscellaneous food items. It is one of the important measures that have been proposed over the years as an alternative means of capturing food access, which is of particular importance in developing countries where diets are composed mostly of starchy staples,

include few or no animal products, and may be high in fats and sugars (Swindale and Bilinsky, 2006; De Cock et al. 2013; FAO, 2013c). Thus, the use of dietary diversity as an indicator of dietary quality both at the individual and household level has been advocated as well, but the empirical evidence remains scant (Carletto et al. 2013). The indicator is usually measured by summing up the total number of foods or food groups consumed over a given reference period (Swindale and Bilinsky, 2006; FAO, 2013c).

1.2.3. Months of adequate household food provisioning (MAHFP)

The Months of Adequate Household Food Provisioning (MAHFP) is another household food security survey instrument developed by the Food and Nutrition Technical Assistance program at United States Agency for International Development (Swindale and Bilinsky, 2010). The survey instrument measures the number of months during which a given household had sufficient food provisioning. This index is administered to one household member who answers on behalf of the rest of the household (preferably the woman that cook food or household head). The stability of household food access is operationalized in the MAHFP as the adequacy of food provisions over a 12 month period (Swindale and Bilinsky, 2010; Leah et al. 2012; Frayne and McCordic, 2015).

1.2.4. Coping Strategies

In areas where households experience recurrent shocks to food security, such as poverty, droughts, households' response is not arbitrary. In these cases, households at risk of food insecurity are known to plan strategically to minimize its impact (Kirkland et al. 2013; Gupta et al. 2015). Such coping strategies include, but are not limited to collection of wild foods, migration in search of employment, rationing available food, eating less desirable foods, reducing household and/or individual consumption, borrowing or stealing money, adults provide food for children before feeding themselves, among others (Maxwell et al. 1999; Maxwell and Caldwell, 2008; Kirkland et al. 2013; Gupta et al. 2015). Importantly,

coping strategies do not necessarily imply that households are getting by, but instead are an indication that the household's food security is declining, often to a nutritionally unsustainable level. Household coping strategies are also often economically and environmentally unsustainable as well, which threaten longer-term household livelihood strategies and further increase future vulnerability (Maxwell and Caldwell, 2008; Kirkland et al. 2013; Gupta et al. 2015).

1.3. RESEARCH OBJECTIVE AND THE EMPIRICAL CONTEXT OF THE THESIS

Various studies have been conducted to assess food insecurity at Mexico. However, the literature is limited as far as rural indigenous communities are concerned. Lack of sufficient studies on the burden of the problem poses a hurdle in formulating strategies to combat this global threat. Taking all this into consideration, the present doctoral thesis was conducted with the overall objective to measure the food security in rural households among of indigenous communities in Sierra Tarahumara, located in the State of Chihuahua, Mexico. When assessing choices aimed at measuring the food security, three research questions arise: Are households living in food insecurity situation? What are the levels of dietary diversity? Do households have access to enough food in any time of the year? This doctoral thesis tries to answer these questions attempting to detect food insecurity and to support policy development to minimize food insecurity and rural poverty in the households of the communities of Sierra Tarahumara.

This doctoral thesis addresses the three above research questions in three specific objectives are as follows:

- To investigate the determinants of food insecurity among the indigenous communities of the Sierra Tarahumara in Mexico.

- To analyse the dietary diversity through the Household Dietary Diversity Score (HDDS) in the indigenous communities of Sierra Tarahumara, State of Chihuahua, Mexico.
- To measure food access and to identify the coping strategies in indigenous households of communities of the Sierra Tarahumara in Mexico.

The present doctoral thesis was household-based and cross-sectional. The representative sample was 123 households from 38 communities, with a confidence rate of 95 percent and a precision rate of 7 percent. Data was collected through household-based face-to-face interviews. The authors were assisted by translators from the area. The surveys were conducted in February and March 2015 (winter season), and were distributed on different weekdays and different times of the day in order to ensure that every household had the same probability of being surveyed. The evaluation was based on a survey of the indigenous households using questionnaires adapted for each methodological tool, such as:

- ELCSA was used to assess the FI level of the household and detect changes in the quality and quantity of food consumed according to the resources to which each household had access during the three months prior to the interview date (FAO, 2012).
- The HDDS, that is based on the food groups proposed by the FANTA (Swindale and Bilinsky, 2006).
- MAHFP, through which respondents were asked to identify the months (during the last 12 months) that they did not have access to enough food to meet their needs (Swindale and Bilinsky, 2010).
- Coping strategies adopted by households to prevent food insecurity. The coping strategy questionnaire was created using different bibliographic references (Maxwell

and Caldwell, 2008; Shariff and Khor, 2008; Ngidi and Hendriks, 2014; Gupta et al. 2015).

It is worth indicating that indigenous communities of the Sierra Tarahumara are very isolated and very few are accessible by road. Also, we could not come to reach many locations, as a result of the prevailing insecurity situation in some areas of the Sierra Tarahumara, especially due to major problems with illegal cultivation of marijuana and drugs trafficking

1.4. OUTLINE AND PUBLICATIONS OF THE THESIS

1.4.1. Outline

The doctoral thesis is structured in five chapters. Chapter one contains a general introduction with the state of the art, the objectives, and of the structure of the thesis and its related publications, presenting also the research context. Chapters two to four report the main original and empirical contributions of the thesis across three studies. Because each study has its own objectives, scope and methodologies, each section is organized authoritatively with an introduction followed by sections containing the methodology, results, discussion and conclusions, respectively. They illustrate the multidisciplinary methodologies applied to explore the food insecurity in indigenous households. Chapter five presents the main conclusions obtained in this doctoral thesis (Figure 1).

Figure 1. Outline of the thesis. Source: own elaboration

1.4.2. Publications

All relevant articles of the thesis have been published or submitted to journal contained in the Journal Citation Reports (JCR) (Q1-Q2). The second and third chapters of the thesis has been published, and the fourth chapter is a manuscript presently under revision (Table 1).

Table 1. Publications and conference proceedings of the doctoral thesis.

Chapter 2: Explaining food Insecurity among indigenous households of the Sierra Tarahumara in the Mexican State of Chihuahua

Publication in JCR journal

Cordero-Ahiman O. V., Santellano-Estrada E., and Garrido A., 2017. Explaining food Insecurity among indigenous households of the Sierra Tarahumara in the Mexican State of Chihuahua. Spanish Journal of Agricultural Research, 15(1): e0106. <https://doi.org/10.5424/sjar/2017151-10151>
(Published).

Chapter 3: Dietary Diversity in rural households: the case of indigenous communities in Sierra Tarahumara, Mexico.

Publication in JCR journal

Cordero-Ahiman O. V., Santellano-Estrada E., and Garrido A., 2017. Dietary Diversity in rural households: the case of indigenous communities in Sierra Tarahumara, Mexico. Journal of Food and Nutrition Research 5(2):86-94. doi: 10.12691/jfnr-5-2-3
<http://pubs.sciepub.com/jfnr/5/2/3>
(Published).

Conference Proceedings

Cordero-Ahiman O. V., Santellano-Estrada E., and Garrido A. 2016. Medición del Acceso a los alimentos en los hogares de comunidades indígenas de la Sierra Tarahumara del estado de Chihuahua, México. XII Congreso Español de Sociología, Gijón, España. [Oral communication]. <http://fes-sociologia.com/medicion-del-acceso-a-los-alimentos-en-los-hogares-de-comunidades-ind/congress-papers/2543/>

Conference Proceedings

Cordero-Ahiman O. V., Santellano-Estrada E., and Garrido A. 2016. Determinación de la diversidad de la dieta y los meses de aprovisionamiento de alimentos en los hogares de comunidades indígenas del estado de Chihuahua, México. VIII Congresso da APDEA. II Encontro Lusófono em Economia, Sociologia, Ambiente e Desenvolvimento Rural, Coimbra, Portugal. [Oral communication and moderator].
http://www.esadr2016.uevora.pt/index.php?/event_en/noticias/Titulos-dos-resumos-submetidos-provisorio_06_08_2016

Chapter 4: Food access and coping strategies adopted by households to fight hunger among indigenous communities of Sierra Tarahumara in Mexico

Publication in JCR journal

Cordero-Ahiman O. V., Santellano-Estrada E, and Garrido A., 2017. Food access and coping strategies adopted by households to fight hunger among indigenous communities of Sierra Tarahumara in Mexico. *Journal of Peasant Studies* (under review).

Conference Proceedings

Cordero-Ahiman O. V., Santellano-Estrada E, and Garrido A. 2016. Measurement of food access in indigenous communities of Sierra Tarahumara – Mexico, using the Months of Adequate Household Food Provisioning (MAHFP) indicator. XI Iberian Conference on Rural Studies (CIER) on Smart and Inclusive Development in Rural Areas, Vila Real, Portugal. [Oral communication].

http://xicier2016.utad.pt/sites/all/themes/professional_responsive_theme/images/files/Book_proceedings.pdf

1.5. STATEMENT OF AUTHORSHIP OF THE THESIS

This thesis contains no material which has been accepted for a degree or diploma by the University or any other institution, except by way of background information and duly acknowledged in the thesis, and to the best of my knowledge and belief no material previously published or written by another person except where due acknowledgement is made in the text of the thesis, nor does the thesis contain any material that infringes copyright. The following persons contributed to the publication of the work undertaken as part of this thesis:

- Otilia Vanessa Cordero Ahiman, Technical University of Madrid (UPM) (in Spanish: Universidad Politécnica de Madrid, UPM): Candidate and Author 1.
- Eduardo Santellano-Estrada, Autonomous University of Chihuahua (UACH), (in Spanish: Universidad Autónoma de Chihuahua, UACH): Author 2.
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Authors' contributions in the three articles (Chapters 2, 3 and 4): Candidate (author 1) was the primary author. Authors 2 and 3 contributed to the idea. Candidate (author 1) and

author 2 collected the data. Candidate (author 1) performed the quantitative analysis, interpreted the results and paper writing. Author 3 revised the manuscript, polished language and presentation.

1.6. RESEARCH CONTEXT

This research was completed as part of the Binational Cooperation Project for Extension and University Innovation, under the Land Grant Model. The objective of this project is to contribute to the reduction of poverty in Mexico, combining efforts and resources aimed at the extension of scientific technical knowledge through a comprehensive plan of institutional linkage that responds to the needs of the environment, cultural, economic and social. This project was funded by the Mexican Ministry of Agriculture, (in Spanish: Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación, SAGARPA), within agreement with the Autonomous University of Chihuahua (UACH), (in Spanish: Universidad Autónoma de Chihuahua, UACH) (grant number CONV/UACH/SAGARPA2014). As part of my field work, I spent three months in Chihuahua, Mexico. The research was undertaken at the Research Centre for the Management of Agricultural and Environmental Risks (CEIGRAM), Technical University of Madrid (UPM) (in Spanish: Universidad Politécnica de Madrid, UPM). The research was developed as part of the international PhD Program in Agricultural, Food and Natural Resources Economics program (in Spanish: Doctorado en Economía Agraria, Alimentaria y de los Recursos Naturales) of the Department of Agrarian Economy, Statistics and Business Management (in Spanish: Departamento de Economía Agraria, Estadística y Gestión de Empresas).

As part of my training program, I could enjoy two research stays abroad in two different international institutions (sponsored the SENESCYT and Consejo Social of UPM, respectively) aiming to enrich the research and provide support in specific thematic areas.

First, a three-month stay (16 January – 16 April 2015) was developed at the Northwest Centre of Extension and Rural Innovation (CEIR) (in Spanish: Centro de Extensión e Innovación Rural Noroeste, CEIR), at UACH, under the supervision of Dr. Eduardo Santellano Estrada. The second stay, three-month stay (17 January 2017 – 21 April 2017) took place at the Department of Economic and Social Development Department (ESADD), in Food and Agriculture Organization of the United Nations (FAO), under the supervision of Dr. Cristian Morales Opazo. Each stay allowed me to gain experience and knowledge in different aspects. The first stay focused in the fieldwork, surveys were conducted in households in rural indigenous communities. As a result of these surveys, I was able to collect the empirical data used in chapters two to four of the thesis. While the second stay contributed to further my knowledge in and increase my expertise mainly in relevant methodologies to household food and nutrition security analysis, and deepening in household survey analysis.

CHAPTER 2.-

EXPLAINING FOOD INSECURITY AMONG INDIGENOUS HOUSEHOLDS OF THE SIERRA TARAHUMARA IN THE MEXICAN STATE OF CHIHUAHUA

2.1. INTRODUCTION

About 795 million people are undernourished globally. Therefore, the eradication of hunger and poverty is still a challenge to be addressed with even greater intensity and focus (FAO et al. 2015; United Nations, 2016).

The measurement of food security status in households has been the subject of numerous investigations. The first measurement scales began in the USA, as laid down in the report to National Nutrition Monitoring and Related Research Act. This report tried to standardize measurement tools to get and set data on the prevalence of food insecurity (FI) (Melgar-Quiñónez and Hackett, 2008; Hamilton et al., 1997; FAO, 2012). As a result of this research, two instruments of measurement were defined: the Community Childhood Hunger Identification Project (CCHIP) (Wehler et al. 1992; Carlson et al. 1999; FAO, 2012) and Radimer/Cornell hunger scale (Radimer et al. 1992; Carlson et al., 1999; FAO, 2012). In the mid-1990s, these two instruments were replaced by the Household Food Security Supplemental Module (HFSSM). The HFSSM provided a clear assessment of the food security situation of the USA. This instrument has been adjusted and validated since then. This adjusted and validated HFSSM has been included in several population and health surveys in a number of countries around the world (Carlson et al., 1999; Nord et al. 2007; Melgar-Quiñónez and Hackett, Nord and Parker, 2010; 2008; FAO, 2012; Pérez-Escamilla, 2012).

In Latin America and the Caribbean, variants of these scales measuring FI were adapted and applied in the Community Childhood Hunger Identification Project (CCHIP) in Venezuela (Lorenzana and Sanjur, 1999). The HFSSM was later adapted in Colombia (Hackett et al. 2008), Brazil (Brazilian Food Security Scale (EBIA)) (Segall-Corrêa et al. 2014), Bolivia (Melgar-Quinonez et al., 2006; Pérez-Escamilla, 2012), Ecuador (Hackett et al. 2007) and Trinidad and Tobago (Gulliford et al. 2006). These previous experiences of

scales measuring food security at household level were consolidated in the Latin American and Caribbean Household Food Security Measurement Scale (ELCSA). This scale can be used to assess the FI level in households and detect changes in the quality and quantity of food consumed, taking into account the resources available to each household in the past three months (FAO, 2012). Several studies were conducted to validate this new instrument in a number of countries in this region, including Guatemala (Hugo Melgar-Quiñonez et al., 2010), Haiti (Pérez-Escamilla et al., 2009), Mexico (Melgar-Quiñonez et al. 2005; Melgar-Quiñonez et al., 2010; Shamah-Levy et al. 2014; Villagómez-Ornelas et al., 2014), Dominican Republic (Bezuneh et al. 2007) and other countries.

Mexico has not been impervious to the economic and financial price crisis. This has resulted in an increase in the number of households and people having insecure access to food (FAO, 2013a). The 2011 reform of the Mexican Constitution to consider the right to food was a major advance. But the FI situation still paints a complex picture. Poverty levels tend to be higher in states that have been identified as priority areas, where the population is rural (<2500 inhabitants), indigenous (more than 40% of Mexican population is indigenous) and settled at a distance from metropolitan areas. Such states also tend to have the highest deficiency levels with respect to food access (FAO, 2013a, 2015; CONEVAL, 2016a). The indigenous population is among the poorest and most disadvantaged strata of society, where living standards are below national and regional averages and the minimum welfare levels defined by various international organizations (CDI and PNUD, 2006a; Suárez, 2006).

In Mexico there are food aid programs that aim to contribute to improving the nutritional status of the most vulnerable populations: 1) Prospera is the main social inclusion program providing bimonthly conditional cash transfers; 2) the Food Support Program (PAL) provides bimonthly cash or card transfers for the purchase of a set of predefined products in stores supplied by DICONSA; 3) the Rural Supply Program run by DICONSA (PAR)

provides a basic food basket at reduced rates (<15%); 4) the Social Milk Supply Program run by Liconsa (PASL) targets the population with income below the poverty line and provides for weekly milk delivery through the sale of liquid and powdered milk for community supply or under agreement with social players (CONEVAL, 2016b).

Delving into the socioeconomic problems and the FI situation affecting most of the rural population, especially indigenous communities, is essential for the design and evaluation of public policies in the Mexican scenario. It is vital in this context to have accessible, accurate and up-to-date information on the problems of rural households that could be addressed by public policies. While there are several sources of information that provide insight into specific aspects of rural households in Mexico, none is sufficient to paint a complete picture of this sector of the population. The fact that they share the same general shortcomings does not mean that all indigenous peoples are alike (Fernandez et al. 2006; CONEVAL, 2015a).

In Mexico, the severe drought that occurred in 2012 left two million people without access to water and, in addition to, devastated cropland in nearly half of the country. This lack of and accessibility to food had a significant negative impact on the nutrition and health status fundamentally of poor Mexican population. Among the more seriously affected were the indigenous communities of the Sierra Tarahumara, which are known to stand among the Mexico's poorest citizens (Zabludovsky, 2012).

There has been no recent update of information on the FI situation of indigenous communities in Mexico and in particular the Sierra Tarahumara. This constitutes an important limitation for monitoring the Global Sustainable Development Goals (Goal 2: Zero Hunger) (United Nations, 2016), signed by the Mexican government. Indigenous communities of the Sierra Tarahumara are very isolated and very few are accessible by road, infrastructure is very expensive. This is an obstacle to the provision of services like

education, healthcare, water and electricity. These long-term disadvantages have driven this region into poverty and FI (Saucedo et al. 2012). According to development indicators in Mexico, the Sierra Tarahumara ranks 20th (Human Development Index (HDI) of 0.64) with lower development and greater inequality of indigenous (HDI of 0.54) with respect to non-indigenous (HDI of 0.78) people, that is, a 30.3% difference between the two populations (CDI and PNUD, 2006b). On this ground, the Mexican Ministry of Agriculture (Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food, SAGARPA) supported this research that should help to provide local and national political decision makers with updated information in order to identify inconsistencies in policies and programs related to food security. Our research is up-to-date and helps to identify the determinants of FI in households of the Sierra Tarahumara, located in the southwestern part of the state of Chihuahua.

2.2. MATERIAL AND METHODS

2.2.1. Study area

The Sierra Tarahumara is a mountain range located in the Sierra Madre in the state of Chihuahua in northwestern Mexico. It consists of a series of deep canyons alternating subtropical high mountains up to 3300 m asl. It is characterized by a great diversity of flora and tropical, subtropical and temperate wildlife, including a number of unique species in the world (Laroche and Berkes, 2003). The Sierra Tarahumara is considered a forest region and has 4.5 million hectares of pine-oak forests. The area accounts for about 15% of forest cover in Mexico and 10% of national forest area under management. User groups —ejidos and agricultural communities (Pérez-Cirera and Lovett, 2006)— manage 84% of forests under a common property regime. The Sierra Tarahumara is also an area of cultural diversity, since there are four indigenous ethnic groups: Rarámuri or Tarahumara, Pima, Guarojío and Tepehuanes. Most of the indigenous population of the Sierra is Rarámuri, one of the largest groups of indigenous peoples in Mexico (Laroche and Berkes, 2003; Saucedo et al. 2003).

2.2.2. *Data collection*

The communities of the Sierra Tarahumara in Chihuahua were selected using a simple random sampling method. They were classified according to the distance to the nearest centre of development, which, in this case, was the town of Creel (0-3 km, 3-6 km, 6-9 km and 9-12 km). Creel is considered to be the gateway to the Sierra Tarahumara and has a developed tourist sector (Farías and Aranda, 2008). The communities were selected from a list of communities provided by the Mexican National Institute of Statistics and Geography (INEGI). The representative sample was made up 125 households in 38 communities, with a confidence level of 95% and a precision of 7%. The survey was conducted face to face and lasted approximately two hours. All respondents were Rarámuris, and interviewers were assisted by interpreters to translate to and from their language. The survey was conducted between February and March 2015 and was spread across different days of the week and different times of the day in order to ensure that all households had an equal chance of being surveyed. Pilot testing of the survey was conducted prior to the definite survey. Apart from expert opinion, the results from the pilot test were used to refine the questions contained in the survey. The sample was rather small because the Rarámuri are the most disperse of all the indigenous groups of Mexico: almost 70% live in communities of 1 to 99 people (CDI and PNUD, 2006a).

2.2.3. *Questionnaire*

The survey consisted of two questionnaires: a) ELCSA was used to assess the FI level of the household and detect changes in the quality and quantity of food consumed according to the resources to which each household had access during the three months prior to the interview date (FAO, 2012); and b) the agro-socioeconomic questionnaire provided information about the head of household and household characteristics, and land tenure and production.

2.2.4. *ALCSA Analysis*

ELCSA contained 15 questions that were divided into two sections. Section 1 was related to a number of situations that lead to the FI experienced by households and adult household members (questions P1 to P8). Section 2 was related to the conditions affecting children aged under 18 in households (questions P9 to P15) (FAO, 2012). Each question had two possible answers: yes (1) or no (0) (Table 2). From the aggregate score of positive responses, we could estimate the degree of FI of households divided into four levels according to the cutoff points used by ELCSA: 1) no FI, with 0 positive responses; 2) mild FI, between 1 and 5 affirmative responses; 3) moderate FI, between 6 and 10 positive responses; and 4) severe FI, with 11 or more affirmative responses (FAO, 2012).

Two households were excluded from the sample because respondents did not complete the 15 necessary questions to define the ELCSA. Therefore, the final sample consisted of 123 households. In each selected household, we surveyed the head of household and/or the woman in charge of preparing food for the family.

Table 2. Food insecurity questionnaire items. English back-translation from Spanish

Items	In the past 3 months, because of a lack of income or other resources,
Q1	Did you ever worry about your household running out of food?
Q2	Did your household ever run out of food?
Q3	Was your household deprived of eating a healthy diet?
Q4	Did you or any other adults in your household ever have an unbalanced diet?
Q5	Did you or any other adults in your household miss breakfast, lunch or dinner?
Q6	Did you or any other adults in your household eat less than you should?
Q7	Were you or any other adults in your household ever hungry and had nothing to eat?
Q8	Did you or any other adults in your household not eat for a whole day or eat only once a day?
Q9	Were any household members deprived of a healthy diet?
Q10	Did any household members under 18 have an unbalanced diet?
Q11	Did any household members under 18 ever miss breakfast, lunch or dinner?
Q12	Did any household members under 18 not have enough to eat?
Q13	Did you ever have to cut the size of the meals prepared for any household members under 18?
Q14	Were any household members under 18 ever hungry and had nothing to eat?
Q15	Did any household members under 18 ever not eat for a whole day or eat only once a day?

Source: (FAO, 2013a)

2.2.5. Evaluation of ELCSA reliability using Cronbach's alpha

Cronbach's alpha coefficient measures the reliability of questionnaire responses and falls within the interval (0, 1). If α is near 0, then the quantified answers are not at all reliable; and if it is close to 1, the responses are very reliable. As a rule of thumb, if $\alpha \geq 0.8$ then the answers are considered reliable (Cronbach, 1951; Leontitsis and Pagge, 2007; FAO, 2012). Therefore, this coefficient was used to assess the reliability of the ELCSA.

X is an $n \times k$ matrix of the quantified questionnaire responses. Each row of X represents a subject and each column a question. In this case, the quantified responses are on the scale of 0 to 1. Cronbach's alpha is expressed as:

$$\alpha = \frac{k}{k-1} \left[\frac{\sigma_t^2 - \sum_{i=1}^k \sigma_i^2}{\sigma_t^2} \right] \quad [\text{Eq.1}]$$

Where σ_i^2 is the variance of each column of X, σ_t^2 the variance of the sum of each row of X. In Equation (1), k is a correction parameter. If the quantified responses are consistent, then σ_t^2 will be relatively large. This will lead α to tend to 1. Otherwise, random responses will lead σ_i^2 to be comparable with the sum of individual variances ($\sum \sigma_i^2$). This will in turn lead α to tend to 0 (Leontitsis and Pagge, 2007).

2.2.6. Empirical models

The first step was to identify the dependent and the independent variables that are likely to provide information to explain FI. The models tested all the independent variables in Table 3. However, the variables that best explain the models in this study were: income, consumed seed stocks, tons of maize produced, casual employment, age, household size and Prospera. The second step was to estimate the statistical models.

2.2.7. Ordered logit model (OLM)

There are several types of logistic models. However, when, as is the case of our FI variable, the outcome represents an underlying continuous scale subdivided into many

categories, the best modeling framework is an ordered logit model (Greene, 2003; Long and Freese, 2006; Ingelmo et al. 2011). The OLM is widely used for analyzing such categorical dependent variables (Greene, 2003; Train, 2009) The OLM can be derived based on the level of an unobserved variable. One fundamental assumption of this model is that the data should meet the proportional odds assumption. The relationship between two levels in the dependent variable group is the same, and therefore the slope coefficients do not vary across different alternatives, except at the cutoff points (Train, 2009; Sasidharan and Menéndez, 2014).

Food insecurity is divided into four categories in increasing order of insecurity and coded as: 0 = no FI, 1 = mild FI, 2 = moderate FI and 3 = severe FI. Note that level $J = 0$ is defined as the minimum value of the variable (no FI). Let Y_i denote the observed food insecurity level in household i , Y_i^* the latent food insecurity measure, X the matrix of independent variables. In this study, $J = 4$. The latent regression of food insecurity Y_i^* is expressed as:

$$Y_i^* = X_i \beta + \varepsilon_i \quad [\text{Eq.2}]$$

Where i is the observation, β are the regression coefficients for X , ε is the identically and independently distributed error term.

Let μ_k be the food insecurity (FI) thresholds= 1, 2,..., $J - 1$. Level $k = 1$ represents the minimum threshold (no FI). The values of Y are represented as:

$Y=0$ no FI if $Y^* \leq \mu_1$

$Y=1$ mild FI if $\mu_1 \leq Y^* \leq \mu_2$

$Y=2$ moderate FI if $\mu_2 \leq Y^* \leq \mu_3$

$Y=3$ severe FI if $Y^* > \mu_3$

Since J is the number of insecurity levels, then the probability of FI level (j) for a given household (i) can be specified as

$$P(Y_i > j) = P_{ij} = \frac{e^{(\alpha_j + X_i \beta)}}{1 + e^{(\alpha_j + X_i \beta)}}, \quad [\text{Eq.3}]$$

Where β are the regression coefficients for X, α_j is the intercept for j logit.

The β values for all J insecurity levels are the same. However, this parallel lines assumption may very often not hold (Sasidharan and Menéndez, 2014).

2.2.8. Binomial logit model (BLM)

The BLM is a discrete choice model that has only two possible alternatives, 0 and 1, also called binary response model (Pérez, 2012). The BLM parameters were estimated using the maximum likelihood estimation (MLE) technique. The binary logistic specification is suited to models where the endogenous variable is dichotomous. In this alternative modeling approach, the food security condition was measured using a one or zero, where zero represents food security (no FI and mild FI), and one represents food insecurity (moderate FI and severe FI). The logistic distribution function represents a generalized form of the model for each dependent variable (Gujarati and Porter, 2009).

$$P_i = \frac{1}{1 + e^{-Z_i}} = \frac{e^Z}{1 + e^Z} \quad [\text{Eq.4}]$$

Where $Z_i = \beta_1 + \beta_2 X_i$ and X_i are the logit model independent variables chosen for the regression.

As Z_i is within a range between $-\infty$ and $+\infty$, the probability of the households having the food security condition is somewhere between 0 and 1. As explained below Eq.4, the logit model implies that the logarithm of the ratio is linearly related to X_i . Thus, when the logit result is positive, the value of the regressor will be higher and the value of the regression is more likely to be closer to one (Gujarati and Porter, 2009).

$$L_i = \ln \left(\frac{P_i}{1 - P_i} \right) = B_1 + B_2 X_i + u_i \quad [\text{Eq.5}]$$

The significance level of the models used in this study for acceptance and rejection of the null hypothesis is 0.01, 0.05 and 0.10, respectively. The STATA[®] 12.1 statistical package was used to conduct the logistic regression analysis.

2.2.9. Comparison of ordered logit and binomial logit models

The OLM and BLM were compared using Akaike's information criterion (AIC) and Bayesian information criterion (BIC). The AIC and BIC are two measures for evaluating the quality of the estimated statistical models. These are estimated by simultaneously considering the goodness of fit and complexity of the model. Both criteria use the log-likelihood ($\ln \text{Lik}$), which is the log of maximum likelihood, also subtracting a term proportional to the number of parameters (k) in the model: $\ln \text{Lik} - \alpha k$, where α is equal to 2 for AIC and $\ln(N)$ for BIC (Sasidharan and Menéndez, 2014; Posada and Noguera, 2016).

2.3. RESULTS

2.3.1. Descriptive analysis of the household

This research was conducted in indigenous communities of Sierra Tarahumara in the Mexican State of Chihuahua. It found that, on average, a household is made up of 4.28 members with an average age of 40 years. Of the heads of household, 65% are men, whereas 35% are women. In most households, the marital status is non-marital cohabitation (57.72%). The heads of household have a low level of education (23.58% are uneducated and 61.79% have primary education). With regard to the household economy, 34.15% are casual laborers, and the average income is 2199.92 Mexican pesos. Using the poverty line, we were able to calculate how many of the households in our survey were living in poverty in 2015. We found that 26% and 18.7% were living in poverty and extreme poverty, respectively. However, even if they were above the poverty line, there was at least one issue of social deprivation in 24.39% of households. Therefore, they also fall within the poverty category, since they are vulnerable due to social deprivation. Of the surveyed people, 21.95% do not

own any land, whereas 54.47% have between one and two hectares. The main crop is maize, with an average production of 4.94 tons. Also, the households in these communities were found not to have access to an improved source of safe water, where 70.73% use well water and 29.27% use water from rivers and springs for cooking and drinking purposes. In terms of sanitation, only 30.89% of people use toilets as sanitation facilities, whereas 69.11% have to defecate in the open. Again, 82.11% are not connected to an electricity network, and 92.68% use firewood for cooking. Finally, we found that 66.67% are beneficiaries of the Prospera conditional cash transfer (Table 3).

Table 3. Descriptive analysis of the household.

Variables		Description	
Quantitative		Mean	Standard Deviation
Income	Income of head of household in Mexican pesos	2199.92	1634.87
Maize production	Tons of maize produced per household	4.94	13.24
Household size	Number of people living together in one house	4.28	1.71
Age	Age of head of household	40.66	13.90
Qualitative		Percentage	
Gender:	Gender of head of household.		
Female			34.96
Male			65.04
Marital status:	Marital status of head of household		
Non-marital cohabitation			57.72
Married			14.63
Widower			13.82
Separated			13.82
Education:	Educational level of head of household		
Uneducated			23.58
Primary			61.79
Secondary			10.57
Higher			4.07
Access to water facilities:	Water source used by households		
No facilities			29.27
Waterwheel or well			70.73

Toilet:	Sanitation services	
No access		69.11
Access		30.89
Electricity:	Electricity services	
No access		82.11
Access		17.89
Energy for cooking:	Source of energy for cooking	
Firewood		92.68
Gas		7.32
Land ownership:	Amount of available land owned by head of household	
None		21.95
< 1 Ha		9.76
1-2 Ha		54.47
>2 Ha		13.82
Casual employment:	Householders with temporary employment	
No		65.85
Yes		34.15
Consumed seed stocks	Households consumed seed reserves for next planting season	
No		58.50
Yes		41.50
Situation of poverty	When a person has at least one social deprivation and income is insufficient to purchase the goods and services required to meet their food and non-food needs	26.00
Situation of extreme poverty	When a person has three or more social deprivations and is also below the minimum poverty line. Income is not sufficient for food purchases, i.e., the person is living on less than US\$1.25 per day	18.70
Poverty line (vulnerable due to social deprivation)	Denotes the population that does not have sufficient resources to purchase the goods and services required to meet their basic (food and non-food) needs	24.39
Prospera (CCT):	Families that are or are not beneficiaries of this social inclusion and conditional cash transfer program	
Non-beneficiary		33.33
Beneficiary		66.67
Dependent		
Food Insecurity:	Food insecurity condition (OLM)	
None	0	13.82

Mild	1	10.57
Moderate	2	16.26
Severe	3	59.35
F Insecurity:	Food insecurity condition (BLM)	
Food security	0 (0 = no FI and mild FI)	24.39
Food insecurity	1 (1 = moderate FI and severe FI)	75.61

Note: Ha= hectares (n=123).

2.3.2. Predictive models

This section evaluates the FI status of households in the indigenous communities of the Sierra Tarahumara and describes the results of the two predictive models developed in the study: OLM and the BLM.

ELCSA was analyzed at household level. The Cronbach's alpha coefficient was 0.96, which means that ELCSA consists of a set of highly correlated items with good internal reliability for the data (Table 4).

Table 4. Cronbach's alpha for households assessed using ELCSA

Average inter-item covariance:	0.14														
Number of items in the scale:	15														
Scale reliability coefficient:	0.96														
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
Q1	0.19														
Q2	0.13	0.25													
Q3	0.1	0.08	0.14												
Q4	0.12	0.09	0.11	0.15											
Q5	0.12	0.17	0.1	0.1	0.23										
Q6	0.15	0.12	0.11	0.12	0.13	0.18									
Q7	0.14	0.16	0.09	0.1	0.12	0.14	0.22								
Q8	0.15	0.17	0.1	0.09	0.15	0.14	0.19	0.23							
Q9	0.12	0.1	0.12	0.12	0.1	0.11	0.1	0.1	0.17						
Q10	0.13	0.11	0.12	0.13	0.12	0.12	0.12	0.12	0.16	0.18					
Q11	0.14	0.16	0.08	0.1	0.15	0.13	0.15	0.17	0.13	0.13	0.24				
Q12	0.16	0.15	0.1	0.11	0.15	0.14	0.15	0.18	0.14	0.16	0.19	0.23			
Q13	0.14	0.16	0.09	0.1	0.14	0.13	0.19	0.19	0.13	0.14	0.2	0.2	0.24		
Q14	0.13	0.18	0.08	0.1	0.15	0.11	0.16	0.17	0.11	0.13	0.18	0.17	0.18	0.25	
Q15	0.13	0.17	0.08	0.1	0.14	0.12	0.16	0.18	0.12	0.13	0.21	0.18	0.22	0.2	0.25

Source: Computed from field data, 2015 (n=123)

We found different FI categories among the households surveyed in the communities of the Sierra Tarahumara, as shown in Table 3. Considering the FI categories accounted for in the OLM, we found that 13.8% of the surveyed households had no FI, 10.6% had mild FI, 16.3% had moderate FI and 59.3% had severe FI. Considering the FI categories accounted for in the BLM, we found that approximately 75.6% of the surveyed respondents reported being food insecure and 24.4% claimed that they were food secure.

The results of the OLM and the BLM developed for the different FI levels are shown in Table 5. Table 5 shows the coefficients of the different predictors, the odds ratios, their associated standard errors and the cutoff thresholds. According to the OLM used in this study, five variables were important for explaining the food security condition of households. These were income of the head of household, consumed seed stocks, maize production, casual employment, and age of the head of household.

The OLM shows that the income of the head of household had a negative and significant relationship with household FI. The odds of being in the lower FI interval are 0.99 times ($p<0.01$) higher for households that have income, all other predictors being equal. The BLM also reveals that the income of the head of household had a negative and significant ($p<0.01$) relationship with household food security. If the other variables were unchanged, the odds ratio of being food secure increased by 0.99 when income increased by one Mexican peso (Table 5).

The OLM shows that the odds of suffering higher FI were 4.95 times ($p<0.01$) higher for households that consumed seed stocks, if the other predictors were unchanged. Likewise, the BLM demonstrates that the odds ratio of being food insecure increased by 16 times ($p<0.01$) when households consumed reserves of seeds for the next planting season (Table 5).

The two models showed that maize production had a significant and negative ($p<0.01$) relationship with household FI. The OLM revealed that the odds of having a lower FI level

are 0.90 times ($p < 0.01$) higher for households that produced maize. Similarly, the BLM showed that the odds ratio of being food insecure decreased by a factor of 0.86. This indicates that more food was available for consumption when there was a larger harvest, if the other variables were constant.

Furthermore, the OLM showed that the odds of suffering higher FI were 2.92 times ($p < 0.05$) higher for households whose external income came from casual labor. Likewise, the BLM showed that the odds of suffering higher FI level were 3.5 times ($p < 0.1$) higher for households who were in temporary employment, if the other variables were constant.

The age of the household head was statistically significant only in the OLM. The odds of having a lower FI level were 0.97 times ($p < 0.1$) higher for households with elderly heads of household, if the other predictors were unchanged.

The Prospera variable was not significant in either of the two models proposed to measure FI.

The cut1, cut2, and cut3 values for the OLM in Table 4 are the threshold cutoff values that separate the different levels of FI. The thresholds indicate the predicted cumulative likelihoods when the independent variables are equal to zero. None of the confidence intervals for the three thresholds overlapped, showing that the four different food security levels were significantly different from one another. We used the Brant test to check the proportional odds assumption or the parallel regression assumption of the OLM. This test performs a series of Wald X^2 tests to determine whether the coefficients differed across equations. The results show that X^2 is 8.16, indicating that there is no violation of the proportional odds assumption across different FI levels. The BLM predicts 88.62% of the observations correctly (Table 5).

Table 5. OLM and BLM regression coefficient estimates

	OLM		BLM	
Dependent variable	Food insecurity		Food insecurity	
Independent variable	Coefficient	Odds Ratio	Coefficient	Odds Ratio
Income	-0.0004*** (0.0001)	0.9996 (0.0001)	-0.0007*** (0.0003)	0.9993 (0.0003)
Consumed seed stocks	1.6002*** (0.4901)	4.9540 (2.4280)	2.7821*** (1.1074)	16.1529 (17.8883)
Maize production	-0.1047*** (0.0272)	0.9006 (0.0245)	-0.1515*** (0.0438)	0.8594 (0.0376)
Casual employment	1.0714** (0.4680)	2.9193 (1.3663)	1.2642* (0.7105)	3.5401 (2.5152)
Age	-0.0284* (0.0155)	0.9720 (0.0151)	-0.0172 (0.0247)	0.9830 (0.0243)
Household size	0.1431 (0.1359)	1.1539 (0.1568)	0.0910 (0.2105)	1.0953 (0.2306)
Prospera	-0.2067 (0.4614)	0.8133 (0.3752)	0.2684 (0.7067)	1.3079 (0.9242)
Constant			2.6721 (1.5743)	14.4696 (22.779)
Cut1	-3.8705 (1.0913)		-	-
Cut2	-2.6215 (1.0331)		-	-
Cut3	-1.3857 (1.0069)		-	-
Likelihood ratio	-103.1992		-35.6409	
Brant test χ^2	8.16		-	
Correctly classified (percent)			88.62	
Observations	123		123	

Source: Computed from 2015field data. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors are given in parentheses below the parameter estimates.

The OLM and BLM were compared using AIC and BIC selection criteria. These two measures evaluate the quality of the estimated statistical models. Figure 2 shows that the AIC (87.28) and BIC (109.78) values were lower for OLM than for BLM (AIC 226.40 and BIC 254.52) in this study. This shows that OLM outperformed BLM and can, consequently, be considered as a viable method for determining FI.

Figure 2. Comparison of ordered logit and binomial logit models

2.4. DISCUSSION

We found that indigenous households were in a situation of poverty and extreme poverty, and many lack basic services. These results are comparable with those of (CONEVAL, 2016a) which reported that the minimum poverty line and food basket in February 2015 were 887.58 and 1,661.54 Mexican pesos, respectively. United Nations (2015) found that, worldwide, people living in rural areas and from poor and marginalized groups tend not to have access to an improved water source (about 16%) and sanitation facilities (about 50%) and are less likely to have piped water on the premises.

The internal consistency of ELCSA was good (Cronbach's $\alpha = 0.96$). Similar results were reported by Muñoz-Astudillo et al. (2010) and Villagómez-Ornelas et al. (2014), where Cronbach's reliability coefficient was 0.95 and 0.93, respectively.

The value of this coefficient was well above the minimum recommended by the (FAO, 2013a) (0.85). The FI categories described in our findings were comparable with results reported by Pérez-Escamilla et al. (2009), who studied a sample of 153 women with children aged from 1 to 5 years in Camp Perrin (South Haiti). Their findings suggested that

2% of the households were food secure, 17% had mild FI, 25% had moderate FI and 57.3% had severe FI. Similarly, Melgar-Quiñónes (2010) analyzed the results of the 2010 Municipal Census conducted by the National Statistics Institute (INE) in Guatemala, applying a version of ELCSA. The results showed that 8.1% of the households were food secure, 18.4% had mild FI, 16.7% had moderate FI and 46.8% had severe FI. However, Shamah-Levy et al. (2014) reported different results based on the analysis of the 2012 Mexican National Survey of Health and Nutrition (ENSANUT). They found that seven out of 10 households suffered some degree of FI (41.6% had mild FI, 17.7% had moderate FI and 10.5% had severe FI).

Like other authors, we found that income increases improve access to food, whereby households can afford healthier foods and better quality diets (Bauermann et al. 2010; Bashir et al. 2012; Vieira et al. 2013). According to SHCP (2016), the minimum wage in Mexico was 70.10 Mexican pesos per day in 2015. This amounts to 2,103.00 Mexican pesos per month and contrasts with the results of this research, because most of the heads of households were located in the low- and medium-income tercile.

The main crop cultivated by the surveyed indigenous communities is maize. According to Generoso (2015), a dry cereal-based diet is less diversified, but remains the chief source of energy, proteins, vitamins and mineral salts for the poorest rural populations. In this respect, we can assume that the production of this crop in rural households is aimed mainly at self-consumption (FAO, 2013a; CONEVAL, 2015a).

We found that farmers consume their seed stocks. According to other authors, farmers in most developing countries use their own seeds saved from the previous year's harvest to meet the production needs for the next growing season. In times of food scarcity, however, farmers may be driven to consume their own seeds as a way of coping with hunger. This is an indication that the household is suffering from FI (FAO, 1999, 2008; Cohen and Smale,

2012; GTZ, 2014)). This may be because the scale of production does not meet household demand, which is a sign of the low productive capacity of households (CONEVAL, 2015a).

Our study also found that the group of households whose householders are engaged in casual labor is food insecure. These findings are in contrast with (Benson, 2007) who studied poor neighborhoods in Bangladesh and found that households whose members have stable and well-paid employment were less prone to reduce food consumption.

Our results indicate that households headed by older people are more likely to be food insecure. Bashir et al. (2012) found that an increase by one year of age in rural households in the Punjab (Pakistan) decreases the chances of a household becoming food insecure by about 3%. Similar results were reported by Maitra and Prasada (2015) who studied poverty and food security based on a survey conducted among urban slum dwellers in Kolkata. They found that a larger share of working age adults in the household implies fewer dependants and, hence, a greater earning capacity for the household.

Our research found that Prospera has not managed to reach all poor households. Sonnino et al. (2014) and FAO et al. (2015) suggest that the primary reason is that the coverage of the social assistance programs is still limited. According to Neufeld (2007), this program has had a smaller impact than expected. We leave the analysis of possible measures for improving the impact of the Prospera program in the Sierra Tarahumara for future research.

Based on our results, we concluded that indigenous households do not have access to sufficient food, and therefore are living in a FI situation. It is recommended that the government should help households increase agricultural production, since rural families in a FI situation mainly depend on agriculture for their livelihoods. In addition, the government must provide access to basic services, which are deficient in the study of research. We believe that developing and fostering social policies that create work opportunities may be

beneficial for food access, and eradicate the poor diets. Prospera does not seem to successfully lift people out of FI and poverty.

There are some limitations to this study. First, the sample size is relatively small and not necessarily representative of the entire Sierra Tarahumara, although the agro-socioeconomic holding structure is more or less in line with the region's demographics. A similar study with a larger number of participants should be conducted to consolidate our preliminary findings. Second, the econometric models applied to the survey results only provide an evaluation of positive or negative effect of the determinants of FI and do not provide a monetary evaluation. Despite these limitations, the main results of this analysis constitute an initial baseline and provide a better comprehension of the food situation of agricultural communities in the Sierra Tarahumara. These findings will help decision makers develop effective strategies for combating food insecurity. The developed methodology could be applied on a larger scale and in different regions. Future research should focus on conducting studies on food security, primarily in rural areas, paying special attention to local communities and indigenous people.

CHAPTER 3.-

DIETARY DIVERSITY IN RURAL HOUSEHOLDS: THE CASE OF INDIGENOUS COMMUNITIES IN SIERRA TARAHUMARA, MEXICO

3.1. INTRODUCTION

Food security is still one of the global concerns and its measurement may facilitate the development of policies on the improvement of health (Lo et al. 2012; Hinrichs, 2013). Several studies have shown that ingesting a more varied diet is associated with a higher quality diet and proper nutrition around the world. Therefore, the diversity of the diet is an indicator of health related to the quality of the diet and a useful instrument to measure food security (Mirmiran et al. 2006; Azadbakht and Esmailzadeh, 2012).

Households have food security when they have access throughout the year to the quantity and variety of safe foods that its members require to lead an active and healthy life. At home, food security means the ability to ensure the availability of foods, either because the family produces or buys them, in order to satisfy the needs of all its members (FAO, 2010). This is why methodological tools have been developed to allow the identification of dietary diversity in the households and individually, such as the Household Dietary Diversity Score (HDDS) elaborated by the FANTA Project (Food and Nutrition Technical Assistance) (Swindale and Bilinsky, 2006). The HDDS is a qualitative methodology that has been validated in different countries as an approximate measure of energy consumption per capita of the household (De Cock et al. 2013; Kennedy et al. 2010; Legwegoh and Hovorka, 2013; Maxwell et al. 2014; Nyantakyi-Frimpong et al. 2016; Tsiboe et al. 2016). It also allows to identify the population's food deficiencies or excesses and it works as a baseline to implement interventions that improve the food consumption in households (Swindale and Bilinsky, 2006). This indicator assesses the number of different food groups consumed in the household during a defined reference period, such as the last 24 or 48 hours or the last 7 or 14 days (De Cock et al. 2013; Legwegoh and Hovorka, 2013; Nyantakyi-Frimpong et al. 2016). A diversified diet is linked to the economic ability of a household to access a variety of foods

by obtaining a number of different food groups consumed during a determined period (FAO, 2013b).

A varied, nutritional and balanced diet prevents the lack or excess of nutrients in the diet and reduces the malnutrition rates in the population (WHO, 2015). However, malnutrition is still high in rural populations and they have higher risk of food and nutritional insecurity, mainly where indigenous population prevails (FAO, 2015a; FAO et al. 2015). For this reason, the need for an analysis on the dietary diversity in rural areas of Mexico emerged, which is related to the high levels of poverty. The Household Dietary Diversity Score (HDDS) was determined as an indicator of the economical access to foods. It was also analysed which are the food groups consumed the most by the indigenous communities of Sierra Tarahumara, State of Chihuahua, Mexico. In addition, the following question of the research was answered: What are the levels of dietary diversity in the households of the communities of Sierra Tarahumara? This work was undertaken through surveys of households carried out in situ.

3.2. MATERIALS AND METHODS

3.2.1. Study site

This research was carried out in Sierra Tarahumara that is a mountain chain located in the Sierra Madre in the Mexican State of Chihuahua (Salmón, 2000). It has a number of deep canyons alternating with high subtropical mountains of up to 3,300m above sea level. It is characterised by a great diversity of tropical, subtropical and mild flora and fauna, including a number of unique species on Earth (LaRochelle and Berkes, 2003). Sierra Tarahumara is also an area of cultural diversity, since there are four ethnic indigenous groups: Rarámuris o Tarahumaras, Pima, Guarijío and Tepehuanes. Most of the indigenous population is Rarámuri, one of the biggest groups of the indigenous communities in Mexico (Larochelle

and Berkes, 2003; Ramírez-Romero, 2007). Despite its significance, there are no studies determining the HDDS of the communities located in Sierra Tarahumara.

3.2.2. Data collection

The ethical approval of this research was given by the Research Council of the Centro de Extensión e Innovación Rural del Noroeste (CEIR) of the Universidad Autónoma de Chihuahua, Mexico. The communities of Sierra Tarahumara from Chihuahua were chosen on the basis of their main socioeconomic characteristics. These communities were classified according to the closest distance to the development centre, in this case, the city of Creel (0-3 km, 3-6 km, 6-9 km y 9-12 km). The selection of communities was made from a list of communities provided by the Instituto Nacional de Estadística y Geografía de México (INEGI) (Mexican Institute of Statistics and Geography) (INEGI, 2010). The representative sample was made of 124 households from 38 communities, with a confidence level of 95% and an accuracy rate of 7%. However, the analysis was made with 123 surveys because one of them had to be discarded due to lack of information. All participants of the research gave their informed consent before being surveyed. Each survey was made in person, and since all the surveyed households were formed by *rarámuris* indigenous, they responded in their dialect; therefore, the authors were assisted by translators from the area. In terms of food preparations in the household, the mother of the family or person in charge of preparing the foods was surveyed, seeking to obtain more information of the consumed foods. The survey was carried out in February and March 2015. The surveys were distributed on different weekdays and different times of the day in order to ensure that every household had the same probability of being surveyed. The pilot test of the survey was performed before the final survey. Along with experts' opinion, the results of the pilot test were used to refine the questions contained in the survey

3.2.3. *Questionnaire*

The survey consisted in the following questionnaires: a) The HDDS, that is based on the food groups proposed by the FANTA (Swindale and Bilinsky, 2006); b) the socioeconomic, that provides information about the head and characteristics of the household; and c) the agricultural questionnaire that, among others, provides information about the land tenure and production.

3.2.4. *Analyses of HDDS*

The Household Dietary Diversity Score (HDDS) was obtained from a number of 12 food groups (A. Cereals; B. Roots and tubers; C. Vegetables; D. Fruits; E. Meat/poultry/offals; F. Eggs; G. Fish and seafood; H. Pulses/legumes/nuts; I. Milk and dairy products; J. Oils/fats; K. Sugar/honey and L. Miscellaneous). The applicable values among the groups from letter A to L were "0" or "1". Then, the HDDS was calculated adding the number of each food group consumed at the household, which value varies among 0 and 12.

To use this indicator in the assessment of the improvements of food security, the changes in the HDDS must be compared with levels of dietary diversity. Although there are no established cut-off points regarding the number of food groups used to indicate levels of food diversity, the target score could be established by taking the average of 33% of the households with bigger HDDS (the highest tercile). It is thus that we generated a categorical variable with three levels. 1) Low dietary diversity (1-6 food groups); 2) Medium dietary diversity (7-8 food groups); and 3) High dietary diversity (9-12 food groups). This is useful for the monitoring of the purposes since any increase on the food diversity of the households reflects an improvement on the households diet (Swindale and Bilinsky, 2006; FAO, 2013b).

Finally, the average HDDS indicator was calculated for the total of the demographic sample.

3.2.5. Statistical analyses

First of all, some descriptive statistics were obtained related to the different characteristics of the households. The dependent variable was dietary diversity levels, considered as the group variable and it is divided into three categories: Low food diversity = 1; Medium food diversity = 2 and High food diversity = 3. The independent variables were (Table 6):

Table 6. The independent variables

Gender:	Dichotomical variable (0, 1), where 0 is woman and 1 man.
Age:	Ordinal variable (17-29 years old, 30-44 years, 45-59 years, 60-74 years, 75-80 years).
Marital status:	Nominal qualitative variable (non-marital cohabitation, married, widower, separated).
Level of education:	Ordinal variable (without education, basic education, secondary education, higher education).
Access to water facilities:	Water used at the households. It has to be mentioned that no household of this research has access to an improved installation of drinking water service. However, this variable studies where the households obtain water. It is a dichotomical variable (0,1), where 1 indicates that the water is obtained from a well and 0 that it is obtained from some river or spring.
Electricity:	Dichotomical variable that assumes two values -0 and 1- where 0 indicates absence of toilets in the household and 1 indicates that there are toilets in the household.
Gas use for cooking:	Dichotomical variable that assumes two values - 0 and 1- where 0 indicates they do not have and 1 they do.
Casual employment:	Dichotomical variable that assumes two values - 0 and 1- where 0 indicates they use firewood and 1 means the use of cooking gas.
Own lands:	Dichotomical variable (0, 1), where 1 indicates that the head of household has some casual employment and 0, unemployed or self-employed.
Prospera:	The amount of land available that the head of household owns (doesn't have, <1 Ha., 1-2 Ha., >2 Ha.), that is a qualitative variable.
Size of the household:	Dichotomical variable (0, 1) that indicates if the families are (1) or not (0) beneficiaries of this social inclusion and conditional cash transfer program.
	The number of members of a household. Continuous variable.

Poverty:	When a person has at least one social deprivation and their income is insufficient to acquire the goods and services to satisfy their Food and non-food needs. Continuous variable.
Extreme poverty:	When a person has three or more social deprivations, in this situation they have an income so low that they could not acquire the nutrients needed to have a healthy life. Continuous variable.
Welfare line:	Monetary value of a basket of basic foods, goods and services. Continuous variable.
Food spendings per capita:	It is defined as the relationship between the total expenditure by the household on foods in relation to the size of the household. We used the food spending per capita as a substitute for the income, since the foods are a significant component of the households' expenditure. It is a continuous variable measured in Mexican pesos.

Source: own elaboration from surveys

Secondly, a discriminant analysis was carried out because the dependent variable is qualitative (levels of dietary diversity). It can be classified in groups (low, medium and high dietary diversity) and the belonging to the groups of a set of predictor variable can be predicted (both qualitative and quantitative). The objective is to determine a function that maximises the existing distance between the groups with the DA; this is, to reach a function with a strong power of discrimination between the dietary diversity levels. In particular, we conducted the DA in this research with the steps inclusion method, whereby in each step, all the predictor variables are revised and assessed to determine which is going to contribute more to the discrimination between groups. This is, what set of variables predicts better the dietary diversity of the households (Babu et al. 2009; Shankar et al. 2013; Pérez, 2014). A DA model is expressed in the following way:

$$D_i = d_{i1} X_1 + d_{i2} X_2 + \dots + d_{ik} X_k$$

Where D_i is the score of Fisher's discriminant function, d_i is the coefficient of the discriminant function and X_k is the score of the predictor variable that can be discrete or continuous.

The statistical significance of the discriminant function was assessed by the Wilks' lambda test, eigenvalues, canonical correlation and F-statistics. In this case, since the group variable (dietary diversity levels) is composed of three groups, two discriminant functions and two eigenvalues can be extracted. The canonical correlation and eigenvalues' statistics measure the relationship of the discriminant function regarding the total variance. It is expected that the canonical values and eigenvalues to be high, because the power of discrimination of the model will be larger. On the other hand, the Wilks' lambda test is used to check the null hypothesis that populations have the same measures in the discriminant function. Wilks' lambda values are expected to be low, since the effect of the independent variable is more important for the discriminant function. The null hypothesis can be rejected when the value of the test statistic is higher than the F-critical value for the desired significance level. The average values or centroids of each of the functions for each group were also examined. These group centroids will indicate if the discriminant function contributes significantly to the separation of the groups. The main objective of this analysis is to maximise the amount of variation between each group and the overall average for every group, whereas simultaneously, the amount of variation existing inside each group is minimized (Babu et al. 2009). This statistical analysis was performed using the software SPSS, version 20.0

3.3. RESULTS

3.3.1. Socioeconomic characteristics of the household

The research was conducted in indigenous communities of Sierra Tarahumara of the Mexican State of Chihuahua, finding that 65% of the heads of household are men, whereas 35% are women. The age of most of them varies between 30-44 years old and they are living, mainly, in a marital status of non-marital cohabitation (57.72%). On average, a household is made up of 4.28 members. The heads of household have a low level of education (23.58%

with no studies and 61.79% of basic education). On the other hand, it was observed that the households of these communities do not have access to an improved installation of safe water; and 70.73% use water to cook and drink which comes from pits and 29.27% use water which comes from rivers and springs. In terms of sanitation, only 30.89% of people use the toilet as type of sanitation facility, whereas 69.11% have their bowel movements outdoors. 82.11% are not connected to an electricity network and 92.68% use firewood to cook. With regards to the household economy, 34.15% had casual employment and the rest were unemployed or self-employed. 34.96% and 31.73% of households are in the low and medium income terciles, respectively. Through the line of economic welfare, we could calculate the situation of poverty in which the households of our research were in 2015. We found that 26% and 18.7% live in a situation of poverty and extreme poverty, respectively. However, 24.39% of households, despite they were inside the line of welfare, they had at least one social deprivation. Therefore, they are also located in the poverty category, since they are vulnerable due to social deprivation. 21.95% of the surveyed people do not have lands of their own, while 54.47% have between one and two hectares. 66.67% are beneficiary of the Prospera conditional cash transfer (Table 7).

Table 7. Descriptive statistics of the characteristics of the household.

Variables	%	Min.	Max.	Average	SD
Qualitative					
Gender of the head of household:		0	1	0.65	0.48
Woman	34.96				
Man	65.04				
Age:		1	5	2.26	1.01
17-29 years	22.76				
30-44 years	43.09				
45-59 years	22.76				
60-74 years	8.13				
75-80 years	3.25				
Marital status of the head of household:		1	4	1.84	1.12

Non-marital cohabitation	57.72				
Married	14.63				
Widower	13.82				
Separated	13.82				
Level of education:		0	3	0.95	0.71
No studies	23.58				
Primary	61.79				
Secondary	10.57				
Higher	4.07				
Access to water facilities:		0	1	0.71	0.46
Don't have	29.27				
Waterwheel or well	70.73				
Toilet:		0	1	0.31	0.46
Don't have	69.11				
Do have	30.89				
Electricity:		0	1	0.18	0.38
Don't have	82.11				
Do have	17.89				
Gas use for cooking:		0	1	0.07	0.26
Firewood:	92.68				
Gas	7.32				
Income:		1	3	1.98	0.83
Low income tercile	34.96				
Medium income tercile	31.71				
High income tercile	33.33				
Own lands:		0	3	1.60	0.98
Doesn't have	21.95				
< 1 Ha.	9.76				
1-2 Ha.	54.47				
>2 Ha.	13.82				
Casual employment:		0	1	0.34	0.48
No	65.85				
Yes	34.15				
Prospera (CCT):		0	1	0.67	0.47
Non-beneficiary	33.33				
Beneficiary	66.67				
Dietary diversity levels:		1	3	1.89	0.83
Low dietary diversity	39.84				
Medium dietary diversity	30.89				
High dietary diversity	29.27				
Quantitative					
Size of the household		1	14	4.28	1.71
Poverty	26.02	900.00	1650.00	1297.19	242.29

Extreme poverty	18.70	0.00	800.00	495.65	265.40
Welfare line (vulnerable due to social deprivation)	24.39	1,900.00	1,2120.00	3,835.33	2,056.85
Food spendings per capita	100.00	33.33	1,500.00	390.55	2,70.12
Note: Ha= Hectares. Min=Minimum Max=Maximum. DS= Standard Deviation (n=123).					

3.3.2. Access to food

It was found that 6.50% and 4.07% of the surveyed households consume between 10 and 11 food groups, respectively; whereas 18.70% consume 9, 20.33% consume 8 and most of them (50.41% approximately) consume less than 8 food groups. The most consumed food groups by the households were: cereals (100%); legumes or nuts (96.7%); eggs (78.9%); sugar/honey (78%); oils/fats (77.2%), vegetables (63.4%) and root crops (56.1%). The animal protein, fish, dairy and fruits were consumed the least (Figure 3).

Figure 3. Aspects related to the food consumption pattern of the households (%). (A) Number of consumed foods and (B) Consumed food groups.

The 39.84% and 30.89% of the families from the communities of Sierra Tarahumara have a low and medium dietary diversity respectively, while 29.27% of the households have a high dietary diversity (Table 6).

In this research, it was found that the average HDDS stood at the lowest HDDS tercile (6.89), what means that in the indigenous communities of Sierra Tarahumara there is a low dietary diversity. This result was reaffirmed with the discriminant analysis (DA).

3.3.3. *Results of the discriminant analysis (DA)*

The DA, under the steps inclusion method, identified two statistically significant discriminant functions ($p < 0.05$). Although all the predictor variables of Table 7 were introduced in the model, this DA method determined that the variables that most discriminate the functions were casual employment, the marital status of the head of household, the food spending per capita and Prospera cash transfer variable (Wilks' lambda $p < 0.05$). The eigenvalues of the first and second discriminant function were 0.48 and 0.08, respectively. The variances explained by both functions were 85.82% and 14.18%, respectively; and the canonical correlations of both functions were 0.57 and 0.27, respectively. This indicates that the first discriminant function is the one that is going to explain best the model (Table 8). To describe the two canonical discriminant functions, the standardised coefficients were used, to be as follows:

$$D_1 = 0.804 \text{Casual_employment} + 0.641 \text{Marital_status} - 0.475 \text{foodexpend_percap} - 0.266 \text{Prospera}$$

$$D_2 = 0.795 \text{Prospera} + 0.518 \text{Casual_employment} + 0.454 \text{foodexpend_percap} - 0.267 \text{Marital_status}$$

It is clear that for the first standardised discriminant function, the maximum impact in the dietary diversity of the household comes through the casual employment (0.80) and marital status of the head of household (0.64). An increase of a unit of casual employment

increments the dietary diversity levels by 0.804 units. This result suggests that, if this type of work increases, the possibility for these households to have a low dietary diversity will also grow. It was also found that an increase in a unit of the marital status enlarges the dietary diversity levels by 0.64 units. This means that the marital status may influence on increasing the low dietary diversity or reducing the others. Likewise, if the food expenditure per capita reduces in a unit, the medium and high dietary diversity levels would diminished by -0.47 units, so the low dietary diversity will get worse. Also, when the cash transfers reduce in a unit, the medium and high dietary diversity also do, increasing the low dietary diversity in -0.27 units. On the second standardised discriminant function, we found that the maximum effect is produced from the cash transfer and casual employment variables. The independent impact is 0.79 and 0.52, respectively.

This indicates that, when the cash transfers increase in a unit, the dietary diversity levels grow in the household in 0.79 units. What it means that the low dietary diversity is reduced, increasing the medium one. However, it is not observed that the high dietary diversity increases. This may occur because despite of having an allowance from the State, this does not meet the food needs of the household. In respect of the casual employment, an increase in a unit of work force increments the dietary diversity levels by 0.52 units, the low dietary diversity descends and the medium diversity grows. However, the high dietary diversity reduces. This may be because if there is no stable employment, the household lives in economic uncertainty. If the food expenditure per capita grows, it is possible that the dietary diversity increases in 0.45 units.

The centroids or average values of each discriminant function showed that the first function discriminates mainly between the household groups with low dietary diversity and the ones with high dietary diversity. For this function, the average value of low dietary diversity is 0.84, while the average value of high dietary diversity is -0.60. Therefore, the

majority of the discriminatory power of this function comes from differentiating between households with low dietary diversity and the group with high dietary diversity. On the other hand, the second discriminant function does not show any significant difference between the households with low dietary diversity and the ones with high dietary diversity. However, it does show a strong ability to differentiate from the groups of households that are with medium dietary diversity with the households with high dietary diversity. Therefore, most part of the discriminatory power of this second function interposes between the differentiation of the households with high dietary diversity and the households with low dietary diversity (Table 8).

Table 8. Standardised coefficient of the canonical discriminant functions for the dietary diversity levels.

Discriminant functions	Standardised coefficients	Wilks' lambda	Eigenvalues	% of variance	Canonical correlation
Function 1		0.63***	0.48	85.82	0.57
Food spendings per capita	-0.47				
Marital status of the head of household	0.64				
Casual employment	0.80				
Prospera	-0.27				
F1 centroids					
Low dietary diversity	0.84				
Medium dietary diversity	-0.52				
High dietary diversity	-0.60				
Function 2		0.93**	0.08	14.18	0.27
Food spendings per capita	0.45				
Marital status of the head of household	0.27				
Casual employment	0.52				
Prospera	0.79				
F2 centroids					
Low dietary diversity	-0.02				
Medium dietary diversity	0.36				
High dietary diversity	-0.36				

*** $p < 0.01$. ** $p < 0.05$.

In Table 9 it can be observed the classification in which it is assumed that all three groups have the same probabilities in the population. 57% of the original cases have been classified correctly. In the households with low dietary diversity and the ones with high dietary diversity, the rates of correct classification (proportion of successes) are 67.35% and 55.56% respectively. However, the households with medium dietary diversity cannot be properly classified (44.47%). In conclusion, the discriminant functions used in this research describe the clear separation between the high and low dietary diversity types, and they also show that there are significant variations between them

Table 9. Classification of the results obtained by the discriminant prediction model for the dietary diversity levels

			Predicted belonging group			
Original	Dietary levels	diversity	Low dietary diversity	Medium dietary diversity	High dietary diversity	Total
n	Low dietary diversity		33.00	6.00	10.00	49.00
	Medium dietary diversity		8.00	17.00	13.00	38.00
	High dietary diversity		8.00	8.00	20.00	36.00
%	Low dietary diversity		67.35	12.24	20.41	100.00
	Medium dietary diversity		21.05	44.74	34.21	100.00
	High dietary diversity		22.22	22.22	55.56	100.00

57% of the original cases grouped correctly classified.

3.4. DISCUSSION

The purpose of this research was to analyse the dietary diversity through the Household Dietary Diversity Score in the rural areas of Mexico, specifically of the households in the indigenous communities of Sierra Tarahumara, (State of Chihuahua, Mexico). We applied the HDDS to measure the dietary diversity levels in the households and

carried out the estimate of the DA model, by steps inclusion to determine what variables discriminate better the dietary diversity levels.

In Mexico, according to SHCP (SHCP, 2016), the minimum wage on 2015 was 70.10 Mexican pesos per day; this is, 2,103.00 Mexican pesos per month, which contrasts with the results from this research, because most of the heads of households were located on the low and medium income tercile. CONEVAL (2016a), informed that the minimum welfare economic line and economic welfare in February 2015 were of 887.58 and 1,661.54 Mexican pesos respectively. This is in contrast with our findings since the households in our research were found in poverty situation and extreme poverty. This leads us to guess that the households suffer from food insecurity, based on the reason that it is a poverty subcategory; this is the lack of income necessary to buy necessary food to survive in the given conditions (Frayne and McCordic, 2015; Burchi and De Muro, 2016; Gautam and Andersen, 2016; Sonnino and Hanmer, 2016).

Regarding the measurement of the food access in the households, the HDDS was used, methodology proposed by Swindale and Bilinsky, (2006). Our findings indicate that the animal protein, fish, dairy and fruits consumption are poor to the food recommendations made by FAO (2013b) and WHO (2015). These results are related to other studies. Melgar-Quinonez et al. (2006) found in Bolivia, Burkina Faso and Philippines that the lower the expenditure in meats, fruits and dairy are, the bigger is the food insecurity. On the other hand, Vega-Macedo et al. (2014) in their research performed in Mexico, they indicated that the severe food insecurity households tend to substitute the high-quality protein sources such as red meat, chicken, fish and milk by lower cost alternatives such as eggs and legumes. Furthermore, as food insecurity increases, the buying of fruits and vegetables decreases. Also, Legwegoh & Hovorka (2013) found in Gaborone, Botswana, that people frequently consume more cereals (97.2%), sugar/honey (73%), whereas fish/seafood (12.8%), eggs (23.6%) and

beans, peas, lentils or walnuts (27.4%) were the least consumed. Kaiser et al. (2003) in the research they performed in the United States with children from California, they found that 60% of the food insecurity households stop consuming fruits and vegetables, reduce the dairy and meat-products consumption. Prada et al. (2008) described the consumption pattern of the displaced population in Santander, Colombia. They found that the diet quality was poor, the main sources of animal protein were milk and eggs; less than a third consumed some type of meat and 28.7% of the total of the families consumed vegetable proteins from lentils, dried peas and beans. Vegetables and green legumes satisfied just 15%, while the fruits covered just 12.5%. Therefore, in this research we conclude that the diet of the population of study is quite monotonous and it is characterised by having small variety of foods. Also, we observed a diet with a consumption pattern based on carbohydrates, what may reveal a possible deficiency of essential micronutrients for the human development and hence, there is malnutrition in the household. With these findings, it is ratified that the studied population is in food insecurity conditions.

In this study, the HHDS average was of 6.89, a result that differs from the ones found by De Cock et al. (2013) in Limpopo province, South Africa. They reported that the households had an average HDDS of 4.5, whereas Harris-Fry et al. (2015) in their research performed with women from the rural area of Bangladesh reported an average of 3.8 food groups. However, what the HDDS means in terms of public health is not clear, since there is no specific cut points (Swindale and Bilinsky, 2006; FAO, 2013b).

The discriminant analysis (DA) used in this research concluded that the best variables to separate the dietary diversity levels were the food spending per capita, the casual employment, the cash transfer variable and the marital status of the head of household. In some studies, there were found significant positive associations between the diversity of the diet and the food spending variable. This is, the diversity of the diet was consistently bigger

with the growth in consumption and also, significant associations were observed between the diversity of the diet and other socioeconomic status indicators (Jones et al. 2014).

We could also observed that in our results from the DA that, the dietary diversity decreases when the heads of family have casual employment. These results are in contrast with Benson (2007) who studied poor neighbourhoods of Bangladesh and found that, the households whose members have stable and well-paid employment were less prone to reduce the foods consumption. Therefore, the lack of employment is related to a low food consumption and food insecurity.

On the other hand, the DA also showed that if the cash transfers given by Prospera decreased, the high and medium dietary diversity would decrease too. Prospera is a Mexican conditional cash transfer program, with a national commitment to nutrition, health and education (Gil-Garcia, 2015). These findings agrees with FAO et al. (2015) who informs that with no public assistance, numerous poor and vulnerable households will suffer lasting deprivations that would result in poverty for future generations. On the other hand, Hidrobo et al. (2014) in a research carried out in Ecuador about a transfer program, they found that this program contributed to a rise in foods consumption per capita and hence, to dietary diversity. However, in our research it was found that Prospera has not been able to reach some of the poor households. FAO et al. (2015) and Sonnino et al. (2014) suggest that fundamentally, this is because the coverage of the social assistance programs is still limited.

According to Maxwell et al. (2014), higher scores of the HDDS are indicators of a greater frequency of the foods and dietary diversity, therefore, less food insecurity. However, the DA found a clear difference between the dietary diversity types, being the low dietary diversity the best classified; what means that there are problems with the foods access and hence, food insecurity, thereby verifying the average HDDS.

3.5. CONCLUSIONS

The HDDS is a measurement tool for households food access that can be studied along with another information concerning foods to provide a global image of the food and nutritional security state in a community or in a larger area. The dietary diversity questionnaires should be included more frequently in the surveys about nutritional and food security in order to provide food access indicators in the household.

The availability and food access determines the food security. For this reason, the elaboration of studies to analyse the different factors that involve food security are very important, since they are part of basic information to carry out interventions to improve the food and food security in order to prevent the poor-diet and nutrient deficiencies related diseases. The determination of the HHDS as economic access indicator to the foods in Sierra Tarahumara allowed to assess the severity of the food-deficit in the population and value the variety of food groups that are consumed.

From the DA, by steps inclusion, we found that the improvement in employment is still an important topic that must continue to be present in the Mexican public policy agenda, since a significant percentage of households have casual employment or are unemployed. Improving the employment status of the heads of household may have positive consequences on the food access, helping the diet to be more diverse and resulting in an improvement of food security.

In addition, we concluded that the conditional transfers, in this case Prospera, would allow the households to increase the food consumption and dietary diversity. Nevertheless, these conditional transfers, by themselves, are not enough to lift people out of food insecurity and poverty, as this depends on other factors as it has been emerged in this research. The government must intervene in aspects such as safe water services access, sanitation, electrical network and health care, which are deficient in the study of research. As well as performing interventions in agriculture, since rural families in a food insecurity situation fundamentally

depend on agriculture for their livelihoods. Conditional transfers, along with agricultural policies focused on the poor rural population may bring excellent results in the long and short term of food insecurity and poverty reduction.

Some limitations in this research should be mentioned. Firstly, the size of the sample is relatively small and is not necessarily representative of all the Mexican rural areas, although the socioeconomic structure is fairly similar. It would be of great interest to carry out a similar research with a larger number of participants and in different regions to consolidate our preliminary findings, and also, to include in the research the determination of the availability of calories per capita of the household. This is because this research only allowed to measure the access to foods and analyse the dietary diversity levels of the families. Secondly, the statistical analysis applied only provides an assessment of the effect -positive or negative- of the diversity of the diet and it does not provide a monetary evaluation. Despite these limitations, the main results of this research constitute an initial baseline by providing a greater understanding of the dietary diversity of the indigenous communities of Sierra Tarahumara. These findings would help the decision makers to develop effective strategies to fight against food insecurity. Future researches should focus on the conduct of researches on food security, especially, in the rural areas and paying particular attention to the communities at risk and indigenous populations.

CHAPTER 4.-

FOOD ACCESS AND COPING STRATEGIES ADOPTED BY HOUSEHOLDS TO COMBAT THE HUNGER AMONG INDIGENOUS COMMUNITIES OF SIERRA TARAHUMARA IN MEXICO

4.1. INTRODUCTION

Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO, 1996). Unfortunately, food insecurity has been shown to affect many dimensions of well-being as a form of deprivation (Shariff and Khor, 2008). Around the world, hundreds of millions of families are trapped in a cycle of hunger (795 million), mainly in rural areas (FAO, 2015b; FAO et al. 2015).

In Mexico between 2012 and 2014, the population suffering from poverty increased from 53.3 to 55.3 million people, representing a raise of approximately 2.0 million people, and the lack of access to food affected 28.0 million people (CONEVAL, 2015b).

Poverty is primarily concentrated in rural and marginal areas where indigenous people tend to live (Fernández-Ham et al. 2006; Servan-Mori et al. 2014; FAO et al. 2015). The Mexican Constitution recognises indigenous people as an essential component of the nation, as well as their right to the public use of their languages and customs, whether they live in the countryside or in the city. However, at present, the people who belong to indigenous communities suffer from various forms of social disadvantages that leave them behind the rest of the population (CONEVAL, 2014). The Mexican National Commission of Indigenous Peoples Development considers an indigenous person as someone living in a household whose head of the family, spouse and/or an ascendant self-identifies as a speaker of an indigenous language (Fernández-Ham et al. 2006; CONEVAL, 2014; Servan-Mori et al. 2014).

Food insecurity is one of the most important challenges in Mexico. Monitoring food security can be useful to identify population subgroups or regions with particularly severe conditions (Magaña-Lemus et al. 2016). For this reason, methodological tools have been developed to measure the state of food insecurity at household level. The methodology,

called “Months of Adequate Household Food Provisioning (MAHFP)”, developed by the FANTA (Food and Nutrition Technical Assistance) Project (Swindale and Bilinsky, 2010), allows to identify food access levels by counting the months in which a household was unable to provide adequate food. This tool captures changes in the capacity of the household to address vulnerability in such a way, that guarantees a supply above a minimum level throughout the year as well as, to identify the population’s food deficiencies or excesses. It also provides the baseline for interventions that improve the food consumption in households (Leah et al. 2012; De Cock et al. 2013; Frayne and McCordic, 2015).

In addition, households that are vulnerable to shocks such as poverty and food insecurity may develop different temporary or permanent measures or defense mechanisms in order to survive in the absence of food and economic resources. These mechanisms are considered as strategies for coping with food insecurity that can go from dietary changes to permanent migration (Maxwell et al. 1999; Maxwell and Caldwell, 2008; Anater et al. 2011; Frankenberger et al. 2012).

In general, being indigenous in Mexico carries a high probability of being poor and subsequently, food insecure (Navarrete, 2008). Among the indigenous communities most seriously affected we can find the ones from the Sierra Tarahumara, which are known for being the Mexico's poorest citizens, with lower development and greater indigenous inequality (Fernández-Ham et al. 2006). For this reason, the objective of this study was to measure food access and to identify the coping strategies in indigenous households of communities of the Sierra Tarahumara in Mexico.

4.2. MATERIALS AND METHODS

4.2.1. Location

This research was carried out in the Sierra Madre Mountain Range, also known as the Tarahumara region, which is located in the northern state of Chihuahua (Salmón, 2000;

Loera–Gonzalez, 2012; Cordero-Ahiman et al. 2017) . The ecology of the region consists of a system of deep subtropical canyons, alternating with high mountains up to 3,300 meters above sea level where around 15 per cent of Mexico’s national forest surface lies (Pérez-Cirera and Lovett, 2006). It is also an area of cultural diversity, being home to four indigenous groups: Rarámuris or Tarahumara, Pima, Guarojío and Tepehuanes. The biggest group is Rarámuri, one of the largest groups of indigenous peoples in Mexico (LaRochelle and Berkes, 2003). The high poverty levels in the Tarahumara region show how the indigenous population is systematically excluded from access to health services and quality public service, land management benefits and access to income, when compared with the non-indigenous population (Cordero-Ahiman et al. 2017; Loera–Gonzalez, 2012; Pérez-Cirera and Lovett, 2006). Despite the importance of these indigenous communities, this is the first study performed to determine food access throughout the months of adequate household food provisioning (MAHFP) of the communities located in the Sierra Tarahumara

4.2.2. Data Collection

The present research was household-based and cross-sectional. The selection of indigenous communities was made from a list of communities provided by the National Institute of Statistics and Geography of Mexico (INEGI, 2010), and were classified according to the distance to the development centre, in this case, the city of Creel (0-3 km, 3-6 km, 6-9 km y 9-12 km). The representative sample was 123 households from 38 communities, with a confidence rate of 95 percent and a precision rate of 7 percent. Data was collected through household-based face-to-face interviews using a pre-tested coping strategy interview schedule along with experts' opinion. The authors were assisted by translators from the area. The survey was conducted in February and March 2015 (winter season). The participants were females of the household who were involved in cooking and purchasing food and were therefore aware of household food insecurity conditions. Prior to data collection, they gave

their consent to participate in the study. They were also informed that their identity would be kept confidential. The surveys were distributed on different weekdays and different times of the day in order to ensure that every household had the same probability of being surveyed. The ethical approval of this research was given by the Research Council of the Centro de Extensión e Innovación Rural del Noroeste (CEIR) of the Universidad Autónoma de Chihuahua, Mexico.

4.2.3. *Questionnaire*

The survey consisted of the following questionnaires: a) Socio-demographics and household characteristics; b) MAHFP, through which respondents were asked to identify the months (during the last 12 months) that they did not have access to enough food to meet their needs (Swindale and Bilinsky, 2010); and c) Coping strategies adopted by households to prevent food insecurity. The coping strategy questionnaire was created using different bibliographic references (Maxwell and Caldwell, 2008; Shariff and Khor, 2008; Ngidi and Hendriks, 2014; Gupta et al. 2015), and by visiting indigenous communities during preparatory stage (the pilot test of the survey).

4.2.4. *Analysis of the MAHF*

To calculate the months of adequate household food provisioning (MAHFP) indicator, a sum is made for each household in the sample. Twelve months less than the total number of months in the previous 12 months that the household was unable to meet its food needs. The values applicable to the months between the letter A and L will be "0" or "1."

$$\text{MAHFP} = (12 - \sum A + B + C + D + E + F + G + H + I + J + K + L)$$

Second, an average is calculated for all households that participated in the sample.

Third, we considered a logical categorization of low, moderate and high food access to be ≤ 9 , 10–11, and 12 respectively (12: a higher score represents a household that has more

consistent food access all year round, and ≤ 9 : low food access, implying at least a quarter of the year with food access problems) (Swindale and Bilinsky, 2010; Leah et al. 2012).

4.2.5. *Coping strategies' classification*

Food insecure households often use four groups of coping strategies to deal with food insecurity (Maxwell and Caldwell, 2008; Ngidi and Hendriks, 2014; Gupta et al. 2015): 1) Rationing or managing the shortfall strategies (limited portion size at meal times; skip meals and restricted consumption of adults so small children can eat) are the most common. 2) Decreasing number of household members (send household members to eat elsewhere). 3) Dietary changes (rely on less expensive food). 4) Increasing short term household availability of funds (borrow food from a friend or relative; purchased food on credit; send household members to beg; gather wild food, hunt, or harvest immature crops; consume seed stock held for next season; make handicrafts to raise money for food; the household head migrates to work) (Table 10).

4.2.6. *Statistical analysis*

The first step was to identify the variables that are candidates to better explain food access (Table 10). In the second step, the Chi-square (χ^2) test was used to examine associations of variables of the coping strategies by food access levels (MAHFP score category). Also, we used the contingency coefficient, which is a measure of association based on chi-square. The value ranges between 0 and 1, with 0 indicating no association between the row and column variables, and values close to 1 indicating a high degree of association between the variables. It is important to note that all the above variables are nominal or categorical variables. The null hypothesis is that no relationship exists between variables (Sanyal and Babu, 2009; Pérez, 2014). Finally, this study presents the empirical analysis using the one-way analysis of variance (ANOVA) approach. It was used to examine the association of the continuous variables (income, age, size of the households) with food access

levels. The ANOVA procedure uses an F -test with (k-1) and (N-k) degrees of freedom, where k is the number of groups and N is the total number of observations. The null hypothesis is that these sample means of continuous variables from various households are identical for all the food access levels. Levene's statistic was used, which tests the null hypothesis that several sample variances are equal (Sanyal and Babu, 2009; Pérez, 2014). This statistical analysis was performed using the software SPSS, version 20.0.

Table 10. Descriptive analysis

Variables	Description	%	Mean	SD
Socio-demographics and household characteristics:				
Age	The age of the head of household, continuous variable		40.66	13.90
Family size:	Household's size is a continuous variable		4.28	1.71
Income:	It is a continuous variable measured in Mexican pesos		2199.92	1634.87
Respondent sex:	Sex of the head of household.		0.65	0.48
Woman	Dichotomical variable (0,1), where	34.96		
Man	0 is woman and 1 man	65.04		
Family status:			1.84	1.12
Non-marital cohabitation	Civil status of the head of household. Nominal qualitative variable	57.72		
Married		14.63		
Widower		13.82		
Separated		13.82		
Education:			0.95	0.71
No studies	The education of the head of household, ordinal variable	23.58		
Elementary		61.79		
Middle		10.57		
Higher		4.07		
Access to water:	Dichotomical variable, where 1		0.71	0.46
Waterwheel or well	indicates that the water is obtained from a well and 0 that it is obtained from some river or spring.	70.73		
No		29.27		

Access to bathroom:	Dichotomical variable, where 0	0.31	0.46
Yes	indicates absence of bathroom, in	30.89	
No	the household and 1 indicates that	69.11	
	there is a bathroom, in the		
	household.		
Electricity:	Dichotomical variable, where 0	0.18	0.38
Yes	indicates they do not have and 1	17.89	
No	they do.	82.11	
Own lands:		1.6	0.98
Doesn't have	It is a qualitative variable, the	21.95	
< 1 Ha.	amount of land available that the	9.76	
1-2 Ha.	head of household owns (doesn't	54.47	
>2 Ha.	have, <1 Ha., 1-2 Ha., >2 Ha.).	13.82	
Prospera:	Dichotomical variable (0,1).	0.67	0.47
Non-beneficiary	Households that are or are not	33.33	
	beneficiaries of this social inclusion		
Beneficiary	and conditional cash transfer	66.67	
	program.		
Food access:		0.51	0.61
Low	MAHFP was calculated within a	54.47	
Moderate	12-month period that each	39.84	
	household was unable to meet its		
	food needs. Thus, a higher score		
High	represents a household that has	5.69	
	more consistent food access (low		
	<=9, moderate 10-12 and high 12)		
Coping Strategies:			
Skip meals:		0.56	0.50
Yes		56.10	
No		43.90	
	These strategies belong to the	2	
Restricted consumption of	group of rationing or managing the		
adults in order for small	shortfall strategies. Dichotomical		
children to eat:	variable (0,1).	0.53	0.50
Yes		52.85	
No		47.15	

Limited portion size at meal times:			0.50	0.50
Yes		49.6		
No		50.4		
Sent household members to eat elsewhere	It belongs to the group of decreasing number of household members. Dichotomical variable (0,1)		0.16	0.37
Yes		16.3		
No		83.7		
Rely on less expensive foods	It belongs to the group dietary changes. Dichotomical variable (0,1)		0.19	0.39
Yes		18.7		
No		81.3		
Make handicrafts to raise money for food:			0.46	0.50
Yes		45.5		
No		54.5		
Consume seed stock held for next season:			0.41	0.49
Yes		41.5		
No		58.5		
The household head migrated to work:			0.40	0.49
Yes		39.8		
No		60.2		
Occasional job:	These strategies belong to the group increase short-term household food availability. Dichotomical variable (0,1)		0.34	0.48
Yes		34.1		
No		65.9		
Borrow food from a friend or relative:			0.24	0.43
Yes		23.6		
No		76.4		
Purchased food on credit			0.18	0.38
Yes		17.9		
No		82.1		
Gather wild food, hunt, or harvest immature crops			0.06	0.23
Yes		5.7		

No	94.3		
Send household members		0.02	0.15
to beg			
Yes	2.4		
No	97.6		

Nota: Ha= Hectares. DS= Desviación Estándar. (n=123).

4.3. RESULTS

4.3.1. Descriptive analyses

4.3.1.1. Socio-demographics and household characteristics

In our survey sample among indigenous communities of Sierra Tarahumara of the Mexican State of Chihuahua, men run 65% of the households and women 35 %. On average, a household is composed of 4.3 household members. The average age of the household head for indigenous communities of Sierra Tarahumara was 40.7 years old. Furthermore, household heads have a generally low level of education (23.58% with no studies and 61.79% with only elementary education). They live, mainly, in a family status of non-marital cohabitation (57.72%) and the income per household is 2199.92 Mexican pesos. It was observed that the households of these communities do not have access to an improved installation of safe water. Also, 70.73% use water to cook and drink obtained from pits and 29.27% use water taken from rivers and springs. In terms of sanitation, only 30.89% of people use the bathroom as type of sanitation facility, whereas 69.11% have their bowel movements outdoors. 82.11% are not connected to an electricity network. 54.47% of the households had between 1 and 2 hectares of land; 21.95% of the households were landless. 66.67% are beneficiary of the Prospera conditional cash transfer (Table 10).

4.3.1.2. Food Access (as measured by MAHFP)

The MAHFP provides an indication of households' access to food by providing information on the months in which households have food during the year. Figure 4 displays the months of provisioning, showing that in no month all surveyed households have enough

food. May was the month in which the highest number of households (57.72%) were food insecure, followed by January (56.91%), February (55.28%), March (52.03%), and December (49.59%); more than 50% of households reported that they do not have adequate food quantities. The month with the highest food supply is September, with only 16.26% of households suffering some form of food deprivation. December, January, February and March are the winter months with little food available from gardens and plots in this community.

Figure 4. Percentage of households experiencing hunger over a year (n=123).

Table 10 shows that the level of access to food is low in 54.47% of households, while 39.84% has moderate access, and only 5.69% of households surveyed reported having no difficulty in accessing food, obtaining food for their household members in the past year (high food score access 12). On average, MAHFP was 7.83, which means that the sampled population of households has, on average, low access to food (range ≤ 9).

4.3.1.3. *Coping strategies*

As indicated, this study was carried out during the winter season, when food insecurity is most acute. The households used several coping strategies to mitigate the effects

of food shortage (shown in Table 10, and plotted in Figure 5). The main coping strategies used by households were those related to the group of ‘food rationing’: skipping meals (56.10%), restricting consumption of adults to secure small children’s intake (52.85%), and limiting the portion size at meal times of the whole family (49.59%). This was followed by the coping strategies that belong to the group of ‘augmenting short-term household food availability’: making handicrafts for cash to buy food (45.53%), consuming seed stock held for next season (41.46%), the household’s head migrating to work (39.84 %), and the household’s head engaging casual labor (34.15%). The least commonly employed strategies were sending household members to beg and gathering wild food, hunting, or harvesting immature crops.

Figure 5. Coping strategies used by households (n=123)

4.3.2. Results of the statistical analysis

By using cross-tabulation procedures and Chi-square tests, we investigated the relationship between coping strategies and food access levels. The variables of the coping strategies associated with food access included: reliance on less expensive food ($p < 0.01$), purchasing food on credit ($p < 0.05$), limiting portion size at meal times ($p < 0.05$), skipping

meals ($p < 0.10$), and restricting adults' consumption to secure small children's intake ($p < 0.10$). The only household variable characteristic that was significantly associated with food access levels was the access to bathroom ($p < 0.05$). There was no significant association between the following variables of the coping strategies and food access levels: borrowing food from a friend or relative, gathering wild food, hunting, or harvesting immature crops, sending household members to eat elsewhere, consuming seed stock held for next season, the household head migrating to work, occasional job and sending household members to beg (Table 11).

On the other hand, the ANOVA indicated that the null hypothesis cannot be rejected, this is that the population's means of continuous variables (income, age and size of households) derived from various households, are identical across all food access levels. Levene's statistic showed normality in all these continuous variables ($p > 0.05$) (Table 11).

Table 11. Bivariate associations between food access levels (as measured by MAHFP), socio-demographics and household characteristics variables and coping strategies variables.

Food access levels (MAHFP)	Tests	
ANOVA	F	Levene test
Age	0.75	0.38
Family size	1.76	0.21
Income	1.81	1.35
Contingency table analysis	Pearson Chi-Square	Contingency Coefficient
Access to bathroom	6.42	0.22**
Respondent sex	0.76	0.08
Family status	2.25	0.13
Education	1.98	0.13
Access to water	3.31	0.16
Electricity	5.56	0.21

Own lands	10.81	0.28
Prospera	0.45	0.06
<i>Coping strategies:</i>		
Rely on less expensive foods	15.54***	0.34***
Purchased food on credit	6.95**	0.23**
Limited portion size at meal times	8.01**	0.25**
Skip meals dummy	5.50*	0.21*
Restricted consumption of adults in order for small children to eat	4.58*	0.19*
Borrow food from a friend or relative	0.49	0.06
Gather wild food, hunt, or harvest immature crops	1.05	0.09
Sent household members to eat elsewhere	4.53	0.19
Consume seed stock held for next season	2.26	0.13
The household head migrated to work	1.85	0.12
Make handicrafts to raise money for food	2.64	0.15
Occasional job	3.43	0.17
Send household members to beg	2.57	0.14

Association was statistically significant: *** p<0.01. ** p<0.05. * p<0.10.

MAHFP, months of adequate household food provisioning

ANOVA one-way analysis of variance. Association was not statistically significant: p>0.05. Levene's test indicates that exist normality/homoscedasticity

Source: Own elaboration with information obtained from surveys.

4.4. DISCUSSION

In terms of the socioeconomic situation, our results can be compared to other investigations related to households' food access. Legwegoh and Hovorka (2013), found in Gaborone, Botswana, that the households were composed, on average, of 4.4 members; the average age of the head of household was 44.80 years old; around 20% of the heads of household did not have formal education and 50% had basic education; and 15% of the heads of household reported being employed on a part-time basis. For their part, Thorne-Lyman et al. (2010)(Thorne-Lyman et al., 2010), in the rural area of Bangladesh, they found that the

size of the household was 5.7 members. More than 90% of the households had <1 hectare of land; most of the households were landless. Slightly more than half of the heads of household had received some type of formal education and reported having been short-term employed. These sampled populations have similar characteristics to ours.

Regarding the measurement of the food access in the households, the MAHFP was used, a methodology proposed by Swindale and Bilinsky (2010). Our findings indicate that in all months of the year the households do not have enough food, mainly during January, February, March, May and December. However, these results do not match with those reported by Leah et al. (2012) who in three Central Andean metropolitan, peri-urban regions (Cochabamba, Bolivia; Pillaro, Ecuador; Huancayo, Peru) found that 41% of households surveyed do not experienced any difficulties in obtaining food for their home in the last 12 months (MAHFP score 12). In the work of De Cock et al. (2013) carried out in the rural areas of Limpopo province, South Africa, showed that households experienced hunger, the period ranged from 1 to 4 months, with the largest number of households suffering from one or two months of food insecurity (13.2% and 10.2%, respectively). January was the month in which the highest number of households (25.9%) experienced hunger, followed by June (17.2%), February (16.2%), July (15.5%) and December 15.2%). The proportion of households reporting difficulties in obtaining food for their homes for 3 months or more in the last 12 months was 18.6%. In our work, we found that households have low access to food (7.83 on average, range ≤ 9). These findings are lower than those obtained by De Cock et al. (2013), at 10.28, within the range of moderate food access (10-11).

In the present study, we found that the coping strategies used to deal with indigenous household food insecurity were focused on two main groups of strategies, rationing and the group of increased short-term household food availability. This finding was consistent with previous studies done in other countries. In the research Ngidi and Hendriks (2014)

performed at Jozini, a rural Municipality in South Africa, they found that relying on less preferred and/or inexpensive food was the most commonly employed strategy (88.4%) - followed by borrowing food or money for food and begging from friends or relatives for food (85.5%, in both). Grobler (2014) found in Bophelong, a low-income neighborhood in South Africa, that the coping strategies used by most of the households in the sample is relying on less expensive commodities, followed by buying only necessities, sticking to budget, limiting portions and skipping meals. For their part, the work of Chagomoka et al. (2016), carried out in Ghana, pointed out that households used coping strategies more frequently, such as skipping meals the whole day, borrowing food or money to buy food, consuming seed stock and purchasing food on credit. Shariff and Khor (2008) found, in a rural community in Malaysia, that borrowing money to buy food, receiving food from family members, relatives and neighbors and reducing the number of meals seemed to cushion the food insecure households from experiencing food insufficiency. Shisanya and Hendriks (2011) found in Maphephetheni uplands, South Africa, that the most used coping strategies by households were eating smaller meals than they needed (83% of the households) and eating fewer meals in a day (91% of the households).

We showed that there was a statistically significant association between food access levels and coping strategies (relying on less expensive food; purchased food on credit; limited portion size at meal times; skipped meals and restricted consumption of adults in order for small children to eat). In this way, the results suggest that coping strategies can help to determine the food access levels and identify the most vulnerable households.

Overall, despite failing to find significant relationships between the socio-demographics and household variable characteristics and food access levels, our comparison across measures reveals that indigenous households were food insecure. Servan-Mori et al. (2014) and CONEVAL (2014) in Mexico found that municipalities with a higher proportion

of indigenous population have less availability of basic services such as durable homes floor material, access to clean water and sanitation and medical insurance. According to SHCP (2016), the minimum wage in Mexico was 2,103.00 Mexican pesos per month and contrasts with the results of this research, because most of the heads of households had low-income. Also, CONEVAL (2014) indicated that the precariousness of income is one of the most dramatic and particular characteristics of poverty in individuals with some ethnic trait. Servan-Mori et al. (2014) indicated that the distribution of household's expenditure showed that the indigenous populations are disadvantaged economically. They also showed that, regardless of the type of poverty index estimated and the different thresholds of the poverty line, indigenous population consistently have greater poverty index values than non-indigenous populations. In addition, low-income families have been forced to cut their food budgets, which has increased the purchase of cheaper and less healthy food products (Fiese et al. 2016; Ventosa, 2016). On the other hand, it is worth mentioning that no significant difference was found between the Prospera variable and food access levels. According to FAO et al. (2015), Servan-Mori et al. (2014) and Attanasio et al. (2013), Prospera conditional cash transfer (before Oportunidades) has shown positive effects on basic health, nutrition, and education indicators among disadvantaged groups. However, Sonnino and Hanmer (2016), Peña (2014) and Servan-Mori et al. (2014) found that the program requirements applied on indigenous families are often incompatible with their migration patterns tied to family and community obligations. Moreover, Prospera implementation is planned as if beneficiaries were culturally homogeneous, but they are not. Some marginalized indigenous households have not been included in the program due to the remote location of the communities where they live, which is against the Mexican Constitution. According to the Constitution, all citizens are equal regardless of where they live (CONEVAL, 2014; Peña, 2014). This leads

us to think that Prospera may have failed to alleviate poverty significantly in indigenous groups.

4.5. CONCLUSIONS

This study investigated the food access and coping strategies of households in the indigenous communities of Sierra Tarahumara in Mexico. The MAHFP, as food access indicator and coping strategies, was used to determine the status of households. Chi-square and ANOVA tests were used to determine association between food access levels and coping strategies that were used by households.

It was found that all our surveyed households do not have access to enough food in any month. The month with the greatest supply problem was May with 57.72% of households suffering food insecurity, and the one with the highest supply was September, with 16.26% of the households suffering from food insecurity. In addition, households were found to have a low level of access to food (54.47%). Therefore, it is concluded that all surveyed households experienced some difficulties in obtaining food during the 12 months of 2014. Also, the results reported that the households used various strategies to address the problem of access to food, including, eating cheaper food, limiting portion sizes at meals and reducing meals for whole days, among others. From the analysis, one might think that a smaller variety of food was served in the home, since food access is limited. This is a very critical issue, because it is associated with negative health consequences.

The use of the MAHFP indicator and coping strategies to measure food insecurity has low cost, has a simple procedure, it is comprehensible by everyone and can be used in combination with other measures of food insecurity. Coping strategies may vary due to different geography, economy, social and environmental circumstances. For this reason, the type of coping strategies used should be validated against other indicators, such as poverty measures, nutritional status and food consumption. Knowledge on such information will

facilitate efforts to influence public policies and to improve the situation of household food insecurity among rural the areas mainly within indigenous communities.

The limitation of this study is that it consisted of a rather small sample that may not be representative of the general population. Despite this limitation, this study constitutes an initial baseline to understand the food situation of indigenous households in the Sierra Tarahumara and can be seen as a contribution to the growing body of knowledge in food insecurity among indigenous communities. Food insecurity remains a challenge for Mexico. Thus, hunger eradication should remain a key commitment of decision-makers at all levels. It is suggested that policymakers should consider developing a comprehensive food security strategy framework, focusing on promoting growth in agriculture sector, greater social inclusion and improving food security and nutrition of these indigenous communities.

CHAPTER 5.-

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

5.1. SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

There are over 370 million indigenous peoples living in more than 90 countries around the world. Indigenous peoples are known to be among the world's most vulnerable, marginalized and disadvantaged groups. Although they account for less than 5 per cent of the global population, they comprise about 15 per cent of all the poor people in the world (United Nations, 2009)

The difficulties of certain segments of the Mexican population, primarily the rural indigenous communities, revealed throughout the doctoral thesis demonstrate the importance that food security issues can pose a significant challenge to them, despite having regulatory environments and food assistance programs.

Accurately measuring households' food security is essential for high quality research and defining well-targeted policies and programs. Our findings illustrate the importance of considering a suite of issues when addressing food security, namely the time horizon for data collection and the most important particular aspects. The purpose of this thesis was to measure the food security status in rural households among of indigenous communities in Sierra Tarahumara, located in the state of Chihuahua, Mexico. In addition, it is argued that multiple measures and indicators can identify vulnerable households and can more accurately determine the levels of household food insecurity. The food security measures used in this research were focused on ELCSA, HDDS, MAHFP, and food coping strategies.

5.2. CONCLUSIONS

5.2.1. Explaining food Insecurity among indigenous households

In this research (Chapter 2), we investigate how food security determinant factors, such as socio-demographics and household characteristics variables, are related to different levels of food insecurity. For this research purpose, we collected rural indigenous

communities' representative data and the ELCSA. The main conclusions contributing to address the challenge in food insecurity are summarized in the following points:

- The estimation was conducted using the ordered and binomial logit model for the total population. Considering the food insecurity categories accounted for in the OLM, we found that 13.8% of the surveyed households had no food insecurity (FI), 10.6% had mild FI, 16.3% had moderate FI and 59.3% had severe FI. Considering the FI categories accounted for in the BLM, we found that approximately 75.6% of the surveyed respondents reported being food insecure while 24.4% claimed that they were food secure.
- We found that indigenous households were in a situation of poverty and extreme poverty, and many lack basic services. These households were found not to have access to an improved source of safe water, where 70.73% use well water and 29.27% use water from rivers and springs for cooking and drinking purposes. In terms of sanitation, only 30.89% of people use toilets as sanitation facilities, whereas 69.11% have to defecate in the open. Again, 82.11% are not connected to an electricity network, and 92.68% use firewood for cooking.
- Income increases would improve access to food, whereby households can afford healthier foods and better quality diets. However, in this thesis we found that households were more likely to suffer food insecurity and were located in the low- and medium-income tercile.
- The main crop cultivated by the surveyed indigenous communities is maize.
- We found that farmers consume their seed stocks in times of food scarcity as a way of coping with hunger. This is an indication that the household is suffering from FI.
- It appears that the group of households whose householders are engaged in casual labor is food insecure.

- That households headed by older people are more likely to be food insecure.
- Prospera has not being able to reach all poor households. We leave the analysis of possible measures for improving the impact of the Prospera program in the Sierra Tarahumara for future research.

Households in rural areas with income below the food poverty line clearly belong to a vulnerable group. It seems that it is necessary not only to implement policies that will bring the benefits of cash transfers social programs to the residents of isolated rural communities, but also to implement/strengthen complementary public policies to support sustainable local food production and rural development.

5.2.2. Dietary Diversity in rural households

Food diversity is important for health – both in increasing the likelihood of nutrient adequacy and lowering mortality rates. Hence, the HDDS is a health-related indicator for dietary quality and a useful means of measuring food security situation at population level. Also, it is also an attractive choice towards continuous monitoring of programmes and in situations where time and resources for data collection and analysis are limited. Conclusions emerging from this research endeavor are summarized in the following points:

- The determination of the HHDS as an economic access indicator of the foods in Sierra Tarahumara permitted assessing the severity of the food-deficit in the population and valuing the variety of food groups that are consumed. We conclude that these are poverty-stricken indigenous communities whose households suffer from food insecurity.
- From the discriminant analysis (DA), by steps inclusion, we found that the improvement in employment is still an important topic that be kept in the Mexican public policy agenda, since a significant percentage of households have casual employment or are unemployed.

- In addition, we concluded that the conditional transfers, in this case Prospera, would allow the households to increase the food consumption and dietary diversity. Nevertheless, these conditional transfers, by themselves, are not enough to lift people out of food insecurity and poverty. The government must intervene in aspects such as safe water services access, sanitation, electrical network and health care, which are deficient in the study area. As well as performing interventions in agriculture, since rural families in a food insecurity situation fundamentally depend on agriculture for their livelihoods. Extension services should assist with planning food production to provide food year-round, and nutrition advice to support home production of fresh produce is also needed.

5.2.3. Food access and coping strategies adopted by households to fight hunger

In this study (Chapter 4) we set out to measure food access and to identify the coping strategies applied by indigenous households of communities to mitigate the effects of household food insecurity in the Sierra Tarahumara. Conclusions are summarized in the following points:

- Food was not available year-round for most households. May was the month in which the highest number of households (57.72%) were food insecure, followed by January (56.91%), February (55.28%), March (52.03%), and December (49.59%); more than 50% of households reported that they do not have adequate food quantities. The month with the highest food supply is September, with only 16.26% of households suffering some form of food deprivation.
- The level of access to food was low in 54.47% of households, while 39.84% has moderate access, and only 5.69% of households surveyed reported having no difficulty in accessing food, obtaining food for their household members in the past year (high food score access 12). On average, MAHFP was 7.83, which means that

the sampled population of households has, on average, low access to food (range ≤ 9).

- Income appears to be insufficient to meet household food requirements. When confronted with food shortages that limited or changed access to food, households made compromising changes to their diets. Households in indigenous communities applied consumption and income soothing strategies as a means of managing food shortfalls.
- Chi square tests showed that there was a positive association of food access scores and the application of some coping strategies included the following: reliance on less expensive food ($p < 0.01$), purchasing food on credit ($p < 0.05$), limiting portion size at meal times ($p < 0.05$), skipping meals ($p < 0.10$), and restricting consumption of adults to secure children's intake ($p < 0.10$). Therefore, there was a decrease in food security resulted in increased frequency of coping strategies employed.

This doctoral thesis indicates the importance of using food security measures. In this way, the results suggest that multiple indicators can more accurately determine the levels of indigenous household food insecurity and identify the most vulnerable households.

5.3. RECOMMENDATIONS

Food security interventions need to support beneficial strategies that combat food insecurity. Some indigenous households in the study area produce mainly for family auto-consumption. The Mexican Ministry of Agriculture, (in Spanish: Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación, SAGARPA), and local development agencies need to assist these communities by providing production inputs (infrastructure, production techniques, provision of vegetable seeds, mechanization, between other), as well as, proper advice that should be organised through extension and training services. All of this can encourage even households with limited access to land to cultivate mixed gardens around

their homesteads. Home gardens can make valuable contributions to the family food supply and income.

While agriculture may play a major role in the reduction of food insecurity, attention should also be given to the promotion of non-farming activities (such as production, marketing and sale of handicrafts, tourism, processing and direct marketing of agricultural products, services), particularly those which generate income, that would in turn help to reduce poverty and food insecurity in rural indigenous households. However, this non-farming activities are not accessible to the poorest of households because they often lack the education, capital and credit needed to participate in these areas. In any case, the government should actively engage in the design and implementation of policies and strategies that combat food insecurity.

There is a need for more research, particularly to investigate the ways in which households have applied specific coping mechanisms to deal with the food insecurity is required. Therefore, current food security policies and strategies at national, regional and local levels need to be researched to investigate if policies have adequately addressed food insecurity coping strategies and the impact these strategies could have in enhancing food and livelihood security of households.

5.4. LIMITATIONS AND FURTHER RESEARCH

The limitation of this doctoral thesis is that it consisted of a rather small sample that may not be representative of the target population of the research, much less of all indigenous communities in Mexico. However, the agro-socioeconomic holding structure is more or less in line with the region's demographics. It is worth indicating that indigenous communities of the Sierra Tarahumara are very isolated and very few are accessible by road. Also, we could not come to reach many locations, as a result of the prevailing insecurity situation in some

areas of the Sierra Tarahumara, especially due to major problems with illegal cultivation of marijuana and drugs trafficking.

On the other hand, the survey used to undertake the analysis in the Sierra Tarahumara provides data on food access only at the household level, and do not provide data on food access at the individual level. In this way, the analysis does not identify the more vulnerable members within the household. This limits the scope of the analysis to the adult population. Nevertheless, focusing on adult subjects can widen the insights about populations affected by malnutrition.

Moreover, the evaluation undertaken in the Sierra Tarahumara does not give information about the substitution that exist between foods nor gives information about towards which foods consumption shifts in the face of a price increase, and the extent to which the price of food affects household food insecurity.

Despite these limitations, the main results of this doctoral thesis constitute an initial baseline and provide a better comprehension of the food situation of rural indigenous communities in the Sierra Tarahumara. Also, these findings will help to provide local and national political decision makers with updated information in order to identify inconsistencies in policies and programs related to food security, and support the formulation of policies aiming at improving food and nutrition security.

Further research efforts could examine:

The developed methodology in this doctoral thesis could be applied on a larger scale and in different regions to consolidate our preliminary findings. In this sense, a broader focus that includes the impacts from more regional perspectives may provide useful insights into an issue which has global dimensions.

Food and nutrition security issues cannot be completely captured by focusing on a certain dimension and a limited number of indicators, more empirical analyses of microdata

are needed to give a clearer picture of the consequences of increasing food prices on Mexico food consumption, the extent to which the price of food affects household food insecurity. Therefore, it is important to have a clearer picture of how consumers react to increased food prices.

From a policy perspective, evaluate food assistance programs focusing on the segments of the population most at risk of food deprivation. Current food security policies and strategies at national, regional and local levels need to be researched to investigate if policies have adequately addressed food insecurity coping strategies and the impact these strategies could have in enhancing food and livelihood security of households. Also, it is suggested that policymakers should consider developing a comprehensive food security strategy framework, focusing on promoting growth in agriculture sector, greater social inclusion and improving food security and nutrition of these indigenous communities.

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