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Design and Validation of a Survey for the Study of Food and Nutritional Security to Climate Change Vulnerability

Carlos Matias Scavuzzo[1,2*], Eliana Álvarez Di Fino[1], Alberto Ferral[2] and Maria Daniela Defagó[2,3]

[1]*Faculty of Medical Sciences, Nutritional School, National University of Cordoba, Cordoba, Argentina*

[2]*Catedra UNESCO on Human Security and Regional Develop in Latin America, Blas Pascal University, Cordoba, Argentina*

[3]*National Council of Scientific Research and Technological Develop CONICET, Buenos Aires, Argentina*

***Corresponding authors:** *Carlos Matias Scavuzzo, Faculty of Medical Sciences, Nutritional School, National University of Cordoba, Cordoba, Argentina*

Abstract

Human Security is a concept instituted by the United Nations and refers to the possibility that each person can satisfy basic needs of different kinds: Health, food, environment, education, economy, politics, institutional access, etc. Both WHO and FAO emphasize these concepts related to food and nutritional security (FNS), and relate it to the vulnerability derived from emergency and disaster situations. These are increasingly frequent and complex in a context of climate change, since they affect food systems, directly and indirectly impacting the pillars of FNS: availability, economic access, biological use and sustainability. In this context, the concepts of risk, hazards and vulnerability arise, the latter being determined by exposure, susceptibility and resilience. Managing the concept of vulnerability allows us to approach FNS as an essentially dynamic process. Thus, the objective of the work is to develop and validate an instrument for qualitative-quantitative estimation of the vulnerability of the FNS linked to the threats derived from climate change through its implementation in a pilot test. The variables under study are the FNS, the vulnerability of the FNS, associated with climatic events, and climate hazards. The study is observational, descriptive, and cross-sectional. The instrument was designed based on the Guide for Measuring Food Security prepared by the Red Cross; the WFP Manual for the Evaluation of Food Security in Emergencies and the USDA Food Security Measurement Instrument. The instrument was applied in Cruz del Eje City over 59 citizens and four validation test criteria implemented.

Keywords

Food and nutritional vulnerability, Food and nutritional security, Human security, Survey validation

Introduction

Human Security is a concept instituted by the United Nations Development Program (UNDP) referred to the achievement of Human Development, involving the possibility for each person to satisfy his or her basic needs through access to goods and services of various kinds: Food, environmental, educational, economic, political, institutional, health, among others. It can also be defined as the reduction or elimination of the vulnerability of people, communities and ecosystems to threats [1]. Both the World Health Organization (WHO) and the Food and Agriculture Organization (FAO) emphasize the concepts of human rights linked to neglected diseases (dengue, Chagas, ETAs, cysticercocis, leishmaniasis, helminthiasis, etc.) characteristic of poor, rural and marginalized populations, as well as to food security (such as the right to food), linking them intimately with each other and relating them to vulnerability derived from socio-economic and cultural situations. Within this framework, the situation to which populations are exposed in the face of catastrophes and natural disasters is especially problematic, a topic of special attention by international organizations such as the United Nations (UN) in the Sustainable Development Goals (ODS), [2,3]. These situations are more and more frequent and problematic in current climate change scenarios. Thus, it appears the management of risk concepts related to both threats and vulnerability, the latter

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being determined by exposure, susceptibility and resilience [4].

The concept of food and nutritional vulnerability is understood as a set of factors that determine the propensity to suffer inadequate nutrition or for food supply to be interrupted when there is a failure in the provision system understood as a way of violating the right to food. The right to food implies that every person has the right to live in conditions that allow him to feed himself by his own means from the land or other natural resources and/or to have access to efficient distribution, processing and commercialization systems. In addition to have the financial capacity not only to acquire a sufficient quantity of quality food, but also to be able to satisfy his basic needs for food. Finally guarantee access to adequate food in cases of unforeseeable events or force majeure; and access to food that contributes to an adequate diet, clean water, to achieve a state of nutritional well-being in which all physiological needs are satisfied [5]. Food and health vulnerability is a situation that characterizes countries, social sectors, groups and individuals who are exposed or susceptible to hunger, malnutrition or disease because they do not have physical, economic and sustainable access to sufficient, nutritious and culturally acceptable food, or because of exposure to pathogens (viruses, parasites) linked to severe environmental disruption. Managing the concept of vulnerability allows us to address the problem of health/food security as an essentially dynamic process [6].

The World Health Organization estimates that anthropogenic climate change warming and precipitation trends over the past 30 years have already claimed 150,000 lives annually. Many human diseases are related to climate fluctuations, from cardiovascular mortality and respiratory diseases due to heat waves, to the transmission of infectious diseases and malnutrition caused by poor harvests [7].

Despite the magnitude of the problem, there is little literature on the effects of climate variability and extreme weather events on food systems [8]. The report SREX (Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation), in which the implications of these events for society and sustainable development are expressed, gives an account of this. Codjoe and Owusu [9] report in their work in communities in Ghana how extreme weather events affect food production, transport, processing and storage in rural areas. They conclude that food security in this region could be improved by increasing on-farm storage facilities; improving the transport system, especially the secondary roads linking food production areas and major markets; providing farmers with emergency early warning systems; extending credit to farmers; and using supplementary irrigation. These authors emphasize how some cultural practices, particularly those that prohibit the consumption of certain foods, can reduce the resilience of some individuals and ethnic groups to food system disruptions [9]. It is also clear that the nutritional status of both individuals and a community correlates positively with other health indicators resulting from a wide range of factors, and both the adequate amount of calories and the sufficient and nutritionally adequate intake of micronutrients and macronutrients (mainly proteins) are important.

In general, food availability shows a strong correlation with climate variability. The study by Lloyd, et al. [10], based on previous work by Nelson [11], clearly shows that climate change and increased climate variability, through its impact on food production, will have a negative impact on the prevalence of under-nutrition, increasing stunting by 62% in South Asia and 55% in Eastern and Southern Africa by the 2050s. Although adequate food and nutrition is determined not only by food availability but also by access to food, as well as nutritional care and childcare practices, among other dimensions of FNS, there are almost no studies on these other determinants of food security [12]. Climate change has a negative impact on human security by reducing access to and quality of natural resources that are important for maintaining the resources needed for life. Climate change is also likely to diminish the ability of states to provide opportunities and services that help people sustain their livelihoods [13].

So different localities or towns, can have a certain level of Food and Nutritional Security (FNS), which can be measured quantitatively by different instruments such as the one used and suggested by the United States Department of Agriculture (USDA), [14]. However, two localities with the same level of FNS may respond differently to threats from climate change. Then they can have different levels of potential for adaptation or inversely of vulnerability depending on how and where they access the critical inputs that form the basis of their level of FNS [15]. So for example a city without Access to health services, with low levels of State Aid, without social networks and obtaining their food from only one place will be much less resilient to other city with a diversity of source of foods, high social links that generate a resilient behavior to address the threats posed by climate change.

In this framework, the objective of the present work is the design and validation of an instrument for the qualitative-quantitative estimation of the vulnerability of food and nutritional security linked to the threats derived from climate change through its implementation in a pilot test in Cruz del Eje, Córdoba, during 2019.

The instrument developed include three data sources (one at individual/households level-the survey), one on the city level with data obtained by official public source and observational evidence, and one from the

climate change public data bases. It is important to remark that it is totally different to previous works that are focuses in to measure FNS, here we are studding its vulnerability (how the FNS will change/evolved) in the face of climate change. Additionally it should be clear that we do not trait to study the threats posed by climate change, we are addressing elements related to how the FNS will be affected/modified/aggravated by the climate change effects. In addition to the instrument we include in our contribution a novel and showy form of chromatic representation of the risk that we propose to be used in order to apply this instrument at regional level (many cities) in the context of geographical information systems.

Instrument Design

The instrument includes 19 variables that are divided in 3 groups considering their origin (data sources). The first group is obtained from individual survey **"IS"** (representing the households situation), the second one from a city level survey **"CS"** and finally the climate change threats is obtained from climate change scenarios data bases "(Environmental National ministry from Argentine webpage http://simarcc.ambiente.gob.ar/)". That's variables, for other hand, could be grouped regarding the different aspects involved in the studio. I.e. those related with the food security (including its four dimensions: availability, access, biological utilization and stability) and those related with the social and climatic vulnerability.

Variables Considered

Age IS

Sex IS

Food and nutritional security

Access

Price of the basic food basket CS

Type of income/salary IS

Food expenditure IS

Household income IS

Availability

Availability of food in the area CS

Family farming IS

Biological use

Drinking water CS

Electricity CS

Garbage collection CS

Home health services IS

Access to health services IS

Stability

Stability of food consumption IS

Stability of productive resources IS

Social vulnerability

Presence of social networks IS

Presence of State Aid IS

Climate vulnerability

Perception of risk IS

Climate threat

Climate change scenarios

Implementation

The instrument was implemented in the city of Cruz del Eje, located in the NW of Córdoba province, Argentina. Fifty-nine individual surveys were carried out by four different technicians in two different locations in the city. Thirty in a public health center and 29 in a private health center. These were carried out on February 2019.

Validation and Results

Validation

The validation of the instrument (individual survey) is carried out following the guidelines of the mechanisms of validation of health measurement instruments, which proposes to evaluate the psychometric properties to determine the quality of the measurement.

There are basically two essential properties to assess the quality of an instrument and these are ***reliability*** and ***validity***. Reliability refers to constantly measuring a variable and validity relates to the instrument measuring what it wants to measure. It is important to note that the bibliography emphasizes that the validation of an instrument is a continuous and dynamic process. Carvajal in 2011 [16] points out that there is no standard guide to validate measures for health questionnaires, however, criteria designed in the sciences of psychology and education are used.

Reliability: It is often said that Reliability is the constancy and accuracy of the results obtained by an instrument when applied to different samples. Thus, it attempts to measure the degree of consistency in which an instrument measures what it has to measure. Using this concept we can say that an instrument is reliable when the results are similar when it is applied to similar situations.

According to the bibliography there are four ways to estimate reliability and these are: I) Internal consistency, which is the most commonly used method and can be calculated using the half and half technique. II) Stability, repeating if possible the measurement in different moments (test-retest), III) Equivalence, if there were versions of the same instrument their results

could be correlated and IV) Inter-judge harmony, if it were an instrument that includes a personal evaluation of the variables. The method used depends on the nature of the instrument.

In our case, due to the instrument characteristics and the population studied, an internal consistency test of half and half was carried out on a subset of especially relevant questions included in the instrument.

Validity: Validity is the key both in the design and in checking the usefulness of the measure. This can be estimated in different ways: I) Validity of Criteria, the degree of correlation between an instrument and another measure of the variable that serves as reference and II) Validity of Construct, which determines the relationship of the instrument with theory and conceptualization. The methods of convergent-divergent validity, apparent validity and discriminant validity are proposed in the bibliography [16,17] for this case. In particular, the latter (discriminant) measure the extent to which the questionnaire is able to distinguish between individuals or populations that are expected to be different.

In this work due to the characteristics of the study, we propose to estimate apparent validity (with a consultation of 10 professionals), the discriminant validity (on subsets of the population markedly different in their social stratum) and the validity of content obtained by construction of the instrument through the definition and conceptualization of the dimensions of the FNS [18].

So, this section includes the 4 validations carried out, namely: A) Psychometric property: Reliability: Internal consistency test: half and half technique. B) Psychometric property: Apparent validity (with a consultation with 10 professionals), C) Psychometric property: Discriminatory validity (on subsets of the population markedly different in their social stratum) and D) Psychometric property: Content validity.

Psychometric property: Reliability: Internal consistency test: half and half technique: For this technique, the total sample (n = 59) was subdivided into two random subgroups, one of n = 29 and the other of n = 30. The 4 most relevant variables were chosen and the statistics of the 3 samples were compared with the hypothesis that the results would be equivalent (Table 1).

On our results can be observed that the instrument gives equivalent results with minimal deviation of a negligible character among the subgroups, corroborating the hypothesis of this psychometric property and reaffirming its statistical validation. In order to establish statistical significance differences or not between groups, the Wilcoxon non-parametric test was applied for con-

Table 1: Results for random half to half validation technique.

Variable	N = 59	N = 29	N = 30
Family farming (food production)			
Households with family agriculture	18 (30.5%)	8 (27.59%)	10 (33.33%)
Households without family agriculture	41 (69.49%)	21 (72.41%)	20 (66.67%)
Social Vulnerability: Presence of social protection and security (state coverage)			
Households with state coverage.	19 (32.20%)	10 (34.48%)	9 (30.00%)
Households without state coverage.	40 (67.80%)	19 (65.52%)	21 (70.00%)
Expenditure on food			
Food expenses (mean and standard deviation)	514.915 (± 19,9494)	558.621 (± 20,8339)	472.667 (± 18,4203)
Perception of climatic vulnerability in their diet: Drought			
Acute*	44 (74.58%)	24 (82.76%)	20 (66.67%)
Mild*	10 (16.95%)	3 (10.34%)	7 (23.33%)
Medium	5 (8.47%)	2 (6.90%)	3 (10.00%)
Perception of climatic vulnerability in their diet: Frost			
Acute	40 (67.79%)	21 (72.41%)	19 (63.33%)
Mild	11 (18.64%)	6 (20.68%)	5 (16.66%)
Medium*	8 (13.55%)	2 (6.89%)	6 (20%)
Perception of climatic vulnerability in their diet: Floods			
Acute*	42 (71.19%)	24 (82.76%)	18 (60.00%)
Mild*	10 (16.95%)	2 (6.90%)	8 (26.67%)
Medium	7 (11.86%)	3 (10.34%)	4 (13.33%)

*The 5 variables/categories (from 14) with an apparent high differences between groups.

tinuous variables and the Fisher exact test for categorical variables in all the cases. Analyses were performed with *Infostat* software.

In the previous table, we remark with "*" the 5 variables/categories (from 14) with an apparent high differences between groups. To define if really this differences should be consider like equivalents or different in addition we analyze the "**Exact 95% LCL**" and the **Exact 95% UCL,** (where LCL and UCL are the lower and upper limits) representing the statistical probability interval with a 95% of confidence. This methodology was applied to all the variables. As an example of how this is performed, here we show the values for the variable **Perception of climatic vulnerability in their diet: Floods** category **Mild**:

Group A, N = 50: Frec = 10, Porc = 17%, LCL = 8%, UCL = 29%

Group, B N = 29: Frec = 8, Porc = 26%, LCL = 12%, UCL = 45%

Group C, N = 30: Frec = 2, Porc = 7%, LCL = 1%, UCL = 22%

So it is clear that although the percentage values appear very diverse, statistically we cannot say that they are different with 95% confidence, confirming the hypothesis of our half to half test.

Psychometric property: Apparent validity: It was developed through of a questionnaire to 10 professionals. This is part of the validity of content and with which we try to measure the degree to which the items seem to measure what they propose. So for each question on the survey we ask "Do you think it measures what is proposed and relevant to the problem? The results of this evaluation show that more than 85% of respondents agree that the questions are relevant and appropriate [18].

Psychometric property: Discriminant validity: For this evaluation we discriminate the population under and over the threshold of indigence. So we expect the instrument to discriminate certain properties that are expected to be different in these two subpopulations (Table 2).

In this way it is possible to continue comparing the subgroups for the others variables obtaining similar discriminating results for the proposal two groups. So the validity test is again confirmed, since statistical observed variations are consistent with the expected behavior of the subgroups based on understanding social phenomena. In this case and following the same criteria that in the previous section, we can affirm that statistically the discriminant test is met only if we relax the level of confidence to 80%.

Psychometric property: Validity of content: It is obtained by construction of the instrument through the definition and conceptualization of the dimensions of the SAN included. It is not included in detail in this contribution, but can be found completely developed in a previous publication of the authors [18].

Results

Based on the survey of variables on a sample of 59 individuals in the city of Cruz del Eje, from the province of Córdoba, and the global indictors obtained from public data base; we propose to define a vulnerability score for the city. To do that we establish a vulnerability threshold for each variable and so we can count the number of risk criteria that are reached.

So the following table categorizes all the variables according to whether they comply with the negative impact condition (reach to the threshold). The threshold for each variable is defined taking into their negative impact on the vulnerability based in national and international recommendations (Table 3).

From the number of risk indicator that produces a positive value (reach to the threshold), we can generate an evaluation of each dimension previously proposed,

Table 2: A, B,C) Results for social stratification, discriminant validation technique.

A

Percentage of salary in food expenditure	Indigence (N = 17)	No indigence (N = 42)
Mean	64	46
Estándar deviation	19	17

B

Consumption instability frequencies	Indigence (N = 17)	No indigence (N = 42)
yes	15 (88.23%)	29 (69.04%)
No	2 (11.76%)	12 (28.57%)

C

Social networks frecuancy	Indigence (N = 17)	No indigence (N = 42)
No	10 (58.82%)	20 (47.61%)
yes	7 (41.17%)	22 (5.38%)

Table 3: Check list of vulnerability thresholds risk criteria that are reached.

Question/variable	Variable		Reached
No food is produced in the vicinity of the city.	FNS	DIS	NO
Price of the basic basket	FNS	ACC	NO
Percentage of population with access to garbage collection < 50%.	FNS	UB	NO
Percentage of the population that has access to sanitary services within the household with sewage network < 50%.	FNS	UB	NO
Percentage of the population with access to health services < 50%.	FNS	UB	YES
Percentage of the population with access to potable water < 50%.	FNS	UB	NO
Percentage of population with access to electricity < 50%.	FNS	UB	NO
Percentage of households producing food for their own consumption < 50%.	FNS	DIS	YES
Total amount of income for the household in relation to the current basic wage > 50% (less than two basic wages).	FNS	ACC	YES
Type of salary > 30% informal	FNS	ACC	YES
Labour area from which most of the income comes > 50% rural	FNS	ACC	NO
State coverage < 50% if	V-SOC		NO
Percentage of salary spent on food purchases > 50% (more than half)	FNS	ACC	YES
In the last year, did you have to reduce the consumption of any food you consumed regularly? > 50% if	FNS	EST	YES
In the last year did you suffer any loss of your productive resources? > 50% if	FNS	EST	NO
What do you think the impact of an event such as drought, rain, frost would be in relation to your diet? > 50% high	V_CLI		YES
In an emergency situation: do you have someone (people, or institution) to whom you can turn for help? < 50%	V-SOC		NO

given a priory the same weight to each one. So each dimension is evaluated as the number of favorable conditions over the total possible:

- ***SAN_ACC (access) = 3/5 = 0.6***
- ***SAN_DISP (Availability) = 1/2 = 0.5***
- ***SAN_UB (biológic usage) = 1/5 = 0.2***
- ***SAN_EST (stability) = 1/2 = 0.5***
- ***V_SOC (social vulnerability) = 0/2 = 0***
- ***V_CLI (climatic vulnerability) = 1/1 = 1***

So we can calculate the FNS complete as:

Vulnerability_FNS = (FNS_ACC + FNS_DISP + FNS_UB + FNS_EST)/4 V_FNS = 0.15 + 0.125 + 0.05 + 0. 125 = 0.45

And with is, the total vulnerability as:

Total Vulnerability = (V_FNS + V_SOC + V_CLI)/3 Total Vulnerability = 0.15 + 0 + 0.33 = 0.48

Then ***V_TOTAL = 0.48***

In this way we can see that the value of both the vulnerability of the FNS and the total would occupy an intermediate category according to the value on the scale from 0 to 1.

Chromatic view

As we show in the previous section we conceptually have the total vulnerability for a specific city analyzed, composed by three components: FNS Vulnerability, Social Vulnerability and Climate Vulnerability. By the other hand, when a risk map is elaborated, typically a chromatic ramp is used in a geographic information environment.

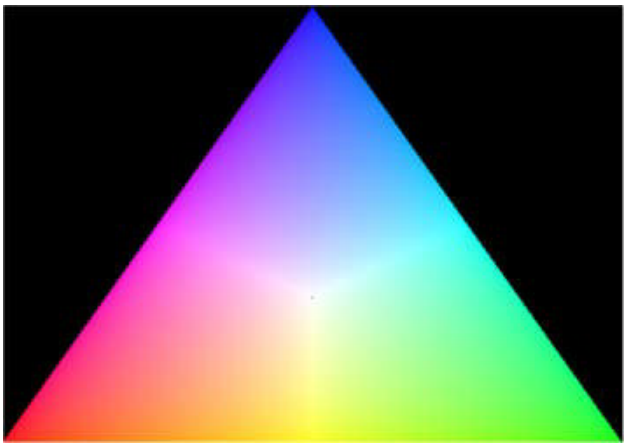

Figure 1: RGB color Composition (red, green and blue).

In this context, in this work a chromatic R_G_B representation is proposed. In it, each locality under study is assigned with a color constructed by the intensity of the primary colors Red, Green and Blue (RGB). Under this chromatic representation any total vulnerability that is generated by 3 components corresponds to a specific

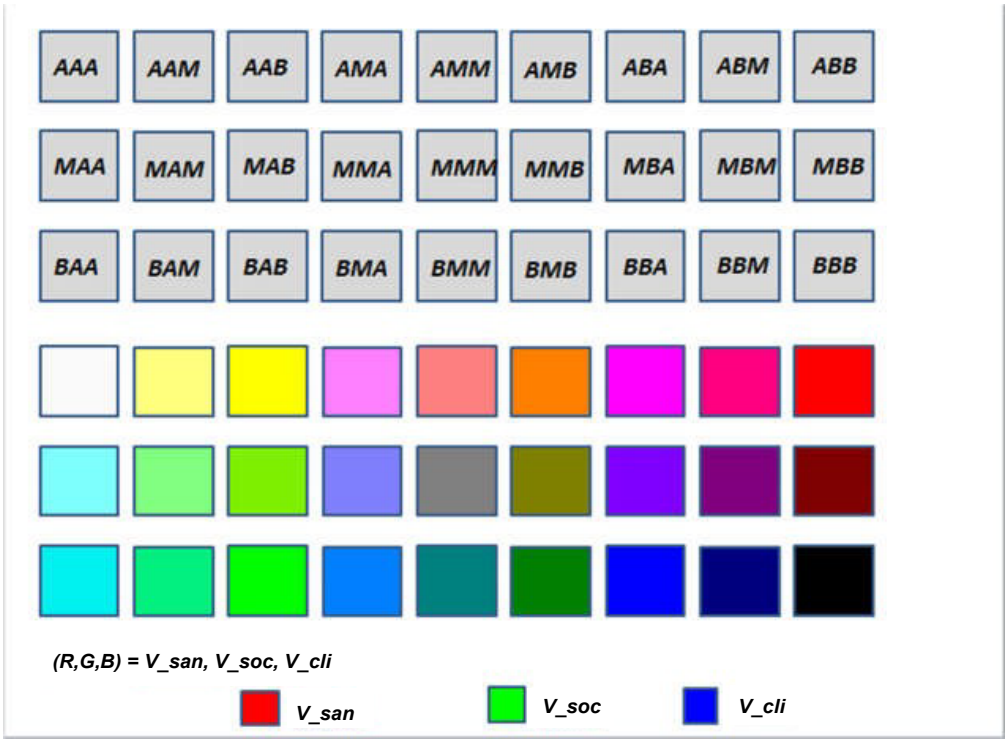

Figure 2: Chromatic risk table to locate the obtained value.

Note: V_SAN (vulnerability of the FNS); V_SOC (social vulnerability); V_CLI (climatic vulnerability); A: high, B: low and M: medium.

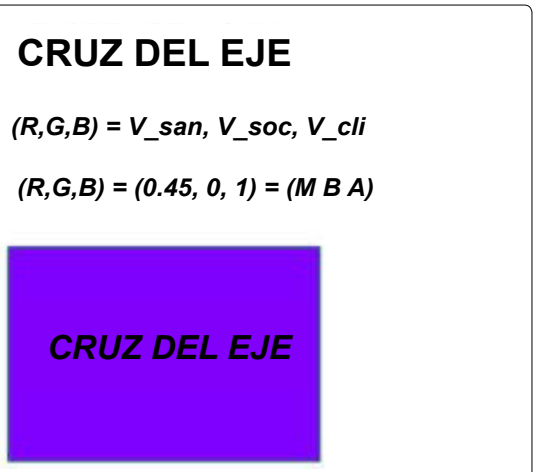

Figure 3: Chromatic risk for Cruz del Eje.

color (Figure 1). In our case, we represent in red the vulnerability of FNS, green for social vulnerability and blue the climatic one. Thus, the vulnerability intensity of these components can be represented by the intensity of the corresponding color, being 0 (low vulnerability), 125 (medium vulnerability) and 255 (high vulnerability).

In this way, we can represent the value of both the vulnerability of the 3 components of the vulnerability and the total one assigning high, medium or low (in a scale 0-1) to each one and their corresponding color (Figure 2). So, cities with the same total vulnerability but obtained from different values of their components will have different colors.

Using this chromatic rule, for the case of the Cruz del Eje city, the values obtained and its corresponding color is shown in the Figure 3. The threshold values for determining the discrete palette of colors are: From 0 to 0.33 (low), from 0.33 to 0.66 (medium) and from 0.66 a 1 (high).

Discussion and Conclusions

We have developed an instrument whose structure facilitated the contextualization of local indicators at the national level immersed in a food system governed by multiple factors. So in the first section of the instrument, at community level we can observe indicators of the dimension “Biological use of food”, specifically access to public services, which determines the social vulnerability of the population, which affects the well-being of households by allowing the use of their own resources or the provision of new resources to achieve greater social mobility [19] or in terms of climate change defined as resilience.

With regard to the dimension of food availability, according to INDEC, it is evident that there are surpluses in terms of the quantity of food per capita, with the appearance that the dimension of availability would be resolved in quantitative terms. However there is a great deal of evidence that demonstrates high values of bad nutrition in Argentina, which problematizes the dimension of real access [20]. It show other evidence, in agrees with the access indicators consulted determining a perspective of the national food system around the business and not the right to food. Numerous studies reaffirm this phenome-

non by explaining that the availability and wealth of food for the Argentine population (rich and poor) decreased drastically, putting at risk the country's food sovereignty [21].

As for the structure of the instrument at the household level, the results were stratified in relation to the indigence line, as suggested by the Committee on World Food Security, which specifies that, in general, not all pregnant and lactating women in a country are vulnerable, as is typically the case for biological dimensions, but only those belonging to households in a precarious situation [22]. Additionally our result about family farming coincides with the conclusion of the World Bank that the trend of this practice is an increase in the middle class in Latin America [23]. Observing our results, about access dimension, variables that determine social vulnerability, such as the type of salary, statal coverage and food expenditure show alarming values on the vulnerability of these households, as stated in the literature consulted by INDEC [24]. Regarding the stability of food consumption, 74.57% of households reported a reduction in habitual food consumption due to lack of access. This situation of instability in food consumption also arises at a global level due to the instability of agricultural product markets and its impact on prices that harm consumers [25].

It should be noted that the perception of the vulnerability of FNS associated with climatic events on all the population under study was of acute intensity for this community, which indicates that the population is not only aware of the existence of the climate change process but also its impact on FNS. That it is an initial kick for the approach of the same as proposed in the study consulted [26].

Finally the case of Cruz del Eje, it was represented with the color violet (125, 0, 255), since the vulnerability of the SAN is medium, the social low and the climatic high.

Specifically, the most vulnerable FNS dimension was that of access. Although there were no antecedents that use this method of weighting and quali-quantitative representation, the result is consistent with that obtained in the experience obtained with the USDA instrument in Argentina in 2002, which gave a value of 17.5% of households with food insecurity.

Regarding the process of psychometric validation; the 4 properties, as suggested in the bibliography, had positive final results since it can be observed that in the property of reliability, the internal consistency test gives statistically equivalent results. The apparent validity evidences the relevance of the aspects considered in the design. As well as the pertinence of the stratification to demonstrate in all the analysis the fulfillment of the discriminant validity and finally in the theoretical framework it is left more than clear the comprehensive approach of the dimensions of the main theoretical variable [16].

As conclusion we can sentence that the design of the instrument and the preparation of the questions comply with the required simplicity since it reacted in the way expected without causing unforeseen events, reducing the margin of error in the field work. The reactivity of the instrument was adequate since it did not affect the attribute of the measured data in question. About the validation, an integral approach was carried out to consider different perspectives and not to fall into a bias. That is why we worked from 4 different psychometric properties to guarantee the fulfillment of the general objective with the maximum possible rigor within the scope of psychometry in qualitative- quantitative health questionnaires. The originality and pertinence of the instrument in validation is emphasized since there are no references of similar processes. The potential to deepen each dimension of the FNS and its indicators is evident, being an effective base to continue working and perfecting. Returning to the hypothesis of the study, it is concluded that the instrument is capable of correctly characterizing the vulnerability of food and nutritional security to climate change. In addition a novel chromatic approach is proposed to make possible the visualization of the three components of the vulnerability at once in a GIS environment. Finally It is extremely important to understand the trans-disciplinary nature of this type of subject (ODS 2030) as it would be impossible to take an integral approach without considering the analysis of other areas that could enrich the research.

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