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**MEASURING VULNERABILITY TO MULTIDIMENSIONAL
POVERTY IN TUNISIA: DUAL CUT-OFF METHOD
AND FUZZY SETS APPROACH**

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CUT-OFF METHOD AND FUZZY SETS APPROACH**

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Abstract

The aim of this paper is to measure the vulnerability of multidimensional poverty in Tunisia. The term vulnerability refers to exposure to shocks and stress, and difficulty in coping with them. In the first part of this study, we intend to identify the Tunisian households who are likely to be multidimensional poor in the future using the dual cut-off method. In the second part, we will use the fuzzy sets theory in order to identify the resilience in exploiting opportunities and in resisting or recovering from the negative effects of the shocks, and to propose a measure of vulnerability for each household identified in the first step. Our empirical findings show that vulnerable households comprise some that are deprived in only one dimension, and thus, are excluded from the group of households considered poor. The vulnerable households are, then, regrouped into three sets that are mutually exclusive and collectively exhaustive with respect to the identified vulnerable population. The individuals with a high degree of membership in each group are in a state of extreme vulnerability and their abilities to cope with shocks effects are low and they can be the poor of tomorrow. Preventive policies must take into account their situations in order to curb the flows of the poor and to protect households from becoming poor in the future. These poverty prevention policies can be an effective means to achieve the first four Sustainable Development Goals (SDGs).

Keywords: Vulnerability, Multidimensional Poverty, Fuzzy Sets and Counting Approach

JEL Classifications: C18, D63, I32

ملخص

الهدف من هذه الورقة هو قياس قابلية التعرض لفقر متعدد الأبعاد في تونس. وهو يشير إلى قابلية التعرض للصدمات والضغوط ، والصعوبة في التعامل معها. في الجزء الأول من هذه الدراسة ، نعتزم تحديد الأسر التونسية التي من المحتمل أن تعاني من فقر متعدد الأبعاد في المستقبل بالاستناد إلى استخدام طريقة مزدوجة لتحديد خط القطع. أما في الجزء الثاني ، نحن نستخدم نظرية المجموعات الهلامية من أجل تحديد المرونة في استغلال الفرص أو الصمود أو التعافي من الآثار السلبية للصدمات ، واقتراح مقياس للضعف لكل أسرة معيشية على أساس ما تم تحديده في الخطوة الأولى. تظهر نتائجنا التجريبية أن الأسر الضعيفة تضم البعض الذي يعاني من الحرمان في بعد واحد فقط ، وبالتالي ، يتم استبعادهم من مجموعة الأسر التي تعتبر فقيرة. ثم يتم إعادة تجميع الأسر المعرضة للخطر في ثلاث مجموعات تكون حصرية ومتباعدة بشكل شامل فيما يتعلق بالسكان المعرضين للخطر. الأفراد ذوو درجة عالية من الاشتراك في كل مجموعة هم في حالة ضعف شديد وقدراتهم على التعامل مع تأثيرات الصدمات منخفضة ويمكن أن يكونوا فقراء الغد. يجب أن تأخذ السياسات الوقائية بعين الاعتبار أوضاعهم من أجل الحد من تدفقات الفقراء وحماية الأسر من أن تصبح فقيرة في المستقبل. يمكن لسياسات منع الفقر هذه أن تكون وسيلة فعالة لتحقيق أهداف التنمية المستدامة الأربعة الأولى.

Introduction

In recent years, poverty is increasingly being understood as a multifaceted phenomenon encompassing deprivations along multiple dimensions. Several normative, practical and political motivations have sufficiently argued this new conception. Academic researchers are currently debating how to incorporate multidimensionality into poverty measures, how to account for the joint distribution of deprivation across the entire population of a country and how to interpret the different categories of the deprived households. The Report by the Commission on the Measurement of Economic Performance and Social Progress (2009) highlighted the relevance of an approach that considered how developments in one domain of quality of life affected other domains and how developments in various fields are related to income. In this context, Atkinson and Bourguignon (1982) argued for the inclusion of these cumulative effects in measures related to quality of life, this is why multidimensional measurement methods have made immense progress for a long time, and they open up new prospects for introducing new non-monetary indicators in measuring poverty. Of course, in practice, the poverty measurement is a step that precedes any public intervention to alleviate the deprivations of the poor. However, between one year and the next, many people move into or out of poverty. Thus measures of who is poor now are imperfect guides to who will be poor next year, yet it is the latter that is relevant for public policies that aim to reduce poverty. The critical need then is to go beyond a cataloging of who is currently poor and who is not, to an assessment of households' vulnerability to poverty. Furthermore, the study of poverty focuses on those who are currently poor (or were poor in the past). This is because poverty can be measured only *ex post*. Such an approach has its merits: for instance, by using actual data one may measure the effects of past public interventions on the extent of poverty; and it allows us to identify whose poverty needs to be alleviated. But governments and policy makers are typically more interested in the effects that their measures will have in the future. For this it would be valuable to be able to identify those who are expected to be poor *ex ante* (that is, in the future). Such households are considered to be vulnerable to poverty. On this matter, Chaudhuri, Jalan, and Suryahadi (2002) put it, "for thinking about appropriate forward-looking antipoverty interventions (. . . that aim to prevent or reduce future poverty . . .), the crucial need then is . . . an assessment of households' vulnerability to poverty." There are many different approaches towards defining and conceptualising vulnerability, which not only differ in terminology but also in the methods applied towards measurement. In this research, we attempt to contribute towards existing literature on vulnerability to the multidimensional poverty measurement in manyways. First, the paper analyse existing literature on measurement of vulnerability and of multidimensional poverty, partly the works of Chambers (1989), Alwang et al (2001) and Alkire and Foster (2007, 2011). Secondly, we follow Qizilblash (2002, 2003) and we link the vulnerability to the vagueness of poverty which is related to the idea that there is no clear cut borderline between the 'poor' and the 'non-poor'. In this case, the concept of vulnerability does not concern the risk of becoming poor, but rather the possibility of being considered as multidimensional poor. And we suggest formalizing the resilience of the

vulnerable households against future shocks from the degree of membership attributed to each one for each dimension.

The rest of the paper is structured as follows. Section 2 presents the different definitions and the analysis methods of the vulnerability, this is in order to motivate our choice of the conceptual framework and the analysis approach adopted in this work. The section 3 describes the methodology, especially, the counting approach, the Venn diagram and fuzzy set theory. This will help us to identify the vulnerable group and to estimate then the degree of belonging to the group of each identified household likely to be poor in the future. Section 4 applies our methodology to the 2010 Tunisian Household Survey and discusses the estimation results. In this section, we offer also some recommendations for public policy. We will conclude this research in section 5.

2- Designs and vulnerability assessment methods

The concept of vulnerability has been a powerful analytical tool for describing states of susceptibility to harm, powerlessness, and marginality of both physical and social systems, and for guiding normative analysis of actions to enhance well-being through reduction of risk. This concept has been amended and adopted in several approaches and disciplines. For example, the biophysical approach mainly focuses on the vulnerability or degradation of biophysical conditions. The approach extrapolates the biophysical estimates to the impact on the human occupancy of a landscape (Liverman, 1990). It widely used in studies of vulnerability to natural hazards and climate change (Adger and Kelly, 1999 and Bohle and Watts, 1994). In the human ecological approach, vulnerability is assessed by embedding the human systems within ecological processes (Moran 1990). The Political Economy Approach nonetheless emphasizes the crucial role that differential economic and political power play in determining the differential vulnerability of individuals and groups. Consequently, the vulnerability is based on the theory of marginalization (Susman et al., 1983) and food entitlements (Sen, 1981). Moreover, the impetus for research on entitlements in livelihoods has been the need to explain food insecurity, civil strife and social upheaval. Research on the social impacts of natural hazards came from explaining commonalities between apparently different types of natural disasters and their impacts on society.

In the development studies, the emergence of the theme of economic vulnerability of populations dates back to the early 2000s. It is in line with poverty analysis and has joined the analysis of the consequences of natural, political or other disasters that plunge or keep part of the population in poverty. An attractive definition of vulnerability to poverty is the propensity to suffer from a significant shock of well-being, bringing the household below a defined level of the social minimum. Alwang et al (2001). In sum, vulnerability refers, on the one hand, to a predisposition of populations to be affected by an external detrimental event, in the sense that individuals face shocks and pressures from their physical, economic and social environment, etc. This dimension corresponds to the idea of exposure. in this sense, identifying the group of individuals likely to be poor in the future becomes a crucial exercise to correctly

measure the degree of vulnerability for each identified individual. On the other hand, vulnerability refers to the inability to react to shocks that may occur; this dimension is interpreted as an internal effect indicating the degree of resilience of individuals. Which is a fundamental property that must be respected by any proposed measure of vulnerability. Although there are a large number of studies offering various conceptions of vulnerability, the empirical evaluation methods of this concept are significantly fewer. In this section, we present only the asset ownership method that is part of the multidimensional approach to poverty. This approach is in line with Chambers' (1989) idea that households with asset structures (eg, durable goods and equipment) have greater responsiveness. Synthetic asset indices, such as those developed in the context of capability approach. Sen, for example, have been interpreted as reverse indicators of vulnerability. An alternative method to asset structure is suggested by expected utility theory (Hoddinott and Quisumbing, 2003). The latter states that the expected utility of risk-averse individuals decreases with increasing variability in consumption. Conceptually, the use of regressions links household exposure (changes in well-being) to their responsiveness (household characteristics), which is a strength of this method. Nevertheless, critics are emerging concerning the lack of a real predictive character of vulnerability (Calvo and Dercon, 2005). Cafiero and Vakis (2006) state that "all these measures are truly focused on the past. This is insufficient because the concept of vulnerability is in itself turned towards the future: it must capture the consequences on the well-being of being at risk, not of being the victim of an event ". They propose, as an alternative, adding to an (absolute) poverty line, an estimate of the cost of insurance needed by households to ensure their exit from poverty. This idea is relatively intuitive in the sense that it is considered that individuals closest to the poverty line, although above, are more likely to experience poverty in the event of an external shock. In the same perspective, Qizilbash (2002, 2003) linked the issue of vulnerability to poverty to the concept of vagueness and suggested that it be formalized from the degrees of belonging attributed to households. So, the notion of vulnerability does not focus on the risk of becoming poor, but rather on the possibility of being considered multidimensional poor. In the Tunisian case, we are not aware of previous work that derives a measure of vulnerability in a multidimensional framework from cross-section data. In this paper, we combine two approaches often used separately in the poverty literature: The counting approach precisely the union criterion will be used to identify the vulnerable group. so, the union criterion indicates the swath of society that risks multidimensional poverty at some point in time. In other words, if a household becomes deprived in one additional dimension, it will fall into the group considered poor. The theory of fuzzy sets then will be introduced in a second step to measure the degree of vulnerability and which informs us about the resilience factors of each household.

3- Measuring Vulnerability to the Multidimensional Poverty in Tunisia

To examine the vulnerability to the multidimensional poverty in Tunisia at a household level, we use a methodology based on two steps.

In the first step, the conceptual underpinnings are based on the identification approach presented by Alkire and Foster (2007,2011) for the measurement of multidimensional poverty. This counting approach assumes that the identification of the poor is more complex; the terms ‘deprived’ and ‘poor’ are no longer synonymous. A person who is deprived in any particular dimension may not necessarily be considered poor. Rather, an identification method with an associated identification function is used to define who is poor. Here, we present briefly the key points of the Alkire-Foster (AF) methodology based on the dual cut-off method.

Consider a nation or any geographic region with (n) households and (d) dimensions. Let $Y = |y_{ij}|$ represents an achievement matrix of a society, where (y_{ij}) is the achievement of the i^{th} household in the j^{th} dimension for all $j = 1, \dots, d$ and all $i = 1, \dots, n$. The row vector $(y_i) = (y_{i1}, y_{i2}, \dots, y_{id})$ summarize the achievements of household in the (d) dimensions, whereas, the column vector $(y_{.j}) = (y_{1j}, y_{2j}, \dots, y_{nj})$ represents the distribution of achievements in the j^{th} dimension across the (n) households. The deprivation cut-off for the j^{th} dimension is indicated by (z_j) . Corresponding to any matrix $Y = |y_{ij}|$, a $(n \times d)$ dimensional deprivation matrix $g^0 = |(g_{ij}^0)|$ is constructed. Each element of g^0 is equal to one when the i^{th} household is deprived in the j^{th} dimension and is equal to zero when the household is not deprived. In other words, each entry of the matrix g^0 can take only two values as follows:

$$g_{(ij)}^0 = \begin{cases} 1 & \text{if } y_{ij} < z_j \\ 0 & \text{if } y_{ij} \geq z_j \end{cases}$$

Based on matrix g^0 , we construct an n-dimensional column vector $c = |c_i|$ where each element c_i indicates the number of deprivations suffered by the i^{th} household. Then, it is a matter of deciding on how many dimensions household should be deprived so as to be considered multi-dimensionally poor. That is equivalent to setting a second poverty line (k). A household is considered multi-dimensionally poor if $c_i \geq k$. The decision on the value of k is left to researcher and several different values can be tested.

In counting identification methods, the criterion for identifying the poor can range from ‘union’ to ‘intersection’. The intersection criterion ($k = d$) identifies a person as poor only if she is deprived in all considered dimensions. In contrast, the union criterion ($k = 1$) identifies a person as poor if the person

is deprived in any dimension and indicates the swath of society that risks poverty at some point in time. In other words, if the intention is to design measures to prevent poverty in the future, vulnerability to poverty must be measured and the union approach is helpful.

Based on Venn diagrams, we illustrate these three identification approaches for the case of three dimensions (d1, d2 and d3). Venn diagrams consist of a collection of closed figures, such as circles and ellipses that include, exclude, or intersect one another such that each compartment is associated with a class.

Table1: the joint distribution of deprivations in three dimensions

		d1		d2		d3	
		Non -deprived	deprived	Non deprived	deprived	Non -deprived	deprived
d1	Non -deprived	n_{0++}	—	n_{00+}	n_{01+}	n_{0+0}	n_{0+1}
	deprived	—	n_{1++}	n_{10+}	n_{11+}	n_{1+0}	n_{1+1}
d2	Non -deprived	n_{00+}	n_{10+}	n_{+0+}	—	n_{+00}	n_{+01}
	deprived	n_{01+}	n_{11+}	—	n_{+1+}	n_{+10}	n_{+11}
d3	Non -deprived	n_{0+0}	n_{1+0}	n_{+00}	n_{+10}	n_{++0}	—
	deprived	n_{0+1}	n_{1+1}	n_{+01}	n_{+11}	—	n_{++1}

Note: (+) can be 0 or 1

Thus, (n) denote the total number of households, n_{111} denotes the number of people who are deprived in all three dimensions, n_{010} denotes the number of people who are deprived in the second dimension only, and so on for other combinations.

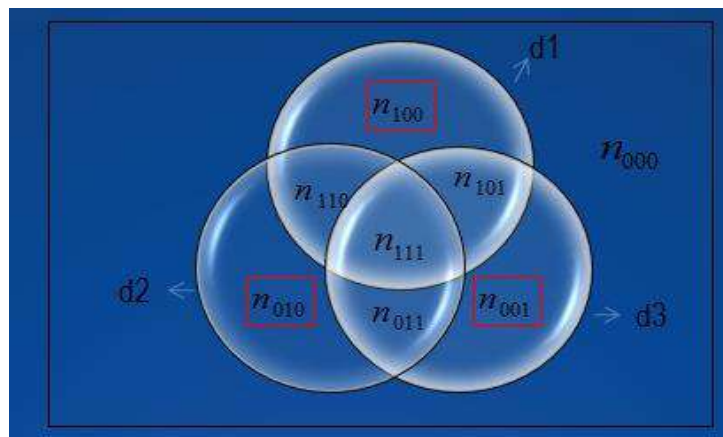


Fig1: Venn diagram of joint distribution of deprivations in three dimensions

Applied to the analysis of multidimensional poverty measurement, the interior of each closed figure in a Venn diagram can be used with a set of indicators and associated deprivation cutoffs to represent the number of people who are deprived in a certain dimension. Naturally, the exterior of each closed figure can be used to represent the number of people who are non-deprived in the same dimension. Note that

these two groups—deprived and non-deprived—within each dimension are mutually exclusive and collectively exhaustive with respect to the considered population. The intersections between the closed figures show the extent to which deprivations in different dimensions overlap, that is, the number of people who are jointly deprived in certain dimensions in a particular society. In this research, each household deprived in just one dimension will be considered vulnerable, and the households who are deprived in more than one dimension will be identified as multidimensional poor.

Generally, the term vulnerability refers to exposure to contingencies and stress, and difficulty in coping with them. In the second step, we will use the fuzzy sets theory in order to identify the resilience or responsiveness in exploiting opportunities and in resisting or recovering from the negative effects of the shocks, and to propose a measure of vulnerability for each household identified in the first step. In fact, we have no information on the resilience capacities of households, which are the subject of our study, in the face of economic shocks. This makes the vulnerability analysis in this case an ambiguous and imprecise exercise. Indeed, Sen (1992) has warned about the risks of merrily ignoring such ambiguity: If an underlying idea has an essential ambiguity a precise formulation of that idea must try to capture that ambiguity rather than attempt to lose it. Even when precisely capturing an ambiguity proves to be a difficult exercise that is not an argument for forgetting the complex nature of the concept and seeking a spuriously narrow exactness. In social investigation and measurement, it is undoubtedly more important to be vaguely right than to be precisely wrong. For the case of the vulnerability to poverty, it is therefore a question of modeling this ambiguity. In this research it is therefore important to modelize the ambiguity related to the households vulnerability. To do this, we use the fuzzy sets theory introduced by Zadeh (1965), from the idea of partial membership of a class and graduality in the transition from one situation to another. It constitutes a generalization of the classical set theory and it deals with intermediate situations between everything and nothing. Moreover, since the fundamental work of Cerioli and Zani (1990), fuzzy sets have been used in multidimensional poverty. A significant academic literature now applies the fuzzy set approach to poverty measurement. The theoretical contributions include Betti and Verma (2008), Chiappero-Martinetti (2008), Belhadj (2010, 2011, 2012) and D'Ambrosio. et al (2011). Alongside these theoretical contributions, there are also other applications adopting fuzzy sets as a framework for analysis. Qizilbash (2002) applied this theory including the method of Cerioli and Zani (1990) and that of Cheli and Lemmi (1995) to study vulnerability in South Africa. In his work, Qizilbash (2002) has assigned for each household a degree of membership and he has interpreted those with a degree between 0 and 1 as vulnerable, the others are considered to be either undeniably rich or the absolutely destitute (poor). In this regard, we assume that the degree of membership to the vulnerable group depends on the distribution of household achievements (y_{ij}) in each dimension exposed to shocks and in which households are not initially deprived, and that people are ranked according to their achievement. L gives the rank order of the level of achievement, and is set to one for the highest ranking level, to two for the second highest level, and so on. For household ranked,

$V(y_{ij}^{(L)})$ denotes the degree of membership to the set of the vulnerable. We set $V(y_{ij}^{(L)}) = 0$ for $L = 1$.

Then, we will write the sampling distribution of (y_{ij}) arranged in increasing order according to L as $H(y_{ij})$.

Then for $L > 1$, the level of vulnerability associated to the dimension j is given by:

$$V(y_{ij}^{(L)}) = V(y_{ij}^{(L-1)}) + \frac{\{H(y_{ij}^{(L)}) - H(y_{ij}^{(L-1)})\}}{1 - H(y_{ij}^{(1)})}$$

For each dimension that can be a recipient of shock, a household with a degree of belonging close to 1 is considered very vulnerable and has a low resilience against the effects of shock. on the other hand, a degree close to zero reflects a strong ability to cope with the shock suffered.

4- Results and Discussion

4.1-Data, dimensions and deprivation thresholds

The data we use are taken from the 2010 Tunisian national consumption survey conducted by the INS (National Statistics Institute of Tunisia). This survey covers the entire country (large cities, small and medium towns and rural areas) and encompasses three areas of study: (i) the expenses and acquisitions of households, (ii) the food consumption and nutritional status of households, and (iii) household access to community services (i.e. health and education). This survey is a primary source of information on the nutritional situation of the Tunisian population and on their access to public services such as health care, education and transport at the regional level. The sampling frame is stratified in two geographic criteria: the governorate and the living environment. The strata used are the following: large corresponding municipalities with over 100,000 citizens, neighbouring towns of small and medium municipalities, and a layer of outlying communities. The 2010 Tunisian national consumption survey covered a sample of 13,392 households theoretically drawn in a random survey. The survey covers the entire year, allowing INS to assess the level of consumption and welfare of Tunisian people based on their geographic, demographic and socioeconomic characteristics. Difficulties in procuring basic resources, such as education, health, etc. in different areas of Tunisia are converted into household expenses and the downstream generation of difficult living conditions. For example, the absence of health services or schools in rural areas implies additional fees for transport, which aggravates the situation of a poor household. The links between dimensions motivate our empirical analysis space. We use household spending in order to analyze vulnerability to the multidimensional poverty. This approach is generally preferred because expenses seem much more closely related to quality of life (Slesnick 1998; Deaton 1997). First, we exclude dimensions that do not reflect hardships on households (Belhadj 2012). Thus, dimensions that are not major sources of deprivation and are very hard to eliminate in developing countries should be excluded. Thus, dimensions that are not major sources of deprivation and are very

hard to eliminate in developing countries should be excluded. These dimensions include leisure and culture; alcoholic beverages and tobacco; furniture and art; and telecommunication. The analysis of deprivations based on a comprehensive study of dimensions that contribute more to the welfare of household's nation wide requires the exclusion of dimensions that do not have magnitudes in nonmunicipal areas (Nasri and Belhadj, 2017). We retain three dimensions (food, health and education) that are related to social public policies in Tunisia. In fact, there are two types of instruments for social transfer in Tunisia, one of which is the Tunisian Universal Food Subsidies Programme. Since 1970, basic foodstuffs have been subsidised to protect the purchasing power and nutritional status of the poor. There is also the National Programme of Assistance to Needy Families, which involves the allocation of monthly financial assistance based on the number of children enrolled in school and the allocation of free health care cards (for which the eligible population is defined according to the national poverty line and regional quotas) or reduced-price health care cards (for which the eligible population is defined based on the minimum wage). In addition, Tunisia allocated close to 6.3% of its national wealth to health spending in 2010. Thus, the share of overall health expenditure covered by social security has increased from 32.2% in 2000 to 47.7% in 2010 (OASIS 2014)¹.

Therefore, we estimate poverty thresholds for each variant in our analysis; each threshold indicates a level of food or non-food consumption below which a person is considered poor. These thresholds take into account the consumption patterns of Tunisians and the cost of living in different regions of Tunisia. In Table 2, we present the strata of Tunisians and the poverty line corresponding to each dimension j. The INS calculates the food poverty line (Z_s^A) by multiplying the median cost k cal of reference group (Cs) by the recommended energy needs (BERs) at each stratum s: $Z_s^A = C_s * BER_s * 365 \text{ days}$.

Table 2. Poverty thresholds for different strata.

Strata	BER*	Z_j^{A*}	Z_j^{NA}	
			Health	Education
Largest cities	2272	382000	348086	71320
Small, medium-sized towns	2305	372000	238678	45503
Non communal areas	2327	301000	166447	20702

***Source: National Statistics Institute of Tunisia (INS).**

The non-food thresholds include a threshold for judging whether an individual is deprived in the health dimension and a threshold to assess their situation in the educational dimension. The selection of average spending in these two dimensions (health and education) as thresholds of poverty is justified by the idea that utility is related not only to absolute consumption or wealth but also to an individual's relative position along these dimensions within a given reference group, as demonstrated by Kuziemko et al.

¹ Organisation Assessment for Improving and Strengthening Health Financing

(2014), who formulated the last-place aversion model to show that the economic benefit and well-being of a household are not determined simply by the desire to accumulate wealth but also by the household's relative position vis-à-vis others who live in the same area. According to this model, the thresholds of the two dimensions (health and education) vary across the geographical areas of Tunisia. These two thresholds are the same calculated by Nasri and Belhadj (2017). To complete the dual-cutoff method, we advocate a line of $K = 2$, from which we consider a household multidimensionally poor.

4.2 Identifying the Vulnerable Groups

According to Table 3, Tunisian households likely to be classified as poor are identified based on $k = 1$: we can see that 91.4% of Tunisian households being deprived in at least one dimension. This rate incorporates the poor (57.7% of households) who are deprived in at least two dimensions including the households deprived on the three deprivations (14.8% of total number of households).

Table 3: the vulnerable households in Tunisia

<i>Poverty cut-offs (k)</i>	<i>Head count ratio (H)</i>	<i>Vulnerable groups</i>
1	0.914	0.337
2	0.577	0.000
3	0.148	0.000

The Vulnerable households group is obtained by subtracting the number of poor households from the number of households who are deprived in just one dimension. 33.7% of households suffer only from one deprivation. This group is the subject of our analysis concern. However, some others will resist against the shock and will keep their situations; these households have relatively significant responses ability. According to this line of reasoning, it is clear that there is a major ambiguity in which households are likely to be identified as poor in the future. This vagueness can be presented in two forms. A horizontal imprecision that indicates the ambiguity of the dimension (s) contributing more to the vulnerability. The second form is the imprecision of those who are at the extreme vulnerability whose their factors resiliencies are weak. This requires the estimation of the degree of vulnerability for each household belonging to this group in each dimension that can be a recipient of shock

4.3 The sources for vulnerability in Tunisia

Our results show that 28 vulnerable households in the sample live below the deprivation threshold of the food dimension. They can undergo shocks in both health and / or education dimensions. Their ability to cope with these shocks depends on their incomes or initial endowments. In addition, the incomes distribution of these 28 households enables us to classify them according to the methodology described above and to represent them in both figures 2 and 3. Considering health as a primary source for the

vulnerability of this group. The membership degree of household 1 is low in the group; he is close to become classified among the rich than among the poor households

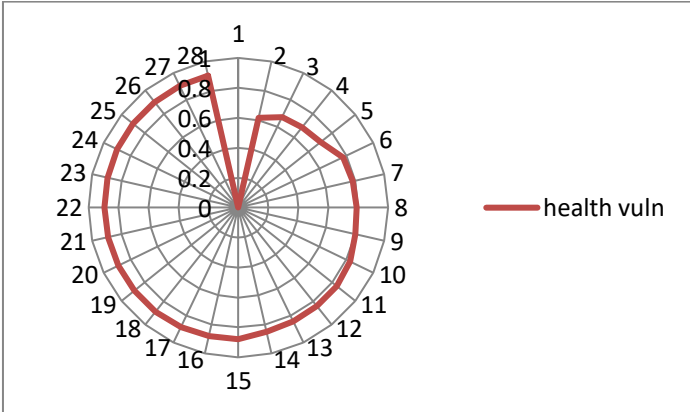


Fig. 2: Membership degrees in the vulnerable group (health dimension)

From the sixth household, the rest of the group has a membership degree greater than or equal to 0.8. This defers slightly for education whose households with a high degree of membership (greater than 0.8) will be counted from the third household. It is important here to note that household ranks do not indicate their identifiers. That is, the household who has a low degree in the vulnerability in health dimension is not necessarily the household that has the lowest degree in the group of vulnerable analyzed in the education dimension. In addition, Table 4 (see Appendix) shows us the identifier of each vulnerable household and its degree of membership to the group and its residence region. Ten households from this group live in Tunisia Center, and they had high membership degrees. Thus, we can conclude that the ability of these households is very weak and they had a difficulties to withstand the impact of an economic shock (price increase, income change or a natural event). A second alternative solicited by Quisblash is to interpret these households as eligible to be permanently poor. From this viewpoint, the vulnerability is related to the possibility of being classified as poor; it is distinct from the vulnerability which is linked to the probability of becoming poor discussed in the economic literature.

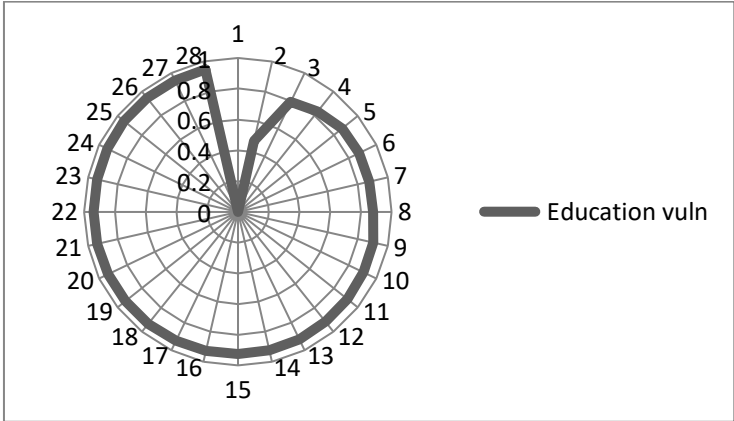


Fig.3: Membership degrees in the vulnerable group (Education dimension)

To refine this analysis, we find that the household with the highest degree of belonging in the education dimension (0.949) is a household composed of five members, two of whom are students (see the initial data base), while his membership degree to the vulnerable group in the health dimension is equal to 0.838. In other words, its resilience is lower in education than in health. However, the most vulnerable household in the health dimension (with a membership degree equal to 0.904) is more vulnerable in education with a membership degree equal to 0.93. This household is a west central resident and he is composed of five persons. In other words, its resilience is lower in education than in health. However, the most vulnerable household in the health dimension (with a membership degree equal to 0.904) is more vulnerable in education with a membership degree equal to 0.93. This household is a west central resident and he is composed of five persons. In the same way, we interpret the other households by specifying for each time their degrees of vulnerability in each concerned dimension. In the rest of this research, we will focus our interpretations on the percentages of the vulnerable in each region.

4.3.1- The vulnerable households deprived on health dimension

1771 Tunisian households are affected by health deprivation and they are exposed to the risk of being poor in the future in the case of shocks in both food and education dimensions. These households are distributed among the seven regions of Tunisia as shown in Table 4.

Table 4: Distribution of vulnerability among regions

<i>Regions</i>	<i>Head count ratio (H)</i>	<i>Extreme vulnerability (Food dimension)</i>	<i>Extreme vulnerability (Education dimension)</i>
<i>Tunisia</i>	1771	1761	1674
<i>Great Tunis %</i>	18.9	18.9	18,3
<i>North East %</i>	14.4	14,4	14.3
<i>North West %</i>	13.0	13,1	13
<i>Central East %</i>	23.4	23,2	23,3
<i>Central West %</i>	8.2	8,1	8
<i>South East %</i>	9.2	9,2	9,4
<i>South West %</i>	12.9	12,8	13.4

The third column of table 4 tells us about the extreme vulnerability of the food dimension. the vulnerability rates varies between regions. 23.2% of extremely vulnerable households living the East Center. This measure exceeds 10% in South West, in North West, in North East and in Greater Tunis regions. The fourth column with the table rows (except the first row) shows the percentages of vulnerable households in the education dimension for each region. 13.4% of these households residing in the South West suffer from deprivation in the health dimension and they living in an extreme vulnerability in education. Moreover, 8% of these households live in the North West are considered close to the poor group because they have already the experience of deprivation in the health dimension.

4.3.2- Distribution of Extreme Vulnerability among Regions

In this section, the vulnerability to poverty will be analyzed from two dimensions (food and health) which will be treated as the shocks recipients.

The second line of the table 5 shows the number of households deprived only in the education dimension, with the last column, displays 2200 households who are concerned by the vulnerability study. More than a thousand of these households reside in Greater Tunis and East Center of Tunisia.

Table 5: Estimates of Extreme Vulnerability by membership degrees at regional level

Région	<i>Great Tunis</i>	<i>North East</i>	<i>North West</i>	<i>Central East</i>	<i>Central West</i>	<i>South East</i>	<i>South West</i>	Total
Head count	547	280	185	493	262	261	172	2200
<i>(A) Vulnerability (Food)</i>								
[0.7, 0.8 [	57	6	4	38	9	13	10	137
[0.8, 0.9 [	231	84	63	202	72	112	66	830
[0.9, 1[	245	189	117	243	176	130	93	1193
<i>(B) Vulnerability (Health)</i>								
[0.7, 0.8 [	15	3	0	10	7	3	2	40
[0.8, 0.9 [	39	12	11	44	16	28	8	158
[0.9, 1[	484	262	173	432	239	226	162	1978

The evaluated households in the North East, Center West and South East regions are 280, 262 and 261, respectively. Indeed, a one deprivation in the food dimension or in the health dimension is sufficient to consider these households as multidimensional poor. This additional deprivation will depend essentially on two factors: The first is called external factor, it takes the form of an economic shock causing a disruption in the household achievement in dimensions undergoing shocks. The second is internal factor; it reflects the household capacity to absorb shocks effects. In other words, this second factor indicates the household resilience against hazards. As indicated above, we focus our research on the second factor and we analyze the membership degree for each household belonging to the vulnerable group. A low membership degree is interpreted as a high level of resistance against shocks, but a low resistance is understood by a high membership degree. For example, with a degree higher than 0.7, the household is getting closer to the poor group and its capacity is more or less low and the risk to have an additional deprivation increases. The panel (A) in Table 5 shows the membership degrees to the vulnerable group if the households will undergo a shock in the food dimension. There are 137 households whose membership degrees lie between 0.7 and 0.8. 57

of this set live in Greater Tunis and they can be considered as the future poor. The entire future poor widens further in the range $[0.8, 0.9]$ and between 0.9 and 1. Our results show 2023 Tunisian households living in extreme vulnerability and they had a low capacity to cope with prejudicial event. In the same way, we present in the panel (B), the vulnerability levels observed from the health dimension. The households' number increases with the increase of the membership degrees. For example, in Greater Tunis, 15 households had a degrees lie between 0.7 and 0.8, and for the same region we estimate 484 households in the interval $[0.8, 0.9]$. Moreover, In the Central West, households living in extreme vulnerability exceed the threshold of 235; it holds 432 in the East Center.

5- Conclusion and recommendation

In this paper, we presented a theoretical framework of vulnerability and their different methods of analysis. The vulnerability design usually depends on the object of work and the subject being analyzed. In the academic literature, vulnerability is viewed from two perspectives, external and internal.

The external viewpoint reflects the predisposition of a group to a prejudicial event causing, downstream, degradation in the living conditions of the group members. As for the internal perspective, it is interpreted as the ability of individuals to shocks. However, the vulnerability to poverty is more complex to understand because it relies on the choice of a well-being indicator and the definition of a poverty line. We have seen how a dual identification method based on a counting approach can provide insight into the undeniably rich and the absolutely destitute. This allows us to identify the group of vulnerable households. In a second step, we used fuzzy sets theory to estimate the membership degrees to each vulnerable group and to understand the sources of vulnerability for each individual in the Tunisian regions. The results obtained show that the sizes of groups identified as vulnerable vary according to the deprivation source. Nevertheless, the number of vulnerable households is growing as the degree of vulnerability increases. This proves that the idea of focusing on vulnerability to poverty makes it possible to guide the outcome of the debate towards the concerns of economic policy essentially in appropriate forward-looking policies aimed at preventing or reducing future poverty. The important implication will arise from this research is the identification of households likely to be poor in the future. Vulnerable households comprise households that are deprived in only one dimension, which—based on our methodology described above—are excluded from the group of households considered poor. This implication underscores the

importance of well-targeted poverty prevention policies in addition to policies aimed at reducing existing poverty. There is an urgent need for the introduction of social protection policies to protect households from becoming poor in the future. Another expected result of this research will also inform us about the resilience capacities of households vulnerable to shocks in each region.

Appendix. 1: The first group of Tunisian vulnerable households and their membership degrees

v001	dpa hygiene and care	rank	region	Membership	v0012	dpa_education	rank3	membership
5327	2538216	1	4	0	9245	912444	1	0
8308	978760	2	5	0,61439082	964	482500	2	0,47120094
9164	834080	3	6	0,67139151	5179	190142	3	0,79161328
8194	798860	4	5	0,6852674	9164	153688	4	0,83156537
5119	749468	5	4	0,70472675	5327	121000	5	0,86739007
5563	567610	6	4	0,77637474	920	113600	6	0,87550017
5181	544880	7	4	0,78532985	8543	111161	7	0,87817321
5179	533514	8	4	0,7898078	1677	110800	8	0,87856885
3601	503966	9	3	0,80144905	5119	87875	9	0,90369371
964	435437	10	1	0,82844794	8308	83100	10	0,90892691
8365	408983	11	5	0,83887023	5181	80200	11	0,91210519

5614	408880	12	4	0,83891081	5563	78514	12	0,91395298
9245	403055	13	6	0,84120573	5935	72600	13	0,92043448
11158	386416	14	7	0,84776112	8981	70454	14	0,92278641
6546	307840	15	4	0,87871831	6546	67520	15	0,92600195
5935	305500	16	4	0,87964022	7159	66800	16	0,92679104
8313	294950	17	5	0,88379668	4293	62800	17	0,93117488
920	283120	18	1	0,88845744	8200	61400	18	0,93270922
5197	279612	19	4	0,88983951	8194	60000	19	0,93424356
8543	274866	20	5	0,89170933	3601	57833	20	0,93661851
9280	271687	21	6	0,89296179	11158	56333	21	0,93826244
7159	267000	22	4	0,89480836	9280	56281	22	0,93831943
7921	259487	23	5	0,89776831	5197	54500	23	0,94027134
1677	258546	24	1	0,89813905	7921	51500	24	0,94355921
3176	258020	25	2	0,89834628	8313	48666	25	0,94666516
8981	256018	26	6	0,89913502	3176	48583	26	0,94675613
4293	250934	27	3	0,901138	8365	48333	27	0,94703012
8200	242600	28	5	0,90442141	5614	46060	28	0,94952123

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