Coping Strategies and Perceived Effects in Response to Climate Shock Exposure: Household resiliency toward food insecurity related to drought in central Tunisian rural communities

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Abstract : Climate change exacerbated droughts by making them more frequent that increased risks of food insecurity faced by rural families in arid areas. Adopting coping mechanisms are necessary to reduce the vulnerability of rural agricultural communities and enhance their resilience to climate change. The main objectives of this paper are i) to assess effectiveness of the adopted coping strategies in rural areas by measuring resilience properties of household livelihoods and ii) to identify their key drivers. we will measure. A cross-sectional survey among 671 sample households was conducted in Kairouan and Zaghouan. To understand the key drivers of each livelihood coping strategy and compare different livelihood strategies we used an updated version of we used and updated the resilience analysis framework. A special attention was given understand how household-level characteristics correspond to household coping strategies towards an identification and assessment of the coping mechanisms adopted by farmers to mitigate the impact of drought on their livelihood and food security. Results showed income and food access, assets possession, access to basic services, adaptive capacity, and social safety nets have positive and significant effect on farm households' resilience to food insecurity. Climate change and stability have a negative and significant effects. This could be due to the negative effect of the climate change especially drought on the household resilience.

Keywords*:* Resilience index; food insecurity; drought, rural area; structural equation modelling, Tunisia.

Résumé : Le changement climatique et la sécheresse ont fortement affecté la sécurité alimentaire des ménages ruraux dans les zones arides. Les mécanismes et stratégies d'adaptation adoptés par les agriculteurs de ces régions sont essentiels pour réduire la vulnérabilité des communautés agricoles rurales et renforcer leur résilience face à l'impact négatif des chocs climatiques tels que la sécheresse. Ce papier fournit une évaluation de l'adoption des stratégies d'adaptation déployées par les agriculteurs dans les zones rurales en mettant l'accent sur leurs facteurs clés. En particulier, l'objectif de l'étude est de contribuer aux efforts en cours pour mesurer et évaluer les dimensions de résilience des moyens de subsistance des ménages, en expliquant pourquoi certains ménages sont plus résilients que d'autres. Une enquête transversale a été menée auprès de 671 ménages dans les villages de Kairouan et Zaghouan. Une analyse factorielle et des modèles de régression ont été utilisés pour analyser les données à l'aide de SPSS version 22. Une attention particulière a été accordée pour comprendre comment les caractéristiques au niveau des ménages agricoles correspondent à leurs stratégies d'adaptation en vue d'identifier et d'évaluer les mécanismes d'adaptation adoptés par les agriculteurs pour atténuer l'impact de la sécheresse sur leurs moyens de subsistance et leur sécurité alimentaire.

Mots clés *:* Index de résilience insécurité alimentaire, sécheresse, zones rurales, modélisation en équations structurelles, Tunisie.

1. INTRODUCTION

Climate change has a strong impact on agricultural sector in Tunisia (GIEC, 2020). Research by the Ministry of Agriculture and Hydraulic Resources (MARH) in collaboration with Germany's GIZ (MARH and GIZ 2012), using the HDCM31 climate model, predicts worsening water stress and land degradation. Deep groundwater aquifers and surface water will face respectively 28% and 5% decline by 2030. Consequently, under the effect of the drought, rainfed cereal production and olive production will decrease by 20% and 52%. Livestock production will be limited by climate change and total production is expected to decline by 36 to 50%, (Gafrej, 2016; AFD, 2021; GIEC, 2020). Furthermore, climate projection predicts an increase of extreme weather-related events, including flash floods, wildfires, and related hazards (Treguer et al, 2018). Recently, drought episode that occurred between 2015 and 2016 reduced land productivity and seriously threatens domestic food and water security (Verner et al., 2018, Treguer et al, 2018). Drylands are particularly affected by climate change through changing rainfall patterns and land degradation and there is often little renewable water stored available to offset resource deficits (Sun et al. 2006). Coping mechanisms and strategies are necessary to reduce the vulnerability of rural agricultural communities and enhance their resilience to climate threats such as drought.

The concept of resilience within food and nutrition security has gained increased recognition among governments, non-governmental organizations, civil society, and research institution (Zseleczky and Yosef, 2014). The use of the resilience concept in the development field is relatively new. Recently a comprehensive theoretical framework for defining and measuring resilience has been proposed (Barrett and Constas, 2014) and applied to analyse the complexes socio-ecological systems were ecological and socioeconomic components are closely integrated. Folke, (2006), Alinovi et al. (2008) define resilience as the capacity of a household to keep a certain level of wellbeing (e.g. food security), notwithstanding shocks and stresses, and reorganize while undergoing change so as to still retain essentially the same function, structure, identity. The Technical Working Group on Resilience Measurement (FSIN, 2014) defines resilience as the capacity that ensures adverse stressors and shocks do not have long-lasting adverse development consequences. Dercon (2001) argued that access to assets is an important determinant of poverty and the ability to cope with vulnerability and reinforce resilience. Indeed, the resilience "is the capacity over time of a person, household or other aggregated unit to avoid poverty in the face of various stressors and in the wake of myriad shocks (Barrett et al, 2014). If and only if that capacity is and remains high, then the unit is resilient. The coping strategies common in agriculture include crop diversification, land and water management land and water management, changing planting dates, changing cropping patterns diversification of crop varieties, crop insurance, income diversification, migration, combined use of surface and groundwater, development of new water sources (deepening of boreholes, purchase, and sale of water in informal water markets) sale of land and conversion to rain-fed agriculture.(Chitongo., 2019 ; Bwamble, 2015 ;Gebrehiwot et al., 2013; Wheeler et al., 2013.Alam, 2015; Bosco et al., 2016).

In Tunisia farmers and civil society stakeholders showed a relative weakness of resilience face to drought over the past 20 years (Verner et al. 2018). Weakness of resilience can be explained by the overexploitation of groundwater resources, which are the primary buffer for drought impacts in most areas, together with the weakening of government-funded safety nets and changes in agricultural and social practices. Poor transport, electricity, water storage, and supply infrastructure compound these problems. Coping mechanisms and strategies adopted by Tunisian farmers in arid areas are necessary to reduce the vulnerability of rural agricultural communities and enhance their resilience towards coping with adverse impact of climate threats such as drought. Climate change and drought have greatly affected the food security of rural families in these areas. Thus, adopting several coping mechanisms to mitigate the effect of drought to their farming production, identifying these strategies and livelihood security pathways that farmers use in the face of this climate shock are required to be investigated and documented. Identifying the coping strategies towards building and improving resilience is essential for rural farm households to reduce food insecurity and poverty among them and the entire rural population, in general, where their livelihoods depend mainly on farming. This is mainly to understand how farmers

[1] *Hadley Centre Coupled Model, version 3.*

minimize the effects of drought on their production, and consequently enhancing livelihood and ensuring food security, especially if faced to harsh climatic conditions. Hence, there is a need to understand the specific coping strategic options that farmers in these dry areas employ in the face of increased drought at the household level, as well as the factors affecting farmers' choice of these coping strategies.

Yet, despite progress made in assessing the impact of climate shocks on rural households' livelihoods and their food security in dry land areas, very little is known about ongoing adaptation strategies and resilience approaches followed by rural communities in the centre of Tunisia to increase food security in the context of drought. This paper provides an assessment of the coping strategies adopted by the farmers in rural areas with special focus on their respective key drivers. Particularly, the objective of the study is to contribute to ongoing efforts to measuring and assessing resilience properties of household livelihoods, explaining why some households are more resilient than others. A special attention was given understand how household-level characteristics correspond to household coping strategies towards an identification and assessment of the coping mechanisms adopted by farmers to mitigate the impact of drought on their livelihood and food security.

2. MATERIALS AND METHODS

3.1. Study area

The study focused on two governorates with similar agro-ecological conditions; Zaghouan (located in Northeast of Tunisia) and Kairouan (located in Central West of Tunisia). Kairouan represents a crossroads between the north, the south, the east and the west of the country. It covers an area of 6712 km^2 and it is characterized by an arid climate in the south and semi-arid climate in the north. Average rainfall ranges between 200 mm in the south to 350 mm in the north (Figure 1). Topography of Kairouan has a clear two-level pattern including flat and fertile plains at the eastern part (100 m above the sea) and medium to high mountain at the west part reaching 700 m altitude with the exception of Jebel Serj which reaches an altitude of 1300 m. Agriculture remains one of the most important economics activities. It employs 30% of the workforce. The agricultural area covers 614,340 ha of which 432,080 ha are arable of which 80% are cultivated (15% in irrigation and the rest in rainfed). Around 33% of agricultural land are in pastureland and 6% in forest (CRDA Kairouan, 2011). Most of the small-holders family farms practice mixed tree-crop-livestock activities. The mixed systems constitute a good basis to enhance the agroecological proprieties of the ecosystems based on the synergies and interaction between agricultural activities. Zaghouan covers an area of 2820 km^2 and is characterized by a semi-arid climate with an average annual rainfall of 450 mm. Agricultural land in Zaghouan covers 270,000 ha (more than 96% of the total area), including 185,000 ha of arable land and 87,000 of forest and rangelands. Agriculture activities is based mainly on cereals and fodder farming system that extends over 25 000 ha. However, there is a potential for forest products to be better exploited and irrigated crops are under development.

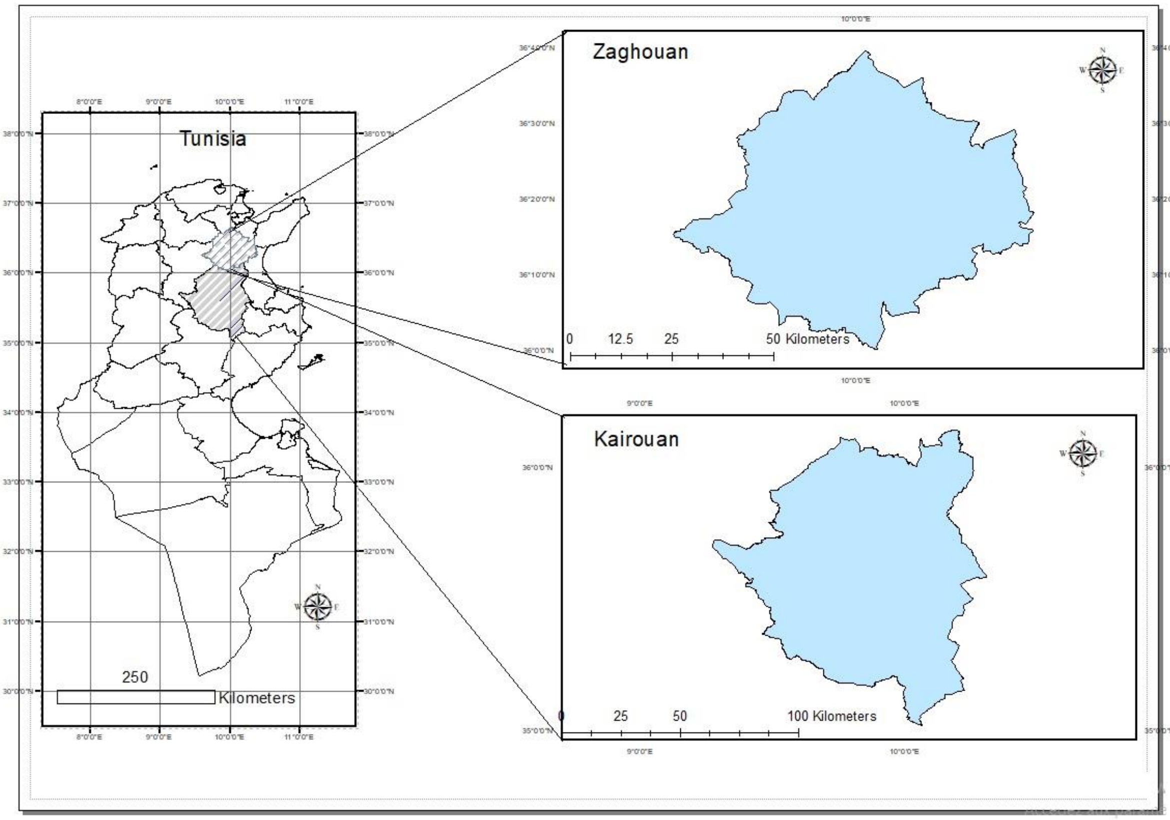

Figure1. Case study location

3.2. Data collection

A household's questionnaire has been conceived within the framework of Min the Gap project to meet our main objective, such as the assessment of the coping strategies to climate change adopted by farmers in rural area. Office of livestock and pasture (OEP), partner of Min the Gap project, provided a list of 700 smallholder farmer in the two governorates. Interviewed smallholder farmers were identified based on the following criteria: (i) ownership of 0–5 ha of land and (ii) ownership of 1–50 small ruminants. Selection procedure resulted into 480 farmers from Kairouan and 220 farmers from Zaghouan. Data for the impact analysis were collected through a follow-up survey conducted in December 2018. The questionnaire was divided into 17 modules covering all the variables that can influence the adoption of coping strategies by smallholder farmers. Statistical analysis was performed with SPSS Version 22.0 statistic software package. The analysis concerned a total sample of 671 HH.

3.3. Theoretical framework and empirical application

A mixed methods research design is used to assess the coping strategies to climate change adopted by farmers in rural area. Descriptive statistics, coefficient of correlation, binomial and multinomial logistic regression models are used for quantitative and qualitative data analysis. Totally, 671 survey have been conducted in central Tunisia (Zaghouan and Kairouan) with farmers whose livelihood is predominantly depending on crop production. To understand and explore household resilience to food insecurity and identify determinant factors of household resilience index (RI) across rural farmers in the target areas, we applied an updated version of the resilience analysis framework (Alinove et al., 2008, 2010; FAO, 2013). This model can be expressed as follow:

$$RI = f\,(AC, AP, S, SSN, IFA, ABS, CC) \qquad \text{(Equation 1)}$$

Where, RI = resilience Index; AC = Adaptive Capacity; AP = asset-possession; S = Stability; SSN= Social Safety Net; IFA = Income and Food Access; ABS = Access to Basic Services; CC = Climate change.

Household resilience to food insecurity related to drought is a latent variable, which in turn is a function of seven latent variables estimated from several observed variables. Taking into account the specificity of the local context (climate, cultural, social, political, etc.), the resilience of a household is assumed depending to options available for a household to better absorb the shock through access to assets such as; income generating activities, access to basic services, social safety nets, adaptative strategies, etc. Consequently, we used binomial and multinomial logistic regression models to identify the determinants of the respondents' perceptions. Finally, we proceed through two-step cluster analysis method to assess mean comparison for the selected resilience clusters of farm households according to their resilience level with respect to the different coping strategies towards drought. The table 1 summarizes the observed variables used to estimate each latent indicator used to estimate household resilience index.

Table 1. Explanatory variables of latent indicators

Latent indicators	Observed variables
IFA	Access to Food (AF): Number of food products eaten in previous 7 days: 16 items Food Outside (FO): Amount in last month (TND) Household food expenditure (HFE) : Amount in last week (TND) Own Food Products (OFP): number between 0 et 16 items Food Spent by person (FSP): Amount (TND)
AC	Income Diversity (ID): with values between a minimum of 1 and a maximum of 13. Available Coping Strategies (ACS): that ranges from 0 to 18. Education Years (EY): Number Number of House and Agricultural Assets (NHAA): Number. Insurance Expenditure (IE): Amount Celebration Expenditure (CE) : Amount
AP	Owned Land (OL): in Hectares Herd size (HS): Number House Asset (HA): Amount in Tunisian Dinars. Smartphone Assets (SMA): Amount in Tunisian Dinars. Phone Assets (PHA): Number Storage Assets (SA): Amount in Tunisian Dinars. Livestock Stable Assets (LSA): Amount in Tunisian Dinars.
ABS	Distance to extension services (DES): in kilometers Distance to College (DC): in kilometers Distance to School (DS): in kilometers Distance to Agricultural Market (DAM): in kilometers Distance to Input Market (DIM): in kilometers Distance to Village Market (DVM): in kilometers Distance to Health Center (DHC): in kilometers
S	Family size (FS): Number of persons Number of Households Off Farm (NHOF): Number of persons Farming Experience (FEX): Number of years Education years (EY): Number of years
SSN	Borrowed money from friends, neighbours, and relatives (BM): (Yes/No) Government transfer (GT): (Yes/No) Remittances/Gifts/Transfers (RGT): (Yes/No) Dependence to others to adopt technology (improved variety) (DTO): (Yes/No) Trade in Agricultural Products (TAP): (Yes/No)
CC	Observed Drought (OD): (Yes/No). Observed Hailstorm (OHS): (Yes/No). Observed Floods (OF): (Yes/No). Observed Wind (OW): (Yes/No). Observed Temperature Fluctuation High (OTFH): (Yes/No).

Source: Own elaboration form field data (2021).

4. RESULTS AND DISCUSSION

4.1. Estimation of the Latent Indicators

To estimate latent indicators, we proceed as following: First, we applied a multivariate analysis (i.e. principal components and factor analysis for continuous variables and optimal scaling for non-continuous variables) using the available indicators of each latent dimension separately. Relevant variables were selected based on the factor loadings and other statistical criteria. These criteria included Kaiser-Meyer-Olkin (KMO) statistics of sampling adequacy and Bartlett's test of sphericity, communalities, and variance explained by the generated factor. Secondly, selected variables were used to estimate the respective subcomponent of the overall RI.

4.1.1. Income and Food Access (IFA)

The observed variables used to estimate IFA indicator are continuous. Thus, the principal component analysis method with a Promax rotation and the scoring method proposed by Bartlett (1937) have been used. The Kaiser- Meyer-Olkin (KMO) measure of sampling adequacy is in the range of 0.567 indicating that the distribution of values is adequate to perform a factor analysis (Table 2). This corresponds well with Field's (2005) suggestion that validates analysis if the KMO test is> 0.5. Furthermore, Bartlett's test is evaluated, and it is significant as the result showed that p=0.000 (<0.05) and chi-square = 590.894 which suggests that the factor analysis was appropriately performed on the data available for the study.

Table 2. Communalities, Factor Loadings, and Correlation of Variables with IFA

Indicators of IFA	Communalities		Factors & their loads		Corr. IFA
	Initials	Extraction	1	2	
AF	1.000	0.289	**0.890**	0.119	**0.672****
FO	1.000	0.618	**0.858**		0.472**
HFE	1.000	0.806	-0.312	**0.802**	**0.820****
OFP	1.000	0.741	0.358	**0.700**	0.156**
FSP	1.000	0.744	0.266	0.468	**0.775****
Eigenvalues	**Total**		1.977	1.221	
	Variance,%		39.548	24.425	
	Cumulative,%		39.548	63.973	
KMO Test of Sampling Adequacy = 0.567 Bartlett's Test of Sphericity = significant at p=0.000; Chi-square=590.894 **Extraction Method: Principal Component analysis** ****. Correlation is significant at the level of 0.01**					

Source: Own elaboration form model results (2022).

All observed variables are positively correlated with the latent indicator, meaning that an increase in each variable increases the level of income and food access, which is mainly correlated with the variables access to food, household food expenditure and food spent by person. Those variables should be considered in the elaboration of development policies and strategies. The factor scores can be used to estimate the IFA as follows: ((FAC1 * 1,977) + (FAC2 * 1,221)) / 2.

4.1.2. Adaptive Capacity (AC)

Table 2 shows that the KMO measure of sampling adequacy is on the order of 0.502 and the Bartlett's test of sphericity is significant (p-value = 0.000, Chi-square = 76.797). These results indicate that our sample presented in Table3 is adequate for the factor analysis. The most observed variables positively correlated with the latent indicator AC are income diversity, available coping strategy and celebration expenditure, indicating that any increase in these variables increases adaptive capacity. Households needed a stable income to adopt costly coping strategies, if household income increases, then the likelihood of adopting a coping strategy will also increase (Muthelo et al., 2019).

Table 3. Communalities, Factor Loadings, and Correlation of Variables with AC

Indicators of AC	Communalities		Factors & their loads			Corr. AC
	Initials	Extraction	1	2	3	
ID	1.000	0.734	0.114		**0.850**	**0.445****
ACS	1.000	0.662		**0.785**	0.211	**0.553****
EY	1.000	0.324	**0.334**		-0.452	-0.068
NHAA	1.000	0.630		**0.758**	**-0.232**	0.363**
IE	1.000	0.569	*0.738*		-0.157	0.378**
CE	1.000	0.571	*0.746*		0.113	**0.548****
Eigenvalues	**Total**		1.277	1.214	1.008	
	Variance,%		**21.283**	**20.242**	**16.799**	
	Cumulative,%		21.283	**41.525**	**58.323**	
	KMO Test of Sampling Adequacy = 0.502 Bartlett's Test of Sphericity = significant at p=0.000**;** Chi-square=76.797 **Extraction Method: Principal Component analysis** ****. Correlation is significant at the level of 0.01**					

Source: Own elaboration form model results (2022).

The equation estimating the AC latent indicator is: ((FAC1 * 1,277) + (FAC2 * 1,214) + (FAC3* 1,008)) / 3.

4.1.3. Asset Possession (AP)

Since all observed variables in table 4 are continuous, we used the principal component analysis method with promax rotation and Bartlett's scoring method. The measure of sampling adequacy KMO is about 0.617 and Bartlett's test of sphericity is significant (p-value = 0.000, Chi-square = 205.417).

Table 4. Communalities, Factor Loadings, and Correlation of Variables with AP

Indicators of AP	Communalities		Factors & their loads			Corr. AP
	Initials	Extraction	1	2	3	
OL	1.000	0.493		**0.634**	0.301	0.459**
HS	1.000	0.825			**0.907**	0.440**
HA	1.000	0.549		**0.736**		0.309**
SMA	1.000	0.417	**0.638**			0.469**
PHA	1.000	0.373	0.209	**0.493**		0.272**
SA	1.000	0.557	**0.741**			**0.608****
LSA	1.000	0.605	**0.776**			**0.582****
Eigenvalues	**Total**		1.666	1.142	1.011	
	Variance,%		**23.804**	**16.307**	**14.445**	
	Cumulative,%		23.804	**40.111**	**54.556**	
	KMO Test of Sampling Adequacy = 0.617 Bartlett's Test of Sphericity = significant at p=0.000**;** Chi-square=205.417 **Extraction Method: Principal Component analysis** ****. Correlation is significant at the level of 0.01**					

Source: Own elaboration form model results (2022).

All variables are positively correlated with the latent indicator "Asset possession". The variables storage assets and livestock stable assets are the most correlated with AP indicating that households are more likely to sell assets to cope with the impact of climate change. Household assets are considered as an influential element in terms of coping strategies of farm households in the face of food insecurity.

(Chitongo, 2019; Goswami et al., 2018). The equation estimating the AC latent indicator is as follow: ((FAC1 * 1,666) + (FAC2 * 1,142) + (FAC3* 1,011)) / 3.

4.1.4. Access to Basic Services

As shown in table 5, the Kaiser-Meyer-Olkin (KMO) Sampling Adequacy Measure is in the order of 0.841 indicating that the distribution of values is adequate to perform a factor analysis. Bartlett's test is significant (p=0.000 (<0.05) and chi-square =2573.731) suggesting that factor analysis was appropriate for the used data.

Table 5. Communalities, Factor Loadings, and Correlation of Variables with ABS

Indicators of ABS	Communalities		Factors & their loads		Corr. ABS
	Initials	Extraction	1	2	
DES	1.000	0.832	**0.906**	0.107	**0.898 ****
DC	1.000	0.776	**0.870**	0.140	**0.873****
DS	1.000	0.546	**0.155**	**0.743**	0.364 **
DAM	1.000	0.742	**0.862**		**0.826****
DIM	1.000	0.726	**0.849**		**0.833****
DVM	1.000	0.674	**0.815**	**0.100**	**0.809****
DHC	1.000	0.647		**0.804**	0.230**
Eigenvalues	**Total**		3.816	1.157	
	Variance,%		**54.514**	**16.526**	
	Cumulative,%		54.514	**71.040**	
	KMO Test of Sampling Adequacy = 0.841 Bartlett's Test of Sphericity = significant at p=0.000**;** Chi-square=2573.731 **Extraction Method: Principal Component analysis** ****. Correlation is significant at the level of 0.01**				

Source: Own elaboration form model results (2022).

All variables are positively correlated with the latent indicator, ABS, which is estimated by the following equation: ((FAC1 * 3,816) + (FAC2 * 1.157)) / 2.

4.1.5. Stability (S)

The four observed variables are continuous. A factorial analysis was therefore carried out using the principal component analysis method with a Promax rotation and the Bartlett scoring method. It is noted that the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy is about 0.501. Bartlett's test of sphericity is significant (p-value = 0.000, chi-square =49.894). These results indicate that our sample is suitable for the factor analysis.

Table 6. Communalities, Factor Loadings, and Correlation of Variables with S

Indicators of S	Communalities		Factors &their loads		Corr. S
	Initials	Extraction	1	2	
FS	1.000	0.300	**0.827**		-0.258**
NHOF	1.000	0.713	-0.823		**0.553****
FEX	1.000	0.679		**0.842**	**-0.640 ****
EY	1.000	0.684		**-0.542**	**0.667****
Eigenvalues	**Total**		1.373	1.003	
	Variance,%		**34.322**	**25.070**	
	Cumulative,%		34.322	**59.393**	
	KMO Test of Sampling Adequacy = 0.501				

	Bartlett's Test of Sphericity = significant at p=0.000**;** Chi-square=49.894 **Extraction Method: Principal Component analysis** ****. Correlation is significant at the level of 0.01**

Source: Own elaboration form model results (2022).

The variables "Family size" and "Farming experience" are negatively correlated with the stability of latent indicator. The variable "Number of households off farm" has the highest positive correlation indicating that off-farm income offers the household more stability facing food insecurity. The equation estimating the S latent indicator is: ((FAC1 * 1,373) + (FAC2 * 1.003)) / 2.

4.1.6. Social Safety Net (SSN)

The observed variables incorporated to generate the latent indicator are dichotomous variables. Thus, optimal scaling was performed to estimate the SSN. The analyses show that Cronbach's alpha is greater than 0.7, indicating a significant and acceptable level of internal consistency, for our scale with the sample presented in Table 7.

Table 7. Communalities, Factor Loadings, and Correlation of Variables with SSN

Indicators of SSN		Factors &their loads 1	2	Corr. SSN
BM		-0.667	-0.356	**-0.729****
GT		0.187	0.576	**0.531****
RGT		-0 .109	0.550	**0.299****
DTO		0.779	-0.120	**0.484****
TAP		0.320	-0.601	**-0.181****
Eigenvalues		1.201	1.132	**Total Cronbach's alpha = 0,715[a]**
	Total Variance,%	**24.023**	**22.728**	
	Cumulative,%		**46.751**	
	[a]The total Cronbach Alpha value is based on total eigenvalue ****. Correlation is significant at the level of 0.01**			

Source: Own elaboration form model results (2022).

All observed variables are positively correlated with SSN, except two variables;Borrowed money from friends, neighbors and relatives andtrade in agricultural product. The equation estimating the SSN latent indicator is as follow: ((FAC1 * 1,201) + (FAC2 * 1.132)) / 2

4.1.7. Climate Change (CC)

Optimal scaling was used to estimate the CC latent variable related to dummy variables. Table 8 shows that 58 % of overall variation is explained by factors 1 and 2 (36.2 and 21.6 % respectively). The variables OW, OHS, OTFH, and OF are strongly correlated with the latent variable, CC. The equation estimating the CC latent indicator is: ((FAC1 * 1,818) + (FAC2 * 1.083)) / 2
all variables are positively correlated to the climate change latent variable.
the first factor.

Table 8: Communalities, Factor Loadings, and Correlation of Variables with CC

Indicators of CC		Factors &their loads 1	2	Corr. CC
OD		0.151	-0.772	**0.266****
OTFH		0.751	-1.175	**0.555****
OHS		0.667	0.138	**0.644****
OW		0.848	-0.007	**0.725****

OF		0.244	0.662	**0.549****
Eigenvalues	**Total**	1.818	1.083	**Total Cronbach's alpha = 0,818[a]**
	Variance,%	**36.242**	**21.663**	
	Cumulative,%		**57.905**	
	[a]The total Cronbach Alpha value is based on total eigenvalue ****. Correlation is significant at the level of 0.01**			

Source: Own elaboration form model results (2022).

4.2. Estimating an Overall Resilience Index (RI)

Results indicated that income and food access, assets possession, access to basic services, adaptive capacity, and social safety nets have positive and significant effect on farm households' resilience to food insecurity. Climate change and stability have a negative and significant effects. This could be due to the negative effect of the climate change especially drought on the household resilience and to the low level of education and the limited off farm income alternatives which negatively impact the household stability.

Table 9: Factor Loadings, Variance Explained, Correlation and Beta (B) coefficient of Latent Dimension with Household Resilience Index (RI)

Variable	Factors & their loads			Correlation with (RI)
	1	**2**	**3**	
S			-0,777	-0.421**
AC	0.466	0.628	-0.175	0.558******
AP	0.724	-0.137		0.412**
IFA	0.760			0.468**
ABS			0.717	0.387**
SSN	-0.122	0.807	0.141	0.461**
CC		-0.402		-0.146**
Eigenvalues	1.356	1.244	1.151	
Variance (%)	19.374	17.778	16.444	
Cumulative (%)		**37.153**	**53.596**	
KMO Test of Sampling Adequacy = 0.500 Bartlett's Test of Sphericity = significant at p=0.000; Chi-square= 137.299 R2: 92.9 **Extraction Method: Principal Component analysis** **** = Correlation is significant at the 0.01 level.**				

Source: Own elaboration form model results (2022).

The equation estimating the IR latent indicator is: ((FAC1 * 1,356) + (FAC2 * 1,244) + (FAC3 * 1,151)) / 3.

4.3. Typology of households by resilience index

To identify farm household clusters, the following ranges of RI scores have been used: (i) Vulnerable (RI < 0.100); (ii) Moderately resilient (0.100 ≤ RI < 0.250); (iii) Resilient (0.250 ≤RI < 0.500); and (iv) Highly resilient (RI ≥0.500) (Daie and Woldtsadik, 2015). Cluster analysis provided four resilience groups in farm households: 65.1% of the surveyed households were vulnerable, while 34.9% were resilient to different degrees (15.6% moderately resilient, 12.7% resilient, and 6.6% highly resilient).

Table 10: Household Resilience spectrum-based analysis in study area

	N	Percentage (%)	Cumulative Percentage (%)
Vulnerable (RI < 0.100)	437	65 .1	65.1
Moderately Resilient (0.100 ≤ RI < 0.250)	105	15.6	80.8
Resilient (0.250 ≤RI < 0.500)	85	12.7	93.4
Highly Resilient (RI ≥0.500)	44	6.6	100%
Total	671	100%	

Source: Own elaboration form model results (2022).

4.4. Determinants of household resiliency

From the multinomial regression analysis, significant (p <0.05) determinants of RI include a combination of resiliency factors. Empirical findings show that a 0.421 unit increase in the household's SSN increases the households' resilience by one standard deviation. A 0.112 unit decrease in climate change increases the households' resilience by one standard deviation. Results show that social safety nets, adaptive capacity, income and food access, assets and access to basic services have positive and significant effect on farm households' resilience to food insecurity related to drought.

Table 11: Relative Importance of Each Latent Variable in Household Resilience

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig
	B	Std. Error	Beta		
Constant	-8,911E-018	0.004		0.000	1.000
IFA	0.462	0.020	**0.346**	23.393	0.000
AC	1.066	0.041	**0.388**	26.138	0.000
CC	-0.337	0.043	**-0.112**	-7.909	0.000
SSN	0.790	0.027	**0.421**	28.815	0.000
ABS	0.424	0.015	**0.391**	27.577	0.000
AP	0.890	0.042	**0.309**	21.039	0.000

Source: Own elaboration form model results (2022).

4.5. Comparison of coping strategies scores for four clusters of farm households according to resilience level

Despite that drought is considered, by 98.5% of farm households, as the major shock observed in last decade and 78.4% of farm households were perceiving this constraint as very high, results showed that more than half of HH (56.2%) do not use any coping strategies to better face climate change shocks .The findings clearly indicate that a low knowledge of drought coping strategies, along with small and fragmented land holdings and low income are related to low and late adaptive measures to drought. The most coping strategies adopted by the farm households were sales of animals (18.3%), borrowing of money (10.6%), opting for non-agricultural employment (10.0%), introduction of supplemental irrigation (2.7%) and adoption of varieties resistant to drought (2.5%). For the vulnerable farm households, 18% have preferred to sell their animals, 9% to borrow money, and 9% to opt for non-agricultural employment. Only 3% of vulnerable farm households have adopted the improved varieties resistant to drought and have introduced the supplement irrigation. This vulnerable cluster had less success in mitigating the drought. In comparison with other groups, the moderately resilient farm households opted more to sale animals (22%) and to borrow money from friends, neighbours, and relatives (17%). Furthermore, changing eating habits, rural exodus and selling part of land were adopted by 2% of this household's group. Concerning resilient farm households, 21% opted to sale animals and for non-agricultural employment, 9% prefer borrow money and 6% to adopt varieties resistant to drought. Those highly resilient farm households opted for the non-agricultural employment (18% of HH) as the main coping strategy to recover from shocks related to drought.

Table 12: Results of mean comparison of coping strategies scores for four clusters of farm households according to resilience level

Coping strategies (1=adoption, 0= No adoption)	Clusters of Resilience to food insecurity							
	Vulnerable (N=437)		Moderately Resilient (N=105)		Resilient (N=85)		Highly Resilient (N=44)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Sale of animals (sheep, goats, cows, etc.)	0.18	0.385	0.22	0.416	0.21	0.411	0.07	0.255
Borrowed money from friends, neighbours and relatives	0.09	0.289	0.17	0.379	0.09	0.294	0.02	0.151
Option for non-agricultural employment	0.09	0.282	0.07	0.251	0.21	0.411	0.18	0.390
Adopted varieties resistant to drought	0.03	0.164	0.00	0.000	0.06	0.237	0.00	0.000
Introduction of supplemental irrigation	0.03	0.157	0.04	0.192	0.01	0.108	0.05	0.011
Less food consumed or changing eating habits	0.01	0.106	0.02	0.137	0.02	0.152	0.00	0.000
Migration to cities / rural exodus	0.01	0.106	0.02	0.137	0.00	0.000	0.02	0.151
Change of sowing date	0.01	0.083	0.00	0.000	0.02	0.152	0.00	0.000
Modified livestock composition (more than robust animals)	0.01	0.083	0.01	0.098	0.00	0.000	0.00	0.000
Fallow land	0.00	0.068	0.00	0.000	0.01	0.108	0.00	0.000
Sell part of the land	0.00	0.048	0.02	0.137	0.00	0.000	0.00	0.000

Source: Own elaboration form model results (2022).

5. CONCLUDING REMARKS AND POLICY IMPLICATIONS

The applied framework of resilience measurement index provided a deep understanding of resiliency of farm households to food insecurity and their determinants. Moreover, we identified a standard framework for assessing the resiliency of households to cope with shocks related to drought. In addition, considering the main differences between farm households in less and more resilient, and identifying effective factors in contributing to household resilience, can provide an opportunity for managers and policymakers in detecting gaps and developing adaptation strategies as well as focused interventions among the vulnerable farm households. Main finding showed a constraint to apply agricultural adaptation strategies in dry land areas were identified to be related to a lack of knowledge, expertise, and data on climate change issues. Furthermore, we note a lack of specific climate change institutions dealing with climate change issues and the need for a better institutional framework in which to implement adaptations.

In this direction, policy interventions should increase the knowledge of farm households about the risks of climate change on their food security and the different coping strategies that can be applied to face harsh climatic conditions. Such policies as:

- Creating opportunities for off-farm income-generating activities, especially for youth, should be included in any program and policy intervention in the study areas.
- Supporting small farmers to improve their income by facilitating access to credit.
- Creating of local markets closes to agricultural households to improve their marketing strategies.

- Regrouping small farmers in agricultural associations. The SMSA (Société Mutuelle de Services Agricoles) could play an important role in providing financial support to poor farm households by ensuring a simple and attractive credit system, enabling families to purchase essential household and food items.
- Enhancing the best agricultural asset management among farm households through specific trainings. Strategies related to improving farmer's knowledge on land and livestock management are also strongly recommended.
- Subsidizing more of what increases households' resilience, such as varieties that are highly drought adaptive
- Implementing programs (drought preparedness plans, soil erosion and water harvesting plans, etc.) that target the farmers' knowledge of how to face climate change difficulties in the best possible ways (Dhraief et al., 2019).

Agroecological practices have been proposed as promising tools for climate change adaptation (Altieri et al., 2015). The agroecological approach addresses the agro-environmental problems through a holistic perspective, which is necessary to tackle the multi-dimensional challenges of agriculture under global change (Lal, 2018). This holistic perspective not only considers the farm scale, but the food system, including environmental and socioeconomic aspects. In Tunisia, agroecological practices have a high adaptation potential through the cocreation of local knowledge based on the integration of scientific and traditional ecological knowledge.

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References

1. AFD, 2021.Rapport de l'agence française de développement, Tunisie contribution aux éléments de la phase préparatoire du processus du plan national d'adaptation (axe 2), Impacts des effets du changement climatique sur la sécurité alimentaire,
2. Alam Khorshed (2015) Farmers' adaptation to water scarcity in drought-prone environments: a case study of Rajshahi district, Bangladesh. Agricultural Water Management, 148: 196-206
3. Alinovi Luka., D'Errico, M., Mane, E., Romano, D. (2010). Livelihood's strategies and household resilience to food insecurity: An empirical analysis to Kenya. FAO, Rome, proceeding of the conference on promoting resilience through social protection in Sub-Saharan Africa, organized by the European report of development in Dakar, Senegal, 28-30 June 2010.
4. Alinovi Luka., Mane, E., Romano, D. (2008). Towards the Measurement of Household Resilience to Food Insecurity: Applying a Model to Palestinian Household Data, FAO, Rome, pp. 52-137, Available at, ftp://ftp.fao.org/docrep/fao/011/i0430e/i0430e.pdf.
5. Altieri, Miguel A., Nicholls, C.I., Henao, A., Lana, M.A., (2015). Agroecology and the design of climate change-resilient farming systems. Agron. Sustain. Dev. 35, 869–890.
6. Barrett, Christopher B., and Derek Headey (2013). Toward a Theory of Resilience for International Development Applications. Unpublished working paper, Cornell University, Ithaca, NY, US.
7. Bartlett, Maurice Stevenson (1937) Properties of sufficiency and statistical tests. Proc. R. Stat. Soc. 1937, 160, 268–282.

8. Vodounou, Jean Bosco K; and Yvette Onibon Doubogan (2016). Agriculture paysanne et stratégies d'adaptation au changement climatique au Nord-Bénin, Cybergeo. European Journal of Geography, http://journals.openedition. org/cybergeo/27836; DOI:10.4000/cybergeo.27836
9. Bwambale, Naboth (2015). Farmers Knowledge, Perceptions, and Socioeconomic Factors Influencing Decision Making for Integrated Soil Fertility Management Practices in Masaka and Rakai Districts, Central Uganda. Master'sThesis, Iowa State University, Ames, IO, USA.
10. Chitongo Leonard (2019). Rural livelihood resilience strategies in the face of harsh climatic conditions: The case of ward 11 Gwanda, South, Zimbabwe. Cogent Social Sciences, 5(1), 1617090.
11. Daie Ferede Guyu and Woldtsadik Muluneh (2015). Household Resilience to Seasonal Food Insecurity: Dimensions and Magnitudes in the "Green Famine" Belt of Ethiopia. Applied Science Reports, 11 (3), pp: 125-143.
12. Dercon, S. 2001. Assessing Vulnerability. https://www.researchgate.net/publication/228378379_Assessing_Vulnerability
13. DFID (UK Department for International Development). 2011. Defining Disaster Resilience: A DFID Approach Paper. London. www.gov.uk/government/uploads/system/uploads/attachment_data/file/186874/defining-disaster-resilience-approach-paper.pdf
14. Dhraief Mohamed Zied; Dhehibi, B; Daly Hassen; Zlaoui M; Khatoui C; Jemni S; Jebali O; Rekik M (2019). Livelihoods Strategies and Household Resilience to Food Insecurity: A Case Study from Rural Tunisia. Sustainability 2019, 11, 907. https://www.mdpi.com/2071-1050/11/3/907
15. FAO. 2013. Globalization of food systems in developing countries: impact on food security and nutrition. Food and Agriculture Organization of the United Nations, Rome, (34): 45-50.
16. Field A., 2005. Factor Analysis Using SPSS, C8057 (Research Method II).
17. Folke Carl (2006). Resilience: The Emergence of a Perspective for Social-Ecological Systems Analyses. Global Environmental Change, 16, 253-267. http://dx.doi.org/10.1016/j.gloenvcha.2006.04.002Folke, C. (2006). Resilience: The Emergence of a Perspective for Social-Ecological Systems Analyses. Global Environmental Change, 16, 253-267. http://dx.doi.org/10.1016/j.gloenvcha.2006.04.002
18. FSIN (Food Security Information Network), 2014. Resilience Measurement Principles : toward an agenda for measurement design. Technical Series No. 1,35 p. https://www.fsinplatform.org/sites/default/files/paragraphs/documents/FSIN_TechnicalSeries_1.pdf
19. Gafrej Raoudha (2016). Avec le changement climatique, quel avenir de l'agriculture en Tunisie?. CIHEAM Watch Lett, 2016, 37.
20. Gebrehiwot Tagel; Anne Van Der Veen (2013). Farm level adaptation to climate change: the case of farmer's in the Ethiopian Highlands. Environmental management, *52*(1), 29-44.
21. GIEC (2020). Le rapport spécial du GIEC sur le changement climatique et les terres émergées, Quels impacts pour l'Afrique ?). Disponible sur http://cdkn.org/sites/default/2021-07/IPCC%20Land_Africa_French_WEB_7Apr2020.pdf
22. Goswami R K ; Maiti S ; Garai S; Bhakat M; Chandel B; Kadian S (2018). Coping mechanisms adopted by the livestock dependents of drought prone districts of Bihar, India. Indian Journal of Animal Sciences, 88(3), 356-364.
23. https://openknowledge.worldbank.org/bitstream/handle/10986/16639/826480WP0v10Bu0130Box3798 6200OUO090.pdf?sequence=1.
24. Lal Rattan (2018). Digging deeper: A holistic perspective of factors affecting soil organic carbon sequestration in agroecosystems. Glob. Chang. Biol. 24, 3285–3301.
25. Muthelo Dakalo; Enoch Owusu-Sekyere; and Abiodun A. Ogundeji (2019). Smallholder Farmers' Adaptation to Drought: Identifying Effective Adaptive Strategies and Measures. Water, 11(10), 2069.
26. Pierre V.V ; Rigobert C.T ; Houinsou D ; Hervé G ; Olivier C.C ; Simplice D.V ; Euloge K., (2012). Perceptions et stratégies d'adaptation aux changements climatiques : le cas des communes d'Adjohoun et de Dangbo au Sud-Est Bénin. Les Cahiers d'Outre-Mer, 260: 479-492
27. Stéphane S (2011). Adaptation au changement climatique dans le secteur de l'eau en Méditerranée : situation et perspectives. Les Cahiers du Plan Bleu, 10. http://planbleu.org/sites/default/files/publications/ cahier10_eaucc_fr.pdf
28. Sun Ying; Solomon S; Dai A; Portmann R (2006). "How often Does it Rain?" Journal of Climate 19: 916–34.
29. USAID (United States Agency for International Development). 2012. Building Resilience to Recurrent Crisis: USAID Policy and Program Guidance. Washington,DC.https://www.usaid.gov/sites/default/files/documents/1866/Policy%20&%20Program% 20Guidance%20-20Building%20Resilience%20to%20Recurrent%20Crisis_Dec%202012.pdf.

30. Verner Dorte; Treguer D.O ; Redwood J; Christensen J; Mcdonnell R; Elbert C; Konishi Y (2018) Climate Variability, Drought, and Drought Management in Tunisia's Agricultural Sector. World Bank Group, Washington DC, USA, 2018, 114 pages.
31. WheelerSarah; Alec Zuo; and H. Bjornlund (2013). Farmers' climate change beliefs and adaptation strategies for a water scarce future in Australia. Global Environmental Change, 23(2): 537-547.
32. World Bank. 2013. Building Resilience: Integrating Climate and Disaster Risk into Development. Washington, DC.
33. Zseleczky Laura; Sivan Yosef (2014). Are shocks becoming more frequent or intense? In R. Pandya-Lorch S., Fan S Yosef, Resilience for food and nutrition security (pp. 9-17)? Washington, DC: International Food Policy Research Institute (IFPRI).