



Food Security and Environmental Change

Linking Science Development and Policy for Adaptation

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Measuring Household Resilience to Food Insecurity

An Application to Palestinian Households

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Research questions

- Vulnerability vs. Resilience: related but different concepts
- Objectives:
 - clarify the meaning of resilience as applied to food systems
 - discuss the relationship between vulnerability and resilience
 - develop a conceptual framework for defining HH resilience to food insecurity
 - apply the proposed methodology to the 11th Palestinian Public Perception Survey 2007.



Outline

- **Concepts**
 - resilience: ecological vs. engineering
 - HHs as (sub)systems within the broader food system
- **From concepts to measurement**
 - conceptual framework
 - modeling
- **Empirical application**
 - methodological approaches
 - estimation
 - validation
- **Implications**
 - policy implications
 - management implications



The concept of resilience

■ Definition

- engineering: ability to return to the steady state
- ecological: ability to absorb disturbances before changing state
- economic?

■ Economic definition of resilience

The ability of the household to keep with a certain level of well-being (e.g. food security) withstanding shocks and stresses, depending on:

- the options available to the household to make a living
- its ability to handle risks



Definition of Food Security

“Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life”
(FAO, 1996 World Food Summit)



Households as (sub)systems

- Decision unit

- entry point for food security analysis
- relationships with the broader food system

- System definition (Spedding, 1988)

“A group of interacting components, operating together for a common purpose, capable of reacting as a whole to external stimuli: it is affected directly by its own outputs and has a specified boundary based on the inclusion of all significant feedback.”

- complex adaptive systems:

- ◆ HH survival depends less on stability of its individual components than on its ability to maintain its self-organization in face of stress or shocks

⇒ Resilience

Analytical framework

- Wellbeing (e.g. poverty): ex-post measure
- Vulnerability: ex-ante description of the process outcome

		Expected future food security status	
		<i>Food secure</i>	<i>Food insecure</i>
Present food security status	<i>Food secure</i>	Food secure	Potentially food insecure
	<i>Food insecure</i>	Potentially food secure	Chronically food insecure
		<i>Non-Vulnerable</i>	<i>Vulnerable</i>



Analytical framework

■ Vulnerability

- economic (Dercon, 2001; Chaudhuri et al., 2002)
 - ◆ risks faced by the HH
 - ◆ options available to the HH
 - ◆ ability to handle risks
- disaster mngt / global change (Ahmad et al., 2001)
 - ◆ exposure to risks
 - ◆ sensitivity
 - ◆ adaptive capacity
- food security (FIVIMS-FAO, 2002)
 - ◆ nature of risks
 - ◆ HH responses



Analytical framework

- Households: (assets – income – wellbeing) x risks



Analytical framework

■ vulnerability

- output-based: asset-income-wellbeing (Dercon, 2001)

- $V = f(\text{exposure to risk, resilience})$

◆ risks faced by the HH

◆ options available to the HH

◆ ability to handle risks



■ resilience

- risk reduction and mitigation (ex-ante actions)

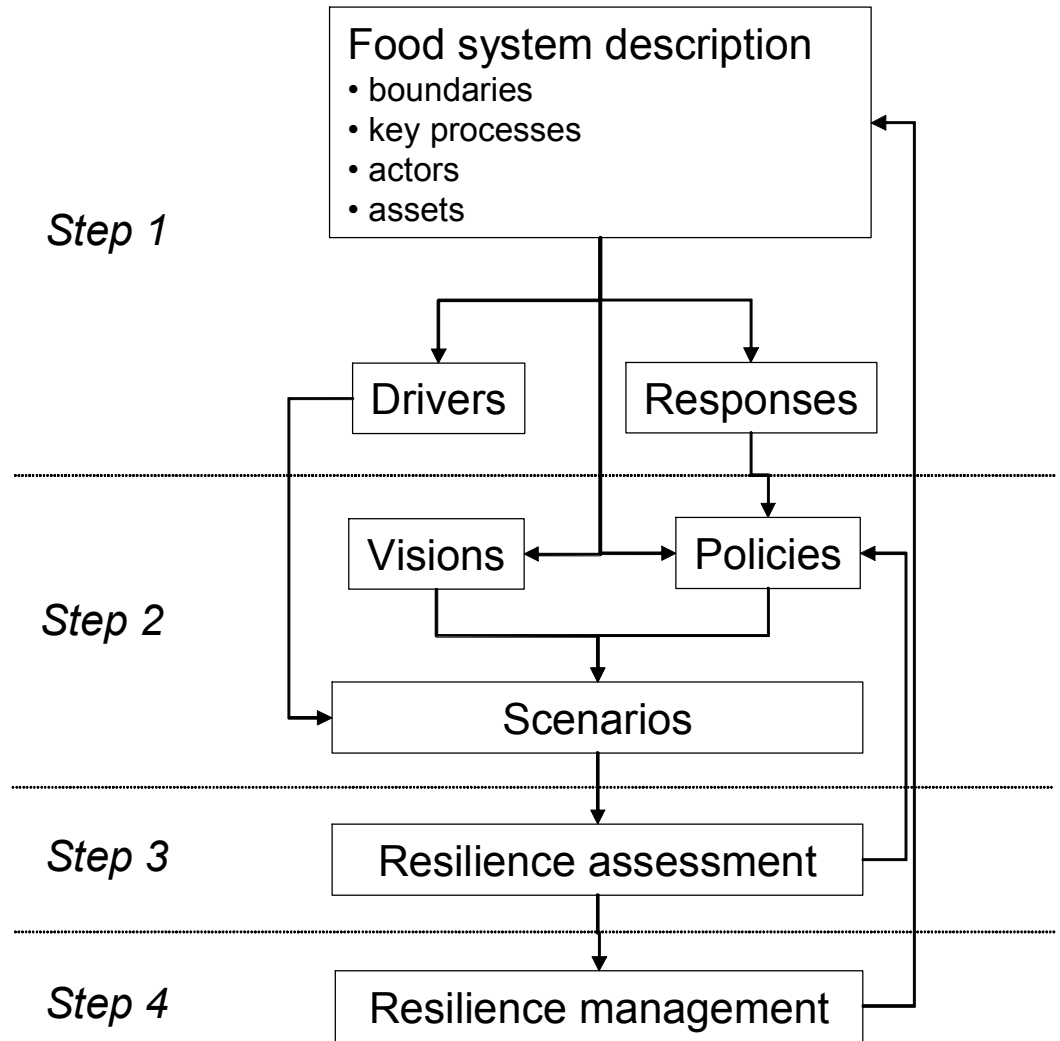
- coping strategies (ex-post actions)

- short term vs. long term

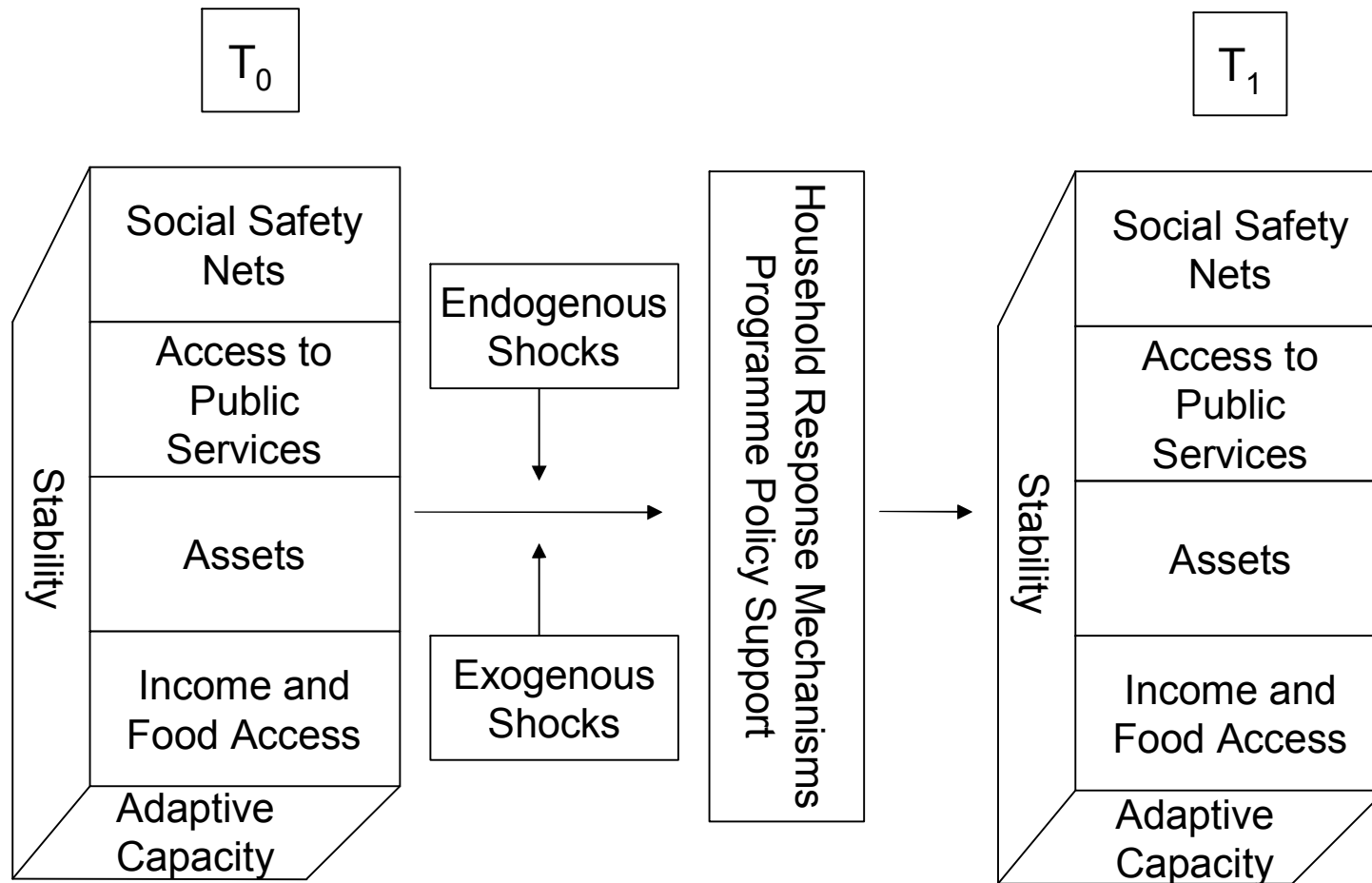
⇒ We focus only on resilience

Management implications

- Resilience of what?
- Resilience to what?
- Resilience assessment
- Resilience management

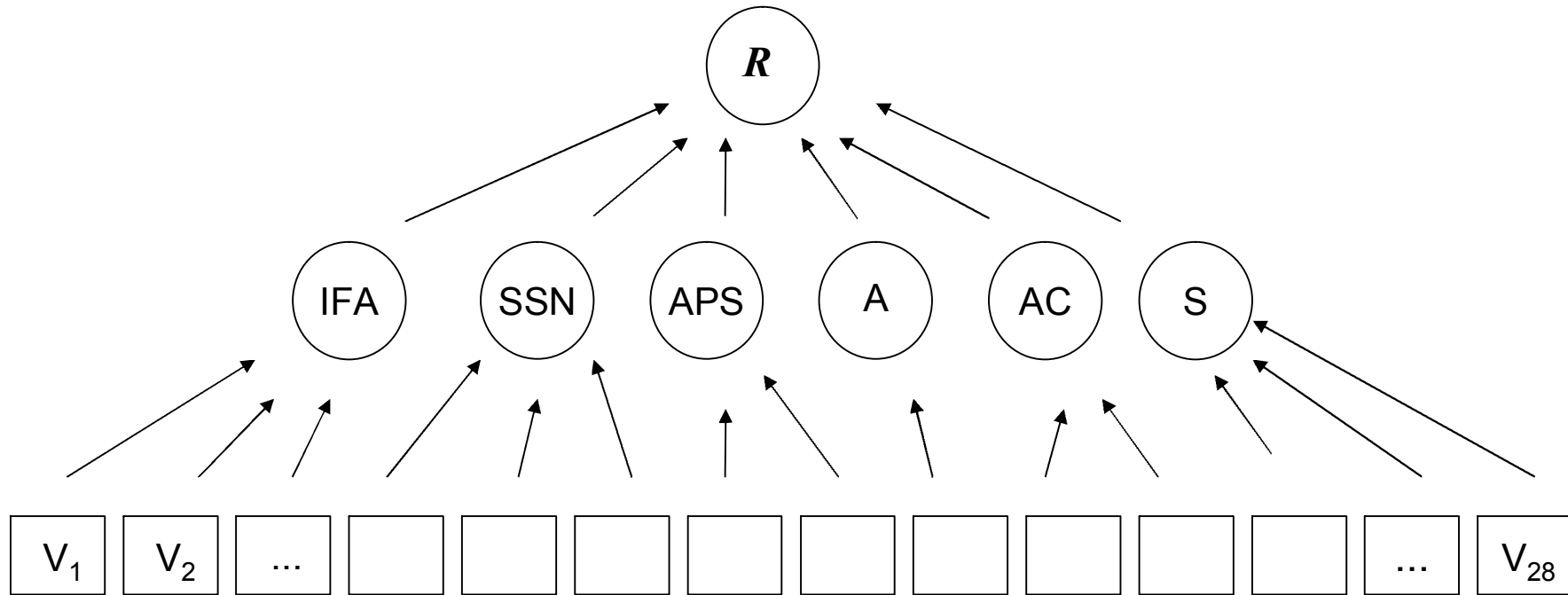


Resilience Conceptual Framework

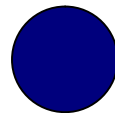


$$R_i = f(IFA_i, APS_i, A_i, SSN_i, S_i, AC_i)$$

Resilience Path Diagram



Observed variables



Unobserved (latent) variables



Methodological Approaches

■ Multi-Stage Approach

The measurement of each latent variable is done separately using different multivariate techniques (factor analysis, principal components, optimal scaling etc...)

■ Structural Equation Models (Not treated in this paper)

This method estimates the model as a whole and allows for testing procedures on the interactions among components. But, it is less flexible and, computationally, more difficult to estimate. Mostly, based on normality condition. (Polichoric correlations, MIMIC)



Data Set

- Palestinian Public Perception survey (2007)
- Sample Size: 2087
- Content:
 - The Roster (household's demographics, employment and education)
 - Security/Mobility
 - Labour Market
 - Economic Situation (includes the food security module)
 - Assistance/Assistance Priorities
 - Infrastructure
 - Coping Strategies
 - Health/Children/Women
 - Politics/Peace/Managing Security/Religion



Empirical Strategy

- Identification and processing of the variables relevant to each component of the resilience framework
- Application of multivariate methods (factor analysis, principal components analysis, optimal scaling etc.) to estimate an indicator for each component
- Application of the Classification and Regression Trees (CART) methodology to build precise decision rules based on the regression tree for a better understanding of the whole process and to easily transfer it to new data sets
- Link with Vulnerability to Food Insecurity



Income and Food Access

- Average per person daily income (NIS/person/day)
- Household food insecurity access score (HFIAS)
- Dietary diversity and food frequency score (DD)

Results of Factor Analysis

- Correlation Matrix analyzed through principal factor method
- Bartlett's scoring method used for to generate the latent variable *IFA*

Table 1. Eigenvalues

Factor	Eigenvalue
Factor1	1.54613
Factor2	0.75363
Factor3	0.70024

Table 2. Factor loadings and correlations

Variable	Factor1	IFA
Income	0.4466	0.6779
DD	0.4786	0.7308
HFIAS	-0.4860	-0.7431



Access to Public Services

- The public services considered in the analysis are the following:
 - Physical Access to Health Service (ordinal, 1 to 3)
 - Quality score of Health Service
 - Quality of Educational System (ordinal, 1 to 6)
 - Perception of Security (ordinal, 1 to 4)
 - Mobility and Transport Constraints (ordinal, 1 to 3)
 - Water, Electricity and Phone networks (count)



Problem

- Measurement Scale of the Variables (Categorical or Ordinal)
- Traditional Multivariate Methods are based on continuous variables

Solution

- Optimal Scaling
- PRINCALS algorithm

Description: This method estimates simultaneously optimal scaling and principal components. The estimation is conducted minimizing the following objective function (*loss function*):

$$\sigma(X, Y) = m^{-1} \sum_j SSQ(X - G_j Y_j)$$

where; SSQ is used to denote the sum of squares, m is the number of variables, X is the matrix of object scores, G_j is the indicator matrix for variable j and Y_j (scaling) is the matrix of category quantifications for j .



Correlation of *APS* with Transformed Variables

Transformed Variable	<i>APS</i>
Physical Access to Health	0.6040
Health Care Quality	0.5984
Educational System	0.4329
Perception of Security	0.5317
Mobility Constraints	0.5451
Water, Electricity and Phone	0.2838



Social Safety Nets

- Amount of Cash and In-kind Assistance (continuous, NIS/person/day)
- Goodness of Assistance (ordinal scale, 4 classes)
- Job Assistance (dummy, yes/no)
- Monetary value of 1st and 2nd type of assistance (continuous, NIS/person/day)
- Evaluation of the main type of assistance (ordinal scale, 4 classes)
- Frequency of assistance (count, number of assistance received in the last 6 months)
- Overall opinion on targeting (categorical; assistance targeted to the needy, even to some not needy; and targeted without distinction)



Correlation of SSN with Transformed Variables

Transformed Variable	SSN
Amount of Cash & In-kind Ass.	0.1669
Goodness of Assistance	0.7347
Job Assistance	0.3794
1 st and 2 nd Type of Assistance	0.7223
Evaluation of Main Assistance	0.7304
Frequency of Assistance	0.6775
Opinion on Targeting	0.4462



Adaptive Capacity

The adaptive capacity is measured through the following indicators:

- Diversity of income sources (count, 0 to 6)
- Available Coping Strategies (count, 0 to 18)
- Capacity to keep up in the future (ordinal, 1 to 5)

Correlation of AC with transformed variables :

Transformed Variable	AC
Diversity of Income Sources	0.3659
Coping Strategy Index	0.7551
Capacity to keep up in future	0.7800



Stability

The variables used for the measurement of stability are the following:

- Professional Skills (continuous)
- Educational Level (continuous)
- Employment Ratio (ratio, from 0 to 1)
- Number of HH members that have lost their job (count)
- Income Stability (ordinal; increased, the same, decreased)
- Assistance Dependency (ratio, from 0 to 1)
- Assistance Stability (ordinal; increased, the same, decreased)
- Health Stability (count, 0 to 8)
- Education System Stability (ordinal; increased, the same, decreased)



Correlation of *Stability* with Transformed Variables

Transformed Variable	S
Professional Skills	0.7234
Educational Level	0.7930
Employment Ratio	0.6786
HH members have lost their job	-0.0609
Income Stability	0.2112
Assistance Dependency	-0.3723
Assistance Stability	0.3116
Health Stability	0.1198
Education System Stability	-0.1315

Estimation of Resilience Index

Iterated Principal Factor Method (normally distributed variables)

Eigenvalues and σ^2 explained

	Eigenvalue	% Variance
Factor 1	1.31558	0.7134
Factor 2	0.30528	0.1656
Factor 3	0.21988	0.1192
Factor 4	0.00341	0.0018
Factor 5	-0.00017	-0.0001

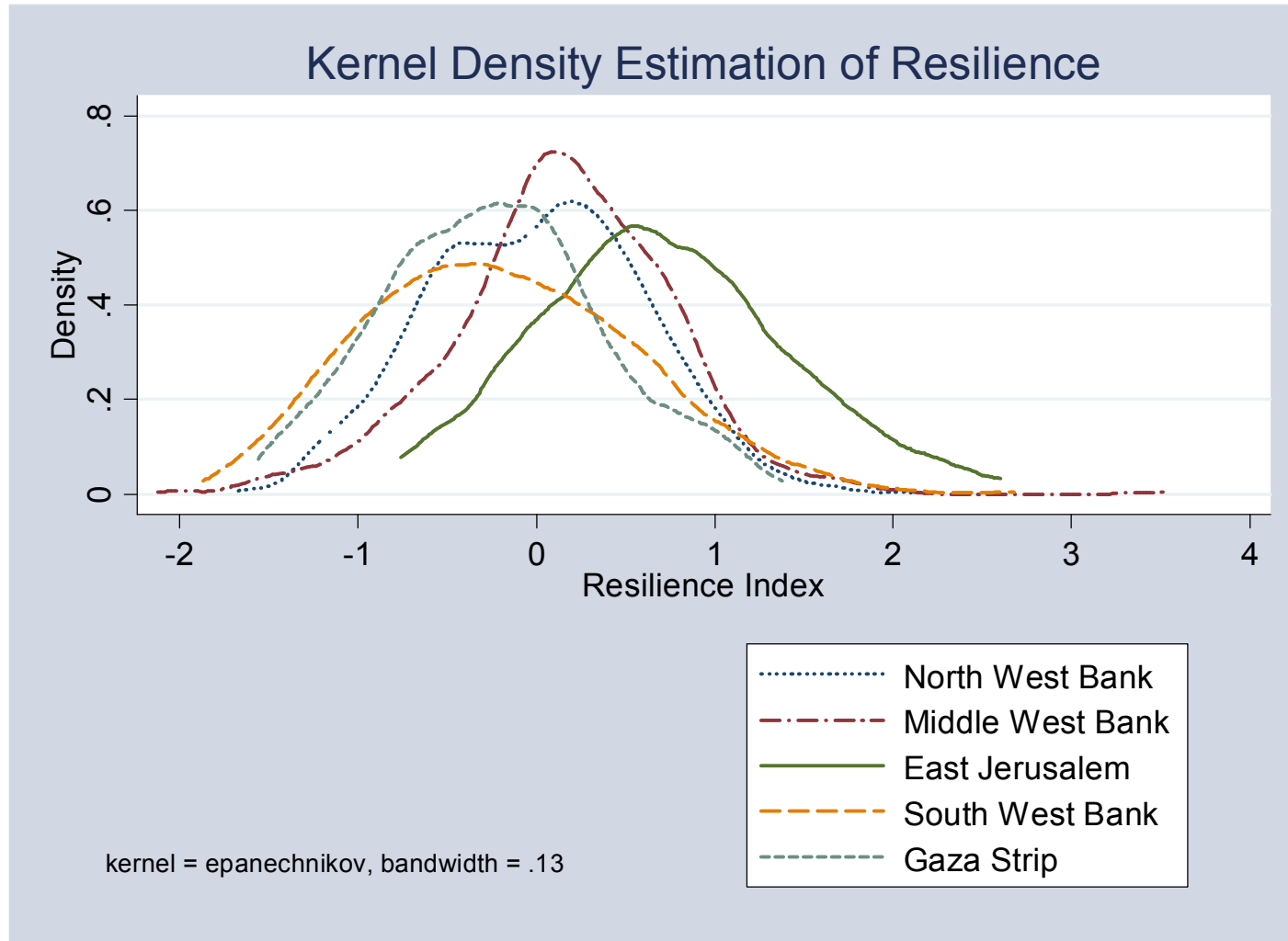
Factor Loadings

	Factor 1	Factor 2	Factor 3
IFA	0.6850	-0.0989	0.1750
AC	0.4856	0.3410	-0.1116
S	0.6332	-0.0210	-0.2647
APS	0.2911	0.1763	0.3261
SSN	-0.3534	0.3844	-0.0200

$$\text{Resilience} = 0.71 \cdot \text{Factor1} + 0.17 \cdot \text{Factor2} + 0.12 \cdot \text{Factor3}$$

Discussion of Results

The Kernel Distribution of Resilience in the 5 Palestinian sub-regions.



Parametric Estimates

Mean and standard deviation of resilience and its components

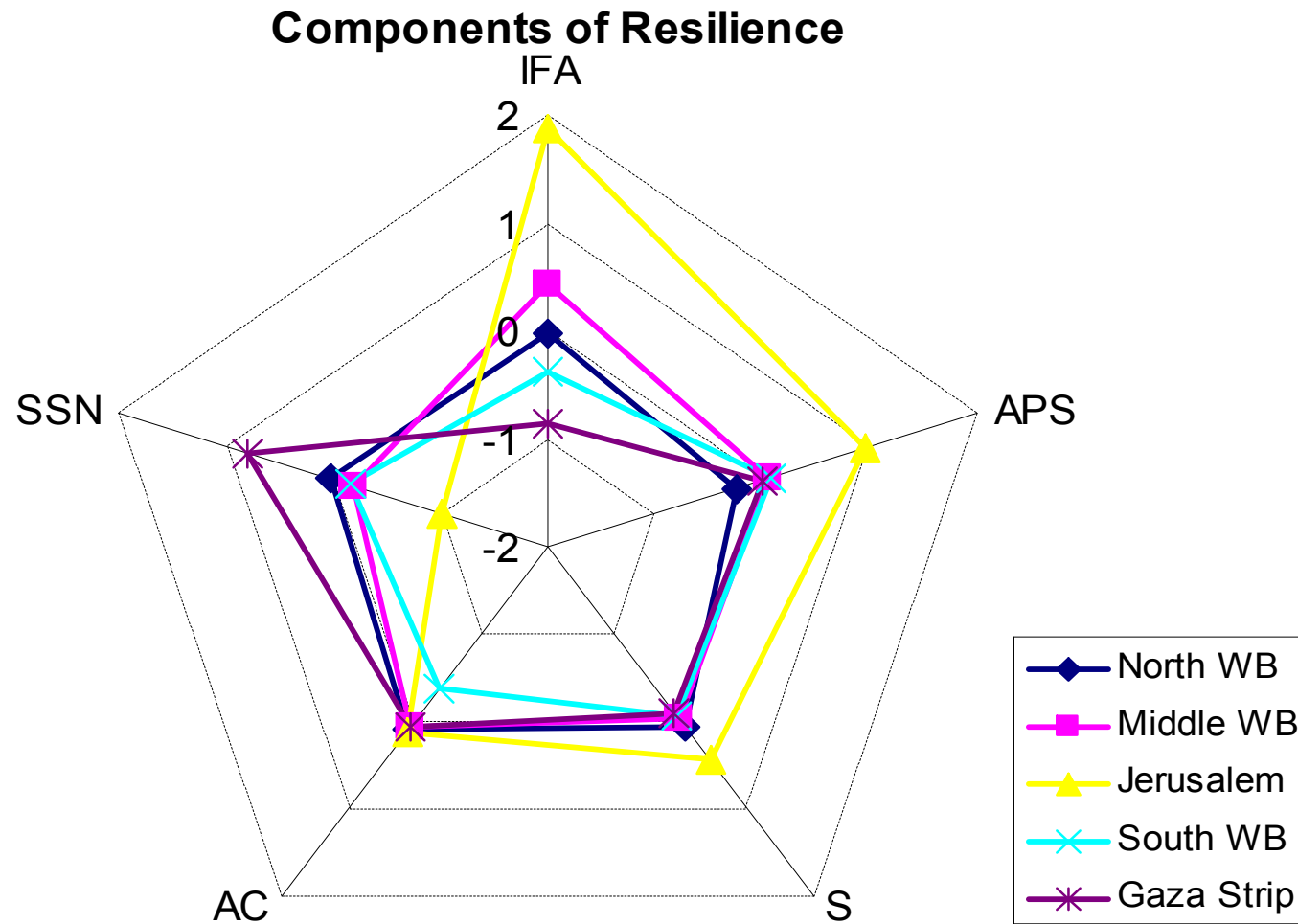
Regions	Freq	Resilience		IFA		APS		SSN		AC		S	
	N	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
North WB	648	-.0429	.5232	-.131	.760	-.242	.966	.017	1.017	.106	1.022	.054	.961
Middle WB	614	.0911	.5781	.214	1.033	.058	.936	-.190	.830	.077	.984	-.036	.981
Jerusalem	93	.8388	.7305	1.767	1.511	.951	1.021	-1.014	.395	.119	1.066	.452	1.226
South WB	408	-.1133	.6594	-.136	.937	.080	1.089	-.143	.992	-.372	.934	-.053	1.079
Gaza Strip	324	-.1851	.4458	-.480	.498	.000	.862	.797	.874	.075	.941	-.104	.898
Total	2087	0	.6037	0	1	0	1	0	1	0	1	0	1

The Matrix of t-statistics for the Comparison between Means

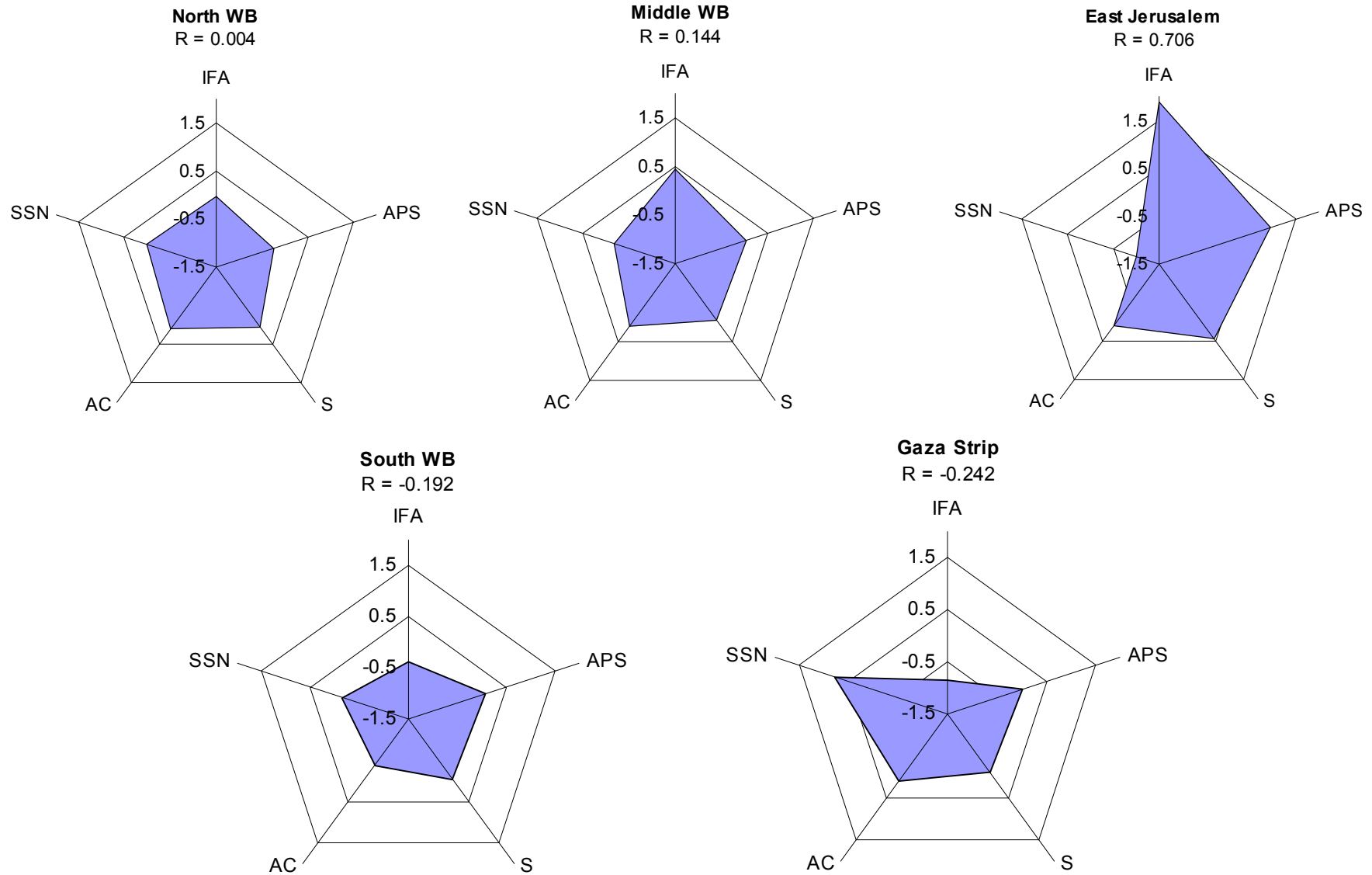
	North WB	Middle WB	Jerusalem	South WB	Gaza Strip
North WB	0				
Middle WB	-4.3220	0			
Jerusalem	-14.3101	-11.1937	0		
South WB	1.9221*	5.2309	12.3087	0	
Gaza Strip	4.1914	7.5036	16.6572	1.6794*	0

* Not significant at 95%, but significant at 90%

...discussing results

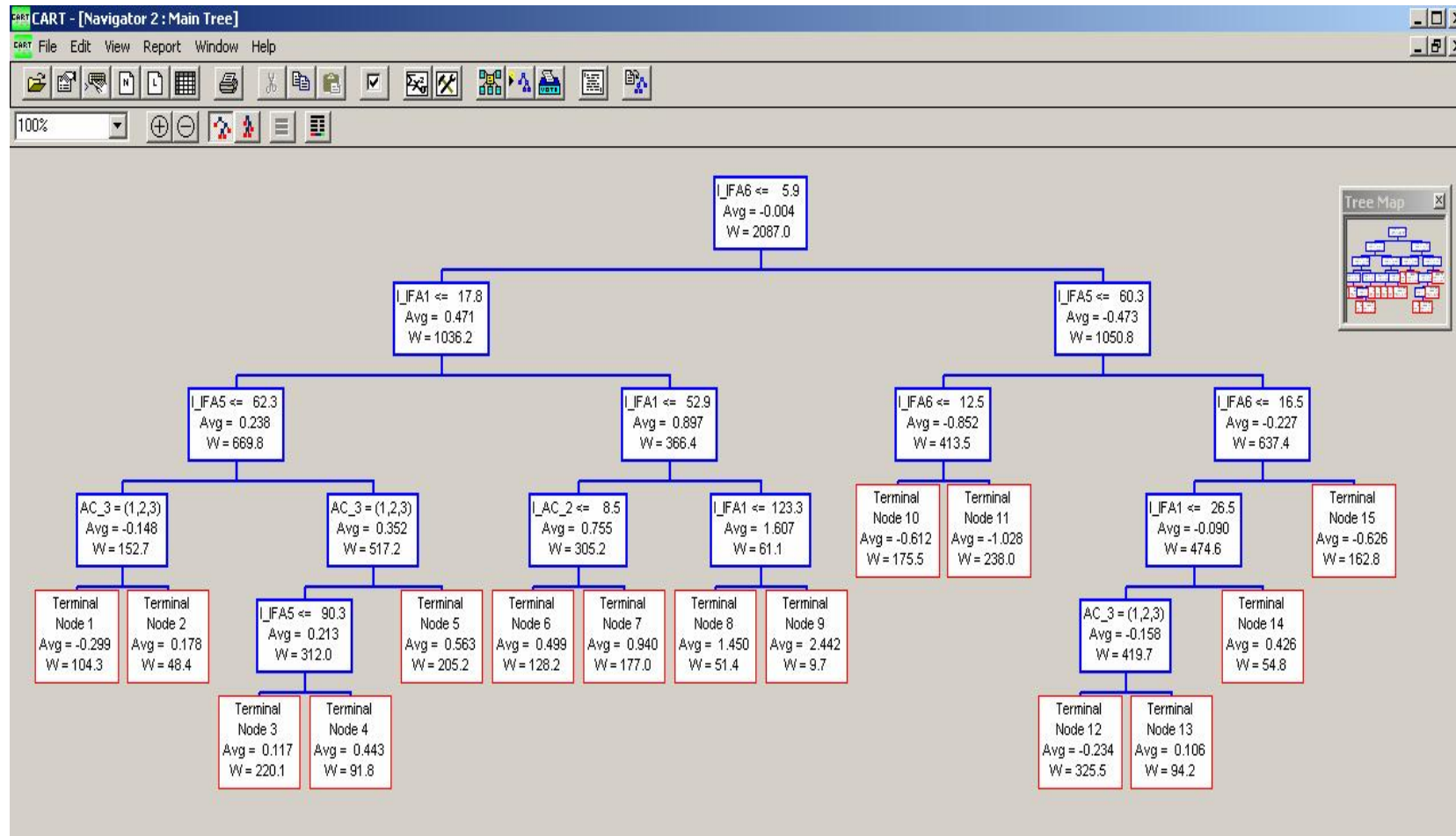


The components in the 5 macro-regions



Process Validation with CART

The Upper part of the Regression Tree (281 terminal nodes)



Predictors = 28

Approximated R-squared = 1 - resubstitution error = 1 - 0.019 = 0.981

Variable Importance

Code	Description	Import.	Code	Description	Import.
IFA1	Income	100	SSN4	Monet. value of 1 st and 2 nd type	2.069
IFA3	HFIAS	91.543	APS3	Educational System	1.854
IFA2	Dietary Diversity	86.325	SSN2	Goodness of assistance	1.458
AC2	Coping Strategies	72.959	S6	Assistance Dependency	1.450
AC3	Capacity to keep up in future	65.945	S9	Educational System Stability	1.241
S3E	Employment Ratio	53.730	APS4	Perception of Security	1.210
S2	Educational level	15.162	S7	Assistance Stability	1.168
SSN5	Evaluation Main Assistance	5.315	APS1	Physical access to health	1.161
S1W	Professional Skills	4.502	SSN6	Frequency of assistance	0.917
APS2	Health Service quality	3.770	APS5	Mobility Constraints	0.689
AC1	Diversity of Income Sources	3.590	S5	Income Stability	0.623
SSN1	Cash and In kind assistance	3.304	SSN7	Opinion on targeting	0.609
S8	Health Stability	2.670	S4	# HH members have lost work	0.194
APS7	Water, electricity & phone	2.078	SSN3	Employment Assistance	0.070

Forecasting resilience

$$R = \alpha + \beta_1 IFA1 + \beta_2 IFA2 + \beta_3 IFA3 + \beta_4 AC2 + \beta_5 AC3 + \beta_6 S3 + \beta_7 S2 + \varepsilon$$

OLS estimates: Resilience	Coefficients
Income	0.011 (0.000)*
Dietary Diversity	0.011 (0.000)*
HFIAS	-0.031 (0.000)*
Coping Strategies	0.029 (0.000)*
Capacity to keep up in the future (expectation)	0.104 (0.000)*
Employment ratio	0.382 (0.000)*
Educational level	0.025 (0.000)*
Constant	-1.466 (0.000)*
Observations	2087
R-squared	0.967
Breusch-Pagan Test for Heteroskedasticity (p-value)	0.08
* p-value: significant at 1%	

Role of resilience on vulnerability to food security

$$\text{LogToTFC} = \alpha + \beta_1 R + \beta_2 \text{HSize} + \beta_3 \text{MWB} + \beta_4 J1 + \beta_5 \text{SWB} + \beta_6 \text{GS} + \beta_6 \text{Gender} + \varepsilon$$

OLS estimates: Log Total food consumption (MV)	Coefficients
Resilience	0.381 (0.000)**
Household Size	-0.084 (0.000)**
Middle West Bank (dummy)	0.128 (0.001)**
East Jerusalem (dummy)	0.465 (0.000)**
South West Bank (dummy)	0.053 (0.199)
Gaza Strip (dummy)	-0.327 (0.000)**
Gender Household Head (dummy; female=1)	0.112 (0.037)*
Constant	2.281 (0.000)**
Observations	2087
R-squared	0.528
Breusch-Pagan Test for Heteroskedasticity (p-value)	0.480
Robust p-values in parentheses: * significant at 5%; ** significant at 1%	



Policy implications

- How policies should be designed?
 - adaptively monitor key variables
 - provide and sustain diversity (ecological, economic, cultural)
 - provide and sustain natural, social and cultural capital
 - seek integrative (system-wide) understanding

- ⇒ From policies that aspire to control change in a system assumed as stable to managing the capacity of socio-economic system to cope with, adapt and shape change



Conclusions and Follow Up

- We have developed a conceptual framework in order to measure household resilience and to monitor each component of it for policy implications
- We need to analyze resilience in time and comparing it across countries:
 - Availability of panel data allows to analyze the effect of the shocks on resilience and to identify the vulnerable people
 - Replications in other countries (HBS/LSMS and RIGA data)
- The use of *Structural Equations Modeling* may improve the estimates and will allow for more rigorous testing procedures



Thank You!

For more info:

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