Resilience to food insecurity and households' head gender: insides from food assistance in Malawi

Monserrath Ximena Lascano Galarza*

University of Bologna

Contributed Paper prepared for presentation at the 94th Annual Conference of the Agricultural Economics Society, University of Warwick, England (online)

29 – 30 March 2021

*Department of Agricultural and Food Sciences (DISTAL), Viale Fanin 50, 40127 Bologna (Italy) - monserrath.lascano2@unibo.it

Acknowledgements: The author would like to thank the Food Security, Markets and Vulnerability Analysis Unit (OSZAF/VAM) of the World Food Programme (WFP), and the Agricultural Development Economics Division Team (ESA) of the Food and Agriculture Organization (FAO) for the dataset and useful information provided for the preliminary part this research. Special thanks go to Marco d'Errico, Calogero di Gloria di Gloria, Stefania Di Giuseppe, Rebecca Pietrelli, Pierluiggi Montalbano and Donato Romani for their valuable comments, technical advice, and discussion.

Abstract

This research aims at investigating the impact of food assistance programmes on the resilience to food insecurity levels of rural agricultural households headed by females that are beneficiaries of the project "The R4 Rural Resilience Initiative" of the World Food Programme and Oxfam America's, implemented during the period 2015-2016. During the empirical analysis, first, resilience and food security levels are estimated using the Resilience Index Measurement and Analysis II methodology of the Food and Agriculture Organization. Second, a reflective and reflexive method are used for a descriptive performance assessment of female vs male-headed households, before and after the project implementation. Finally, matching and difference-in-difference techniques, with an emphasis on gender, are used for impact evaluation. The performance analysis shows positive and significant effects of the project participation on male and female-headed households, being these effects on male-headed larger than in their counterparts. The impact evaluation shows a negative and significant relationship between female headed households' programme participation and the variation of the outcome variables, but a positive and significant relationship between program participation and the levels of resilience and food security of female-headed households.

Keywords: Resilience, food security, food assistance, Malawi, female-headed households, impact evaluation

JEL code: Farm households Q12, Food Policy Q18, provision & effects of welfare programs I38, Microeconomic analysis of economic development O12, International Linkages to Development; Role of International Organizations O19, Climate, natural disasters and their management Q54

1. INTRODUCTION

Although resilience has an ecological and engineering origin (Holling, 1973; Walker *et al.*, 1981; Pimm, 1984; O'Neill, *et al.*, 1987; Levin *et al.*, 1998), it has been adapted and applied to various disciplines, and more recently, it has been used in the assessment of more complex ecological and socioeconomic systems (i.e. agri-food systems in developing countries) (Folke, 2006; d'Errico, Romano and Pietrelli, 2018). Resilience is most commonly understood as *the capacity that ensures adverse stressors and shocks do not have long-lasting adverse development consequences* (Constas, Frankenberger and Hoddinott, 2014). Resilience can be determined by tangible and subjective factors (Maxwell *et al.*, 2015; Béné *et al.*, 2016), for instance, information about risks or shocks, individuals' self-assessments or perceptions of their capacities to deal with stressful situations that could explain their short and long term coping strategies or wiliness to engage in different types of shock responses. Food security has often been studied from a vulnerability's perspective; thus, humanitarian and development interventions commonly focus on relieve rather than on a long-term objective to decrease peoples' vulnerabilities to shocks.

The last decades have been characterized by an increment of the frequency and intensity of climatic shocks that exacerbate already vulnerable communities, heavily dependent on agriculture. Consequently, humanitarian and development actors have intensified their efforts to deliver more efficient and comprehensive interventions to the affected populations, aiming at providing the tools to prevent harmful impacts, preparing for shocks, and avoiding harmful coping mechanisms, building on peoples' ability to adapt and reorganize, looking for a prompt recovery that allows them to bounce back better (Pingali, Alinovi and Sutton, 2005). To successfully targeting populations and designing customized interventions, it is essential to understand the context and the beneficiaries' characteristics, as, for instance, the factors that conditions a community's resilience to adverse shocks (Caldera Sánchez, Rasmussen and Röhn, 2015). International Organizations, Governments, Non-Governmental Organizations, and different Institutions have been more frequently using Resilience as a core approach for policies and programme design, mainly due to this concept's dynamic nature, which allows its use as a process and an outcome (Sturgess, 2016). Despite the greater interest in the topic and the spread of the use of resilience as a focal concept or as a long-run objective in policies and programs, no agreements on definitions, frameworks, or common robust tools have yet been made, mainly due to its unobservability and ex-ante characteristic, resulting in theoretical and empirical constraints (von Grebmer *et al.*, 2013; Alfani *et al.*, 2015; Cisse and Barrett, 2015; Béné *et al.*, 2016; Sturgess, 2016).

Most of the contemporary literature on resilience to food insecurity tries to overcome the empirical limitations of resilience measurement and focuses on understanding the determinant of resilience to food insecurity. Different measurement methods centred in the estimation of attributes, dimensions, and capacities, using ex-ante and ex-post effects of a shock, have been proposed that are (Vaitla *et al.*, 2012; FAO, 2013, p. 213, 2016; Hughes and Bushell, 2013; von Grebmer *et al.*, 2013; Constas *et al.*, 2014;

IIED, 2014; Béné *et al.*, 2016; Sturgess, 2016). Other authors look for a rigorous approach that could smoothly be applied in practice (Béné *et al.*, 2017), while others look at operationalizing the concept of resilience (Alinovi, Mane and Romano, 2008; Alinovi *et al.*, 2010; Tefera and Demeke, 2011; Ciani and Romano, 2013; Smith *et al.*, 2014; Alfani *et al.*, 2015; Cisse *et al.*, 2015; Kimetrica, 2015; Tefera and Kayitakire, 2015; Constas *et al.*, 2016; d'Errico and Di Giuseppe, 2016; Cissé and Barrett, 2018). However, just a limited body of the literature studies resilience and food insecurity from a clear gender perspective, focusing more on understanding the factors that trigger women's vulnerabilities and lower levels of food security, or women's contribution to their household's food security levels. For instance, Babatunde *et al.*, (2008) studied the determinants of vulnerability to food insecurity by gender of households heads in rural Nigeria. More recently, Perez *et al.*, (2015) performed a quantitative and qualitative analysis to assess the conditions that trigger vulnerability and resilience among households and communities of nine African countries facing and responding to climate changes.

Similarly, Kassie *et al.*, (2015) investigated the underlying causes of the food security gap between female and male-headed households. Mallick and Rafi, (2010) studied the food security of indigenous and ethnic Bangladeshi households based on the heads' gender; authors found no significant differences, mainly due to women greater freedoms to participate in labor and contribute to their family's food security. In the work of Ibnouf, (2013), the author used a qualitative-quantitative approach to assess the role of rural Sudanese women in reducing hunger and malnutrition and their contribution to their households' food security levels; the findings of this research showed that women play an essential role to improve the food security of their families in terms of food availability, use and allocation. To the best of the author's knowledge, no gender-based investigation has been made on the effects of assistance programmes to the levels of resilience to food insecurity. The linkages between resilience, food security, nutrition security, climate shocks and their connotations in the design of policies and interventions results are complex, as represented in Figure 1. Nutrition security can be considered as *an input* to and *an outcome* of strengthened levels of resilience and food security. Higher levels of nutrition and food security contribute to better cope with external shock that otherwise would intensify households' vulnerabilities. Vulnerable households are then pushed to adopt coping strategies that provide relieve in the first instance but that can be detrimental in the long run (Maxwell, 1996; Ciani and Romano, 2013; Béné *et al.*, 2014; Frankenberger *et al.*, 2014). To reduce the adoption of detrimental coping strategies, enhance food and nutrition security and the capacity to withstand shocks, to subsequently improve well-being levels, programmes and policies should consider all dynamics of resilience (IISD *et al.*, 2013; Fan, Pandya-Lorch and Yosef, 2014) with a special focus on gender.

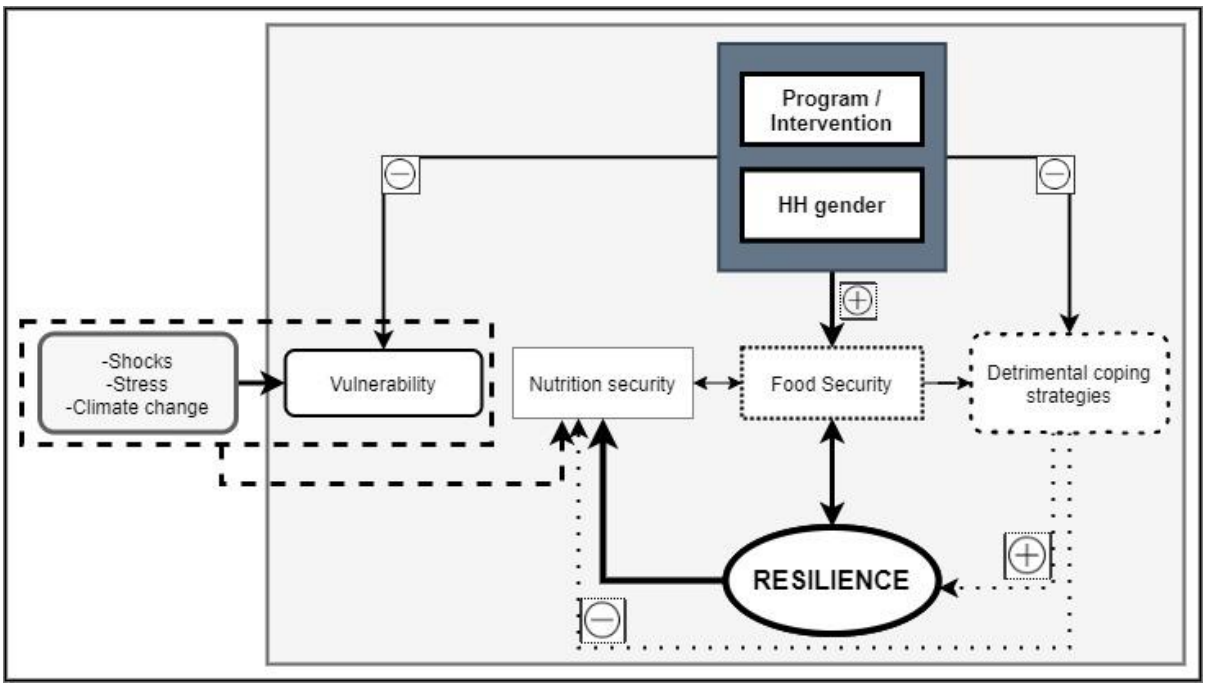

Figure 1 Resilience, nutrition and food security, and intervention links
Source: Authors' representation based on (Lascano G., 2020)

This research aims to investigate the impact of food assistance programmes on the resilience and food security levels of rural agricultural households beneficiaries of the project "The R4 Rural Resilience Initiative" of the World Food Programme and Oxfam America's, implemented during the period 2015-2016, using a gender-based approach. The dataset was obtained from the R4 and Food for Assets (FFA) baseline and outcome survey. To improve the analysis's external validity, the R4 dataset was pooled with data obtained from the Malawi 2010-2016 Living Standards Measurement Study of the World Bank. The first part of the empirical analysis consists in the estimation of resilience (R) and food security (FS) indexes, using the Resilience Index Measurement and Analysis II (RIMA-II) model. The second part of the analysis uses a reflexive method to track the changes of the outcome indicators of resilience and food security before and after the project's programme implementation while using a reflective approach to compare the results between female-headed households (FHH) and male-headed households (MHH). Finally, nearest-neighbor matching methodologies are used to pool the panel data with a control group to perform a difference in difference (DID) model for impact evaluation with a gender focus. This research contributes to the existing literature regarding the relationship between gender, food insecurity, and resilience-building by using primary data collected from beneficiary populations benefiting from food assistance, and from a practitioner's approach, it contributes to a better understanding and a more rigorous analysis of the impacts of this kind of programmes on the beneficiary population.

2. CONTEXT

The Sub-Saharan African countries are among the most vulnerable to climatic change due to their high

level of vulnerabilities and dependence on climate-vulnerable activities. Malawian rural households are characterized for having widespread levels of poverty, especially those headed by females. Most Malawian rural households' economy depends on agriculture, resulting in households highly vulnerable to the effects of natural and climate disasters. Severe droughts and flooding have hit one-quarter of Malawian people during the last decade (World Bank, 2016; Ministry of Finance, Economic Panning & Development, 2017). For instance, the year 2015 marked record levels of flooding that resulted in damaged agricultural assets and infrastructure and shortages in production with severe consequences to food and nutritional levels, that triggered a national emergency that affected the most vulnerable households, especially those headed by females, depriving them of adequate time to recover.

The R4 Rural Resilience Initiative (R4) is a comprehensive risk management initiative first implemented in Malawi in 2015 as a three-year pilot project that targeted 500 participants (WFP and OXFAM, 2016). This initiative targets vulnerable households that experience seasonal food gaps and that have labor capacity to engage with the project. The objective is to build resilience among participants, by reinforcing their abilities to withstand and recover from shocks, while maintaining their essential functions to go back to a previous or stronger state. The R4 builds resilience grounded in five strategies: risk reserve (savings promotion), prudent risk taking (credits facilitation and access), risk transfer (access to weather, livestock and yield index insurance), risk reduction (access to climate resilient assets, conservation agriculture, climate services and community risk management), and social safety nets (food and cash assistance) (WFP, 2017).

3. METHODS AND DATA

This research used information on rural farming Malawian households from the Balaka district, obtained from the WFP's R4 and FFA Baseline, Midterm, and Outcome Household Monitoring Survey in Malawi. The survey includes information regarding households' demographics, assets, agricultural inputs and production, shocks and coping strategies, food and non-food consumption and expenditure, income sources, credit, savings, social networks, associations, safety nets, and participation in assistance programmes. The empirical analysis is based on a balanced panel dataset, for the period May 2015 to December 2016, formed by 216 households (432 observations) distributed among four Group Village Heads (GVHs) (Mtumbwe, Pongolani, Zalengera, and Hambahamba). Most of the households (HH) are conformed by 4 (19.9%) or 5 (16.6%) members, 74.4% of the households are male-headed (MH), and 25.6% have a female head (FH). Male heads (MH) are, on average, 48 years old, and female heads (FH) 42 years old. Most of the heads of the households (HHH) attended primary school, 67% male heads and 65.5% female heads; however, while 22% of MH attended secondary school, only 8% of FH attended secondary school; the remaining heads never attended school. While 95% of MH are married, 46% of FH are widowed, 24% divorced, 18% are married, 10% separated, and 2% are single. All 216 households are R4 beneficiaries, which supposed a constrain and allowed only for a longitudinal analysis without a control group. Information of 930 rural agricultural Malawian households was

obtained from the *Integrated Household Panel Survey of Malawi's 2010-2013-2016 Living Standards Measurement Study of the World Bank* and matched with our panel dataset to control for the effects of the R4 Initiative on the beneficiary group against a non-beneficiary one.

In the ***first part*** of our empirical analysis, resilience was estimated using the RIMA II model of FAO that uses a mixed-methods approach and allows for context adaptation, rigorous analysis and comparison of the households, and the effects of shocks on the households' resilience and food security (FAO, 2013). The Resilience Capacity Index (RCI) relies on pillars. Productive and non-productive Assets (**AST**)[1] as an indicator of households' living conditions and shocks' effects on households' behavior and coping strategies. Proxies may include Wealth index, land owned. **ABS** represents the HHs' ability to meet its basic needs, quality and use and access to basic services. An example of ABS is the access or the monetary cost of health services. A household (HH) ability to access formal and informal assistance is represented by Social Safety Nets (**SSN**) (i.e., support groups, informal loans). Adaptive capacity (**AC**) describes a HH's ability to face and adapt to a new situation after a shock; it can be estimated from a HH's income sources, education level, among others (FAO, 2016). The RIMA model considers Food security (FS) as a well-being indicator, closely linked to resilience, where resilience is the ex-ante link between well-being and shocks and ex-post capacity to preserve the well-being after the shock (Constas, Frankenberger and Hoddinott, 2014). FS was measured using two proxies: a weighted value estimated by weekly frequency of different food groups consumption, known as Food Consumption Score (***FCS***) (WFP, 2008), and the monetary value of food consumption or food expenditure (***FX***), which is an indirect measure of food caloric intake and is expressed in Malawian kwacha (includes bought, self-produced, received in-kind or in-cash as part of food assistance programmes, and stored foods).

The RIMA-II model supposed a descriptive and a causal analysis. During the first part of the **descriptive analysis**, the four pillars of resilience and the FS proxies are constructed using factor analysis of observable variables. In the second stage of the descriptive analysis, the Resilience Capacity Index (RCI) is estimated using a Multiple Indicators Multiple Causes (MIMIC) model from the pillars, taking into consideration the relationships between RCI and FS indicators. Equation (1) represents the measurement component of the MIMIC model (where observed indicators are assumed to be imperfect indicators of resilience), while equation (2) represents the structural component of the MIMIC model (it correlates de pillars to resilience):

$$\begin{bmatrix} FCS \\ FX \end{bmatrix} = [\Lambda_1, \Lambda_2] \times [\eta = RCI] + [\varepsilon_2, \varepsilon_3] \quad (1)$$

[1] See information on variables and indexes in the Annex.

$$[\eta = RCI] = [\beta_1, \beta_2, \beta_3, \beta_4] \times \begin{bmatrix} ABS \\ AST \\ SSN \\ AC \end{bmatrix} + [\varepsilon_3] \quad (2)$$

The coefficient of *FX* (Λ_1 loading) is restricted to unity and is not estimated, which means that one standard deviation increase in *RCI* results in a single unit increase in the standard deviations of *FX* (FAO, 2016). This defines the unit of measure for Λ_2 and the variance of both *FX* and *FCS*, as represented in equation (3) and (4):

$$FCS = \Lambda_1 RCI + \varepsilon_2 \quad (3)$$

$$FX = \Lambda_2 RCI + \varepsilon_3 \quad (4)$$

RCI lacks a natural scale of unit or measurement, so, to ease the interpretation of the regressions, a 0 to 1 scale has been defined, using a min-max rescaling approach, as shown in equation (5):

$$X_{i^*} = (X - X_{min})/(X_{max} - X_{min}) \quad (5)$$

After resilience has been estimated, it is used in a **causal analysis** that aims at establishing a causal relationship between observed variables and well-being indicators (food security); shocks and coping strategies are included in the model for estimating their impact on resilience and food security indicators. The causal analysis model, represented in equation (6), contains multiple *j*s, or independent variables, to predict multiple *Y*s, or outcome variables ($Resilience, FCS, FX$), with each Y in a different formula, based on the same data. The model was applied to two subsamples according to the gender of the household head:

$$\boldsymbol{Y_{ikt} = \beta_{0kt} + \alpha_{jk} S_{ijt} + \delta_{jk} X_{ij} + \gamma_{jk} CS_{ijt} + \varepsilon_{ikt}} \quad (6)$$

For i {1, . . ., n} and k {1, . . ., m} where:

- Y_{ik} is the k-th real-valued response for the i-th observation:
  (k response for $Resilience, FCS, FX$);
- S_{ij} is the j-th predictor for the i-th observation for S$hock$:
  (the S predictor for $Weather\ Shock$)
- X_{ij} is the j-th predictor for the i-th observation for $HH\ characteristics$:
  (X predictor for households' characteristics $Elderly\ HHH,\ Education\ level\ HHH,\ Marital\ status\ HHH$)
- Cs_{ijt} is the j-th predictor for the i-th observation for $Coping\ strategies$:
  (Cs predictor for three coping strategies: Asset smoothing, Non-consumption Smoothing, and Adaptive capacity)
- ε_{ik} is a multivariate error vector

The ***second part*** of the empirical analysis supposed a performance assessment of the key indicators of the R4 initiative. We employed a reflective approach to compare results between female and male-headed households while comparing two points of the same observation of the treated group without any knowledge on the untreated group (reflexive method), as represented in equation (7):

$$\Delta Y = \frac{Y_1 - Y_0}{Y_0} \quad (7)$$

Where:

- Y_0 is the response for *Resilience*, *Food Security* indicators at t_0 (pre-intervention)
- Y_1 is the response for *Resilience*, *Food Security* indicators at t_1 (post-intervention)
- ΔY is the percentage of variation of the outcome

In the ***third and last part*** of the empirical analysis, we used propensity score matching to construct a control group based on a participation probability model. The probit model in equation (8) meets the underlying assumptions of conditional independence and common support and estimates the propensity score of the observations to be allocated into the treated group, where $\boldsymbol{T}$ represents the treatment or R4 participation and $\boldsymbol{X}$ the given pre-treatment characteristics that may affect the probability of the observations to be assigned into the treated group. Equation (9) represents a counterfactual situation and compares the outcomes $\boldsymbol{Y}$ between the treated and control observations $\boldsymbol{T}$, using the propensity score to match observations with the nearest neighbor, and measuring the treatment effects:

$$p(X) = prob(T = 1|X) = E(T|X) \tag{8}$$

$$Y = \begin{cases} Y_1 \; if \; T = 1 \\ Y_0 \; if \; T = 0 \end{cases} \tag{9}$$

Subsequently, a difference-in-difference model was applied to assess the programme's effects by comparing the outcomes across treatment and control units before and after the programme intervention, also implementing at this stage comparisons between female and male-headed households. Equation (10) estimates the average effects of the R4 initiative from pre- to post-treatment periods on the variation of the outcome variables $\boldsymbol{\Delta Y}$, between treated and controls $\boldsymbol{T}$, while controlling for pre-treatment characteristics $\boldsymbol{X}$, weather shocks $\boldsymbol{S}$, and coping strategies $\boldsymbol{CS}$:

$$\Delta \boldsymbol{Y_{ikt}} = \boldsymbol{\beta_{0kt}} + \boldsymbol{\alpha_{jk}} \boldsymbol{T_{ijt}} + \boldsymbol{\alpha_{jk}} \boldsymbol{S_{ijt}} + \boldsymbol{\delta_{jk}} \boldsymbol{X_{ij}} + \boldsymbol{\gamma_{jk}} \boldsymbol{CS_{ijt}} + \boldsymbol{\varepsilon_{ikt}} \tag{10}$$

Finally, we test the effect of treatment $\boldsymbol{T}$ on the households' resilience and food security indicators, considering the head's gender. The model represented in equation (11) test the effect of treatment $\boldsymbol{T}$ on the total levels of resilience and food security indicators $\boldsymbol{Y}$. The model described in equation (12) tests the impact of treatment $\boldsymbol{T}$ on the variation of the outcome variables $\boldsymbol{\Delta Y}$; interactions between project participation and household head gender are tested in both models:

$$\Delta \boldsymbol{Y_{ikt}} = \boldsymbol{\beta_{0kt}} + \boldsymbol{\alpha_{jk}} (\boldsymbol{T} \times \boldsymbol{FHH})_{ijt} + \boldsymbol{\alpha_{jk}} \boldsymbol{S_{ijt}} + \boldsymbol{\delta_{jk}} \boldsymbol{X_{ij}} + \boldsymbol{\gamma_{jk}} \boldsymbol{CS_{ijt}} + \boldsymbol{\varepsilon_{ikt}} \tag{11}$$

$$\boldsymbol{Y_{ikt}} = \boldsymbol{\beta_{0kt}} + \boldsymbol{\alpha_{jk}} (\boldsymbol{T} \times \boldsymbol{FHH})_{ijt} + \boldsymbol{\alpha_{jk}} \boldsymbol{S_{ijt}} + \boldsymbol{\delta_{jk}} \boldsymbol{X_{ij}} + \boldsymbol{\gamma_{jk}} \boldsymbol{CS_{ijt}} + \boldsymbol{\varepsilon_{ikt}} \tag{12}$$

4. RESULTS AND DISCUSSION

4.1. RIMA-II analysis

The first part of the RIMA-II analysis supposes estimating the pillars of resilience using factor analysis of observable variables. Figure 2 illustrates the most relevant variables per pillar depending on the gender of the household head. The MIMIC model results, presented in Table 1 and shown in Figure 3,

report the pillars weights in determining the resilience.

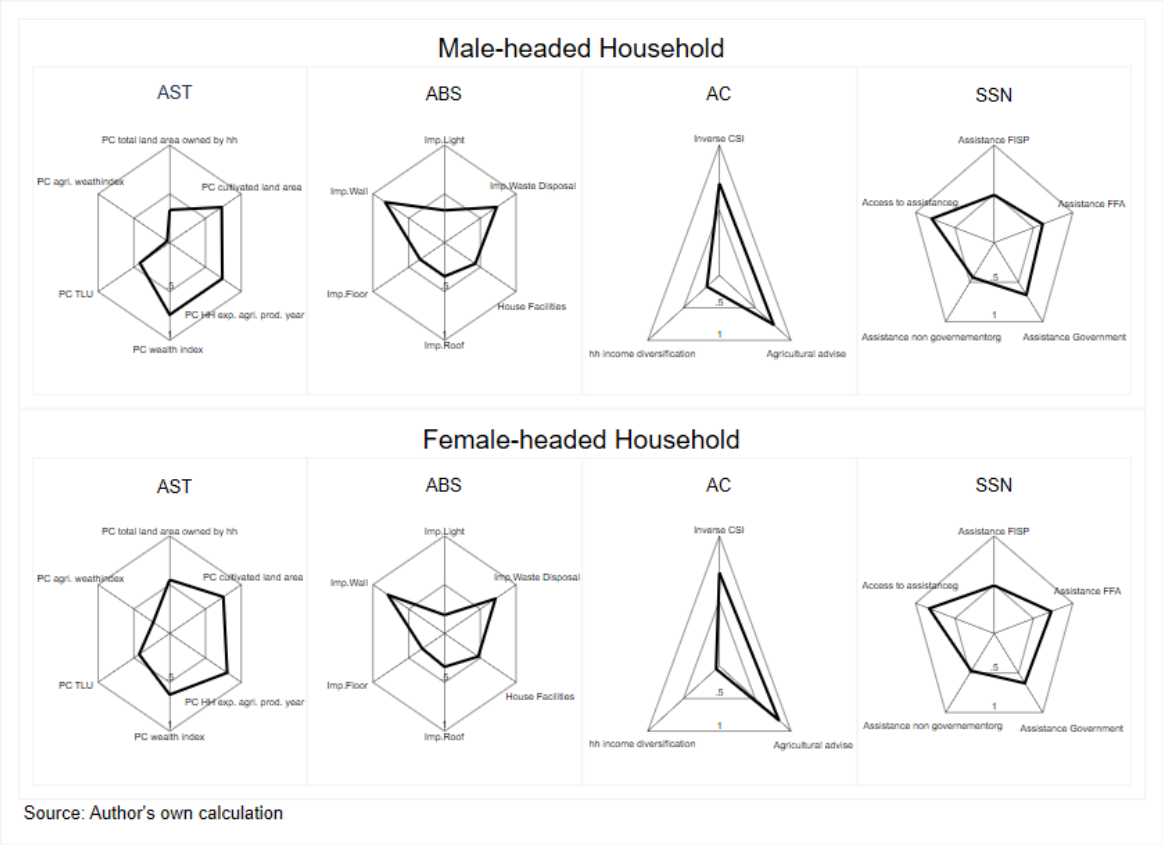

Figure 2 FHH vs MHH resilience structure by pillars disaggregation, Malawi panel dataset 2015 (pre-treatment) to 2016 (post-treatment)

Table 1
MIMIC model of RCI: coefficients of structural and measurement components

VARIABLES	(1) Female-headed households	(2) Male-headed households
Structural components		
Access to basic services	-0.0860	0.0115
	(0.867)	(0.817)
Assets	2.204***	2.643***
	(0.822)	(0.742)
Social safety nets	-1.682	-5.894***
	(1.036)	(1.086)
Adaptive capacity	-0.104	-0.927**
	(0.358)	(0.426)
Measurement component		
Food consumption score	1	1
	(0)	(0)
Food expenditure	468.3**	249.0***
	(182.5)	(36.93)
Goodness of fit statistics		
X^2	11.59	6.24
p value	0.0089	0.1006
RMSEA	0.158	0.059
Pr RMSEA	0.027	0.332
CFI	0.868	0.984
TLI	0.603	0.952
Observations	116	316

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
Source: Author's own calculation

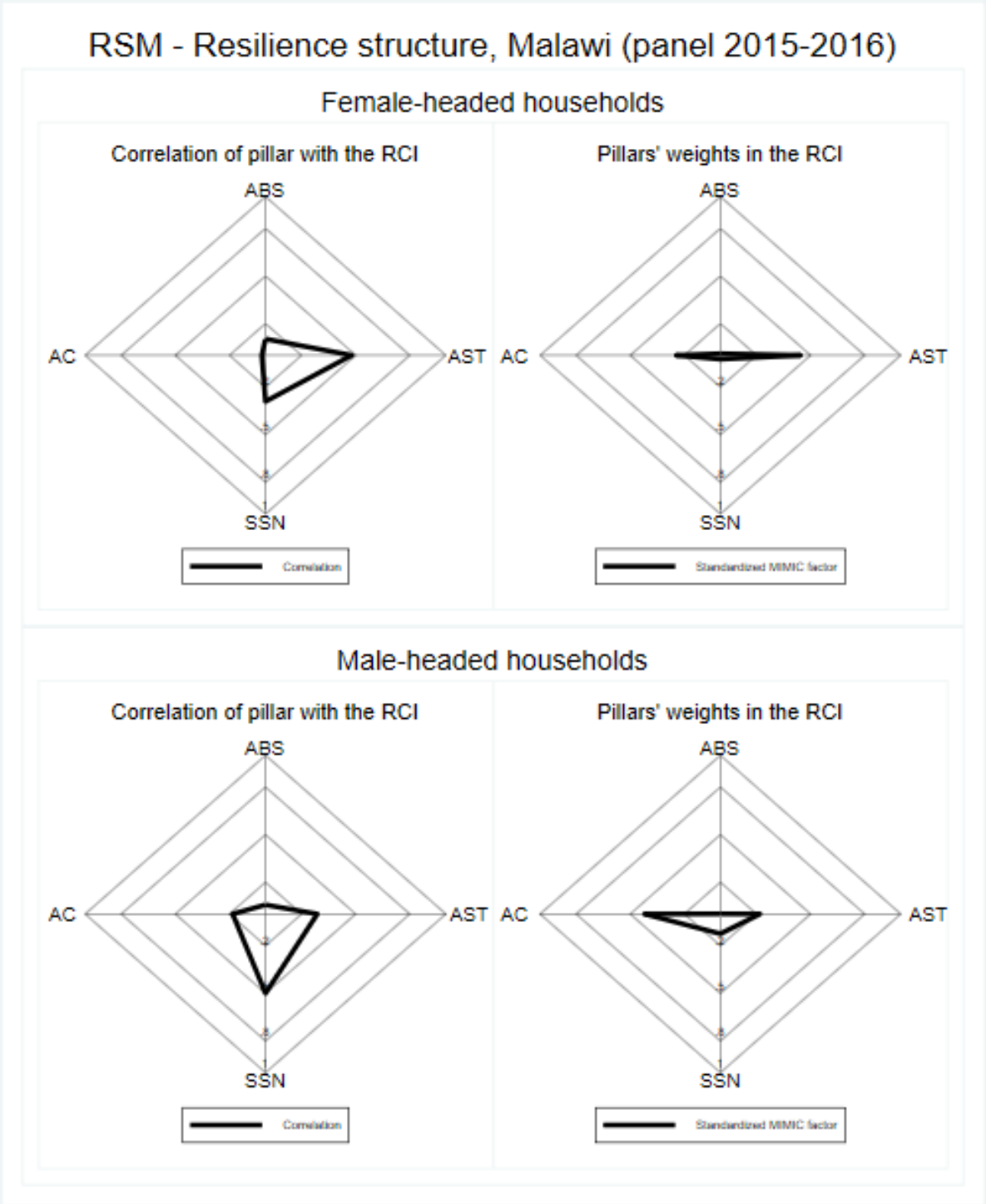

Figure 3 Pillars' correlation and significance to Resilience Capacity Index, distribution FHH vs MHH, Malawi panel data 2015 (pre-treatment) to 2016 (post-treatment)
Source: Author's own calculation

Results show that although resilience and its pillars are similarly structured in FHH and MHH, there are some marked differences in both groups, which is an indicator of gender disparities or inequalities. For instance, SSN in both households' types is mainly explained by *access to assistance*; however, *government assistance* weights less in FHH's resilience which suggests that government programmes focus on activities of difficult access for women. Another example is the lack of weight of *income diversification* on the FHH's AC; this suggests that female heads have less access to the labor market

than male heads. Regarding AST, results show that the explanatory weights of *per capita agricultural wealth index, per capita expenditure in agricultural products*, *total land area owned*, and *cultivated land area* are higher in FHH than in MHH. On the other side, the AST of MHH is mainly explained by *per capita wealth index*. Moreover, results show a lack of AC's explanatory power and lower a weight of SNN in FHH's resilience while AST is the pillar that mainly explains their resilience. The results regarding AST and AC evidence the high levels of dependency of FHH on agricultural-related activities. SSN's results suggest a lack of efficient and well-directed support tailored for FHH needs from the government and institutions.

Table 2
Effects of weather shocks and coping stategies on RCI and FS indicators

VARIABLES	(1) FHH-RCI	(2) FHH-FCS	(3) FHH-FX	(4) MHH-RCI	(5) MHH-FCS	(6) MHH-FX
HH suffered weather shock	-0.118***	-14.56***	-1,933***	-0.190***	-22.65***	-3,326***
	(0.0273)	(2.007)	(549.0)	(0.0145)	(1.548)	(284.6)
Coping strategies						
Adaptive capacity	-0.00223	1.593	-169.4	0.0561**	5.482**	1,014**
	(0.0362)	(2.779)	(726.3)	(0.0225)	(2.377)	(450.3)
Non-food consumption	-0.0416	-1.773	-710.4	-0.0150	-3.066*	-121.8
smoothing	(0.0276)	(2.113)	(555.0)	(0.0149)	(1.566)	(298.8)
Asset smoothing	-0.0594	-2.437	-1,345	-0.00612	-3.738	-70.27
	(0.0696)	(5.310)	(1,397)	(0.0268)	(2.825)	(535.4)
HH's characteristics						
Elderly household head	0.0555*	-3.288	1,139*	0.0422*	2.339	823.5
	(0.0322)	(2.730)	(647.1)	(0.0244)	(2.527)	(502.6)
Level of education, in comparison to secondary school						
Never been to school	-0.0451	-4.309	-1,144	-0.0374	-3.096	-756.0
	(0.0537)	(4.465)	(1,078)	(0.0281)	(2.903)	(580.2)
Primary	-0.0957**	-1.429	-2,279**	-0.0178	-2.395	-274.6
	(0.0478)	(3.934)	(958.9)	(0.0185)	(1.906)	(381.2)
Constant	0.405***	41.97***	7,506***	0.324***	47.86***	5,334***
	(0.0506)	(4.104)	(1,015)	(0.0190)	(1.977)	(388.1)
Observations	116	116	116	316	316	316
Number of hh	74	74	74	174	174	174

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's own characteristics

The second part of the RIMA analysis looks at understanding the determinant of resilience. The panel data was divided into two subsamples, according to household head gender. Subsequently, the model described in equation (6) was applied once for every outcome variable (RCI, FX and FCS). The models presented in Table 2 and Table 3 show the effects of the shocks and the adoption of coping strategies on the households' resilience and food security, considering the households' characteristics (households' heads' age, education, and marital status). The results show that both types of households' resilience and food security levels are significantly impacted by the weather shocks a household face.
Regarding households' adoption of coping strategies, results show that only Adaptive Capacity has a significant positive effect on the levels of food security and resilience of MHH. In contrast, contrary to the literature, *non-food consumption smoothing* has a significant negative impact on the food consumption of MHH. These could suggest that activities, such as harvesting immature crops or eating

the seeds that were supposed to be used in the following agricultural season, have an immediate positive effect; however, in the long run, this could result detrimental to the well-being of the household. On the other hand, the negative impact of *non-food consumption smoothing* on FCS reflects that although the households have engaged in activities such as relocating money destined to education and health to increase food consumption, it has had the opposite effect on the food security of the household. Contrary to what could be expected, having an elder head has a positive and significant impact on resilience and food expenditure levels. However, it seems to have a significant negative effect on the food consumption score, which could mean that elder-heads prioritize quantity rather than foods' quality.

Regarding education levels, results show that FHH, whose heads never have attender school or have attended only primary school, have lower levels of resilience and food security than FHH, whose heads have attended secondary school. Regarding marital status, results suggest that when a female head is single, her household's levels of resilience and food security tend to be higher. In contrast, in male-headed households, resilience and food security are positively associated with the head being divorced or widowed.

Table 3
Effects of weather shocks and coping stategies on RCI and FS indicators

VARIABLES	(1) FHH-RCI	(2) FHH-FCS	(3) FHH-FX	(4) MHH-RCI	(5) MHH-FCS	(6) MHH-FX
HH suffered weather shock	-0.125***	-13.72***	-2,135***	-0.187***	-22.61***	-3,258***
	(0.0293)	(2.112)	(589.1)	(0.0145)	(1.569)	(285.7)
Coping strategies						
Adaptive capacity	0.000742	1.484	-123.9	0.0557**	5.570**	998.3**
	(0.0363)	(2.765)	(729.8)	(0.0222)	(2.377)	(444.3)
Non-food consumption smoothing	-0.0358	-1.611	-564.4	-0.0149	-3.289**	-111.1
	(0.0283)	(2.135)	(568.2)	(0.0148)	(1.573)	(295.8)
Asset smoothing	-0.0380	-1.571	-965.8	-0.00430	-3.785	-26.01
	(0.0766)	(5.660)	(1,539)	(0.0265)	(2.831)	(529.2)
HH's characteristics						
Elderly household head	0.0568*	-5.346*	1,224*	0.0312	1.229	630.9
	(0.0337)	(2.798)	(678.1)	(0.0233)	(2.454)	(477.0)
Marital status in comparison to "single"						
married	-0.207**	2.384	-5,037**	0.0993	5.686	1,853
	(0.101)	(8.577)	(2,022)	(0.0917)	(9.633)	(1,887)
separated	-0.206**	-2.764	-4,667**	0.0773	10.10	1,264
	(0.104)	(8.889)	(2,097)	(0.110)	(11.59)	(2,244)
divorced	-0.212**	-3.509	-4,933**	0.228**	0.0838	5,113**
	(0.0989)	(8.500)	(1,988)	(0.110)	(11.59)	(2,245)
widowed	-0.181*	-0.877	-4,364**	0.216**	13.76	4,039*
	(0.0979)	(8.420)	(1,968)	(0.103)	(10.81)	(2,106)
Constant	0.520***	40.91***	10,224***	0.204**	40.31***	3,112
	(0.0971)	(8.317)	(1,952)	(0.0922)	(9.693)	(1,897)
Observations	116	116	116	316	316	316
Number of hh	74	74	74	174	174	174

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's own characteristics

4.2. Performance analysis

The performance assessment results presented in Table 4 suggest that FHH and MHH have more than double their levels of resilience and food security from 2015 to 2016. Although the percentage of change

of the outcome variable is lower in FHH, this change is anyway significant and similar among the three variables. Moreover, the results illustrated in Figure 4 show an improvement in food security levels and the quality of the consumed food in both types of households. FCS thresholds indicate that while after the project implementation, most of the MHH have an acceptable food consumption, this percentage is lower in FHH. In comparison, the latter type of households shows a higher rate of borderline food consumption.

Table 4
Resilience and food security indicators

	Indicator	2015	2016	Δ	%Δ
MHH	RCI	12.92	31.66	18.73	**144.9%**
	FX	2064	5309	3245	**157.2%**
	FCS	22.74	46.03	23.30	**102.5%**
FHH	RCI	18.93	32.28	13.35	**70.5%**
	FX	3356	5610	2254	**67.2%**
	FCS	24.02	38.78	14.76	**61.5%**

Source: Author's own

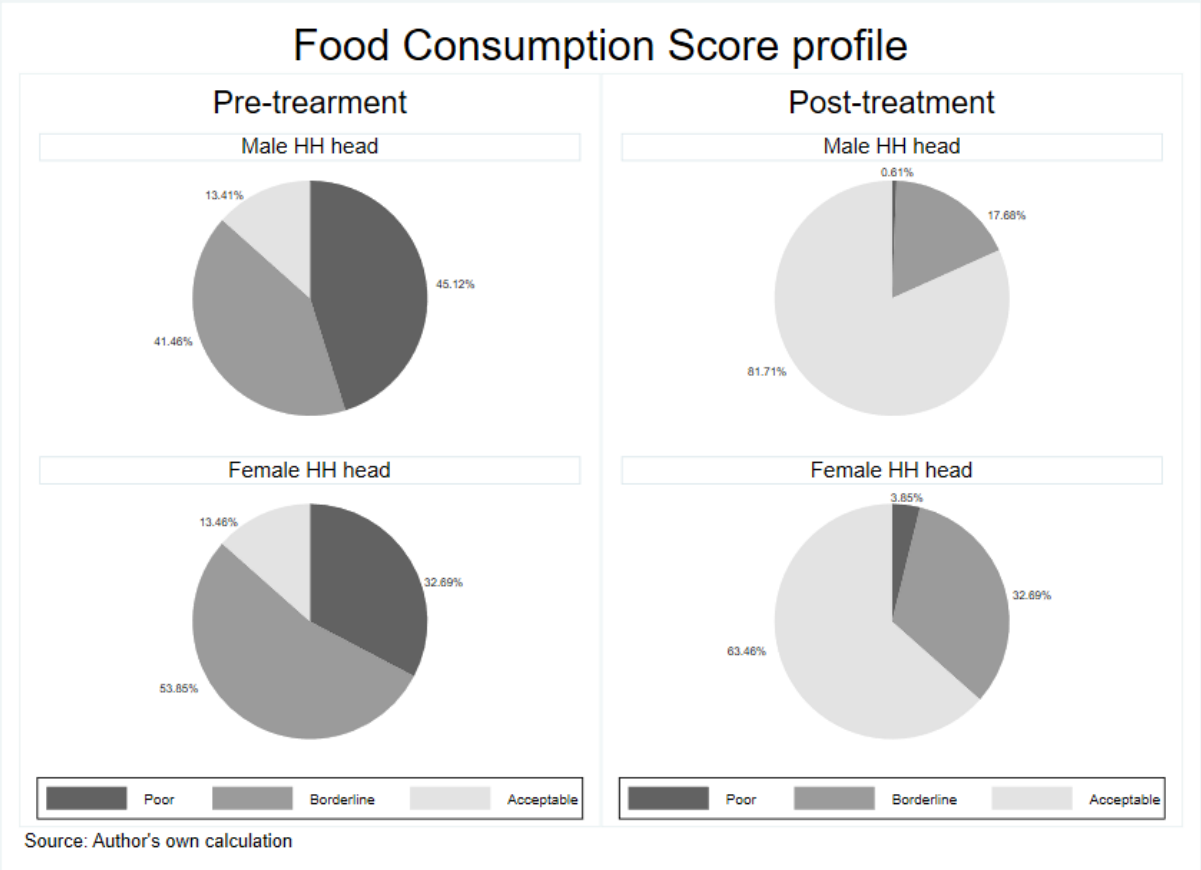

Figure 4 RCI by households' heads' gender, Malawi 2015-2016

Table 5 provides information regarding the performance of the R4 initiative's objectives and strategies. Results show that households headed by women have benefited further from R4 participation, which is shown by the higher increment of households saving and accessing credits. These results suggest that women, who are household heads, benefit more from the strategies "prudent risk-taking" and "Risk reserve" than their counterparts. Results also show that most of the households have more than one income source. In general, results suggest that households are building financial bases that allow them

to have access to credit and improve their ability to cope with shocks.

Table 5
Variation of risk management indicators

	Female-headed households				Male-headed households			
Indicators	2015	2016	Δ	%Δ	2015	2016	Δ	%Δ
Households saving	29	57	28	97%	82	123	41	50%
Households accessing credits	24	34	10	42%	68	78	10	15%
Households accessing loans	0	3	3	*	21	51	30	143%
Income diversification = 0	0	2	2	*	4	4	0	0%
Income diversification = 1	9	24	15	167%	29	48	19	66%
Income diversification >1	43	38	-5	-12%	131	100	-31	-24%

Source: author's own calculation

4.3. Impact evaluation

For impact evaluation purposes, we matched the R4 and FFA survey data with the LSMS dataset of the World Bank (see section 3). To do so, we applied equation (8), and results reported in Table 6 show that the balancing property is satisfied.

Table 6
Propensity score matching model

VARIABLES	Propensity Treatment WFP
Weather shocks	0.242***
	(0.0728)
Coping strategies	
Assets smoothing	-0.745***
	(0.218)
Non-food consumption smoothing	-1.428***
	(0.142)
Adaptive capacity	3.070***
	(0.192)
Households characteristics	
Female-headed households	-0.110
	(0.150)
Elder headed households	0.0214
	(0.190)
Constant	-0.960***
	(0.121)
Observations	1,146

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: The region of common support is [.01204647, .9978722]
The final number of blocks is 6
The balancing property is satisfied

Source: Author's own calculation

Table 7
R4 initiative ATT estimation and robustness check

VARIABLES	ATT on Δ RCI	ATT on Δ FCS	ATT on Δ FX
Nearest neighbour[1]	2.150***	2.178***	1.562**
	(0.195)	(0.540)	(0.659)
Observations	1,146	1,146	1,146
n. treated	216	216	216
n. controls	513	513	513
Robustness check	SATT on Δ RCI	SATT on Δ FCS	SATT on Δ FX
Direct nearest-neighbor matching	2.103***	2.143*	1.151
	(0.419)	(1.260)	(1.278)
Observations	1,146	1,146	1,146
n. matches (m)	1	1	1

*** p<0.01, ** p<0.05, * p<0.1

[1]Note: the numbers of treated and controls refer to actual nearest neighbour matches

Source: Author's own calculation

Table 7 shows the model results represented in equation (10) and the robustness test that uses the direct nearest-neighbor matching method with no propensity score. Results suggest that the R4 initiative has positively impacted the beneficiaries' resilience and food security.

Table 8
Resilience and Food Security indicators variation, and treatment interaction with FHH

VARIABLES	(1) Δ RCI	(2) Δ FX	(3) Δ FCS
Treatment =1, yes	2.477***	2.658***	2.163***
	(0.274)	(0.969)	(0.426)
Female household head = 1, yes	0.0988	2.029	0.183*
	(0.0938)	(1.376)	(0.103)
Treatment=1# Female household head=1	-0.878**	-3.285**	-1.487**
	(0.345)	(1.585)	(0.723)
Shock			
HH suffered weather shock	0.0718	0.532	0.104
	(0.106)	(0.688)	(0.225)
Coping strategies			
Asset smoothing	0.0626	-0.301	-0.280
	(0.291)	(0.573)	(0.357)
Adaptive capacity	-0.942***	-1.369***	-1.514
	(0.276)	(0.421)	(0.951)
Non-consumption smoothing	0.0149	-2.151**	1.020
	(0.353)	(0.842)	(1.104)
HH characteristics			
Elderly household head	-0.163	0.355	-0.416*
	(0.191)	(1.138)	(0.245)
Constant	-0.0563	1.877***	-0.0802
	(0.0706)	(0.558)	(0.132)
Observations	430	430	430
R-squared	0.277	0.048	0.050

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Author's own calculation

Results presented in Table 8 and Table 9 show the model's results in equation (11) and equation (12). Such models test the effects of the treatment on both, the variation of the outcome variables and the total values of them, testing at the same time, the interaction between participation in the R4 program and having a female head. Results show that, although the delta R, FCS and FX have significant positive relationships with the participation in the R4 programme, in general, resilience and food security level are negatively related to the project participation, which can be understood since benefices of the project are households in need. However, the positive effects on the delta of the outcomes show that the project have a positive effect on households. Results regarding female-headed households, on the other hand, show that participating in R4 has a negative and significant impact on the variation of the outcomes, however, their participation has positively impacted their levels of resilience. These results suggest that, FHH that are beneficiaries of the R4 initiative have higher levels of resilience and food security even if the percentage of variation of the outcome variables is lower, in comparison to FHH that do not participate in the treatment.

Table 9
Resilience and Food Security indicators levels, and treatment interaction with FHH

VARIABLES	(1) RCI	(2) FCS	(3) FX	(4) HDDS
Treatment =1, yes	-0.0255**	-15.96***	-412.2	-0.197
	(0.0123)	(1.518)	(424.0)	(0.122)
Female household head = 1, yes	-0.0325**	-6.657***	-238.9	-0.436***
	(0.0133)	(1.633)	(458.1)	(0.132)
Treatment=1# Female household head=1	0.0683***	4.063*	1,039	0.295
	(0.0188)	(2.315)	(644.5)	(0.186)
Coping strategies				
Asset smoothing	0.0227	0.976	607.8	0.232
	(0.0158)	(1.965)	(500.6)	(0.150)
Non-consumption smoothing	0.00576	-1.700	1,543***	-0.0121
	(0.00981)	(1.224)	(305.6)	(0.0920)
Adaptive capacity	-0.0148	-0.661	-628.3*	-0.134
	(0.0111)	(1.382)	(354.6)	(0.106)
Shock				
HH suffered weather shock	-0.115***	-14.12***	-2,094***	-0.322***
	(0.00865)	(1.082)	(265.3)	(0.0804)
Constant	0.307***	57.30***	5,169***	5.385***
	(0.00937)	(1.159)	(314.1)	(0.0911)
Observations	860	860	860	860
Number of hh	430	430	430	430

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Author's own calculation

5. CONCLUSIONS

The literature suggests that strategies to enhance resilience do not always result in improved well-being levels when referring to the linkages between resilience and food and nutrition security. The theory also acknowledges that, despite the greater levels of vulnerabilities, women have an essential role in the food security and resilience of their households and that if given the same access to resources and opportunities as men, the socioeconomic level of their households and nations could increase (Habtezion, 2017). Thus, to guarantee an efficient design and later implementation of programmes and policies, government and institutions' initiatives to build resilience should consider all dynamics, timing, and context of the beneficiary households, including having a female head.

The analysis of this research evidences the extreme dependence of FHH on farming activities and assets. Moreover, during the study, we found evidence of gender inequality, especially regarding their AC, AST, and SSN. The performance assessment shows that among the R4 participants, the improvements of R and FS indicators of FHH are lower than in MHH. However, the impact assessment shows a positive and significant relationship between R4 participation and FHH compared to FHH that did not participate in the R4 project. These results suggest that despite the positive outcomes of the R4 Rural Resilience Initiative on the levels of resilience and food security of the total population studied during the analysis period, the initiative's impacts are more significant in male than in female-headed households. A possible explanation is that the R4's assistance and benefits are mainly directed to farming activities mostly carried out or controlled by men, which causes challenges to households with female heads. Thus, a focus on FHH's needs should be done so that all R4' beneficiaries experience the same amount of positive impacts.

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APPENDIX

Annex 1 RIMA's variables and indexes description

	Pillar	Variable	Description
Mimic model	**AC**	Inverse CSI	The Coping Strategy Index "CSI" refers to households' strategies to cope with acute food shortages and deals with severity and frequency of food consumption (e.g. reduced number or portions of meals eaten per day). It is a relative measure to compare trends of food insecurity over time, as well as cross-sectional differences in food insecurity among subgroups. The CSI is inverted for the estimation of SEM.
	AC	Agricultural advice	A dummy variable is constructed based on whether or not the household received advise on agriculture from the extension services of the WFP
	AC	Household income diversification	Number of different sources of households' income over a maximum of 6 activities: sale of crops, the sale of animals and animal products, casual labour, self-employment, remittances, other sources
	ABS	Improved lighting	The variable is a dummy equal to one if the household uses improved lighting (for instance: electricity, electricity generator) and zero otherwise (candle, torch, a lamp with batteries) or other
	ABS	Improved waste disposal	The variable is a dummy equal to one if the household uses improved waste disposals (for instance close pit burying or open-pit deposit) and zero otherwise (waste burning, waste throw away) or other
	ABS	Improved house roof	Dummy variable equal to one if the household's house has a safe finished roof (finished: metal; wood; calamine/ cement fibre; ceramic tiles; cement; roofing shingles) and zero if the material of the dwelling roof is natural (no roof; thatch/ palm leaf; grass; sod), rudimentary (mat; palm/bamboo; wood planks; cardboard) or other
	ABS	Improved house floor	Dummy variable equal to one if the household's house has a safe finished floor (namely finished: parquet, vinyl or asphalt strips, ceramic tiles, cement, carpet) and zero if the material of the dwelling floor is natural (earth/sand; dung) or rudimentary (wood planks; palm/bamboo) or other
	ABS	Improved house wall	Dummy variable equal to one if the households' houses have safe finished walls (finished: cement; stone; bricks)
	ABS	Household's house facilities index	Index-based out of access to Safe Water, Sanitation and Cooking Energy
	SSN	Government assistance	Dummy variable equal to one if the household receives assistance from Government, zero otherwise
	SSN	Non-government assistance	Dummy variable equal to one if the household receives assistance from NGOs, zero otherwise
	SSN	Access to assistance	Dummy variable equal to one if the household receives assistance from any kind and source, zero otherwise
	SSN	FISP	Dummy variable equal to one if the household main source of assistance comes from Farms Inputs Subsidy Programmes "FISP", zero otherwise
	SSN	FFA	Dummy variable equal to one if the household main source of assistance comes from Food for Asset Programmes "FFA", zero otherwise
	AST	TLU	Tropical Livestock Units standardises different types of livestock into a single unit of measurement. The conversion factor adopted is: 0.7 cattle; 0.5 donkeys; 0.2 pigs; 0.1 sheep/goats; 0.01 chickens/guinea fowls / ducks/ pigeons
	AST	Land area owned	Per capita total agricultural land area owned by a household (acre) during the agricultural periods 2014-2015 and 2015-2016
	AST	Cultivated land area owned	Per capita total land area cultivated during the agricultural periods 2014-2015 and 2015-2016
	AST	Agricultural household expenditure	Per capita monthly household expenditure on agricultural products
	AST	Per capita wealth index	Index based on the possession of non-productive assets, domestic and personal appliances such as mosquito nets, blankets, lamps, TV, radio, mattresses and vehicles
	AST	Per capita agricultural wealth-index	Index based on the possession or not of agricultural supplies, tools, vehicles, and productive assets
	AST	Conservation agriculture	Per capita total land area cultivated under conservation agriculture during the agricultural periods 2014-2015 and 2015-2016
	Food	Food Consumption score FCS	The food consumption score captures the quantity, dietary diversity and nutrient value of the food that the household consumes. It is calculated from the types of foods and the frequency with which they are consumed over seven days
	Food	Per capita monthly food expenditure	Monetary value, expressed in Kwacha, of monthly per capita food consumption, including bought, auto-produced, received for free (as gifts or part of a conditional project) and stored food.
Causal analysis	**Shock**	Weather shock	Weather shocks faced by the household during the last 6 months (drought, dry spells/erratic rainfall, too much rain, floods, soil erosion, windstorms). This variable is represented into two ways, first as a dummy variable equal to one if the households faced weather shocks, second, as a variable representing the number of weather shocks the households experienced
	Coping strategy	Asset smoothing	Dummy variable equal to one if the household has employed coping activities of asset smoothing (e.g. selling productive assets or means of transport, selling non-productive assets, selling more non-productive animals, sell last female animals)
	Coping strategy	Non-food consumption smoothing	Dummy variable equal to one if the household has employed coping activities of non-food consumption smoothing (e.g. lower expenditure for non-food expenditure: education, health)
	Coping strategy	Adaptive capacity	Dummy variable equal to one if the household has employed activities for adaptive capacities (e.g. consumption of seeds in stock, take out children from school, send household members to beg, harvest immature crops, increased causal labour)
	Control	Household head marital status	Categorical variable equal to one if the household is single, equal to two if married, three if separated, four if divorced, and five if widowed
	Control	Household head level of education	Categorical variable equal to zero if the household head never attended school, equal to one if the household head attended only primary school, and equal to two if the household head attended secondary school
	Control	Elderly-headed household	Dummy variable equal to one if the household's head is an elder (65 years old and over), zero otherwise

Annex 2 Performance analysis' variables and description

Indicator		Description
Well-being indicator	RCI	Resilience Capacity Index, constructed over the pillars, ABS, AST, SSN, AC
	Household income diversification	Number of different sources of households' income over a maximum of 6 activities: sale of crops, the sale of animals and animal products, casual labour, self-employment, remittances, other sources
	Food Consumption score FCS	The food consumption score captures the quantity, dietary diversity and nutrient value of the food that the household consumes. It is calculated from the types of foods and the frequency with which they are consumed over seven days
	Per capita monthly food expenditure	Monetary value, expressed in Kwacha, of monthly per capita food consumption, including bought, auto-produced, received for free (as gifts or part of a conditional project) and stored food.
Households' characteristics	Female-headed household	Dummy variable equal to one if the household's head is female, zero otherwise
	Elderly-headed household	Dummy variable equal to one if the household's head is an elder (65 years old and over), zero otherwise

Annex 3 Impact evaluation's variables and description

Variable		Description
Treatment "WFP"		Dummy variable equal to one if the household participated in the WFP's R4 Rural Initiative
Outcome	Delta resilience	It's the percentage change in resilience between 2015 and 2016
	Delta FCS	It's the percentage change in FCS between 2015 and 2016
	Delta FX	It's the percentage change in food expenditure between 2015 and 2016
Controls	Weather shock	Number of weather shocks faced by the household during the last 6 months (drought, dry spells/erratic rainfall, too much rain, floods, soil erosion, windstorms)
	Coping strategy: Asset smoothing	Dummy variable equal to one if the household has employed coping activities of asset smoothing (e.g. selling productive assets or means of transport, selling non-productive assets, selling more non-productive animals, sell last female animals)
	Coping strategy: Non-food consumption smoothing	Dummy variable equal to one if the household has employed coping activities of non-food consumption smoothing (e.g. lower expenditure for non-food expenditure: education, health)
	Coping strategy: Adaptive capacity	Dummy variable equal to one if the household has employed activities for adaptive capacities (e.g. consumption of seeds in stock, take out children from school, send household members to beg, harvest immature crops, increased causal labour)
	Female-headed household	Dummy variable equal to one if the household's head is female, zero otherwise
	Elderly-headed household	Dummy variable equal to one if the household's head is an elder (65 years old and over), zero otherwise