Infrastructure Growth, Household Vulnerability and Response to Shocks in Kenya

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Abstract

Households in most rural areas of developing countries are likely to suffer shocks contributed by their livelihoods' dependence on natural resources as well as due to their physical isolation from the mainstream economy Using pooled cross-sectional data from Kenya, this paper investigates the association between changes in physical infrastructure stocks and access levels on one hand, and household vulnerability to shocks as well as the response strategies to shocks as markets for risk sharing develop and transaction costs are reduced over time through physical infrastructure growth. Results reveal that between 2005/06 and 2015/16, there was a reduction in household vulnerability to the general shocks with the reduction being higher for urban households; rural households' vulnerability to food shocks reduced more compared to urban households; and finally, both rural and urban households increased their use of infrastructure-supported ex-post coping strategies such as savings and borrowing to respond to food-security shocks, with the adoption being higher by five percentage points among rural households. The study finds a plausible association between physical infrastructure changes and household vulnerability and coping strategies to shocks. The findings imply the importance of developing physical infrastructure as a strategy for reducing vulnerability to livelihood shocks.

Key words: vulnerability, shocks, coping strategies, infrastructure

JEL: D10, O12, H54

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1 Introduction

Households in most rural areas of developing countries are most prone to shocks partly because of their livelihoods' dependence on natural resources and the physical isolation from the mainstream economy (Harvey, et al., 2014). They are thus most likely to suffer shocks emanating from natural calamities such as droughts, floods, earthquakes and landslides; agricultural shocks such as crop diseases and pests, loss of livestock to diseases and theft. In addition, the remoteness of rural settlements from the main infrastructural networks and facilities (for example roads, telephony networks, markets and health facilities) exposes households to shocks such as low prices of agricultural outputs, higher prices for food and other basic commodities and higher incidence of diseases and illnesses. Also, because of the inherent weak systems for resiliency, subsequent shocks usually compound household vulnerability with the ultimate consequence of expanding and entrenching rural poverty.To protect consumption from livelihood shocks ex-post, households use a variety of response mechanisms such as liquidating assets, selling labour, seeking assistance from relatives, friends, institutional well-wishers and government.

Kenyan households, both in the rural and urban areas constantly face food insecurity due to frequent droughts in the country's arid and semi-arid lands (ASALs), frequent price inflation of the major staples and persistent below-average domestic food production as well as limited distribution networks between food-surplus and food-deficit zones (Orindi, Nyong and Herrero, 2008; Gathiaka and Muriithi, 2017).Physical infrastructure promotes the advancement and betterment of the human welfare through increasing factor productivity; contributing to better social outcomes such as education, health, equality and justice; stimulating further growth through innovation, connecting local and international markets and promoting social ties and growth of social capital (Ndulu, 2006; Stern and Dillman, 2006; Calderón and Servén, 2010). The growth of different components of physical infrastructure such as energy, telecommunications and water and sanitation have been empirically found to have positive impact on per capita gross domestic product (GDP) growth especially in low-income countries with low physical infrastructure stocks (Imran and Niazi, 2011).

Kenya's stock of physical infrastructure started increasingsignificantly since 2003 owing to sustained increase in public spending on the sector. The expansion in the country's physical assets can be demonstrated by the changes in gross fixed capital formation, which expanded by a factor of five in the period between 2005 and 2015 (Republic of Kenya, various years).Infrastructure development, together with other aspects of economic transformation provides opportunities such as jobs, education, health and poverty reduction that reduces exposure and vulnerability to common livelihood risks and shocks. In addition, infrastructure provides alternative and more effective means and mechanisms forhouseholds to cope with shocks that cannot be completely eliminated ex-ante. Indeed, World Bank (2014) highlights key social and economic systems that collaboratively contribute to effective risk management. These systems include government-provided goods and services such as infrastructure that potentially reduces household exposure and vulnerability to shocks. For instance, a community proximity and access to physical infrastructural goods and services influence how households cope with livelihood shocks (Berchoux et al., 2019).

Physical infrastructure has unique characteristics that influence its impact on household welfare outcomes. World Bank (1994) and Agenor (2010) identifies two: first, accumulation of an absolute critical mass of infrastructure stocks and second, networking of necessary and complementary components of infrastructure to produce positive externalities. On the other hand, the welfare outcomes brought about by infrastructure projects are manifested in household utility gains through, for example, accessibility of essential services (Klytchnikova and Lokshin, 2009).

Studies have found out that the household livelihood environment contributes significantly to its vulnerability (Mogues, 2011; Andersen and Cardona, 2013; Akampumuza and Matsuda, 2017). In addition, other studies link the absence of risk sharing markets (such as savings, credit and insurance) and high transaction costs to the choice of existing response and coping mechanisms to shocks among households in less developed countries (Deaton, 1989; Deaton, 1992; Ellis, 1998; Dercon, 2002; McPeak, 2004; Dercon, Hoddinott and Woldehanna, 2005). However, less is known known about what happens to vulnerability of households to livelihood shocks as the immediate environment transforms over time; for instance, as the rural areas are opened up and connected to urban centres, technologies advance, livelihoods diversify and rely less on the natural environment. Also, less is known about what happens to household response strategies to shocks as markets for risk sharing develop and transaction costs are reduced over time through physical infrastructure growth. Accordingly, this study seeks to find out if there were differences in household vulnerability to general and food-security shocks in Kenya between 2005/06 and 2015/16; whether there were differences in household ex-post coping strategies to food-security shocks in Kenya between 2005/06 and 2015/16; and finally, whether these differences varied between rural and urban households.

Among the few studies that explore the connection between infrastructure access and livelihood risks is Jack and Suri (2014) who established household welfare gains emanating from reduced transaction costs on household risk sharing at the advent of mobile money transfer system in Kenya. However, Kenya's infrastructural transformation has not been limited to mobile money innovations, but other stocks of physical infrastructure especially in rural areas have also increased. This study contributes to the existing related literature by examining whether Kenya's infrastructural transformation has contributed to changes in vulnerability of households' livelihoods as well as risk management. This is done by considering infrastructure as a bundle of benefits that include electricity connections, information communication technology, irrigation, water and sanitation, roads and markets. Unlike the previous studies, this study assesses the evolution of vulnerability and response strategies to shocks over time and disaggregating households according to geographical locations.

By comparing rural and urban households' vulnerability to shocks and coping mechanisms before and after a significant infrastructural transformation, this study illuminates on whether the infrastructure growth experienced in the country after 2002 has been pro-poor and broad-based. Findings of this study are also useful in informing national policies on poverty reduction efforts such as Kenya Vision 2030 and the President's Big Four Agenda as well as internationally agreed commitments such as the sustainable development goals (SDGs).

1.1 Description of Vulnerability to Livelihood Shocks in Kenya

Households in Kenya have had their welfare adversely affected by various shocks experienced at the household, community, regional and national level. These include droughts and floods, crop and animal diseases, economic shocks such as food and farming-inputs price inflation, loss of employment, diseases and deaths and shocks caused by social conflict such as ethnic clashes.Droughts and resulting famine are constant features among the households in the country's, which represent 36 percent of the human population and over 70 percent of livestock (Republic of Kenya, 2018b) and cause the GDP to contract by up to two percent in severe cases (Demombynes and Kiringai, 2011).Between 2012 and 2016, the annual food price inflation in the country averaged about 12.5 percent, approximately double the non-core inflation average of 7.0 percent in the same period (World Bank, 2019). Inadequate physical infrastructure for storing food as well as roads and railway lines for facilitating regional food trade in Kenya have been found to contribute to the vulnerability to food price inflation especially in marginalized rural areas (Emongor, 2014). Vulnerability to health-related shocks that include diseases, injuries, accidents and deaths of economically productive family members were found to have significant cost as measured by the years of life lost due to premature deaths (Institute for Health Metrics and Evaluation, 2017). In addition, the economy incurs both direct costs for disease treatment as well as indirect cost in the form of labour days lost and school days missed by the sick members and those caregiving (Chuma, Okungu and Molyneux, 2010).

1.2 Review of Evolution of Physical Infrastructure Stocks and Population Access in Kenya between 2005 and 2016

Between 2005 and 2016, there were notable changes in Kenya's economic, social and political landscape which subsequently contributed to changes in the country's stocks of physical infrastructure. The GDP growth rate in this period was more than double the rate in the previous equivalent period, the country also experienced a destructive post-election violence, heralded a comprehensive constitutional change since independence, successfully managed a political regime change in 2013, and continued its commitment to international calls for action, notably the Millennium Development Goals and the SDGs, to advance attainment of social development indicators. The bitumen road network increased from 8,850 to 14,500 kilometres while the earth/gravel road network increased from 54,360 to 72,500 kilometresbetween 2005 and 2016. A 472-kilometres standard gauge railway line connecting the two main cities in the country was commissioned in 2017.Between 2005/06 and 2018/19, the irrigated agricultural land increased from 0.04 percent to two percent of the total agricultural land. Between 2005/06 and 2015/16, the percentage of sampled households with access to improved drinking water sources rose from 58.9 percent to 72.6 percent (Republic of Kenya, 2018a). The national stocks of agricultural produce markets as well as connectivity of rural population to the markets also increased following increased funding of the Local Authority Transfer Fund, Constituencies Development Fund, implementation of Kenya Economic Stimulus Program, county governments' funding and donor projects supporting rural markets linkages and infrastructure growth. In addition, the national aggregate electric power consumption (kWh per capita) increased by 28 percent between 2005 and 2014, indicating an increase in the installed national electric power capacity. Mobile telephone subscriptions moved from 12.8 per 100 people to 79.8 per 100 people. Mobile-money services were introduced starting 2007 in the country to ride on the mobile telephone infrastructure.Population above 15 years with accounts at financial institutions or mobile-money

service providers increased by 32.3 percentage points between 2011 and 2014 (World Bank, 2019).

The remainder of this study is organized as follows. Section 2 presents the theoretical framework for assessing household vulnerability to shocks as well as the accompanying estimation procedures, including the incorporation of evolution of time. Section 3 describes the data used in the study. Section 4 presents the empirical results of the estimated models as well as discussions of the generated results. Finally, in section 5, the study's key findings are summarized and conclusions drawn, before finally recommending policy options for addressing household welfare vulnerability in Kenya.

2 Methodology

2.1 Theoretical Framework for Assessing Household Vulnerability to Shocks

The concept of vulnerability has diverse epistemology that is dictated by the realm in which it is being investigated. In the domain of social welfare and livelihoods, vulnerability measures household exposure, sensitivity and resilience to livelihood shocks inferred in the household intrinsic and extrinsic capacities (Adger, 2006). Exposure to shocks manifests in how variations in household environments explain the nature of shocks experienced, the extent and the time span of vulnerability (Adger, 2006). Sensitivity measures the susceptibility or the extent to which households suffer welfare loss depending on their livelihood entrenchment in the shock-causing stress (Adger, 2006). Household sensitivity to shocks is also determined by its inherent poverty level (measured, for example, by number and value of assets) and the extent of livelihood diversification (Devereux, 2001). In the case of food-security shocks, livelihood diversity could imply household sources of food. Resilience refers to the capacity of household welfare to withstand negative shocks over a sufficient period of time (Barrett and Constas, 2014). In other words, this means that welfare measures of resilient households will be insulated from adverse effects of shocks.

Sarris and Karfakis (2006) represent the welfare reduction as a household consumption (c_h) reduction below a certain known and agreed standard (z), and go on to formally state the vulnerability as a function of the probability that household welfare will fall beyond this stated standard (see equation one);

$$V_{ht} = Pr\left(c_{h,t+1} \leq z\right) \quad (1)$$

As indicated, welfare in this study is indicated by the household self-reported welfare reduction due to adverse effects of shocks, measured as a binary outcome taking one if the result is positive and zero otherwise. Self-reported shocks have been found to accurately capture household welfare, producing statistically significant estimates and with the correct sign and magnitude (Sabelhausand Ackerman, 2012). Based on these findings, Sabelhausand Ackerman (2012) conclude that self-reported shocks are indeed exogenous and thus reliable in explaining household behavior.

Guided by the theoretical background explained above, a regression model in equation two is built in which a household self-reported measure of adverse effects of shocks represents

vulnerability against an array of independent variables that contribute to the state of vulnerability. For econometric estimation purpose, the equation is specified as;

$$\Pr(Shock_i) = \alpha_0 + \alpha_1 HCI_i + \alpha_2 Consn_i + \alpha_3 Loc_i + \mu_i \quad (2)$$

2.2 Evolution of Vulnerability and Ex-Post Coping Mechanisms to Food-Security Shocks

The livelihood risks facing households in most of developing countries are highly variable across time due to a variety of triggers, such as the intrinsic vulnerability to natural climatic conditions (Ravallion, 1988). Over time, the sources of vulnerability change as well as changes in the elements of the household external environment such as technology and physical infrastructure. Also liable to change are the specific household characteristics such as household size, education qualification of household head and intra-household relationships. In this study, we postulate that the physical infrastructure development in Kenya between 2005/06 and 2015/16 influenced the household vulnerability as well as choice of ex-post coping mechanisms. The hypothesized change in the household vulnerability and response mechanisms to shocks due to change in the stocks of physical infrastructure in the two periods is theoretically modelled as a case of structural breaks.

We assume a single structural break and therefore compare pre-break and post-break data, in which model parameters change over the two periods. Specifically, the increment in the stocks of physical infrastructure and the associated connectivity is perceived to be a unique event that changes the model parameters under investigation. Following Zeileis et al. (2003), the influence of structural breaks in economic relationships as the one hypothesized in this study is formally presented in the standard linear regression model as in equation three.

$$y_t = x_t^{\mathrm{T}} \beta_t + \mu_t (t = 1, \ldots\ldots, T) \quad (3)$$

in which y_t is the observed outcome variable at time t, x_t is a $k \times 1$ vector of explanatory variables andβ_t being a $k \times 1$vector of regression parameters which are hypothesized to change over time due to the perceived structural transformation in the household vulnerability and coping mechanisms to livelihood shocks.

As per the objective of this study, relating physical infrastructure transformation on household vulnerability and coping mechanisms to shocks in the two data collection periods amounts to testing the null hypothesis that the regression coefficient on the two study periods remain constant against an alternative hypothesis that the coefficient changes over time (Zeileis et al., 2003). This is formally represented as;

$$H_0: \quad \beta_t = \beta_0 (t = 1, \ldots\ldots, T)$$

$$H_a: \quad \beta_t \neq \beta_0 (t = 1, \ldots\ldots, T) \quad (4)$$

The nature of infrastructural transformation in the country in the period under review was not specific to certain locations or sections of the population, rather it was a general phenomenon affecting the whole economy. Accordingly, the evaluation of the impact of the infrastructural difference on household vulnerability to shocks and coping mechanisms could not be implemented using the standard difference-in-difference procedures. However, because rural areas had lower baseline levels of physical infrastructure stocks and population access, it is

postulated that the effect of this intervention on household vulnerability and change in ex-post coping strategies to shocks would be higher among rural households compared to those in urban areas.

2.3 Estimation Model Specification

The outcome variables being investigated in this study have binary responsesin the form of (i) a household reporting vulnerability to shocks or not and (ii) a household reporting the use of infrastructure-aided ex-post coping strategies or not. These decisions are therefore modelled based on the observed choices, using the standard logistic regression. Logistic regression will enable prediction of the household decisions based on an array of predictor variables theorized *a priori* to have predictive power on the response variable (Long and Freese, 2006; Agresti, 2018). The probability of the observed household choice $P(Y = 1)$ depends on the values of explanatory variables $\pi(x)$ represented in a vector. The logarithm of the odds are presented as;

$$logit[\pi(x)] = log\left[\frac{\pi(x)}{1-\pi(x)}\right] = \alpha + \beta x \quad (5)$$

To capture the evolution of time in the household decisions, the time element (year dummy) is introduced into equation five. The coefficient on the year dummy measures the effect of the physical infrastructure stocks and access levels realized between 2005/06 and 2015/16 period on the probability of changes in household vulnerability to shocks as well as changes in the household probability of using physical infrastructure-aided ex-post coping strategies.

2.4 Variable Measurement and Summary Statistics

Based on the objectives of the study, the outcome variables investigated are household vulnerability to shocks and the choice of infrastructure-supported ex-post coping strategies. Shocks refer to events and experiences that were reported in the two data-collection periods as having severely affected the household welfare negatively, leading to both quantifiable and unquantifiable losses. Explanatory variables used in the models were inferred from the review of literature. Some of the variables are presented in table one and their mean values compared for 2005/06 and 2015/16.

Table 1: Comparison of mean values of key variables in 2005/06 and 2015/16

Variables	2005/06 Mean	SD	2015/16 Mean	SD	All Mean	SD	t-stat
Household size	5.05	2.81	4.26	2.53	4.56	2.66	25.99***
Number of household members between ages:							
0 and 17	2.51	2.09	2.16	2.13	2.29	2.03	15.72***
18 and 64	2.37	1.42	1.95	1.15	2.11	1.28	30.57***
Over 65	0.16	0.43	0.16	0.42	0.16	0.42	0.62
Gender of household head (Male=1)	0.70	0.46	0.66	0.47	0.68	0.47	8.37***
Age of household head (years)	44.28	15.25	44.66	16.11	44.52	15.79	-2.21**
Education of household head (years)	6.94	5.20	7.18	5.10	7.09	5.14	-3.77***
Location (Rural=1)	0.64	0.48	0.60	0.49	0.62	0.49	7.62***
Electricity (Yes=1)	0.16	0.37	0.34	0.47	0.27	0.45	-36.32***
Access to piped water (Yes=1)	0.32	0.47	0.36	0.48	0.35	0.48	-6.92***
Housing quality index	-2.88e-08	1.00	0.06	1.02	0.036	1.01	-5.15***
Log of total household consumption expenditure (KES)	11.46	0.85	11.02	0.71	11.18	0.80	51.92***
Number of shocks reported	1.92	1.14	1.26	1.19	1.51	1.22	50.76***
Credit access (Yes=1)	0.29	0.46	0.32	0.47	0.31	0.46	-4.62***

***, **, * denotes significance at 1%, 5% and 10%, respectively

Information contained in table one indicates statistically significant differences in the mean values of some of the variables used in the study. These include household characteristics such as household size, gender, and age and education status of the household head, in which the mean values for the 2005/06 period were higher compared for households sampled in 2015/16. Physical infrastructure indicators such as access to water, electricity, and credit as well as related infrastructure advancement indicators such as attained education levels, levels of urbanization show a statistically significant increases between 2005/06 and 2015/16. Household welfare indicators also show a marked improvement between the two study periods. The quality of housing units improved, while the average number of shocks severely affecting household welfare reduced from a mean of 1.92 to 1.26 in 2015/16.

3 Data

This study uses two cross-sectional data sets collected by the Kenya National Bureau of Statistics (KNBS). The data sets came from the Kenya Integrated Household Budget Surveys (KIHBS) collected in 2005/06 and in 2015/16, which were nationally representative and covering a 12-month period. The 2005/06 and the 2015/16 KIHBS used similar data collection tools and approach in sampling. The similarity in the surveys therefore makes pooling the two cross-sectionals into one dataset feasible.

In developing countries where panel data are rare, pooled cross-sectional data are second best for analyzing household welfare dynamics (Dang and Carletto, 2018). In addition, pooling confers unique advantages such as isolating effects of specific public policies (Wooldridge, 2010) as well as increasing heterogeneity and degrees of freedom in samples since each cross section draws different observations (Hicks, 1994).

To build up the sample for the 2005/06 data, 861 and 482 rural and urban clusters respectively were randomly selected from across the country to ensure effective representation. The clusters are the primary sampling units as per the National Sample Survey and Evaluation Programme IV (NASSEP IV), which is the sampling frame and contained 1,800 clusters chosen based on the size proportion of the enumeration area created using the 1999 Population and Housing Census (Republic of Kenya, 2007). Ten households were then randomly selected from each of the national tally of 1,343 clusters giving a total sample size of 13,430 households. This nationally representative sample size accordingly comprised of 8,610 rural and 482 urban households. The overall sample size was then reduced to 13,154 after factoring the non-response (which was less than one percent) and data cleaning. The final tally of households used in this study therefore comprises of 8,447 rural and 4,707 urban households. Samples for the 2015/16 KIHBS were drawn from the fifth edition of the National Sample Survey and Evaluation Programme V (NASSEP V) This sampling frame, containing 5,360 clusters was similarly constructed from the enumeration areas designed in the 2009 Kenya Population and Housing Census. From the 5,300 clusters in the national sample frame, 2,400 were randomly selected constituting 1,412 from rural areas and 988 from the urban centres (Republic of Kenya, 2018a). The next stage in the sampling process involved selecting 16 households from each of the 2,400 clusters selected in the first step. Finally, 10 households were randomly selected from the 16 households, producing a final sample size of 24,000 households that participated in the study consisting of 14,120 and 9,880 from rural and urban areas respectively. The final tally of sample size that was used in this study after non-response and data cleaning by KNBS is 21,773 households, consisting of 13,092 and 8,681 from rural and urban areas respectively.

4 Empirical Results and Discussions

To ensure that the estimated coefficients in this study can be discussed and interpreted reliably, various diagnostics were conducted on the data and the models used. First, the time differences of the expenditures between 2005/06 and 2015/16 study periods as well as spatial differences were compared using the appropriate regional and time price deflators. Secondly, sampling bias is ruled out because the NASSEP-drawn clusters were randomly selected and nationally representative. Also, the necessary cleaning, including addressing duplicates, missing and illogical observations was undertaken in both samples. Outliers were identified and examined further to determine whether it was due to measurement error before deciding to correct the incorrectly reported observation, capping the data to exclude the outliers, or dropping the observations altogether.

The disturbance term in all the models being estimated in this study is assumed to be normally distributed and so the p-values of the estimated coefficients are reliable for significant testing. This is due to the fact that the sample sizes used in this study are sufficiently large, and therefore according to the central limit theorem, the disturbance term follows a distribution that approaches normality (Baltagi, 2013). Also tested was the appropriateness of logistic regression

to model the postulated relationships in the study. In all the models, the likelihood ratio (LR) and the goodness-of-fit tests indicated that the models used fit the data well and were thus well specified Tests also revealed that in all the models estimated, there were no serious collinearity among the independent variables.

In both periods of data collection, households were asked to report shocks that led to welfare reduction. Households reported a maximum of three shocks ranked in terms of severity but the listing in the questionnaire was not entirely based on severity. However, an analysis revealed for instance that the monetary loss from shocks was higher for the shocks listed first and reduced accordingly. In addition, idiosyncratic shocks were the ones mostly listed on top of the list (however, 57 percent of all the reported shocks were idiosyncratic in nature). The existence of this pattern in the two datasets reveals that the data collected through recalling of shocks accurately approximates the actual adverse events that affected household welfare within the recall period. The consistency of household responses confirms that the self-reported data on shocks is valid for use in this study and the estimated coefficients are reliable for policy inference.

4.1 Analysis of Household Vulnerability to Shocks

Estimation results of the determinants of household vulnerability to the general welfare shocks are presented in table two separate for 2005/06 and 2015/16 data study periods and for the pooled cross-sections. The pooled cross-sections has the time variable (year dummy) to assess the extent to which household vulnerability to the general livelihood shocks has changed between the two study periods.

The coefficient of the year dummy measures the effect of time on household vulnerability to shocks between 2005/06 and 2015/16. This coefficient measures the evolution of household vulnerability to shocks across the reference period. The results show a statistically significant difference in the household probability of reporting vulnerability to shocks between the two reference periods. Specifically, as the reference period changes from 2005/06 to 2015/16, the probability of an average household reporting vulnerability to a shock reduces by 20 percentage points, holding all other variables at their means. The results are consistent when estimated separately for rural and urban households. The probability of reporting shocks reduces as the reference period changes from 2005/06 to 2015/16 for both households, but the magnitude is higher by five percentage points for urban households. The similar effect of time passage on both rural and urban households' probability of reporting shocks explains the non-significance of the coefficient of interaction between location and time. This shows in effect that there are no statistically significant differences between rural and urban households' vulnerability to shocks in 2005/06 and 2015/16. These findings indicate an increase in both rural and urban households' resiliency at the same reference period when physical infrastructure stocks and access levels also increased in both rural and urban areas.

Table.2: Analysis of household vulnerability to all categories of shocks (marginal effects)

	2005/06	2015/16	Pooled cross-section 2005/06 and 2015/16
Housing quality index	-0.0255***	-0.0406***	-0.0353***
	(0.0057)	(0.0058)	(0.0043)
Log of total household annual expenditure	-0.0153**	0.0477***	0.0162***
	(0.0064)	(0.0078)	(0.0050)
Location (Rural =1)	0.0181*	0.0462***	0.0396***
	(0.0101)	(0.0090)	(0.0121)
Sex of household head (Male =1)	-0.0376***	-0.0548***	-0.0484***
	(0.0094)	(0.0091)	(0.0068)
Age of household head	0.0046**	0.0049**	0.0045***
	(0.0019)	(0.0020)	(0.0015)
Age squared of household head	0.0000*	0.0000	0.0000*
	(0.0000)	(0.0000)	(0.0000)
Household size: 0-17 years old	0.0170***	0.0277***	0.0216***
	(0.0023)	(0.0026)	(0.0018)
Household size: 18-64 years old	0.0090**	0.0119**	0.0069**
	(0.0035)	(0.0043)	(0.0029)
Household size: 65 and more years old	0.0189	0.0274	0.0194
	(0.0170)	(0.0185)	(0.0135)
Education of household head ('no formal education' is reference category)			
Primary	-0.0179*	0.0025	-0.0045
	(0.0099)	(0.0100)	(0.0074)
Secondary	-0.0194*	-0.0142	-0.0156*
	(0.0109)	(0.0115)	(0.0084)
Tertiary	-0.0538***	-0.0493**	-0.0525***
	(0.0185)	(0.0175)	(0.0133)
Employment of household head ('Salaried/waged' is reference category)			
Small business	0.0256**	0.0214*	0.0245***
	(0.0103)	(0.0110)	(0.0082)
Agriculture	0.0090	0.0817***	0.0584***
	(0.0112)	(0.0109)	(0.0082)
Year dummy (2015 = 1)	_____	_____	-0.1996***
			(0.0094)
Location dummy interacted with Year dummy	_____	_____	-0.0060
			(0.0131)

Standard errors are in brackets. ***, **, *: significant at 1%, 5% and 10% respectively

4.2 Analysis of Household Vulnerability to Food Security Shocks

Food security shocks directly and adversely affect household's ability to access food and thus make them food-insecure. In this study, they include droughts, floods, crop diseases and pests, death or theft of livestock, inflation of food and farming inputs prices and severe water shortages. Food security shocks are prevalent and have significant ramifications on household welfare and in general on the country's human capital development.

Table.3: Estimation of household vulnerability to food security shocks (marginal effects)

	2005/06	**2015/16**	**Pooled cross-section 2005/06 and 2015/16**
Housing quality index	-0.0228***	-0.0508***	-0.0377***
	(0.0078)	(0.0069)	(0.0051)
Log of total household annual expenditure	-0.0212**	-0.0185**	-0.0251***
	(0.0094)	(0.0093)	(0.0060)
Location (Rural=1)	0.0987***	0.0290**	0.0805***
	(0.0140)	(0.0108)	(0.0121)
Sex of household head (Male=1)	0.0378***	0.0256**	0.0316***
	(0.0123)	(0.0105)	(0.0080)
Age of household head	0.0022	-0.0001	0.0008
	(0.0027)	(0.0024)	(0.0018)
Age squared of household head	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)
Household size: 0-17 years old	0.0147***	0.0142***	0.0146***
	(0.0030)	(0.0030)	(0.0021)
Household size: 18-64 years old	0.0146***	0.0289***	0.0211***
	(0.0047)	(0.0052)	(0.0034)
Household size: 65 and more years old	0.0390*	0.0349	0.0350**
	(0.0223)	(0.0212)	(0.0153)
Household main source of food ('Purchased' is the reference category)			
Own-produced	0.0013	0.0404***	0.0313***
	(0.0191)	(0.0126)	(0.0104)
Gifts	0.0066	0.0842**	0.0517**
	(0.0389)	(0.0301)	(0.0239)
Own-stocks	0.0409	0.0182	0.0284
	(0.0335)	(0.0350)	(0.0243)
Education of household head ('no formal education' is reference category)			
Primary	0.0137	0.0145	0.0152*
	(0.0135)	(0.0121)	(0.0090)
Secondary	0.0113	0.0513***	0.0365***
	(0.0154)	(0.0137)	(0.0102)
Tertiary	-0.0454*	0.0727***	0.0287*
	(0.0270)	(0.0202)	(0.0161)
Employment of household head ('Salaried/waged' is reference category)			
Small business	0.0538***	0.0235*	0.0377***
	(0.0153)	(0.0138)	(0.0102)
Agriculture	-0.0077	0.0285**	0.0112
	(0.0151)	(0.0134)	(0.0099)
Year dummy (2015/16=1)	_____	_____	-0.0129
			(0.0110)
Location dummy interacted with Year dummy	_____	_____	-0.0443***
			(0.0143)

Standard errors are in brackets. ***, **, *; significant at 1%, 5% and 10% respectively

The estimation results of household vulnerability to food-security shocks are presented in table three. The results indicate that, in general and holding all other variables at their means, there

were no statistically significant changes in household vulnerability to food-security shocks between 2005/06 and 2015/16. However, the coefficient of the interaction of time and location of household was found to be statistically significant at one percent. Compared to urban households, the rural households' probability of reporting vulnerability to food-security shocks reduced by four percentage points in 2015/16 sample compared to 2005/06 sample. These findings are consistent with the study's hypothesis that rural households' vulnerability to food-security shocks reduced due to increases in the stocks of physical infrastructure in the country between 2005/06 and 2015/16. However, since by design this is an observational study and not a randomized controlled experiment, it is not possible to infer that the reduction in household vulnerability to food-security shocks was caused by the increase in physical infrastructure stocks within the reference period. The results are therefore interpreted to mean that a statistically significant association was established, which could be could be attributed to infrastructure growth, but other possible explanations cannot be ruled out (Ramsey and Schafer, 2013).

4.3 The Role of Infrastructure Growth in the Evolution of Ex-Post Coping Strategies to Food-Security Shocks in Kenya

Households ranked up to three strategies in terms of importance in responding to the adverse effects of shocks. In this study, only the first choice is used for the analysis. Coping mechanisms which are households' first choice represent 57 percent in the 2005/06 sample and 70 percent in the 2015/16 sample. The ex-post coping strategies for the general shocks and for food-security shocks are assessed for the two study periods. To ensure comparability of the two data sets, the response 'did nothing' reported for 7,990 responses in the 2015/16 data set was expunged.

Table four provides the estimation results of households' probability of using infrastructure-supported ex-post coping strategies when adversely affected by shocks that significantly contribute to food insecurity. Infrastructure-supported ex-post coping strategies include use of financial savings, formal credit facilities and borrowing from relatives and friends. These strategies are regarded more effective in stabilizing household welfare from the adverse effects of shocks and do not compromise ability to cope with future shocks, as is likely to be the case with strategies such as distress sales of productive assets and taking children off school to go work (Alpízar, 2007).

Results show that the coefficient of time-period dummy was statistically significant at five percent level of significance. Specifically, the probability of a household using infrastructure supported coping strategies increased by 3.7 percentage points as the reference period changes from 2005/06 to 2015/16, holding all other variables at their means. The results indicate that when affected by food-security shocks, households were in 2015/16 than in 2005/06 more likely to use financial savings, formal credit facilities and borrowing from relatives and friends as ex-post coping strategies. This could mean that in 2015/16, the physical infrastructure supporting these coping options were accessible to more households and that there was increased use among the households. In the absence of a randomized-controlled experiment, it is not possible to attribute the changes in the use infrastructure-supported ex-post coping strategies exclusively to the country's infrastructure transformation between the reference periods.

Table 4: Estimation of household probability to use infrastructure-supported ex-post coping strategies to food security shocks (marginal effects)

	2005/06	2015/16	Pooled cross-section 2005/06 and 2015/16
Reported food shocks (Yes=1)	0.0666***	0.0539***	0.0613***
	(0.0129)	(0.0129)	(0.0091)
Housing quality index	0.0177**	0.0104	0.0177***
	(0.0086)	(0.0090)	(0.0061)
Log of total household annual expenditure	0.0663***	0.0685***	0.0600***
	(0.0105)	(0.0124)	(0.0072)
Location (Rural=1)	0.0024	0.0234*	-0.0224
	(0.0158)	(0.0142)	(0.0138)
Sex of household head (Male=1)	0.0161	0.0456***	0.0292***
	(0.0139)	(0.0136)	(0.0097)
Age of household head	0.0026	0.0053*	0.0045**
	(0.0030)	(0.0031)	(0.0021)
Age squared of household head	0.0000	-0.0001***	0.0000*
	(0.0000)	(0.0000)	(0.0000)
Household size: 0-17 years old	-0.0035	-0.0013	-0.0002
	(0.0032)	(0.0037)	(0.0024)
Household size: 18-64 years old	-0.0032	0.0167**	0.0023
	(0.0050)	(0.0065)	(0.0038)
Household size: 65 and more years old	-0.0290	0.0449*	0.0040
	(0.0234)	(0.0270)	(0.0175)
Reported access to credit (Yes=1)	0.0372***	-0.0164	0.0114
	(0.0122)	(0.0125)	(0.0087)
Access to formal insurance (Yes=1)	_____	0.0322*	_____
		(0.0166)	
Access to mobile money transfer platform (Yes=1)	_____	0.0625**	_____
		(0.0229)	
Education of household head ('no formal education' is reference category)			
Primary	0.0507***	0.0051	0.0295**
	(0.0146)	(0.0151)	(0.0104)
Secondary	0.0453**	0.0130	0.0343**
	(0.0168)	(0.0179)	(0.0122)
Tertiary	0.0185	0.0188	0.0258
	(0.0293)	(0.0291)	(0.0203)
Employment of household head ('Salaried/waged' is reference category)			
Small business	0.0035	-0.0154	-0.0099
	(0.0171)	(0.0186)	(0.0123)
Agriculture	-0.0596***	0.0134	-0.0289**
	(0.0166)	(0.0180)	(0.0120)
Year dummy (2015/16=1)	_____	_____	0.0367**
			(0.0139)
Location dummy interacted with Year dummy	_____	_____	0.0506***
			(0.0173)

Standard errors are in brackets. ***, **, *; significant at 1%, 5% and 10% respectively

To assess robustness of the claim that adoption of these specific coping strategies are attributable to infrastructure growth, a comparison was done of the changes in their use across the reference period and between the rural and urban households when faced by general food-security shocks. Separate estimation results indicate that passage of time was associated with increased probability of using the infrastructure-supported coping strategies in both rural and urban households. This is plausible given that infrastructure growth in the country during the reference period was not limited to rural areas. While the status of the rural-urban gaps in basic physical infrastructure stocks and access between 2005/06 and 2015/16 could not be determined in the scope of this study, it is assumed to exist on almost all key indicators. However, infrastructure stocks and access levels grew between the reference periods in both rural and urban areas. For example, mobile telephone connections and money transfers were negligible in both areas at the baseline (2005/06) but the access was relatively higher in urban areas in 2015/16. In order to capture both the level and trend effects, a variable interacting household location and year dummy was introduced in the estimation model. The coefficient of the interaction term shows that the probability of using infrastructure-supported coping strategies increased by five percentage points more for the rural households facing food-security shocks than the urban households facing similar shocks in 2015/16 compared to 2005/06, holding all other variables at their means.

The results reveal greater changes in the adoption of infrastructure-supported coping strategies in the sampled rural households compared to urban households. This revelation strengthens the claim that the infrastructure growth between 2005/06 and 2015/16 contributed to the observed evolution of household ex-post coping strategies. This is because, given that rural areas had lower baseline infrastructure stocks and access levels than urban areas, it is therefore possible that any infrastructure growth in the intervening period (new roads, new electricity connections, new bank branches, mobile telephone subscription and money transfer services) should result to higher changes in the group with lower baseline figures (rural households) than in the group who already had higher baseline infrastructure stocks and access (urban households).

5 Conclusions and Policy Recommendations

This study set to establish whether the changes in physical infrastructure stocks and population access levels in Kenya between 2005/06 and 2015/16 had an association with changes in the household vulnerability to the general and food-security shocks as well as the ex-post coping strategies adopted. In order to ascertain the role of physical infrastructure on household shocks' vulnerability and resultant ex-post coping strategies, the study disaggregated rural and urban samples in addition to the time differences because of the apparent differences in the stocks physical infrastructure and population access levels between the rural and urban areas in developing countries like Kenya. Food-security shocks are specifically highlighted because they are most prevalent especially among rural households and low-income earners in urban areas. Kenya's stock of physical infrastructure and population access levels increased significantly between the two data collection periods.

Estimation results indicate a significant changes in household vulnerability and ex-post coping strategies across the two reference periods and between rural and urban sampled households. First, we find a reduction in household vulnerability to the general shocks between 2005/06 and 2015/16, with the reduction being higher for urban households by five percentage points in

relation to the reduction in rural households. Secondly, although generally there was no observed change in household vulnerability to food-security shocks in the reference period, disaggregating the households by geographical location reveals that rural households' vulnerability dropped by four percentage points compared to urban households between 2005/06 and 2015/16. Lastly, we found that between 2005/06 and 2015/16, both rural and urban households increased the use of infrastructure-supported ex-post coping strategies such as savings and borrowing to respond to food-security shocks. The magnitude of adoption was higher by five percentage points among rural households compared to the urban households between the reference periods. The study concludes that there is a plausible association between physical infrastructure changes and household vulnerability and coping strategies to shocks across time and in different geographical locations. Specifically, the magnitude of reduction in vulnerability to shocks and the increase in effective ex-post coping strategies is greater for rural households than for urban households.

The findings of this study, though not generated through a randomized controlled trial process, were nevertheless produced from a nationally-representative samples and used time passage – an exogenous variable- to assess changes in household vulnerability and coping response to livelihood shocks. Accordingly and based on these grounds, important policy recommendations can be deduced. First, policy interventions to reduce vulnerability to livelihood shocks should consider that vulnerability is a dynamic aspect across time and space. Secondly, relevant stakeholders should incorporate development of physical infrastructure as an important strategy for reducing vulnerability especially in the country's marginalized areas. Third, the development of infrastructure stocks need to be implemented as a bundle of inter-related elements to create bigger impact in vulnerability reduction and building of household resiliency to shocks. For example, rural electrification should be complemented with motorable roads, agricultural produce market centres, functional education and health infrastructures as well as promotion of establishment of financial institutions

6 Acknowledgements

The authors acknowledge the financial support from the African Economic Research Consortium (AERC) towards this study. The findings, opinions and recommendations are those of the authors, however, and do not necessarily reflect the views of the Consortium, its individual members or the AERC Secretariat. The authors appreciate helpful comments received on earlier drafts of this paper. Any errors are the responsibility of the authors.

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