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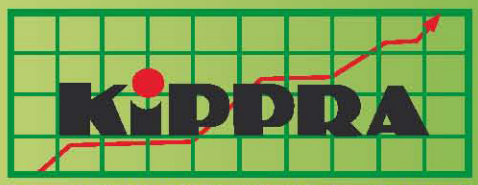

The KENYA INSTITUTE for PUBLIC POLICY RESEARCH and ANALYSIS

Firms Coping Mechanisms and Resilience to the Impacts of Droughts and Floods in Kenya

Adan Guyo Shibia

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THE KENYA INSTITUTE FOR PUBLIC POLICY RESEARCH AND ANALYSIS (KIPPRA)

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Kenya Institute for Public Policy
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Abstract

With the climate change predicted to increase, the recurrence and severity of droughts and floods are projected to rise. Building coping mechanisms of firms is crucial in reducing social-economic costs associated with droughts and floods. Scarcity of research on how firms cope with droughts and floods, and factors that affect their resilience remains a hindrance to policy interventions. This study sought to accomplish two objectives; first to understand the coping mechanisms employed by firms in Kenya to manage the impacts of droughts and floods; and second to enrich insights on factors that affect firm resilience to the impacts of droughts and floods. The analyses employed a unique survey of about 800 firms across 27 Kenyan counties in three sectors: Wholesale and retail trade, accommodation and food services, and manufacturing. Descriptive statistics and regression analysis, principally bivariate Probit models and univariate Probit models were used to achieve the objectives of the study. Bivariate Probit Models were preferred for analysing choices firms make given multiple use of different coping mechanisms. This study systematically analysed how firms employ finance and non-finance coping mechanisms towards mitigating the impacts of droughts and floods. Finance coping measures were further disaggregated into formal finance and informal finance; while non-finance coping mechanisms were further disaggregated into sustainable and unsustainable measures.

The findings suggest that firms employ multiple coping mechanisms including use of formal and informal finance, sustainable and unsustainable non-finance coping measures. The firms' choice of coping measures varies by firm-specific characteristics, geographical characteristics and the sector in which the firms operate. Moreover, the use of finance and sustainable non-finance coping mechanisms are shown to be complementary. This suggests the importance of deepening use of financial instruments as a strategy for building firm resilience to the impacts of droughts and floods. Costs imposed on firms through infrastructure are found to worsen resilience. The paper calls for deepening use of financial instruments; tailoring interventions to firm-level characteristics; and the need to enhance efforts in building resilient infrastructure such as electricity, water and roads.

Abbreviations and Acronyms

EDE	Ending Drought Emergencies
GDP	Gross Domestic Product
GoK	Government of Kenya
KIPPRA	Kenya Institute for Public Policy Research and Analysis
KNBS	Kenya National Bureau of Statistics
MTP	Medium Term Plan
NDMA	National Drought Management Authority
NDRM	National Disaster Risk Management
OECD	Organisation for Economic Cooperation and Development
SDGs	Sustainable Development Goals
UNFCCC	United Nations Framework Convention on Climate Change

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1. Introduction

1.1 Background

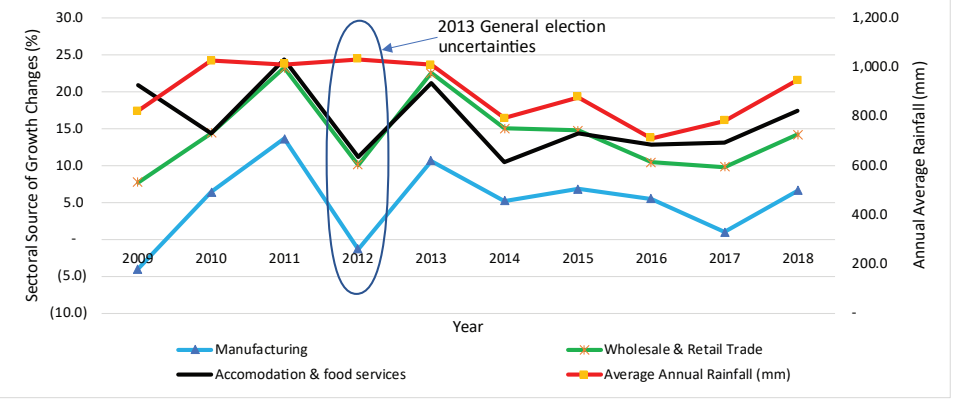
Climate induced shocks such as droughts and floods pose significant risks to the performance of firms in developing countries through various mechanisms, including disruption of production processes, increased costs of inputs, supply chain disruptions, dampened product demand and infrastructure damages (Agrawala, et al., 2011). Since 1960s drought alone is estimated to have accounted for 25% of all natural disasters in Africa compared to 8% global average (Gautman, 2006); and with the projected increase in climate change the situation can only be expected to deteriorate. There is increasing policy interests in how firms in developing countries cope with droughts and floods as they are disproportionately affected by climate-induced shocks owing to weak investments in climate security interventions and institutional frameworks (Fankhauser & McDermott, 2014). There is however a lacuna in literature with regards to firms' coping mechanisms in developing countries given existing research are biased towards the households and communities (Crick, et al., 2018a). This is surprising given firms, particularly the Micro and Small Enterprises (MSEs), play a crucial role in employment and income generation that can cushion households in times of climate-induced shocks.

Kenya's long-term aspirations anchored in the Kenya Vision 2030 is to transform the economy into a middle-income industrialised status with high quality of life. The Big Four Agenda of the government has prioritised four pillars for socio-economic transformation: Manufacturing, universal health coverage, food and nutrition security, and affordable housing. The increasing recurrence and severity of external shocks linked to climate change however pose constraints to realization of these development aspirations. Commencing with the Second Medium Term Plan (MTP) of the Kenya Vision, the government prioritized to end emergencies of droughts from culminating into disasters, reflecting the scale of the problem and the resulting policy commitments. Within the formal sector 42% of the 2.6 million persons employed is within the Micro and Small Enterprises (MSEs); defined as firms employing less than 50 persons (KNBS, 2019a). The MSEs are particularly vulnerable to external shocks due to limited internal resource capabilities and constraints in exploiting external opportunities, including access to credit and insurance services.

This study aimed to generate evidence and deepen insights into the coping mechanisms used by firms through an establishment-level survey in 27 drought and flood prone Kenyan counties within three sectors: Wholesale and retail,

accommodation and food services, and manufacturing. The first two sectors are the dominant business activities in the sampled counties while the third was chosen based on Kenya's aspiration to industrialise through a vibrant manufacturing sector. In aspirations of the Kenya Vision 2030, and the Big Four Agenda, the share of manufacturing in GDP is envisaged to double to 15% by 2022 (GoK, 2018) from an estimated 7.7% as of 2018 (KNBS, 2019b). The three sectors jointly accounted for 18.6% of GDP in real terms and 23.5% of the formal sector employment as of 2018 (KNBS, 2019a). The comparative county level contribution of the three sectors to GDP in real terms is shown in Annex 1. The 2016 Micro, Small and Medium Enterprises (MSMEs) survey in Kenya shows there are over 1.6 million licensed MSMEs with a further 5.9 million micro enterprises operating without licenses (KNBS, 2016)[1]. The three sectors of interest in this paper accounted for about 77% of the licensed MSMEs and 84% of unlicensed MSMEs. Overall MSMEs share in GDP is about 31.4%, of which the three sectors' share in MSMEs GDP is about 49.6% (KNBS, 2016). As shown in Figure 1.1 there appears to be a tendency for the average annual rainfall and the contribution of the three sectors as sources of GDP growth to move in tandem, with manufacturing and wholesale and retail trade depicting magnified shocks. The shocks to the three sectors if not well managed can therefore have a significant impact on the performance of the economy, employment and household incomes.

Figure 1.1: Trends in Annual Average Rainfall (mm) and Sectoral Significance as Sources of Growth (Per cent Changes)



Data Source: (KNBS, 2014; 2018; 2019b)

1 Licenses are issued by county governments and serves largely as a revenue generation tool. Unlicensed businesses are largely informal businesses such as hawkers (open air venders) who in some instances are required to pay daily market fees.

As part of the foundations of national transformation the Second MTP of the Kenya Vision 2030 prioritised ending drought emergencies through strengthening resilience, monitoring and response to droughts. The Third MTP of the Kenya Vision 2030 builds on the Second MTP, recognising ending drought emergencies as one of the foundations for national development (GoK, 2018).

1.2 Statement of the Problem

Recognising the adverse socio-economic consequences of climate-induced shocks, the Kenyan government has recognized the importance of managing the impacts of droughts and floods as a strategy for realisation of development agenda. Despite such recognitions, droughts and floods continue to impose significant losses to the private sector. The economy is estimated to lose 8.0% of GDP every five years and 5.5% of GDP every seven years to the impacts of droughts and floods, respectively (GoK, 2017). In a single but prolonged instance such as the 2008-2011 drought, GDP was estimated to have been dampened by an average of 2.8% annually, resulting to US$12.1 billion losses of which 93% was due to lost income flows across various sectors of the economy (GoK, 2013; GoK, 2015). With increasing frequency and severity of droughts and floods, the situation will likely worsen in the absence of effective coping mechanisms. Given the externally-induced nature of climate shocks such as droughts and floods, firms just like other economic agents, have no option but to devise coping mechanisms to reduce the resulting impacts. Adoption of effective coping mechanisms is not only vital for the firms' survival, but also in reducing the economy-wide effects through transmission channels such as employment, output and incomes. Not all coping mechanisms however prove to be of equal importance. Market-based coping mechanisms tend to cushion private sector agents such as firms from impacts of climate-induced shocks much better than informal coping mechanisms that are unsustainable (Agrawal & Perrin, 2009; Crick, et al., 2018b; Agrawala, et al., 2011). So far there is limited research to gain insights into the coping measures employed by the private sector firms to guide appropriate policy interventions. It is also important to quantify the relative impacts of droughts and floods on the performance of the enterprises in the three sectors that form the economic pillar of the Kenya Vision 2030. This paper is therefore aimed at generating research evidence on coping measures used by firms, gain insights into the relative impacts of droughts and floods on the three sectors, and understand factors that enhance firms' resilience in the three sectors to guide areas for policy interventions.

1.3 Research Objectives

1.3.1 General Objective

The general objective of this study was to establish how firms in Kenya cope with the impacts of droughts and floods and analyse factors that affect their resilience to the droughts and floods shocks.

1.3.1 Specific Objectives

The specific objectives were to;

1. Identify and analyse the coping mechanisms firms employ to manage the impacts of droughts and floods in Kenya;
2. Analyse the factors that contribute to the firms' resilience to the shocks of droughts and floods in Kenya.

1.4 Institutional Framework on Mitigating Drought and Floods in Kenya

At the global and regional levels, various policies guide adaption to climate change, including policy measures to build resilience to climate-induced shocks. These include the 1992 United Nations Framework Conventions on Climate Change (UNFCCC) aimed at curbing green-house gas emissions (United Nations , 1992); the 1997 Kyoto Protocol that was aimed at committing UNFCCC Parties to greenhouse emission targets (United Nations , 1997); the 2015 Paris Agreement (United Nations, 2015a), whose main aim was to strengthen global response to climate change through measures such as technology, capacity development and financing. Other global initiatives include the Sendai Framework for Disaster Risk Reduction 2015-2030 (United Nations, 2015c) that prioritised shifts from disaster management to disaster *risk* management. The Sustainable Development Goals (SDGs) (United Nations, 2015b); and the African Union Agenda 2063 (African Union, 2014) are among two recent global and regional initiatives that have set forth roadmaps for adaptation to climate change and implementation of measures for supporting climate change mitigation. The key aspirations of SDGs are articulated in Goals 1, 11 and 13. These include efforts to reduce exposure to extreme climate-induced shocks, reducing economic losses caused by natural disasters, and strengthening the resilience and adaptive capacity of private sector to climate-induced disasters. The AU Agenda 2063 aspirations include deepening adaptation to climate change through measures such as finance, human capital development, technology and inter-disciplinary synergy.

At national level, the Kenyan government has mainstreamed these global and regional aspirations through policies and strategies including the Kenya National Adaption Plan 2015-2030 (GoK, 2016b) that calls for a holistic approach to climate change adaptation through planning, budgeting and implementation; and the National Climate Change Action Plan 2018-2022 (GoK, 2018) that calls for enhanced adaptation to climate change and reduce greenhouse gas emissions at national and county levels. The five-year Kenya National Adaptation Plan is a requirement under the Climate Change Act of 2016 (GoK, 2016a), aimed at mainstreaming climate change response, resilience, adaptations and mitigation actions at the national and county government levels.

The policy initiatives in Kenya are guided by the Kenya Vision 2030 that outlines the long-term development goals, and the Constitution of Kenya 2010 that creates two levels of independent and interrelated government. The function of disaster management is a concurrent function as per the Fourth Schedule of the Constitution of Kenya (Republic of Kenya , 2010), meaning both the national and county governments have roles to play. The Kenya Vision 2030 is anchored on three pillars: The economic pillar that envisages 10% annual GDP growth rates; the social pillar that envisages building a just and cohesive society with equitable social development in a secure environment; and the political pillar that aims to achieve a robust democratic political system built on issue-based politics, respect for the rule of law and protection of the rights of the citizens. The Kenya Vision 2030 is implemented in five-year MTPs commencing in 2008; with the third MTP under implementation during 2018-2022 period. The MTPs have provided important avenues for reviewing medium term development progress and emerging challenges, including prioritization of initiatives to address the impacts of droughts and floods. As part of the long-term environmental planning and governance the Kenya Vision 2030 envisages reducing effects of desertification and disasters with the goal of significantly reducing losses attributed to droughts and floods and establish trends and impacts of climate change on sensitive sectors (GoK, 2007). Key strategies identified towards achievement of these goals include promotion of adaptation activities to climate change, generation of scientific evidence to inform policy making and a shift from disaster response to disaster risk reduction.

The national government institutionalised the National Drought Management Authority (NDMA) in 2011, whose mandate has been strengthened through the NDMA Act, 2016. The NDMA Act, 2016 establishes the National Drought Emergency Fund to facilitate a timely response to drought during its different stages. The Common Programme Framework for Ending Drought Emergencies (EDE) was developed in 2015 to serve as a strategic framework for drought risk management through collaborations and synergy across various sectors

and institutions (GoK, 2015). The Common Programme Framework for EDE is anchored on six pillars: Resilient infrastructure; human capital development; peace and security; sustainable livelihoods; drought risk management; and institutional development and knowledge management. The NDMA provides a coordination role for implementation of the six pillars - together with respective county governors, it serves as a joint secretariat for County Steering Group in various ASAL counties. Given disaster management is a concurrent (shared) function, county governments play important roles in developing county-level policies (including mainstreaming national policies into county level policies such as county integrated development plans), resource allocation, and creation of synergy with national government institutions and development partners.

Besides NDMA, other key institutions include the National Disaster Operations Centre (NDOC) and the National Disaster Management Unit (NDMU). NDMU is an inter-agency unit established by a presidential directive in August 2013, and it operates under the ambit of the Ministry of Interior and National Coordination. NDOC has been in existence since 1998, initially mandated to coordinate efforts in mitigating impacts of the *El Nino* rains on infrastructure and the environment.

The National Drought Emergency Fund Regulations, 2018 and the National Disaster Risk Management Policy were approved by the cabinet in mid-2018. The Regulation is aimed at operationalising the National Drought Emergency Fund and a framework for resource mobilisation. The NDRM Policy on the other hand outlines the strategies and commitments of the government to reduce disasters.

The review of the institutional framework reveals two policy gaps. First, most of the initiatives are largely targeted at households and community level adaptations; and little focus seems to be paid to the coping measures employed by firms. The goals and behaviour of firms may generally be incongruent with those of the households given their unique goals and constraints. Second, much of the policy focus has been on droughts until 2018 with the cabinet approval of the NDRM that aimed to holistically address different kinds of risks including floods.

2. Literature Review

2.1 Theoretical Literature

The theoretical foundations of firms' coping measures to build resilience to manage impacts of droughts and floods provides a way to analyse the issues in a comprehensive and coherent ways. The theoretical underpinning of this study is largely rooted in the production theory approach to economic resilience, complemented by other relevant theoretical views including those on finance and supply chain resilience. The production theory approach to economic resilience (Dormady, et al., 2019) postulates that firms utilize inputs in a manner that optimize goals such as reaching production targets or profit maximization. The approach recognises roles of ex-ante and ex-post measures employed by firms to mitigate adverse effects of external shocks related to input shortages and price shocks through measures such as input substitution, technological change (mix of factors of production), relocation, resource isolation, resource pooling, import substitution and management effectiveness (Dormady, et al., 2019). The production theory approach views economic resilience through microeconomic lenses in terms of measures to mitigate loss of flow of goods and services or capital stock.

Some dynamics affect choices employed by firms to cope with shocks of droughts and floods, and eventually their resilience. Climate-induced shocks causes variabilities in cashflows of the firm, making it difficult either to use internal finance or credit to finance business operations. The theory of financing constraints and firm dynamics (Clementi & Hopenhayn, 2006) argue that as age and size of the firm increases, the variance of the firm's growth reduces, which tend to enhance its survival even in the phase of external shocks. The theory also argues that the ability of the firm to generate cashflows tend to increase its value, and hence the ability to secure external financing. In a related view, the theory of insurance (Borch, 1985) argues that insurance premiums reflect the compensation for the insurer for accepting the risks. Factors such as firm size and vulnerability to shocks are therefore expected to affect insurance premiums, which may have demand implications due to affordability concerns to businesses. Recently, financial literacy strand of theoretical literature has emerged (Lusardi & Mitchell, 2014) arguing limited financial literacy serves as a constraint to demand for financial products. Financial literacy is viewed as a welfare-enhancing investment in human capital, which can be deployed over time through return-maximising decisions.

The supply chain resilience strands of theoretical literature (Mason-Jones & Towill, 1998; Christopher & Peck, 2004; Simangunsong, et al., 2012) underscores *ex-ante* resilience measures as a strategy to mitigate disruptions to supply chains. The framework identifies risks internal to the firm (process and control); risks external to the firm but internal to the supply chain (demand and supply risks); and risks external to the supply chain network such as environmental, socio-political, economic and technological shocks. These strands of theoretical literature are important in illumination coping measures used by firms given that shocks such as droughts and floods often weaken the operations of supply chains due to reasons such as shortage of raw materials, quality of raw materials and access to suppliers (input markets) and customers (output markets). While supply chain resilience view is largely focused on *ex-ante* coping measures, the production theory approach is more comprehensive in focusing on both *ex-ante* and *ex-post* measures, hence provides a robust foundation for analyses in this research paper.

2.2 Empirical Literature

2.2.1 Finance

The use of financial instruments is increasingly recognized as an important strategy for building private sector resilience to climate-induced risks. The Sendai Framework for Disaster Risk Reduction 2015-2030 (United Nations, 2015c) recognizes the importance of disaster risk transfer and insurance, risk sharing and financial protection for public and private sector investments to mitigate economic impacts of disasters. Majority of the enterprises in developing countries, Kenya included are Micro and Small Enterprises (MSEs), and this poses unique challenges in deepening financial instruments as a coping measure. Access to finance decreases with firm size due to market failure related factors such as asymmetric information, limited credit history, volatility in cashflows, high risk premiums and monitoring costs (Kersten, et al., 2017; Quartey, et al., 2017). Firms require finance to invest in innovative technologies to build their resilience to external shocks and recover when shocks occur and cause damages. Constraints in accessing finance push firms to adopt unsustainable adaptations such as cutting back on production which in turn limit growth opportunities (Crick, et al., 2018b; Atela, et al., 2018). With severe limitations in the use of formal financial market instruments such as credit and insurance, MSEs are shown to rely on social networks such as informal financial groups and lending networks especially among female-owned enterprises (Atela, et al., 2018). The large-scale

and recurrent nature of drought and floods however make use of social networks as a coping measure less effective.

Emerging literature suggests that climate variability affect return on investment and thus drives up costs of debt in developing countries. Precisely, it is estimated developing countries pay US$1 as climate variability premium for every US$10 paid in interests (Buhr, et al., 2018; Kling, et al., 2018). Investment in coping measures that build resilience for firms is needed to partly shield firms against escalation of such costs. If left unaddressed, such dynamics would erode financing opportunities of firms in developing countries.

2.2.2 Gender

Gender of the firm owner may also play significant role in firm investments and coping measures used to mitigate impact of drought and floods. It has been observed that female-owned firms demonstrate lower productivity relative to male-owned enterprises (Campos & Gassier, 2017) which points to the role of underlying gender dynamics in firms' performance. Climate risks adversely affect firms through asset losses and dampened growth, with the impact disproportionately felt by female-owned enterprises partly due to their concentration in climate-sensitive sectors such as agriculture (Atela, et al., 2018). These findings have important policy implications given that majority of female entrepreneurs who are unable to secure formal employment venture into entrepreneurship and tend to employ other females (Cirera & Qasim, 2014). Moreover, the performances of female-owned enterprises can be disadvantaged by a range of factors such as social norms, institutional arrangements and access to resource endowments and concentration in vulnerable sectors (Johnson, 2004; Campos & Gassier, 2017; Atela, et al., 2018). Gender-based risk preferences are also shown to affect entrepreneurial strategic choices, which in turn affect firm performance (Cirera & Qasim, 2014). Drought and floods may cause significant volatility in firm revenues and returns on investment, and risk preference may play important roles in shaping strategic choices such as capital investment and contractual strategies aimed at cushioning the firm against adverse impacts.

2.2.3 Firm size

Resource-based view of the firm (Penrose, 1959; Wernerfelt, 1984) posits that internal resources are fundamental for exploiting the external opportunities and shaping external constraints. As firm size decreases, they face more severe capital and managerial resources deficits which in turn dampen opportunities to

exploit external markets for inputs and outputs. The Micro, Small and Medium Enterprises (MSMEs) are relatively vulnerable to adverse climate shocks given they are resource constrained and less resilient due to impediments imposed by limited access to capital, labour, logistics and markets (Samantha, 2018). Furthermore, smaller firm size is associated with constrained customer base diversification, input diversification and export market participation (KNBS, 2016). These characteristics may perhaps have serious ramifications given the large-scale occurrences of climate-induced shocks such as droughts and floods. These dynamics corroborate emerging literature in supply-chain resilience that is anchored on the drive to cope with disruptions of inputs through measures such as input substitution, technological change, import substitution and relocation (Dormady, et al., 2019).

2.2.4 Sector

One of the economic arguments is that there are winners and losers at sectoral level, even when there may exist neutral consequences of climate-induced shocks at aggregate level. Impacts of climate-related natural disasters vary significantly by sector, with some sectors experiencing negative, neutral or positive outcomes (Kousky, 2014). The nature of the impacts also depends on the exposure to damages and resource distributional and allocation dynamics (Kousky, 2014). While some sectors such as agriculture and livestock are largely affected directly, some sectors such as manufacturing, trade or services can be affected directly or indirectly through availability of inputs, costs of inputs and supply chain disruptions. There is evidence that the impact of natural disasters such as floods on firms vary by the firm's position in the supply chain (Altay & Ramirez, 2010). Firms in different sectors also have different factor input shares (Abdisa, 2018) (i.e. proportions of capital, labour, materials, energy) that have implications for micro-level productivity and response dynamics to environmental shocks. Firms in the industrial sectors such as manufacturing are usually electricity intensive (Abdisa, 2018) and higher cost or rationing of electricity attributable to drought can have significant impacts and response incentives.

2.2.5 Business environment

In addition to access to external finance elaborated earlier in this paper, other key elements of business environment are vital to provide options for private sector firms to select appropriate coping mechanisms. Building firms' coping mechanisms and resilience to climate induced shocks is dependent on the general private sector development (Crick, et al., 2018a). Key among these elements include access

to information on climate change and climate adaptation options, institutional support (policies, regulations, incentives), infrastructure, availability and costs of finance (Crick, et al., 2018a). Access to climate information and government adaptation support services are shown to encourage firms adopt sustainable coping measures that enhance resilience (Crick, et al., 2018b). Climate-resilient infrastructure lowers direct losses to firms as well as indirect losses that occur through disruptions of supply chains (OECD, 2018).

3. Methodology

3.1 Survey Design

This study utilised an establishment-level survey of 802 enterprises in 27 of the 47 counties that are prone to droughts and floods in Kenya. Among the 27 counties, 22 counties (81.5%) are classified as ASALS (Ministry of Devolution and ASAL, 2018). The data was collected through interviewer- administered questionnaires between 10th February 2018 and 10th March 2018. The survey covered three sectors; namely manufacturing, wholesale and retail trade, accommodation and food services in both formal and informal sectors. The three sectors account for majority of the private sector enterprises and are well distributed across the 47 counties of Kenya. The three sectors account for 80% and 23.5% of the informal sector and formal sector employments, respectively as of 2018 (KNBS, 2019b).

About 30 establishments were targeted for each county covered by the survey. The survey resulted to 802 successful interviews, of which 9.3% were in manufacturing, 59.6% were in wholesale and retail trade and 31.1% were in accommodation and food services. Majority (85.0%) of the establishments sampled were micro enterprises employing less than 10 people, with small enterprises (10-49 employees) accounting for 12.4% and medium and large enterprises (≥ 50+ employees) accounting for 2.6%. The sample distribution largely reflects the distribution of Micro, Small and Medium Enterprises (MSMEs) which as of 2016 was established to be about 94.6%, 4.8% and 0.6% across the three sectors (KNBS, 2016).

3.2 Conceptual Framework

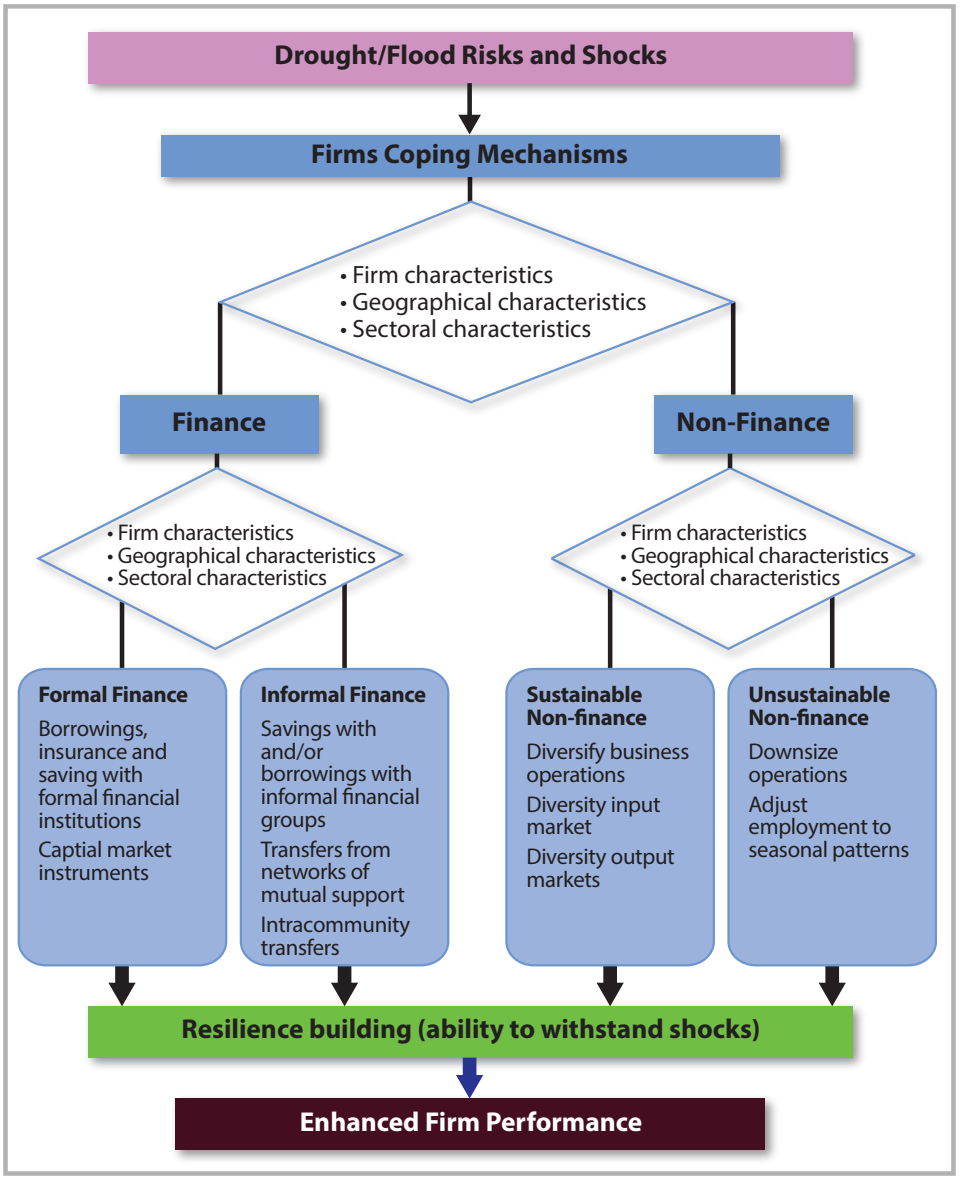
Firm behaviour is anchored on profit maximization goals given constraints such as factors of production and output prices. The economic goal of the firm would be to maximise profit (Mendelsohn, 2012) as follows: $max\ \pi = P_Q\ Q\ (Z, C) - \sum P_Z Z$; Where P_Q is price of output Q; P_Z is the price of intermediate inputs (Z) and $Q(.)$ is a production function. Climate shocks such as drought and floods have implications for the production function and would alter the relationships between inputs and outputs. The firm would employ each factor of production up to the point where $P_Z = \partial\ Q(.)/\partial Z$ that satisfy the first order condition for optimality. This condition equates the prices of inputs to their respective marginal productivities. The change

in productivities of the factor inputs either positively or negatively (Mendelsohn, 2012) would incentivize the firm to alter its production technology (mix of factor inputs) or shifts in output, which calls for employment of one or more coping measures.

A profit maximising firm chose coping measures such that the chosen alternative maximises net benefits (Mendelsohn, 2000; Mendelsohn, 2012; Dormady, et al., 2019). Constraints related to financial markets (e.g. costs, availability), access to inputs or factors of production and the associated costs can limit the extent to which firms employ market-based coping measures. Such constraints can make firms vulnerable or perhaps induce them to take unsustainable coping measures such as downsizing of operations, sale of assets or industry exit.

The nature and extent of usage of different coping measures depend on both internal and external factors. Internal factors related to resource capacity, including firm size and ownership can lessen constraints that hinder investments to cushion firms against the impacts of droughts and floods. Medium and large firms generally tend to have a wider human and non-human resource pool for investing in coping measures, compared micro and small firms. Human capital such as education of the firms' owner and manager's experience in the sector and access to relevant information as well as external conditions such as market barriers and business environment can also affect choice of coping mechanisms (Crick, et al., 2018b). Human capital such as education and experience aids in evaluating different coping alternatives in terms of costs and benefits. Availability of some resources may also be linked to these human capital components (Crick, et al., 2018b). The choice and effectiveness of the different coping measures may vary depending on the unique characteristics of the firm such as the sector in which the firm operates, gender of the entrepreneur, and the geographical location. Some sectors are more intensive in physical capital investments, while others are labour intensive. These conditions can dictate the speed of flexibility and the capability to undertake various coping measures. Gender of the entrepreneurs play a role in the choice of coping mechanisms principally through risk preferences by different genders, and the underlying institutional factors that affect resource accessibility. For instance, female entrepreneurs tend to be disadvantaged in access to finance. Geographical location may affect the severity of impacts and hence the incentives to undertake coping measures; as well as affecting access to some critical coping measures. Table 3.1 shows typology of various coping mechanisms available to firms. It should be noted that some coping mechanisms that have negative net benefits are likely to reduce firms' resilience and performance.

Figure 3.1: Conceptual Framework of Firms Coping Mechanisms and Resilience



Source: Author's Conceptualization

3.3 Analytical Framework

3.3.1 Firms Coping Mechanisms

The analysis employed descriptive statistics and econometric modelling. The descriptive statistics was used to gain insights into sample characteristics and coping measures used by the sampled firms. The econometric modelling was used to gain a deeper understanding on different coping mechanisms used by the firms, and factors that affect the resilience of firms to the impacts of droughts and floods. The characteristics of the dependent variable determines the nature of the econometric model to be used. Firms are shown to employ multiple coping mechanisms in coping with climate-induced shocks (Crick, et al., 2018b). The analysis therefore calls for econometric models that allow for the effects of covariates on the coping measures to be determined simultaneously while allowing for the error terms of various coping strategies to be correlated. In such cases, bivariate Probit model can be ideal for two equations (Crick, et al., 2018b) or in case of more than two equations multivariate Probit model (Mulwa, Marenya, Rahut, & Kassie, 2017). Bivariate Probit model is used for analyses of factors determining coping choices in this paper. This class of qualitative response models simultaneously estimate the probabilities of the firms' use of different coping measures. Only in one case where the condition for bivariate Probit model fails to hold, is binary Probit model used. The bivariate Probit model is derived from the underlying latent variables as follows (Greene, 2018):

$$y_1^* = x_1'\beta_1 + \varepsilon_1, \quad y_1 = 1\ (y_1^* > 0), \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1a)$$

$$y_2^* = x_2'\beta_2 + \varepsilon_2, \quad y_2 = 1\ (y_2^* > 0), \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1b)$$

$$\begin{pmatrix}\varepsilon_1\\ \varepsilon_2\end{pmatrix}\Big|\boldsymbol{x}_1,\ \boldsymbol{x}_2 \sim N\left[\begin{pmatrix}0\\0\end{pmatrix},\begin{pmatrix}1 & \rho\\ \rho & 1\end{pmatrix}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1c)$$

Where the errors are jointly normally distributed with:

i) Means 0, $\sum(\varepsilon_1) = \sum(\varepsilon_2) = 0$; ..... (2a)

ii) Variances 1; $var(\varepsilon_1) = var(\varepsilon_2) = 1$; ..... (2b)

iii) Correlation ρ; $cov(\varepsilon_1, \varepsilon_2) = \rho$; ..... (2c)

The $\boldsymbol{\beta}_s$ and ρ in bivariate Probit model are estimated through maximum likelihood estimation method. The ρ usually is a measure of conditional tetrachoric[2] correlation between y_1 and y_2. The variables in $\boldsymbol{x}$ include firms' characteristics,

2 Tetrachoric correlation is used to measure correlation ('rater agreement') for two dichotomous variables.

geographical locations and sectoral characteristics. The bivariate Probit model leads to four possible outcomes:

$$P_{00} = P(y_1 = 0, y_2 = 0) \quad \text{..... (3a)}$$

$$P_{10} = P(y_1 = 1, y_2 = 0) \quad \text{..... (3b)}$$

$$P_{01} = P(y_1 = 0, y_2 = 1) \quad \text{..... (3c)}$$

$$P_{11} = P(y_1 = 1, y_2 = 1) \quad \text{..... (3d)}$$

The probabilities of selecting coping measures are shown by P_{00}; P_{10}; P_{01}; P_{11}; where:

P_{00} is probability of selecting neither of the coping measures; y_1 nor y_2.

P_{10} is probability of selecting coping measure y_1 but not y_2.

P_{01} is probability of selecting coping measure y_2 but not y_1.

P_{11} is the probability of selecting both coping measures y_1 and y_2.

Three sets of regressions were estimated separately for droughts and floods (combined); droughts only and floods only as summarised in Table 3.1.

Table 3.1: Type of Coping Mechanisms and Possible Outcomes of Bivariate Probit Models

Type of Coping mechanisms	Possible Outcomes of bivariate Probit Model
Finance and/or non-finance coping mechanisms (y_1 = Finance coping mechanisms; y_2 = Non-finance coping mechanisms)	P_{00}: Neither finance nor non-finance coping mechanism was employed
	P_{10}: Only finance coping mechanism was employed
	P_{01}: Only non-finance coping mechanism was employed
	P_{11}: Finance and non-finance coping mechanism were employed
Formal finance and/or informal finance coping mechanisms (y_1 = Formal finance coping mechanisms; y_2 = Informal finance coping mechanisms)	P_{00}: Neither formal finance nor informal finance coping mechanism was employed
	P_{10}: Only formal finance coping mechanism was employed
	P_{01}: Only informal finance coping mechanism was employed
	P_{11}: Formal finance and informal finance coping mechanisms employed

Sustainable and/or unsustainable non-finance coping mechanisms (y_1 = Sustainable non-finance coping mechanisms; y_2 = Unsustainable non-finance coping mechanisms)	P_{00}: Neither sustainable non-finance nor unsustainable non-finance coping mechanism was employed
	P_{10}: Only sustainable non-finance coping mechanism was employed
	P_{01}: Only unsustainable non-finance coping mechanism was employed
	P_{11}: Sustainable non-finance and unsustainable non-finance coping mechanisms employed

Source: Author's construct

The following two latent variable models are estimated for each type of coping mechanisms shown in Table 3.1, from which bivariate Probit model is derived as per equations *1a - 1c*:

$$y_{1i}^{*} = \beta_o + \beta_1 firmage_i + \beta 2\, educ_i + \beta_3\, managerexper_i + \beta_4\, sector_i + \beta_5 firmsize_i + \beta_6 sales_i + \beta_7\, sales^2{}_i + \beta_8 femaleshare_i + \beta_9\, cluster_i + \beta_{10}\, ownership_i + \varepsilon_i$$

$$y_{2i}^{*} = \alpha_o + \alpha_1 firmage_i + \alpha_2\, educ_i + \alpha_3\, managerexper_i + \alpha_4 sector_i + \alpha_5 firmsize_i + \alpha_6 sales_i + \alpha_7\, sales^2{}_i + \alpha_8 femaleshare_i + \alpha_9 cluster_i + \alpha_{10}\, ownership_i + u_i$$

Where the errors ε_i and u_i are jointly normally distributed as elaborated in equation *1c*. The explanatory variables are: *firmage* is age of the firms in years; *educ* is education level of the top manager; *sector* is the sector in which the firm operates; *firmsize* is size of the firm; *sales* is the firms sales; $sales^2$ is the squared term of sales; *cluster* is the geographical location of the firm and *ownership* is the ownership characteristics of the firm. The detailed variable explanations, including levels of measurements and codes, where applicable are provided in Table 4.6.

3.3.2 Firms Resilience

To test the hypothesis that firm resilience (as measured by variability in sales during drought or floods relative to 'normal' period) could be explained by firm-specific, geographic/agro-ecologic and business environment (infrastructure) variables, the study employs Probit regression model. The dependent variable is categorized into whether the firm reported drought or flood to be a constraint or not, coded 1 (if reported to be a constraint) or zero otherwise. The binary nature of the dependent variable makes use of a binary response variable such as Probit appropriate. For a firm that pursues to maximise its profits through employment of coping measures against the impacts of drought and floods, adverse changes or situation that affects operations of the firm worsens the firm's value as a going

concern. Assume that the latent variable is related to as set of covariates such that:

$$y_i^* = x_i \beta + \varepsilon_i \quad \text{..... (4a)}$$

The link between the observed binary variable and the latent variable is demonstrated by the measurement equation:

$$y_i = \begin{cases} 1 & if\ y^* > 0 \\ 0 & if\ y^* \leq 0 \end{cases} \quad \text{..... (4b)}$$

where y^* is observable as $y = 1$ where cases with $y^* \leq 0$ are observable as $y = 0$.

In the Probit model $y = 1$ if the firm reported drought or flood to be a constraint, and $y = 0$ if reported not to be a constraint.

The following latent variable model is estimated for firm resilience, from which bivariate Probit model is derived as per equation *4b*:

$$y_i^* = \gamma_0 + \gamma_1 firmage_i + \gamma_2 managerexper_i + \gamma_3 femaleshare_i + \gamma_4 educ_i + \gamma_5 sector_i + \gamma_6 firmsize_i + \gamma_7 sales_i + \gamma_8 sales^2_i + \gamma_9 infrastructure_i + e_i$$

The covariates *firmage*; *managerexper*; *femaleshare*; *educ*; *sector*; *firmsize*; *sales*; and $sales^2$ are as earlier defined. The variable *infrastructure* is an index of business environment indicators including water, electricity and water as elaborated in Table 4.16 in Section 4.2 of this paper.

4. Results and Discussions

4.1 Firms Coping Mechanisms

4.1.1 Descriptive Results

a) Firms Basic Characteristics

A total of 802 firms were surveyed in the three sectors: manufacturing, whole and retail trade, and accommodation and food services. In terms of sectoral characteristics, 59.6% were in wholesale and retail trade, 31.1% were in accommodation and food services and 9.3% were in manufacturing. With regards to firm size, 85.0% were micro enterprises (<10 employees); 12.4% were small enterprises (10-49 employees) and 2.6% were medium and large enterprises (50+ employees). As illustrated in Table 4.1, at individual sectoral level most of the firms sampled were micro and small enterprises (73.0% for manufacturing, 92.0% for wholesale and retail; and 75.0% for accommodation and food services). Besides the general characteristics of the Kenyan enterprises, the dominance of micro enterprises among the sampled firms reflects the fact that the survey was undertaken outside major urban counties where one would expect to find medium and large enterprises.

Table 4.1: Distribution of Sampled Firms by Size and Economic Sector

Firm size	Manufacturing		Wholesale and retail		Accommodation & food services	
	Frequency	%	Frequency	%	Frequency	%
Micro (<10 employees)	54	73.0	437	92.0	186	75.3
Small (10-49 employees)	13	17.6	30	6.3	56	22.7
Medium & large (50+ employees)	7	9.5	8	1.7	5	2.0

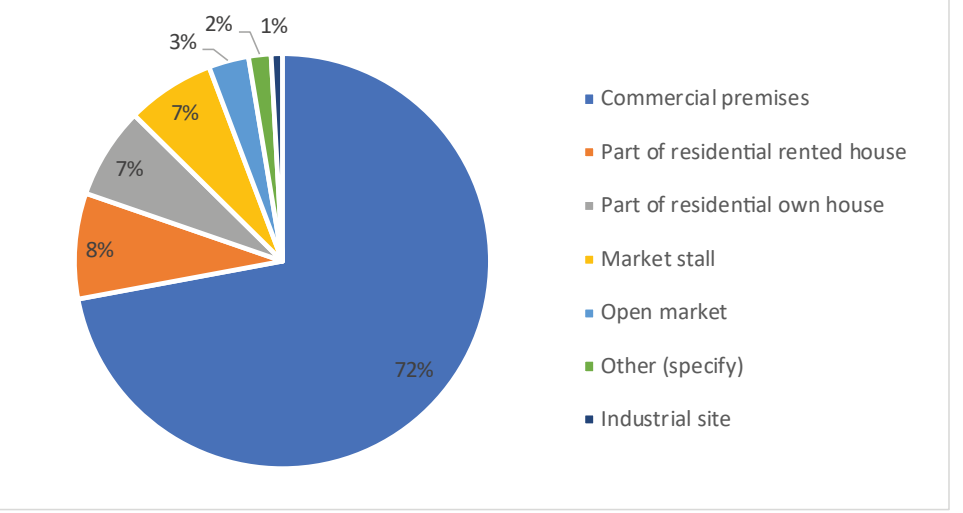
Data Source: (KIPPRA, 2018)

In terms of the sampled firms' operating characteristics, 71.3% were licensed sole proprietorship[3], 13.8% were private limited company, 7.7% were partnership, 5.4% operate without licenses or registration, 1.4% are public limited company, and 0.5% are cooperatives. The quality of work stations provides an important platform for the operations of the enterprises and building resilience to disasters.

3 Note that among the sole proprietorships it is possible some firms are not registered with the registrar of companies in a strict sense to be considered formal firms, but rather that they were simply owned and operated by a single owner. The licenses referred to in this context are issued by county governments in form of single business permits.

As shown in Figure 4.1, most of the enterprises surveyed reported that they operate from commercial enterprises (72.1%), while those operating from residential own house or residential rental house were 15.3%.

Figure 4.1: Nature of the Premises from which the Establishments Operates



Data Source: (KIPPRA, 2018)

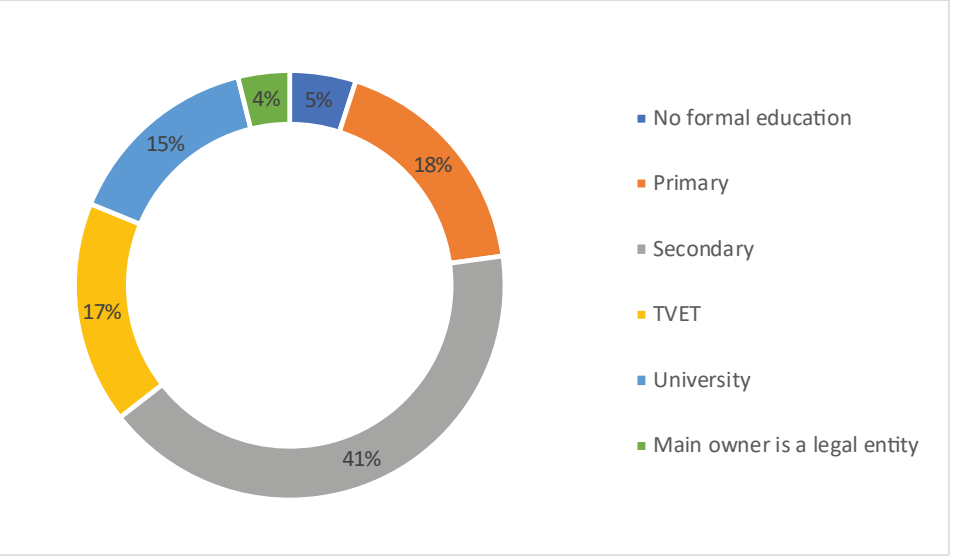
With regards to main ownership characteristics 64.4% of the enterprises were indicated to be male-owned; 31.9% female-owned; while for 3.7% the main owner was reported to be a legal entity. Further analysis shows that average female ownership is 42.6%[4] (In terms of distribution of ownership 53% of the sampled firms had less than 50% female ownership; 12% of the firms had 50% female ownership while 35% had more than 50% female ownership). With regards to education level of the main owner (Figure 4.2), majority have completed secondary education (41.6%) while 17.8% were reported to have completed primary education. Those with Technical Vocational Education and Training (TVET) and university education are 31.7%. From the resource-based view of the firm (Penrose, 1959; Wernerfelt, 1984), human capital is seen as internal capabilities that can be harnessed to reduce vulnerabilities and mobilise resources to make investments in resilience measures.

b) Implications of Droughts and Floods on Firms Performance

Drought was reported pose more constraints to the operations of firms compared to floods. About 94% of the firms sampled reported droughts pose moderate or severe constraints, compared to about 55% who reported floods pose moderate or severe constraints to their operations.

4 This refers to actual shareholding of the firms, rather than an indicator of whether female is the main shareholder or not.

Figure 4.2: Education Level Completed by the Firm's Main Owner



Data Source: (KIPPRA, 2018)

It is possible that floods seasons may create opportunities for some enterprises, through mechanisms such as increased generation of hydroelectricity or increased supply of raw materials for industries such as agro-processing. There is however a limit to which such occurrences are beneficial to the firms. Floods beyond some points can create massive infrastructure destructions (OECD, 2018) that dampen realization of such opportunities.

Table 4.2: Extent to which Droughts and Floods Constrain Performance of Firms

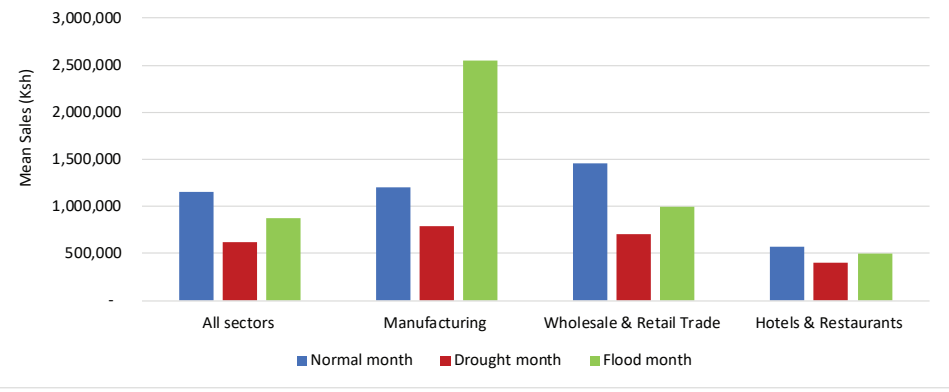
Constraint level	Droughts		Floods	
	Freq.	Per cent	Freq.	Per cent
Severe constraints	409	60.5	89	28.3
Moderate constraints	224	33.1	85	27.1
Not constraints	43	6.4	140	44.6
Total	**676**	**100.0**	**314**	**100**

Data Source: (KIPPRA, 2018)

The analysis in terms of sectoral impacts of droughts and floods on firms' performance show interesting results. Across the three sectors combined (Figure 4.3), estimated mean sales for the sampled firms were reported to decline by 24.2% during flood months compared to normal season months. The impacts are more severe during drought months, for which the estimated mean sales were reported to decline by about 46.1%, about twice the decline reported during flood

months. At sectoral level estimated mean sales during droughts for firms in the manufacturing sector were reported to decline by 33.8%, while those of wholesale and retail trade declined by 51.7% and those of accommodation and food services declined by 28.2%. The result suggests that firms in the wholesale and retail trade sector are disproportionately affected compared to those in the accommodation and food services and the manufacturing sectors. With regards to floods impacts, manufacturing firms estimated mean sales increased by 112.1%, while those of wholesale and retail trade, and accommodation and food services declined by 31.8% and 12.4%, respectively. One of the reasons that can explain the gains in the manufacturing sector during floods is that majority of them falls in the agro-processing subsector such as food and beverage; for which during heavy rains raw material inputs may increase, possibly at favourable prices. Manufacturing is also an intensive user of electricity, and during flood months generation of electricity from hydro sources may become abundant. On the contrary, a possible reason the trade sector appears to suffer most in both the case of drought and floods could be damages to infrastructure by floods and high costs of living that depresses purchasing power of consumers during droughts.

Figure 4.3: Sectoral Performance During Normal Months Vs. Drought and Flood Months

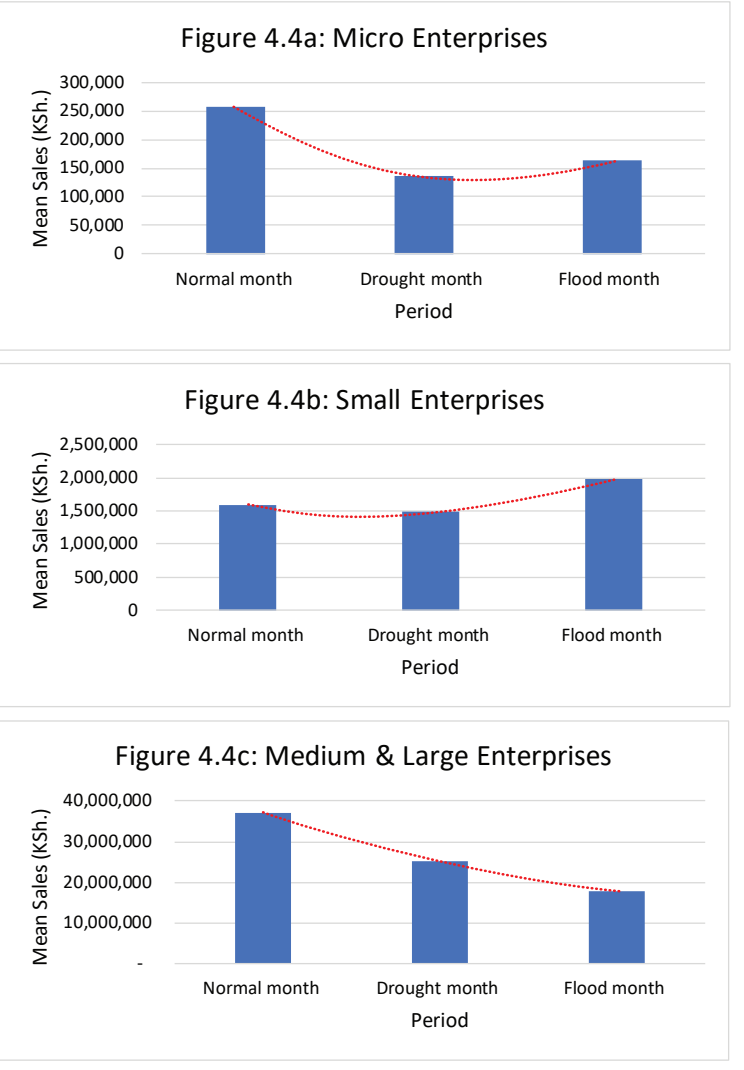


Data Source: (KIPPRA, 2018)

As shown in Figure 4.4, the impacts of droughts and floods by firm size (Micro enterprises; small enterprises; and medium and large enterprises) show some variations. With regards to droughts estimated mean sales were reported to decline by 47.2% for micro enterprises and by 7.0% for small enterprises, while those for medium and large firms were reported to decrease by 32.0%. The relatively moderate impacts on small firms compared to micro and medium/large firms can be linked to better resource bases and access to finance (as compared to micro firms), and less macroeconomic-related shock that are related to factors such as

exchange rate fluctuation and electricity costs compared to medium and large firms. With regards to floods, the estimated average sales for micro enterprises declined by 36.3%, those for small enterprises declined by 24.0%, while those of medium and large firms declined by 52.0%. Medium and large firms tend to trade beyond local geographic boundaries such as sub-county or county; hence they can be prone to floods as a result of damages to infrastructure which disrupts input supplies and market access.

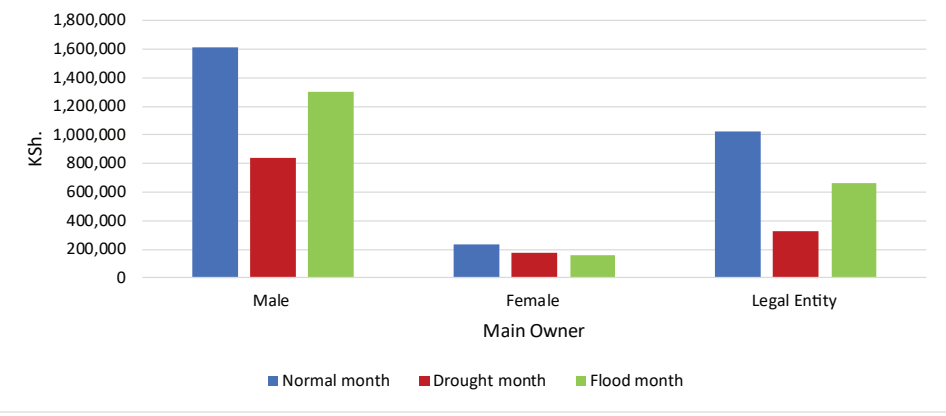
Figure 4.4: Size-Based Performance During Normal Months Vs. Drought and Flood Months



Data Source: (KIPPRA, 2018) Micro firms (<10 employees); small firms (10-49 employees); medium & large firms (50+ employees). The red broken lines indicate the trends of mean sales across different periods.

Gender level analysis, as shown in Figure 4.5, demonstrate that firms with male as the main owner has mean average sales of about KSh. 1.6 million during a normal month, while those with female as the main owner has mean monthly sales of about KSh. 231, 000 during a normal month[5]. With regards to impact of droughts, firms with female as the main owner however seem to be more resilient. The average monthly sales for female owned firms were reported to decline by 23.1%, compared to male owned firms which were reported to experience an average monthly sales decline of about 47.8%. For flood impacts, estimated average sales for male owned firms declined by 19.6%, while those of female owned firms declined by a larger proportion of 32.0%. The differences in impacts of droughts and floods across the sampled firms by gender can be linked to the variation of the underlying institutional constraints and gender-based risk preferences (Cirera & Qasim, 2014) that affects strategic decisions and coping measures.

Figure 4.5: Gender-Based Performance During Normal Months Vs. Drought and Flood Months



Data Source: (KIPPRA, 2018)

c) Drought and Floods Coping Measures

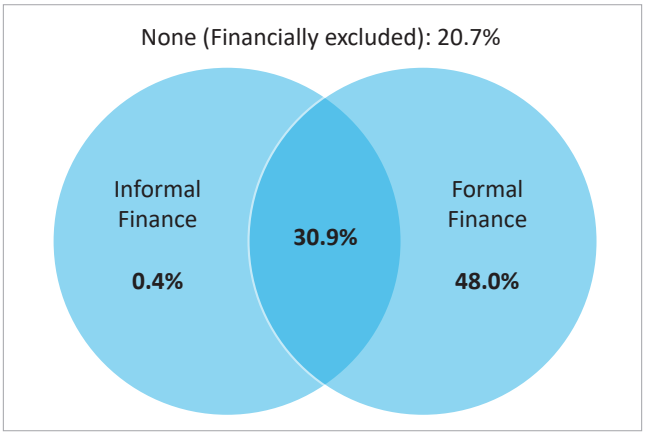
The survey explored the various measures firms *usually undertake* to manage the incidences of droughts and floods. The results are analysed first by finance coping measures, and then by non-finance coping measures. The finance coping measures are further disaggregated into the use of formal financial instruments and informal financial instruments.

5 The statistics translate to about seven-fold better performance in favour of male-owned firms

i) Finance Coping Measures

Overall the use of formal financial instruments such as savings with and borrowings from formal financial institutions among the sampled firms is high (Figure 4.6). About 48% of the firms sampled reported to usually use formal financial products to cope with the impacts of droughts and floods. The firms tend to use formal and informal financial instruments jointly (About 40%). Financial exclusion in managing droughts and floods impacts is also substantial, with 21% of the sampled firms reporting that they usually do not employ any financial coping measure to manage the impacts of droughts and floods.

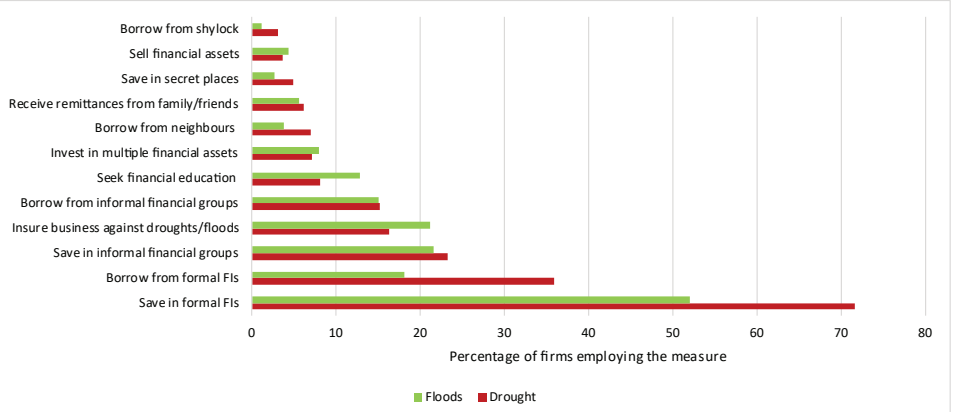
Figure 4.6: Venn Diagram of firms' Usage of Financial Instruments



Data Source: KIPPRA (2018)

The details on financial coping measures are depicted in Figure 4.7. The common measures reported to be undertaken include saving in formal financial institutions (71.6% for floods and 52.0% for droughts); borrowing from formal financial institutions (35.9% for droughts and 18.1% for floods); and savings with informal financial groups (23.3% for droughts and 21.6% for floods). Other relatively popular measures include use of insurance and borrowings from informal financial groups, which are on average used by about 15% of the sampled firms for both droughts and floods. Generally, there is a high level of correlation (0.88) among the coping measures used for drought and floods, that is found to be significant at 1% significance level. The correlation depicts similar patterns in the use of coping measures to mitigate the impacts of droughts and floods.

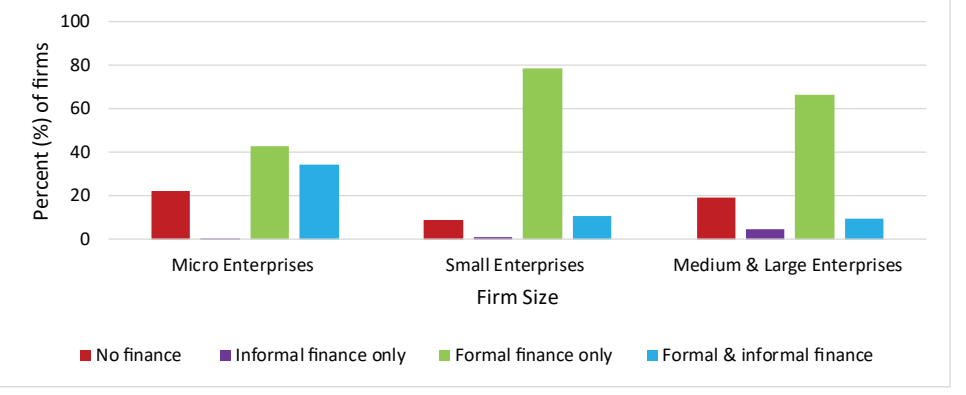
Figure 4.7: Measures Usually Employed by Firms to Cope with Droughts and Floods



Data Source: (KIPPRA, 2018)

With regards to the firm size, micro enterprises have lower usage of both formal and informal financial instruments compared to small, medium and larger enterprises (Figure 4.8), which largely reflects firm-size effects on access to finance (Kersten, et al., 2017). A higher proportion of micro enterprises however tend to use formal financial instruments jointly with informal financial instruments. Limited usage of formal financial instruments as a coping measure can significantly hinder micro enterprises' investments in resilience strategies. The micro enterprises are therefore disadvantaged in coping with droughts and floods.

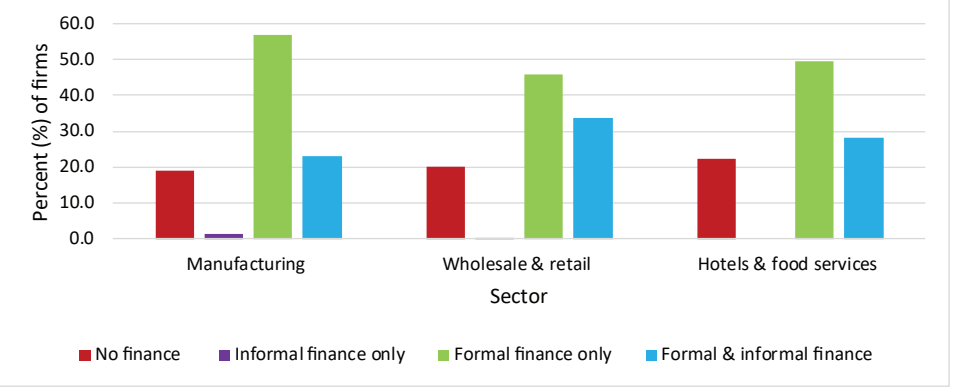
Figure 4.8: Use of Financial Instruments by Firm Size



Data Source: (KIPPRA, 2018)

Use of financial instruments by the three subsectors was also explored, as illustrated in Figure 4.9. The use of formal financial instruments was relatively high in the manufacturing sector (56.8%) followed by accommodation and food services (49.6%) and wholesale and retail trade (45.9%). The joint use of formal and informal financial instruments was however relatively high among the wholesale and retail trade sector (33.7%), followed by accommodation and food services (28.2%) and manufacturing (23.0%). One of the reasons for relatively high usage of informal finance in the wholesale and retail trade sector is the dominance of micro and informal enterprises. The wholesale and retail trade, together with accommodation and food services generally accounts for about 60% of the informal sector employment in Kenya (KNBS, 2018). The relative dominance of micro enterprises is also evident from earlier subsections of this paper.

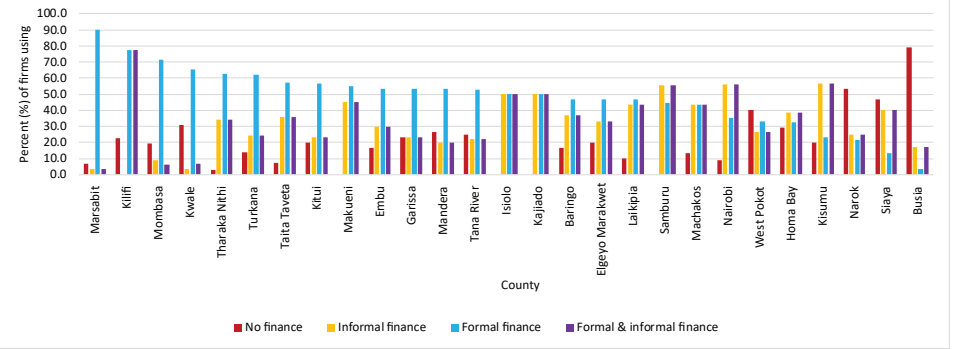
Figure 4.9: Financial Instruments Usage by Sub-Sector



Data Source: (KIPPRA, 2018)

Cross-county analysis of firms' usage of financial instruments is illustrated in Figure 4.10. The graph shows disparities in usage of formal and informal financial instruments. Among the 27 counties where the survey was undertaken, it is only in 37% of the counties where 20% or more of the firms reported not to have used finance (either formal or informal) as coping measures. There is also evidence of substantial joint usage of formal and informal financial instruments, especially in Kilifi, Kisumu, Nairobi, Samburu, Kajiado, Isiolo, Makueni, Laikipia, Machakos, Siaya, Homa Bay, and Baringo counties. Usage of formal financial instrument by the firms is surprisingly high in Marsabit County despite being an ASAL and expansive geographically, with presence of few formal financial institutions such as banks and insurance companies. The finding can be explained by growth of SACCOs and disproportionately high impacts of drought that drive precautionary savings; as well as borrowings when drought occurs.

Figure 4.10: Cross-County Firms Usage of Financial Instruments to Cope with Droughts and Floods



Data Source: (KIPPRA, 2018)

Financial Behaviour During the Most Recent Drought/Flood

On the borrowing front, only 30.4% of the firms reported to have borrowed credit during the most recent drought or flood experienced. Among the firms that reported to seek credit, 49.6% borrowed from banks, 16.7% borrowed from *chamas*[6], 16.2% borrowed from SACCOs, and 0.9% borrowed from government funds. Among the firms who borrowed from commercial banks they are mostly from Kenya Commercial Bank (36.2%), Equity Bank (34.5%), Cooperative Bank (6.9%) and Family Bank (6.0%). For those who did not borrow, the main reasons cited were that they did not need additional money (38.5%); denial by lenders (4.5%); high costs of borrowing (23.0%); insufficient business income to facilitate repayments (16.8%); and religious reasons (9.7%).

With regards to the insurance uptake, at the time of the survey about 17% of the sampled firms reported to have insurance for cushioning the business against droughts and floods incidences. Among the firms who reported they don't have drought or weather related insurance, the main constraints reported were high cost of premiums (41.8%); lack of understanding of how insurance works (18.7%); lack of perceived benefits of having insurance (15.9%); religious reasons (7.7%); lack of knowledge on where to get insurance (4.8%); lack of trust in insurance companies and agents (4.6%); and the perception that family or friends would come to aid when in need (1.5%).

On the savings front, about 70% of the firms reported they had saving for emergencies of droughts and floods at the time of the survey. Among those who reported they were not saving for droughts/floods, the main constraints noted were that the business was not generating enough income to save (48.5%) and the perceived lack of benefits to save for future uncertain events of droughts/floods.

6 *Chamas* mean informal groups

Table 4.3: Constraints to Saving to Manage Drought or Floods

Constraints to saving for droughts/floods	Freq.	Percent
Business not generating enough income	96	48.5
See no benefits to save for future uncertain events of droughts/floods	65	32.8
Lack financial institutions in the locality	16	8.1
Other	21	10.6
Total	**198**	**100.0**

Data Source: (KIPPRA, 2018)

Emerging Challenges and Opportunities

Challenges and emerging opportunities in the use of financial instruments as coping mechanisms were also explored. The emerging challenges reported by the sampled firms are presented in Table 4.4. The main challenges identified were failure of financial institutions to respond to the dynamics of droughts and floods in developing appropriate products; interest rate capping[7] that made it harder to access bank loans; challenges accessing services through technology; and the fact that more family and friends are affected and therefore making access to informal credit difficult.

Table 4.4: Emerging Challenges

Emerging challenges	Freq.	Per cent
Financial institutions not responding to dynamics of droughts & floods	244	33.0
Interest rate capping has made it difficult to access bank credit	243	32.9
Challenges in accessing services through technology	76	10.3
More family & friends are affected by droughts/floods, thus no one to borrow from	125	16.9
Other	51	6.9
Total	**739**	**100.00**

Data Source: (KIPPRA, 2018)

Key emerging opportunities cited by the firms included adoption of technology; emergence of suitable financial products and support from multiple institutions. Adoption of technology reflects the deepening of mobile phones ownership with data (internet) capability and the growing use of mobile money for banking and payments of social transfers. The emerging opportunities cited by the firms are detailed in Table 4.5.

7 The interest rate capping was introduced in September 2016 through an amendment of the Kenya's Banking Act. However, the clause in the Banking Act (i.e. Section 33B) capping interest rates has since been repealed through the Finance Act, 2019.

Table 4.5: Emerging Opportunities

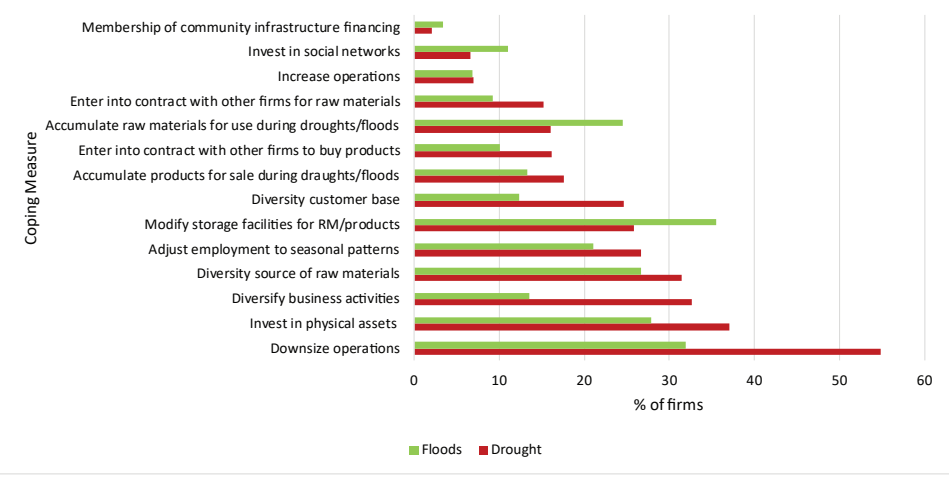
Emerging opportunities	Freq.	Per cent
Adoption of technology e.g. mobile phones	286	38.4
Support from multiple institutions	281	37.7
Availability of suitable financial products	115	15.4
Other	63	8.5
Total	**745**	**100.00**

Data Source: (KIPPRA, 2018)

ii) Non-Finance Coping Mechanisms

The non-finance coping measures explored include a range of tactics such as variation in scales of operations, employment variations and altering product markets for inputs and outputs. Overall 83.3% of the sampled firms reported to employ one or more non-finance coping measures. As illustrated in Figure 4.11, the main non-finance coping measures reported by the sampled firms to mitigate the impacts of droughts include downsizing of operations, investment in physical assets, diversification of business activities and diversification of the sources of raw materials. The main coping mechanisms for floods include modification of storage facilities for raw materials and products, downsizing of operations, investment in physical assets, diversification of sources of raw materials and accumulation of raw materials.

Figure 4.11: Details of the Non-Finance Coping Measures

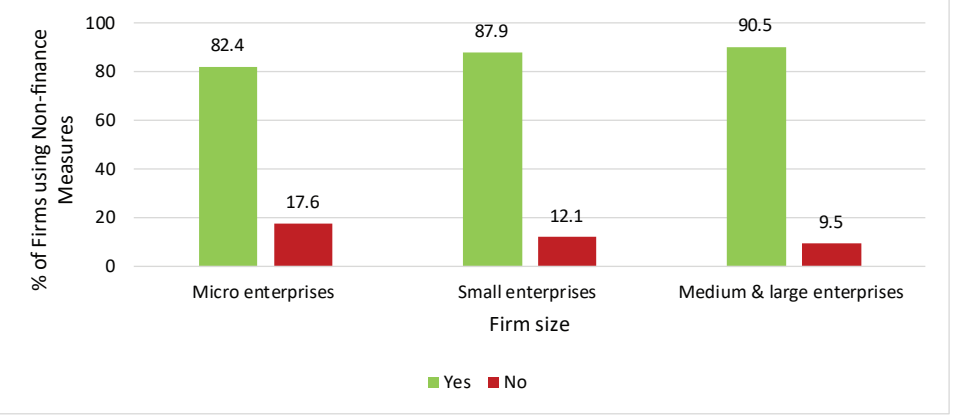


Data Source: (KIPPRA, 2018)

With regards to variation of coping measures by firm size, the use of non-finance coping measures increases with firm size as illustrated in Figure 4.12.

The difference in the usage of non-finance coping measures between medium/ large enterprises and micro enterprises is about 10 percentage points. The micro enterprises are generally resource constrained, including access to credit which may hamper their capability to invest in non-finance coping measures.

Figure 4.12: Use of Non-finance Coping Measures by Firm Size



Data Source: (KIPPRA, 2018)

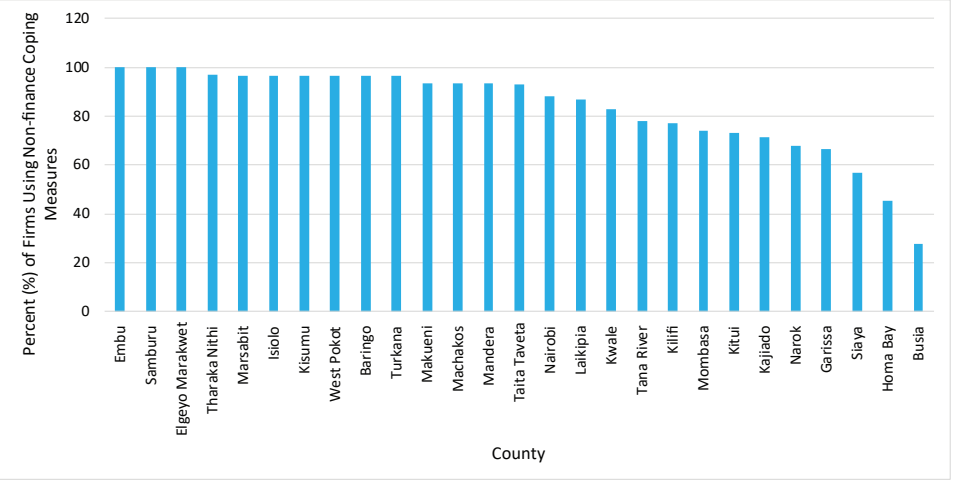
The sub-sectoral dynamics (Figure 4.13) shows the usage of non-finance coping measures is relatively higher among the firms in the manufacturing sector compared to those in the wholesale and retail trade, and the accommodation and food services sectors. Manufacturing firms are generally heavily dependent on raw materials that are directly affected by climate-induced shocks including droughts and floods, and this may explain their tendency to undertake non-finance coping measures compared to the firms in the other sectors.

Figure 4.13: Use of Non-finance Coping Measures by Sector

Data Source: (KIPPRA, 2018)

County-level analysis in the use of non-finance coping measures shows some disparities (Figure 4.14). The usage of non-finance coping measures is high among the firms in Embu, Samburu, Elgeyo Marakwet, Tharaka Nithi, Marsabit, Isiolo, Kisimu, West Pokot, Baringo and Turkana counties. Firms in Busia, Homa Bay, Siaya, Garissa, and Narok counties demonstrate low usage of non-finance coping measures.

Figure 4.14: Use of Non-finance Coping Measures across the Counties



Data Source: (KIPPRA, 2018)

4.1.2 Regression Results

This section provides a bivariate Probit Model results for the use of finance and non-finance coping mechanisms. The analysis on coping mechanisms have three subsections. The first one integrates coping measures for droughts and floods. This is followed by how firms cope with droughts only; and finally, how firms cope with floods only. Within each sub-section, the results are provided in the following order: First, the broad use of finance and non-finance coping mechanisms are explored. Second, the usage of finance is considered in terms of usage of formal finance and informal finance. Third, the usage of non-finance coping measure is considered in terms of sustainable non-finance use and un-sustainable non-finance use. The analyses thus closely follow the conceptualisation in Section 3.2. The variables used, their descriptions, measurement levels and coding are detailed in Table 4.6.

Table 4.6: Variable Measurements and Descriptions

Variable	Variable Description	Variable Measurement Level	Variable Codes
Dependent variable			
Finance use	Weather the firm reported to use any form of finance as a coping mechanism. This can be formal finance or informal finance.	Nominal	0=Don't use any financial coping mechanisms 1=Use at least one form of finance coping mechanisms
Non-finance use	Weather the firm reported to use any form of non-finance coping mechanism. This can be sustainable non-finance or unsustainable non-finance.	Nominal	0=Don't use any non-finance coping mechanisms 1=Use at least one form of non-finance coping mechanisms
Formal finance use	Weather the firm reported to use formal finance as a coping mechanism.	Nominal	0=Don't use formal finance coping mechanisms 1=Use formal finance coping mechanisms
Informal finance use	Weather the firm reported to use informal finance as a coping mechanism.	Nominal	0=Don't use informal finance coping mechanisms 1=Use informal finance coping mechanisms
Sustainable non-finance use	Weather the firm reported to use sustainable non-finance as a coping mechanism.	Nominal	0=Don't use sustainable non-finance coping mechanisms 1=Use sustainable non-finance coping mechanisms
Unsustainable non-finance use	Weather the firm reported to use unsustainable non-finance as a coping mechanism.	Nominal	0=Don't use unsustainable non-finance coping mechanisms 1=Use unsustainable non-finance coping mechanisms
Covariates			
firmage: Firm's age	Log of the firm's age measured as the year of the survey minus the year the firm started its operations	Ratio	N/a

educ: Education level of the top manager	Years of formal education completed by the top manager of the firm	Nominal	1=No formal education 2=Primary education 3=Secondary education 4=TVET 5=University
managerexper: Experience of the top manager	Log of the years of experience of the top manager of the firm in the sector in which the firm operates	Ratio	N/a
sector: Economic activity/sector	The main sector in which the firm operates	Nominal	1=Manufacturing 2=Wholesale/retail 3=Accommodation & food services
firmsize: Establishment size	Firm size as measured by number of employees. The small enterprises (10-49 employees) were categorized with medium and large enterprises (50+ employees) for econometric reasons given medium and larger enterprises have very few observations to support econometric analysis as a category.	Nominal	1=Micro enterprises (<10 employees) 2=Small, medium and larger enterprises (10+ employees).
sales: Sales	Log of turnover during a normal period as reported by firms. The turnover proxy for both firm's size (on turnover basis) and the ability to generate cash flows	Ratio	N/a
sales^2: Sales squared	Square of log of turnover during a normal period as reported by firms. This is aimed at capture non-linearity effects.	Ratio	N/a
femaleshare: % of female share	Log of the percentage of the establishment owned by female	Ratio	N/a
cluster: Cluster	Whether the firm is in urban or rural location	Nominal	1=Urban 2=Rural
ownership: Ownership type	Broad ownership characteristics of the firm	Nominal	1=Limited company 2=Partnership/ cooperative 3=Sole proprietorship

Source: Author's construct

a) Determinants of Droughts and Floods Coping Mechanisms

i) Use of Finance and Sustainable Non-Finance Coping Mechanisms

This section provides the bivariate Probit Model results for the use of finance and sustainable[8] non-finance coping strands by the sampled firms. The correlation among the two choices ρ, is positive (0.429441) and statistically significant *(Prob > chi² = 0.0000)*. The statistically significant ρ confirms suitability of the bivariate Probit model, as opposed to separate univariate Probit models for correlated choices. The positive coefficient suggests complementarities among the use of finance and sustainable non-finance coping mechanisms. The findings of the complementarities between finance and sustainable non-finance coping mechanisms are in congruence with the existing literature (Crick, *et al.*, 2018b) and provides evidence of indirect role of finance in building resilience to climate-induced shocks.

The bivariate Probit model marginal effects for the use of finance and non-finance coping mechanisms are shown in Table 4.7. The results indicate firm-level characteristics affect the choice of using finance and non-finance coping mechanisms. Firms for which the main owners have primary or secondary education have lower probabilities of *not* using any of the finance or non-finance coping measures compared to those without formal education, *P (00)*. The firms in the wholesale and retail trade sector and those in the accommodation and food services have a higher probability of *not* undertaking any of the finance or non-finance coping measures, compared to those in the manufacturing sector. These sectoral findings can be linked to higher usage of formal finance but lower usage of unsustainable non-finance coping mechanisms among the manufacturing firms, as is evident from the descriptive statistics shown earlier. An increase in firm size (at much larger firm size as proxied by the squared term of sales) is associated with a lower probability of *not* using any of the finance or non-finance coping mechanisms. Firms owned by sole proprietors have a higher probability of *not* employing any of the finance or non-finance coping mechanisms compared to limited companies. These results (firm size and ownership characteristics) suggests that firms with lower resource base, in congruence with the resource-based theory of the firm (Penrose, 1959; Wernerfelt, 1984) may have lower flexibility in adapting to the dynamics of external business environment.

Turning the focus to the use of *finance coping measure* only, *P (10)* in Table 4.7; firms with main owners possessing secondary level education have a lower probability of using finance coping strand compared to those without formal education. Sole proprietor firms have a higher probability of using finance as a

8 For sustainable coping mechanisms, firms continue to operate at a pre-shock or higher level of performance; as opposed to unsustainable coping mechanisms for which the firm's performance deteriorate relative to pre-shock operation level.

coping mechanism compared to limited companies. These seemingly counter-intuitive results can be explained by the aggregation of formal and informal finance usages into a single finance strand coping mechanism; and given that firms owned by entrepreneurs without formal education and those that are sole proprietors (mostly operating informally) tend to have relatively higher usage of informal finance. The 2019 FinAccess Survey also confirms this aspect of households with lower education levels having disproportionately lower usage of formal finance but higher usage of informal finance (FinAccess, 2019). For micro and small firms, that form majority of the Kenyan enterprises, comingling of business finance and those of the household is common, meaning household behaviours can be inferred to the business behaviour.

For the use of *non-finance coping mechanisms* only, *P (01)* in Table 4.7; firms in the wholesale and retail trade sector and those in the accommodation and food services sector have a higher probability of usage compared to those in the manufacturing sector. Increase in female ownership and firm size (at much larger firm size level) are associated with lower probability of using non-finance coping mechanisms. Lower probability of using non-finance coping mechanisms associated with incremental female ownership can be attributed to disproportionately lower access to formal finance by female entrepreneurs (Aterido, et al., 2013; Aristei & Gallo, 2016) and complementarity between finance and non-finance coping mechanisms. Smaller firms are generally constrained in accessing finance (Samantha, 2018) due to factors such as weak collateral base, information asymmetry and the perceptions of their vulnerability to shocks. Larger firms tend to overcome these constraints.

For the *joint usage of finance and sustainable non-finance coping mechanisms*, *P (11)* in Table 4.7, education level of the main owner, the sector in which the firm operates, share of female ownership, and firm size as proxied by turnover are the key driving factors of the coping decisions. Firms whose main owners have primary or secondary education have a higher probability of *jointly using* finance and non-finance coping mechanisms compared to the firms owned by those without formal education which can be understood in the context of the resource-based view of the firm (Wernerfelt, 1984). The firms operating in the wholesale and retail trade sector and those operating in the accommodation and food services sector have a lower probability of *jointly using* finance and sustainable non-finance coping mechanisms compared to those operating in the manufacturing sector. An increment in female share in the firm ownership is associated with a higher probability of joint usage of finance and non-finance coping mechanisms, which can be largely due to female entrepreneurs' efforts to overcome institutionally disadvantaged opportunities in participating in formal financial markets (Johnson, 2004).

Table 4.7: Bivariate Probit Marginal Effects (Finance and Non-Finance Coping Mechanisms)

Variables	*P (00)* Neither finance nor non-finance coping mechanisms	*P (10)* Finance coping mechanisms only	*P (01)* Non-finance coping mechanisms only	*P (11)* Finance & non-finance coping mechanisms
Age of the firm (logs)	-0.00241 (0.0113)	-0.0154 (0.0183)	0.0122 (0.0173)	0.00560 (0.0306)
Education level of main owner: Primary	-0.126** (0.0636)	-0.0977 (0.0656)	-0.0345 (0.0531)	0.258** (0.102)
Education level of main owner: Secondary	-0.134** (0.0631)	-0.130** (0.0634)	-0.00935 (0.0517)	0.272*** (0.0976)
Education level of main owner: TVET/University	-0.102 (0.0651)	-0.0403 (0.0696)	-0.0453 (0.0532)	0.187* (0.104)
Years of experience of top manager in the sector (logs)	-0.00525 (0.00989)	0.000948 (0.0176)	-0.0104 (0.0187)	0.0147 (0.0270)
Firms sector: Wholesale/ retail trade	0.0428*** (0.0131)	0.0552 (0.0375)	0.0594** (0.0303)	-0.157*** (0.0508)
Firms sector: Accommodation & food services	0.0673*** (0.0185)	0.0499 (0.0397)	0.107*** (0.0361)	-0.224*** (0.0568)
Firm size: Small, medium & large	0.0159 (0.0353)	-0.0137 (0.0420)	0.0464 (0.0625)	-0.0486 (0.0878)
Share of firm owned by females (percent, logs)	-0.00603* (0.00327)	1.01e-06 (0.00524)	-0.0107** (0.00525)	0.0168** (0.00852)
Cluster: Rural	0.00426 (0.0190)	-0.0105 (0.0293)	0.0199 (0.0342)	-0.0136 (0.0504)
Sales (Normal period, logs)	0.0973* (0.0579)	-0.00621 (0.0920)	0.180* (0.108)	-0.271* (0.152)
Sales squared (Normal period, logs)	-0.00539** (0.00264)	0.000695 (0.00411)	-0.0103** (0.00501)	0.0150** (0.00685)
Ownership: Partnership/ Cooperative	0.0546* (0.0301)	0.0925* (0.0506)	0.00330 (0.0821)	-0.150 (0.0966)
Ownership: Sole proprietor	0.0434*** (0.0153)	0.0804*** (0.0278)	-0.00277 (0.0744)	-0.121 (0.0756)
Observations	485	485	485	485

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

ii) Use of Formal Finance and Informal Finance Coping Mechanisms

This section provides the regression results for the use of formal finance and informal finance coping mechanisms by the sampled firms. The bivariate Probit model correlation among the two choices as measured by ρ, is positive (0.1812269) and statistically significant *(Prob > chi² = 0.0466)*. The statistically significant ρ suggests that bivariate Probit model is appropriate. The positive coefficient suggests complementarities among the use of formal finance and informal finance coping mechanisms among the sampled firms.

First, consider non-usage of any of the formal finance or informal finance, *P (00)* in Table 4.8. Firms with main owners possessing primary education have a lower probability of not using any of the formal finance or informal finance compared to those without formal education. The effects of education on non-usage of any of the formal finance or informal finance appears to diminish as the main firm owners fall into higher education brackets (secondary and TVET/University) compared to those without formal education. Firms operating in the accommodation and food services have a higher probability of not using any of the formal finance or informal finance compared to those operating in the manufacturing sector. This can be explained by the evidence of bias of the firms operating in the accommodation and food services against the use of informal finance only as shown in the descriptive statistics section of this paper. A marginal increment in female ownership is associated with a lower probability of not using any of the formal or informal finance as a coping mechanism to manage the impacts of droughts and floods. Female entrepreneurs tend to employ diverse range of formal and informal finance, but disproportionately have a higher usage of informal finance due to membership in informal financial groups (Johnson, 2004).

Second, consider the usage of formal finance only, *P (10)* in Table 4.8. More years of formal education of the main firm owner is associated with a higher probability of using formal finance, compared with those without formal education, to cope with droughts and floods. This is consistent with extant literature generally demonstrating the positive effects of formal education on formal finance use (Shibia, 2012). Key channels through which formal education drives usage of formal finance included enhanced capability in terms of financial literacy and participation in economic activities that are linked to use of formal financial services. Firms in the wholesale and retail trade sector and those in the accommodation and food services have a lower probability of using formal finance only to cope with droughts and floods, compared to the firms operating in the manufacturing sector. This perhaps is explained by higher proportions of firms in these sectors operating informally compared to the manufacturing sector. Increment in firm size (at much larger firm size) is associated with a firms' higher

probability of using formal finance to cope with droughts and floods. Partnership firms have lower probability of using formal finance compared to limited companies, possibly suggesting the role of resource pool in accessing market opportunities by companies; consistent with the resource-based theory of the firm (Penrose, 1959; Wernerfelt, 1984). Firms operating as sole proprietors also have a lower probability of using formal finance only, compared to those operating as companies, though this is only statistically significant at 10%.

Table 4.8: Bivariate Probit Marginal Effects (Formal Finance and Informal Finance Coping Mechanisms)

Variables	***P (00)*** **Neither formal finance nor informal finance coping mechanisms**	***P (10)*** **Formal finance coping mechanisms only**	***P (01)*** **Informal finance coping mechanisms only**	***P (11)*** **Formal finance and informal finance coping mechanisms**
Age of the firm (logs)	0.0132 (0.0225)	-0.0310 (0.0325)	0.0156 (0.0152)	0.00207 (0.0309)
Education level of main owner: Primary	-0.174** (0.0875)	0.190*** (0.0695)	-0.178** (0.0744)	0.162** (0.0819)
Education level of main owner: Secondary	-0.154* (0.0864)	0.229*** (0.0624)	-0.188*** (0.0729)	0.113 (0.0744)
Education level of main owner: TVET/ University	-0.136 (0.0907)	0.340*** (0.0716)	-0.223*** (0.0735)	0.0191 (0.0780)
Years of experience of top manager in the sector (logs)	-0.0298 (0.0197)	0.0331 (0.0343)	-0.0199 (0.0162)	0.0166 (0.0270)
Firms sector: Wholesale/retail trade	0.0645* (0.0392)	-0.180** (0.0847)	0.0610*** (0.0193)	0.0542 (0.0726)
Firms sector: Accommodation & food services	0.144*** (0.0457)	-0.226*** (0.0865)	0.0956*** (0.0243)	-0.0134 (0.0749)
Firm size: Small, medium & large	0.0699 (0.0788)	0.150* (0.0845)	-0.0503** (0.0235)	-0.169*** (0.0608)
Share of firm owned by females (percent, logs)	-0.0125** (0.00625)	-0.0151* (0.00842)	0.00377 (0.00387)	0.0238*** (0.00841)
Cluster: Rural	-0.0252 (0.0355)	-0.120** (0.0472)	0.0493* (0.0259)	0.0960* (0.0580)

Sales (Normal period, logs)	0.101 (0.117)	-0.278* (0.146)	0.137* (0.0728)	0.0406 (0.142)
Sales squared (Normal period, logs)	-0.00719 (0.00533)	0.0150** (0.00659)	-0.00773** (0.00336)	-5.49e-05 (0.00633)
Ownership: Partnership/ Cooperative	0.115 (0.0790)	-0.245** (0.121)	0.105** (0.0479)	0.0254 (0.120)
Ownership: Sole proprietor	0.0839 (0.0645)	-0.173* (0.105)	0.0641*** (0.0249)	0.0252 (0.104)
Observations	462	462	462	462

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

Third, consider the usage of informal finance only, *P (01)* in Table 4.8. Firms with the main owners possessing primary, secondary and TVET/university education have a lower probability of using informal finance as a coping mechanism, compared to those without formal education. The firms operating in the wholesale and retail trade sector and those operating in the accommodation and food services have a higher probability of using informal finance as a coping mechanism compared to those operating in the manufacturing sector. As noted earlier, this can be due to the firms in the wholesale and retail trade sector and those in the accommodation and food services operating informally. An increment in firm size (at much large firm size levels) is associated with lower usage of informal finance. Narrow resource-based ownership characteristics such as partnerships and sole proprietorship are associated with higher usage of informal finance compared to limited companies.

Fourth, consider the joint usage of formal and informal finance, *P (11)* in Table 4.8. Firms with main owners having primary education have a higher probability of jointly using formal and informal finance to cope with droughts and floods, compared to those without formal education. Small, medium and large firms (≥ *10 employees*) have a lower probability of jointly using formal and informal finance, compared to micro firms (< *10 employees*). An increment in female ownership is associated with a higher probability of jointly using formal and informal finance.

iii) Sustainable Non-Finance and Unsustainable Non-Finance Coping Mechanisms

This section provides the regression results for the use of non-finance coping mechanisms; delving deeper into the use of sustainable and unsustainable non-finance coping mechanisms. The marginal effects for the bivariate Probit model are shown in Table 4.9. The bivariate Probit model correlation among the two choices as measured by ρ, is positive *(0.3131136)* and statistically

significant *(Prob > chi² = 0.0005)*. The statistically significant ρ suggests the appropriateness of using bivariate Probit model over separate univariate Probit models for correlated choices. The positive coefficient on ρ is an indication that the sampled firms tend to jointly employ sustainable and unsustainable non-finance coping mechanisms.

First, consider the non-usage of any of the sustainable or unsustainable non-finance coping mechanisms, *P (00)* in Table 4.9. Firms in the wholesale and retail trade sectors and those in the accommodation and food services have a higher probability of not using any of the sustainable or unsustainable non-finance coping mechanisms to mitigate the impacts of droughts and floods. Firms operating as partnership/cooperative, and sole proprietorship both have higher probabilities of not using any of the sustainable or unsustainable non-finance coping mechanisms.

Second, consider the use of sustainable non-finance coping mechanisms only, *P (10)* in Table 4.9. Firms with main owners having secondary education have a higher probability of using sustainable non-finance coping mechanisms compared to those without formal education. Firms operating in rural areas have a lower probability of using sustainable non-finance coping mechanisms compared to those operating in the urban areas. Firm-size as proxied by sales level tend to have non-linear relationship. Initially, an increment in firm size is associated with a lower probability of using sustainable non-finance; but this changes at much larger levels of firm size as the change is associated with higher probability of sustainable non-finance usage.

Third, consider the use of unsustainable non-finance coping mechanisms only, *P (01)* in Table 4.9. The unsustainable coping mechanism is represented by use of downsizing of the firm's operations during droughts and floods as reported by firms. Firms, whose main owners have secondary education have a lower probability of using unsustainable non-finance coping mechanism compared to the firms whose main owners have no formal education. Firms that operate in the accommodation and food services sector have a higher probability of employing unsustainable non-finance coping mechanisms compared to those operating in the manufacturing sector. It is possible that firms in the accommodation and food services sector target clients largely in the local environment; and the covariate nature of climate-induced shocks dampens demand for their services, thus forcing them to employ unsustainable measures such as downsizing of business operations. Firms operating as sole proprietors have a higher probability of undertaking unsustainable non-finance coping mechanisms compared to limited companies. One intuition is that because sole proprietors in Kenya are largely micro enterprises that operate informally; they have limited opportunities in using market-based sustainable coping mechanisms.

Fourth, consider the joint usage of sustainable and unsustainable non-finance coping mechanisms, *P (11)* in Table 4.9. Only the marginal effect for cluster variable is statistically significant at 5% significance level. Firms that operate in rural areas have a higher probability of jointly using sustainable and unsustainable coping mechanisms, perhaps suggesting their limited opportunities to fully rely on sustainable coping mechanisms.

Table 4.9: Bivariate Probit Marginal Effects (Sustainable and Unsustainable Non-Finance Coping Mechanisms)

Variables	***P (00)*** **Neither sustainable non-finance nor unsustainable non-finance coping mechanisms**	***P (10)*** **Sustainable non-finance coping mechanisms only**	***P (01)*** **Unsustainable non-finance coping mechanisms only**	***P (11)*** **Sustainable and Unsustainable non-finance coping mechanisms**
Age of the firm (logs)	-0.00826 (0.0161)	0.0129 (0.0348)	-0.00680 (0.0121)	0.00214 (0.0312)
Education level of main owner: Primary	-0.0937 (0.0695)	0.121 (0.0812)	-0.101* (0.0574)	0.0743 (0.107)
Education level of main owner: Secondary	-0.115* (0.0679)	0.181** (0.0761)	-0.122** (0.0569)	0.0571 (0.102)
Education level of main owner: TVET/University	-0.0366 (0.0720)	0.121 (0.0793)	-0.0782 (0.0590)	-0.00647 (0.105)
Years of experience of top manager in the sector (logs)	0.000420 (0.0142)	0.0161 (0.0339)	-0.00386 (0.0113)	-0.0126 (0.0297)
Firms sector: Wholesale/retail trade	0.0745*** (0.0271)	0.0528 (0.0788)	0.0276 (0.0186)	-0.155* (0.0795)
Firms sector: Accommodation & food services	0.0716** (0.0296)	-0.0433 (0.0811)	0.0535** (0.0229)	-0.0817 (0.0830)
Firm size: Small, medium & large	-0.0212 (0.0382)	-0.0720 (0.0723)	0.00837 (0.0288)	0.0848 (0.0884)
Share of firm owned by females (percent, logs)	-0.00330 (0.00490)	0.00822 (0.00937)	-0.00349 (0.00323)	-0.00143 (0.00988)
Cluster: Rural	-0.0366 (0.0260)	-0.151*** (0.0478)	0.0234 (0.0212)	0.164** (0.0652)
Sales (Normal period, logs)	-0.00919 (0.0805)	-0.270** (0.109)	0.0639 (0.0497)	0.215* (0.125)
Sales squared (Normal period, logs)	-0.000304 (0.00351)	0.0102** (0.00475)	-0.00271 (0.00219)	-0.00724 (0.00530)

Ownership: Partnership/Cooperative	0.120** (0.0492)	0.0290 (0.118)	0.0417 (0.0273)	-0.191 (0.116)
Ownership: Sole proprietor	0.0807*** (0.0245)	-0.0432 (0.0928)	0.0475*** (0.0149)	-0.0849 (0.101)
Observations	477	477	477	477

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

b) Determinants of Droughts Coping Mechanisms

i) Use of Finance and Sustainable Non-Finance Coping Mechanisms

This section provides the regression results for the use of finance and sustainable non-finance coping mechanisms. The marginal effects for the bivariate Probit model are shown in Table 4.10. The bivariate Probit model correlation among the two choices as measured by ρ, is positive *(0.4396541)* and statistically significant *(Prob > chi² = 0.0000)*; confirming the suitability of the bivariate Probit model over separate univariate Probit models. The positive coefficient on ρ suggests the complementarities of finance and sustainable non-finance coping mechanisms to mitigate the impacts of droughts.

First, consider the non-usage of any of the finance or non-finance coping mechanisms, *P (00)* in Table 4.10. Firms with main owners having primary, and secondary education have lower probability of not using any of the finance or non-finance coping mechanisms to mitigate the impacts of droughts. Firms in the whole and retail trade sectors, as well as those in the accommodation and food services sector have higher probabilities of not using any of the finance or non-finance coping mechanisms. Sole proprietor firms have a higher probability of not using any of the finance or non-finance coping mechanisms compared to limited companies.

Second, consider the use of finance only, *P (10)* in Table 4.10. The only marginal effect that is statistically significant at 5% significance level is that for ownership type. Sole proprietors have a higher probability of using the broad finance strand (formal/informal finance) as a coping measure, compared to limited companies. This can largely be driven by the use of informal finance.

Third, consider the joint usage of finance and non-finance coping mechanisms for mitigating the impacts of droughts, *P (11)* in Table 4.10. Firms with main owners having primary or secondary education have a higher probability of jointly using finance and non-finance coping mechanisms, compared to those without formal education. Firms in the accommodation and food services sector have a lower probability of jointly using finance and non-finance coping mechanisms compared

to those in the manufacturing sector.

Table 4.10: Bivariate Probit Marginal Effects (Finance and Non-Finance Coping Mechanisms)

Variables	***P (00)*** **Neither finance nor nonfinance coping mechanisms**	***P (10)*** **Finance coping mechanisms only**	***P (01)*** **Non-finance coping mechanisms only**	***P (11)*** **Finance & nonfinance coping mechanisms**
Age of the firm (logs)	-0.00452 (0.0120)	-0.0141 (0.0198)	0.00655 (0.0170)	0.0121 (0.0312)
Education level of main owner: Primary	-0.150** (0.0715)	-0.0981 (0.0741)	-0.0462 (0.0657)	0.295*** (0.107)
Education level of main owner: Secondary	-0.152** (0.0711)	-0.114 (0.0718)	-0.0305 (0.0634)	0.297*** (0.103)
Education level of main owner: TVET/University	-0.120* (0.0730)	-0.0283 (0.0772)	-0.0585 (0.0642)	0.207* (0.108)
Years of experience of top manager in the sector (logs)	-0.00370 (0.0105)	0.00821 (0.0195)	-0.0139 (0.0187)	0.00936 (0.0275)
Firms sector: Wholesale/retail trade	0.0351** (0.0176)	0.0572 (0.0402)	0.0215 (0.0407)	-0.114* (0.0611)
Firms sector: Accommodation & food services	0.0619*** (0.0231)	0.0565 (0.0433)	0.0620 (0.0477)	-0.180*** (0.0683)
Firm size: Small, medium & large	0.0227 (0.0369)	-0.0222 (0.0414)	0.0646 (0.0584)	-0.0651 (0.0834)
Share of firm owned by females (percent, logs)	-0.00616* (0.00362)	-0.000585 (0.00580)	-0.00922* (0.00529)	0.0160* (0.00910)
Cluster: Rural	0.00621 (0.0225)	-0.0211 (0.0317)	0.0341 (0.0391)	-0.0192 (0.0571)
Sales (Normal period, logs)	0.0593 (0.0665)	0.0555 (0.106)	0.0402 (0.118)	-0.155 (0.170)
Sales squared (Normal period, logs)	-0.00367 (0.00302)	-0.00240 (0.00472)	-0.00349 (0.00539)	0.00956 (0.00761)
Ownership: Partnership/Cooperative	0.0437 (0.0316)	0.0968* (0.0516)	-0.0590 (0.0849)	-0.0815 (0.0989)
Ownership: Sole proprietor	0.0410** (0.0201)	0.0884*** (0.0276)	-0.0555 (0.0793)	-0.0739 (0.0791)
Observations	429	429	429	429

Standard errors in parentheses

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

ii) Use of Formal Finance and Informal Finance Coping Mechanisms

The results in this section provides the regression analysis for the factors determining firms' choice of formal and informal finance in coping with droughts only. The bivariate Probit model correlation among the two choices as measured by ρ, is positive *(0.1776155)* but statistically insignificant *(Prob > chi² = 0.0687)* at 5% significance level. The statistically insignificant ρ suggests suitability of separate univariate Probit models over a bivariate Probit model. The marginal effects for the binary Probit models for the use of formal finance and informal finance in coping with droughts are shown in Table 4.11. With regards to the use of formal finance, firms with main owners having primary, secondary and TVET/ university education have higher probabilities of usage compared to those whose main owners lack formal education. Top manager's experience in the sector; and sectoral characteristics (operating in wholesale/retail trade sector compared to manufacturing) are only statistically significant at 10% significance level. Firms operating in the accommodation and food services have a lower probability of using formal finance in coping with droughts. With regards to the use of informal finance, firms operating in wholesale/retail trade sector have a higher probability of usage compared to those operating in the manufacturing sector. Small, medium and large firms (as measured by employment size) have a lower probability of using informal finance to cope with droughts, compared to the micro enterprises.

Table 4.11: Probit Marginal Effects (Formal Finance and Informal Finance Coping Mechanisms)

Variables	*P (Formal finance)*	*P (Informal finacne)*
Age of the firm (logs)	-0.0189 (0.0302)	0.0214 (0.0386)
Education level of main owner: Primary	0.441*** (0.112)	-0.0583 (0.127)
Education level of main owner: Secondary	0.447*** (0.109)	-0.0885 (0.121)
Education level of main owner: TVET/University	0.440*** (0.113)	-0.214* (0.124)
Years of experience of top manager in the sector (logs)	0.0508* (0.0293)	-0.0105 (0.0368)
Firms sector: Wholesale/retail trade	-0.105* (0.0546)	0.164** (0.0821)
Firms sector: Accommodation & food services	-0.161** (0.0643)	0.109 (0.0867)

Firm size: Small, medium & large	-0.0628 (0.0811)	-0.206*** (0.0731)
Share of firm owned by females (percent, logs)	0.00519 (0.00844)	0.0192* (0.0105)
Cluster: Rural	-0.00334 (0.0510)	0.130* (0.0705)
Sales (Normal period, logs)	-0.00419 (0.178)	0.153 (0.152)
Sales squared (Normal period, logs)	0.00354 (0.00810)	-0.00632 (0.00664)
Ownership: Partnership/ Cooperative	-0.0956 (0.107)	0.146 (0.131)
Ownership: Sole proprietor	-0.0470 (0.0882)	0.0881 (0.106)
Observations	432	410

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

iii) Sustainable Non-Finance and Unsustainable Non-Finance Coping Mechanisms

This section provides the regression results for the firms' use of non-finance coping mechanisms to mitigate the impacts of droughts; delving deeper into the use of sustainable and unsustainable non-finance coping mechanisms. For sustainable coping mechanisms, firms continue to operate at pre-shock or higher level of performance; while for unsustainable coping mechanism, the firm's operations are worsened compared to pre-shock operation level. The marginal effects for the bivariate Probit model are shown in Table 4.12. The bivariate Probit model correlation among the two choices as measured by ρ, is positive *(0.3372433)* and statistically significant *(Prob > chi² = 0.0003)* at 5% significance level. The statistically significant ρ confirms the appropriateness of the bivariate Probit model over separate univariate Probit models for correlated outcomes. The positive coefficient on ρ suggests tendency of the firms to use together sustainable and unsustainable non-finance coping mechanisms.

First, consider the non-usage of any of the sustainable or unsustainable non-finance coping mechanisms to manage the impacts of droughts, *P (00)* in Table 4.12. Firms operating in the wholesale and retrial trade sector as well as those operating in the accommodation and food services sector have higher probabilities of not using any of the sustainable or unsustainable non-finance coping mechanisms, compared to those operating in the manufacturing sector. Firms that operate as partnerships, cooperatives or sole proprietorship have higher probabilities of not

using any of the sustainable non-finance or unsustainable non-finance coping measures, compared to those operating as companies.

Second, consider the usage of sustainable non-finance only for coping with droughts, *P (10)* in Table 4.12. Firms whose main owners have primary or secondary level education have higher probabilities of sustainable non-finance usage, compared with those whose main owners lack formal education. Firms operating in rural areas have a lower probability of using sustainable coping mechanisms, compared to those operating in urban areas. This suggests limited drought coping opportunities available to rural firms and their disproportionate higher vulnerabilities due to weak investments in sustainable coping measures.

Third, consider the usage of unsustainable non-finance only for coping with droughts, *P (01)* in Table 4.12. Firms with main owners possessing primary or secondary education have lower probabilities of using unsustainable non-finance coping measures, compared to those whose main owners lack formal education. Firms operating in the accommodation and food services sector have a higher probability of using unsustainable non-finance coping mechanisms compared to those operating in the manufacturing sector. Sole proprietors have a higher probability of using unsustainable non-finance coping mechanism, compared to limited companies. With regards to joint usage of sustainable and unsustainable non-finance coping mechanisms, *P (11)* in Table 4.12; firms in rural areas report to have higher usage compared to those operating in urban areas.

Table 4.12: Bivariate Probit Marginal Effects (Sustainable Non-finance and Unsustainable Non-Finance Coping Mechanisms)

Variables	***P (00)*** **Neither sustainable nor un-sustainable non-finance coping mechanisms**	***P (10)*** **Sustainable non-finance coping mechanisms only**	***P (01)*** **Unsustainable non-finance coping mechanisms only**	***P (11)*** **Sustainable and Unsustainable non-finance coping mechanisms**
Age of the firm (logs)	-0.0105 (0.0169)	0.00619 (0.0368)	-0.00636 (0.0137)	0.0107 (0.0326)
Education level of main owner: Primary	-0.0805 (0.0738)	0.166** (0.0808)	-0.131** (0.0663)	0.0458 (0.120)
Education level of main owner: Secondary	-0.0916 (0.0720)	0.192*** (0.0730)	-0.141** (0.0657)	0.0407 (0.114)
Education level of main owner: TVET/University	-0.0168 (0.0758)	0.144* (0.0756)	-0.0984 (0.0679)	-0.0290 (0.117)
Years of experience of top manager in the sector (logs)	0.00976 (0.0151)	0.0240 (0.0363)	-0.00247 (0.0130)	-0.0313 (0.0313)

Firms sector: Wholesale/ retail trade	0.0745** (0.0292)	0.0536 (0.0819)	0.0300 (0.0219)	-0.158* (0.0841)
Firms sector: Accommodation & food services	0.0845** (0.0332)	-0.00924 (0.0845)	0.0540** (0.0264)	-0.129 (0.0880)
Firm size: Small, medium & large	-0.0181 (0.0407)	-0.0482 (0.0748)	0.00497 (0.0304)	0.0614 (0.0888)
Share of firm owned by females (percent, logs)	-0.00546 (0.00542)	0.00115 (0.00982)	-0.00273 (0.00365)	0.00704 (0.0106)
Cluster: Rural	-0.0431 (0.0295)	-0.155*** (0.0490)	0.0260 (0.0242)	0.172** (0.0738)
Sales (Normal period, logs)	0.0246 (0.0911)	-0.180 (0.119)	0.0614 (0.0588)	0.0936 (0.138)
Sales squared (Normal period, logs)	-0.00187 (0.00397)	0.00719 (0.00522)	-0.00285 (0.00261)	-0.00247 (0.00581)
Ownership: Partnership/ Cooperative	0.119** (0.0498)	0.0210 (0.121)	0.0417 (0.0283)	-0.182 (0.119)
Ownership: Sole proprietor	0.0856*** (0.0272)	-0.0598 (0.0965)	0.0527*** (0.0161)	-0.0786 (0.105)
Observations	419	419	419	419

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

c) Determinants of Floods Coping Mechanisms

In this section codes for two categorical variables were combined due to fewer observations. For education of the main owner, those without formal education and those with only primary education were recorded into one category. For the ownership characteristics, companies and partnerships/cooperatives were recorded into a single category due to their similarities in resource-pooling.

i) Use of Finance and Sustainable Non-Finance Coping Mechanisms

The marginal effects for the bivariate Probit model are shown in Table 4.13. The bivariate Probit model correlation among the two choices as measured by ρ, is positive *(0.7562318)* and statistically significant *(Prob > chi² = 0.0000)*. The statistically significant ρ confirms suitability of the bivariate Probit model over binary Probit model. The positive coefficient on ρ suggests the complementarities of finance and sustainable non-finance coping mechanisms to mitigate the impacts of floods.

First, consider the case of non-usage of any of the finance or non-finance coping mechanism with floods, *P (00)* in Table 4.13. Firms whose main owners have TVET/University education have a lower probability of not using any of the finance or non-finance coping mechanisms. An increment in firm size as proxied by sales, is initially associated with a higher probability of not using any of the finance or non-finance coping mechanism; but at much larger levels of firm size, the increment is associated with lower probability of not using any of the finance or non-finance coping mechanisms.

Second, consider the case of finance use only as a coping mechanism with floods, *P (10)* in Table 4.13. Small, medium and large firms have a lower probability of using finance as a coping mechanism to mitigate the impacts of floods, compared to micro firms. This seemingly counter-intuitive result is possibly due to the aggregation of formal and informal finance usages. Firms operating as sole proprietors have a higher probability of using finance as a coping mechanism, compared to those operating as companies/partnerships/cooperatives. Aggregation of formal and informal finance, and relatively higher usage of informal finance by sole proprietors can offer the explanation.

Third, consider the case of non-finance use only as a coping mechanism with floods, *P (01)* in Table 4.13. Firms operating in the wholesale/retail trade sector have a higher probability of using non-finance coping mechanism, compared with firms operating in the manufacturing sector. An increment in firm size (at much larger firm size level) is associated with lower probability of using only non-finance coping mechanisms. Firms operating as sole proprietors have a lower probability of using non-finance coping mechanisms only, compared to companies.

Fourth, consider the case of jointly using finance and non-finance coping mechanism for floods, *P (11)* in Table 4.13. Firms with main owners having secondary education have a higher probability of jointly undertaking finance and non-finance coping mechanisms, compared to firms whose main owners lack formal education, or only have primary level education. Small, medium and large enterprises have a lower probability of jointly using finance and non-finance coping mechanisms to mitigate the impacts of floods, compared to micro enterprises. With regards to firm size as measured by sales level, an increment in firm size is initially associated with lower probability of jointly using finance and non-finance measures, but at much larger size of the firm, the probability of joint usage for a marginal increment becomes positive. Firms operating as sole proprietors have a higher probability of jointly using finance and non-finance coping measures to cope with floods, compared to firms operating as companies, partnerships or cooperatives.

Table 4.13: Bivariate Probit Marginal Effects (Finance and Non-Finance Coping Mechanisms)

Variables	***P (00)*** **Neither finance nor nonfinance coping mechanisms**	***P (10)*** **Finance coping mechanisms only**	***P (01)*** **Non-finance coping mechanisms only**	***P (11)*** **Finance & nonfinance coping mechanisms**
Age of the firm (logs)	0.0426 (0.0598)	0.0155 (0.0316)	-0.00698 (0.0531)	-0.0512 (0.0845)
Education level of main owner: Secondary	-0.171* (0.0920)	-0.0514 (0.0450)	0.0228 (0.0488)	0.200** (0.101)
Education level of main owner: TVET/University	-0.213** (0.102)	-0.0863* (0.0460)	0.0671 (0.0640)	0.232* (0.123)
Years of experience of top manager in the sector (logs)	-0.0336 (0.0559)	-0.0494 (0.0354)	0.0645 (0.0558)	0.0185 (0.0815)
Firms sector: Wholesale/ retail trade	0.141 (0.0956)	-0.00392 (0.0595)	0.110** (0.0546)	-0.247 (0.189)
Firms sector: Accommodation & food services	0.165 (0.103)	0.0340 (0.0650)	0.0613 (0.0561)	-0.260 (0.194)
Firm size: Small, medium & large	0.266 (0.167)	-0.0611** (0.0240)	0.189 (0.129)	-0.394*** (0.106)
Share of firm owned by females (percent, logs)	-0.0222 (0.0147)	-0.00994 (0.00795)	0.00658 (0.0115)	0.0255 (0.0193)
Cluster: Rural	0.0276 (0.0866)	0.0136 (0.0583)	-0.00991 (0.0766)	-0.0312 (0.111)
Sales (Normal period, logs)	0.502** (0.237)	-0.116 (0.107)	0.393* (0.205)	-0.778** (0.338)
Sales squared (Normal period, logs)	-0.0242** (0.0103)	0.00649 (0.00479)	-0.0204** (0.00935)	0.0380*** (0.0147)
Ownership: Sole proprietorship	-0.0398 (0.110)	0.0740*** (0.0226)	-0.279*** (0.0992)	0.244** (0.116)
Observations	129	129	129	129

Standard errors in parentheses

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

ii) Use of Formal Finance and Informal Finance Coping Mechanisms

The bivariate Probit model correlation among the two choices as measured by ρ, is positive *(0.6377747)* and statistically significant *(Prob > chi² = 0.0001)*, suggesting the suitability of the bivariate Probit model, as opposed to separate univariate Probit models for correlated outcomes. The positive coefficient suggests complementarities among the use of formal finance and informal finance coping mechanisms by the sampled firms to manage the impacts of floods.

First, consider the case of non-usage of any of the formal finance or informal finance coping mechanisms to mitigate the impacts of floods, *P (00)* in Table 4.14. Small, medium and larger enterprises have a higher probability of not using any of the formal finance or informal finance, compared to micro enterprises. This may reflect the survival tactics by micro enterprises to employ multiple finance sources to overcome challenges in accessing formal financial markets.

Second, consider the case formal finance usage only to cope with floods, *P (10)* in Table 4.14. Small, medium and large enterprises have a lower probability of using formal finance only to cope with floods, compared with micro enterprises. This finding mirrors that one for the firm size, proxied by sales level where increase in firm size is initially associated with lower probability of formal finance usage to cope with floods, but the probability of usage becomes positive for a marginal increment at much larger firm size (as proxied by squared term of the sales).

Third, consider the case of informal finance use only to cope with floods, *P (01)* in Table 4.14. Small, medium and large enterprises compared to micro firms have a lower probability of using informal finance only to cope with floods. As observed from the firm size as measured by sales level, an increment in firm size is initially associated with higher probability of informal finance usage, but the probability of usage decreases for a marginal increase in firm size at much larger levels of firm size.

Fourth, consider the case of joint usage of formal finance and informal finance to cope with floods, *P (11)* in Table 4.14. Small, medium and larger firms have a lower probability of jointly using formal finance and informal finance, compared to micro enterprises. As observed from descriptive statistics, small firms tend to be less impacted by floods, compared to micro firms and medium and large firms. The regression results here, consistent with previous studies (Crick, et al., 2018b) may suggest that motivation to take coping measure can be driven by the severity of impacts experienced. The larger proportion of small firms in the category for 'small, medium and large' enterprises may have had dominating effects in the regression analysis.

Table 4.14: Probit Marginal Effects (Formal Finance and Informal Finance Coping Mechanisms)

Variables	***P (00)*** **Neither formal finance nor informal finance coping mechanisms**	***P (10)*** **Formal finance coping mechanisms only**	***P (01)*** **Informal finance coping mechanisms only**	***P (11)*** **Formal finance & informal finance coping mechanisms**
Age of the firm (logs)	0.120 (0.0939)	0.0349 (0.0574)	-0.0361 (0.0392)	-0.119 (0.0816)
Education level of main owner: Secondary	-0.0630 (0.102)	0.102* (0.0572)	-0.0732 (0.0483)	0.0344 (0.0857)
Education level of main owner: TVET/University	-0.0630 (0.126)	0.139 (0.0964)	-0.0922 (0.0589)	0.0164 (0.108)
Years of experience of top manager in the sector (logs)	-0.0983 (0.0926)	-0.0456 (0.0519)	0.0411 (0.0349)	0.103 (0.0820)
Firms sector: Wholesale/ retail trade	0.128 (0.122)	-0.0119 (0.155)	0.0122 (0.0758)	-0.128 (0.151)
Firms sector: Accommodation & food services	0.217* (0.128)	-0.111 (0.157)	0.0754 (0.0839)	-0.182 (0.152)
Firm size: Small, medium & large	0.540*** (0.0824)	-0.159** (0.0784)	-0.111*** (0.0266)	-0.270*** (0.0455)
Share of firm owned by females (percent, logs)	-0.0217 (0.0206)	-0.0192 (0.0143)	0.0152 (0.00977)	0.0256 (0.0174)
Cluster: Rural	-0.0352 (0.122)	-0.105* (0.0633)	0.0911 (0.0646)	0.0491 (0.114)
Sales (Normal period, logs)	0.604 (0.398)	-0.798*** (0.233)	0.477*** (0.181)	-0.284 (0.353)
Sales squared (Normal period, logs)	-0.0308* (0.0179)	0.0398*** (0.0109)	-0.0238*** (0.00863)	0.0148 (0.0160)
Ownership: Sole proprietorship	-0.159 (0.170)	0.108 (0.104)	-0.0584 (0.118)	0.109 (0.110)
Observations	114	114	114	114

Standard errors in parentheses

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

iii) Use of Sustainable Non-Finance and Unsustainable Non-Finance Coping Mechanisms

This section provides the regression results with regards to the use of non-finance coping mechanisms to mitigate the impacts of floods; unpacking the use of sustainable and unsustainable non-finance coping mechanisms. The marginal effects for the bivariate Probit model are shown in Table 4.15. The bivariate Probit model correlation among the two choices as measured by ρ, is positive *(0.6528743)* and statistically significant *(Prob > chi² = 0.0015)*, confirming suitability of the bivariate Probit model over separate use of univariate Probit models. The positive coefficient on ρ suggests that firms tend to jointly use sustainable and unsustainable non-finance coping mechanisms to manage the impacts of floods.

First, consider the case of non-usage of any of the sustainable or unsustainable non-finance to cope with floods, *P (00)* in Table 4.15. Firms whose main owners have secondary or TVET/university education have lower probabilities of not using any of the sustainable or unsustainable coping mechanisms to manage the impacts of floods. Second, with regards to the usage of sustainable non-finance only, *P (10)* in Table 4.15. key driving factors include firm owner's education level, sector in which the firm operates and female ownership. Firms whose top owners possess formal education at the levels of secondary and TVET/university have higher probabilities of using sustainable non-finance mechanisms for coping with floods, compared with those whose main owners lack formal education or only have primary level education. Firms in the accommodation and food services sector have a lower probability of using sustainable non-finance coping mechanisms, compared to those operating in the manufacturing sector. An additional female share is associated with a higher probability of using sustainable non-finance coping measure to mitigate the impacts of floods.

Third, consider the case of unsustainable non-finance use only to cope with floods, *P (01)* in Table 4.15. In contrast with sustainable non-finance use, firms whose main owners have secondary or TVET/university education levels have lower probabilities of using unsustainable non-finance measures to cope with floods, compared to firms whose main owners lack formal education or only have primary-level education. The sectoral and female-share variables also have contrasting effects compared to the use of sustainable non-finance coping measures.

Table 4.15: Bivariate Probit Marginal Effects (Sustainable Non-finance and Unsustainable Non-Finance Coping Mechanisms)

Variables	**P (00) Neither sustainable nor unsustainable non-finance coping mechanisms**	***P (10)* Sustainable non-finance coping mechanisms only**	***P (01)* Unsustainable non-finance coping mechanisms only**	***P (11)* Sustainable non-finance and unsustainable non-finance coping mechanisms**
Age of the firm (logs)	0.0874 (0.0741)	-0.0218 (0.0564)	0.00218 (0.0106)	-0.0677 (0.0657)
Education level of main owner: Secondary	-0.187** (0.0903)	0.255*** (0.0712)	-0.0845** (0.0379)	0.0166 (0.0740)
Education level of main owner: TVET/University	-0.233** (0.102)	0.393*** (0.0822)	-0.102** (0.0399)	-0.0582 (0.0831)
Years of experience of top manager in the sector (logs)	-0.112 (0.0738)	0.0282 (0.0531)	-0.00284 (0.0101)	0.0866 (0.0674)
Firms sector: Wholesale/ retail trade	0.110 (0.151)	-0.0207 (0.162)	3.75e-05 (0.0112)	-0.0891 (0.153)
Firms sector: Accommodation & food services	0.107 (0.148)	-0.313** (0.158)	0.0618** (0.0254)	0.145 (0.155)
Firm size: Small, medium & large	0.203 (0.145)	-0.0672 (0.119)	-0.00256 (0.0194)	-0.134* (0.0751)
Share of firm owned by females (percent, logs)	-0.0261 (0.0173)	0.0446*** (0.0169)	-0.00842** (0.00379)	-0.0100 (0.0168)
Cluster: Rural	-0.0241 (0.0985)	-0.0832 (0.111)	0.0194 (0.0302)	0.0878 (0.103)
Sales (Normal period, logs)	0.247 (0.211)	-0.355* (0.193)	0.0660 (0.0423)	0.0417 (0.172)
Sales squared (Normal period, logs)	-0.0119 (0.00902)	0.0137* (0.00814)	-0.00248 (0.00171)	0.000740 (0.00723)
Ownership: Sole proprietorship	0.0528 (0.107)	0.00299 (0.100)	-0.000767 (0.0198)	-0.0550 (0.109)
Observations	135	135	135	135

Standard errors in parentheses

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

4.2 Factors Determining Firm Resilience to the Impacts of Droughts and Floods

The understanding and measurement of economic resilience of firms is imperative for policy decisions. Past studies on economic resilience of firms is however scarce (Graveline & Grémont, 2017), thus limiting the options for policy interventions. There are indications that a range of barriers impede firms from effectively responding and building their resilience to climate-induced direct impacts such as loss of assets; and indirect impacts such as losses occasioned through disruptions of supply chain (Herrmann & Guenther, 2017). The resilience of firms is argued to be dependent on the sectors in which firms operate, size of the firm as measured by employment and sales, demographic characteristics of the firm owners, and coping mechanisms employed before or during the climate-induced shock (Graveline & Grémont, 2017). This section provides econometric analysis of factors affecting firm's resilience. The analysis closely mirrors previous conceptualization of resilience as the ability to absorb shocks (Graveline & Grémont, 2017), but focuses only on changes in sales as an aggregate indicator of resilience. Further, firm's resilience can be inherent, in that it is inbuilt into the system, or it can be adaptive, in that they are responses once a shock occurs (Graveline & Grémont, 2017). Quality of infrastructure can form part of inherent resilience and has been shown to support firms resilience through supply chain channels (OECD, 2018). The dependent variable for analysis in this paper is the change in firms' sales during drought or flood compared to a normal period, coded 1 (if sales reduced) or 0 otherwise. Probit model is used for the regression analyses. The variable descriptions, measurement levels and variable codes are detailed in Table 4.16.

Table 4.16: Variable Measurements and Descriptions

Variable	Variable Description	Variable Measurement Level	Variable Codes
Dependent Variables			
Drought impacts	Sales level during a drought period compared to normal period as reported by the firms	Nominal	1 if sales declined during drought, 0 otherwise
Flood impacts	Sales level during a flood period compared to normal period as reported by the firms	Nominal	1 if sales declined during floods, 0 otherwise
Covariates			
firmage: Firm's age	Measured as the year of the survey minus the year the firm started its operations in logs	Ratio	N/a
managerexper: Top manager experience	Years of experience of the top manager of the firm in the sector in which the firm operates in logs	Ratio	N/a

femaleshare: Female share	Share of the firm owned by female entrepreneur, in logs	Ratio	N/A
educ: Manager education	Years of formal education completed by the main owner of the firm	Nominal	1=No formal education 2=Primary education 3=Secondary education 4=TVET 5=University
sector: Sector	The main sector in which the firm operates. For floods the sector was categorized into manufacturing/trade; and accommodation and food services due to fewer observations for the manufacturing if only flood is considered.	Nominal	1=Manufacturing 2=Wholesale/retail 3=Accommodation and food services
firmsize: Establishment size	Firm size as measured by employment size. The small enterprises (10-49 employees) were categorized with medium and large enterprises (50+ employees) for econometric reasons given fewer observations of the later.	Nominal	1=Micro enterprises (<10 employees) 2=Small, medium and larger enterprises (10+ employees).
sales: Sales	Estimated sales level during a normal period in logs, to also proxy for firm size	Ratio	N/a
$sales^2$: Sales squared	Square of log of turnover during a normal period as reported by firms. This is aimed at capture non-linearity effects.	Ratio	N/a
infrastructure: Infrastructure index (Relates to roads infrastructure index; water infrastructure index; and electricity infrastructure index)	Business environment variable computed as an index on four parameters resulting from drought/flood: (i) damage to products, (ii) cost of transport, (iii) raw material availability and (iv) access to markets/ customers. Negative rating is given a score of 1 on each parameter. The index can therefore range from 0 (No negative outcome on all the four parameters) to 4 (Negative outcome on all the four parameters) for each of the infrastructure. A higher index reflects undesirable infrastructure related impacts. Note that the questions on the four parameters were posed to the respondents on each of the infrastructure - Roads, water and electricity.	Ratio	N/a

Source: Author's construct

4.2.1 Firms Resilience to Droughts

Due to moderate correlation among the infrastructure variables (roads, water and electricity), four Probit models were estimated, first with all of them included in the regression and then using only one at a time. Such a graduated approach

to analyses would also help in gaining insights in terms of the extent to which different infrastructure covariates affect firms' resilience as well as robustness checks. The results are provided in Table 4.17a and Table 4.17b. The results suggest that droughts resilience of the firms depend on the resilience of the infrastructure including roads, water and electricity (Computation of these variables are provided in Table 4.16). Adverse impacts transmitted through infrastructure worsens firms' resilience during drought period compared to a normal period as reported by the sampled firms. These findings echo previous research (Graveline & Grémont, 2017; Crick, et al., 2018a) on indirect impacts of climate-induced shocks through infrastructure channels; and the call to consider building firm resilience as the wider policy efforts towards private sector development. The roads and water elements of business environment particularly seem to be important. When all the infrastructure variables are included in the model, the marginal effects for electricity is insignificant. When considered in isolation as an infrastructure variable this marginal effect is however statistically significant. The implications of these findings are that investment in infrastructure is key in building firm resilience. It is also an indication that building firm resilience to the impact of droughts should be integrated into the wider private sector development initiatives. There are also sectoral differences at 5% significance level, but these are revealed only when roads infrastructure index is excluded from the model. The accommodation and food services are shown to be more resilient (less likely to report decline in sales during drought) compared to the manufacturing and the wholesale and retail trade.

Table 4.17a: Determinants of Resilience to Droughts

	Probit Marginal Effects			
Variables	**Model 1 All 3 infrastructures**	**Model 2 Road infrastructure only**	**Model 3 Water infrastructure only**	**Model 4 Electricity infrastructure only**
Firm age (logged)	0.0176 (0.0161)	-0.00117 (0.0156)	0.0133 (0.0149)	-0.00960 (0.0171)
Top manager years of experience in the sector (logged)	-0.0271 (0.0176)	0.00862 (0.0186)	-0.0248 (0.0180)	0.0134 (0.0203)
Firm's ownership female share (% logged)	0.00398 (0.00594)	0.00937 (0.00582)	0.00431 (0.00597)	0.00910 (0.00622)
Top manager education: Primary	0.129 (0.0913)	0.159* (0.0935)	0.114 (0.0995)	0.0759 (0.0863)
Top manager education: Secondary	0.136 (0.0892)	0.158* (0.0929)	0.121 (0.0976)	0.0860 (0.0846)

Top manager education: TVET/University	0.121 (0.0924)	0.133 (0.0966)	0.112 (0.0995)	0.0614 (0.0882)
Sector: Wholesale & retail trade	0.0213 (0.0539)	-0.00800 (0.0357)	-0.00285 (0.0365)	-0.000234 (0.0340)
Sector: Accommodation & food services	-0.0709 (0.0647)	-0.0656 (0.0418)	-0.107** (0.0501)	-0.0968** (0.0472)
Firm size: Small, medium & large	-0.0310 (0.0416)	-0.0507 (0.0450)	-0.0275 (0.0414)	-0.0322 (0.0441)
Sales during normal period (logged)	-0.0407 (0.0642)	-0.0674 (0.0673)	-0.0504 (0.0739)	-0.0416 (0.0702)
Sales squared during normal period (logged)	0.00166 (0.00261)	0.00258 (0.00284)	0.00200 (0.00300)	0.00162 (0.00293)
Roads infrastructure index	0.0301*** (0.00825)	0.0284*** (0.00713)	...	...
Water infrastructure index	0.0374** (0.0156)	...	0.0477*** (0.0171)	...
Electricity infrastructure index	-0.00117 (0.0123)	...	...	0.0299** (0.0116)
Observations	350	426	369	391

Standard errors in parentheses

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

4.2.2 Firms Resilience to Floods

The Probit results for floods resilience largely mirrors those for drought with respect to infrastructure indexes, except for that sector differences are revealed only when roads and electricity are excluded. Firms in the accommodation and food services sector have a lower probability of experiencing deterioration in resilience and the effect is particularly strong when road infrastructure index is omitted from the regression (not controlled for). Effects of firm-size tend to be non-linear. Initially, with an increase in firm size resilience improves as shown by a lower probability of decline in sales; but at much larger firm size (as shown by squared sales variable) an increase in firm size is associated with deterioration in resilience as shown by a higher probability of decline in sales. The findings suggest, firms whose main owners have secondary education have a higher probability of experiencing deterioration in resilience compared to those whose main owners have no formal education. This might reflect some underlying institutional dynamics such as the nature of enterprises operated and business infrastructure that is associated with different education levels.

Table 4.17b: Determinants of Resilience to Floods

	Probit Marginal Effects			
Variables	**Model 1 All 3 infrastructures**	**Model 2 Roads infrastructure**	**Model 3 Water infrastructure**	**Model 3 Electricity infrastructure**
Firm age (logged)	0.0258 (0.0540)	-0.0113 (0.0574)	-0.00283 (0.0619)	-0.0196 (0.0639)
Top manager years of experience in the sector (logged)	-0.0620 (0.0479)	-0.0126 (0.0523)	-0.0571 (0.0556)	-0.0330 (0.0557)
Firm's ownership female share (% logged)	0.00624 (0.0137)	0.00415 (0.0138)	0.00863 (0.0149)	0.00725 (0.0155)
Top manager education: Primary	0.0124 (0.127)	0.0629 (0.180)	0.0600 (0.163)	-0.0215 (0.183)
Top manager education: Secondary	0.257** (0.115)	0.295* (0.167)	0.295** (0.146)	0.190 (0.164)
Top manager education: TVET/University	0.0735 (0.126)	0.0620 (0.180)	0.0816 (0.159)	-0.133 (0.182)
Sector: Accommodation & food services	-0.111* (0.0650)	0.00704 (0.0620)	-0.178*** (0.0661)	-0.129* (0.0718)
Firm size: Small, medium & large	-0.127 (0.109)	-0.149 (0.137)	-0.122 (0.129)	-0.196 (0.147)
Sales during normal period (logged)	-0.600*** (0.208)	-0.848** (0.347)	-0.603*** (0.233)	-0.778** (0.310)
Sales squared during normal period (logged)	0.0294*** (0.00957)	0.0396** (0.0154)	0.0297*** (0.0106)	0.0373*** (0.0137)
Roads infrastructure index	0.0505*** (0.0159)	0.0678*** (0.0159)	...	...
Water infrastructure index	0.0895*** (0.0251)	...	0.116*** (0.0252)	...
Electricity infrastructure index	-0.0126 (0.0298)	...	...	0.0821*** (0.0270)
Observations	125	149	128	133

Standard errors in parentheses

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

5. Conclusion and Recommendations

5.1 Conclusion

This study sought to achieve two principal goals – first to understand the coping mechanisms employed by firms to manage the impacts of droughts and floods; and second to deepen insights on factors that enhance or worsen firm resilience to the impacts of droughts and floods. The coping strategies are broadly conceptualized into finance and non-finance coping measures. The finance coping mechanisms are further classified into formal finance and informal finance, while the use of non-finance coping measures is further classified into sustainable and unsustainable measures. The findings suggest that disproportionately higher number of firms are adversely affected by droughts than floods. This is not surprising given that a larger share of Kenya's land mass is largely ASALs with recurrent droughts, though the incidences of floods are also likely to escalate in future owing to climate change. Faced with droughts and floods, larger firms report more variability in sales than micro and small firms. While female ownership is associated with lower mean sales/turnover (implying female-owned firms are relatively smaller in size), the adverse volatility in sales due to drought lessens with higher share of female ownership. With regards to the usage of finance, there are overlaps in the use of formal and informal finance coping mechanisms, the main financial instruments being saving (the dominant financial instrument) and to some extent borrowings from formal financial institutions such as banks and SACCOs, followed by savings in informal financial groups. With regards to use of nonfinancial coping mechanisms, the main strategies used for floods, in decreasing order of importance, include modification of storage facilities, downsizing operations, investment in physical assets, diversification of sources of raw materials and accumulation of raw materials for use during floods. For droughts, the main nonfinance coping strategies in decreasing order of importance include downsizing operations, investment in physical assets, diversification of business activities and sources of raw materials, and adjustment of employment levels to seasonal patterns.

Some key conclusions can be drawn from the analyses in this paper. Firms use multiple coping mechanisms, be it use of financial instruments or non-finance measures. An important finding emerging from this paper is that usage of finance and sustainable non-finance coping mechanisms are complementary, a possible indication of role of finance in supporting investments aimed at building firms' resilience. This serves as an important evidence for deepening private sector use

of financial instruments as coping mechanisms for droughts and floods. Principal reasons cited by the sampled firms for low usage of financial instruments as coping mechanisms include high costs of insurance premiums, high costs of credit and low financial literacy in terms of understanding how formal financial markets work. Different sectors of the economy demonstrate some peculiarities in their propensities to employ coping mechanisms towards mitigating the impacts of droughts and floods. Firms in the manufacturing sector tend have higher usage of both finance and non-finance coping measures compared to the firms in the wholesale and retail trade, and accommodation and food services sectors. Building resilience of the firms should therefore extend beyond addressing firm-specific and sectoral issues to consider business environment especially physical infrastructure including roads, water and electricity.

Poor infrastructure including roads, water and electricity has been shown to worsen firms' resilience to the impacts of droughts and floods. This is a pointer that building firm resilience should be an integral part of the wider initiatives targeted at private sector development.

5.2 Recommendations

5.2.1 Policy Recommendations

i) It is imperative to deepen use of financial instruments given their role in encouraging use of sustainable non-finance coping measures. This requires addressing both supply side constraints (costs of credit, insurance premiums) and demand side constraints, particularly financial illiteracy, which have been identified by the respondents in this study as the factors hindering their usage to cope with droughts and floods.

ii) Policy interventions should also be tailored to firm-level characteristics given that micro enterprises and firms with main owners having lower education levels tend to be associated with lower usage of formal finance and sustainable non-finance coping mechanisms.

iii) Enhance investments in infrastructure, including roads, electricity and water infrastructure that are resilient to impacts of droughts and floods. Firms that report to incur high costs of doing business induced through infrastructure as a result of droughts or floods tend to be less resilient as measured by decline in sales.

5.2.2 Areas for further research

Research on how firms cope with climate-induced shocks such as droughts and floods is scarce to guide policy decisions. More research needs to be done in future build on this work and other previous work. The following initiatives can enhance future empirical work needed to guide policy directions.

i) Embrace initiatives to gather and use longitudinal micro datasets to understand dynamics of firm coping mechanisms and resilience. There is need to invest in building such datasets to unpack some dynamics that may not be visible in cross sectional analysis such as the one done in this paper or other studies referenced in this paper.

ii) Future surveys should attempt to gather rich information, that for instance address issues such as multiple dimensions of firm resilience, and how aspects such as access to climate information or other policy interventions influences choice of coping mechanisms and resilience.

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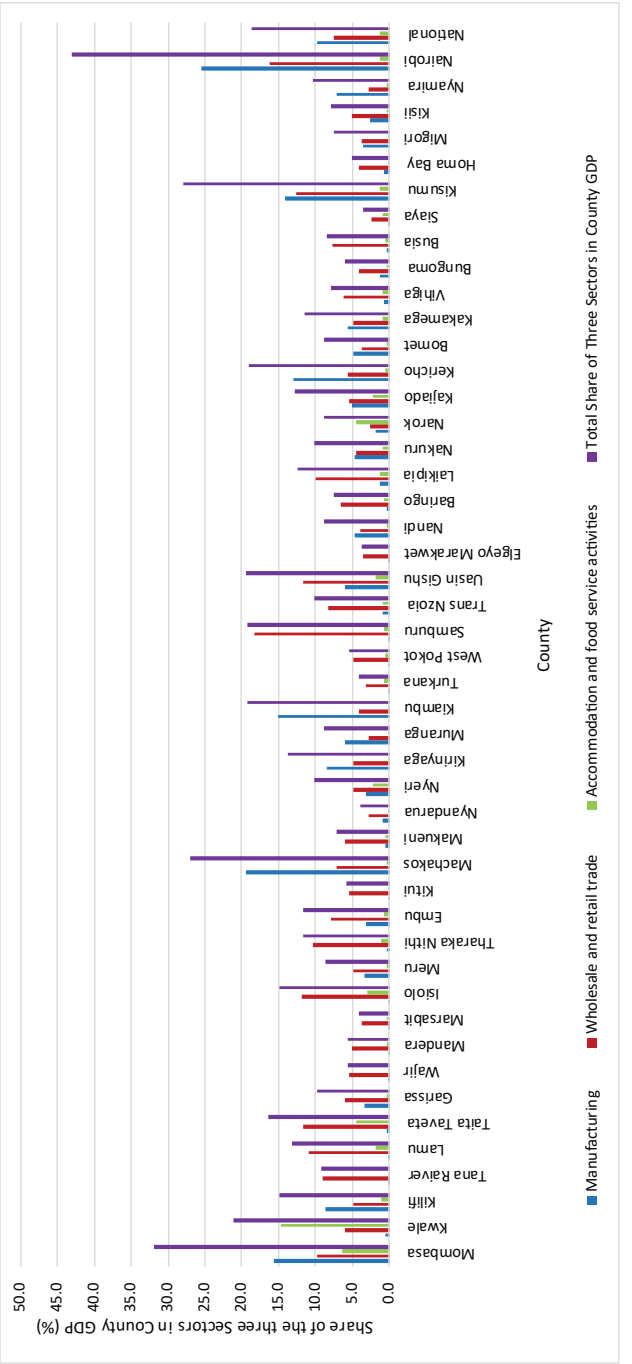
Annexes

Annex 1: County Level GDP Shares for Manufacturing, Wholesale & Retail Trade, and Food & Accommodation Services, 2017



Data Source: (KNBS, 2019b; KNBS, 2019c)

Annex 2: Mapping of Coping Mechanisms

Finance	Non-finance
Formal Finance measures • Savings in and borrowings from banks, SACCOs, microfinance institutions • Insurance • Financial education programmes • Investment in or selling of financial assets *Informal Finance measures* • Savings in or borrowings from informal sources - RoSCAs, table banking, chamas • Savings in secret "under the mattress" places • Transfers from friends/family members	*Sustainable measures* • Increase operations • Diversify business activities • Diversify sources of raw materials/ inputs • Diversify customer base • Modification of storage facilities • Accumulate raw materials for using during drought/floods • Accumulate products for sale during droughts/floods • Enter into contract with suppliers of raw materials • Enter into contract with buyers of firm's products • Invest in physical assets - land, livestock, movable property • Invest in social networks for reciprocal support *Unsustainable measures* • Downsize operations • Adjust employment to seasonal patterns

Annex 3: Counties Covered by the KIPPRA Survey

County	Aridity Level (%) for ASALs
1. Baringo*	30-84
2. Elegeyo Marakwet	10-29
3. West Pokot*	30-84
4. Kajiado*	30-84
5. Machakos	30-84
6. Isiolo*	85-100
7. Marsabit*	85-100
8. Samburu*	85-100
9. Embu*	30-84
10. Tharaka Nithi*	30-84
11. Laikipia*	30-84
12. Kitui*	30-84
13. Garissa*	85-100
14. Tana River*	85-100
15. Kilifi*	30-84
16. Kwale*	30-84
17. Mandera*	85-100
18. Turkana*	85-100
19. Narok*	10-29
20. Makueni*	30-84
21. Taita Taveta*	30-84
22. Homa Bay	10-29
23. Mombasa	Flood prone
24. Busia	Flood prone
25. Siaya	Flood prone
26. Kisumu	Flood prone
27. Nairobi	Flood prone

Source: Authors Compilations, and Ministry of Devolution and ASAL (2018)

Counties classified as ASALS but not in the table (not covered by the survey) with respective aridity levels are Wajir (85-100%); Meru (30-84%); Lamu (10-29%); Nakuru (10-29%); Nyeri (10-29%); Migori (10-29%) and Kiambu (10-29%). Homa Bay is both a semi-arid (10-29% aridity) and flood prone county.

**Represent ASAL counties covered by the NDMA activities.*

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