

# Complexities of drought adaptive behaviour: Linking theory to data on smallholder farmer adaptation decisions

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## ABSTRACT

Smallholder farmers in semi-arid regions continuously face drought risk, leading to recurring crop damage, income loss and food insecurity, and they are taking adaptive measures to cope with this risk. By comparing and combining empirical data and existing behavioural theories, we studied the complexity of smallholder farmers' adaptive behaviour in Kitui, Kenya. We conducted interviews with key informants, a survey of disaster managers and an extensive questionnaire and choice experiment among local smallholders, and found that mistrust in forecasting and a strong belief in God appeared to be barriers to adaptation, while farm groups and past adaptation decisions seemed to stimulate the intention to adopt new measures. Our results confirmed the importance of several components of existing bounded rational theories in that risk appraisal, social norm, self-efficacy and response cost and efficacy significantly influence adaptive behaviour under drought risk. However, none of the evaluate theories could fully explain the observed behaviour. We further demonstrated that tailored extension services, improved early warning systems, ex-ante cash aid and low interest credit schemes increase the intention to adapt. While a general aversion to the current situation was evident, there was great heterogeneity in the preferences for these policies. Findings of this the extensive data collection and analysis can be used to identify the most vulnerable groups and develop well-targeted adaptation policies, and for designing, calibrating and validating of utility functions to model heterogeneous adjustment decisions in dynamic drought risk models.

## 1. Introduction

Increasing climate variability and changing socioeconomic conditions exacerbate the frequency and intensity of drought disasters, aggravating local food insecurity and dependency on external food aid in agriculture-dependent regions [1–4]. Given these challenges, the adoption of drought adaptation measures is critical to reduce existing and future drought risk, particularly for smallholder farmers in low- and middle-income countries [5]. From a socio-hydrological perspective, unravelling the adaptive behaviour of people responding to changing environmental and social conditions is a way to improve the assessment of current and future drought risk [6–9]. Insight into this co-evolution of human adaptation and drought risk is vital to the evaluation of future drought impacts and the development of any disaster risk reduction strategy [10–12]. There are different models which can be applied to capture socio-hydrological feedbacks, such as agent-based models or system dynamics models, that allow to model drought risk in a dynamic

way [13,14]. However, such models need an elaborated description and quantitative information on the drivers and barriers of the adaptation decision process.

While ample of empirical studies try to uncover the relation between socio-economic, political and environmental variables and (past) adaptation, there is little scientific agreement on which factors that influence decisions on water harvesting measures and other climate-smart agricultural practices [15–17,17]. One can observe that risk reducing measures are often taken after disasters occur, and since adaptation can alter the likelihood of future impacts, this can in turn affect forthcoming human decisions [18,19]. However, there are barely any longitudinal surveys to evidence the cause-effect relationships, to really understand the underlying processes behind the relations between such variables [20]. Moreover, the choice of investigated factors often seems rather eclectic—it remains unclear whether all relevant cognitive-behavioural processes were included in many of these studies [21]. Both reverse causality and omission can result in a biased estimation of the effects and

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lead to inaccurate interpretation [22]. The use of a psychological or economic theory in the data collection process can create a solid base to discuss behavioural factors, and it also supports asking the right questions [20]. Linking theory with observations allows for a better generalisation of the quantified link between drivers/barriers and the adaptation response, which is necessary when one's aim is to draw conclusions on future behaviours and challenge the wide applicability of these results in different case studies [23]. Only then this information can be used to describe the decision rules and structure of dynamic drought risk models that are able to capture the intertwined nature of drought impacts and adaptation.

In this manuscript, we evaluate different types of survey data about the drivers and barriers of adaptation, in the light of existing behavioural theories. Zooming in on the case of smallholder farmers in Kitui, Kenya, we analyse the heterogeneity of individual adaptive behaviours under drought risk. The data was collected using commonly employed, complementary techniques: interviews, fuzzy cognitive mapping, semi-structured questionnaires, and discrete choice experiments. These methods were designed to evaluate the applicability of existing behavioural theories to the case of Kitui, a semi-arid agro-pastoral area in Kenya. Therefore, this study adds to the available empirical data describing factors that motivate smallholder farmers to (not) implement drought adaptation measures, but is novel as it combines multiple empirical methods while also being grounded in renowned economic and psychological theories. Our aim is to support a better understanding of processes that shape farmers' adaptation to drought risk, and to creating a knowledge base that can be used to calibrate and validate dynamic drought risk models.

The remainder of this article is organized as follows: Section 2 introduces the case study area in Kenya. Section 3 provides an overview of potential drivers for adaptation decisions by smallholder farmers and related behavioural theories. Section 4 outlines the methods used to collect empirical data on adaptive behaviour while section 5 contains the results of these different data collection methods. Section 6 presents an overview of the empirically and theory-supported drivers for drought adaptation among smallholders, linking empirical observations with existing behavioural theory, and Section 7 concludes.

## 2. The Kitui study area in semi-arid Kenya

Food production in Kenya heavily depends on smallholder rain-fed agriculture; however, farmers are challenged to match the erratic rainfall with crop water requirements [24,25]. Droughts are the most frequently occurring natural hazard in Kenya, causing devastating and pervasive socioeconomic impacts every 4–5 years [26–28]. In Kitui County, in the southeast of Kenya, water availability is the preeminent factor for socioeconomic development. Water resources in this semi-arid county are scarce, unevenly distributed, and often unpredictable. The county receives approximately 1000 mm of rainfall per year, of which almost all falls erratically during two rainy seasons: March–May, and October–December [29]. Kitui is seen as highly vulnerable to drought disasters [30,31] as most of the water that can be used for domestic or irrigation use comes from ephemeral rivers which largely fall dry during the dry season. With less than 20% of the population having access to piped water – mainly households living in the towns-, woman and children of rural farmers travel approximately 8 km in regular years to fetch water or up to 15 km on foot during prolonged droughts [32].

Kitui county is labelled as a marginal farming zone; most rural people are subsistence crop and livestock farmers [33]. The main source of income is rain-fed agricultural production, and irrigation is only possible close to rivers or with expensive groundwater wells [34]. Maize, the main staple crop of the region, is grown by most farmers but is quite vulnerable to water shortages. A changing climate has already led to more frequent and longer droughts, which is also perceived as a worsening situation by Kitui smallholder farmers [2,33,35]. Having frequently experienced climate-related crop failures, the farmers in the

area have a long history of adapting to drought disasters (for examples of measures, see Table 1).

While water harvesting systems and climate smart agricultural practices can reduce a household's vulnerability to drought by 40% [36], the adoption of these proactive drought risk reduction strategies has remained surprisingly low [37–44]. Okumu et al. demonstrated that, while droughts were acknowledged to be the main cause of food insecurity (96% of respondents) and seem to have prolonged over time (55% of respondents), only 15% of respondents in Kitui had adopted water harvesting measures [38]. This was confirmed by Khisa et al., who reported that 74% of respondents did not employ any coping strategy to prepare for the effects of climate change [45]. The high level of poverty in Kitui, estimated at 47.5% compared with the national average of 36.1%, is both a cause and consequence of this limited adaptation to climate change and extreme events [46].

## 3. Identifying the factors influencing drought adaptation decisions of smallholder farmers

### 3.1. Empirical drivers of and barriers to adaptive behaviour

With perfect awareness of future drought risk, flawless early warning systems, and without socioeconomic limitations, people would be able to make proactive, rational decisions and achieve optimal economic drought risk management [20]. However, assumptions about perfect information and sufficient investment capacity do not hold when examining real-world empirical adaptation responses [23,50–52]. Adaptation decisions are often steered by stakeholders' risk perception, experiential factors, feelings of dread or worry, perceived self-efficacy, and perceived behavioural control, which all introduce a bias to rational economic decision making [53–60]. A growing body of research aims to understand the factors influencing the choice to adopt adaptation measures [26–30,61–67]. Here, we present relevant review studies on the drivers of drought adaptation by farmers in Africa, and some specific studies relevant for Kenya and its Kitui region, summarized in

**Table 1**

Drought adaptation measures against drought impact taken by farmers in Kitui County, Kenya (TEGEMEO TARPA household survey data 2000, 2004, 2007, 2010 [47–49]).

Measures	Description
Fanya-Juu	Terraces formed for easier cultivation and prevention of soil erosion.
Zai-pit	Dug pits in the soil during the pre-season to catch water and to concentrate compost.
Cistern/tank	A waterproof receptacle for holding liquids, in this case, water.
Shallow well	A well is a hole that has been dug, bored, driven or drilled into the ground for the purpose of extracting water. A shallow well is approximately 7–15 m deep.
Mulch	Mulch is a layer of material applied to the surface of soil to conserve soil moisture, and to improve the fertility and health of the soil.
Irrigation	Irrigation infrastructures are technologies that assist in the spreading of water onto crops.
Conservation agriculture	Conservation agriculture is a farming system used for minimum soil disturbance, maintenance of a permanent soil cover, and diversification of plant species.
Stone terraces	Traditional simple cultivation technology used in dry areas and/or sloping land.
Farm pond	A water harvesting structure that can also be used for fishing
Roadside harvesting	A water harvesting structure. To collect runoff from the roads
Hybrid crop varieties/diversification	Drought tolerant or short cycle varieties of the main staple crops (maize, beans) or varying the amount of crop types per year
Adding manure	Soil fertility influences the water holding capacity of the farmland, diversification

**Table 2**

Factors driving adaptation decisions, investigated in literature about Eastern Africa, climate change and drought risk adaptation. references: [35,39,45,68–95].

DRIVERS	References (non-exhaustive list of Sub-Saharan reviews and Kenyan case studies)
<b>NATURAL CAPITAL</b>	
Land ownership, tenure security	Muhammad et al., 2010 Speranza 2010 Owuor 2005 Bedeke 2019 Below 2012 Gbegbebege 2017 Di Falco 2014; de Jalon et al., 2018
No access to water, long distance	Okumu 2013 Nthenge 2016 Oromo 2015 Khisa 2014
Larger field size, flatness of soil	Muhammad et al., 2010 Nkatha 2017 Villaneuva 2016 Gbegbebege 2017 Bryan et al., 2013 Tongruksawattana 2019 Arslana 2014
<b>FINANCIAL CAPITAL</b>	
No shortage of assets	Muhammad et al., 2010 Nkatha 2017; Speranza 2010 Nthenge 2016 Okumu 2013 Oromo 2015 Khisa 2014 Owuor 2005 villaneuva 2016 Gbegbebege 2017 Tongruksawattana 2019 Shikuku 2017 Bryan et al., 2013
More external, off-farm income	Nkatha 2017 Bedeke 2019 Bryan et al., 2013 Bryan et al., 2013 Muhammad et al., 2010
Aid, remittances	Nkatha 2017
Access micro credit/loans	Muhammad et al., 2010 Nkatha 2017; Speranza 2010 Khisa 2014 Mutunga 2017 matere 2016 Bedeke 2019 Holden 2017 Below 2012 Gbegbebege 2017 Tongruksawattana 2019 Shikuku 2017 Bryan et al., 2013
Larger Animal stock	Speranza 2010 Owuor 2005
Radio, bike, phone	Muhammad et al., 2010 Owuor 2005 Arslana 2014
Having a stable food security	Muhammad et al., 2010
<b>HUMAN CAPITAL</b>	
Having Labour power	Muhammad et al., 2010 Nkatha 2017 Nthenge 2016 Senyolo 2018 villaneuva 2016
Hiver Education, literacy	Nkatha 2017 Okumu 2013 Mwangi et al., 2015 Oromo 2015 Bedeke 2019 Below 2012 Tongruksawattana; Bryan et al., 2013 de Jalon et al., 2018
Access to extension training, farmer field school	Muhammad et al., 2010 Nkatha 2017 Nthenge 2016 Okumu 2013 Mwangi et al., 2015 Oromo 2015 Khisa 2014 Mutunga 2017 matere 2016 Bedeke 2019 Mfitumukiza1, Below 2012 Bryan et al., 2013 Tongruksawattana 2019 Arslana 2014 Shikuku 2017 Di Falco XXX; Nkatha 2017
Agricultural support	Nkatha 2017 Mwangi et al., 2015 Oromo 2015 Bedeke 2019 Bryan et al., 2013 Shikuku 2017
Farm experience	Okumu 2013
Health	Bryan et al., 2013 Shikuku 2017
Household size	Gbegbebege 2017
Planning skills	Speranza 2010 Mwangi et al., 2015 Drechsel 2005
Agricultural skills	Bryan et al., 2013
<b>SOCIAL CAPITAL</b>	
Membership association	Muhammad et al., 2010; Nkatha 2017 Bedeke 2019 Gbegbebege 2017 Tongruksawattana Shikuku 2017
Gender (being male)	Muhammad 2010; Nkatha 2017 Mwangi et al., 2015 Bedeke 2019 Shikuku 2017
Neighbours, social capital	Khisa 2014 Bedeke 2019 Below 2012 Drechsel 2005; de Jalon et al., 2018; Wossen 2013
<b>INFRASTRUCTURAL CAPITAL</b>	
Institutional support	Nthenge 2016; Gbegbebege 2017 Drechsel 2005 Di Falco XXX
Access to input markets	Muhammad et al., 2010 Nkatha 2017 Oromo 2015 Khisa 2014 Below 2012 Drechsel 2005 Bryan et al., 2013
Access to output markets	Muhammad et al., 2010; Speranza 2010 Oromo 2015 Bedeke 2019 Arslana 2014; Below 2012
Good Infrastructure	Owuor 2005
<b>PERCEIVED CLIMATE TRENDS</b>	

**Table 2 (continued)**

DRIVERS	References (non-exhaustive list of Sub-Saharan reviews and Kenyan case studies)
Access to Climate info services	Mutunga 2017
Not believing in GOD as savior	Center for Science and technology innovation 2009
Perceiving drought to be frequent and severe	Muhammad et al., 2010 Rao 2011 Holden 2017 Below 2012 Tongruksawattana 2019 Arslana 2014 Shikuku 2017; Drechsel 2005
Awareness of climate change	Center for science and technology innovation 2009 Villaneuva 2016 Arslana 2014; Drechsel 2005
Low risk averseness	; Nkatha 2017 Holden 2015 Holden 2017; Drechsel 2005
<b>MEASURE Characteristics</b>	
Yield variability	Muhammad et al., 2010 Shikuku 2017
Awareness of benefits	Villaneuva 2016 Drechsel 2005
Cost effectiveness of the measure	Nkatha 2017 Mwangi et al., 2015 Muhammad et al., 2010; Drechsel 2005
Positive perception of technology	Nkatha 2017

**Table 2.**

Research on climate change adaptation practices in Africa shows that the characteristics of the proposed technology (e.g. gain, costs, maintenance, distance to markets), farmers attitude towards risk and climate change perceptions, knowledge (e.g. through social networks, farmer groups or extension services), institutional support, and the financial (e.g. distance to markets, access to credit markets) and policy (e.g. security of land holdings) environment are important drivers of adoption of adaptation measures [96–99]. Also socio-demographic characteristics such as household size, sex and age of the household head appear significant [99]. Scientists focussing on Kenyan farmers specifically found similar drivers and barriers to adaptation, adding socio-economic factors such as poverty, off-farm income, farm expenditure, food expenditure and human capital to the list [41,100–103]. Research from Kitui confirmed these factors, but also mention distance to water sources, farming experience, access to forecasts, and influence of social network as important for the decision whether or not to adapt to drought risk and climate change [25,45,91,104,105].

In general, the adaptation response of farmers to drought or climate change is found to be heterogenic in time and space [60]. However, with regression analyses - commonly applied in the cited studies - the heterogeneity in behaviour and the cognitive processes behind the found relationships are not always explored, hindering the use of the results when one’s aim is to draw conclusions on future behaviours or to model drought risk in a dynamic way. Furthermore, while knowledge/skills, assets/market, and risk perception are cited as dominant factors, different drivers of and barriers to adoption appear more or less significant in different case studies. The absence of theories to frame such results challenges their use in other case studies because generalizing them requires making multiple assumptions that are hard to substantiate.

**3.2. Existing theories on adaptive behaviour**

A commonly used economic model for decision making under uncertainty is the (subjective) Expected Utility Theory, which is based on the supposition that people can make rational choices (allowing for biased risk knowledge) and choose the option with the highest utility [106,107]. Such utility maximizing theories, however, assume people have perfect knowledge on the probability of shocks as well as the costs and benefits of actions, and ignore the complexity of human adaptation decisions: emotional, psychological, and social factors – along with objective arguments – affect individuals’ evaluation of drought, leading to imperfect judgement [20,73,74,111]. Observed adaptive behaviour in the face of disaster risk is found to be bounded rational and

heterogeneous in time and space; smallholder farmers tend to look for satisfaction rather than utility maximisation when making relevant decisions about their farm water management in the face of droughts [52, 74,75,112–115]. Table 3 describes the behavioural factors used in existing socio-cognitive theories that aim to describe the decision-making process of humans based psychological and economical sciences. Other adaptive behaviour theories link economics to psychological and sociological sciences. Examples of more complex theories about adaptive behaviour are the agricultural adaptation and perception model [116], the trade-off analysis model for multi-dimensional impact assessment [117], the Consumat approach [118], the technology acceptance model [119], Rogers’ innovation diffusion model [120], the prospect theory [55], the protection motivation theory [56], the socio-cognitive model of private proactive adaptation to climate change [121], the value-belief-norm theory of environmentalism [122], and the theory of planned behaviour [57,123].

Empirical evidence is required to validate these behavioural theories, translate them into measurable characteristics of farm households, and formalise them in quantitative terms. Only few authors have empirically quantified the link between drivers and drought adaptation intentions through the use of a theoretical decision-making framework, thus overcoming the gap between case-specific empirics and generalisable theory—in most cases the Protection Motivation Theory, and sometimes the Theory of Planned Behaviour (e.g. Refs. [109,124–130]). While multiple studies outside of Kenya have successfully applied the Expected Utility Theory and PT (e.g. Refs. [131,132]), Bryan (2013) did not find strong evidence to support those theories for climate change adaptation behaviour of Kenyan farmers. Several studies on smallholder farmers have applied the Theory of Planned Behaviour (e.g. Refs. [133–135]), but for example Niles et al. (2016) did not find empirical evidence to support the theory among farmers in drought-prone New Zealand [136].

The Protection Motivation Theory yielded more successes in explaining empirically observed adaptation decisions; Dang et al. (2014) demonstrated its application for private adaptive measures to climate change among rice farmers in the Mekong Delta, Vietnam [137], Van Duinen et al. ([99,100,138]) followed the theory investigating social networks and farmers’ adoption of irrigation infrastructure in The Netherlands, and Keshavarz and Karami ([127,128]) illustrated that the theory, in combination with farmers’ social environment significantly influenced pro-environmental behaviour under drought in. Zooming in on Africa and Kenya, both Regasa et al. (2019), Hailegiogris et al. (2018) and Gebrehiwot and Van der Veen (2015) successfully used the

Protection Motivation Theory to describe the sociocognitive behaviour of rural households toward climate change and droughts in Ethiopia [108,109,139,140]. Moreover, Stefanovi (2015) found the Protection Motivation Theory provided a solid background to explain the sociocognitive-behavioural processes influencing climate change adaptation among smallholder farming systems in Kenya [125]. Therefore, in the presented research, the Protection Motivation Theory received special attention and was used to frame the data collection process. However, also additional factors regarding adaptive behaviour (from other theories or empirics) were investigated because they could approve or disprove the applicability of these theories for the Kitui case study.

4. Data collection and processing

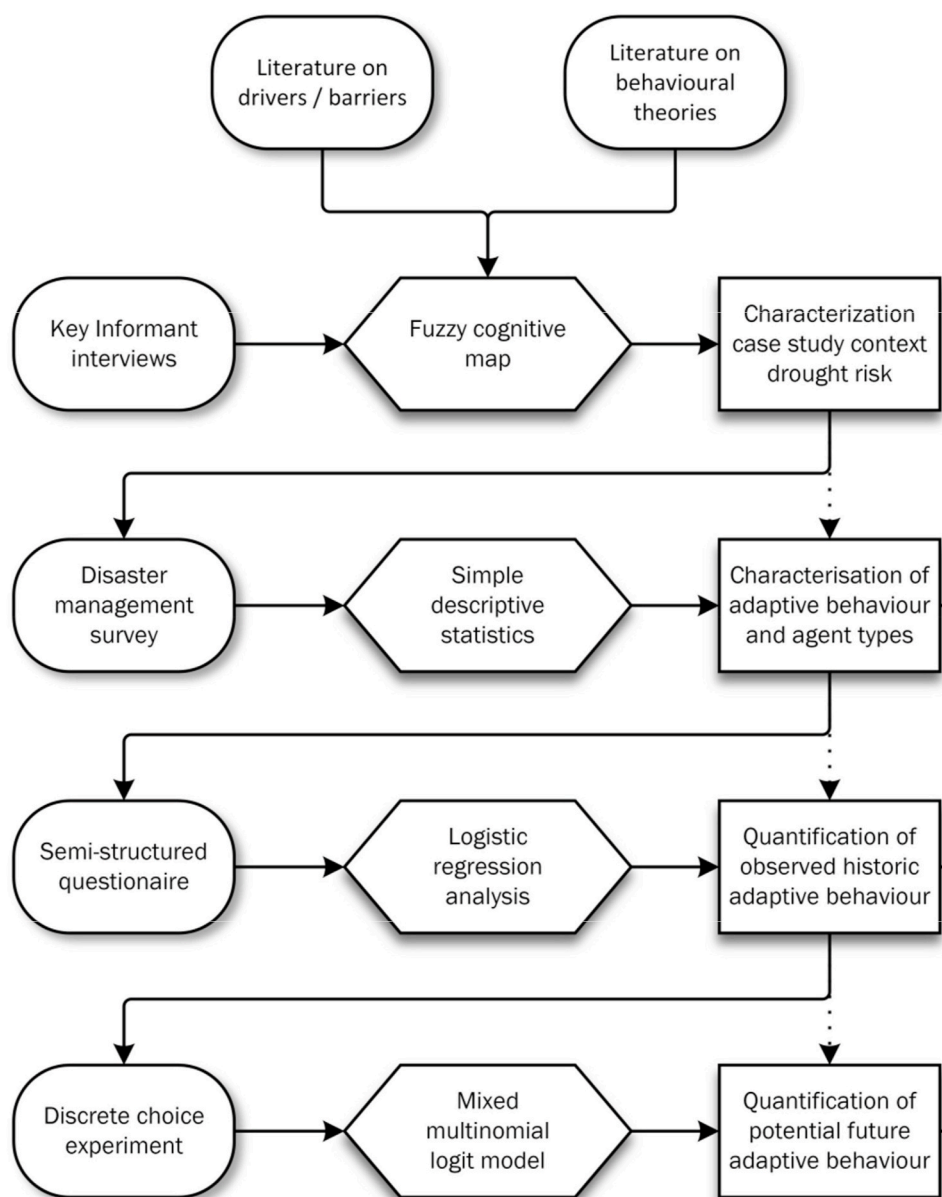
Information on drought adaptation, farm characteristics, potential policies, risk perceptions, and various other potential drivers and barriers to adaptation decisions [21] was collected in a participatory manner [141–143]. The survey methods and designs were supported by existing literature (Section 3) and follow the recommendations of [140], and [142] regarding collecting data for quantifying behavioural rules. Four methods) were applied in this study: interviews with key informants, a structured questionnaire among disaster managers, a semi-structured questionnaire among farm households, and a choice experiment among farm households. Fig. 1 presents a flow diagram illustrating the four data collection and data processing methods that were applied to qualitatively and quantitatively describe the adaptive behaviour of smallholder farmers under drought risk in Kitui. They are elaborated in the following subsections.

4.1. Key informant interview design

Relevant key informants (see Annex Table A) were consulted to provide their view on the most important drought risk measures, drivers for adaptive behaviour, and issues that limit the adoption of said measures. All key informants were dealing directly or indirectly with the agricultural impacts of droughts and were experienced in the field of water management in Kitui or Kenya. First, five ‘example farmers’ were interviewed about their experience of searching for knowledge and money to invest in certain drought adaptation measures as well as their experience of showcasing their climate-smart farm practices to other farmers. The opening question for these interviews was as follows: “If we wanted to predict which farmers are going to adopt new adaptation measures

Table 3 Schematic overview of behavioural factors used in existing socio-cognitive theories.

THEORY	BEHAVIOURAL FACTORS INCLUDED IN THE THEORY				
Trade-Off Analysis Model	Feasibility of the measure			Costs of the measures	
Consumat Theory	Repetition, imitation, inquiring, optimising	Needs satisfaction		Experienced uncertainty	Behavioural control
Agricultural Adaptation And Perception Model	Vulnerability	Livelihood trends	Climate impacts	Climate perception	Potentials and obstacles
Technology Acceptance Model	perceived usefulness (subjective norm, output quality, result demonstrability, ...)			perceived ease of use (experience, voluntariness)	
Rogers’ Innovation Diffusion Model	relative advantage	compatibility	complexity	trial ability	observability
Prospect Theory	Financial costs		Financial gains (avoided loss)		risk averseness
Protection Motivation Theory	risk appraisal (perceived frequency, severity)			coping appraisal (adaptation costs, efficacy, self-efficacy)	
Value-Belief-Norm Theory Of Environmentalism	values (altruism, worldview, egoism)		beliefs (consequences, perceived ability)		personal norms (sense of obligation)
Theory Of Planned Behaviour	subjective norm		attitude		perceived behavioural control



**Fig. 1.** Flow diagram showing literature overview (top row), data collection (left column) and data processing (diamond shapes) activities done to describe, qualitatively and quantitatively, the adaptive behaviour of smallholder farmers under drought risk in Kitui (squares) done in this research with the eventual purpose to calibrate and validate adaptation dynamics in dynamic drought risk models.

in the next season and which are not, which information about these farmers do we need and what do you think are the most important drivers and barriers for them?” Additionally, local and national stakeholders were asked to participate in a fuzzy cognitive mapping exercise centred around this question. Fuzzy cognitive mapping, a combination of fuzzy logic and cognitive mapping, is a participatory technique to find cause-effect relations between environmental and social variables in data-scarce conditions [144,145].

Aiming to sketch the drought risk system and the perceptions of the participants thereof, participants were then asked to draw lines between the detected root causes, existing dynamic pressures, and observed vulnerabilities to the adoption of drought adaptation and drought risk. We started from white sheets to prevent participants being influenced by existing theories or drivers/barriers mentioned by previous participants [146], and collected all concepts mentioned by the participants (called nodes) and all causal relations (called connections) in one overview schedule. By combining the information from all interviews and

grouping them according to factors from the existing theories, the main links and interactions between drivers and barriers that affect the risk and adaptation were visualised in a schematic overview (Annex figure A). Marking concepts in bold if they were seen as key concepts by multiple stakeholders, the overview provides a macro-level, qualitative view of the drought risk system in Kitui (similar to Refs. [147–150]). This bottom-up, participatory approach provided a first insight of which causes and effects matter most in the Kitui context, and to refine or refute initial assumptions related to the adaptive behaviour of farmers; information which was used to shape the questions for the consecutive disaster management survey (4.2) and the household survey (4.3).

#### 4.2. Disaster management survey design

A short, eight-question survey among African disaster management officers was executed to obtain input from policymakers and disaster risk reduction experts. The survey reached 54 Sub-Saharan African

disaster managers from 9 different countries, of whom 8 were from Kenya. 28 worked on national planning and policy, 4 on local planning and policy, 10 on local civil protection and disaster response, and 12 on local education and raising awareness. They were contacted over email through an existing network of disaster risk management (over 150 recipients), but participation was anonymous. The top-down view of these disaster managers – Kenyan or other - on the limitations for the adoption of drought adaptation is insightful as their policies are based in such information – and learns us something about the potential generalizability of the adaptive behaviour of smallholder farmers, beyond the case study.

Given the promising results in studies on the Protection Motivation Theory, and the Protection Motivation Theory factors' appearance in the key informant interviews (4.1), factors of this sociocognitive model of proactive private adaptation were explicitly included in the questions. Moreover, questions related to “subjective norm” that is, normative beliefs or perceived social pressure by the farmer network, -a factor of the Theory of Planned Behaviour (Section 3) -, were included. This allowed for the investigation of whether, according to disaster managers, risk appraisal processes (such as those studied in Ref. [151]) and coping appraisal processes (such as those studied in Ref. [152]) indeed play a role in determining smallholder farmers' intention to adapt to droughts. Simple descriptive statistics were applied to investigate the answers of the disaster managers, so as to evaluate if the top-down view of adaptive behaviour matches with the inquired and observed behaviour of the smallholder farmers, as well as to compare the factors of importance according to the disaster managers with the components of the existing bounded rational behavioural theories.

#### 4.3. Semi-structured smallholder farmer questionnaire design

Additional empirical data about farmer behaviour was collected in a semi-structured questionnaire among 260 smallholder farmers in Kitui East, around different markets along the Kibwezi-Kitui-Kandwia road (Fig. 2). Cluster sampling and a simple random approach were adopted to gather quantitative data – once a specific neighbourhood was randomly picked, all households in the neighbourhood were contacted

for participation. Four trained enumerators, originating from the study area, used the smartphone application KOBO-Toolbox to collect the answers of households willing to participate. A pilot survey of 30 households was conducted to ensure clarity of the questions and to train the enumerators, after which the list of questions was optimized.

The literature overview and the expert feedback from the key informant interviews (4.1) and disaster managers (4.2) were the basis for a household questionnaire designed to validate the use of the Protection Motivation Theory and others for the case study of smallholder farmers in Kitui (see Annex Table B). We adopted the approach suggested by Temessa et al. (2019) on testing for the links between drivers and adaptation in three steps: the direct-enquiry method, the direct-ranking method and recording proxies to be used in statistical models (Tessema et al., 2019). This resulted in a set of 85 questions verbalising multiple behavioural factors—including people's drought experience, risk perception, susceptibility, coping capacity, self-efficacy, perceived adaptation benefits, perceived adaptation costs, motivation and barriers to adapt, and questions related to the socioeconomic and demographic status of the respondents (descriptive statistics on the socio-economic characteristics of respondents can be found in Annex table C).

The collected data was used to uncover statistical correlations between socioeconomic, behavioural, or cognitive variables and farmers adaptive behaviour (e.g. Refs. [142,153]) (please find an overview in Annex table D and E). We used binary logistic regression techniques to relate these variables to the farmers' intention to adopt new measures in the next season and farmers' past adoption of measures. After doing a Pearson correlation analysis, we performed stepwise logistic regressions and evaluated their goodness of fit based on the Akaike Information Criterion and R-squared values. The boruta and backward Wald methods were used as stepwise elimination algorithms on the logistic regression, thereby automatically optimising the models (removing correlated and redundant variables; obtaining the best AIC value) [154]. The p-values and coefficients of the independent variables of the optimized models were used to identify the most critical drivers for adaptive behaviour.

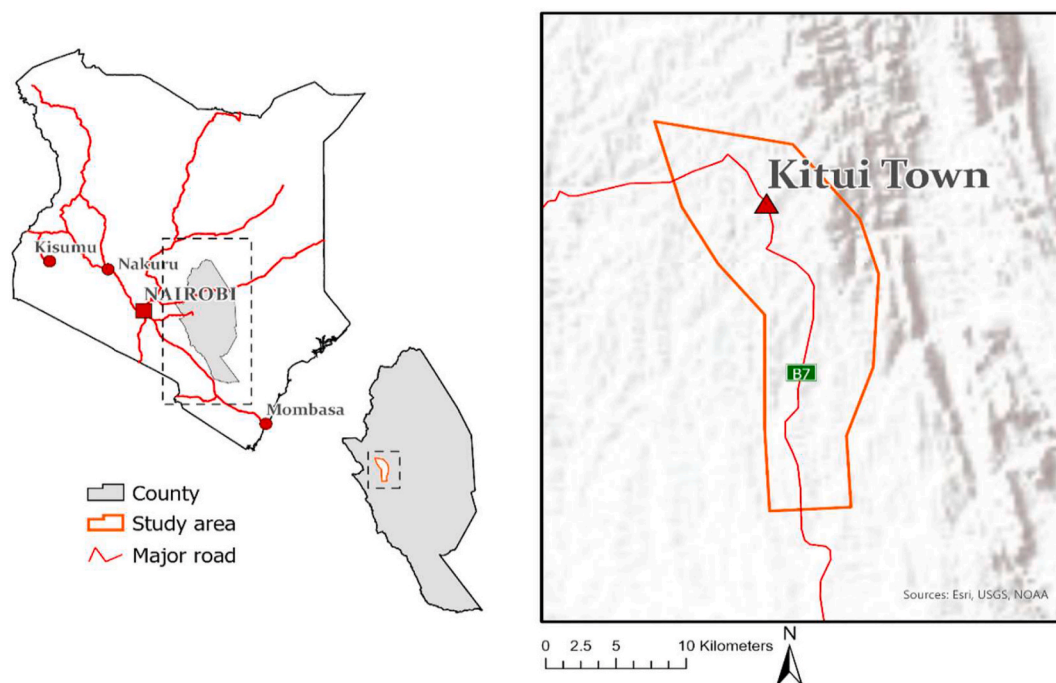


Fig. 2. LEFT: Location of study area (orange) within Kitui County (center, grey) in Kenya; RIGHT Kitui town (triangle) and the Kibwezi-Kitui-Kandwia road (B7) along which the survey took place.

#### 4.4. Smallholder farmer choice experiment design

In addition to semi-structured survey questions, the 260 smallholder farmers were also asked to participate in a discrete choice experiment (DCE), a stated preference technique used to investigate smallholder farmers' preference towards policy actions, as suggested by Refs. [155, 156]. DCEs are often used to describe the different effects of both attributes of scenarios and characteristics of decision makers on choices they are presented with. Discrete choice analysis, an econometric approach, is often used to evaluate the preference for risk-reducing measures (e.g. Refs. [157,158]). DCE models specify the probability that an individual respondent chooses a certain scenario among a set of alternative scenarios: in this case a specific combination of governmental drought policies. Farmers are assumed to select the scenario that would increase their likelihood of adopting the most. This highest utility scenario is the sum of the utilities of each attribute, but is also influenced by the farmers' socioeconomic situation [159]. The relative importance of the attributes of a DCE provides valuable information for the prediction of future adaptive behaviour under changing policy conditions [160].

The DCE in this research was designed to evaluate the change in farmers' intention to adopt drought adaptation measures, for scenarios with a mix of governmental drought actions (attributes) that could potentially erase the current barriers to adoption. This list is based on the current policies regarding drought adaptation in Kenya. For example, the Kenya Vision 2030 promotes integrated proactive drought management for dryland farmers through improved extension services and increased access to financial services, such as affordable credit schemes for people in the Arid And Semi-Arid Lands of Kenya [161]. Besides, building on the Ending Drought Emergencies plan (2013–2017) [162], the National Drought Management Authority prioritises drought early warning systems, and aims to establish ex-ante cash transfers to upscale drought risk financing [163]. Also other authors concluded that more resources in terms of credit facilities, access to climate change information, and extension services should be availed to farmers in areas affected by climate change and variability [35].

Using a DCE (Table 4) can help identify preferences for governmental policies as well as analyse to what extent drought management policies will steer adaptive behaviour, which explains how effective they are at reducing the farm household drought risk. Respondents were asked to choose eight times between two alternative policy scenarios (a combination of four governmental actions with various combinations of level 1 and 2) and the business-as-usual case (the four governmental actions on level 0), and indicate in which scenario they would most likely adopt a new adaptation measure. The experimental design was controlled random – the actions and their levels on each choice card were balanced and could overlap. Level overlap was allowed to occur, meaning that in a single decision situation an action could have the same level in both options presented [164].

**Table 4**  
Choice experiment setup: attributes (governmental actions) in the first column, their possible levels right of it.

	Level 0 (business as usual)	Level 1	Level 2
Extension services	Infrequent; access for 15–25% of the households	Access for everyone, Once a year	Access for everyone, every season (Twice a year)
Early Warning system	Not reliable	Yearly outlooks	Seasonal predictions
Cash transfer	Ex-post at best; for less than 40% of the farmers	Ex-ante (lump sum) for all farmers in need	Ex-ante (two sums) for all farmers in need
Credit schemes	Access for only 1.5% rates at >10%	Access to everyone, rates at 5%	Access to everyone, rates at 2%

Multiple applications of a mixed multinomial logit model, which assumes heterogeneity in preferences for different alternative-specific variables [165,166], were tested to investigate the policy preferences of the 260 farmers. The utility functions of this mixed – also called random parameter – logit model consisted of the linear sum of the attribute values and their weight coefficients, indicating their importance and random variation error terms per attribute [167]. Using 1000 draws, random parameters with normal distributions were estimated for all attributes, and an error-component was included for the two options versus the opt-out. They showed not only the average preferences of the respondents but also its heterogeneity, indicating a distribution of preferences caused by both observable and unobservable alternative characteristics [167]. The goodness-of-fit of the models was checked using the AIC test, a measure of the relative quality of statistical models, analysing the trade-off between model complexity and goodness-of-fit for a given set of data.

## 5. Results

### 5.1. Key informant interview outcomes

The concept diagram in Annex B was created by combining Fuzzy Cognitive Maps of all key informant interviews, a bottom-up way of displaying the Kitui context of smallholder drought disaster risk management. Three layers can be distinguished: (1) adaptation measures, signifying the level of vulnerability to drought risk; (2) adoption factors, identifying the drivers for adaptation; and (3) governmental and nongovernmental organisations (NGOs), representing the policy context. Three types of adaptation measures were identified by the respondents: practices related to soil and water conservation (i.e., grey infrastructure and techniques to avoid degradation); climate-smart agriculture (agronomic practices to avoid drought-induced crop loss); and livelihood diversification (directly increasing resilience to shocks). The adoption factors revealed in the Fuzzy cognitive Map can be classified into drivers or barriers related to knowledge, self-efficacy, response efficacy, response costs, attitude, risk perception, and social networks. This means that the Protection Motivation Theory alone is not able to explain all possible drivers for adaptive behaviour mentioned by the key informants, as social network and attitude, two factors covered the Theory Of Planned Behaviour, also appeared on the map. Lastly, key informants perceived that governmental organisations and NGOs can affect all of the acknowledged drivers of/barriers to adoption through direct and indirect policies and actions.

Moreover, from the key informant interviews with example farmers, three additional conclusions could be drawn: (1) Farmer-to-farmer networks spread the knowledge on adaptation strategies (guided by NGOs), thus enhancing the implementation of adaptation measures. There are pioneer farmers who do not receive extension services but nevertheless want to adopt new structures; however, they lack the knowledge or financial means. (2) When not in poverty, and with knowledge on business and farm financial management (i.e., education), farmers have fewer barriers. However, when trapped in poverty, conditional food and financial aid can help build sustainable livelihoods, creating families that are not dependent on external support anymore. (3) Corruption is a critical factor hindering the implementation of adaptation measures. Large costs are not bearable because of corruption and fluctuating market prices. Interestingly, two of the three key aspects mentioned above – networks, corruption - are not so pronounced or even absent in the Protection Motivation Theory, although one could argue that they indirectly influence the coping appraisal (self-efficacy, coping efficacy, and coping cost). The influence of networks however also strongly relates to the subjective norm factor in the Theory of Planned Behaviour, giving credibility to this latter theory.

5.2. Disaster manager survey outcomes

Based on the survey among policymakers and disaster risk reduction officers, the policy makers' perspectives on smallholder drought risk and adaptation could be obtained (Fig. 3). Increasing knowledge was (on average) ranked as the most important motivation to adapt, above expected financial gain (on average 2nd), financial help (on average 3rd) and experienced drought risk (on average 4th). While the effect of neighbours is on average ranked lowest, opinions vary as 26% has ranked this as most important but 34% as least important. Asked about the timing of decisions by smallholder farmers, they were thought to have the highest motivation to adapt right after a drought (52%) or after they receive training (33%), aligned with increasing knowledge (79%) and increasing awareness (71%) being the best strategies for supporting smallholder adoption of adaptation measures. The disaster manager survey further revealed that adaptive behaviour is thought to be bounded by risk perception, response appraisal, and knowledge. These outcomes support the Protection Motivation Theory rather than the Theory of Planned Behaviour as the theory describing smallholder farmer adaptive behaviour under drought risk, but it should be noted that de answers varied significantly among respondents making it challenging to draw hard conclusions. No pattern (e.g. country based differences or local versus national managers) in this heterogeneity of answers could be found either.

5.3. Semi-structured smallholder farmer questionnaire outcomes

When farm households were asked about the importance of various factors in their decision whether to adopt new drought adaptation measures (Figs. 3), 50% found the yield gain, net present value, essential to be essential for their adaptive behaviour, whereas 48%, 47%, 46% found social influence (actions of neighbour), experience of multiple crop failures (drought risk), and efficiency in reducing water shortages (adaptation efficacy), to be essential, respectively. Moreover, 43% of the farm households would not install measures if the installation costs were higher, 40% would not if they did not receive financial help and 39% would not if they did not receive extension services. Here, the social norm factor of the Theory of Planned Behaviour seems essential, in contrast to the results of the disaster manager survey, which estimated social influences as less important. However, risk and efficacy, factors in

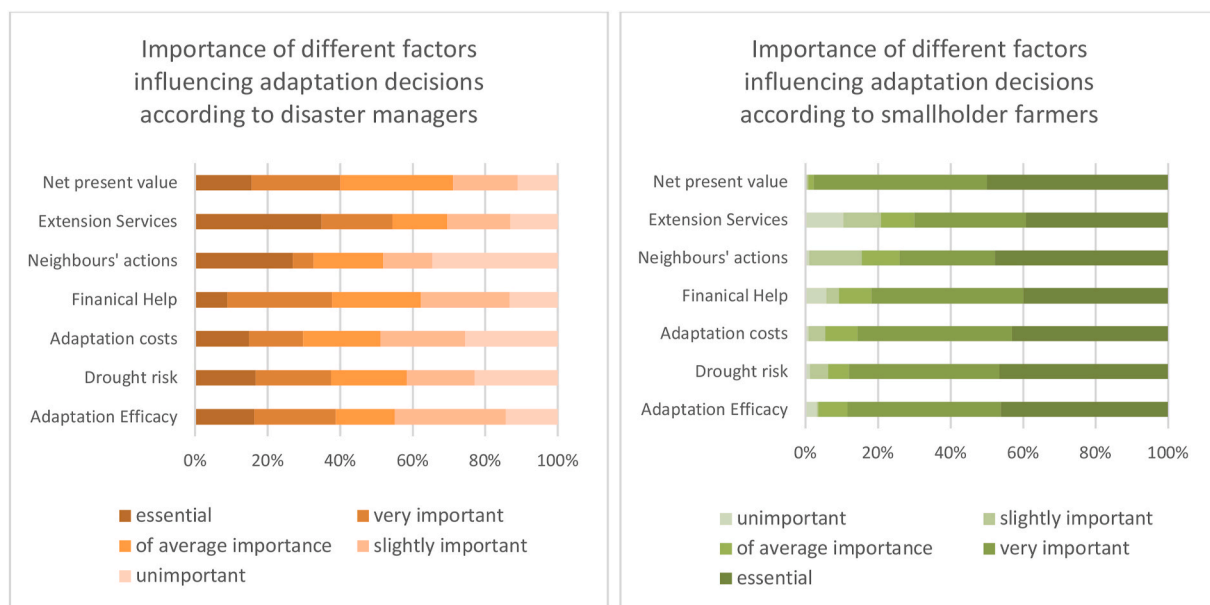
the Protection Motivation Theory, are also seen as critical by almost half of the respondents.

Looking into the barriers (Table 5), clearly poverty tops the list in challenges to overcome for the decision to adopt measures. Both money and labour capital stops people from planning to adopt measures even while wanting to do so. Lack of necessary skills is another important barrier, and also a lack knowledge on which measure to install is limiting adoption. Clearly, the (perceived) self-efficacy, a factor in both the Theory of Planned Behaviour and Protection Motivation Theory, matters, next to purely financial constraints present in all theories. Moreover, contrasting the importance of yield gain, net present value of the measures, more than 50% of the farm households never did perform a proper cost–benefit analysis, revealing a split in the respondent pool and refuting the assumptions of perfect information and economic rationality used in e.g. the Expected Utility Theory.

A logistic regression analysis (Table 6, accuracy 83%) evaluating the factors related to having adaptation measures, revealed that people who have adopted measures in the past have experienced less droughts. This

**Table 5**  
Percentage of respondents acknowledging to have experienced the limiting factor in question. Table showcases (left) the barriers to adopting new adaptation measures (based on future adoption behaviour): challenges foreseen by those who plan to adopt new measures soon (N = 106) and (right) the hurdles for those who wish to but are not able to plan to adopt new measures (N = 147). 6 Households indicated they had no intention to have more measures, and thus were not asked either of these questions.

Barriers for adoption of adaptation measures	% of those who plan to adopt	% of those who wish but not plan
Limited access to credit markets	42%	20%
Limited skills to implement measures	48%	24%
Lack of a suitable location for the measures	20%	16%
Lack of labour to install the measures	51%	35%
Limited financial capacity to adopt the measures	86%	83%
Limited access to input materials	35%	
No knowledge on effective measures		31%



**Fig. 3.** Ranking of importance of different factors influencing the decisions whether or not to adopt by LEFT Disaster risk managers (N = 49) and by RIGHT smallholder farmers (N = 260).

**Table 6**

Binary logistic regression with “having adopted adaptation measures” as dependent variable. Model selection was based on maximizing overall fit for main effects with an estimated AIC of 215. Odds ratio and interval of odds ratio are shown. Significance levels:  $p < 0.1$ .;  $p < 0.05$  \*;  $p < 0.01$  \*\*;  $p < 0.001$  \*\*\*.

Drivers PAST behaviour	ODDS Ratio	2.50%	97.50%	Link with theory
(Intercept)	0.58	0.16	2.13	
Experience seasons with water scarcity	1.18	.	0.99	1.41
Scared of climate change	1.41	.	0.97	2.06
Fear from droughts and water shortage	2.07	***	1.55	2.83
Number of drought disasters experienced	0.84	**	0.75	0.93
Trust in forecasts	0.72	.	0.48	1.06
Access to forecasts	0.71	.	0.45	1.11
Attended extension service trainings	2.97	**	1.33	6.96
Access to group credit scheme	1.82E8			Financial strength
Recipient of farm subsidies	1.54E9			Financial strength
Size of own land	1.65	***	1.27	2.24
				Financial strength

is possibly a result of being more resilient to drought disasters after adapting to them, rather than a driver at the time of making the decision. However, risk perception (a factor in the Protection Motivation Theory) clearly plays a role: people who experience frequent seasons with water scarcity, and/or those who fear such seasons, and/or those who are afraid of climate change, were more likely to have adopted measures. Furthermore, farm households with larger land had a 65% higher likelihood of having adopted measures, a factor that can indicate the potential gain of adaptation – assuming the drought-induced losses have a bigger influence on the livelihoods of households with more land. Also household heads who attended extension services were almost three times more likely to have adopted measures in the past. Hence, access to knowledge, a factor also apparent in the Fuzzy Cognitive Map, indicated by the disaster managers and strongly linked to perceived self-efficacy (a factors of both the Protection Motivation Theory and Theory of Planned Behaviour), is an important driver for adaptation. Interestingly, farm households who trust forecasts were less likely to have adopted, maybe because they rely on preparedness rather than long-term adaptation.

When analysing the multilinear relationship between household characteristics and the number of drought adaptation measures adopted (Table 7), risk perception and knowledge appeared to be relevant again:

**Table 7**

Multinomial poisson regression with “number of adopted adaptation measures” as dependent variable. Model selection was based on maximizing overall fit for main effects with an estimated AIC of 757. Odds ratio and interval of odds ratio are shown. Significance levels:  $p < 0.1$ .;  $p < 0.05$  \*;  $p < 0.01$  \*\*;  $p < 0.001$  \*\*\*.

Drivers PAST behaviour	ODDS Ratio	2.50%	97.50%	Link with theory
(Intercept)	0.69	0.44	1.08	
Perceived vulnerability	0.83	***	0.74	0.93
Fear from droughts and water shortage	1.23	***	1.11	1.37
Trust in forecast	0.84	***	0.76	0.93
Member of a farm group	1.38	**	1.11	1.70
Performed a cost-benefit analysis	1.41	**	1.15	1.74
Size of own land	1.05	***	1.03	1.08
Age of household head	1.01	.	1.00	1.02
Amount of household members	1.06	*	1.00	1.12

fear of droughts and water shortage and the ability to perform a cost–benefit analysis were positively related to the number of measures. The model (accuracy of 78%) showed that older people (having experienced more drought years) and larger households (more labour power), are positively linked to having more measures: both can be linked to the perception of self-efficacy. Also people with a larger farm size (more benefits) have a higher odds. Again, farm households with less trust in forecasts appeared to have adopted more measures, supporting the notion that forecasts (trust) move people from relying on preparedness to investing in adaptation. Elements from the Expected Utility Theory (cost–benefit rationale), and Protection Motivation Theory (perceived capacity, perceived risk) were visible, but not one theory was able to contextualise all regression results.

When statistically analysing potential future actions – namely predicting farmers’ plans to adopt new adaptation measures (Table 8, accuracy of 78%) – it was clear that having adopted multiple measures before, having a larger household, having performed a cost–benefit analysis, and having a positive attitude toward the efficiency of these measures increased the likelihood of planning for new measures by 44%, 12%, 91%, and 77%, respectively. These factors are related to the perceived self-efficacy and perceived adaptation efficacy of the Protection Motivation Theory. Understandably, the belief that god is the only one that can protect households from disasters – decreasing self-efficacy – reduced the intention to adopt. On the other hand, having access to credit made farm households three times as likely to plan for new adaptation measures, possibly because this reduces initial investment costs. While having access to forecasts seemed to increase adaptation intention by 65%, trust in forecasts again appeared to negatively incentivise people to adopt new measures in the same analysis. Surprisingly, finding extension service training less useful increases the likelihood of planning for new measures: maybe this shows that lack of knowledge has hindered them from adopting a measure before or maybe the lack of extension support related to agronomic practices steers them to into making permanent adaptation decisions, but there may as well be another explanation for this.

5.4. Smallholder farmer choice experiment outcomes

In a first analysis evaluating discrete choices (Table 9), results indicated that, as expected from the key informant interviews and disaster

**Table 8**

Binary logistic regression with “planning to adopt new measures” as dependent variable. Model selection was based on maximizing overall fit for main effects with an estimated AIC of 280. Odds ratio and interval of odds ratio are shown. Significance levels:  $p < 0.1$ .;  $p < 0.05$  \*;  $p < 0.01$  \*\*;  $p < 0.001$  \*\*\*.

Drivers FUTURE behaviour	Odds Ratio	2.5%	97.5%	Link with theory
(Intercept)	0.22	0.06	0.75	
Usefulness of Extension Services	0.47	.	0.20	1.09
Faith in god as saviour	0.42	***	0.26	0.64
Household size	1.12	.	1.00	1.28
Influence of adaptation neighbours	1.42	.	0.92	2.21
Number of adopted measures	1.44	**	1.12	1.86
Access to forecasts	1.64	*	1.11	2.45
Trust in forecasts	0.71	.	0.49	1.00
Perceived efficiency of the measures	1.77	**	1.17	2.77
Access to group credit scheme	6.90	.	0.81	152.06
Access to individual credit scheme	3.30	.	0.95	13.74
Performed a cost-benefit analysis	1.91	.	0.99	3.71
Total farm expenses	1.00	.	1.00	1.00

**Table 9**

Random parameter logit model of the discrete choice experiment. Log-Likelihood: -1497. Odds ratio and interval of odds ratio are shown. Significance levels:  $p < 0.05$  \*;  $p < 0.01$  \*\*;  $p < 0.001$  \*\*\*.

Attributes	Odds Ratio		2.5%	97.5%
Extra extension services	1.51	***	1.38	1.65
Better early warning system	1.54	***	1.33	1.69
Ex-ante cash transfers	1.11	*	1.03	1.20
Low-rate credit schemes	0.93	***	0.91	0.95
Business-as-usual	0.01	***	0.003	0.03
standard deviation extension service		***		
standard deviation early warning		*		
standard deviation cash transfer		***		
standard deviation credit scheme		***		
standard deviation business-as-usual		***		

manager survey, receiving more and better tailored extension services, having an improved early warning system, receiving ex-ante cash transfers, and having easier access to low-rate credit schemes - none of which were the case in the current situation (business-as-usual) - all increase farmers' intention to adopt new drought adaptation measures. Clearly, overcoming the barriers of access to credit, trust in forecasts, and relevance of training - as was evident from the previous regression analyses - can indeed increase farm households' intention to adopt. If people received extension services about innovative adaptation measures, they would be 51% more likely to adapt; if they received timely and trustworthy early warning systems, they would be 54% more likely to adapt; and if they received ex-ante cash transfers, they would be 11% more likely to adapt. The attribute credit was negative as lower interest schemes were preferred: per unit increase in the interest rate, their likelihood to adopt decreased by 7%.

Significant standard deviations existed in the random parameters, revealing considerable heterogeneity. The standard deviations for all attributes, except early warning, were larger than the means of the random parameters: there was a sign-switch within the sample meaning some respondents assigning positive utility changes to an attributes, while others expressed negative utility change - showing substantial heterogeneity in the preferences. However, in general, the opt-out rate was low, with only 21% of choices for the business-as-usual scenario. The main motivation for choosing for this scenario was that respondents already planned to adopt new measures, and thus, governmental drought management policies would not increase their intention to adopt. It is thus not surprising that the business-as-usual situation (alternative-specific constant) had a large negative effect size and was significant, reflecting a general interest in change and dissatisfaction with the current situation - as was also clear from the survey where more than 80% indicated that the government should be responsible for increasing farm resilience to drought. There was also a large significant standard deviation, demonstrating heterogeneity towards business as usual, but there was no immediate switch in sign.

By evaluating discrete choices that allow for mixed interaction effects between scenario attributes themselves (Annex Table F) and socioeconomic farm household characteristics (Annex Table G, left) or cognitive-behavioural factors and perceptions (Annex Table G, right), it is evident that multiple factors influenced preferences for the four investigated attributes. Indeed, a preference for more extension services went hand in hand with one for ex-ante transfers and good credit schemes, and also transfers and credit schemes concurred. A preference for early warning systems did not quadrature with one for extension services or ex-ante transfers. The following two paragraphs try to scrutinize the underlying reasons why these preferences are heterogeneous and correlated.

Firstly (Annex Table G, left), households with more measures preferred extra extension services, better early warning systems, and ex-ante cash transfers more than average, and increased the effect of lower-rate credit schemes on adaptation intention. Possibly, the need for

tailored extension services (training) and ex-ante cash transfers (financial aid) to maintain already adopted measures when a drought early warning is sent out, can improve the effect of these measures in mitigating the drought impact. Factors such as age, education level, and already attending extension training decreased the effect of providing extra extension services on the intention to adapt: more experienced farmers did not prefer policies related to additional training. The effect of better early warning systems was lower for more educated households and those who were members of a farm group, probably because they have other means of accessing up-to-date climate and weather data. Education level, attending extension training, and a larger off-farm income decreased the effect of credit policies; logically wealthy households do not need such a policy. Being a member of a group strengthened the effect of credit policies, probably because of the existence of group credit schemes, and also those with more land did prefer low-rate credit schemes. Clearly - but not surprisingly, a differentiated "business-as-usual" or baseline regarding knowledge and finances strongly influences the effect of the four policies on the intention to adopt new adaptation measures.

Secondly (Annex Table G, right), factors such as "being influenced by actions of neighbours (social norms)", "having experienced more droughts (risk appraisal)", and "having access to enough information (self-efficacy)" decreased the positive effect of extension services on the intention to adapt. However, these factors had a positive interaction effect with credit schemes: having access to enough information increases the effect of credit schemes on the intention to adapt; making this governmental action more successful in increasing uptake of measures among well-informed farm households. Total income (cost perception) had negative interactions with both extension services and early warning systems. Furthermore, perceiving that once has the capacity to cope (self-efficacy) had a positive interaction with early warning systems. Moreover, performing a cost-benefit analysis (behaving economically rational such as assumed in the Expected Utility Theory) and having large adaptation spending (adaptation appraisal) had positive interactions while being influenced by neighbours (social norm) had a negative interaction with ex-ante cash transfers. Clearly, the factors of the socio-cognitive theories influence the effect of governmental policies.

## 6. Discussion

### 6.1. Adaptive behaviour of smallholder farmers in Kitui

By analysing interviews with key informants, the answers of the disaster risk managers and the results from the smallholder farmer survey, we revealed that o.a. experience with water scarcity, perception of climate change, fears from drought and water shortage, as well as attendance to trainings, faith in god, access to and faith in forecasts, the number of previously adopted measures, size of farm land, perceived efficiency of measures, access to credit, total expenses and performing a cost-benefit analysis explain past and future adaptive behaviour. Comparing answers from disaster managers and smallholder farmers, the former seem to overestimate the effect of extension while underestimating the effect of gains: while extension services indeed explain past behaviour in the regression analysis-usefulness of extension services seemed to limit the intention to adapt in the future. Summarizing all these findings, we can identify five main outcomes:

First of all, both adaptation costs and adaptation efficacy (linked amongst others with field size) are of uttermost importance, as financial strength is the most-mentioned barrier - similar to Refs. [70,75,77,86,88,90,91,93,99,168,169] and others - and yield gain the most important motivator for decisions of the smallholder farmers in this case study. The fact that farmers able to perform a cost-benefit-analysis have a higher likelihood of adoption further strengthens this evidence, which is also found in Refs. [77,83,86,88]. While considering costs and benefits hints to utility maximizing behaviour (Expected Utility Theory), it is also on

the basis of the Theory of Planned Behaviour [57] and is in a less direct way present in the Protection Motivation Theory where coping appraisal is influenced by the response costs of action and the perceived response efficacy [56].

Secondly, our multi-method analysis proves the significance of knowledge as driver for adaptation decisions in this case study. Attendance to trainings, farmer networks and access to forecasts, can be all classified under human capital. This human capital factor, leading to a perceived own ability to respond, is found to determine the adoption of farm-level adaptation measures in preceding studies (e.g. Refs. [41,67,88,92,170–173]) and can be seen as a proxy for perceived self-efficacy. Also mistrust in forecasts (from the questionnaire), corruption (from the interviews), belief in god as saviour (from both) and the influence of already adopted measures (from the DCE) can be related to this self-efficacy factor, although not much existing research literally mention these proxies. Self-efficacy, the perception of how well one is able to cope with a situation based on their skills and circumstances, is an essential factor to describe the decision making process in both the Protection Motivation Theory and the Theory of Planned Behaviour [109,127,136,137].

Thirdly, social networks (i.e. farm groups) were mentioned in the interviews (also in Refs. [92,174]) but appeared not to be significant in the statistical analyses, and showed a lessening effect on the influence of governmental actions. They clearly influence adaptation decisions but this can be through knowledge distribution - influencing the self-efficacy factor, or through inflicting normative beliefs, the subjective norm factor in the Theory of Planned Behaviour. Fourthly, the importance of (a subjective) drought risk as driver for adaptation decisions is apparent in this case study, through perceived vulnerability, experience with and fear of droughts and water scarcity, and perception of climate change. This risk-appraisal factor is found to motivate adoption of farm-level drought adaptation measures in preceding studies (e.g. Refs. [4,175–178]; but not found in Ref. [179] and varying results in Ref. [180]). Threat appraisal is an important factor in the Protection Motivation Theory, which states that people have to perceive a certain level of risk before they will consider taking action (REF).

Finally, assessing the effect of policy measures related to extension services, early warning systems, ex-ante cash transfers, and credit schemes, we evidence that all would have a positive influence on adaptation intention, thus encouraging adaptation decisions; a similar positive link was found in Refs. [4,171,180] (credit) [172,173]; (extension services) [73,105], (early warning) [41,73], (aid). However, the effect was found to be highly heterogeneous: Farm households who were already able to adopt certain measures generally had a higher preference for the policies, and household heads with higher education levels generally had a lower preference; however, the opposite was true for low-rate credit schemes. The effect of neighbours or farm groups decreased the positive effects, showing the capacity of social networks to complement the need for governmental action.

Clearly, even with the strong presence of financial factors in the decision-making process of smallholder farmers in Kitui, this study shows that the assumption of purely economic rational behaviour should be avoided. From the more complex behavioural theories, most of the factors with significant influence in this case study can be linked to factors of the Protection Motivation Theory (such as in Refs. [60,121,127,152,175] and others), while there is less evidence for the other theories. For multiple variables, it remains unclear whether they can be seen as a proxy for a factor in one of the decision-making theories, which complicates validating the use of a specific theory in this case study. Moreover, the heterogeneity in and correlation between policy preferences are not apparent in most behavioural theories, which in general assume that people behave more or less in the same way, while this case study evidences the opposite. Notwithstanding, it is evident that if adaptive behaviour is to be included in dynamic drought risk models, in addition to the costs and benefits, the perceived self-reliance, the perceived risk, the social network and the knowledge must also be taken

into account.

## 6.2. Future modelling applications

The information presented in this manuscript – combining theories and empirics-brings insight in the complexities of the adaptive behaviour of smallholder farmers in Kitui. It can be useful for both scientific and decision maker audiences as it can help improve the vulnerability and adaptation dynamics in drought risk models and it can thus both directly and indirectly support the design drought risk reducing policies that are effective and efficient. Our findings could be used to create a theoretical agent-based drought risk model with simple rules depicting the adaptive behaviour of smallholder farm households in semi-arid Kenya [181] and also provide quantitative evidence of the factors shaping adaptive behaviour, which can be used to calibrate the decision rules of ABMs. Besides, they could be used to structure a system dynamics model [182] depicting the socio-hydrological reality of smallholder farmers under drought risk. Such models can deepen the understanding of the intertwined nature of the human and hydrological systems as well as the role of drought risk perception therein. Moreover, the DCE in this study allows to explore future adaptation decisions under a changing policy context, providing input for predictive models capable of simulating the effect of policies on future drought risk.

## 6.3. Methodological considerations

The mixed-methods data collection presented in this article was based on both empirical evidence from other studies as well as behavioural theories, thereby overcoming the limitations of both. The participatory cognitive mapping exercise allowed to address the drought risk perceptions of the key informants and improved our understanding of the decision making of smallholder farm households in the semi-arid-Kenyan context. The interviews with the disaster managers provided a top-down view on current drought management practices and policies. As such, the methods can be seen as complementary to study adaptive behaviour, and assure both views are included in the design of a detailed household survey with smallholder farm households in Kitui.

Ideally a multi-year survey would have been set up to evaluate the adaptation decisions of smallholder farmers over time in relation to socio-economic, environmental and policy changes. In our study, this was not feasible so as a proxy, both smallholder farmers' past adaptation decisions and their intention to adopt were evaluated. While doing the former, it is hard to extract the drivers and barriers that existed at the point of decision – as they might have changed over time-, the latter is based on self-reported plans to invest in measures, which might deviate from reality. While both are not ideal, evaluating past behaviour is a method frequently applied in adoption studies and evaluating the intention to adapt is also relevant as this might even better reflect the behavioural drivers for decision [183]. Further, the unconventional application of discrete choice experiments in this study does not investigate a willingness to pay for policies. Rather, we investigated preferences for policies and the potential of policies influencing the respondent's intention to adapt, a technique also applied in other fields [184–186]. This application can be seen as complementary to the logistic regressions linking drivers, barriers and past or intended actions, as this method is able to link factors, smallholder farmer characteristics, not directly to adaptation actions but to preferences for support concerning these adaptation actions.

## 7. Conclusion

In this study, interviews with key informants and a disaster manager survey, complemented by scientific literature on the application of sustainable drought management practices, were used to identify the factors influencing the adaptive behaviour of smallholders at risk of drought. The significance of these factors was tested using data from an

extensive survey of small farming families, including a questionnaire and a choice experiment. We compared the empirically discovered drivers and barriers to adaptation with components of existing behavioural theories, and found that risk perception, social networks and knowledge, in addition to adaptation costs and benefits, are essential for drought adaptation decisions among smallholders in Kitui, semi-arid Kenya. In addition, we found that there is significant heterogeneity in the adaptive behaviour of smallholders, which also translates into the heterogeneous - although moderately positive - effect of different government policies, such as relevant extension services, reliable early warning systems, reduced credit rates or cash transfers.

This study supports the conclusion of a variety of research that has suggested the presence of adoption restrictions (such as access to training or financial markets) that hinder the implementation of drought adaptation. Clearly, the assumption of economic rationality and perfect information in the Expected Utility Theory is not sufficient to explain perceived adaptive behaviour. The drivers and barriers that appeared to influence behaviour in this case study have been linked to components of more complex cognitive theories such as the Protection Motivation Theory and Theory of Planned Behaviour: multiple factors, which have been found to be significantly related to past adaptation decisions or adaptation intentions, can be seen as proxies for threat appraisal, self-efficacy and social norms. However, for our case study, no theory could fully describe the observed adaptive behaviour.

Nevertheless, the applied theories were useful in explaining the causal relationships between different socioeconomic and cognitive factors and the eventual adaptive behaviour. The findings help unravel the processes behind smallholder farmer adoption decisions in Kitui and evaluate the impact of four drought policies in this region, while the method showed promise for evaluating the complexity of drought adaptation behaviour, including outside semi-arid Kenya or a smallholder context. Both can be used to identify the most vulnerable groups and developing well-targeted adaptation policies, and to design, calibrate, and validate utility functions to model heterogeneous individual adaptation decisions in dynamic drought risk models.

#### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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#### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijdr.2021.102435>.

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