Relational rationality in land- and water use: Facing Mount Kenya in times of change

Margaret N. Githinji

Propositions

1. Collective management of the commons is not necessarily for the benefit of the commons.
   (this thesis)

2. You never play the same game twice.
   (this thesis)

3. Triangulation of research methods increases relevance, credibility and legitimacy of research outputs.

4. People from diverse cultures and disciplines enrich a research team.

5. Difficulty in publishing interdisciplinary research, limits its popularity among young researchers.

6. Combining PhD research with a job outside academia is key in ensuring relevance of research.

7. There is more to a PhD research project than the thesis.

Propositions belonging to the thesis, entitled

Relational rationality in land- and water use: Facing Mount Kenya in times of change

Margaret Ngunju Githinji
Wageningen, 17th June, 2024

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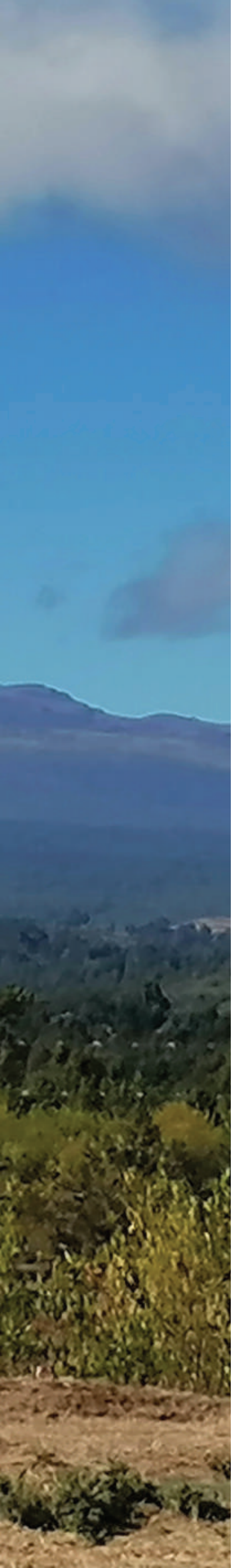


Chapter 1

Introduction

1.1 My relationship to farmers' decision making

Coming from Mt. Kenya region, surrounded by smallholder farmers, I grew up observing multiple land-uses on my parents' farm, often wondering why my parents would focus more on the laborious maize option rather than what 'seemed' as a less laborious wheat option. My village had diverse land-use patterns, with a combination of food crops, cash crops and livestock keeping. Farmers with less than 20 hectares of land, subdivided their pieces of land to accommodate cash crops for instance pyrethrum, and crops that could serve as both cash and food crops for instance maize, vegetables, beans, peas, potatoes, among others. This scenario was replicated in many Kenyan landscapes. The most common crops were maize and beans since the *githeri* (a mix of maize and beans), was a common meal in most households. But also, maize was (and still is) a common ingredient for making *Ugali*, the Kenyan staple food. It was therefore easy to sell a surplus in the local market. A short distance up-slope from the farm, water was so abundant that tapped water from the rivers, did not have a valve to regulate the flow. From the residents' perspective, water was in plenty such that it did not need to be regulated. My grandmother's farm in the upstream was full of arrowroots and vegetables, crops that are high water consumers. While there could have been other options with a possibly higher profit from a market perspective, the aforementioned crops dominated my early years with little to no diversification to other practices.

Notably, in the Kenyan setting and possibly African setting, there have been two ways of doing things, on one hand the western-institutionalized behaviour in the minds of people, using acquired knowledge to harvest economic benefits from nature; on the other hand the African way where despite the need to economically benefit as an individual, decisions are considered rational if they are relationally acceptable, that is, if the option does not compromise relations that individuals have with their gods and others. Consequently, it would have been difficult for an external person or entity – considered as non-community member – to introduce a new practice unless it was through a well-respected person such as a government extension worker. The PhD-thesis of one of the first Kenyan-born academic anthropologists, 'Facing Mount Kenya,' gave a detailed account of the lives and landscape of my grandparents' generation. Unlike the western culture where learning focused on knowledge acquisition, learning in Mt. Kenya region focused on relations (Kenyatta, 1938). From a young age, individuals were trained to behave in a manner that ensured sustaining good relations with others. The inculcated behaviour was driven by the need to maintain strong ties with people of the same family (which included ancestors), clan, and age-group. At the same time religion – pleasing the gods – held a strong position in peoples' minds, such that a contrary behaviour was believed to attract a punishment from the gods. Belonging to a group was the most important thing, self-serving individuals were looked down upon, and it was believed that a curse would befall them since religion encouraged unity and collectivity. In the Kikuyu community, one of the largest ethnic groups in Kenya, "…there was no individual affair since everything had a moral and social reference".

Figure 1.1: Collaborative reforestation work on Mt. Kenya water tower. Photo by Peter Mathenge from Likii Water Resource Users Association.

In such a society where groups and relations matter, individual decisions would therefore be expected to align to communal sharing, or authority ranking and/or equality sharing (Fiske, 1992). This is unlike the western way of thinking where decisions would have price connotations with marketing pricing (Fiske, 1992) possibly taking precedence. Under community sharing, everyone in the group has a right to resources and can use the resource in any way they choose to. In authority ranking people have moral responsibility to please those in authority for example God, parents, while those in authority are obligated to care for low-ranking members of the group. Additionally, in a relational society, harm/care towards nature is associated to relations individuals have with nature and others; fairness in sharing of resources and reciprocity of similar behaviour for those in the group is expected; being part of a group and loyal to it matters; interaction with nature would seek to respect and comply with the authority; and retaining sanctity/purity of nature (Haidt & Graham, 2007). Noting the importance placed on groups, for a researcher, the question could then be when it comes to farmer decisions, which group matters most? Allegiance to former groups such as clans, age-group or ancestors described by Kenyatta (1938), could have changed over time, but still an individual's behaviour could possibly still be aligned to groups (albeit different groups), with relations and commitment to these groups shaping behaviour. It is with this understanding of the community social context that this study delved into understanding the rarely explored influence of relations on individuals and particularly farmer decisions.

In this thesis, I take you (the reader) through the story of farmers whose decisions are not only self-serving – maximizing farm-outputs and income – but also consider perception of their important others; I put emphasis on reconciling economic and relational rationality. Thus, rationality of their decisions is based on relations with others. They are not an anthropologic peculiarity studied for academic interest only. People everywhere are not atomic individuals. They grow up in a community. They know very well to which group, or groups, they belong, and what this implies in terms of duties, responsibilities, rights, and relationships. They are, in other words, relational at their core: "it takes a village to raise a child." People are also rational, meaning they try to act for the benefit of themselves and their groups. This rationality is embedded in their relational world. In this thesis, I talk about relational rationality to express this concept. Theorists of decision-making have adopted various angles to express it. For the case of farming in Mt. Kenya region, we looked for a theory that caters for the existence of different groups, in which both individuals and groups have meaningful mutual relationships.

1.2 Context of farmers' rationality

Water means life, as plants can grow, livestock fed. Water management, in a country with a highly variable climate, is essential to match the sustainable development ambition of a growing human population. Where demand for water, for an intensifying agricultural sector, exceeds what is available, a rational use of the scarce resource is needed. But rationality can be understood in multiple ways as there can be many good reasons for farmers to do what they do. Land- and water use decisions are driven by socioeconomic factors, local and global markets, population growth, government policies among other factors. The decisions shape the state of the ecosystem, impacting the social and ecological conditions, and triggering responses from individuals, collectives, and/or institutions (Van Noordwijk et al., 2020) (Figure 1.2). The impacts are likely to be exacerbated by a projected increase in global food demand of more than 50% in 2050 (FAO, 2022; van Dijk et al., 2021), a changing climate, an increasing population, and insufficient water governance policies. Although strategies exist to sustain food production amidst water scarcity, they are challenged by their adaptability, acceptance, and application at the farm level. Engagement of local stakeholders – with the farmer at the centre of decision-making – would make the strategies more relevant to farmers, easier to implement and more sustainable. Understanding drivers of farmer decisions could be a start to adoption of sustainable land- and water use.

It is typically assumed that farmers are "instrumentally rational" in their land use decisions. Under instrumental rationality, farmers weigh their decisions against a cost-benefit analysis of a land- and water use decision (van Noordwijk, Villamor, et al., 2023), where costs could be financial investments and benefits could be for instance crop production, or profits. Of course, an attempt to maximize benefits from an option is limited by a farmer's knowledge (for instance on ways to sustainably produce crops, access markets), time to make a decision, or farmer's own ability to analyse available options. This perspective is known as bounded rationality (Simon, 1990; van Noordwijk, Villamor, et al., 2023). Therefore, decisions made may not be optimal but satisfactory given the conditions. Instrumental rationality aims to maximize individual economic benefits, at times at the expense of protecting the shared resources or consideration of the needs of others who depend on the shared resources. This may cause ecological and social externalities, and a social dilemma of individual economic benefits versus collective interests.

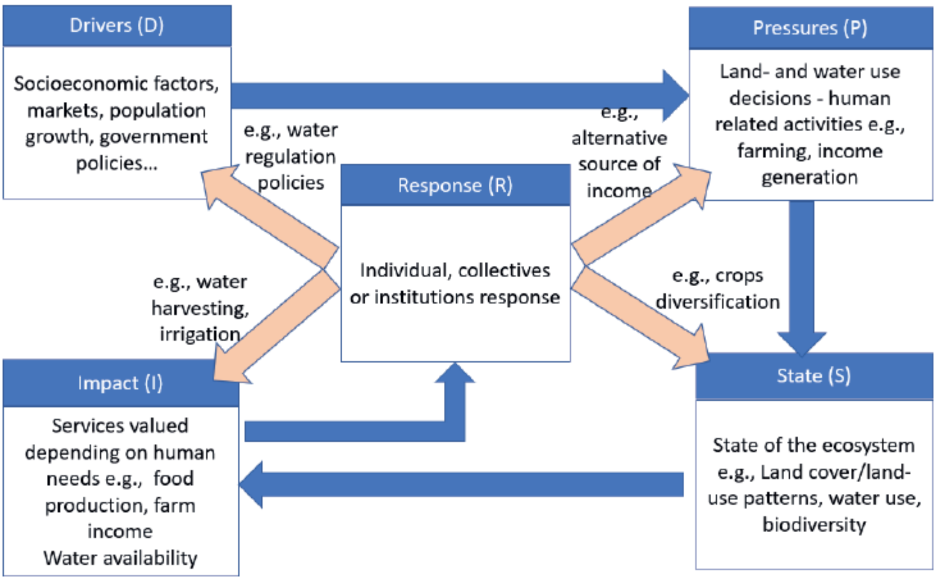


Figure 1.2: A representation of a socioecological system using DPSIR[1] framework. The state of the ecosystems(s) e.g., land- water use patterns may emerge from pressures (P) of human related activities as farmers seek to increase their food and income in the context of local and global market demands, population growth demanding more food and underlying government policies (D). The state of the ecosystems directly impacts services/benefits obtained from the ecosystem (I) e.g., food production and water availability. The state of the ecosystem triggers response (R) from individual farmers, collectives (collective action), and or institutions. Response can be directed to the drivers, pressures, state or impacts of the socioecological system.

However, farmers do not necessarily just focus on profits (Foguesatto et al., 2020; Joao et al., 2015). Like everybody, farmers live in a relational world, such that their land- and water use decisions can be affected by others, i.e. they are relationally rational. Under

[1] DPSIR (Drivers, Pressures, State, Impact, Response) is a causal framework that was designed by European Environment Agency (EEA) in 1999, to describe interactions between society and the environment. The framework describes **D**rivers that put **P**ressures (anthropogenic pressures) into the **S**tate of the system causing both positive and negative **I**mpacts and triggering **R**esponse.

relational rationality, decisions are weighed against the costs-benefit of pleasing or offending those whom a farmer considers important in their social world (van Noordwijk, Villamor, et al., 2023). Relational rationality values perceptions of other people, respect or recognition for a decision made, fear of retribution for a contrary decision, and/or reciprocity of a similar action from others. Under relational rationality, a farmer decision may be informed by what s/he believes is an acceptable decision in her/his social world; important others shape a farmer decision.

1.3 Status-power and reference groups perspective to social relations

Ajzen (1991), in an influential theory – the theory of planned behaviour – described two ways in which an individual's decision can be influenced by others: 1) an individual chooses options he thinks others would like to have him/her implement; 2) an individual chooses options that have been, are being, or are likely to be implemented by others (Ajzen, 1991; Fishbein & Ajzen, 2011). The 'others' that an individual subconsciously considers in his decision making, are those whom s/he considers important (Fishbein & Ajzen, 2011; Kemper, 1968). These have been referred to as "reference groups" (Kemper, 1968). A limitation of the theory of planned behaviour is that implicitly there is just one reference group. In reality there can be different groups that pull a decisionmaker in different directions. Reference groups are real or imagined beings, groups of people, institutions that exist in the mind of an individual influencing decisions (Kemper, 1968, 2017). Real reference groups could be for instance neighbours, or government while imagined reference group could be for instance spiritual deities. However, whether real or imagined their importance and opinions are entirely perceived in the mind of the individual. A reference group influences an individual's behaviour depending on its status-power standing in the mind of the individual (Figure 1.3), that is, if the individual believes the reference group deserves status or is likely to accord status by doing its bid, and/or has potential to use power against the individual (salient reference group) (Kemper, 2011, 2017). A relation between status and power is that a status-worthy reference group may attract authority; a power accepted trait. In this instance – unless misused – power-use is accepted and may not generate resentment since it has been willingly given. Status fosters voluntary compliance to the bidding of a reference group; an individual willingly accepts, approves, supports, respects, admires, and, ultimately, loves to do the bidding of the reference group without compulsion or coercion. An individual can also do the bidding of a reference group to gain status from the reference group for example recognition, congratulatory message, reward or a 'thank you' note. Power prompts involuntary compliance against the will of an individual for example through sanctions, or punishment; the individual adheres to requirements of a reference group to avoid power use. An individual can have multiple salient reference groups with varied levels of importance depending on their status-power standing in the mind of the individual (Kemper, 2017). An individual may perceive conflicting opinions from her/his multiple salient reference groups. These conflicts are resolved in a mental reference group meeting, also referred to as 'thinking' (Kemper, 1968, 2017). In the meeting, cost, and benefits of obeying a reference group against defying it, are weighed. The decision is to take an option in which an individual will be accorded the most status, and/or avoid power-use but also with the least level of disagreement among the salient reference groups. Importance of a reference group may vary with impacts of previous decisions. A switch to do the bidding of a new reference group shows that the benefit for aligning with the new reference group outweighs the cost of leaving the previous reference group (Kemper, 2017).

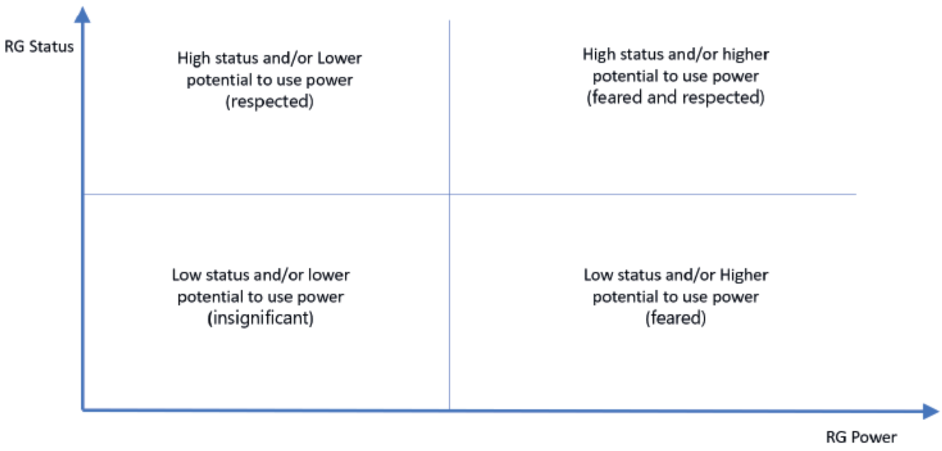


Figure 1.3: Quadrants of status and power of reference groups (RG). Each individual perceives a reference group as important depending on its status-power standing in the mind of the individual. Reference groups in the bottom-left quadrant are less likely to influence a farmer decision compared to those in the top-right quadrant. Reference groups in the top-left are likely to influence decisions since they are respected while those in the bottom-right are obeyed due to their potential to use power.

An option that pleases a farmer's reference groups may seem rational to the farmer at the moment. However, the option can have immediate negative impact on other farmers and possibly on the same farmer and others in the long-term. For instance, decision to irrigate from scarce water commons in an attempt to abide to a contract with agro-export companies or satisfy an individual's family needs, could lead to water scarcity for others. Thus, a farmer who has other farmers as an important reference group could be conflicted on whose opinion matters most; agro-export companies for short-term self-interests or other farmers for maintaining harmony. Further, accumulation of individual land/water-degrading choices, for instance deforestation to expand crop land, may affect a landscape's microclimate creating a social problem. Such a social problem could benefit from understanding drivers for individual decisions with a possibility of transitioning from self-interest to group goals through collective action. Under collective action, each individual gives precedence to the community.

That community then becomes a reference group whose priorities are on group goals over and beyond each individual's self-interests.

1.4 Roots of collective action

Collective action involves sacrificing self-interest to achieve group goals. Under collective action, everyone gets to benefit from the common pool resources; where common pool resources are any natural or man-made natural resources meant to service the needs of a defined group of people (Ostrom, 1990). While faced with a social dilemma on how to manage common pool resources, individuals are capable of organizing themselves to collectively address the problem. They can define whom to collaborate with; set rules on how to interact with the common pool resources; establish strong internal mechanism to track compliance with set rules, graduated sanctions for non-compliance, and conflict resolution mechanism (Ostrom, 1990). Under collective action, a reference group whose rules are to be prioritized over and above those of individual's own reference groups, is formed in the minds of all those individuals who chose to participate in collective action. This reference group attains its salience out of respect (status) or to avoid sanctions (power-use) for non-compliance with its set rules. Collective action can also be vested in existing governance institutions such as government (Ostrom, 1990). Such institutions can trigger collective action where self-organization is not evident, and support implementation of sanctions where internal mechanisms fail to work. This approach may at times face acceptance challenges among the local stakeholders who are meant to implement the rules (Nordman, 2021; Ortiz-Riomalo et al., 2023; Ostrom, 1990), but also self-organized collective action may not always emerge. According to Olson (1965), self-organized collective action could possibly not emerge where individuals have no incentive to join, or the individuals benefits from collective action with or without their contribution. Thus, unless a farmer feels part of the community that uses the collective resource, can visualize the benefits of collective action (going beyond instrumental to relational benefits), is empathetic enough to join, is coerced, or believes others would reciprocate, the farmer may not sacrifice individual instrumental benefits for the common good. Collective action depends on relational values to provide shared instrumental benefits. For this reason, the next paragraph will discuss serious games. These could be one way to build on the relational values of participants, and trigger collective action (Janssen et al., 2023).

1.5 Using games to catalyse collective action

Serious games, also referred to as 'simulation games' or simply 'games', simulate real situations in a simplified model that participants can easily engage with. Here, we discuss serious games that simulate socioecological systems. Through playing a hypothetical world that models their shared scarce resources, participants can fail, try again, and in this way, collectively look for options on how best to manage the common resources. Games provide a shared platform for stakeholders from different spheres (for instance government, researchers, farmers), to engage, discuss, establish a common understanding of their socioecological system, and possibly explore options for a shared social dilemma (Barreteau et al., 2022; Biggs et al., 2021; Edwards et al., 2019; Van Noordwijk et al., 2020). Games promote social learning among players and empower participants to contribute towards collective management of resources (Barreteau, Abrami et al., 2021). Serious games have been developed and used in various fields including climate change, land, water, and environment management (Bars et al., 2014; Ferrand et al., 2009; García-Barrios et al., 2008; Hertzog et al., 2014; Lankford et al., 2003; Le Bars et al., 2004; Loudin, 2019; Rakotonarivo et al., 2021; Rooney-Varga et al., 2020; Speelman et al., 2014; Sterman et al., 2015; Villamor & Badmos, 2016). While games have proved useful in research, there are pitfalls. Social, economic, and/or political class may interfere with the playing, learning environment and outcomes in communities where people of different classes or groups do not normally interact (Barreteau et al., 2022; Hofstede et al., 2010; Van Noordwijk et al., 2020). Thus, power relations and social status of participants need to be identified to plan sessions with a chance of success. These relations must also be clear to enable meaningful analysis of results (De Vente, Reed et al., 2016, Barreteau, Abrami et al., 2021). To date, most games that have been used to explore farmers' decision making have not explicitly explored the effect of relational rationality as a key factor in decision making. Relational rationality in this case infers that farmers make rational decisions within the context of relations they have with salient reference groups. Players carry along their social status, power, and voices from referent others to the game sessions, and therefore do not play only according to the set rules. There is also a possible emergence of new reference groups as players interact in a game session. This implies that a game played with different players whether within the same study site may yield different patterns of collaboration, leading to vastly different results. Hence the need for comprehensive analysis of relations and their effects on a game's outcomes.

1.6 Research gap

The concept of social relations as an influencer of farmer decisions is yet to be adequately explored. In the above sections, I present farmers as relationally rational; relations that farmers have with their important others (reference groups) in their social world, can significantly affect their decisions. Seeing oneself or household as the most important reference group – gaining self-interests – may have negative impacts on others or long-term negative impacts on the individual and others. Pleasing a shared reference group – a reference group salient to all farmers – could be of interest to an individual farmer if (and when) it can offer long-term benefits to the farmer or can promote better relations with other farmers and avoid conflicts. For such a reference group to emerge in a farmer's mind, that is, a reference group that propagates collective approach to decisions, farmers can self-organize and define how to attain group goals or an institution such as government may need to initiate collective action. But collective action does not always emerge because on the one hand, farmers may not be aware of impact of their action on others or not be willing to collaborate; on the other hand, policies emanating from government or other institutions to propagate collective action at times face resistance. A serious game could help foster collective action.

A serious game designed to foster collective action and explicitly explore effects of status-power and reference groups on a game's outcomes, does not exist. In this thesis, I explore serious games as a tool to foster collective action. Serious games can help stakeholders visualize and understand the workings of their socio-ecological system. They get to interact with the system, act and see impacts of their decisions, learn, discuss, and experiment alternative options to manage their system. Players' interactions in a game session happens at a relational level, with relations (in and outside a game session) significantly impacting a game's outcome. However, most of the games that have been used to explore farmers' decision making have not explicitly explored the effect of social relations in decision-making processes and a game's outcomes.

In this thesis, I sought to address these gaps by reviewing existing theories on decision making processes; exploring effect of social relations on farmer decisions, and engaging stakeholders in a serious game as a strategy to capture effect of social relations on game outcomes but also as a tool to prompt collective exploration of alternative options for sustainable land- and water management. Towards this end, I used the status-power theory of relations as a powerful theory that can be used to understand relational rationality on farmer land- and water use decisions. I also designed a serious game KILIMO NA MAJI game to explore the influence of social relation in a game's outcomes and to engage stakeholders in experiencing, reflecting, and experimenting alternative options to sustainable crop production in scarce water commons.

1.7 Research objectives and questions

The main objective of this study is to contribute to better management of scarce common water resources. The sub-objective is to create and use serious game in supporting achievement of the stated main objective. Towards achievement of these objectives, I was guided by the following research questions:

1. Research Question 1 (RQ1): Which theories can be used to better understand farmer land- and water-use decision making?
2. Research Question 2 (RQ2): To what extent can relational rationality (status-power and reference group theory) explain farmer land- and water-use decisions in a given context?

3. Research Question 3 (RQ3): To what extent can relational rationality help better understand the outcomes of a game that represents local land- and water-use choices?
4. Research Question 4 (RQ4): Can such serious games strengthen relational rationality to achieve collective goals?

1.8 Study site

To achieve these objectives, the Upper Ewaso Ng'iro North River Basin in Kenya was used as the case study site. The region forms part of the arid and semi-arid lands in Kenya receiving an average of 350 MM of rainfall in the downstream and 2000 MM per annum in the upper zone. This increases dependence on rivers that flow from the glaciers of Mt. Kenya as the main supply of water through dry periods. More often, this leads to water-related conflicts among multiple users that depend on scarce water commons. Conflicts are usually between, farmers and pastoralists, small- and large-scale farmers, up and downstream communities. This is more so since farmers in the up- and midstream zones use available water to irrigate leaving little or no water for the downstream communities (Figure 1.4). The region has been facing changes such as population growth, increasing demand for commercial crops, and illegal water harvesting. Coupled with changing climate, this has created a challenge of ensuring equitable distribution of water. Farmers in this region are therefore faced with a challenge to increase food

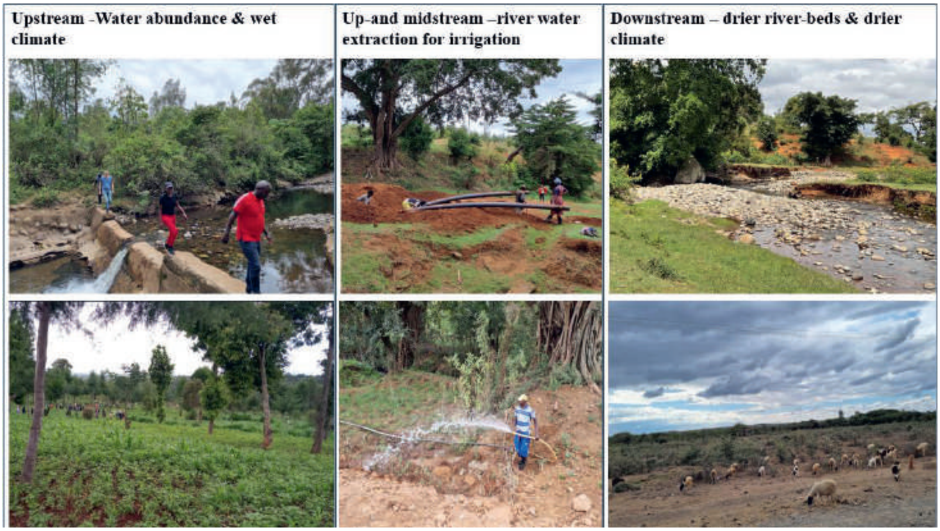


Figure 1.4: A photograph presentation of the study site. On the left, there is the up-stream water abundance with better climate for crop production and river water to enable irrigated farming. On the right, there is the downstream water scarce landscapes with a dry climate and drier riverbeds. In the centre, there is the up- and midstream water extraction from the rivers for irrigation (a photo of farmers laying water extraction pipes and a farmer irrigating his farm). This could partially explain water scarcity in the downstream.

production in a scarce water environment. In this region, multiple reference groups could be having an influence on a farmer's thoughts, for instance, local traders and agro export companies ever demanding more crops produce from the farmers, water regulatory bodies that seek to regulate and ensure equity in water use, and multiple water users with individual interests. This could be in addition to other imagined reference groups such as ancestors, or God. With these diverse scenarios, the site presented a good case to assess the impact that a farmer's social relations with his/her reference groups, have on their decisions.

1.9 Thesis outline

This thesis constitutes of six chapters of which Chapter 2 to 5 are the main chapters. Chapter 1 provides general introduction and overview of the thesis, while Chapter 6 presents a synthesis of results from the main chapters (Figure 1.5).

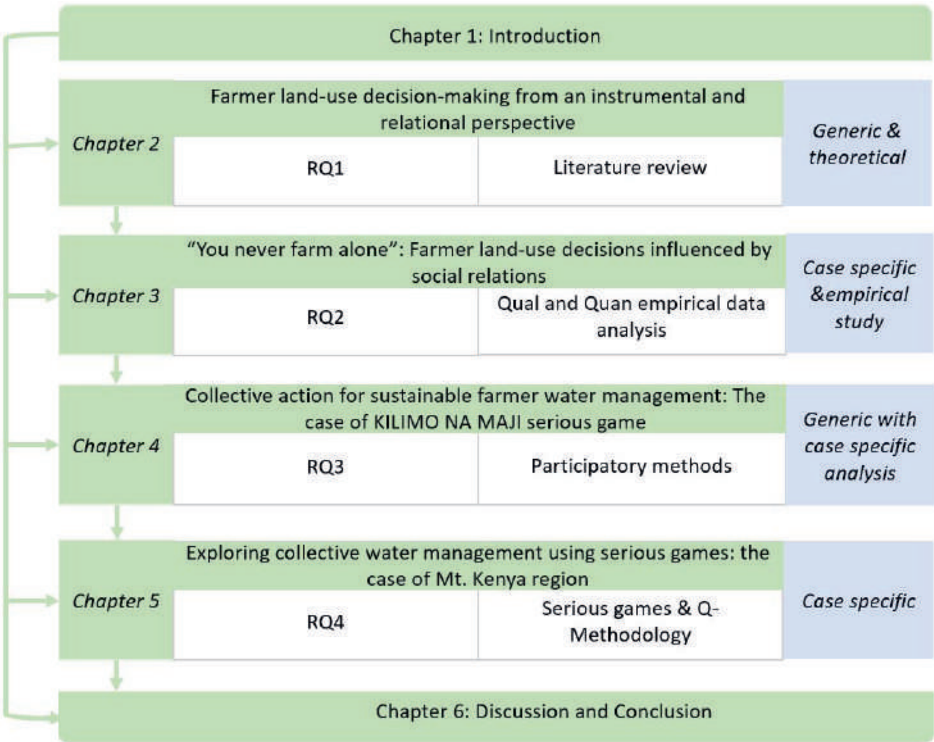
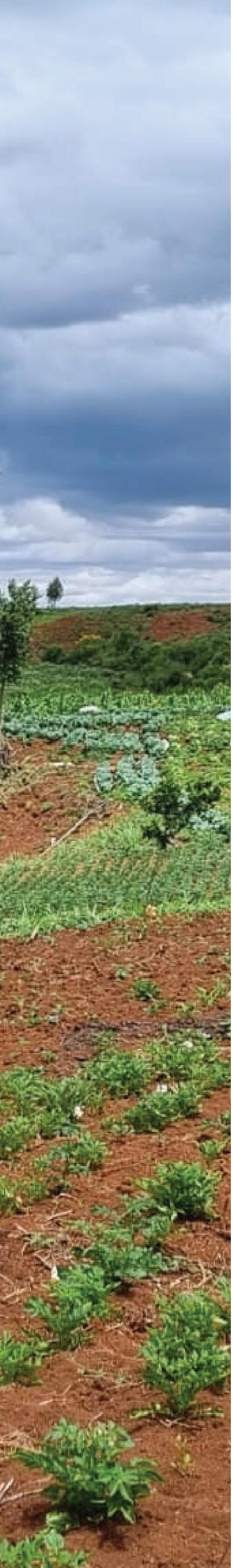


Figure 1.5: Thesis outline: illustrates the main chapters of the thesis, guiding research question for each Chapter, approach taken (literature review, empirical cases study with qualitative and quantitative (Qual and Quan) analysis, participatory methods), and if the Chapter presents generic information or specific analysis of the case study site.

In Chapter 2, I start by presenting the approach adopted in this research i.e., the social relational perspective to farmer decisions. This is a purely theoretical Chapter that benefited from an in-depth review of literature. The Chapter highlights some of the theories commonly used to analyse farmer decisions. It further underscores the importance of analysing social relations, from a status-power and reference groups perspective, as a possibly significant influencer of farmer decisions. In Chapter 3, I used empirical data to assess the influence of social relations using status-power and reference groups perspective. Data were collected from a random sample of respondents in the Upper Ewaso Ng'iro North River Basin where relational rationality was expected to have significant effect on farmer decisions. In the Chapter, I present analysis of finding from the study, highlighting farmer decisions explainable by the status-power theory of relations that could have otherwise not been explained by a farmer's sociodemographic or economic factors. Noting that at times it would be difficult to collect information on social relations using conventional methods (questionnaires in my case), in Chapter 4, I designed a serious game, KILIMO NA MAJI game. In the Chapter, I present KILIMO NA MAJI as a generic game that can be adapted and used in different contexts for analysis of social relations and fostering collective action. I also present results from the initial game sessions to demonstrate its application. In Chapter 5, I present more results from KILIMO NA MAJI game sessions with a focus on detailing the emergence of collective action (or lack thereof) and its impact on a game's outcome. Before each game session, I used Q-methodology to identify pre-game participant's opinions on land- and water management. In the analysis, I compared player's actions in the game with their pre-game opinions to assess if the game had any possible impact on the player's opinions; more specifically, if there was a shift from self-interests to group goals. The Chapter structure varies across Chapter 2 to 5 since each Chapter follows outline of the journal the Chapter was (or is to be) published with.



Chapter 2

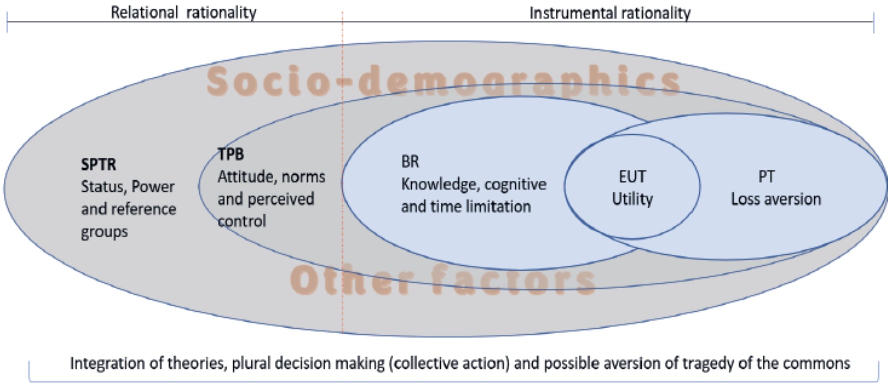
Farmer land-use decision-making from an instrumental and relational perspective

The Chapter is based on:
Githinji, M., van Noordwijk, M., Muthuri, C., Speelman, E. N., & Hofstede, G. J. (2023). Farmer land-use decision-making from an instrumental and relational perspective. Current Opinion in Environmental Sustainability, 63, 101303.

Abstract

Farmer decisions shape land-use systems, with consequences for a landscape's economy, ecology, and the well-being of its inhabitants. These decisions are central in the management of natural resources as they may contribute to the tragedy of the commons, or ways to avoid it. Farmer decisions have been explained by several concepts and theories including sociodemographic factors, expected utility theory, prospect theory, bounded rationality, and the theory of planned behaviour as variations on goal-oriented (instrumental) decision-making. This review provides an analysis of each theory, in comparison to Kemper's theory on status-power and reference groups as a primarily social relations lens through which to understand decision-making. Combining relational and instrumental perspectives on decision-making may be key to understanding the emergence of collective action and avoidance of tragedy of the commons.

Graphical abstract



Key: SPTR (Status-Power Theory of relations, TPB (Theory of Planned Behaviour), BR(Bounded Rationality), EUT (Utility Theory), PT(Prospect Theory)

Keywords: Agent based models; bounded rationality; collective action; expected utility theory; prospect theory; status-power theory of relations; theory of planned behaviour

1. Introduction

Sustainable agricultural practices that maximize land productivity while minimizing negative effects on the environment are the holy grail of natural resources management (Jhariya et al., 2021; Setsoafia et al., 2022). Farmers play a central role in the conceptualization, design, and adoption of such practices through the land-use decisions they make. These land-use decisions have consequences for markets, local communities, national economies, food sufficiency, water resources and environmental quality. However, farmer decisions are constrained by social, economic, and cultural institutions both formal and informal. The basic instruments for 'land-use policy' are the setting of (enforceable) rules, providing incentives (by taxation, subsidy, and insurance) and the support for existing or innovative land-use tools and practices for example mobile phones, farmer support systems, and climate smart agriculture.

Development and implementation of land-use policies may depend on recognition that issues exist ('agenda setting'); shared understanding of their causes and consequences; formulation and agreement on goals to deal with the issues; effective means of implementation; and a continued learning, monitoring and periodical reassessment of the progress made. All these steps involve decisions, many of them at the interface of 'instrumental' (goal oriented) and 'relational' perspectives and values (van Noordwijk, 2021). This implies combining individual benefits of stakeholders with collective interests in shared resources which can at times be achieved via collective action.

Collective action is identified as a critical step in sustainable management of common pool resources (Ostrom, 1990; Yoder et al., 2022) to avoid tragedy of the commons (Hardin, 1968; Nayak & Berkes, 2022). It involves evaluating existing rules, improving them and at times setting of new rules that respective individuals or stakeholders should adhere to (Nayak & Berkes, 2022). Its emergence is driven by the need to harmonize conflicting interests of the multiple stakeholders, but its successful implementation is also challenged by these multiple groups, and at times lack of motivation to collaborate if persons contributing to exploitation of the commons are not part of those who experience the consequences (Yoder et al., 2022). For example, opportunities for market-driven intensification of export-oriented agriculture can undermine social norms on water sharing.

Comprehensive modelling of farmer's land-use decisions with a possibility of collective action, therefore, needs a clear understanding of both instrumental and relational values for the multiple groups. While measures for instrumental values for example economic benefits are well documented, indicators to measure relational values have not been adequately explored (Schimmelpfennig & Muthukrishna, 2023). Relational values refer to desired relationships either among people (social relations) or between people and nature, often involving metaphors for nature as 'relatives' of people (Chan et al., 2016; van Noordwijk, 2021).

To model social relations, Agent Based Models (ABMs) are used due to their capacity to simulate individual agent's behaviour with their relational traits (Gilbert, 2020; Steven F & Volker, 2019). ABMs adopts a bottom-up approach enabling an agent to interact with other agents and its environment and self-organize resulting to unexpected (emergent) behaviour with feedback loops. They allow going beyond observed data to exploration of counterfactuals in a safe environment (Steven F & Volker, 2019), relevant for the dynamic social relational world. Their capacity to simulate the relational behaviour of individuals and emerging self-organization, makes ABM a more realistic approach to simulation of individual farmer decisions with possibilities for collective action.

Although other theories and concepts have been used in ABMs (as discussed later in this chapter), they lack a comprehensive modelling approach to social relations (Scholz et al., 2023). In this review we discuss Kemper's status-power theory of relations (Kemper, 1968, 2006, 2011, 2017) as a theory that can holistically capture and model complexities of social relations. Kemper's theory acknowledges existence of multiple groups in the minds of people known as reference groups. These groups give people their social identities. Reference groups could be stakeholders such as government or traders but also could be imagined groups such as spiritual deities or ancestors. Importance of a reference group depends on the status (respect, love) an individual attaches to it, its potential to use power against the individual, or both. Reference groups use voluntary (status) and involuntary (power) means to inculcate a desired behaviour. A behaviour considered acceptable by a reference group is rewarded with status, alternate behaviour may lead to status withdrawal, power use or both. An individual that feels treated right by a reference group may acquire a higher opinion of that reference group (consider it more status worthy) while unfair treatment may lead to defiance (power use) (Hofstede et al., 2021). Status and power are like currencies of exchange between reference groups and an individual. Status may include giving admiration, incentives, recognition, respect, and rewards while use of power may include imprisonment, penalty, curse, or banishments from a community. Most status-power exchanges are for instance, glances, smiles, or the lack of them. In their millions, they exert a strong socializing force.

The purpose of this chapter is to present Kemper's theory to understand effect of social relations and as a novel approach to strengthen agent-based modelling by accounting for complex social relations with a possibility of collective action in a society characterized by reference groups with conflicting interests. Strengthening the ABM includes increasing its ability to represent the actual process of decision-making as closely as possible (credibility,) and its ability to respond to issues of interest(relevance) (Lusiana et al., 2011).

2. Perspectives on farmer decision-making

There are different concepts and theories used in decision-making models. These include those discussed in this thesis and other important concepts such as consumat (Jager & Janssen, 2012; Pacilly et al., 2019), reinforcement learning (Lindqvist & Norberg, 2014; Vlaev & Dolan, 2015), social identity theory (Ambrosius et al., 2022; Michael A, 2016).

2.1 Sociodemographic factors

The most used approach to understanding farmer decision-making is through analysing the sociodemographic factors that include a farmer's age, gender, economic status, education level, household size, land ownership, land size, among others. However, a review on some of the studies shows inconsistent results with other studies for example indicating that older farmers prefer indigenous land-use practices compared to young farmers (Jha & Gupta, 2021) while others indicate no correlation between farmer's age and land-use decisions (Yigezu et al., 2018).

In some studies, male farmers are more likely to practice sustainable land-use management options (Oduniyi, 2022) while others showed female farmers as more likely to do so (Musafiri et al., 2022; Pello et al., 2021). Some studies indicate that highly educated farmers farm a wider variety of crops including emerging crops, use technology, maintain high levels of biodiversity, water, and soil quality (Ambrosius et al., 2022; Yigezu et al., 2018). In other studies, education is not a significant factor in land-use decisions (Beyene et al., 2019). Also, household size has been proven insignificant on farmer decisions in some studies (Ochieng et al., 2016) while in other studies, households with more members have a higher likelihood to adopt new farming practices, crops that are labour-intensive and sustainable land management options (Bartkowski & Bartke, 2018; Kansanga et al., 2021; Setsoafia et al., 2022).

Other factors that have been explored over the years include market characteristics, government policies, globalization, infrastructure development, parallel employment, biophysical properties, climatic conditions among others (Bakker et al., 2023; Cosmas & Valsamis, 2001; Ume, 2023; van Aalst et al., 2023; van Tilburg & Hudson, 2022). However, the sociodemographic and these other factors can only partially and under specific conditions accurately model the farmer decisions. Hence the need to explore other perspectives which include instrumental values and relational values.

2.2 Homo economicus and social classification

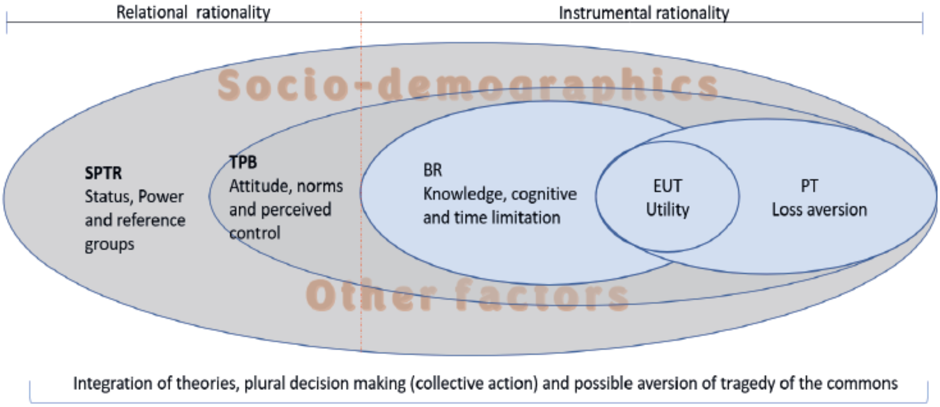
The concept of Homo economicus from the 17th century would expect farmers to make rational decisions to maximize their utility (Congiu & Moscati, 2022). However, the shift

Table 2.1: Concepts and theories used to explain farmer decisions, their strengths, limitations

Concept/theory, origin	Strength	Limitation	Context suitability	Recent applications
Sociodemographic factors	Assess the effect of individual's sociodemographic characteristics.	Does not account for economic rationality and social relations.	Understanding patterns based on farmer sociodemographic and spatial characteristics.	(Ambrosius et al., 2022; Bartkowski & Bartke, 2018; Beyene et al., 2019; Jha & Gupta, 2021; Musafiri et al., 2022; Ochieng et al., 2016; Oduniyi, 2022; Pello et al., 2021; Setsoafia et al., 2022; Yigezu et al., 2018)
Expected utility (Shoemaker, 2013) Switzerland	Incorporates economic rationality.	Assumes an individual picks the option with the highest utility. It does not account for social relations.	Understanding effect of incentives/ sanctions and possible interventions for change of farmer actions.	(Ryan et al., 2022; Ullah & Dwivedi, 2022)
Prospect theory (D. Kahneman & Tversky, 2013; T. Kahneman, 1979) Israel	Discounts for gains versus losses.	Misses out on social environment and assumes perfect knowledge.	Understanding effect of incentives/ sanctions and possible interventions for change of farmer actions.	(Biswal & Bahinipati, 2022; Huber et al., 2022; Julia Ihli et al., 2022; Shin et al., 2022; Villacis et al., 2021)
Bounded rationality (Simon, 1990) USA	Accounts for the decision-making process that includes imperfect knowledge and limited cognitive ability and time.	Does not explicitly include measures for social relations.	Understanding the influence of individual's constraints.	(Cordaro & Desdoigts, 2021; Huber et al., 2022; Qiao et al., 2022; H. Wang et al., 2022; Wens et al., 2021)
Theory of planned behaviour (Ajzen, 1991) USA	Accounts for individuals' attitude towards an option, inculcated norms, and perceived behavioural control.	Does not account for more than one reference group with conflicting interests.	Understanding the effect of social environment and allowing documentation of intermediate steps that is thoughts, intention, and actual behaviour.	(Elahi et al., 2021; Sarma, 2022; Si et al., 2022; Ulhaq et al., 2022)
Status-power theory of relations (Kemper, 1968, 2006, 2011, 2017)	Accommodates any number of reference groups with different interests.	Data are difficult to obtain.	Understanding the social environment, and effect of interrelations.	-

towards behavioural economics identifies people as social beings whose decisions are affected by their social world (Abaci & Demiryürek, 2022; Angner, 2020). There exist many perspectives on the social side of decision-making defined by concepts and theories whose predictive power has been tested in a wide range of circumstances. Table 2.1 highlights details on a few of these theories.

Sociodemographic factors model a farmer's decision based on the human characteristics. Expected utility and prospect theory focus on instrumental values, bounded rationality and theory of planned behaviour incorporate psychological and social factors while Kemper's theory expands on capabilities of these other theories to define farmer decision-making as a process of optimizing instrumental values within the realm of the social world. Kemper's theory acknowledges the need for farmers to harvest instrumental benefits from nature, while seeking to sustain healthy social relations. Figure 2.1 presents the interrelations across the discussed theories. Plural decision making (collective action) starts with acknowledgment of the divergent reference groups with possible divergent objectives and identification of their status-power dynamics.



Key: SPTR (Status-Power Theory of relations, TPB (Theory of Planned Behaviour), BR(Bounded Rationality), EUT (Utility Theory), PT(Prospect Theory)

Figure 2.1: Interrelation of theories that seeks to maximize utility with Homo economicus perspective on the right and both economic and social classification on the left.

2.3 Expected utility theory

Expected utility theory posits that the rational choice is to choose an option with the highest expected utility of outcomes compared to the alternatives (Schoemaker, 2013). For example, a study on afforestation undertaken in Ireland, demonstrated that farmers sort to increase utility defined not only by income but also land value and leisure hours (Ryan et al., 2022).

2.4 Prospect theory

Under prospect theory, there is asymmetry in reflecting gains and losses in utility, with avoidance of (negative) risks (D. Kahneman & Tversky, 2013; T. Kahneman, 1979). Individuals differ in their attitude towards risks, with some being more strongly risk averse (Villacis et al., 2021). For example, two different studies undertaken in Kenya and India on insurance to cushion farmers against risks of climate change unveiled two types of farmers: those against insurance since they view insurance as a loss due to the instant premium payment and those for insurance since they view insurance as an assured future gain (Biswal & Bahinipati, 2022; Shin et al., 2022; Villacis et al., 2021).

2.5 Bounded rationality theory

Bounded rationality theory acknowledges that when trying to be economically rational, individuals are limited by imperfect knowledge (for instance knowledge on markets, weather patterns, natural resources), cognitive ability and time (Simon, 1990). An increase in knowledge, cognitive ability or time is expected to have an impact on farmer decisions. For example, a study undertaken in China, showed that farmers' training increased use of organic fertilizer (Wens et al., 2021; Qiao et al., 2022). Another study undertaken in Kenya showed that trainings, raised adoption of drought adaptive measures.

2.6 Theory of planned behaviour

The theory of planned behaviour adds social framework to sociodemographic factors and the bounded rational choice. It defines farmer decisions as an outcome of attitudes, subjective norms, and perceived behavioural control (Ajzen, 1991). Attitudes refer to the belief that an option would give a desired outcome, for example, the belief that planting export crops will generate higher income. Subjective norms refer to the belief that important persons or groups of people (so-called referent others) would approve/disapprove of an action. Perceived behavioural control refers to an individual's perception that s/he has control and the capacity (such as knowledge, skills and abilities, time, finances) to undertake the selected option (Ajzen, 1991, 2020; Fishbein & Ajzen, 2011). This theory has been used in several studies for example a study undertaken in Bangladesh to assess effect of attitudes, subjective norms, and perceived behavioural control in the intent to comply with pesticides use requirements (Sarma, 2022). The theory of planned behaviour uses intent to predict behaviour, while acknowledging that the intention does not always lead to the actual behaviour. This could be attributed to conflicting preferences of referent others. The existence of multiple reference groups with conflicting interests has been exhaustively discussed by Kemper's theory.

2.7 Status-power theory of relations (Kemper's theory)

Kemper's theory goes beyond modelling bounded rational choices to include the effect of social relations. Social relations can explain why farmers with same characteristics (sociodemographic, knowledge, cognitive abilities, social environment) may choose different land use options. Farmers, consciously or not, choose land-use options that please their salient reference groups to acquire status from these groups or to avoid power use (Kemper, 2017). A farmer who believes that salient reference groups approve of a decision, and no reference groups object, that farmer will be contented and may continue implementing the same land-use option over several years. Otherwise, a farmer becomes discontented and may reduce salience of the reference groups that withhold status possibly to another that recognizes the farmer's efforts. This may be signified by changing land-use decisions in subsequent years. Additionally, if a farmer implements an option that leads to power use by a salient reference group for example surcharge for illegal water abstraction, that farmer may be forced to change to other options.

A farmer may have salient reference groups with conflicting opinions. For example, a farmer in a semi-arid area may be faced with two conflicting options 1) to farm low-water-requirement crops using rainfall with a possible outcome of low profits or 2) high-water-requirement crops using irrigation from nearby rivers with a possible outcome of high profits, but less water for downstream communities. These two options would be of interest to several reference groups for example: family would be pleased with high-water-requirement crops for a higher income; the government may prefer low-water-requirement crops in view of promoting sustainable agricultural practices; downstream communities may prefer the low-water-requirement crops for less water abstraction upstream which translates to more water downstream. A farmer who has family, government, and downstream communities as salient reference groups, may intend to please all of them, but such an option may not always exist, implying conflicting interests.

Conflicts among salient reference groups are resolved in a mental reference group meeting which happens in the minds of individuals (the organism with its gut feelings is also a reference group with a voice). During this meeting, the opinions of all the salient reference groups are weighed against their level of status worthiness, and their expected power use if thwarted. A farmer can therefore choose to please the reference group which will confer most status while risking power use by another reference group or look for an alternative that is perhaps less glorious but pleases all the salient reference groups. Kemper's theory has recently found adoption in ABM. The concept of reference groups was used in exploratory research on organic farming among Dutch pig farming (Ambrosius et al., 2022).

3. Application in Agent based models and opportunities of theories in plural decision-making

The discussed theories have been used in different ways in Agent based modelling. Table 2.2 presents sample studies. Each theory has its own space in literature and can be used depending on the objectives of the study. However, models that integrate different theories and concepts are more robust in capturing dynamics of decision making (Cordaro & Desdoigts, 2021; Epanchin-Niell et al., 2022; Preston et al., 2015). An addition of Kemper's to theories presented in Table 2.2, is that the theory increases relevance and credibility of an ABM by illuminating the effect of status-power of referent others.

Table 2.2: Application of theories in land-use Agent Based Models (ABM)

Theory	Disciplines	Application	Key variables used in the ABMs
Expected Utility	ABMs for natural resources	Used to explore willingness to grow bioenergy crops (Ullah & Dwivedi, 2022).	Utility (profit) is based on yield, selling price and production cost
Prospect theory	Several disciplines including ABM for environmental studies, economics, insurances	A combination of prospect theory and bounded rationality was used to design an ABM to explore heterogeneous farmer decisions on weed control (Huber et al., 2022).	The study used gross and cumulative sum of income, average change in income and individual tolerance level of which if not met the agent may socialize to increase knowledge.
Bounded rationality	Several disciplines including ABM for natural resources, environment, economics, political sciences		
Theory of Planned Behaviour	Several disciplines including ABMs in environmental studies	Used to assess adoption of agroforestry among smallholder farmers in Rwanda (Noeldeke, 2022).	Weights for each factor (attitude, social norms perceived behavioural control) are determined from collected data and used to calculate the intention to adopt agroforestry or not.

Aggregation of individual farmer decisions has emergent effects on the commons. What may seem like a rational decision at individual level can lead to harmful outcomes (tragedy of the commons) for the individual and at the level of collectives (Epanchin-Niell et al., 2022; Ostrom, 1990). In Kemper's terms, this means that a reference group of 'all stakeholders' is not salient to the farmers. However, people are also socially relational with the capacity to self-organize for the collective good of the commons (Nordman, 2021; Ostrom, 1990).

Understanding and capturing motives that drive farmers in their land-use decisions in an ABM could be a beginning to plural decision-making of a multistakeholder group and collective action (Bakker et al., 2023; Yoder et al., 2022). Therefore, for a successful collective action, all reference groups both real world and imagined with their respective status-power dynamics need to be explored and understood by all. This is from the perspective of the local communities (farmers, community water management bodies, local markets) and non-local stakeholders (national government, agro-export companies, international NGOs) where both sides understand reference groups salient to the other group, their interests, and their status-power dynamics. This would lead to reducing blind spots henceforth promoting plural decision making.

4. Conclusion

In this review, we present farmer decisions from both instrumental and relational perspectives while proposing strengthening of farmer decision models by agent-based modelling (ABM) through which to explore emergent land-use patterns occasioned by agents' interactions in a social relational setting. The social relations dynamics are defined using Kemper's status-power theory of relations. Kemper's theory enhances credibility and relevance of an agent-based model by incorporating the element of farmer decisions as the need to satisfy the requirements of salient reference groups. Successful use of this theory relies on correctly identifying salient reference groups, their level of importance (status and potential use of power), and their preferred land-use options (interests). Kemper's theory provides an option to transition from individual to collective action in agent-based models through setting of rules that lead to agreement in a common cause against opposing forces possessed by individual reference groups. In this case, local and non-local reference groups, real-world and imagined reference groups collate as one reference group with a common goal to avert tragedy of the commons.

Chapter 3

"You never farm alone": Farmer land-use decisions influenced by social relations

The Chapter is based on:
Githinji, M., van Noordwijk, M., Muthuri, C., Speelman, E. N., Kampen, J., & Hofstede, G. J. (2024). "You never farm alone": Farmer land-use decisions influenced by social relations. Journal of Rural Studies, 108, 103284.

Abstract

Context: Farmer land-use decisions are commonly explained and predicted by sociodemographic, economic, ecological, and psychological factors. However, these models explain only part of the empirical data without accounting for the effect of social relations.

Objective: This chapter aimed at exploring the effect of social relations on farmer land-use decisions using the status-power theory of relations. We hypothesised that farmer land-use decisions are driven by the need to comply with requirements of their salient reference groups, such as family, government, and spiritual beings.

Methods: We undertook a case study in the Mt. Kenya region where we conducted individual interviews and focus group discussions among smallholder farmers. We then used chi-square automatic interaction detection (CHAID) to explore influence of social relations on land-use practices.

Results and conclusions: Reported social relations were diverse and accounted for land-use decisions that could not be explained by sociodemographic, economic or ecological factors. The results showed that a farmer seemed more likely to choose a land-use option if he/she believed his/her salient reference groups would be pleased with the option. Reconciling social relations with other factors such as farmer's sociodemographic factors and geographic location also had a significant effect on the results.

Significance: Insights into the impact of social relations in farmer land-use decisions can explain the often-heterogeneous decisions and can complement the economic analysis that is the conventional focus in analysis of farmer decisions. An understanding of the effects of social relations can strengthen development of policies that motivate implementation of more sustainable agriculture options.

Keywords: Farmer land-use decisions; land-use practices; Mt. Kenya region; social relations; status-power; reference groups

1. Introduction

In arid and semi-arid areas, intensification of farming practices usually requires irrigation, which imposes additional stress on already scarce water resources (Abou Zaki et al., 2022; Ochoa-Noriega et al., 2022). Although irrigation increases food production and income, it leads to unsustainable agricultural practices and, at times, water-related conflicts among stakeholders (Abou Zaki et al., 2022; Ochoa-Noriega et al., 2022). Farmer land-use decisions impact significantly on sustainable agricultural practices (Githinji et al., 2023). For many years, sustainability has been linked to a ‘triple bottom-line’ of planet, profit, and people (Elkington and Rowlands, 1999). These three elements can be identified with three realms: ecological, economic, and social-relational. The ecological perspective on land suitability emphasises variation in soils and climate, the economic lens of profitability adds the way costs and benefits vary with location, land/labour ratio and resource endowment of an enterprise or household, while the social relations lens includes emotions such as pride or loyalty.

Effects of the realms of sustainability on farmer land-use decisions have been explored by means of various theories. Such theories include expected utility theory, which postulates that a rational individual makes decisions based on his/her risk tolerance and personal preferences (Birthal et al., 2021; de Frutos Cachorro et al., 2018; Schoemaker, 2013); the prospect theory, which analyses farmer’s decisions as influenced by prospective loss or gain from a land-use option (Villacis et al., 2021; Wang et al., 2018); the theory of bounded rationality, which states that a farmer’s decision is bounded or limited by resources such as finances, time and knowledge (Cordaro and Desdoigts, 2021; Home et al., 2019; Křečková and Brožová, 2017; Wens et al., 2022); and the theory of planned behaviour, which assesses the influence of attitude, subjective norms, and perceived behavioural control on farmers’ decisions (Ajzen, 1991; Buyinza et al., 2020; Senger et al., 2017). While the ecological and economic realms have been extensively explored in literature, the influence of social relations has yet to be adequately assessed. The theory of planned behaviour covers part of the social relations by analysing the role of referent others in inculcating social norms that affect an individual’s decision. However, this theory does not account for multiple reference groups—with possibly conflicting interests—that can potentially impinge on farmers’ decisions (Githinji et al., 2023). Reference groups are persons or groups of persons, real or imagined, that an individual takes into account while taking an action (Kemper, 1968). The status-power theory of relations (Kemper, 2017, 2011, 2006, 1968) referred to in this paper as Kemper’s theory, can model elements that are beyond the range of the theory of planned behaviour, including a diverse set of reference groups. In Kemper’s theory, there is no difference between an individual’s attitude and group norms, but an individual’s decision is the outcome of the subconscious ‘reference group meeting’ that takes place in the mind of an individual. While the theory of planned behaviour is targeted to conscious behaviour on a particular decision, Kemper's theory is about feelings, emotions and behaviour in general that subconsciously influence decisions.

Kemper's theory defines a farmer's decision within the context of the farmer's social world. The theory is not a substitute for ecological and economic analysis of land-use patterns, but rather a complement to them. It suggests that economic and ecological rationality can influence farmer land-use decisions through social relations, with 'relational rationality' complementing other factors. Relational rationality is driven by relations a farmer has with an important person or persons that form so-called reference groups (Kemper, 2017). Reference groups may include family, farmer groups, religious leaders, government, or spiritual entities. Kemper's theory would expect a farmer to make decisions that are aligned to his perceptions of the preferences of his/her important reference groups.

We hypothesised that social relations, as understood from Kemper's theory, influence farmer land-use decisions. To test this hypothesis, we collected and analysed data from the Upper Ewaso Ngíro North River Basin in Mt Kenya. The study site lent itself especially well to the study of reference groups since its land use has 'upstream' agricultural market connections, and 'downstream' impacts on water availability. Farmers in the study site are not only conflicted between ecological and/or economic benefits but could also be interested in sustaining good relations with their important reference groups. These reference groups might include community water project members, neighbours, friends, family, community leaders and extension workers, all of whom have been identified in other studies in the region. (Giroux et al., 2022; McCord et al., 2015).

2. Status-power theory of relations and farmer land-use decisions

The status-power theory of relations defines individual decisions as actions that give voice to salient reference groups (Kemper, 2017). A reference group is salient if it has a strong status-power position, which can be built up by any combination of status-worthiness and power. If the reference group is status-worthy, the individual will voluntarily comply with its bidding. If it is powerful, the individual will comply involuntarily to avoid punishment (Kemper, 2017, 2006). Voluntary compliance is driven by status accord, whereby respect or love leads an individual to take an action that they perceive to be pleasing to a salient reference group. The individual will expect the salient reference group to reciprocate the status conferral. Failure to do so may evoke negative emotions and the individual may reduce the salience of such a group. Regarding involuntary compliance, the salience of a reference group and its influence is upheld if it can use power against the individual. The relation between an individual and the reference group revolves around rules, fear, and sanctions for non-compliance. An individual may thus have no option but to oblige. Substantial use of power can be socially accepted. However, excessive use of this power may evoke negative emotions that can lead to action (sometimes collective action) against the power-wielding reference group. In this case, collective action is taken by some, if not all, individuals who feel afflicted.

We posit that farmers, consciously or subconsciously, identify with specific reference groups and undertake land-use decisions that they believe will please those reference groups. Farmers may attach various levels of salience to reference groups that could lead to heterogeneous land-use practices. Their actions are not only to please the reference groups but also an attempt to gain status or power of their own. In the minds of the individuals, the influence of the reference groups is exerted at an emotional level. If several reference groups exist in the minds of the individual, mixed emotions may occur, and it is not always easy to differentiate which reference group is shaping this individual's behaviour (Kemper, 2017). People themselves may not be aware of how this works. However, in situations where decisions made do not follow economic rationality or ecological factors, these decisions might be explained by identifying the salient reference groups and their perceived opinion on a particular decision.

3. Methodology

3.1 Study site

We used the Upper Ewaso Ngíro River Basin to assess the influence of social relations on farmer land-use decisions. The study site (Figure 3.1) is located on the northwest side of Mt Kenya between longitudes 36°48´42˝E and 37°41´17˝E and latitudes 0°44´3˝N and 0°13´58˝N. It includes parts of Meru and Laikipia counties and totals approximately 2,500 km^2. The study site cuts across a humid-to-semi-arid gradient, receiving an average of 2000 mm per annum in the upper region but less than 350 mm per annum in the lower region (Kimwatu et al., 2021). Besides rainfall, other major sources of water in this region are groundwater and rivers that flow down the slopes of Mt. Kenya. There have been major land-use changes over the years. Before Kenya's independence in 1963, land was being converted from dominant pastoralism to large-scale arable farming and ranching, and this period was followed by subdivision of some of the arable large farms into smallholder farms (Eckert et al., 2017; Roden et al., 2016; Taylor et al., 2005). The most common food and cash crops are potatoes, maize, vegetables (kale, cabbage, spinach) tomatoes, onions, and fruit (McCord et al., 2015). A growing agribusiness environment has enabled the smallholder farmers to shift slowly from habitually grown crops to more profitable horticultural export crops such as French beans, garden peas, and flowers (Dickson Kinoti, 2018). Farmers sell their produce to the local traders, but some also access the global market by engaging in contract farming with agro-exporters or large farm owners (McCord et al., 2015). To sustainably produce enough for the markets throughout the year, farmers mostly use river water to irrigate their crops. Access to irrigation water increases chances to engage in irrigated farming (Giger et al., 2022). Therefore, most of the irrigation is done in the water-abundant upper and middle zone, reducing water availability downstream (Wamucii et al., 2023). This leads to conflicts among pastoralists, smallholder farmers, large-scale farmers and conservancies, especially during the dry season when water is scarce and insufficient to meet all water demands (Eckert et al., 2017; Ulrich et al., 2012; Zaehringer et al., 2018).

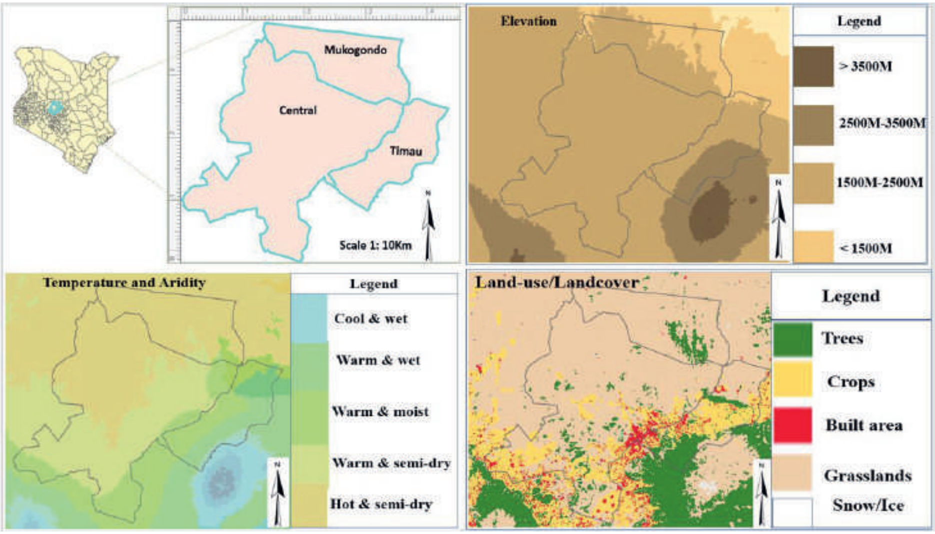


Figure 3.1: Case study site covered three administrative units: Central ward and Mukogondo ward in Laikipia County, and Timau ward in Meru County (DIVA-GIS, 2023); Elevation ranged from upstream (close to the top of Mt. Kenya over 3500 m a.s.l.) to downstream(less than 1500 m a.s.l.) (Esri, 2020a); Mean annual temperatures and humidity range from cool (<12.3°C) and wet (P/Epot >1) to hot (>19.2°C) and semi-dry (P/Epot<0.6, where P = precipitation, Epot = potential evapotranspiration (Esri, 2020b); Land-use cover include crops, trees, grasslands and built areas (Esri, 2023).

3.2 Study design and data collection

Data were collected in two phases using a sequential exploratory design (Creswell and Clark, 2017) (Table 3.1). With this design, qualitative data is collected first, followed by quantitative data collection. This approach is often used where qualitative data is needed to inform the development and administration of quantitative data collection tools, and the quantitative results are used to verify the qualitative results using a larger sample (Creswell and Clark, 2017). In this study, we collected qualitative data in phase 1 and used it to prepare a questionnaire for data collection in phase 2. This approach facilitated an in-depth analysis of existing reference groups. We applied qualitative interviews and focus group discussions to explore the study area, its land and water use practices and social relations that had a possible effect on farmer land-use decisions. Our aim was to identify i) existing reference groups; ii) what made reference groups salient (status, power, or both); and iii) how farmers perceived the land-use preferences of these reference groups. The analysis of these data helped in narrowing down to the main reference groups included in the questionnaire for phase 2. In the quantitative phase (phase 2), we collected data on i) land-use practices, ii) relative importance of identified reference groups and their preferred land-use practices as reported by interviewed farmers. Details for each phase are provided in subsequent sections.

Table 3.1: Overview of methods used for data collection in the two phases

Overall method	Sequential exploratory design	
Phases	Phase1	Phase 2
Objective	Support designing and administration of questionnaire in phase 2	Verify results from the exploratory qualitative survey using a larger sample
Sampling method	Purposive & snowball sampling. The aim was to get farmers with different crops (subsistent, for local and export market), engaged and those not engaged in contract farming. This presented an opportunity to assemble a diverse set of reference groups	Purposive & snowball sampling
Data collection method	• Semi-structured questionnaires (questionnaire is provided in supplementary Material) • Individual interviews • Focus group discussion • Literature review • Transect walk and observation	• Structured questionnaire (Questionnaire is provided in supplementary Material) • Individual interviews
Sample demographic variables	• 59 respondents • 38 male & 21 female • 5 villages • Age 21-70 years	• 199 respondents • 83 male, 116 female • 6 villages • Age: 21-70 years
Thematic areas/ main topics	• Land-use practices (current, past, and future practices) • Drivers for land-use decisions • Reference groups, their level of importance and opinion on different land and water uses	• Farmer sociodemographic information and geographic location • Current land-use practices • Relative importance of reference groups • Opinion of reference groups on different land-use decisions as reported by interviewed farmers

3.2.1 Qualitative data collection (phase 1)

We conducted a literature review of past studies, government reports and documents to get more information on land-use practices, water management and possible drivers for land and water use practices in the region. Transect walks and observation were used to identify and document land-use patterns, water availability and use (irrigation or not, type of irrigation, by whom and where). Once an understanding of the landscape was obtained, the case study site was divided into three geographical locations: i) upstream, characterised by more rainfall and more rivers with high river flow; ii) midstream, with less rainfall and fewer rivers; and iii) downstream, which was drier, with much less rainfall and lower water levels in the few existing rivers. This categorisation allowed us to identify any significant difference in land and water use practices as well as any possible differences in dominant reference groups in the different locations. Specific areas visited within the landscape were Central ward and Mukogondo ward in Laikipia County, and Timau ward in Meru County. Individual interviews were conducted, followed by two distinct focus group discussions between April and August 2021 until there was no generation of new information in terms of land use, water use and reference groups. This led to a total of 59 interviews. Our interviews focused on farmers who were easily accessible, gave written consent to interviews and use of information they provided, and had adequate information on the identified thematic areas (listed in Table 3.1). Thus, respondents were identified through snowball (Berndt, 2020), and purposive sampling (Etikan et al., 2016). Most respondents were 31-40 years old (41%) followed by those between 21-30, 41-50 years and 51-60 years at 19% each, while respondents above 60 constituted 3% of the sample. The number of people living in each of the sampled households ranged from 1 to 13 with an average household size of 4.6 people. Out of the total respondents, 43% had secondary education. Other educational levels were primary (39%), college (10%), university (5%) and no formal education (3%).

3.2.2 Quantitative data collection (phase 2)

We used information obtained from phase 1 to develop the questionnaire for phase 2. The questionnaire was comprised of four main sections. Section 1 covered general questions on the farmer's age, gender, number of people living in the household, size of rented land, size of owned land, level of education, average monthly expenditure (as a proxy for economic status) and whether a farmer was engaged in other economic activities. Section 2 covered current land-use practices, section 3 dealt with ranking of reference groups, while section 4 was about the farmer's opinion on preferred land-use options for each reference group. From 2nd to 5th November 2021, the questionnaires were administered face-to-face to facilitate clarification of questions and translation to local language if necessary. Snowball and purposive sampling were used to identify farmers engaged in small-scale farming for the local market, contract farming with existing export companies, and a mix of farmers who accessed river water directly and/or through community water projects (CWPs). This was to enable identification of the level of influence of the different reference groups that had been identified earlier in phase 1 of data collection. A total of 199 questionnaires were used in this study.

Out of the total respondents, 58% were female and 42% were male. When arranged by age, the highest proportion of respondents were 31-40 years (36%), followed by 41-50 years (26%), 21-30 years (22%), and 51-60 years (14%), while those above 60 years were 2%. Out of the total respondents, 49% had secondary education, 31% had primary education, and 19% had tertiary education, while 1% of the respondents had no formal education. The average household size for this sample was equal to that in phase 1 i.e., 4.6 people per household.

3.3 Data analysis

3.3.1 Qualitative data analysis

The main documents used for qualitative analysis were farmers' respondent sheets, voice and video recordings, and photographs. The collected data were transcribed and analysed with ATLAS.ti version 9.0.23.0 (ATLAS.ti, 2022). To this end, we conducted a thematic analysis where rounds of open (in vivo) coding were followed by axial coding. This procedure led to an inventory of reference groups and/or individuals that influenced farmer land-use decisions, factors that made a reference group salient, and farmers' perceived land-use preferences. Identification of reference groups from the respondents' statements was based on authors' judgement, since it was sometimes difficult for respondents to distinguish whether a reference group's salience resulted from status or from potential for using power. Additionally, status-worthiness usually conferred some power. For instance, a knowledgeable farmer might be chosen as a chairman of a farmers' association, giving him power to influence decisions. Conversely, a powerful actor/reference group might be given status; for instance, a rich farmer might be listened to or copied.

3.3.2 Quantitative data analysis

Descriptive analysis of data was performed to provide frequencies and percentages concerning age, gender, number of people living in the household, size of rented land, size of owned land, level of education, average monthly expenditure, and current land-use practices, as well as information on reference groups, their perceived opinion on different land-use options, and level of importance. This was essential information for the next step of drawing inferential statistics on the effect of different variables on land-use decisions. We used chi-square automated interaction detection (CHAID) (Wilkinson, 1992) to explore relations between land-use practices and reference groups. The CHAID procedure assessed and generated a simplified visual tree-like structure that predicted the dependent variable (i.e., the land-use decision; for instance, whether or not to farm maize), as an equation of independent variables (i.e., scores of the reference group). In this process, the score of a reference group *j* on crop *i* (S_{ij}), is a composite variable based on relative importance of reference group *j* and the extent to which a farmer believes that reference group *j* would prefer farming of crop *i*. Thus, we have $S_{ij} = W_j{*}P_{ij}$, where W_j denotes the weight (i.e., relative importance/salience) of reference group *j*; and P_{ij} is the farmer's perceived preference of reference group *j* for crop *i*. We had three categories of predictors: i) a salient reference group with a negative opinion of a land-use decision; ii) a salient reference group with a positive opinion of a land-use decision; and iii) a salient reference group with a neutral opinion of the land-use decision.

Besides the analysis of social relations, we further performed CHAID analysis to test the effect of sociodemographic and geographic location factors on land-use options. Additionally, we assessed the combined effect of sociodemographic, geographic location factors, and social relations on land-use decisions. Quantitative data were analysed using IBM SPSS Statistics 25.

4. Results

4.1 Qualitative results

The majority of farmers interviewed (95%) practiced smallholder farming on land that was either rented or privately owned land, while community land was mainly used by pastoralists. The size of smallholder farms ranged between 0.4-1.2 hectares. There were three farmers with larger sizes of land, namely 2.8, 6.9 and 48.5 hectares. Farmers had various land-use practices: they farmed multiple crops, kept livestock, and planted trees. Commonly grown crops were maize and potatoes, both of which were farmed by 25% of respondents, while French beans were farmed by 24% of respondents. Out of the total number of respondents, 19% had trees (mostly *Grevillea robusta*, pine and fruit trees) on their farms. Other crops farmed by less than 8% of respondents were carrots, beans, wheat, fruits, onions, Napier grass, flowers, sweet potatoes, tomatoes, baby corn, canola, millet, and khat. Most farmers indicated that they were shifting from growing crops such as wheat and large-scale maize farming, either in totality or having left only a small portion of land for such crops as a result of decreasing farm sizes and a growing export market. Commonly reared livestock were cattle, raised by 48% of respondents and poultry, raised by 17%.

The most frequently mentioned reference groups were family, community water project/water resource users' association/water regulatory authority, agro-export companies, local community, neighbours, local traders/intermediaries/brokers, and the local government (Table 3.2). Other rarely mentioned reference groups included friends, private training farms, NGOs, and dairy farmer associations.

Most farmers considered family as the most salient reference group. They found it a responsibility to satisfy the family's food and income requirements first, before pleasing

Table 3.2: List of reference groups, the reason for their salience (status, power, or both), accompanied by number of times a reference group was referenced and an example of comments made by respondents. Key words that were used to identify a statement with a particular reference group have been highlighted in the respondents' statements. This list is not comprehensive. It was narrowed down to those reference groups that were frequently mentioned and those that the authors thought would be interesting to explore based on reviewed literature.

Reference groups (coded)	Status/ power	Number of occurrences	Sample of comments
Family	Status	28	*'I plant different crops for food or cash to sustain my **family**. I am interested in pleasing my family, their opinion matters.'* *'I breed fish since this is what my **grandfather** used to farm, and he is happy when I follow in his footsteps.'*
Community water project/water resource users' association/water regulatory authority	Status and power	24	*'I regulate my water use while irrigating to avoid conflict with **members of my community water projec**t.'* *'At times I have to pump water at night to avoid confiscation of my water pump and fines by the **water resource user's association'*** *'When pumping water directly from the river, I have to be on the look-out for the **water scouts** who can confiscate my water pump and surcharge me'*
Agro-export company	Status and power	*14*	*'I choose to plant **French beans** since I get subsidised seeds, fertiliser and agrochemicals from **the company.'*** *'I am planning to start planting **flowers** (**geraniums**) since the flower **company** has assured me of a ready market.'* *'I am in contract farming with an **agro-export company**. Therefore, I must irrigate my crops to meet the standards of the agro-export company.'*
Local community/ downstream communities/ neighbours	Status and power	*8*	*'I am satisfied if my **community** is happy. Therefore, I plant crops that will create more jobs for the **community**.'* *'I keep cattle for prestige. My **community** will respect me more if I have cattle.'* *'Sometimes we have to reduce our water intake to prevent **pastoralists** from migrating upstream in search of water and destroying our crops in the process.'*
Local traders	Status	*5*	*'I plant several crops such as onions, potatoes, tomatoes and vegetables because **local traders** provide competitive price for my crops.'*
Government	Status and power	*2*	*'As a youth, I started farming because our **county Government** started the 'Youth into farming competition'; I get a cash reward if I win the competition.'*

other reference groups. The community water project (CWP) was recognised as a salient reference group worthy of high status due to its position as a community-owned organization composed of community members. Also, as one of the water regulatory bodies, the CWP possessed a great deal of power, whereby it could cut off access to water for farmers who failed to comply with the set rules. The relation between farmers and agro-export companies was a combination of status accord and power use. Agro-export companies would acknowledge the importance of farmers (that is, accord status) by having agents on the ground interacting with farmers, incentivising farmers with quality seeds, trainings, and a stable market for their crops. In return, farmers would feel obligated to confer status in return by farming crops needed by the agro-export companies and adhering to their required level of quality. Even without such a status motive, farmers might comply because of the agro-export companies' power over them. After all, non-compliance to the agro-export companies' requirements, for example use of poor-quality seeds, use of prohibited herbicides or failure to irrigate as required, would lead the agro-export company to exert power by refusing to buy produce from non-compliant farmers.

Neighbours were considered significant, and their influence could be noted from similarities between crops planted by farmers within close range. Farmers would only learn from those neighbours/community members whom they perceived to be status-worthy, either because they were wealthier or simply because they had had a better harvest in the previous season. To some respondents, downstream communities were a salient reference group: these farmers said they would regulate their water use to allow good river flow to the downstream communities. In return, these farmers expected to be respected or accorded status not only by the downstream communities but also by the rest of the community. Local traders were considered important since they provided attractive gate prices for the crops. At times some local traders provided advance loans which would be considered to drive farmer land-use decisions towards a particular crop; upon receipt of the loan, a farmer would not have no choice but to do the trader's bidding. There were two respondents whose responses could be interpreted as recognition of government as a salient reference group. The government was recognised since it was providing farm input subsidies, a market for cereals, and training, especially for tree planting, in addition to resolving inter-community conflicts. Some of the farmers interviewed noted that they rarely took government into account while making their land-use because of the decline in their extension services support compared to that provided by agro-export companies.

4.2 Quantitative results

Most of the sampled respondents (82%) privately owned land. A proportion of respondents (29%) rented land; some landowners rented extra land for farming to increase their farm income. Use of community land was not common in the study site, with only 4% of the population making use of it. Most farmers used their land to farm crops that are considered food for family and those that are widely consumed in the local market or among the local community, such as maize, potatoes and vegetables. Some farmers had also diversified to include export crops, with 49% of the farmers planting French beans. Average farm sizes were 0.1 hectare for rented land and 0.4 hectare for privately owned land. The small farm sizes had affected adoption of agroforestry by some households. A full description of farmed crops is shown in Table 3.3.

Table 3.3: Description of respondents’ land-use practices at the time of data collection

Farmed crop	Proportion of respondents farming crop	Standard deviation
Potatoes	0.86	0.3
Maize	0.84	0.4
Vegetables(spinach, kales, cabbage)	0.69	0.5
French beans	0.49	0.5
Trees	0.47	0.5
Beans	0.28	0.5
Fruits	0.24	0.4
Peas	0.19	0.4
Tomatoes	0.17	0.4
Onions	0.15	0.4
Drought-resistant crops	0.09	0.3
Wheat	0.03	0.2

4.2.1 Farmer opinions of land-use preferences of reference groups

Farmers ranked reference groups depending on their perceived level of importance. On average, family was considered the most important, followed by agro-export companies, the community water project, local traders, neighbours, government, and downstream communities, while ancestors were the least important (Table 3.4). We measured the level of concurrence/variation on the importance of reference groups among farmers across the landscape. It was notable that most farmers agreed that ancestors were not important; however, there was a wider divergence in ranking of the community water project and government (Table 3.4). A detailed ranking of each reference group is provided in the Appendix (Table 1A).

Farmers felt that different reference groups would be pleased, displeased, or neutral regarding their land-use decisions to farm different types of crops. For instance, out of the total respondents, 92% felt that their family would be pleased if they farmed potatoes while 63% felt family would be displeased if they farmed wheat and 47% felt family would be neutral if they chose to farm drought-tolerant crops (Figure 3.2).

Another example with the community water project (CWP) as a salient reference group is that 83% of the respondents felt that the CWP would be pleased if they planted trees, while 27% felt the CWP would be displeased if they farmed vegetables (Figure 3.2). Other interesting results were that most respondents (more than 75%) felt the local market would be pleased with all crops. Detailed information for each crop is provided in the supplementary Material.

Table 3.4: Relative ranking of reference groups and spread (standard deviation) as calculated using the average rank across respondents

Reference group	Average rank	Rank	Standard deviation
Family	2.88	1	1.7
Agro-export company	2.92	2	1.5
Community water project	3.78	3	2.0
Local trader	3.88	4	1.9
Neighbour	4.4	5	1.9
Government	4.44	6	2.0
Downstream communities	5.38	7	1.6
Ancestor	7.23	8	0.8

4.2.2 Influencers of land-use decisions

a) Sociodemographic influencers

There was a significant relation between some sociodemographic variables and farming of maize, tomatoes, fruits, and trees (Table 3.5). For example, maize farming was influenced by household size and location (county). The probability that a household with less than two members would farm maize was 33%. On the other hand, the probability that a household with more than two members in Laikipia County would plant maize was 91%, while in Meru it was 80%. There was no correlation between any of the sociodemographic variables and potatoes, vegetables, French beans, beans, peas, onions, drought-tolerant crops or tree farming.

b) Social relations

There was a significant relation between reference groups and some of the land-use decisions (Table 3.6). For example, potato farming was influenced by neighbours and the local market. There was a 100% chance that a farmer who believed neighbours were in support of potatoes would farm the crop. Further, there was a 72% chance that a farmer who believed that neighbours and local market did not support potato farming would farm the crop anyway. While negative opinion was expected to lower the chances of farming a crop, we had some interesting results on French bean farming. Here, the highest probability (78%) of farming French beans was when a farmer believed the agro-export company would support farming that crop, but neither the local market

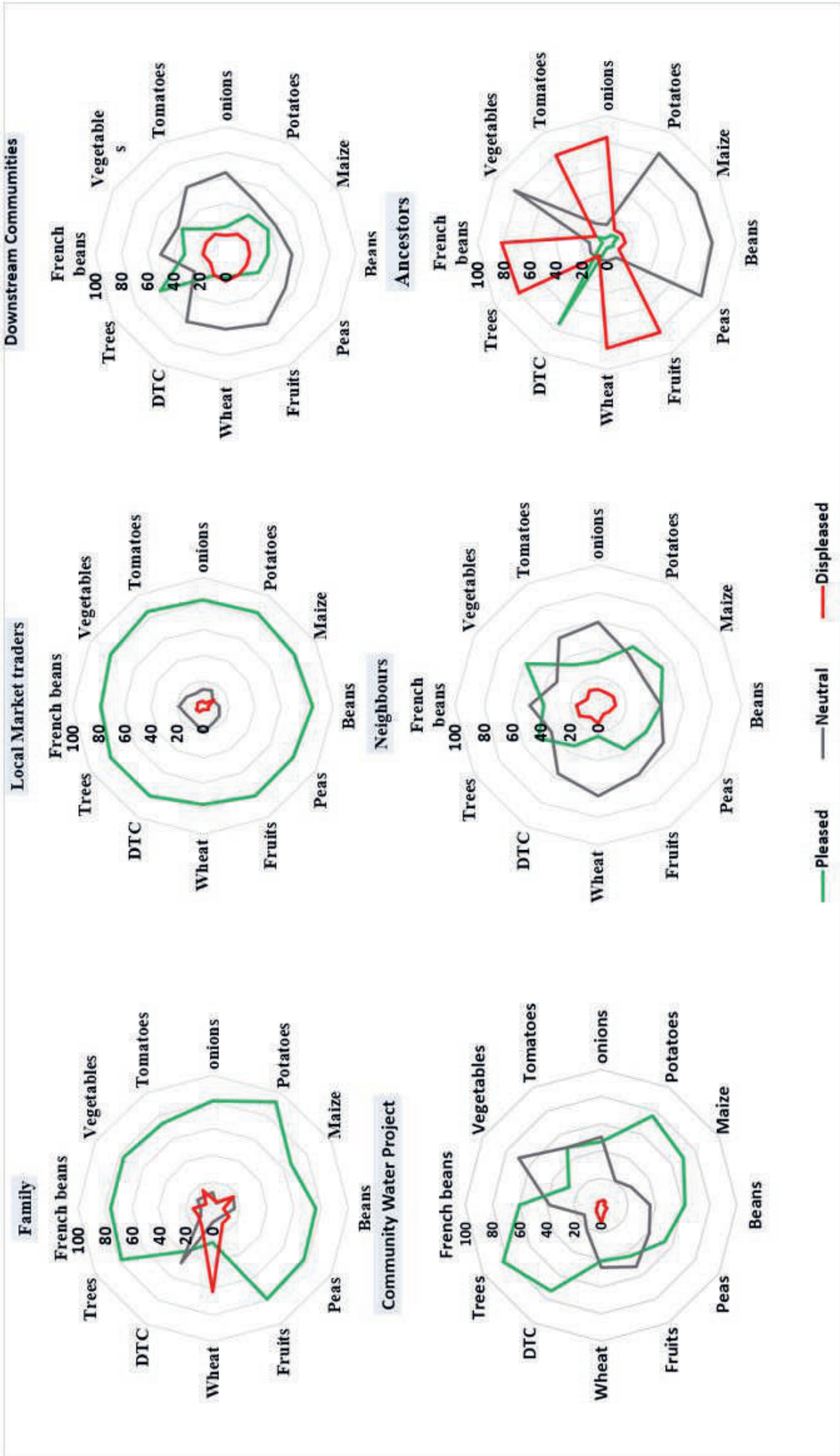


Figure 3.2: Farmers' perceived preferences of reference groups on select crops. The diagram shows the proportion of respondents that felt a reference group would be pleased, displeased or neutral if a farmer chose to farm a select crop.

Table 3.5: Results from CHAID analysis showing probability of farming select crop given the listed sociodemographic factors and geographic location. Insignificant results were not included.

Land-use option (% of respondents farming crop)	Significant sociodemographic variable	Variable description			p-value	Chi-square	Accuracy of predictions (%)
Maize (84%)	Household size	<=2 members	>2 members		<0.001	17	
	County		Laikipia	Meru	0.03	4	
	Probability of farming maize (%)	**33**	**91**	**80**			86.4
Tomatoes (17%)	Engagement in other economic activities	No	Yes		0.018	5	
	Probability of farming tomatoes (%)	**21**	**7**				83
Fruits (24%)	Engagement in other economic activities	No		Yes	0.006	7	
	County	Laikipia	Meru		0.02	5	76
	Probability of farming fruits (%)	**34**	**14**	**11**			
Trees (47%)	Age in years	<=45	>45		0.039	7	
	Probability of planting trees (%)	**51**	**26**				56

Table 3.6: Summary of results from CHAID decision trees showing probability of farming select crop given the opinion of salient reference group. ✓ represents a positive opinion while × represents a negative opinion from the corresponding reference group. Merged cells show a node that has been split further due to existence of other salient reference groups affecting results within the node. Reference groups that have no significant influence on land use according to the CHAID test were not printed.

<table>
<tr><th>Land-use option (% of respondents farming crop)</th><th>Significant reference group</th><th colspan="4">Opinion</th><th>p-value</th><th>Chi-square</th><th>Accuracy of predictions (%)</th></tr>
<tr><td>Potatoes (86%)</td><td>Neighbours</td><td>✓</td><td colspan="2">×</td><td></td><td><0.001</td><td>17</td><td>86</td></tr>
<tr><td></td><td>Local market</td><td></td><td>✓</td><td>×</td><td></td><td>0.001</td><td>12</td><td></td></tr>
<tr><td></td><td>Probability of farming potatoes (%)</td><td>100</td><td>94</td><td>72</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Maize (84%)</td><td>Family</td><td>✓</td><td colspan="3">×</td><td><0.001</td><td>53</td><td>90</td></tr>
<tr><td></td><td>Local market</td><td></td><td colspan="2">✓</td><td>×</td><td><0.001</td><td>24</td><td></td></tr>
<tr><td></td><td>Government</td><td></td><td>✓</td><td>×</td><td></td><td>0.001</td><td>11</td><td></td></tr>
<tr><td></td><td>Probability of farming maize (%)</td><td>99</td><td>93</td><td>59</td><td>0</td><td></td><td></td><td></td></tr>
<tr><td>Vegetables (69%)</td><td>Local market</td><td>✓</td><td>×</td><td></td><td></td><td>0.001</td><td>12</td><td>69</td></tr>
<tr><td></td><td>Probability of farming vegetables (%)</td><td>80</td><td>58</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>French beans (49%)</td><td>Agro-exporters</td><td colspan="3">✓</td><td>×</td><td>0.041</td><td>5</td><td>63</td></tr>
<tr><td></td><td>Local market</td><td>✓</td><td colspan="2">×</td><td></td><td>0.015</td><td>5</td><td></td></tr>
<tr><td></td><td>Government</td><td></td><td>✓</td><td>×</td><td></td><td>0.004</td><td>8</td><td></td></tr>
<tr><td></td><td>Probability of farming French beans (%)</td><td>44</td><td>45</td><td>78</td><td>36</td><td></td><td></td><td></td></tr>
<tr><td>Beans (28%)</td><td>Neighbours</td><td colspan="2">✓</td><td>×</td><td></td><td>0.012</td><td>7</td><td>72</td></tr>
<tr><td></td><td>CWP</td><td>✓</td><td>×</td><td></td><td></td><td>0.021</td><td>6</td><td></td></tr>
<tr><td></td><td>Probability of farming beans (%)</td><td>41</td><td>23</td><td>0</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Fruits (24%)</td><td>CWP</td><td>✓</td><td>×</td><td></td><td></td><td>0.006</td><td>8</td><td>76</td></tr>
<tr><td></td><td>Probability of farming fruits (%)</td><td>40</td><td>19</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Peas (19%)</td><td>CWP</td><td>✓</td><td>×</td><td></td><td></td><td>0.002</td><td>10</td><td>81</td></tr>
<tr><td></td><td>Probability of farming peas (%)</td><td>32</td><td>12</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Tomatoes (17%)</td><td>CWP</td><td>✓</td><td>×</td><td></td><td></td><td>0.003</td><td>9</td><td>83</td></tr>
<tr><td></td><td>Probability of farming tomatoes (%)</td><td>30</td><td>11</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Onions (15%)</td><td>CWP</td><td>✓</td><td>×</td><td></td><td></td><td>0.002</td><td>11</td><td>85</td></tr>
<tr><td></td><td>Probability of farming onions (%)</td><td>29</td><td>9</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

3

nor the government would support the decision. There were no significant relations between reference groups and farming of wheat, trees, or drought-resistant crops. Table 3.6 also provides the accuracy of the predictions. For example, in maize farming, the percentage of correct classification was 92%, This signifies a 92% probability that a farmer who the model predicted would farm maize would actually do so. Salient reference groups that had no significant influence on land-use decisions according to the CHAID test were not printed.

c) A combined effect of sociodemographic, geographic location, and social relations
Noting that the theory of reference groups complements other theories, we tested the combined effect of using sociodemographic variables and reference groups in predicting probabilities of farming selected crops. The precision of predictions increases when one combines social demographics, geographic factors, and effect of reference groups as explanatory variables of farmer land-use decisions. To illustrate, exclusive use of sociodemographic and geographic variables as the only influencers of farmer decisions shows no association of these factors with farmer decisions, while use of social relations as the only predictors shows that there is a chance that 72% of farmers would farm potatoes despite a negative opinion from neighbours and local market traders. However, combining all the factors shows that the likelihood that farmers will farm potatoes despite a negative opinion from salient reference groups (i.e., neighbours and local traders) varies with geographic location. For example, farmers in Meru County were more likely (87%) to farm potatoes than those in Laikipia County (64%). Similarly, the probability of farming vegetables varies not only with opinions from local markets but also with land ownership and household size. In Table 3.7, we highlight instances of significant variation in predictors and probabilities of farming select crops while using a combined model. A comprehensive table that includes areas where there were no significant changes is provided in the Appendix (Table 1B).

5. Discussion

In this paper, we used the status-power theory of relations to explore the effect of social relations on farmer land-use decisions. This is in addition to other concepts and theories that have been used before, notably sociodemographic factors, utility theory, prospect theory, bounded rationality, and theory of planned behaviour. Our results showed that sociodemographic factors can be used to predict farming of a few crops, i.e., maize, tomatoes, fruits, and trees. A household with more family members living in the homestead was more likely to farm maize. The results were consistent with other studies in which larger families were found likely to focus on food crops such as maize (Siphesihle and Lelethu, 2020). Since maize and fruits are considered low-water requirement crops, the prevalence of these crops in Laikipia County, which is drier than Meru County, shows

Table 3.7: Presents the percentage of farming select crops using sociodemographic and geographic factors, reference groups, and when using a model combining all three factors. The figures in round brackets show the probability of farming a crop given the predictors. An X before a reference group, indicates instances where the reference group is perceived to be against farming of the crop, while * signifies a combined effect of two factors in a model. For instance, Family*Neighbour means support from both family and neighbour, while Family*XNeighbour means support from family but not neighbour. We note that while there could be other explanatory factors that affect farmer decisions, only a few were tested in this study.

Crop	Sociodemographic & geographic factors model	Reference groups model	Combined model
Potatoes	None	Neighbours (100%) XNeighbour *Local trader (94%) XNeighbour*Xlocal trader (72%)	Neighbours (100%) XNeighbour *Local trader (94%) XNeighbour*Xlocal trader*Meru (87%) XNeighbour*Xlocal trader*Laikipia (64%)
Maize	Hhsize<=2 (31%) Hhsize>2* Laikipia (91%) Hhsize>2* Meru (80%)	Family (99%) XFamily*Local traders*Government (93%) XFamily*Local traders*XGovernment (59%) XFamily*XLocal traders*XGovernment (0)	Family (99%) XFamily*Local traders*Government (93%) XFamily*Local traders*XGovernment (59%) XFamily*XLocal traders (0)
Vegetables	None	Local traders (80%) Xlocal traders (58%)	local traders*own land*HH>5(100%) local traders*own land*HH<=5 (79%) local traders*rented land (60%) XLocal traders*own land (53%) XLocal traders*rented land (76%)
Trees	Age <=45 years (34%) Age >45 years (11%)	None	Age<=45 (51%) Age>45*Neighbours (47%) Age>45*Xneighbours (6%)
Fruits	Off-farm activity (11%) No off-farm activity * Laikipia (34%) No off-farm activity * Meru (14%)	CWP (40%) XCWP (19%)	CWP*Meru (13%) CWP*Laikipia (50%) XCWP (19%)
Peas	None	CWP (32%) XCWP (12%)	CWP (32%) XCWP*Meru (22%) XCWP*Laikipia (6%)
Tomatoes	Off-farm activity (21%) No off-farm activity (7%)	CWP (30%) XCWP (11%)	CWP (30%) XCWP*age>30years (14%) XCWP*age<30years (0)

that farmers did consider ecological factors. This perspective is corroborated by other studies on ecology and land-use decisions (Wanyama et al., 2021; Zobeidi et al., 2022). Regarding tomato farming, farmers engaged in off-farm activities are less likely to farm tomatoes. Although lack of engagement in off-farm activities ensures availability of labour and the care that is needed for tomato farming, this finding is contrary to some studies where alternative sources of income are critical in financing crops such as tomatoes, which need huge capital investment (Giller et al., 2021). In our study, younger farmers were more likely to plant trees than older farmers because of prospective long-term benefits. This finding contrasts with some studies that indicate older farmers are more likely to plant trees because of their prolonged interaction with the environment and understanding of the importance of tree planting (Wijayanto et al., 2022).

Other variables exist that were not significant in this study but have been attributed to land-use patterns. For example, farmers with greater land sizes were found to engage in more sustainable management practices (Kansanga et al., 2021; Oduniyi, 2022) and were likely to invest in tree planting (Beyene et al., 2019; Kansanga et al., 2021; Lambert and Ozioma, 2012; Oduniyi, 2022; Pello et al., 2021). Farming of traditional crops was found to be significantly influenced by a farmer's age or level of education (Brown et al., 2019; Dhraief et al., 2018; Jha and Gupta, 2021; Lambert and Ozioma, 2012) while larger households were likely to adopt new land-use practices (Bartkowski and Bartke, 2018; Kansanga et al., 2021). Finally, an increase in land, labour, capital, and knowledge was likely to increase sustainable crop production (Marinus et al., 2022).

Besides sociodemographic factors, there are economic and ecological perspectives on farmer land-use decisions. In our study, most farmers prioritised potatoes and maize farming, while fully aware that these crops are less profitable than other crops such as French beans or snow peas. This finding fits the prospect theory (Kahneman and Tversky, 2013, 1979), in which farmers would be expected to choose safe options to avoid losses. Potatoes and maize are considered less prone to losses since they can be consumed in the family, are easy to store for a longer period and can also be easily sold in the local market. Moreover, crops such as French beans are mainly grown as a cash crop, making them vulnerable to market dynamics, and they are also difficult to manage after harvesting. It is then understandable that farmers would choose a crop that has sure gains and avoid crops that are subject to possible losses. Farmer land-use decisions have also been attributed to limitations of knowledge, cognitive ability, and time (Simon, 1990). An increase in either of these attributes has been found to increase chances of sustainable crop production (Hammond et al., 2021; Marinus et al., 2021). This is confirmed in our study where export crops (French beans, garden peas, geraniums, basil), despite their possible good profits, were not common due to limited knowledge of markets and how to farm them, in contrast with crops such as maize and potatoes about which farmers have extensive knowledge.

In this study, sociodemographic factors could only account for decisions on a few crops. Further, while some results are consistent with past studies, others are contradictory. This contradiction is not an exception; an analysis of past studies also shows that findings using sociodemographic factors, economic and ecological perspectives have been inconclusive (Githinji et al., 2023). Furthermore, those studies which used the theory of planned behaviour to capture the effect of attitudes, norms and perceived behavioural control on farmer land-use decisions have produced varied results (Borges et al., 2016, 2014; Lalani et al., 2016). This could be because there was no shared norm. From the perspective of the theory of planned behaviour, social norms are inculcated by a society holding an opinion that is shared by all individuals. From Kemper’s perspective, this would imply that all farmers have the same salient reference groups with the same opinion, for instance, which type of crops should be farmed. This would constitute a norm across those reference groups. In instances where this holds, predicting behaviour using the theory of planned behaviour could be accurate, but this is not always the case. We use Kemper’s theory as an approach that acknowledges existence of multiple reference groups with divergent opinions affecting the decision process. Kemper’s theory uses the status-power analysis to determine which reference groups mould observed behaviour.

5.1 Social relations as an additional perspective on farmer land-use decisions

The contribution of Kemper adds another perspective to farmer land-use decisions. It makes explicit which reference groups matter to farmers when they decide on their land use. Farmers’ land uses may vary across farmers who have the same sociodemographic characteristics, as a result of the weight that individual farmers place on specific reference groups. From Kemper’s perspective, since farmers seek to please their salient reference groups (Kemper, 2017), we expect a perceived opinion from a salient reference group, whether positive or negative, to have a significant effect on land-use decision. To a substantial extent, our results concur with Kemper’s theory. Indeed, farmers practice land-use options that they believe would please their salient reference groups. For example, none of the farmers would farm maize if they believed family and local market traders would not support the option. The probability of farming maize rises to 99% if they believe that their family, which is a particularly important reference group, supports maize farming. The same applies to most of the other land-use options. Reference groups ranked as the least important have less or no influence on the farmers’ land-use decisions. For instance, downstream communities and ancestors do not have any significant relations with any of the land-use options. Although ancestors were perceived to have a strong negative opinion on French beans, tomatoes, onions, fruits and wheat as viable land-use options, their influence on these crops was not significant, as a result of the low salience of this reference group. Downstream communities would be expected to have a strong opinion and possibly influence on some crops, especially high-water requirement crops since they affect water availability downstream. However, our results contradicted this expectation. Apparently, farmers considered downstream communities as having little authority over water regulation and most of the land-use options, making them less salient.

Puzzlingly, we have instances where, irrespective of a negative opinion from a salient reference group, a substantial percentage of farmers would still farm the crop. For example, 78% of farmers who got a positive opinion on French beans farming from agro-export companies were likely to farm the crop despite perceiving a negative opinion from government and local markets. The move to defy the perceived negative opinion could have been largely attributed to other factors. French beans are grown mainly for the export market and more specifically Europe. The highest export market demand and consequently the best prices for the crop are between October and April, during and slightly after the winter season in Europe. During the period within which these data were collected, i.e., November, there was a high likelihood that, despite farmers' respect for local market and governments, their negative opinion would carry less weight than the positive opinion from agro-export companies. This result does not discount the effect of government or local markets; rather, it implies that the reference group that offers/provides more economic benefits, for instance the agro-export company or family, takes precedence.

Economic, ecological, and social-relational perspectives can be interrelated, and if used simultaneously, they could increase understanding of farmer land-use decisions. The expected utility, defined by economic models, can be attributed to the perceived preferences of reference groups. If farmers believe their salient reference groups would be pleased with land-use decisions that maximise economic or ecological gains, they are likely to implement such decisions. Basically, reference groups mould an individual's priorities. A strong contribution of Kemper's theory is that it explains why farmers with the same demographic characteristics and context would make different land-use decisions. Noting the significant role of reference groups, it would then be important to know i) what makes a reference group gain or lose its salience, and ii) what informs farmers' perception of preference of reference groups.

5.2 Salience of reference groups

The salient reference groups were family, community water project (CWP), agro-export companies, local market traders, government, neighbours, downstream communities and ancestors among others. This finding is in line with those of studies conducted in the Upper Ewaso Ngíro North River basin where neighbours, friends, family, community leaders, extension workers, and community water project members were found to influence land-use decisions (Giroux et al., 2022; McCord et al., 2015). Ancestors were considered the least important reference group. This is possibly because most of the farmers, who came from different parts of Kenya, settled in the region more than 20 years ago, and their norms blended with time into one, forming new practices that were compatible with local conditions (Giger et al., 2022). This scenario may change if a similar study is conducted in an indigenous community which these farmers originated from; there is likely to be a self-selected difference between those who emigrate and those who stay.

5.3 Farmers’ perceived preferences of reference groups

Farmers believed that family preferred land-use practices that would ensure there is enough food and income. Hence, family was perceived to support all crops except drought-tolerant crops, and wheat, which takes longer to mature and has less profit. Notably, since family is the most salient reference group on average, the dominant food crops are those that can also be easily sold in the local market such as maize, potatoes and vegetables. The CWP was perceived to be supportive of options that led to protection of the water tower and less abstraction of river water. This is in line with the CWP policy documents (Kenya Water Act., 2016) and other studies on community-driven water projects (Dell’Angelo et al., 2016; Gidey and Gidey Weldeabzgi, 2021; Villamayor-Tomas and García-López, 2017). The agro-export companies and local market traders were perceived to be interested in land-use practices that would produce enough crops for the export market, such as French beans, peas, and fruits, as well for the local market, including such as maize, potatoes and vegetables. The government was perceived to be more supportive of most of the crops, since its main intention is to ensure adequate food production and income generation across seasons for its citizens. Most of the farmers felt neighbours and downstream communities did not strongly support or object to any land-use option. Unlike the other reference groups, neighbours rarely voiced their preferences and despite the influence from neighbours, it was difficult for a farmer to establish what their neighbours supported or opposed, and hence settled for the neutral option. Downstream communities were perceived to be neutral on most of the crops, including those with a high-water requirement. This was an unexpected result, since there is documented evidence of persistent water-related conflicts between pastoralists in the downstream and crop farmers in the upstream, originating from what downstream communities consider as excessive irrigation in the upstream region (Gichuki, 2002; Kiteme, 2020; Lesrima et al., 2021; Mutiga et al., 2010). This could mean that although farmers were aware of the downstream communities’ preferences, this awareness yielded to the need to please other reference groups. Possibly it was easier for the respondents to present themselves as less aware of the opinions of downstream communities than to seem unempathetic to them. Continuous engagements on shared platforms with farmers across the landscape could possibly generate empathy and status-worthiness of the downstream communities.

6. Conclusion and future research

We explored farmer land-use decisions from the perspective of social relations using the status-power theory of relations. The study indicates how the status-power theory of relations can complement other theories and help explain inconsistent results. The theory views human life, including decision-making processes, as happening within the context of social relations. It posits that farmer land-use decisions are not only influenced by prospective loss or gain; attitudes towards an option; limitations in knowledge, cognition or time; or farmer's sociodemographic and geographic location. Apart from these factors, farmers associate with salient reference groups that they try to please to gain status in the group's eyes, and whose power use against them they try to avoid. A limitation of using status-power theory of relations is that most of the time individuals may not be aware of which reference group moulded their decisions. Additionally, it may be difficult to differentiate whether a reference group used status, power or both to influence a decision. Our data relied heavily on authors' judgements of the respondents' statements. Despite these limitations, we were able to produce a rich data set from which we drew our conclusions. Using empirical data from the Mt. Kenya region, we note that i) reference groups exist with various levels of salience, i.e., combinations of status-worthiness and power; ii) farmers had a perception of which land-use options their salient reference groups would like them to choose; and iii) these perceptions did indeed influence land-use practices. Therefore, researchers and policy makers should identify and account for the effect of social relations on farmer land-use decisions within and across groups. One way to do this is through consultation and active engagement of stakeholders, including local stakeholders in a shared platform. This platform would acknowledge that farmers on the same landscape have vastly different reference groups: for instance, some might love and admire the water regulatory bodies, while others despise them. Farmers are also likely to disagree about measures such as water regulation. However, the shared platform would also generate discussions that clarify areas of misunderstanding and congruence of opinions.

We note that the effect of social relations on land-use patterns (which farmers use land in what way) likely varies with culture. The more the prevailing culture has strongly embedded relational ties (in other words, the more collectivistic and hierarchical it is), (Hofstede et al., 2010), the more one expects an important role in decision-making for relational factors such as obedience, allegiance, and loyalty, and other non-economic factors as well. Apart from these considerations, other significant factors will be social diversity (for instance, migrant, or long-term settled communities), geography (homogeneous lowlands or structured mountain systems) and accessibility patterns (for instance, distance to markets). Although our study did not include cultural dimensions, exploration of social relations in a cross-cultural setting would be an interesting topic for future research.

Chapter 4

Collective action for sustainable farmer water management: The case of KILIMO NA MAJI serious game

The Chapter is based on:
Githinji, M., Speelman, E. N, van Noordwijk, M., Muthuri, C., Hofstede
Hofstede, G. J. (2024). Collective action for sustainable farmer water management: Kilimo na maji serious game.
The paper is currently under review for the Simulation and Gaming Journal

Abstract

Background: Farmers in water scarce landscapes adapt in response to the erratic weather conditions. Adaptation through irrigation, depend on water access, while impacting on downstream water availability. Competition for **scarce water commons** among multiple users defines a **collective action** problem. Farmer land- and water-use **decisions** are based on both economic rationality of cost-benefit expectations, and relational rationality of reconciling conflicting opinions of important person(s) in a farmer's social world, such as other water users, government, or spirits. **Serious games** that represent this duality of choices can help both players and interested others to analyse how **social relations** influence farmer decision-making.

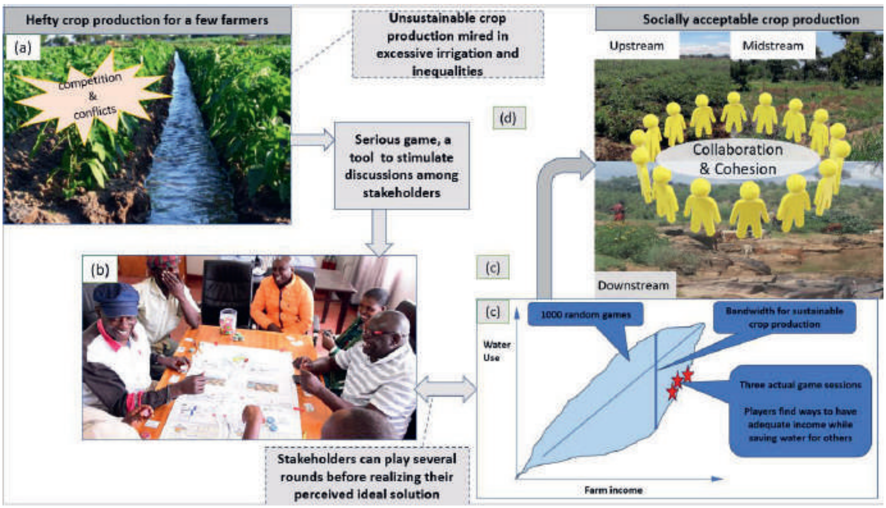
Intervention: Here we describe the generic design and early experiences with specific use of the KILIMO NA MAJI game. The game is designed to analyse effect of social relations as farmers individually and/or collectively explore alternative options for crop production in scarce water commons.

Methods: We designed and applied the game in the Mt. Kenya region; a semi-arid region, ranging across a gradient of upstream water abundance to downstream water scarcity. The design of the game was informed by literature, and information from local stakeholders. We analysed data from the pilot game sessions to assess effectiveness of the game.

Results: The game defines a '**solution space**' with a bandwidth around the mean where trade-offs between farm-income and water-use can be partially managed. Playing the game with local stakeholders showed that social relations that participants had with traders, agro-export companies and other important persons determined where their game outcomes were positioned within the solution space.

Conclusion: Playing KILIMO NA MAJI can help assess influence of social relations and support collective exploration of alternatives to crops production in water scarce landscapes.

Graphical abstract



KILIMO NA MAJI game prompts discussions to transition farmer decisions from individual interests in (a) to collective and socially acceptable crop production in (d). (b) Farmers explore options for crop production in a game session. (c) shows all possible results where farm-income and water-use can be partially managed in a game session and three results from an actual game session.

Keywords: Collective action; farmer decisions; Mt. Kenya; serious games; scarce water commons; social relations

1. Background

Farmers in regions with seasonal droughts adapt their land- and water-use decisions to sustain crop production for food and income during dry season. They adapt in several ways which include farming drought tolerant crops, shifting planting seasons, and practicing irrigation (Kom et al., 2022; Ng'ang'a et al., 2021; Njinju et al., 2022; Peter & Imatari, 2019; Pilarova et al., 2022; Ratemo et al., 2020; Sindhu et al., 2019; Sollen-Norrlin et al., 2020; Van Noordwijk, 2019). Although irrigation can sustain crop production over dry periods in certain areas, it meets with socio-economic, technical, and institutional challenges (Fanadzo & Ncube, 2018; Kanda & Lutta, 2022; Pilarova et al., 2022; Timothy et al., 2022). Unregulated irrigation from common water resources more often leads to conflicts among the multiple users who depend on the same common water resources. Governing the commons becomes a collective problem in instances where individual interests supersede shared goals (Janssen et al., 2023). Despite possible self-interests, individuals are capable of self-organizing and shifting focus from individual interests to shared goals (Ostrom, 1990). Collective action is built on trust and cooperation (Ostrom, 1990). It starts with understanding the impact of one's actions and willingness to sacrifice one's own interests for the common good.

Researchers and policy makers have used participatory approaches to create this understanding among stakeholders and to promote collective generation of local and sustainable strategies to management of resources (Tolno et al., 2015, Mohamed Gedi et al., 2019, McConville et al., 2023). Such approaches include, among others, serious games. Serious games represent real systems in a simplified model that participants (community, researchers, and policy makers) can engage with on a shared-learning platform, experiment and experience impacts of their decisions, learn, reflect, built trust, and jointly identify alternative sustainable options in a safe environment (Biggs et al., 2021; Edwards-Jones, 2006; Falk et al., 2023; Fjællingsdal & Klöckner, 2020; Janssen et al., 2023; Kriz, 2017; McConville et al., 2023; Speelman et al., 2018, 2023; Toshiko et al., 2022; Van Noordwijk et al., 2020). In addition, serious games have been said to strengthen problem solving skills and decision making of the players through experimenting and observing outcomes resulting from different strategies (Janssen et al., 2023; Fjællingsdal & Klöckner, 2020; Toshiko et al., 2022). Serious games have been developed and used in various fields including climate change, land, water, and environment management (García-Barrios et al., 2008; Janssen et al., 2023; Lairez et al., 2020; Rakotonarivo et al., 2021; Rooney-Varga et al., 2020; Sari et al., 2023; Sterman et al., 2015; Villamayor-Tomas & García-López, 2017; Villamor & Badmos, 2016; Villamor & Van Noordwijk, 2011). Serious games have also been used for diagnosis of a phenomenon; establishing a better understanding of land-use decisions and their impacts on water flow among local stakeholders; and instigating responses from external stakeholders including support to collective management of shared water resources (Edwards et al., 2019; Janssen et al., 2023; Toshiko et al., 2022; Van Noordwijk et al., 2020).

In the context of farmer land- and water-use decision making, relevant games include, RIPERWIN River Basin Game (Lankford et al., 2003) that was developed to enhance farmers understanding of their role in water management, explore solutions and engage institutions in looking for alternatives in improving water supply in an up-downstream gradient of farms; MEDTER game (Le Bars et al., 2004), designed to enable actors (farmers) make individual decisions but also to discuss with other actors on land-use options that balance water demand and availability; Aquafej (Bars et al., 2014), designed to increase farmer's awareness on water sharing and scarcity based on their decisions; FOWIS (Hertzog et al., 2014), developed to increase awareness on land- and water-use choices, experience consequences on water availability and explore options for better water management in Mali; Wat-A-Game (Ferrand et al., 2009) , a generic game designed to support management of common pool resources with participation of both local stakeholders and external actors (e.g. policy makers); and CAPPWAG (Loudin, 2019) designed to assist a researcher in assessing the capability of players in making individual choices, collective diagnosis of a problem and development and implementation of water management rules.

In a game session (including the ones we have mentioned), participants are presented with rules to engage with the game, test possible interventions and explore alternative outcomes (Biggs et al., 2021; Edwards et al., 2019; Toshiko et al., 2022). However, it is not always that players play by the rules, other social and cultural factors can affect decision making processes in the game (Edwards et al., 2019; Hofstede et al., 2010; Van Noordwijk et al., 2020). Although serious games have been used widely to explore decision making process, there has been less emphasis on the effect of social relations compared to instrumental rationality (Githinji et al., 2023; Van Noordwijk et al., 2023). Instrumental rationality places value on economic and ecological benefits, and relational rationality weighs rationality from the perspective of relations that individuals have with their social world (Hofstede et al., 2019; Van Noordwijk et al., 2023). Social relations that individuals have with their reference groups affect their decisions. A reference group is an individual or group of individuals which a person considers while making decisions (Kemper, 1968, 2017). Reference groups can be alive (for instance neighbours), or dead (for instance ancestors); real or imagined (for example spiritual deities). Reference groups can be tutelary making their preferences known to the individual for instance government, and/or models whose behaviour is to be emulated for instance peers or other players in a game (Kemper, 1968, 2017). An individual complies with the perceived preferences of a reference group either voluntarily (status-accord) out of respect, love, concern expecting to be accorded the same, and/or involuntarily to avoid power use for instance punishment, surcharge (Kemper, 1968, 2006, 2011, 2017). Accordingly, players may make decisions that aim to meet individual or collective goals depending on salience of their reference groups.

In a game session, reference groups that are already existing in a player's mind (for instance family, or local market traders), in the room (for instance other players or participants), and/or those who emerge during a game session can influence the player's decision. A player may have multiple reference group, some more salient than others. Reference group influences a player action depending on their relative salience compared to others. According to Kemper (2017), people who are wealthier, more educated and those in leadership positions are likely to be accorded more salience. Such people may become a salient reference group in a game session if other players are aware of their status-power standing in the society. Further, at times power wielded by an institution may be confused with power of an individual representing the institution (Kemper, 2017). Thus, other players may do the binding of such an individual. Some players may also gain status during a game session, for instance if they seem to understand the game better or if they make more profit. These players in turn may unintentionally affect decisions of others in subsequent rounds. Additionally, a game session can evoke emotions creating new reference groups whom players' feel the need to do their bidding. In a game session, players can observe the landscape as a whole; see and feel the impact of their action and that of others possibly generating an array of new emotions that can steer cooperation among players.

Figure 4.1: Players use KILIMO NA MAJI game to identify feasible options to produce crops with the limited water. Thought clouds on the left indicate economic rationality while those on the right show social relations rationality.

Despite possible effect of social relations on a game's outcomes, most of the games that have been used to explore farmers' decision making have not explicitly explored the effect of social relations as a concept in decision making processes. More specifically, a game that can capture the effect of social relations in areas characterized by pressures to increase crop production amidst water scarcity, to our knowledge, does not exist yet. To address this gap, we designed and used a serious game to analyse the influence of social relations. This paper has two main objectives, i) to describe the design of KILIMO NA MAJI (meaning farming and water in Swahili language), a serious game designed to engage stakeholders in exploration of land and water management options that would sustain crop production in water scarce landscapes, and ii) present results from two game sessions providing insights into application of KILIMO NA MAJI game and analysis of game's outcomes from a social relations perspective. To achieve the objectives, KILIMO NA MAJI was developed and piloted in the upper Ewaso Ng'iro North River Basin in Mt. Kenya region.

2. Design of KILIMO NA MAJI

2.1 Game objectives

The game has two main objectives i) provide a shared platform for stakeholders (farmers, regulators, policy makers and researchers) to jointly experiment various land- and water use options, observe impacts, reflect, and generate alternatives to sustainably produce crop with scarce water; and ii) Support exploration of the influence of social relations on player decisions and game outcomes.

2.2 Game features

2.2.1 Game board

The game board simulates a landscape occupied by smallholder farmers and a shared river that flows and serves up-, mid-, and then downstream communities (Figure 4.2a).

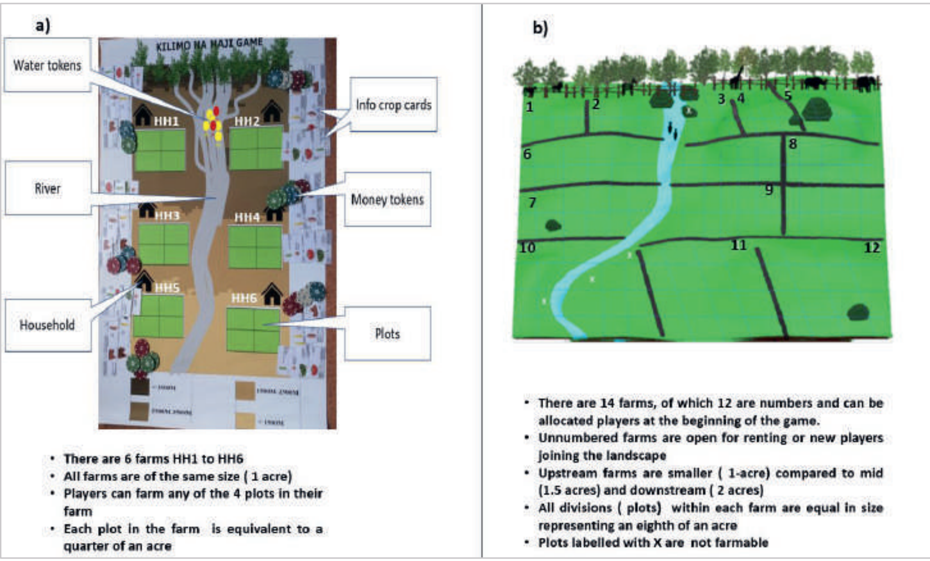


Figure 4.2: Two types of the game board with distinctive features. on the left we have we have a more abstract game board with six players and equal sizes of land. on the right we have a more complex game board of 12 players with varied sizes of plots from small, medium to large farms.

The landscape has farms; each farm has four plots equivalent to a quarter ha and is managed by an individual household (player). The game board can be expanded (Figure 4.2b) or contracted to have more or less plots depending on the objectives of the user. While a game with more plots – hence more players – can generate more discussions, the game may take more time and possibly need more than one facilitator to track players' actions and discussions. The minimum number of plots and players on the game board should be at least three plots to represent up-, mid-, and downstream regions.

2.2.2 Cards & tokens

Kilimo Na Maji has info crop cards, tree models, water, and money tokens.

a) Info crop cards (Figure 4.3) are in three categories – *Category A: High Water Requirement Crops (HWC)* for instance French beans, tomatoes, vegetables, and onions. These crops are highly profitable, but a farmer must irrigate to get a good harvest. *Category B: Medium Water Requirement Crops (MWC)* for instance maize, and potatoes. In this category, profits are lower than HWCs, crops can serve as family food, and do not have to be irrigated to get a good harvest. *Category C: Low Water Requirement Crops (LWC)* for instance cassava. These crops may have low profit margin, but they can survive though seasons without irrigation.

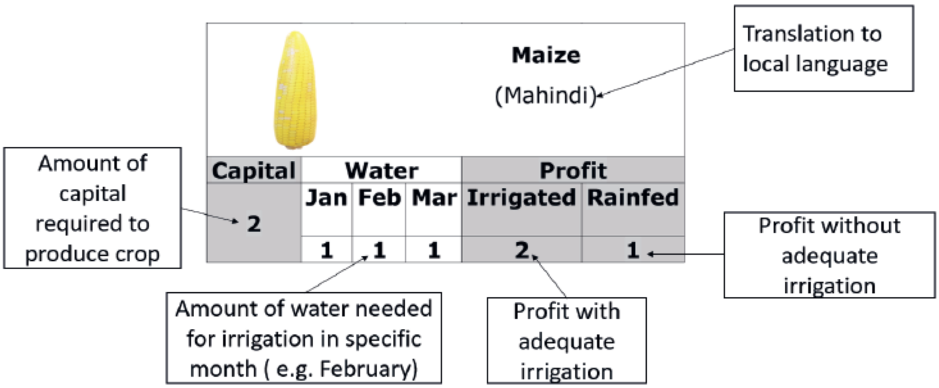


Figure 4.3: Info Crop Card. Each player is issued with three types of cards: low-, medium-, and high-water requirement crops. The info crop cards have name of the crop with its translation into local language, capital investment (in cash tokens) required to farm the crop, a crop's water irrigation needs per month (in water tokens), expected profit if crop is irrigated as required, and profit if the crop is not irrigated or is inadequately irrigated.

b) Tree models – usually given out for free by the government (the facilitator) in support of agroforestry.
c) Water tokens – 1 token represents 300 MM of water volume. There are twelve sets of water tokens representing mean monthly river flow for every month of the year.

At the beginning of each month, the facilitator places the monthly water tokens on the simulated river ready for any extraction by players. A table of coded river flow information from our pilot case study site is presented in Appendix 2A, Table 2B.

d) Money tokens – can be in terms of fake currencies, tokens of a certain value or made-up print outs of a specific value to allow transactions e.g., paying out the required capital.

2.3 Game play conditions

Playing the game requires a large room (or open space) with a table where the game board is placed. Players sit around the table and adjacent to their allocated plots. This is to allow easy access to their plots where they will be required to place their chosen info crop cards. Ideally, players should be seated throughout the game for their own comfort and for the facilitator to be able to get a better view of the whole game and players' actions.

2.4 Participants, players, and roles

a) **Players** – The Kilimo Na Maji game has players playing the role of farmers making decisions on what to farm, whether to use irrigation, or whether to collaborate and with whom.
b) **Reference groups** – Noting that social relations are a key component of this game, the role of reference groups need to be clear. A game can have three types of reference groups '*visible*' (such as government, water regulatory body, agro-export company, brokers, NGO), the '*invisible*' (such as ancestors and family) and '*somehow visible*' (such as neighbours and downstream farmers). A facilitator can approach the role of 'visible' reference groups in three ways as shown in Table 4.1. Where facilitator choose to have farmers play the role of reference groups, these actors should be adequately briefed. Optionally, they can be allowed to have flexibility to simulate how they perceive reference groups.
c) **Policy maker** – the policy maker is the person in charge of administering set policies on water regulation. In the Kenyan context, this was chairperson of Water Resource Users Association (WRUA) or his representative. In the game, the person has three roles: a) regulate water use by prohibiting extraction of any more tokens or fine players for over-extraction of provided tokens; b) advice on water use c) in cases where players do not self-organize for better water management, the policy maker can initiate collective action discussions.
d) **Logistics manager** – is charged with invitation of participants as per the researchers' requirements, organizing the game room to the comfort of the players and other logistics.

Table 4.1: Pro and cons on different approaches to reference group actors

	Approaches to reference group players	Pro	Cons
1	Farmers play the role of reference groups	Identify farmers' perception of the reference groups	A possible misrepresentation of preferences of the reference groups since farmers may not fully understand the role of reference groups
2	Real world reference groups play as themselves e.g., have a government representative	Reference groups get to understand and clarify any misconceptions farmers may have on them	Too powerful/ high-status reference group may interfere with players' actions
3	Reference groups exist entirely in the minds of the players	The option is close to reality since ideally reference groups exist in the minds of individuals. It may also take less time to play the game	May be difficult to identify salient reference groups and their influence

e) **Facilitator** – is charged with briefing and debriefing of the participants. Specifically, before the game starts the facilitator explains the basics of the game, its objectives, how to play and the general conduct of all the participants in the room. The facilitator also explains and responds to any questions participants may have during the game playing session. Afterwards, the facilitator guides the debriefing session. The researcher can also hold the role of the facilitator.
f) **Observer** – silently observes all the proceedings for later discussions during the debriefing session or for later discussions with the researcher.
g) **Camera person(s)** – to record all the proceedings for later use by the researcher in the analysis.

2.5 Rules of the game/decision tables

The Game has three tables representing the rules of the game. The most critical rules are also included in the info crop cards i.e., capital required, profits, and monthly irrigation requirements.

a) Coded crop irrigation requirements – this data is generated using CROPWAT based on climate data/ET, rainfall, crop requirements, soil type, cropping pattern, and proportion of acreage under a particular crop. The data is coded to manage the number of water tokens availed to the players and adjusted to account for farmers' perceived crop water requirements.
b) Crop characteristics – maturity duration, capital investment, labour requirements, land rates (rent), profit margin with and without irrigation, price fluctuation. Although all this information increases representation of reality, it was noted that

it can be overwhelming for players. In cases where time is limited, some of these elements can be omitted.

c) Reference groups (optional)– reference groups accompanied by their perceived preferences, rules, incentive, and sanctions for non-compliance with their rules.

2.6 The Game processes

KILIMO NA MAJI game has three stages: stage 1 comprises of activities before the game, stage 2 is the game playing session while stage 3 is the Debriefing session.

Stage 1: Before the game

a) Players' sociodemographic data is collected including, age, gender, economic activity, level of education, leadership, and geographic location. The role of each player is noted i.e., those who will play as farmers or those who will play the role of reference groups. Farmers' data is linked to the plots they will be allocated on the game board. Farmers' (player's) data is collected since it can give an indication if a player could be a salient reference groups before the game starts. A farmer's sociodemographic data can be used as proxy indicators for status and power. The facilitator should also find out if other participants are aware of each other's status and power by asking whether they knew each other before the game.
b) Players are briefed on how to play, and the available land- and water-use options. Options include trees, crops, and irrigation (done by picking the water tokens). Basic rules include: a farmer can choose more than one crop but may be limited by available resources; farmers can talk and discuss among themselves; reference groups (if in the room) can share their land- and water-use preferences with the farmers.
c) Facilitator and players discuss on other possible decisions such as: repeating/ changing crop over the seasons, deforest/harvest/prune trees, expand land for crops, abandon/sell/fallow land, sub-division of land. This is to allow creativity of players as well as identify some options that could have been left out.
d) Reference group players (if any) are briefed on their roles. Such roles include giving input subsidies; sanction for unacceptable behaviour; advice on crops to adopt; buy crops. A sample of the reference group roles are presented in Appendix 2A, Table 2E.

Stage 2: Playing the game

Players are allocated plots on the game board, set of crops cards, and money. One round represents a season (Figure 4.4). Each round has monthly sub-steps which farmers choose to irrigate their crops or not. The session has six main steps with one round taking approximately 30 minutes.

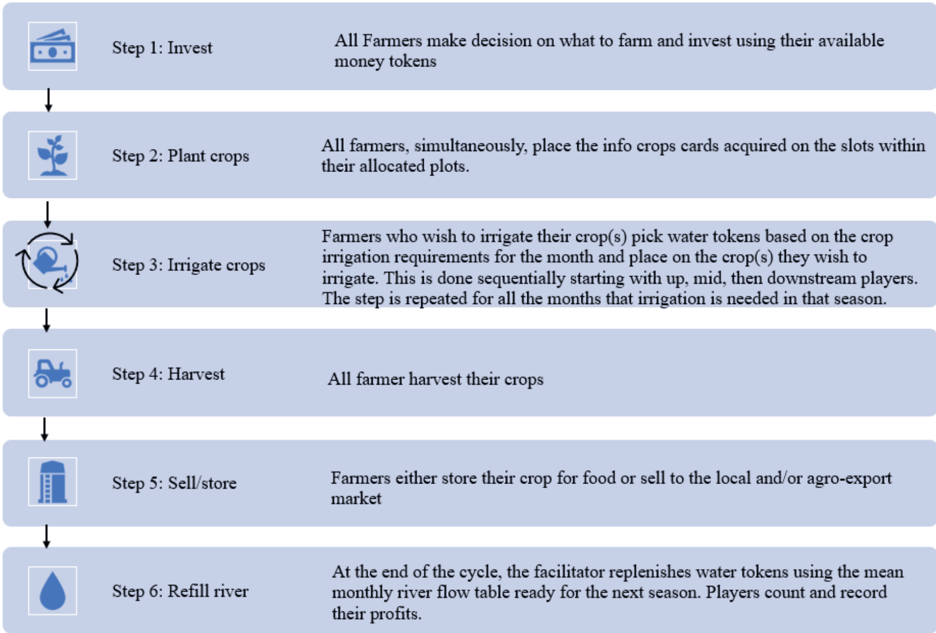


Figure 4.4: Steps in KILIMO NA MAJI game play session. These steps are repeated until players identify alternative options to sustainably produce crop amidst water scarcity. Subject to availability of water, step 3 is repeated for all the months that irrigation is required, otherwise, players move to the next step.

This game is played by six smallholder farmers(players). After the briefing session, players assess their land- and water use options and potential economic and ecological outcomes before making three main decisions i.e., what to farm; whether to irrigate; to collaborate or not. At the beginning of each round, all players select crop(s) to farm, invest some money tokens on their choices and place these crops on their allocated plots. The next decision is whether to irrigate or not. Failure to irrigate crops that need irrigation leads to less profit. One round represents a season. Each round has monthly sub-steps for irrigation. At every sub-step, farmers interested in irrigation pick the available water tokens starting upstream, then midstream and finally downstream. At the end of the sub-step, facilitator refills the river with new water tokens as per the mean monthly river flow table. This step is repeated for all the months that crops need to be irrigated. At the end of each round, farmers harvest and sell their crops. Players earn income depending on the type of crop and whether the crop was irrigated as required. The target for each player is to earn a good income but also to avoid conflicts. Considering that water tokens are limited, irrigation by one player means less water tokens and profit for the other player. Therefore, players must decide on whether to collaborate and take collective actions or not. Under collective action, players look for alternatives that would be acceptable to all players. The game continues until players can sustainably produce crops with the available water. During this stage, the facilitator takes note of any emerging social relations and its effects by observing player actions, and discussions among players. For instance, who is copying who, who is advising whom, whose actions caused a change in another player's action. This is because it is not always that people would be able to identify the relative importance of a reference group (which reference group influenced their choices), but it can be reflected in the choices they make during a game session. While transiting from one round to the next, facilitator can choose to allocate plots differently in view of assessing any change in farmer decisions while placed in a different part of the landscape. The two options are:

Scene 1: Farmers play as their own selves at the landscape i.e., upstream play as upstream farmers, and so does mid and downstream farmers. This setting represents the existing situation and helps understand the existing issues/ problems and their causes. In a landscape characterized by water related conflicts, players may be uncomfortable to play their own roles due to a possible infiltration of real-life frustrations in a game session. The facilitator should be weary of such cases and can avoid conflicts by opting to play scene two.

Scene 2: Farmers shift places. Balloting or a dice will be thrown to allocate farmers their lands. Farmers will only be allowed to draw ballots outside their actual locations. This setting is not only ideal for avoiding tension in an already water-conflicted landscape but can also be ideal in ensuring advantaged players experience and feel the impact of their actions and generate empathy for the disadvantaged farmers. The scene may also make players understand how they are perceived by other players through their actions.

Stage 3: Debriefing session

After the Game, the facilitator leads a debriefing session where players discuss the game, motivation for their choices, and extent to which players were able to learn from the exercise. In this stage, the facilitator should identify what kind of social relations impacted player decisions. Specifically, the effect of already existing relations with reference groups in the minds of the players; effect of other participants in the room; and the effect of emerging relations during game play. Assessment on social relations can be obtained by asking players what informed their choice/ who benefits from their choice of crop/ why they choose a certain practice. Other questions should be around the game quality: its functionalities, its representation of the actual context, the extent to which farmers are able to learn from the game and policy recommendations. A Likert scale questionnaire can be used to assess the quality of the game. The Likert scale and a sample of debriefing questions are provided in Appendix 2A (Table 2H), and Appendix 2B, respectively.

2.7 Adaptation of the game

KILIMO NA MAJI game is a generic game that can be adapted to different socioecological systems by changing the crop choices, crop irrigation requirements water tokens, reference groups, cash tokens, and sometimes the game board. A detailed procedure of 'how to' is provided in Appendix 2A.

3. Application of KILIMO NA MAJI: Results from two games sessions

KILIMO NA MAJI was piloted in the Upper Ewaso Ng'iro North River Basin to test its effectiveness in achieving its two objectives. The pilot site lies in the leeward side of Mt. Kenya. It forms part of the arid and semi-arid lands in Kenya with an average of 2000 mm rainfall per annum in the upstream and less than 350 mm per annum in the downstream (Kimwatu et al., 2021). Despite the limited rainfall, the region has high agribusiness potential supported by irrigation. The Government of Kenya with partners, implements several interventions to promote sustainable crop production while regulating water use. The interventions include a polycentric governance structure that manage water resources from national to community level. The governance structure includes a community-based water management institution known as the Water Resource Users Association (WRUA). WRUA manage specific water sheds with the main role of monitoring water use and curbing misuse. Despite this, a large amount of water is extracted for irrigation in the up and midstream region, leaving little or no water for downstream communities, often leading to water-related conflicts (Kiteme, 2020; Lesrima et al., 2021). In its application, KILIMO NA MAJI was adapted to incorporate features from the case

Table 4.2: Players' sociodemographic characteristics in the two application sessions

		Characteristics		
	Group	Average	Min	Max
Age in years	1st	36	27	42
	2nd	53	45	65
Gender	1st	Male (3), Female (3)		
	2nd	Male (4), Female (2)		
Level of education	1st	Secondary (5), tertiary (1)		
	2nd	Primary (2), Secondary (4)		
		Average	Min	Max
Land size in hectares (owned)	1st	0.5	0.0	2.4
	2nd	1.2	0.4	2.0
Leadership	1st	1 out of the 6 held different leadership positions		
	2nd	All six held different leadership positions		

study site to present an interactive game with the right amount of pressure for players as they make their land- and water-use decisions. Two sub-watersheds (*Nanyuki* and *Teleswani*) in the Upper Ewaso Ng'iro North River Basin were used in the pilot sessions. Players' sociodemographic characteristics for each sub-watershed are shown in Table 4.2. 1st group comprised of members from *Nanyuki* sub-watershed while 2nd group were from *Teleswani* sub-watershed. Players were randomly selected within stratified group that represented up-, mid-, and downstream zones.

3.1 Data collection

Our game sessions had three stages of data collection, before, during and after the game. Before the game, farmers' characteristics were recorded, i.e., age, gender, level of education, land owned in hectares, positions of leadership held and location (up-, mid- or downstream farmer). During game playing stage, data on a player's crop selection, use of irrigation or not and income were recorded on data sheets. Interactions among players and discussions during this session were also recorded. After the game (debriefing session), the facilitator used guiding questions (sample provided in the Appendix 2B) to guide a focus group discussion with participants. All game sessions were also video recorded, and photos taken to support analysis.

3.2 Data analysis using the 'solution space'

To test the capacity of the game in achieving its main objectives, we introduced an innovative approach of using the 'solution space.' In KILIMO NA MAJI, farmer decisions could lead to different land- and water use choices with direct impact on farm-income and water availability. This gives a wide range of possible outcomes, 'the Solution space.' The solution space was developed by running 1000 random choices thereby generating 1000 possible outcomes; equations used to generate the solution space are provided in Appendix 2A, Table 2I. There is a bandwidth around the mean that suggests trade-offs can be partially managed, for instance by limiting water use in dry season, or by increasing water availability through water harvesting. Two variations of the solution space were i) players make random choice of crops but follow water sharing rules i.e., extract only the amount of water required by each crop starting with upstream players, followed by midstream and finally downstream (Figure 4.5 a, b, c); ii) players make random land- and water use choices without following any rules (Figure 4.5 d, e, f). In the first option, the outcomes in the solution space were further disaggregated by different player groups i.e., up-, mid-, and downstream. The solution space showed that in a dry season only the upstream players benefit (Figure 4.5 a), while a dry season with water harvesting is like a wet season where everyone benefits since there is enough water (Figure 4.5 b, c).

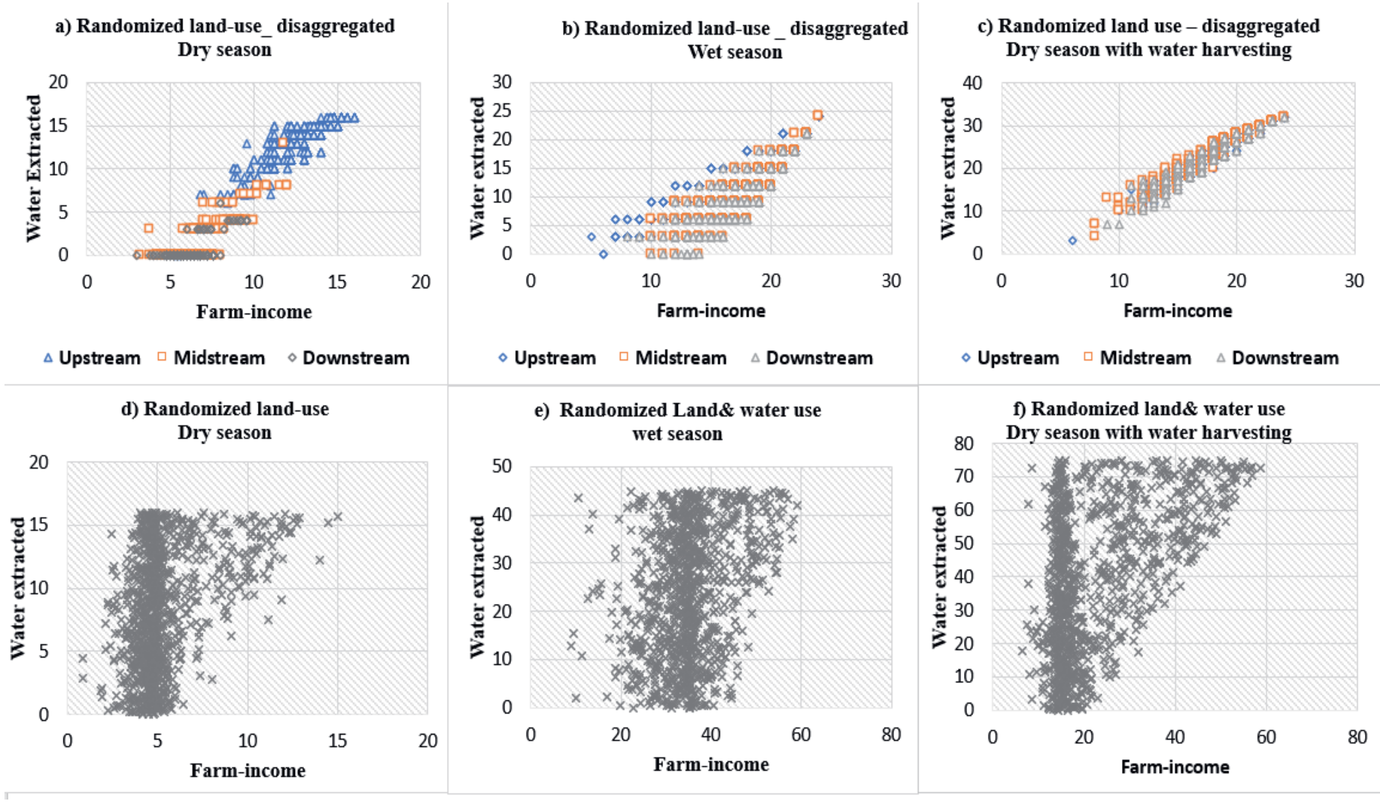


Figure 4.5: Shows a solution space for both dry and wet seasons. a, b, and c show all possible game outcomes on farm-income versus water extracted for random choices within strict water use, i.e., a crop is irrigated with the exact amount of water needed for maximum yield. Figure d, e, and f, shows all possible outcomes on farm-income versus water extracted for random choices without restricted water use.

To test one of the objectives of the game i.e., providing a shared platform for participants to jointly experiment and generate alternatives to sustainably produce crop with scarce water, results from a game session are mapped into the solution space. If the results are within this space, then this is an indication that the objective is achieved. The other objective of the game i.e., assessment of the effect of social relations, we incorporated a discussion session to identify relations that players have with reference groups that could have placed the outcomes at specific points of the solution space. Further, we analysed player's sociodemographic data as proxy indicators of player's status and power as possible reference groups during a game session. Furthermore, before the game, players ranked reference groups (that had been identified as salient reference groups in the region in Chapter 3) using a scale of -3 to 3 (where -3 is least important, and 3 most important).

4. Results from the Pilot sessions

4.1 Game outcomes

While the solution space provided all possible outcomes of the game, playing KILIMO NA MAJI with people added the influence of social relations on player actions and outcomes of the game. In both groups, players started off with high-water requirement crops to get higher profits. Since upstream players accessed water first, they made more money in the first round of the game (Figure 4.6 a and b). This was followed by the realization that water is not enough for all and pressures from those who did not get water. Resultantly, a reference group comprising of all players emerges. Players collectively defined rules(opinions) for this new group which included water harvesting for the 1st group and equal water sharing for the second group. Under collective action, the difference on farm-income reduces across up-, mid-, and downstream players (Figure 4.6 c and d). Opinions for the 'all players' reference group significantly impact the game outcomes, such that the 2nd group which did not harvest water, get much lower farm-income compared to players from the 1st group (Figure 4.6 c).

4.2 Salience of reference groups

Results showed that on average, family was the most important reference group while ancestors, government, and peers are not important in both groups. Downstream communities and agro-export companies were not important for the 1st group but were considered salient in the 2nd group (Figure 4.7).

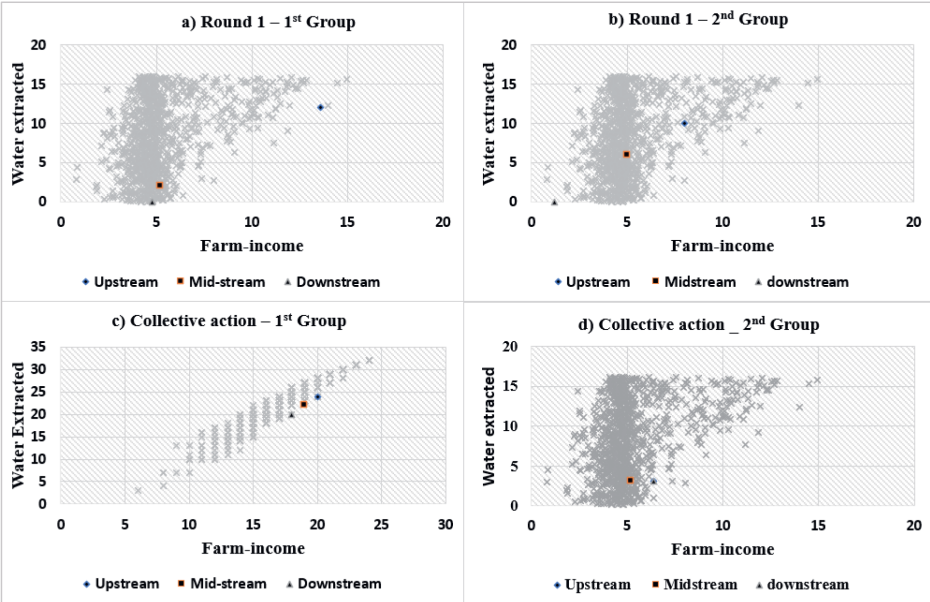


Figure 4.6: (a) and (b) shows impacts of individual land-use choices on water and farm-income for both groups within the solution space of randomized land- and water use choices without water harvesting. (c) shows results of collective decisions in the first group within all possible solutions of randomized land-use choices during dry season with water harvesting while (d) shows results of collective action for the 2nd group during a dry season without water harvesting.

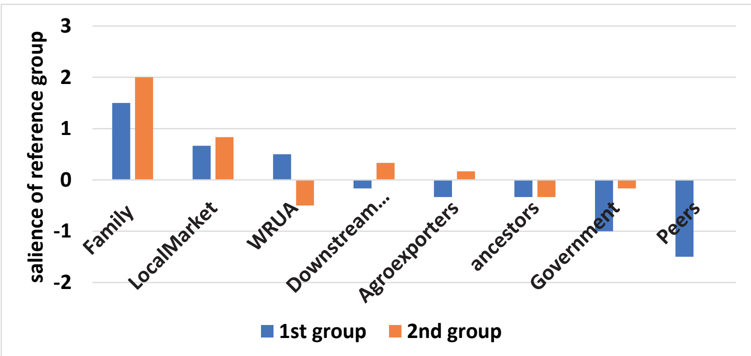


Figure 4.7: Salience of reference groups as averaged across players in the two groups.

5. Discussion of pilot sessions

Application of KILIMO NA MAJI was meant to assess its effectiveness in achieving its objectives. We first discuss results against these two objectives and then other observed results from the game sessions.

5.1 Objective 1: Catalyse collective exploration of alternatives for crop production

We found that KILIMO NA MAJI did indeed prompt different interactions and player decisions in the two game sessions. KILIMO NA MAJI was simple enough for players to understand, relate with and prompt collective water management discussions as should be in a serious game (Edwards et al., 2019; Falk et al., 2023; Fjællingsdal & Klöckner, 2020; Janssen et al., 2023; Kriz, 2017). Resultantly, players identified alternative options to water scarcity including 1) strengthening water regulatory institutions 2) increasing water supply through water harvesting; and 3) managing available water by shifting planting seasons and type of crops. During the game sessions, and according to results from the game session, players' statements and actions showed that they were able to relate the game to reality. For instance, a player who in reality harvested water, proposed doing so in the game. This option is not provided in the briefing session of the game. However, although in most cases players are expected to play according to the rules provided (Biggs et al., 2021; Edwards et al., 2019) there may be other undefined rules that can emerge as participants interact with each other in the game. This provides an opportunity for facilitator-player and player-player learning.

5.2 Objective 2: Assess influence of social relations on game outcomes

The decisions (on what to farm, whether to irrigate, to collaborate or not and when) placed a game's outcomes in a particular position on the solution space. To a large extent, the results showed that players carried along their social status, power, and voices from their salient reference groups to the game sessions. Salient reference groups at the beginning of the game were family, local market traders, Water Resource Users Association (WRUA), downstream communities, and agro-export companies. Although the identified pre-game relative importance of reference groups was not fully reflected in the game sessions, there are instances where player decisions seemed to be aligned to perceived preferences of their reference groups. For instance, players prioritized crops that could ensure food for their families and income; family was the most salient reference group. The influence of local market traders and agro-export companies could have created a significant difference between choices made by the two groups. The 1st group constituted of farmers influenced by local market traders in real lives; hence they chose crops that could sell in the local market such as vegetables, tomatoes, and potatoes. The 2nd group constituted of farmers in contract farming with agro-export companies; they chose crops for export for instance French beans.

During the game, other reference groups emerged including a high-status individual in the 1st group and 'all-player' reference group in both game sessions. Player(s) can be a salient reference group if they are of a higher status-power standing in the society. Players in the 1st group were not familiar with each other nor each other's status-power standing. However, early in the game session, the only player with leadership position (a proxy indicator for status-worthiness- power), in society exerted his status and claimed more status by issuing suggestions, opinions and non-verbally through his sitting position and confidence in addressing other players. Results showed that this player benefitted more from the shared water resources causing a gap in water-use and farm income between upstream players and other players. In the 2nd group, players were well known to each other and held leadership positions in their respective communities. Each player felt he/she had and deserved a higher status than the other. The game session was therefore characterized by less asking but more status claiming: giving, opinion, or suggestions. Additionally, any sense of status deficit, for instance through water overextraction by upstream or mid-stream players, was countered with an equal status claiming force from afflicted players. Thus, instead of being encompassed by sadness and depression (Kemper, 2006) and looking for support from institutions, the group was driven by anger (Kemper, 2006), leading to intense disagreements until a compromise was achieved.

In both game sessions, water inequalities and hence farm-income raised concern and complains among some of the players. Since players are relationally rational, i.e., rational within the context of their social world (Hofstede et al., 2019), choices that seemed economically rational at the beginning of a game session were socially irrational in subsequent rounds. This led to conflicts among players and ultimately collective action. Collective action was driven more by pressure from other players (Van Noordwijk et al., 2023a). Each of the two groups formed an 'all-players' reference group that was salient to all players, the pleasing of whom was more important than other reference groups. In the 1st group, WRUA representative led other players to collective action, and they jointly agreed on harvesting water to increasing income for all players. In the 2nd group, collective action could be considered to have been self-organized, emerging from the players after intense arguments over water resources. In both cases, the game was critical in visualizing the problem and for jointly looking for options. In reality, collective action may take many forms and lead to varied outcomes depending on, a society's cultural orientation; motivation; rules, monitoring systems, incentives, and sanction (Hofstede et al., 2010; Hofstede & Liu, 2020; Kemper, 2017; Nordman, 2021; Ostrom, 1990; Toshiko et al., 2022; et al., 2023). Whatever the outcome, under collective action players made what they perceive to be socially rational choices.

5.3 Limitations of the study and future research

Despite the capabilities of KILIMO NA MAJI, the game has limitations that are experienced in most serious games. Among them, 1) limited number of players against the population represented, presenting a possible bias of results; and 2) limited time for playing the game leading to inadequate exploration of all scenarios (Biggs et al., 2021; Edwards-Jones, 2006). Due to time limitations and to reduce complexities, there are various scenarios we could not try out. For instance, unexpected weather conditions, reference groups with varied opinions, introduction of a new government policy, diverse cultural orientations. These could be options that can have significant effect on a player's actions and possibly of interest to some researchers. While these can be included in future cases, another option that can facilitate exploration of many scenarios could be programming the game in Agent Based Modelling (ABM). ABM can be used to explore variations in different study sites, and viable solutions while making individual or collective decisions. Despite the reduced complexity, some players felt that the game sessions were still too long. Thus, for future research, we would recommend prioritization of elements that are a 'must-have' depending on the objective of the user of the game.

One limitation of analysing influence of social relations from the Kemper's perspective is that the analysis heavily depends on the capacity of the researcher in analysing player' actions, their discussion during the game session and responses in the debrief session. The data collection is also affected by difficulties in identifying reference group that motivated a certain action. Kemper (2016) notes that individuals may not always be aware of their reference groups; additionally, some actions may have been motivated by more than one reference group and it may become difficult to identify which reference group motivated which action.

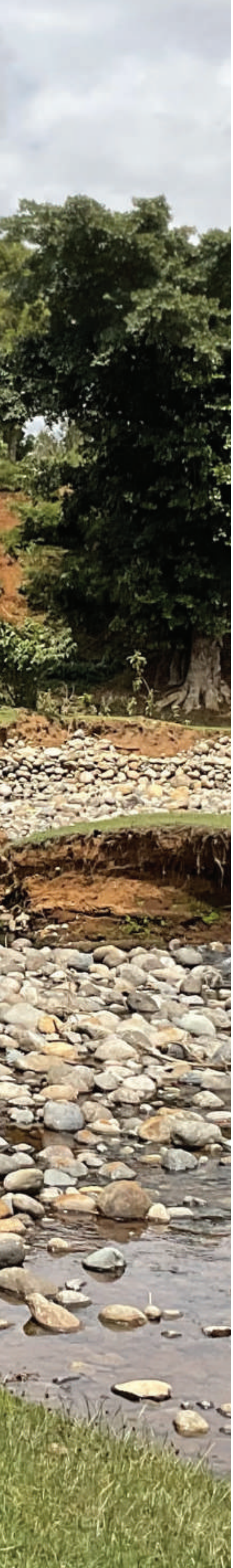
5.4 Possible uses of the game

KILIMO NA MAJI can be adapted and used to support management of scare water commons in different landscapes. Possible users of the game can be policy makers, research institutions, water regulatory bodies, local communities among others. The game can be used, to engage local stakeholders in co-production of alternatives to sustainably produce crops amidst water scarcity; experiment and assess impacts of policy interventions a safe environment; train on farm water management; exploring influencers of farmer decisions; visually demonstrate workings of a socio-ecological system.

As first step, users of the game need to adapt various components to their objectives. For instance, for a researcher that wish to demonstrate different irrigations strategies and their impact on water availability and food production, more specific measurements of the crop irrigation need and impact on production may be needed; while for a stakeholder that wishes to inform local communities of the impact of their actions on others, exact measures may not be necessary. The next steps would be to understand the processes of applying the game and analysis of results.

6. Conclusion

In this study, we describe the design and show application of KILIMO NA MAJI as a serious game that can be used i) to engage farmers in understanding and exploring options for sustainable crop production during dry periods, and ii) to assess effect of social relations on farmer decisions. Over the years, there have been an increase in the use of games in various kinds of social ecological systems such as environment, water, land, climate change. However, to our knowledge, none have provided for capturing and analysis of social relations as a factor that affect farmer decisions. In this chapter therefore we present the design of a game that captures the effect of social relations, and its application in Mt. Kenya region. In the results, we map outcomes from an actual game session onto a defined solution space; solution space is a set of all possible outcomes from a game session. We find that game outcomes can end up in different positions in the solution space; varying from high to low water consumption and low to high farm-incomes depending on relations that farmers have in their social world. Therefore, the game can be used by stakeholders (policy makers, farmers, researchers) to explore alternatives to sustainably produce crops in scarce water commons. KILIMO NA MAJI is generic with capability to be adapted to fit any other water-scarce region. The concept of the game can also be used to design an Agent Based Model that explores diverse options.



Chapter 5

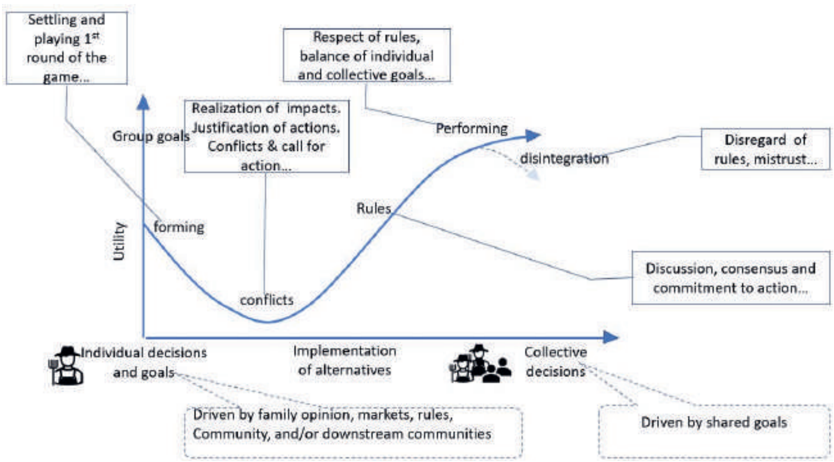
Exploring collective water management using serious games: The case of Mt. Kenya region

The Chapter is based on:
Githinji, M., Speelman, E. N, van Noordwijk, M., Muthuri, C., Hofstede, G. J. (2024). Exploring collective water management using serious games: the case of Mt. Kenya region.
The paper is currently under review for the Ecology and Society Journal

Abstract

Collective resource management of water commons can arise as self-organized, bottom-up collective action, but the social conditions under which this can be successful are not yet fully understood. Serious games allow for early stages of emerging collective action to be experienced by the players and studied by a researcher. In a semi-arid region in the Mt. Kenya region, we used a locally developed serious game, Kilimo Na Maji (Swahili for 'farming and water'), to represent the water shortage problem and explore the participants' responses. The region has a vibrant agribusiness environment sustained by irrigation from shared water resources. Despite existence of a water governance structure that includes collective water management, water inequalities and conflicts persist among multiple water users. Using a stratified random sample of participants, we collected opinions on social relations that drive farmer land- and water management decisions. Subsequently, the Kilimo Na Maji game engaged participants in exploring options that can sustainably ensure crop production. Results revealed five types of opinions: family-centric, market-driven, rule-driven, community-oriented, and focused on care for the downstream community. Observing the impact of upstream choices on downstream water shortage in the game, prompted participants to shift their opinion from a family and/or market-centred discourse to alternative options that could consider the interests of all participants. The game simplified the socio-ecological system and helped players recognize the impact of their actions in the real-world system. Proposed alternatives to land- and water use went beyond those that could only be implemented in game sessions to those that should be implemented in the farmers' real environment. By combining the game and analysis of discourses we gained insights into the emergence of collective action while also facilitated the identification of options for sustainable water management by and for the players.

Graphical abstract



Emergence of collective action starts with formation of group; then conflicts may emerge, initiating discussions; setting the rules and tracking compliance with rules; and finally performing, and delivering on common goals. Some groups can disintegrate once or more repeating the process again until a common group that delivers group goals is formed. Collective action implements alternatives (for example water harvesting) that satisfy a group's expected utility (for example income, food).

Keywords: Collective action; common pool resources; Mt. Kenya region; reference groups; social relations; water scarcity

1. Introduction

The need for and challenges to collective resource management of water commons differ between climate zones. Currently, 3, 17 and 11% of the population in the tropics live in arid (<0.2), semi-arid (0.2-0.5) and subhumid (0.5-0.65) zones respectively, with zone definitions based on the ratio of precipitation to potential evaporation; a further 15% of people live in 'water towers' that potentially provide irrigation water to drier zones and can be affected by water conflicts with their downstream neighbours (Dewi et al., 2017). The proportion of the human population experiencing water scarcity is likely to increase from 47% in 2019 to 57% by 2050 (Boretti & Rosa, 2019; UNESCO et al., 2019). The scarcity is driven by global climate change making water supply more variable, and a continuously increasing population demanding more water (Dolan et al., 2021; Rosati et al., 2021; UNESCO et al., 2019). In Kenya, 80% of its land area is classified as arid and semi-arid. In its Upper Ewaso Ng'iro North River Basin, Northwest of the Mount Kenya water tower, precipitation ranges between 2000 mm per annum in the upstream zone and less than 350 mm per annum in the downstream zones (Kimwatu et al., 2021; Wamucii, Teuling, et al., 2023). The limited rainfall constrains crop production, amidst high agribusiness opportunities for irrigated export crops. To increase crop production, farmers in the up- and midstream zones extract water from rivers often leading to water-related conflicts among multiple water users (Eckert et al., 2017; Wamucii, Teuling, et al., 2023). The Kenyan government has established several institutions to manage water resources and reduce conflicts related to water (Lesrima et al., 2021), but tensions remain.

5

1.1 Status, power, and reference groups

As the established institutions such as Kenya water resource authority and water resource users' association manage water resources, other influential groups in a farmer's social world, drive farmers to specific practices. These groups could be material or spiritual and pertain to any sphere of life. For describing these groups and their importance three concepts introduced by Kemper (Kemper, 1968, 2006, 2011, 2017) can be used. The first concept is "reference groups." Farmers make decisions they consider rational within their life's context. This context consists of relations they want to, or must, honour. These relations are referred to as reference groups (Kemper, 2017). A reference group can be a person, or a group of persons regarded highly by an individual (Kemper, 1968, 2017), for example, family, government, or local traders. Farmers have multiple reference groups of which some would be more salient than others. For deciding which actions to take, they subconsciously consult their reference groups. The second key concept is "status," as relational currency; status can be aspired, claimed, deserved, or conferred upon someone. Status that one confers on others stands for things such as attention, respect, love. Worthiness of status can be called, among many others, respectability, wisdom, fame, charm. A third, closely relayed concept is "power," in the limited sense of ability to coerce others against their will. One may obtain something either by being sufficiently worthy, or by coercing others (Kemper, 2017). Salience of a reference group varies with its ability to confer status or to use power.

Status prompts voluntary compliance through recognition, tokens of appreciation, incentives for example better prices or free farm inputs. Conversely, power force involuntary compliance through sanctions, for example, surcharge for illegal water extraction. Accordingly, in Kemper's perspective, farmers adopt practices to gain status or to avoid the use of power by those more powerful. A region characterized by multiple reference groups with divergent opinions, may lead to unsustainable livelihoods if trade-offs and conflicts are not managed. Collective action among stakeholders, could be an option for convergence of the multiple reference groups and identification of sustainable options (Githinji et al., 2023). Collective action establishes a collective reference group that pursues group-level goals over and beyond conflicting individual interests (Falk et al., 2023; Janssen et al., 2023; Ostrom, 1990).

1.2 Collective action and serious games

To achieve group goals, all those who subscribe to collective action must agree to follow a set of rules. Collective action, whether initiated by external stakeholders or self-organized, often faces challenges (Ortiz-Riomalo et al., 2023; Ostrom, 1990). For example, collective action led by external stakeholders may face rejection among the local stakeholders especially if it does not adequately demonstrate inclusion of local knowledge and priorities of local stakeholders (Ortiz-Riomalo et al., 2023; Ostrom, 1990). Self-organized collaboration of local stakeholders could be more acceptable to the community and rich on integration of local knowledge (Bélisle et al., 2018; Nyong et al., 2007; Ortiz-Riomalo et al., 2023; Ostrom, 1990; Sikor, 2012; Valencia et al., 2015; Van Laerhoven & Barnes, 2014). However, it does not always emerge and is not always successful. This is because actors may lack a full understanding of the common pool; ways to communicate or coordinate collective action; trust; and might experience difficulties in balancing individual interests and group interests (Dell'Angelo et al., 2016; Janssen et al., 2023; Ostrom, 1990). Participatory methods such as serious games, have been proposed as an option to foster active and joint engagement of policy makers, researchers, and local stakeholders (Janssen et al., 2023; Ortiz-Riomalo et al., 2023). Serious games foster learning, collaboration, and exploration of sustainable management practices (Janssen et al., 2023; Speelman et al., 2014). Use of games in supporting collective management of natural resources has increased since they simplify complex systems; allow stakeholders to interact with the systems and among themselves; explore and experiment in a safe space; build consensus and commitment to actions (Andreotti et al., 2020; Biggs et al., 2021; Bosma et al., 2020; Falk et al., 2019, 2023; García-Barrios et al., 2008; Janssen et al., 2023; Mangnus et al., 2019; Rakotonarivo et al., 2021; Sari et al., 2023; Speelman et al., 2018). Although serious games have been used to engage stakeholders in collective exploration of options for management of natural resources, the impact of social relations on collective action process and outcomes is yet to be adequately assessed.

The main objective of this study was to explore collective action from a social relational perspective using serious games. The game used in this study, Kilimo Na Maji game was developed and tested using Kenyan data. An overview of the game is described in the methods section and full description is provided in Chapter 4. Our study site was the Upper Ewaso Ng'iro North River Basin in Mt. Kenya a region which has persistent water related conflicts. Our specific questions were 1) What are the existing social relations that impact individual and collective farmer decisions; 2) Can serious games catalyse collective identification of water management options in the water scarce landscapes; and 3) What are the perspectives of local stakeholders on water managements options? As a first step, we clarified how participants in the game perceived individual and collective aspects of water management, before and during the game. This allowed analysis of the significance of serious games in catalysing collective action.

2. Methods

2.1 Study area and its collective water management dynamics

The study site comprised of seven sub-watersheds in agro-ecological zones of the Upper Ewaso Ng'iro North River Basin (Figure 5.1 a, and b). We selected this site due to persistent water-related conflicts among multiple users over the years despite existence of a water governance structure. Each sub-watershed is managed by its own Water Resource Users Association (WRUA) namely: Nanyuki, Ngusishi, Likii, Sirimon, Ontulili, and Timau. The study area covers an approximate area of 1200 Miles squared and between the latitudes of 0° 15´S and 0° 38´ N and longitudes of 36° 52´E and 37° 23´E (Figure 5.1 a, and b). The site has diverse climatic conditions from cool and wet in the upstream to hot and semi-dry in the downstream (Figure 5.1 d).

The main economic activity is farming, supported by a vibrant local and global market. This encourages intensified irrigation practices in the up- and midstream zones exacerbating water scarcity downstream (Wamucii, Teuling, et al., 2023). Consequently, there are differences in water management that at times lead to water related conflicts (Dell'Angelo et al., 2016; van der Laan et al., 2021; Wamucii, Teuling, et al., 2023). Conflicts occur between up and downstream communities, small- and large-scale farmers, farmers and pastoralists, and at times across households (Dell'Angelo et al., 2016). According to the constitution of Kenya (Constitution of Kenya, 2010), every

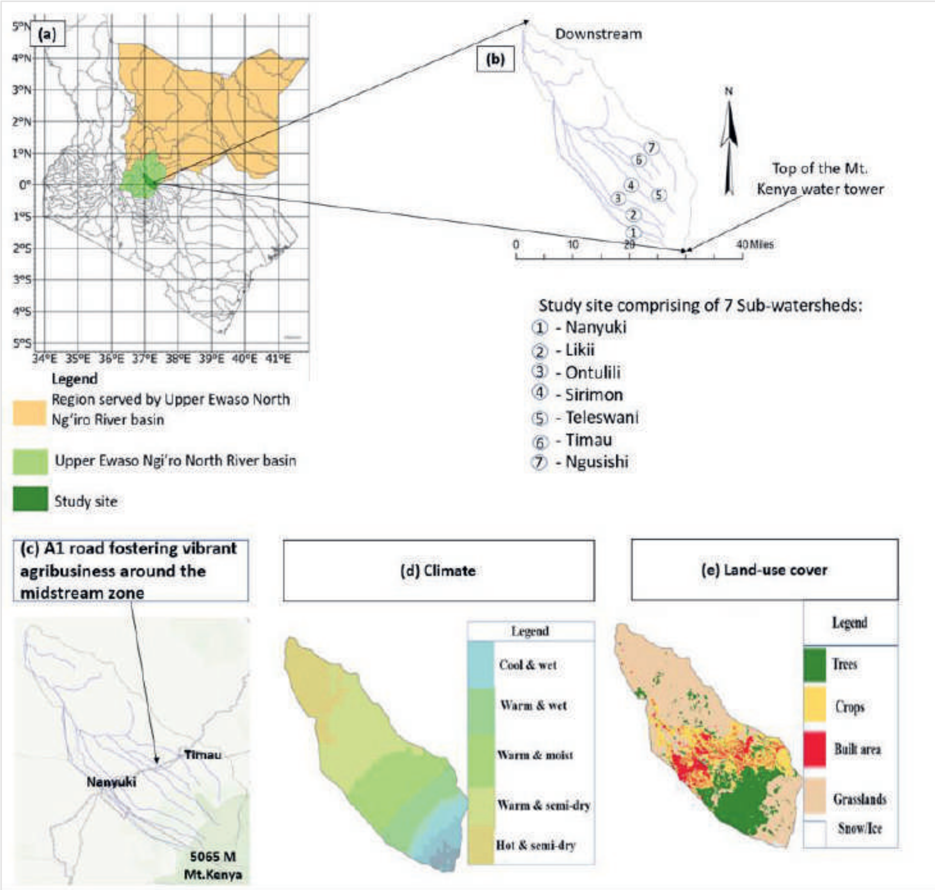


Figure 5.1: a) and b) shows the study site which feeds the larger Upper Ewaso Ng'iro North development block with water from the Mt. Kenya water tower. The study site has diverse climates from cool and wet in the upstream to hot and semi-arid in the downstream (d). With good climate and access road (c), midstream farmers engage in crop farming using irrigation (e). Downstream is drier constituting of grasslands which supports pastoralism while farming is done in small scale along the rivers.

person has a right to access to water. To ensure this, the Kenya water act 2016 (Kenya Water Act., 2016), provides for a polycentric water resource governance framework with interdependent units of governance at National and sub-national levels (Figure 5.2). The National government through the Kenya Water Resources Authority (WRA) has overall mandate to regulate and manage use of all water resources in Kenya. The National Government also sets water services standards through the Water services regulatory board. County governments are mandated to support equitable and responsible water management within their own jurisdictions. Part of this includes provision of water services to households through the water services providers. At the local level, WRUAs are collective action units established to support inclusion and active engagement of up-, mid- and downstream communities in management of sub-watersheds (Baldwin et al., 2018; Kenya Water Act., 2016; Mwaura et al., 2020) .They constitute of smaller units, the Community Water Projects (CWPs) to which households register to legally access water from the rivers. Members of WRUA set their own rules, establish monitoring framework, incentives, and sanctions to ensure compliance with the rules.

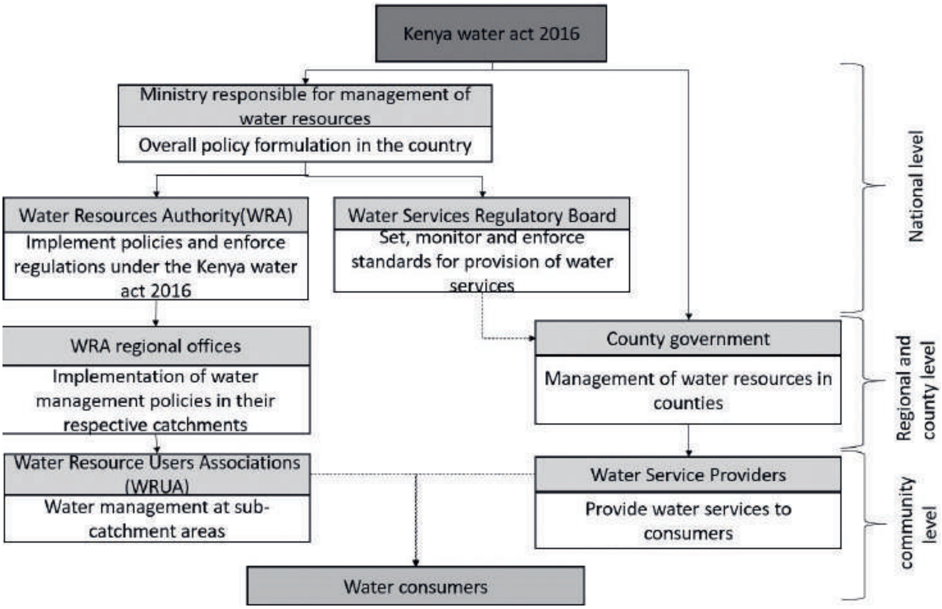


Figure 5.2: Polycentric governance of water resources from National government to community level. Dotted line shows no-direct delegation of powers, but the institution has a role to monitor activities of the other institution. Adapted from the Kenya National Water Resources Strategy (2020-2025).

2.2 Sampling

We used a stratified sampling method to select participants where the 7 WRUAs in the region were considered as strata. Two large WRUAs were split into two to have a larger sample representing their high population. This led to a total of nine groups each with six participants giving a total of 54 participants. With assistance from WRUA Chairperson, purposive sampling of the six participants was done to identify participants from different parts of the landscape i.e., up- mid-, and downstream zones. Data was collected from each of the 9 groups separately over a period of 10 months.

2.3 Data collection and analysis

We collected data using a strategy deployed by (Speelman et al., 2018), i.e., pre-game, during and after data collection (Figure 5.3). Before the game, a questionnaire (Appendix 2A, Table 2F) was used to collect players' sociodemographic data. Also, before the game, opinions on drivers for land- and water use were obtained using Q-Methodology. During the game, we captured player choices and outcomes in a form (Appendix 2A, Table 2G). We also video recorded all sessions to support data analysis. At the end of every session, we debriefed by discussing experiences during game sessions and outcomes The debriefing session was guided by a semi-structured questionnaire (Appendix 2B).

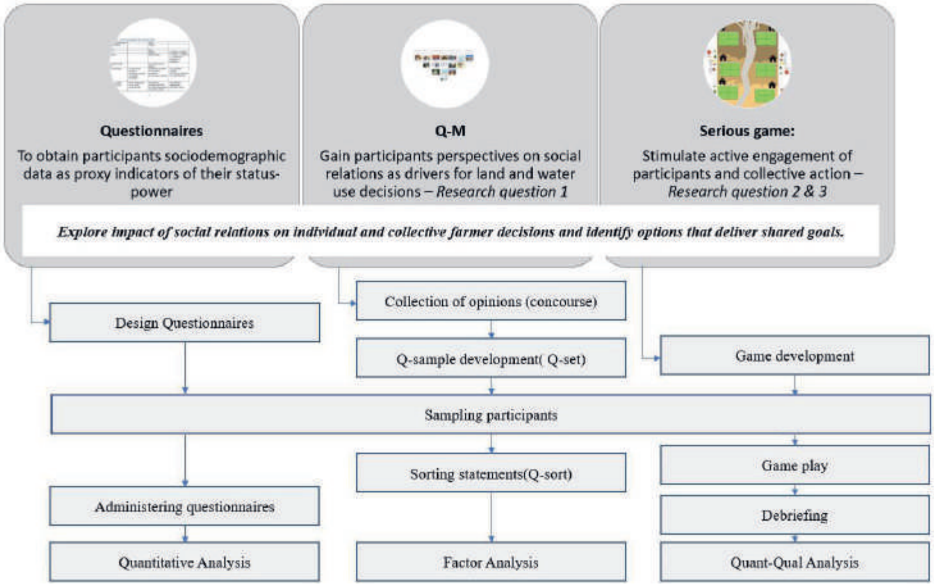


Figure 5.3: Overview of the three methods used in this research article and their contribution in achieving the research objective.

2.3.1 Q-methodology

We used Q-methodology (Bruce & Thomas, 2013) to obtain each participant's perceptions on drivers for land and water management. Q-methodology (Q-M) combines quantitative and qualitative data on a topical issue. A sampled group of participants sorts and ranks a set of statements from those they least agree with to those they most agree with. The statements can be informed by different sources such as surveys, newspapers, and publications (Bruce & Thomas, 2013). The collected data is subjected to factor analysis. Factor analysis can be done using various data analysis software to generate the factor loadings and factor scores (Brown, 1993; Bruce & Thomas, 2013). Our Q-Methodology had a set of 16 statements (Appendix 2C) and 54 participants. The statements were informed by results from Chapter 3. Other inputs such as (Baldwin et al., 2018; Kenya Water Act., 2016; Mwaura et al., 2020) were used to improve the final set of statements. These statements were presented in a simple language and pictures for better understanding. They were also verbally explained to participants before the sorting exercise. They ranged across diverse social relations that influence a farmer decision. Participants sorted and organized the statements from those they least agreed with, at a score -3 to those they most agreed at a score of score of 3, forming a quasi-normal distribution (Figure 5.4). Factor analysis of data was done using principal component analysis and varimax rotation in SPSS software. As per (Bruce & Thomas, 2013), loadings in excess of ± 1.96 *(1/√16) i.e., ± 0.5, were considered statistically significant at 0.05 level. We extracted 5 factors which could explain 69% of total variance. We calculated factor scores from the weighted Q-sort to generate a composite Q-sort (Figure 5.6) for each of the 5 factors. This was then used to interpret the factors. After the Q-M, participants played Kilimo Na Maji game. The game session aimed at catalysing collective action towards crops production with scarce water commons.

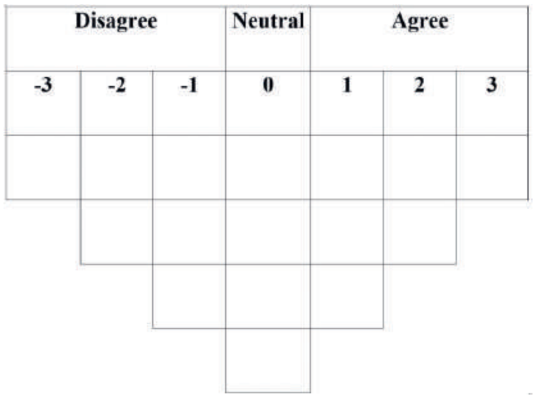


Figure 5.4: Q-methodology grid with 16 slots. A set of 16 statements with different perspectives to a defined topical issue are placed in the slots. Each participant gets their own grid on which they place statements most disagreed with on the left, most agreed with on the right and neutral statements in the middle column.

2.3.2 Overview of the game

Kilimo Na Maji, is a board game for engaging stakeholders in exploration of land and water management options that would sustain crop production in water scarce landscapes. The game board simulates a landscape occupied by smallholder farmers and a shared river that flows and serves upstream, midstream, and then downstream communities (Figure 5.5). This game is played by six players who represent smallholder farmers. Each player is allocated four plots each; each plot can accommodate one type of crop. At the beginning of each round, all players select type(s) of crops to farm among three categories, i.e., high water requirement crops for higher profit for example French beans, tomatoes, vegetables, and onions; medium water requirement crop, for lower profit but can serve as food crop for example maize and potatoes; low water requirement crops comprising sorghum, and cassava. The next decision is whether to irrigate or not. Failure to irrigate high or medium water requirement crops leads to less profit.

One round represents a season (planting to harvesting) covering a 4-month period. Each round has sub-steps for irrigation equivalent to a month. At every sub-step, farmers interested in irrigation pick the available water tokens starting with upstream, then midstream and finally downstream. At the end of the sub-step, facilitator refills the river with new water tokens as per the mean monthly river flow table. This procedure is repeated for all 4 months of the season. At the end of each round, farmers harvest and sell their crops. Players earn income depending on the type of crop and whether the crop was irrigated as required. Considering that water tokens are limited, irrigation by one player means fewer water tokens and less profit for the other player. Therefore, players have to look for alternatives that would be acceptable to all players. The game continues until all players agree on alternatives for crop production and water management. Besides the 6 players playing the role of farmers, the game has WRUA representative playing their actual role in the society: advise farmers on alternatives that would minimize water consumption; and penalize for water overextraction. A comprehensive description of the game is provided in the Appendix 2

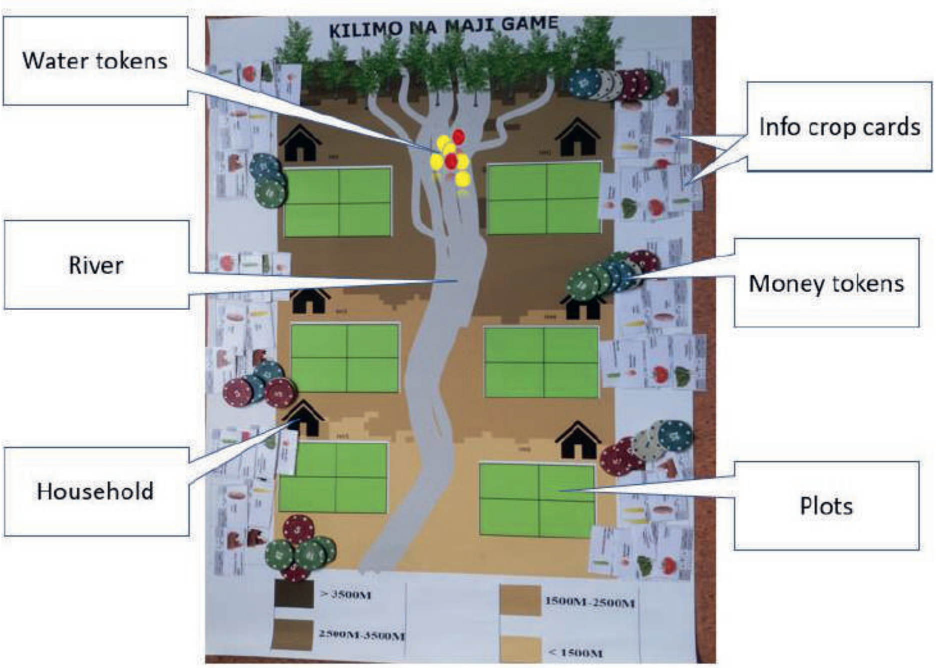


Figure 5.5: Kilimo Na Maji game. Water tokens are red and yellow. Yellow can be extracted for irrigation; red are for domestic use only. Info crop cards have a picture of the crop and information on crop water requirements, capital, and profit. Households own 4 plots which they can farm by placing info crop cards on any of the 4 plots.

2.4 Game sessions and analysis

Out of the nine groups, we used six groups in the current analysis. Data from one group could not be used due to incompleteness while results from two groups were considered as part of the pilot sessions and has been published in another article (Chapter 4). In the analysis, we first quantitatively analysed both individual and collective decisions made on crop choices, water use, and subsequently profits made by players. Then using pre-game data on sociodemographic and discussions during and after the game, we assessed possible impact of players' status-power relations on individual and collective decisions. We used economic status, land size owned, age, and leadership position as proxy indicators of players' status-power standing in the society. We did thematic analysis of statements made during the game and in the debriefing session to identify participant's perspective for sustainable water management.

3. Results

3.1 Opinions on land and water management decisions

A factor analysis of our Q-methodology data revealed 5 types of opinions namely: family-centric (F1), market-driven (F2), WRUA-based fairness or rules driven (F3), community-oriented (F4), and care for downstream community interests (F5) (Figure 5.6). There were two statements with a high degree of consensus across the factors i.e., WRUA should determine water share for each household; and people should not be allowed to get as much water as they want without consideration of others. Statement with the highest degree of disagreement across factors was, equal water sharing. On average, the highest-ranking statement was that people farm for food and income followed by a statement that encourages engagement of all stakeholders in addressing water shortage.

Factor 1_Family-centric: Participants in this category agreed that production of enough food and income for family was particularly important. They also felt equal water sharing was important and all stakeholders should participate in water sharing discussions.

Factor 2_Market -Driven: In this category, participants felt food production and income for the family is important but also farmer decisions should be driven by local market demands; and WRUAs' advice on farming low water consuming crops is not important. They acknowledged that water is not enough, and people should not take as much water as they want.

Factor 3_WRUA-based fairness (Rules driven): Participants strongly agreed with equal water sharing where WRUA takes a strong position. They felt that downstream communities should not be left to deal with the existing water scarcity, and the government advice on crops to be farmed does not have much influence on farmer decisions.

Factor 4_Community-oriented: This group strongly agreed that all stakeholders should jointly address water scarcity, rather than WRUA or downstream communities taking sole responsibility. For this group, addressing water scarcity preceded the need to produce food and income for families or to satisfy the needs of the local market. Additionally, the group disagreed with equating amount of water that one can extract to their financial capacity.

Factor 5_ care for downstream community interests: Participants in this group seemed aware of their water footprints. They felt that crops that could lead to water stress downstream, and those needed by agro-export companies, should be avoided. This group supported equal sharing of available water.

F1	F2	F3	F4	F5	Statements	AV	SD
generally prioritized							
3	3	2	2	0	1. Farm crops that can provide enough food and income for family	2	1.22
2	2	0	3	2	15. Water shortage should be addressed by all stakeholders	1.8	1.10
0	2	1	2	1	5. Farm crops that can be consumed by the local market/brokers	1.2	0.84
1	1	2	1	1	12. WRUA should determine the water share I get	1.2	**0.45**
0	1	0	1	3	7. Avoid crops that reduce water downstream	1	1.22
2	-1	3	-1	2	9. Should get a water share that is equal to everyone else	1	**1.87**
on average neutral							
1	-2	1	0	1	2. Farm crops that would produce within WRUA advised water use	0.2	1.30
1	0	1	-3	0	14. WRUA should address water shortage	-0.2	**1.64**
-2	1	-1	1	-1	3. If my peers made more money from a crop, I will copy them.	-0.4	1.34
0	0	-2	0	0	6. Farm crops advised by government/extension worker	-0.4	0.89
not prioritized							
-1	-1	0	0	-3	4. Farm crops that are need by the agro-export market	-1	1.22
-3	0	0	-1	-1	8. Farm crops that my family has always planted	-1	1.22
-1	0	-1	-2	-1	10. Should get a water share equivalent to my money	-1	0.71
0	-1	-2	-2	0	13. Downstream farmers should address their water shortage	-1	1.00
-2	-2	-1	-1	-2	11. Everyone should get as much water as he/she want	-1.6	**0.55**
-1	-3	-3	0	-2	16. Water is enough for everyone	-1.8	1.30

Figure 5.6: Factor scores for each statement. There are five factors: F1(family centric), F2 (Market-driven), F3 (community-oriented), F4 (WRUA based fairness), and F5 (care for downstream interests). Intensity of colours decreases as a score moves towards a neutral score of zero. Standard deviation (SD) shows general concurrence on a statement across factors. Average score (AV) shows the average scoring of statements across factors from those highly agreed with (generally prioritized) to those highly disagreed with (not prioritized).

3.2 Relation between participants' perspectives and their location on the up-downstream gradient

There was significant difference in opinions across up-, mid- and downstream participants (Table 5.1). Opinions of most midstream participants were aligned to F1 (family-centric) and F2 (market-oriented), compared to up and downstream participants. Also, none of the midstream participants aligned to F3 (WRUA-based fairness). Participants were equally distributed in F4 (community-oriented perspective). F5 which is about water regulation and caring for downstream communities had less representation of the downstream participants.

Table 5.1: The table highlights characteristics of each factor including proportion of participants whose opinion aligned to the factor, their sex and real-world location on the up-downstream gradient of our case study area

	F1	F 2	F3	F4	F5
% variance explained	16	16	13	11	11
Number of participants loaded in the factor	13	11	7	6	8
Z-scores	0.66	0.65	0.74	0.7	0.64
Average age of participants	50	45	50	54	47
Sex expressed as %male, the rest were female	54	64	57	67	50
Proportion of participants in the upstream (%)	31	27	43	33	38
Proportion of participants in the midstream (%)	38	45	0	33	38
Proportion of participants in the downstream (%)	31	27	57	33	25

3.3 Game sessions

In all the six groups, players choose crops that would give more profit in the first round of the game, irrespective of the crops' high-water needs (Table 5.2). With the realization that water is scarce, and it leads to less income, all groups except group 2 changed their choices in subsequent rounds (Table 5.2 column R2 and R3). Some upstream farmers voluntarily or out of peer pressure, chose medium and low water requirement crops. Some mid and downstream farmers changed to crops that needed less water, others cultivated fewer plots. Without a common agreement on water management, dissatisfaction and complains from downstream players and some mid-stream players continued in most of the groups. This was resolved under collective action, where all players collectively brainstormed and agreed on solutions that would create acceptable level of fairness. Under emerging collective action, players in all groups except group 3 and 5 prioritized medium water requirement crops. These are crops that would provide food for family and income, albeit less income. Players avoided the drought-resistant crops that are also promoted by government, alleging poor market, and prolonged maturity period. Group 3 and 5 assumed that they harvested water during the rainy season. Thus, they had more water tokens that could support farming of any type of crop increasing their farm income.

3.4 Individual to collective outcomes

In all six groups (G1, G2, G3, G4, G5 and G6), players started with crops that would ensure production of enough food to feed their families and generate some income (Table 5.2). This is in line with the opinion analysis (Figure 5.6). It could in fact be expected since players, including those who felt caring for downstream communities' interests is important, did not fully understand the impact of their actions on others. Although game rules required water tokens to be taken by upstream players first followed by midstream and finally downstream players, instances of persistent overextraction

Table 5.2: Players' crop choices in different rounds (R1, R2, R3) including a collective action (CA) round where decisions on what to farm, to irrigate or not were made jointly. Choices were among High water requirement crops (HWC), Medium water requirement crops (MWC) and low water requirement crops (LWC). Numeric numbers indicate number of plots in up-mid or downstream zone under a particular crop type in a game round.

		Group 1				Group 2				Group 3				Group 4			Group 5			Group 6		
		R1	R2	R3	CA	R1	R2	R3	CA	R1	R2	R3	CA	R1	R2	CA	R1	R2	CA	R1	R2	CA
HWC	Upstream	5	4	3	2	6	6	4	0	4	3	2	2	4	1	0	3	2	4	2	1	2
	Mid-stream	4	4	0	1	3	3	1	1	4	3	1	4	1	0	1	3	4	3	3	1	2
	Downstream	5	2	2	1	1	1	0	0	3	0	0	5	2	0	1	6	2	2	1	2	2
MWC	Upstream	3	2	2	2	2	2	4	2	3	5	3	4	2	2	3	2	2	4	1	0	2
	Mid-stream	2	1	0	1	3	4	1	3	3	5	3	4	2	0	3	3	4	5	3	3	2
	Downstream	3	2	3	1	4	4	0	2	3	7	0	3	3	2	2	2	2	6	2	1	2
LWC	Upstream	0	1	1	0	0	0	0	0	0	0	2	0	2	2	2	0	0	0	0	0	0
	Mid-stream	3	2	0	1	0	1	3	1	0	0	1	0	4	3	2	0	0	0	0	1	1
	Downstream	0	0	0	1	2	3	4	0	1	1	1	1	2	2	1	0	0	0	0	0	0

of water in the upstream, pushed midstream players to grab water tokens ahead of their time. This occurrence together with a shift from high water requirement crops to medium and low water requirement crops, and farming of fewer plots, explains the reduced water inequalities in round 2 for group G2, G3, G4 and G5 (Figure 5.7).

While some groups managed to figure out how to generate more income through water harvesting, others concentrated on changing their crop choices and equal sharing of the available water. For example, group G3 and G5, harvested water enabling them to farm different type of crops and henceforth getting more income (Figure 5.7). Groups without water harvesting had to restrict water use. For example, group G6 applied strict equal water sharing and hence insignificant variation on water use and income across players in the collective round (Figure 5.7). Other alternatives seen in the game sessions were farming fewer crops, strengthening water surveillance, and enhancing incentives and sanctions mechanism.

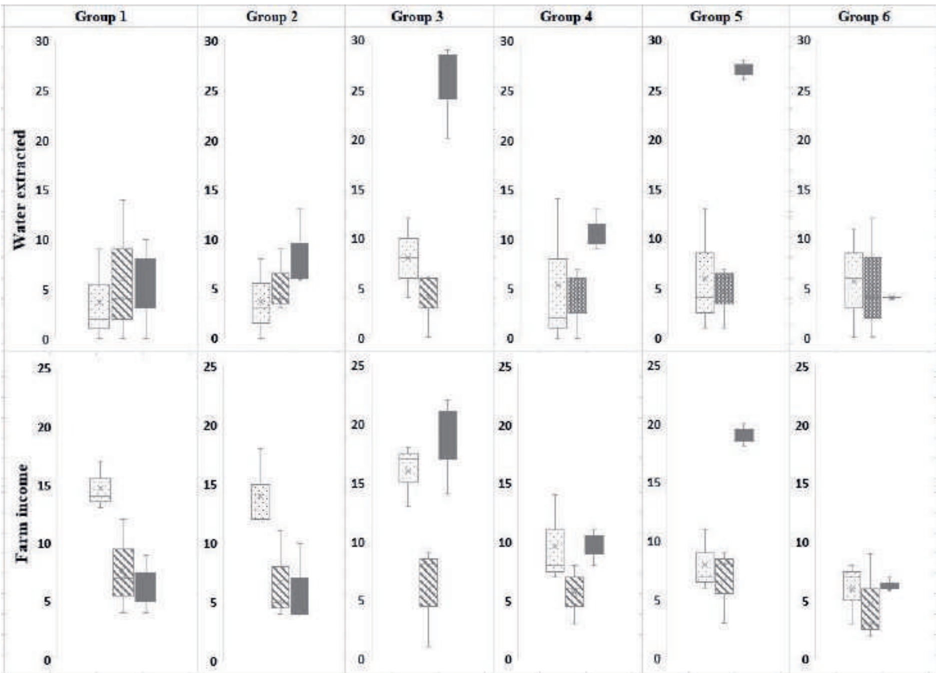


Figure 5.7: Variations in water extracted and farm income (in number of tokens) across players in the six groups. The grey shaded box in every group shows outcomes of the collective game round while dotted and striped bars are results from round 1 and round 2 of the game in each of the six games.

There was significant relation between the time it took to agree on alternatives that would ensure crop production amidst water scarcity and 1) initiator of collective action, 2) age of players, and 3) number of WRUA leaders among players. Collective action triggered by participants or WRUA representative, was characterized by intense discussions, identification of several alternatives and longer time to agree on interventions (Figure 5.8). In group G6 where collective action was triggered by the facilitator, discussions took the least time; the group implemented the only option proposed by the facilitator.

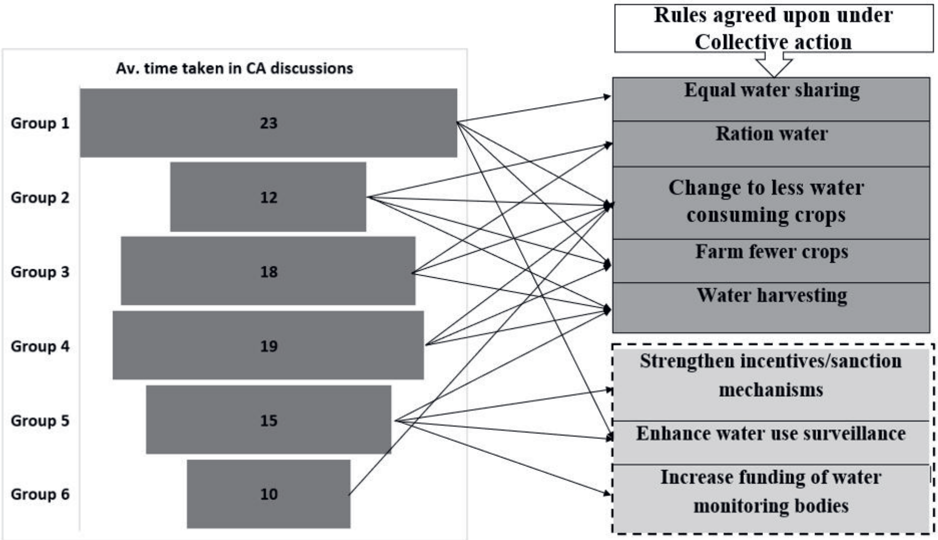


Figure 5.8: On the left, we have grey boxes with the average time (in minutes) it took to agree on crops to farm and how to manage water resources from group 1 (G1) to group 6 (G6). We also have letters in the grey boxes indicating leader of Collective discussions, F- facilitator, P-players, W- WRUA representative. On the right, we have rules agreed upon by each group to be implemented under collective action. The dotted box illustrates rules discussed but were not implemented in the game.

Younger players took much more time compared to older players (Figure 5.9a). Additionally, groups comprising of more players in WRUA leadership positions, reached collective solutions faster (Figure 5.9b). Other sociodemographic factors were statistically insignificant.

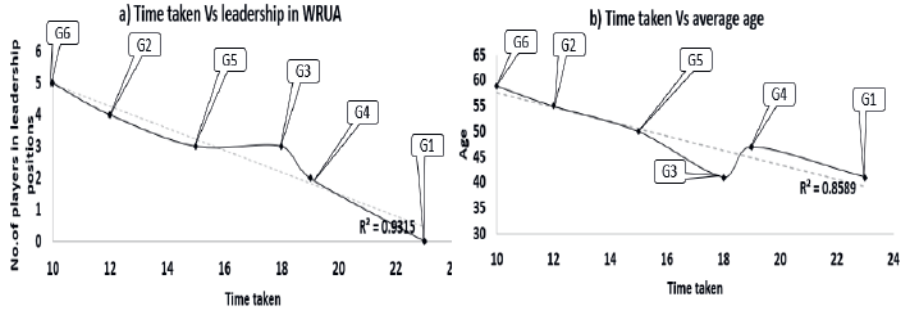


Figure 5.9: Comparison between participant's sociodemographic factors and time it takes to collectively agree on alternative options. G1 to G6 indicate where each of the six groups are positioned along the curve.

4. Discussion

Q-method results unveiled five discourses: 1) family-centric, where decisions prioritize providing food and income for the family; 2) market driven, decisions are based on local and agro-export markets demands; 3) Water Resource Users Association (WRUA) based fairness (rules-driven), decisions are based on established water management rules; 4) community-oriented, decisions on land and water management should be collectively managed by the community; and 5) care for the downstream interests, farmer decisions prioritize land and water management measures that reduce water stress downstream. The diversity in discourses would be expected since every individual has different groups whom they seek to please with their actions (Kemper, 2017). Level of importance is based on whether an individual regards the reference group status-worthy or wants to avoid power use. In factor 1, "family-centric", family is given more status compared to peers. This group would be less likely to manage their water footprints because of peer pressure (van Noordwijk, Leimona, et al., 2023). In factor 2, "market-driven", family and local markets are given more status compared to WRUA. The local market is recognized as an important reference group since they accord farmers status through recognition, better prices, free transport of their crops among other incentives. In factor 3, "WRUA based fairness", participants give a lot of status to WRUA. WRUA is an important reference group with a high status acquired through frequent advice to farmers and resolving water-related conflicts in real life. If not accorded enough status, WRUA also uses power to manage water resources for example through confiscating illegal water pumps. Factor 4, "community-driven", high status is accorded to the community where participants felt collective management of resources should be encouraged. In this case, community which also includes other stakeholders such as WRUA, Government, traders, is a reference group. Factor 5, "care for downstream community interests", participants supporting this opinion accord downstream community high status and therefore all land- and water use decisions are geared towards avoiding water stresses downstream.

Regarding participants' perspectives, we noted the significant relation between participants' actual location on the up-downstream gradient and their perspectives on land and water management decisions. More midstream participants were aligned to factor 1 and 2; where statements included making decisions that ensure crop production for family food and markets demands. This relation is expected since these participants have easy access to the markets and are at close proximity to the main road network. To meet the market demand, while rainfall is inadequate in the region, irrigation is required. It is therefore not surprising that none of the midstream participants loaded in F3 (WRUA-based fairness), where farmers are required to regulate their water use. This result is consistent with other studies which shows that more water is abstracted in the midstream for irrigation (Wamucii, Teuling, et al., 2023). We also note that fewer downstream participants prioritized statements related to factor 5 which was about care for downstream communities. The downstream participants felt most of the statements in this factor do not influence their decisions, but they apply to up- and mid-stream zones, for instance avoidance of high-water requirement crops or agro-export crops.

Playing Kilimo Na Maji game amplified some and suppressed other opinions that participants held before the game. As found from the Q-method, before the game more participants focused on food for family and income with little regard to regulated and fair water use. This could have been due to a lack of comprehensive understanding of the workings of the complex social ecological system. During the game sessions, change was initiated in player actions by clarifying how the system work in a simplified and effective manner. A better understanding of the system, and peer pressure triggered discussions on water scarcity and experimentation of alternatives to water scarcity and inequalities in a safe environment as identified by other authors, such as (Biggs et al., 2021; Bosma et al., 2020; Falk et al., 2023; Janssen et al., 2023; Speelman et al., 2014, 2018). Water inequalities and less profit for some players in the first round created a group of dissatisfied players. Conflicts and complains emerged pressuring those with self-interests to agree on shared goals. In this case, a collective reference group composed of all players became an important reference group (Figure 5.10).

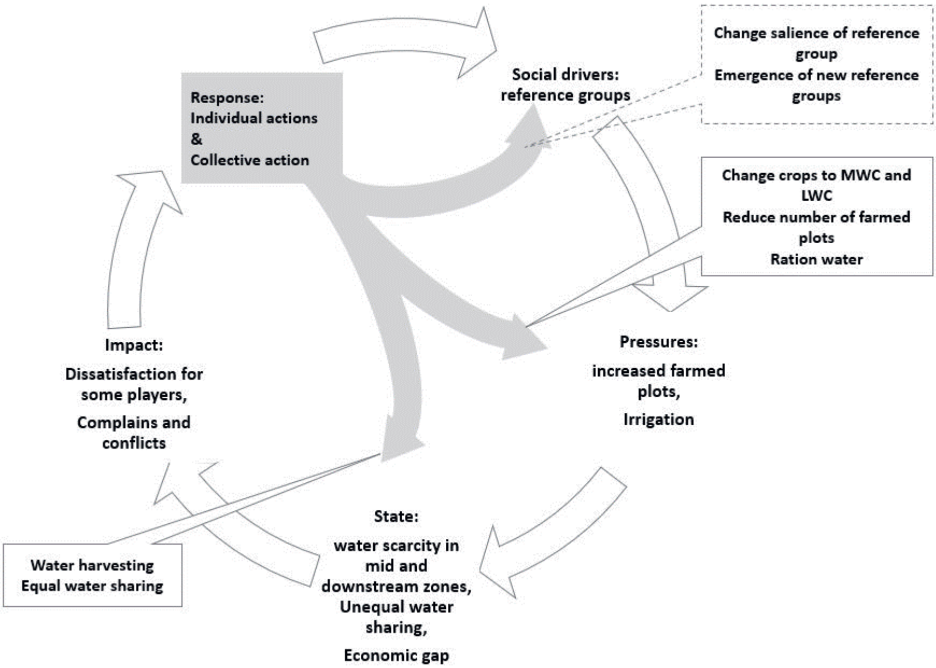


Figure 5.10: General steps that led to discussions on problems and collective identification of solutions. Dotted boxes contain the unseen pressures from reference groups, while the continuous callout boxes show actual changes implemented in game sessions.

In each of the six groups used in this study, the collective reference group had different set of rules on type of crops to be farmed and how water should be managed. Each player in the group was expected to adhere to these rules. Failure to accord this reference group the expected status i.e., non-compliance with agreed rules, led to more disagreements.

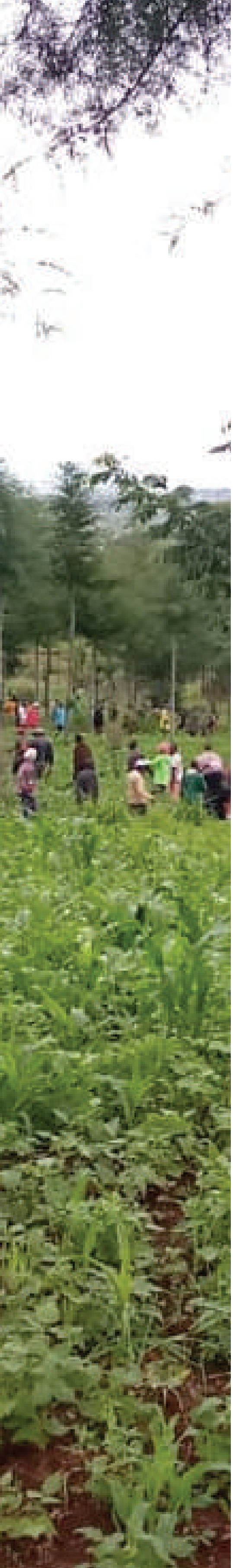
Time it took to agree on alternatives varied across groups with respect to status-power held by leader of collective action. Groups led to collective discussions by WRUA chairperson or facilitator took shorter time to agree on alternatives compared to those initiated and steered by players. In the real-world, WRUA chairperson is accorded higher status since they are usually well conversant with water management issues. We observed this status infiltration in game sessions such that WRUA chairperson would dominate the discussions while players easily followed advice of the WRUA chairperson with less arguments taking shorter time to agree on alternatives. The same status infiltration could explain the facilitator led discussion in one of the groups; where the facilitator could have been considered more knowledgeable and status-worthy hence players implemented the only solution proposed by the facilitator. Additionally, groups comprising of more WRUA officials agreed on solutions faster compared to those that did not. From Fiske's perspective (Fiske, 1992), those in leadership positions feels a responsibility to care for their subordinates. This could explain motivation for WRUA officials to easily let go some of the water to benefit mid-and downstream communities. Furthermore, WRUA officials had also dealt with water scarcity and explored possible solutions over time. Therefore, they already had options they could try out in the game session reducing the time taken on discussions.

Kilimo Na Maji game prompted locally generated alternatives to water managements. The game brought together stakeholders particularly researchers, policy makers (WRUA), and local stakeholders to jointly generate alternative options to water scarcity (Figure 5.11). While WRUA officials had an opportunity to share their ideas and challenges in implementing collective rules documented in the WRUAs constitutions, community members freely shared their opinion on shortcomings of the existing rules. The vibrant discussions during game sessions and debriefing proposed alternatives that went beyond strategies implementable during a game session to those that stakeholders should incorporate in management of their water systems. Participants indicated that they were clear on water resource boundaries defined by their respective WRUA constitutions and had leeway to modify their rules with less interference from external authorities. They therefore focused on addressing existing weak points of their real-world collective action under WRUA. The weak points were on rules, monitoring systems, and sanctions which are part of the Ostrom's principles of collective action (Ostrom, 1990). Modification of rules included: change of farming systems, where all farmers focus on food crops that need less water; and establishing more water harvesting facilities. To strengthen monitoring systems, options included increasing participation of households by registering each household to WRUA, this would strengthen surveillance systems, through subscriptions (Mwaura et al., 2020). Participants felt that funds should also be augmented with government funding to avoid over reliance on household payment. The rationale was a well-funded WRUA, would be adequately equipped and staffed to undertake monitoring activities. Finally, strengthen nested polycentric governance of WRUA within the existing water governance structure, a key principle in collective action (Ostrom, 1990). This governance style should allow government to take a strong position in: 1) Supporting adoption of drought tolerant crops by facilitating access to varieties that are more resistant to pests and diseases and take shorter time to mature; 2) Providing farmer extension services; 3)Strengthening the food value chain including access to good markets and sustainable consumption 4) Providing necessary information on sustainable options; 5) Monitoring and sanctioning for non-compliance with set rules.

Figure 5.11: Collective discussions on land- and water use in one of the game sessions.

5. Conclusion

In this paper we explored collective action from a social relational perspective using the case of Upper Ewaso Ng'iro North region in Kenya. The region has collective action units known as Water resources Users Associations (WRUAs). However, these units have not attained their full potential. Using Q-methodology, we identified some important reference groups such as families and local market that take precedence in the minds of the farmers resulting in dominance of irrigation to feed an almost unsatiable crops market. This results in persistent water-related conflicts particularly between upstream farmers who extract significant amount of water for irrigation, and downstream communities who are greatly affected by water scarcity. We designed a serious game known as Kilimo Na Maji, and used it to bring together WRUA officials, and members of the community to discuss and agree how best to address water scarcity. The game facilitated collective exploration of options which included: lowering demand for already scarce water resource by farming less water requirement crops, strengthening water surveillance to ensure compliance with set water laws; and increasing water supply through water harvesting and storage.



Chapter 6

General discussion and conclusion

The main objective of this thesis was to contribute to sustainable management of scarce common water resources. In the preceding chapters of this thesis, I found that farmer individual decisions do respond to their perceived preferences of their referent others, and collective-action feedbacks that make relational values potential game-changers in water management. A growing population and changing climate will continue putting more pressure on limited land and water resources. The growing population demands more food, whereas the changing climate has caused erratic weather conditions unfavourable for food production (Kandel et al., 2024; Mirón et al., 2023). Prevalence of rainfed agriculture in Sub-Saharan Africa make it more susceptible to impacts of climate change (Leal et al., 2022; Ofori et al., 2021). Frequency and intensity of drought and floods are likely to exacerbate food production in Sub-Saharan Africa (Baptista et al., 2022). While irrigation would be a good option to ensure continued food production during dry periods (Leal et al., 2022), unregulated and poorly managed irrigation systems may trigger competition and at times conflicts among multiple users (B. Kiteme et al., 2020; Lesrima et al., 2021; Mutiga et al., 2010; Wamucii, Teuling, et al., 2023). A farmer is henceforth faced with a decision on the best action to take. In this study, I assessed farmer land- and water use decisions from a social relational perspective using the case of Mt. Kenya region. This is a region with a changing climate, scarce water resources, many agri-business opportunities, and a relationally rich culture. This thesis has four core chapters, Chapter 2 to 5. Chapter 2 presents a theoretical analysis of relational rationality as a factor that shapes farmer land- and water use decisions alongside instrumental values. This is followed by Chapter 3 which uses empirical data to assess the impact of relational rationality on farmer decisions. Using the status-power theory of relations I showed a significant relation between land-use practices and a farmer's reference groups. Chapter 4 presents a serious game, KILIMO NA MAJI, that facilitates further exploration of the effects of social relations and the possibility of using games in prompting collective action towards sustainable land- and water use. Chapter 5 presents further analysis of results from game sessions and a detailed discussion on the impact of the game in shifting players allegiance to reference groups that serve self-interests to a collective reference group that deliver socially acceptable outcomes. All these chapters respond to the following four research questions:

1. Research Question 1 (RQ1): Which theories can be used to better understand farmer land- and water-use decision making?
2. Research Question 2 (RQ2): To what extent can relational rationality (status-power and reference group theory) explain farmer land- and water-use decisions in a given context?
3. Research Question 3 (RQ3): To what extent can relational rationality help better understand the outcomes of a game that represents local land- and water-use choices?

4. Research Question 4 (RQ4): Can such serious games strengthen relational rationality to achieve collective goals?

6.1 Highlights of the findings

This thesis underscores the effect of social relations on a farmer land- and water use decisions as found in the various chapters (Table 6.1).

Table 6.1: Overview of research questions, key findings/results, chapters under which the results were presented, and methods used in each Chapter

Research Question (RQ) and Chapter	Key results/findings	Study type	Data collection methods
RQ1: Which theories can be used to better understand farmer land- and water-use decision making? (Chapter 2)	• Insights into the impact of social relations in farmer land- and water use decisions can explain the often-heterogeneous farmer decisions	Generic	• Literature review
RQ2: To what extent can relational rationality (status-power and reference group theory) explain farmer land- and water-use decisions in a given context? (Chapter 3)	• Social relations explained land-use decisions that could not be explained by sociodemographic, and economic factors. • A farmer seemed more likely to choose a land-use option if he/she believed his/her salient reference groups would be pleased with the option. • Reconciling social relations with other factors such as farmer's sociodemographic factors, and geographic location had significant effect on the results.	Case specific empirical data	• Semi-structured individual interviews • Focus group discussion • Literature review • Transect walk and observation
RQ3: To what extent can relational rationality help better understand the outcomes of a game that represents local land- and water-use choices? (Chapter 4)	• KILIMO NA MAJI, a serious game with a 'solution space' where trade-offs between farm-income and water-use can be managed, was developed. • Social relations that participants had with their reference groups determined where their game outcomes were positioned within the solution space.	Generic with a case specific game session analysis	• Literature review • Databases (CROPWAT & data from Chapter 3) • Companion modelling • Questionnaire • Serious game
RQ4: Can such serious games strengthen relational rationality to achieve collective goals? (Chapter 5)	• Serious game built on relational values to shift players pre-game opinions to alternative options that could consider the interests of all participants.	Case specific empirical data analysis	• Q-methodology • Questionnaire • Serious game

6.1.1 RQ 1: Which theories can be used to better understand farmer land- and water-use decision making?

In Chapter 2, I argue that the effect of social relations has an important influence on farmer decisions using status-power theory of relations (Kemper, 1968, 2006, 2011, 2017). In the Chapter, I reviewed common theories used in explaining individual decision-making which included expected utility theory, prospect theory, bounded rationality, theory of planned behaviour. Expected utility theory and prospect theory align to instrumental rationality with a focus on maximizing utility, where utility can be economic or ecological benefits. Bounded rationality acknowledges that the decision-making process is limited by an individual's cognitive ability, available or accessible knowledge, time and/or other resources. Theory of planned behaviour incorporates psychological and social attributes to define decisions as a product of attitudes towards available options and outcomes, inculcated norms, and an individual's perceived behavioural control over available options. These theories have their strengths and weaknesses which the status-power theory of relations can complement by accounting for the influence of referent others in the social environment. Such that farmer's decisions do not only account for profits and loss but is shaped by the farmers' perceived preferences of their salient reference groups. Farmer decisions are thought therefore not only as instrumental, but also relational driven by the need to please reference groups that holds high status-power currencies in the mind of the farmer.

6.1.2 RQ 2: To what extent can relational rationality (status-power and reference group theory) explain farmer land- and water-use decisions in a given context?

After theoretically building a case for relational rationality in Chapter 2, I assessed the effect of social relations empirically, specifically status-power and reference groups, on farmer land- and water- use decisions (Chapter 3). I found that indeed, farmers were likely to implement land use options that they perceived to be pleasing to their reference groups; there were land- and water use options that did not follow economic rationality but could be explained by relations that farmers had with their referent others. This finding was informed by results from in-depth individual interviews and focus group discussions that I conducted with farmers from Upper Ewaso Ng'iro North River basin in Kenya; an area where relational rationality was expected to have a significant impact on farmer decisions. During data collection, I focused on identifying current land-use practices, and reference groups for each of the sampled farmers. Our analysis showed a significant relation between land-use practices and reference groups. Such that besides instrumental rationality of economic (options that give more profits), farmers prioritized perceived preferences of their salient reference groups, hence a high prevalence of crops that do not necessarily make more profit such as maize and potatoes. Salient reference groups were family, local and agro-export traders, Water Resource Users Association (WRUA) and downstream communities. Diversity of reference groups, and heterogenous decisions that lead to water sharing inequalities, downstream water scarcity, and water-related conflicts in the upper Ewaso Ng'iro North River Basin, inspired development of the KILIMO NA MAJI serious game.

6.1.3 RQ 3: To what extent can relational rationality help better understand the outcomes of a game that represents local land- and water-use choices?

In Chapter 4, I developed a serious game, KILIMO NA MAJI, meaning farming and water in Swahili language, to foster collective action, and possibly support the community in addressing water-related conflicts. In its initial application sessions, we found that KILIMO NA MAJI did indeed prompt different interactions and player decisions, and also prompted collective decisions towards sustainable crop production and water management. Besides documented water-related conflicts in the region and existence of a water governance structure (B. Kiteme et al., 2020; Lesrima et al., 2021; Wamucii, Teuling, et al., 2023), during my field work for Chapter 2, I noted excessive water abstraction and wastage in the upstream, and frustrated, water-stressed downstream communities. Thus, in Chapter 4, I used the serious game to investigate further drivers for farmer land- and water use decisions, and to engage farmers and representatives of water resource users associations, in discussing and identifying alternatives to crop production with their scarce water commons. In the Chapter, I present a description of the game, its development process, and results from two game session played with stakeholders from the Upper Ewaso Ng'iro North River Basin in Kenya. The game was simple enough for players to understand, relate with and collectively identify alternative options to water scarcity which included strengthening water regulatory institutions, increasing water supply through water harvesting; and managing available water by shifting planting seasons and type of crops.

KILIMO NA MAJI provided various options for players to effectively manage their land and water resources. The game's solution space comprised of all possible outcomes of game play (Speelman et al., 2014). It was developed using multiple equations designed to account for every possible decision that players can make. Its main purpose was to assess if players were able to identify options that can ensure efficient use of their land and water resources. Game outcomes were mapped into the solution space and options that provided sustainable water use were noted. As shown in Chapter 4, relations that participants had with their reference groups determined where their game outcomes were positioned within the solution space. In the first round of the game, players played with reference groups in their minds, hence chose options they perceived desirable to their reference groups. For instance, those whom local traders were an important reference group, chose crops that could sell in the local market such as tomatoes while those who were already in contract farming with agro-exporters chose French beans for export. Since games provide an opportunity to observe impacts, reflect and experiment other options

(Biggs et al., 2021), as players interacted, experienced inequalities in water distribution, farm-income, and complains, new reference groups emerged. Feedbacks from game cycles strengthened relational values, to gain group instrumental benefits. Other players became an important reference group that a player took into account. The needs of the group superseded the need to satisfy individual goals. Such that each player voluntarily or involuntarily (through surcharges and/or pressure from other players) sacrificed individual interests for group goals. Whatever the game outcome – economically beneficial or not – under collective action players were satisfied with their relational choices.

6.1.4 RQ 4: Can serious games strengthen relational rationality to achieve collective goals?

In Chapter 4, the two pilot session showed that the KILIMO NA MAJI game can actually foster collective action. Before drawing conclusion that the game actually fosters collective action, I played more game sessions and performed further analysis of games sessions. I found that the game changed some of the opinions that players held before the game to prioritize group goals. Pre-game participants' opinions on land- and water use decisions were classified into five discourses: family-centric, market-driven, rules for water management, community as the epitome of all land- and water use decisions, and empathy for downstream communities. A few rounds into the game, some of the players previously aligned to family-centric and market-driven discourse changed to alternative options that could consider the interests of all participants. The chance to view the landscape as a whole, and visualizing impacts of each other's actions, interactions among players, prompted collective discussions.

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6.2 Findings within the context of existing literature

In Chapter 3, we assess some of the influencers of farmer decisions in the Sub-Saharan Africa which include sociodemographic, geographic factors, economic, and ecological factors as found out in other studies (Beyene et al., 2019; Lambert & Ozioma, 2012; Marinus et al., 2022; Oduniyi, 2022; Pello et al., 2021; Siphesihle & Lelethu, 2020; Wanyama et al., 2021). Besides these factors, rationality of farmer decisions is also based on values they place on nature. Values could be instrumental with cost-benefit analysis of services obtained from nature or relational, based on relations with nature, or individuals (Díaz et al., 2015; Van Noordwijk et al., 2023). Relational values have been explored before in Mt. Kenya region. For instance, a study assessing diversity of valuations of nature and their integration into decision making, showed that value was placed in building and maintaining good relations with other people by improving quality of life for the marginalized people and reducing water-related conflicts (Zafra-Calvo et al., 2020). Although it was not explicitly highlighted, a possible occurrence of relational rationality (including reference groups identified in this thesis), was noted in other studies. Where farmer's decisions would tend to be aligned to perceived preferences of reference groups in their social world for instance, members of the community water project (Giroux et al., 2022), extension workers and social groups (Mutea et al., 2020), large-scale commercial farmers and agro-export companies (Giger et al., 2022; Ulrich, 2014; Zaehringer et al., 2018). This thesis covered extensively, rationality from the perspective of relations that humans have with their reference groups. An interesting area for further exploration could be rationality from the perspective of human relations with nature (Díaz et al., 2015). Where nature, symbolized as 'people,' can be regarded as a reference group that influence decisions.

This thesis developed and used a serious game to support sustainable land- and water use. The developed game, KILIMO NA MAJI, was used to engage local stakeholders in the Upper Ewaso North Ng'iro River basin in Mt. Kenya region. The region is faced with water scarcity, perceived water sharing inequalities to the extent of triggering conflicts among the multiple users (Lesrima et al., 2021; Wamucii, Teuling, et al., 2023). In an effort to curb water-related conflicts, the Government in collaboration with stakeholders have established policy and institutional framework that incorporates participation of local stakeholders (Kenya Water Act., 2016). However, the policy face implementation and compliance challenges with occurrences of excessive water use in the up-stream and scarcity downstream, as found out in this thesis (Chapter 3), and in concurrence with other studies (Lesrima et al., 2021; van der Laan et al., 2021; Wamucii, Teuling, et al., 2023). In this thesis (Chapter 4 and 5), solutions to water scarcity, perceived inequalities and related conflicts were similar to those identified in other studies. They included strengthening of Water Resource Users Association (WRUA) to be able to track water use and sanction (Lesrima et al., 2021; Mwaura et al., 2020; Wamucii, Teuling, et al., 2023; Zafra-Calvo et al., 2020), encouraging household membership to WRUA (Mwaura et al., 2020). One major contribution of this research is that participants in the study, who are members of the community across up-, mid, and downstream parts of the landscape, were able to visualize the problem, discuss and try out several options to land- and water use. In this regard, this thesis proposes implementation of this game in multiple sites, in the sense that farmers are able to understand that there is a threshold where everyone gets to benefit from the shared resource. One of the options being water harvesting whether through common dams or individual water pans, funded by individuals, government or development, partners. Sustainability of water harvesting projects that have been challenged by lack of ownership (Ulrich et al., 2012), can benefit from serious games that can encourage participation of local communities in conceptualization and implementation of projects. Another key contribution is that the game strengthens relational rationality to enable participants care enough about other people enough to sacrifice self-interests to collective goals.

In Chapter 4, the designing of KILIMO NA MAJI Game, is based on the Actors, Resources, Dynamics, and Interactions (ARDI) framework (Etienne et al., 2011). Games that have used similar approach include FORCES, a single-player game designed to engage individual farmers in choosing between annual crops and trees for financial benefits and ecological impacts (Sari et al., 2023); the H2OURS game designed to trigger collaboration in restoration of hydrological conditions, ENGAGE game, designed and used in the Upper Ewaso Ng'iro North River basin to strengthen local stakeholders engagement in addressing human-water related challenges in the region. A contribution of the Chapter into the game design framework is inclusion of 'Relations' into the ARDI (R-ARDI). The concept accounts for relations between players and their salient reference groups. The relations concept can be included into the game in three ways, have reference groups exist entirely in players mind, have some of the players play the role of reference groups, have real-world reference group such as government play as themselves. Chapter 4 and 5 provides an analysis of games outcomes using the solution space and relational rationality approach. The solution space has been used in other serious games such as the FORCES game (Sari et al., 2023), H2OURS game (Tanika et al., 2023), and ENGAGE game (Wamucii, Van Oel, et al., 2023). A contribution of the Chapter is analysis of the position of a game's outcome on the solution space from a relational rationality perspective. Where status-power and reference groups before the game, and those that emerge during a game session significantly impact the outcomes.

6.3 Reflections on findings, theories, and methods used

6.3.1 Status-power theory of relations is a strong theory for analysing farmer's relational rationality

Farmer decisions have been explored extensively from many perspectives but yet from the perspective used in this research. Further, serious games, their application and impacts are yet to be explicitly analysed from the social relational perspectives. An outstanding aspect of the status-power theory of relations is that there is no self, rather actions are viewed as a manifestation of multiple reference groups. In this study I showed that farmers rationalize their decisions from their relations perspective. Also, social relations seemed to have significant effect on game sessions and its ultimate outcomes (Chapter 4 and 5). Status-power theory of relations does not discredit rationality of other theories such as economic rationality, behavioural economics, bounded rationality, theory of planned behaviour rather it complements them (Chapter2). For instance, the theory of planned behaviour defines attitudes, as an individual affective assessment (pleasure/displeasure with the expected outcomes) and instrumental value assessment (cost and benefits) of an option (Ajzen, 1991). Kemper's theory defines the 'who' is to be pleased as the totality of salient reference groups (Kemper, 2017). Where the theory of planned behaviour refers to social norms inculcated by referent others, Kemper's theory expounds on this aspect to allow the influence of more than one reference groups with differing opinions. Prediction of human decisions using bounded

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rationality accounts for limitations encountered in the decision-making processes such as cognitive limitations, time available to make the decision, information available to the farmer, and perceptions (Simon, 1990). Some of these limitations exist since a farmer's thoughts are confined within salient reference groups that they have been exposed to and their perceptions on actions that a salient reference group would approve of (Chapter 2). Exploring reference groups could provide a better understanding of the bounded rationality, but also 'unbound' the farmer's decision-making process. For instance, socialization across the landscape would expose farmers to new reference groups (especially the real-world reference groups such as Agro-export companies), acquire new knowledge, change perceptions, and henceforth land use practices to please these new reference groups. In this study, I noted a shift from crops such as wheat and maize to crops such as French beans, garden peas, exotic vegetables and geranium flowers as the region received more agro-exporters (Chapter 3).

I advocate use of Kemper's work in analysis of farmer decisions (or individual decisions) due to its focus on the individual; noting that aggregation of individual actions have significant effect on the commons (Chapter 2). In this research I noted that first, there exist salient reference groups in the mind of a farmer shaping their decisions (Chapter 3,4 and 5). Second, the reference groups that shape a farmer decision may not always be evident, that is, farmers may not always be aware of reference groups that shape their decisions (Chapter 3,4, and 5). A decision can be shaped by more than one reference group. Third, a farmer is loyal to reference group(s) that accords the farmer enough status, has potential of using power against the farmer and leaving the reference group will cost more than the benefits that can be gained by complying with the bidding of another reference group (Chapter 3). Fourth, it is common for the virtual reference groups to point into different directions pulling a farmer's thought into multiple directions. In such instances virtual negotiations among reference groups occur in the mind of the farmers in a 'reference groups meeting.' The different voices are heard and weighed against the status-power dynamics until a compromise is reached (Chapter 4 and 5). Fifth, accounting for social relations could account for variations in decisions that cannot be accounted for using sociodemographic factors, and instrumental rationality (Chapter 3 and 5). Thus, modelling farmer's decisions should account for effect of social relations.

6.3.2 Collective management of the commons is not necessarily for the benefit of the commons

Collective management of commons depends on relational values to provide instrumental value benefits (Chapter 4 and 5). Under collective action, the benefits of pleasing a collective reference group – whose relations matter to the farmer – supersedes the cost of disobeying self-interest reference groups. At times and under certain circumstances individuals are willing to sacrifice self-interests for the benefit of social group (Haidt et al., 2008; Ostrom, 1990). Transitioning from individual to collective goals requires establishing and elevating the status-power of a collective reference group. From a status-power perspective, if compliance with self-interest reference groups conflicts with the needs of others in the social arena, this can lead to denial of status from others and at times power-use from the afflicted others. An individual, may therefore do the bidding of the collective reference group out of empathy, to gain status and/or to avoid power-use. For example, in the Upper Ewaso Ng'iro North River Basin, collective action is triggered by both status and power use (Chapter 4 and 5). Farmers are expected to regulate their own water use out of respect for others, otherwise they are surcharged, and their water pumps confiscated by the Water Resource Users Association (Chapter 4 and 5). Where collective action is triggered, its sustenance by complying with rules is built on trust and an understanding that adhering to the requirement of the group depends on whether the rest of the members also adhere to its requirements (Ostrom, 1990). Otherwise, collective action may become unsuccessful. Individuals under collective action are bound by rules of the collective action to which they would voluntarily or involuntarily respond. Under collective action, respect, and reciprocity, which are status tokens from Kemper's perspective, are paramount for all those who will be engaged in implementation of collective action rules (Chapter 4 and 5). It is expected with a balanced status exchange among members of collective action, then voluntary compliance with rules of engagement will happen. But then again, if this voluntary compliance fails, the principles provide for graduated sanctions and nesting governance of collective action on other governance bodies to ensure compliance through power-use (Ostrom, 1990; Kemper, 2017). These are some of the recommendations given for water management in Chapter 4 and 5. Chapter 4 and 5 emphasizes that collective action constitutes dynamic land- and water use decisions that cause circumstances (for example water inequalities, water-related conflicts), under which individuals may be compelled to collaborate; and to ultimately look for alternative options to address the problems (Van Noordwijk et al., 2020). One of the ways to achieve this and to prompt collective action among the local stakeholders is through serious games.

6.3.3 Leveraging on serious games to support learning and fostering collective action

Serious games enable participants visualize reality on a model that mimics their real world. In our game sessions I noted several things. First, a game that can be easily understood by players; has the right amount of pressures; a near reality representation of the actual world, with clear rules but also allow a bit of flexibility for players to relate with the game; proper facilitation, a comprehensive brief of the rules of engaging with the game; and clearing any mis-understanding before the game starts, enables achieving more from a game's session (Chapter 4 and 5). Second, situation analysis and co-construction of a serious game with local stakeholders enhances its quality especially in representation of reality and understanding the social and cultural environment of players (Etienne, 2013; Van Noordwijk et al., 2020) (Chapter 3). These could range from participants' best time and duration for game sessions, identification of group of players that cannot sit on the same table for instance based on sex, economic status, ethnic group, and other occurrences for example days of worship, or weather. The quality of the game and game sessions can be improved based on situation analysis and companion modelling, but the facilitator should be alive and flexible to accommodate other emerging social or daily issues that may affect game sessions. Third, identifying a game's solution space (Chapter 4), helps in assessing achievements of the game objectives, particularly if one of the objectives is to support participants in identifying alternative options for an existing social dilemma. For example, in our game, participants were expected to identify land- and water use choices that would sustain crop production in scarce water resources without conflicts. Mapping results from game sessions into the solution space helped conclude that indeed players were able to find options that could work. Fourth, serious games encourage local stakeholder participation, tapping local knowledge, and eliminating roadblocks to better management of the commons. One of the key achievements from our game sessions is that the sessions went beyond benefitting the research to benefit the community. For instance, water managers (leaders in charge of Water Resource Users Association), and water users (farmers from different elevations of the landscape) were able to share their perspectives on land and water management choices (Chapter 4 and 5). The first round usually mimics reality; the choices that farmers made in reality (Chapter 4 and 5). In most groups, the realization that collective goals were more important manifested itself (Chapter 4 and 5). Key highlight of our game sessions was that WRUA officials were able to communicate their reasons behind measures they put in place to regulate water use. On the other hand, farmers demonstrated why the measure do not work; more because, the up- and midstream farmers ride on the loopholes of the existing rules to access more water (Chapter 4 and 5). Such include water abstraction at night where surveillance is low, joining more than one water project to access more water during rationing, the use of communal pay rather than individual payment methods which would possibly promote more responsibility, among others (Chapter 3).

6.3.4 Triangulation of data collection methods for better exploration of social relations

The graduated approach and triangulation of data collection with a mix of in-depth qualitative data collection, quantitative data collection with a wider sample frame, and use of q-methodology which combines both quantitative and qualitative data collection and serious games, provided a better analysis of the effect of social relations. Analysis of theories in Chapter 2 provided an overview of possible theories and ways to analyse an individual's decision-making processes before narrowing down on the status-power theory of relations as a powerful tool for analysing decisions. However, theoretical approach was not enough without some empirical data to support the analysis. Hence, in-depth individual and group interviews in the field to assess the existence of reference groups and their possible effect on decisions were beneficial (Chapter 3). Theoretical and empirical approach complemented each other. Knowledge acquired in the theoretical analysis of theories, equipped the researcher with the ability to detect possible reference groups. In most cases, as noted in Chapter 2 and 3, people may not be aware of reference groups that shape their decisions. However, a researcher who is alive to the existence of reference groups will be able to abstract reference groups and their status-power depending on statements from the respondents. For instance, a farmer who says, "I farm maize and store for our daily food." While no reference group is mentioned in this statement, it is possible to deduce that one of the important reference groups is 'family' of whom it is at the best interest of the farmer to provide enough food for without being coerced by anyone (no power-use) but out of love for the family (status). The empirical data collection, qualitative with a small sample and later on quantitative using a larger sample, provided stronger evidence for existence of reference groups. Furtherance of the study to use serious games in Chapter 4 and 5, not only provided more understanding of social relations on individual farmers but also the effect of feedback on those decisions and adoption of sustainable land- and water use practices.

In this thesis, Q-methodology is used to identify participants' perspectives regarding farmer land and water management decisions in Chapter 5. I used this method due to its capabilities in combining both the quantitative and qualitative data collection techniques. The method quantifies qualitative opinions to allow a quantitate analysis. The Q-methodology allowed participants to identify the most important drivers of their land- and water use decisions. I compared these results with decisions made in the game; taking note of any shift from existing relations to new relations that shape farmer decisions in the game session. The analysis helped abstract the effectiveness of the game in influencing a change from self- to collective interests. In addition to the Q-methodology that helped identify possible effect of reference groups that existed in participants' minds ahead of the game, sociodemographic data helped in analysis of possible effect of individual's own status-power on the game's outcomes. Where participants already with a higher status-power standing in the society – identified using farmer sociodemographic factors as a proxy indicator of status-power – had a higher likelihood of becoming an important reference group influencing decisions during a game session.

6.4 Study limitations and future research

6.4.1 Rational versus rationalization of decisions

In this thesis, status-power and reference groups theory is used to understand farmer decisions. The theory assumes farmers make rational decisions within relations they have with their reference group. However, there is a chance of confusing what is reported as a rational decision versus a rationalized decision. Rationalization is an instance where individuals attempt to justify why they made particular decisions (Cushman, 2020). In most instances rationalization of decisions happens where an individual feels the decision was irrational and/or cannot be understood and hence needs justification to make it rational against some set morals/beliefs inculcated by the important others (Cushman, 2020). Kahneman in his thinking fast-slow has popularized the notion that what people report (and may believe to be true) are post-hoc rationalizations (ways to tell a story that makes sense to the audience), rather than the 'real' ways decisions emerge in human brains, according to neurological data (D. Kahneman, 2017). One factor that was not differentiated in this research while collecting data on why farmers make specific decisions, is whether what farmers reported was a rational decision or a rationalized decision to suit perceived preferences of their reference groups.

6.4.2 Application of KILIMO NA MAJI GAME in multiple sites and evaluation of its impacts on farmers' real-life land - and water use practices

I presented KILIMO NA MAJI as a generic game that can be adapted and used in different contexts, however, due to time limitations, I was not able to test it in different contexts. I therefore propose adaptation of the game and its use in different context starting from a different Kenyan landscape and extending to other tropical landscapes. My game sessions yielded impressive results, where participants were able to identify options to sustainably produce crops and manage their water resources. Although games have been found to impact change in real-life of the participants (Janssen et al., 2023), there is possible variations in what was observed in the game session and what people actually do on their farms. Therefore, follow-up surveys could be useful in assessing influence of the game on participants' decisions in the real-world. The study can consider using a control group to compare behaviour of those who participated in game sessions compared to those who did not. This would be crucial in determining the impact of KILIMO NA MAJI in collective management of land and water resources.

6.4.3 Agent Based Modelling to explore dynamics of relational rationality

In this thesis I designed, developed, and applied a serious game that can be used for multiple purposes. In an attempt to simplify KILIMO NA MAJI GAME, its rules and time taken to play one round, several parameters/scenarios could not be included. This presented the first limitation of representing as much reality as possible while making the game as abstract and easy to play as possible. The second limitation was using a small sample size against the represented population. In my game sessions, a set of 6 players seemed ideal for constructive engagement among player and between players and the facilitator. It also facilitated close follow up of player actions and discussions. This limited coverage of a wider population and generalization of findings to the large population. Every game session was unique, the same game cannot be played twice and so generalization of results from a sample to represent a wider population would not be ideal. As seen in Chapter 4 and 5, game sessions are affected by many factors that include status-power of players, reference groups and other issues such as weather, and planting seasons. The third limitation is caused by the cross-sectional survey approach to data collection, where data was collected from different individuals/groups at specific times (Chapter 3). Although serious games simulated timeseries data collection; the sessions could only account for changes for a short period of 3 to 5 rounds of a game (Chapter 4 and 5). As such variations in salience of reference groups and preferences that could occur in a longer period of time could not be accounted for. This is in addition to scenarios (such as weather, or new government policies) that can significantly affect salience of reference groups. Noting that KILIMO NA MAJI is limited in terms of complexity that can be accommodated (has limited scenarios) and number of rounds a game that can be played, this thesis proposes agent-based modelling of the game.

Agent based modelling (ABM; abbreviation also used for "agent-based model") is a simulation technique that focuses on modelling, usually in simulated two-dimensional space, individual agents (in this case, farmers), their actions, interactions, and cumulative effect on the commons (Gilbert, 2020). It can complement a serious game with its capacity to incorporate a large set of farmer agents, multiple scenarios – including undesired ones – and running of simulations over a longer time scale. Since in an ABM there are no real people, all the agents' motivations have to be given by the modeler. Thus, agents could be created that have, or lack any of the following: sociality, relational memory, group affiliation, economic utility functions. Each agent is programmed with specific decision-making rules, behaviours, and objectives, to allow their interactions with each other and their environment. When it comes to farmer land- and water use decision-making, ABM can capture the heterogeneity and variability among farmers, as farmers often have different goals, resources, knowledge, and risk attitudes, but also in capturing shared elements of sociality such as culture or status-power dynamics across reference groups. ABM can define interactions among farmers, such as social learning, knowledge diffusion, competition, and cooperation. In ABM, environmental factors that affect farmer decisions can be included, for instance weather patterns, soil quality, water availability, and climate change impacts. ABM has been used to explore farmer decisions in response to policies, interventions, market volatility, resource scarcity, climate variability, socio-economic changes, innovations, land, and water management among others (Ambrosius et al., 2022; Kasargodu Anebagilu et al., 2021; Malawska & Topping, 2016; Pacilly et al., 2019; Shahpari & Eversole, 2023; M. Wens et al., 2020). ABMs have also used the status-power theory of relations to model agent's decisions (Hofstede et al., 2018). However, the extent to which status-power relations affect a farmer's behaviour is yet to be modelled. Such an ABM could be useful to policy makers, researchers, and other stakeholders.

6.5 Concluding remarks: Application of results from this thesis

In this conclusion, I highlight on relevance of this research. The main objective of this research was to support sustainable management of land and water resources. Its key outputs were presentation of relational rationality (using status-power and reference groups theory) as a significant influencer of farmer decisions; implicit analysis of game outcomes from a relational rationality perspective; and KILIMO NA MAJI as a tool that can be used to engage local stakeholders in sustainable land- and water use. A review of existing theories and analysis of empirical data showed that farmers are relationally rational; their decisions are impacted by their perceived importance and preferences of other people, groups of people and/or spiritual beings (the reference groups). Relational rationality also seemed to impact outcomes of a serious game session. Serious game is a model designed to mimic real-world systems. Serious games are used not only for fun but for learning or exploring a certain phenomenon. In this thesis, serious games were used to engage participants in exploring options for sustainable use of scarce water commons. One of the key deliverables of this thesis, KILIMO NA MAJI serious game could have a huge opportunity for its application in water scarce landscapes such as the Upper Ewaso Ng'iro North River Basin where the game was applied. Policy makers and other institutions have been using conventional methods for instance focus group discussions to engage stakeholders in water management. However, these approaches are not always successful. Also instances where self-organized collective management of water resources is expected, rarely happens and sometimes if it happens it is not successful. I present KILIMO NA MAJI serious game as a tool that can be used to actively engage stakeholders and possibly foster collective exploration of options for sustainable land and water use. In the game, farmers make land- and water use decisions, and observe impact of their actions in the model. The game has short time feedbacks that stimulates farmers to critically review their decisions based on the impact on the landscape, other participants, and themselves in the long term. One of the successes in its application was that policy makers were able to share their opinion on water management, while farmers at different elevations of the landscape (up-, mid, and downstream), were able to discuss, experiment, and agree on options for better water management. Considering the aim of this research is to support sustainable land- and water use, I presented a solution space for the KILIMO NA MAJI serious game. The solution space provides all possible outcomes from decisions that can be made in a game session. It also provides a range where trade-offs can be partially managed. Basically, where sustainable water management is attained. Placing a game's outcome in the solutions space helps identify alternatives that achieve sustainable water management. Identification of these options can inform development of policies, or development of rules to engage with resources among the local stakeholders. Based on findings presented in this thesis, my conclusion is that relational rationality can explain variations in farmer land- and water use decisions in times of a changing climate, government policies, local and global markets, among other changes in Mt. Kenya region, and possibly in other contexts.

Appendices

Appendix 1: Appendices for Chapter 3

Appendix 1A: Reference groups ranking and perceived preferences

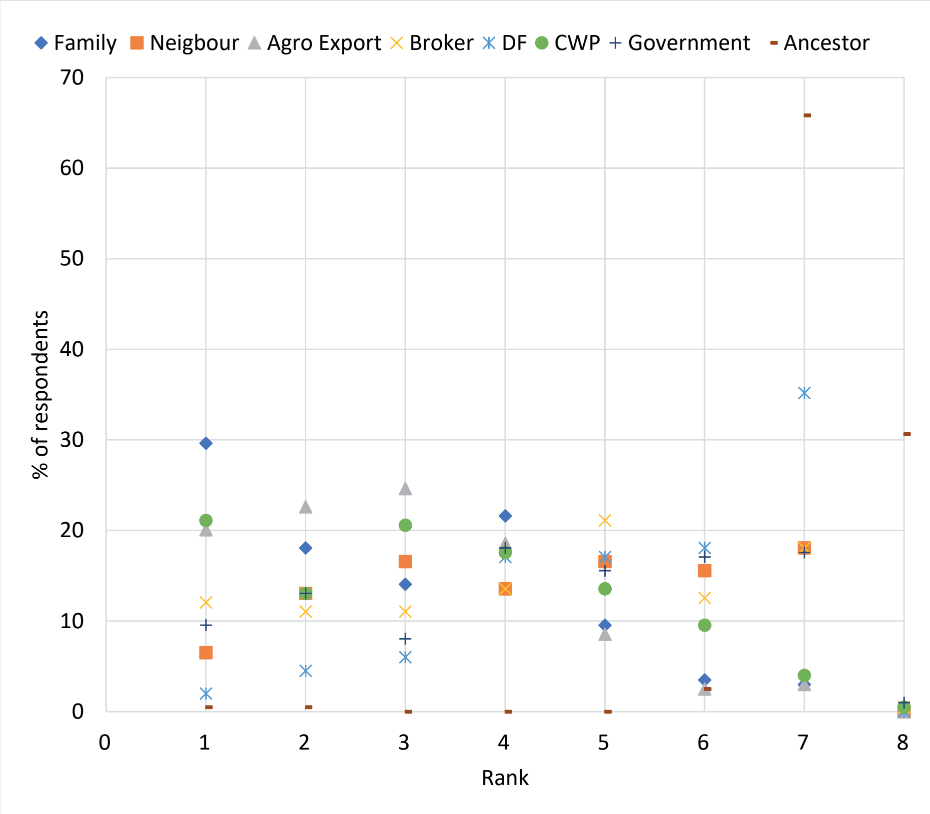

Figure 1A: Ranks of reference groups: The graph shows importance of reference groups as ranked by the respondents. The axis shows proportion of respondents who ranked a reference group in the identified position. For instance, Family was ranked as the most important (at position 1) by 30% of the respondents. Another example is ancestors were ranked as the least important (at position 7) by 31% of the respondents. The abbreviations DF refers to downstream communities while CWP refers to Community water project.

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Table 1A: Reference groups crop preferences from the farmers perspective: The figures indicate percentage of farmers who believe that the indicated reference group would be Displeased (DP), neutral or pleased(P) with the corresponding land-use option.

	Family			CWP			Agro export			Local market			Government			Neighbour			Downstream communities			Ancestor		
	DP	N	P	DP	N	P	DP	N	P	DP	N	P	DP	N	P	DP	N	P	DP	N	P	DP	N	P
Potatoes	5	4	92	4	21	76	14	59	28	3	14	84	4	5	91	10	42	48	18	47	35	12	81	7
Vegetables	6	13	76	3	70	27	10	21	70	5	14	81	3	7	91	9	33	58	18	43	39	10	83	8
Peas	13	10	77	5	41	54	9	9	82	5	15	80	4	6	91	9	53	39	18	53	29	10	84	6
trees	12	11	78	4	14	83	12	21	67	6	14	81	2	4	94	15	38	48	14	28	58	79	15	6
DTR	16	47	37	6	21	73	14	45	41	5	14	81	4	5	92	10	56	34	19	61	20	12	15	74
Maize	17	17	66	4	26	70	18	41	41	10	9	81	3	5	92	12	37	52	19	44	37	13	79	9
Beans	8	16	76	2	36	62	11	36	53	4	13	84	4	5	91	12	44	44	18	51	32	14	81	5
French beans	15	9	76	2	38	60	7	9	85	4	18	78	2	5	93	15	48	38	18	50	32	82	14	4
fruits	13	9	79	5	52	43	11	11	78	3	16	81	2	5	93	7	57	36	19	63	19	82	14	4
onions	7	12	81	3	50	47	11	46	43	4	13	83	3	5	92	11	59	31	15	64	21	83	14	4
Tomatoes	15	11	74	3	49	49	11	39	50	4	11	85	2	5	93	12	55	33	18	60	23	80	17	4
Wheat	63	11	26	13	46	41	18	42	40	3	20	77	3	4	93	13	65	22	21	59	19	83	14	4

Table 1B: Shows the probability of farming select crop while predicting using sociodemographic factors, reference groups and while using a combined model of both sociodemographic variables and reference groups

	Sociodemographic factor	Reference groups	Combined model
Potatoes	None	Neighbours (100) XNeighbour *Local trader (94) XNeighbour*Xlocal trader (72)	Neighbours (100) XNeighbour *Local trader (94) XNeighbour*Xlocal trader*Meru (87) XNeighbour*Xlocal trader*Laikipia (64)
Maize	Hhsize<=2 (31) Hhsize>2* Laikipia (91) Hhsize>2* Meru (80)	Family (99) Family*Local traders*Government (93) Family*Local traders*Government (59) Family*Local traders*Government (0)	Family (99) XFamily*Local traders*Government (93) XFamily*Local traders*XGovernment (59) XFamily*XLocal traders (0)
Vegetables	None	Local traders (80) Xlocal traders (58)	local traders*own land*HH>5(100) local traders*own land*HH<=5 (79) local traders*rented land (60) XLocal traders*own land (53) XLocal traders*rented land (76)
French beans	None	Agro-expo*Local traders (44) Agro-expo*Xlocal trader*Government (45) Agro-expo *Local traders*XGovernment (78) Xagro-expo (36)	Agro-expo*Local traders (44) Agro-expo*Xlocal trader*Government (45) Agro-expo *Local traders*XGovernment (78) Xagro-expo (36)
Tree	Age <=45 (34) age >45 (11)	None	Age<=45 (51) Age>45*Neighbours (47) Age>45*XNeighbours (6)

Table 1B continues on next page.

Table 1B: *Continued*

	Sociodemographic factor	Reference groups	Combined model
Beans	None	Neighbours*CWP (41) Neighbours*XCWP (23) XNeighbours (0)	Neighbours*CWP (41) Neighbours*XCWP (23) XNeighbours (0)
Fruits	Off-farm activity (11) No off-farm activity * Laikipia (34) No other off-farm activity * Meru (14)	CWP (40) XCWP (19)	CWP*Meru (13) CWP*Laikipia (50) XCWP (19)
Peas	None	CWP (32) XCWP (12)	CWP (32) XCWP*Meru (22) XCWP*Laikipia (6)
Tomatoes	Off-farm activity (21) No off-farm activity (7)	CWP (30) XCWP (11)	CWP (30) XCWP*age>30years (14) XCWP*age<30years (0)
Onions	None	CWP (29) *CWP (9)	CWP (29) XCWP (9)

Appendix 1B: Data Collection tools

Questionnaire for phase 1

Introduction

Name of enumerator ______________ Date: _______________

Time started: ___________________ Time Ended: ___________________

County____________________________ Sub-County __________________

Ward ___________ Village _______ Household No_________________________

Location (upstream, middle, downstream) & coordinates_______________________

Section A: General questions

1. Age of HH head (20-24,25-29,30-34,35-39, 40-44, 45 -49, 50-54, 55-59, 60-64, 65-69, 70 and above)
2. Gender of HH head (Male, Female, Other)
3. How many people live in the household? Adults? Children below 18?
4. Economic status, average expenditure in a month? (Education, Food and household supplies, Farming, Clothing and apparel, Medical, Other expenses)
5. Livestock owned and value.
6. Economic activities (Employment, Agriculture and Livestock sales, Land rented out, Pension, Gifts/support from friends...)
7. Level of education (Never went to school, Primary, Secondary school, College diploma/certificate, University degree, post graduate degree, Others (specify
8. With what and with whom do you identify? And how do you describe yourself? (Small scale farmer, environmentalist, agribusiness farmer)

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Section B: Land-use patterns

1. Land size in acres ___________ and sketch a map of your land-use patterns.
2. Land tenure (private, communal, rented)
3. How do you use your land – (mono cropping (which crop), trees Plantation (which trees), Agroforestry (Agrisilvicultural, Clavipectoral, Agrisilvopastoral) -
4. Have you changed your land-use decisions over the past 10 years, (if yes how), what influenced these changes?
5. Do you expect to shift from the current practice in the next period? Why?
6. Rank the land-use options by order of preference and why the preference (use sheet for ranking and reasons below)
7. According to your own understanding, rank the identified crops in order of their

water requirements, capital investment, care required, profits, and price fluctuations (use a sperate sheet)

Section C: Status, power, and Reference Groups

1. What group(s)/Persons informs your land- and water use decisions (family, neighbours, peers, NGO (name), Government, traders, Others (name). Whose opinion matters to you, whom would you like to please as you make your decisions? Or who is likely to punish you? Ex. NGO, Gov, Family, parents, ancestors, region....
2. Matching reference groups with land-use preferences (use drawn table)
3. In the previous exercise, we see that some referents may disagree, or have different opinions regarding different land-uses. What do you do when there is a disagreement? What decision do you make when you are in the middle of a dilemma? Which opinion is the most important? Why? You can rank importance of reference groups using the provided table.
4. Any existing government policies on water, forest, NR management, how effective are they?

Section D: Water use

1. Think about the rivers and water bodies in the region, how would you describe the current condition or volume of water? (Low, somehow low, high, very high do not Know)
2. What is your major water uses and source? domestic, agriculture, pasture, livestock? river, borehole, rainfed) (list uses with corresponding source example crops- rain)
3. How far is the water source (borehole, river, dam...) from your dwelling? (In minutes)
4. If a shared resource, what (whom-reference group) informs your regulation of water use? if upstream, do you consider other households downstream?
5. Does the quantity of water change during the year? (yes/NO) if yes, how? And why?
6. According to your own opinion, is there fairness in distribution? if not what is the scenario like? What would you recommend?
7. How do you expect the water quantity and quality to change in the future? (Improve, deteriorate, no change, do not know), why? And what should be done to sustain or improve water quality and quantity?

Section E: Groups, rituals, affiliation

1. Do you belong to an association? Which ones?
2. What are the rules of the association that all its members must comply with, and what are the benefits of belonging to the association?

3. In which events of your association or group do you have the responsibility to participate? What benefits do you have by participating? What happens if you do not participate?
4. How are decisions made within the associations or groups? Who makes the decisions? Is it consultative?
5. Why would the association's rules change? Why would the association change or adopt other land-use practices? For which reasons, the opinion of the association regarding a type of land-use would change? For example, go from inorganic to organic production or from conventional livestock to a silvopastoral system.

Section F: Collective Action

1. Description of the CA
    a. Have you experienced any situation that would require collaborative efforts with other HHs for it to be addressed?
    b. What was the issue? What NR were you fighting for? What was the tipping point?
    c. How many other households were affected? ______________________________
    d. How many HH joined in action? Whom did you collaborate with? What was the composition of the group (location, economic status, land sizes, farming practices...), why did some not join though affected?
    e. How was the coalition formed?
    f. Who lead the formation of the action group?
    g. Did/Does it have a leader? Attributes of the leader? How was the leader appointed?
2. Operation dynamics of the Group.
    a. Did you seek support from other group(s) / Persons such as political leaders, local government for your group to be operate?
    b. Were there rules defining the operations of the group? Joining, leaving, fees, ...
    c. What were the benefits of being in the group? Environment conservation, equity in water distribution; To be together with friends; for social prestige; for better market of produce purposes; access to forest resources (fruits, timber, wood fuel, grazing etc)
    d. Were there any disadvantages of those who were affected but were out of the group?
3. Sustenance of the CA
    a. How long did the action last?
    b. In your own opinion was the action successful? _____________
    c. If yes, how?
    d. if not why? Leadership, communication breakdown, mistrust self-interest of leaders or some groups within the group, the issue was addressed.

Questionnaire for phase 2

Introduction

Name of enumerator ________________________________Date: _______________

Time started: _____________________Time Ended: __________________________

County __________________Sub-County____________________________

Ward ___________Village _______Household No____________________________

Section A: General questions

1. Household's demographic factors

a)	Age: **(tick)**	Less than 20	20-30	31-40	41-50	51-60	61-70	More than 70
b)	Gender: **(tick)**	Male	Female			Other		
c)	No of people in HH (**Indicate number):**							
d)	Size of Land size (**Indicate number in acres):**		Private (Owned)	Rented	Communal (indicate acres and approx. number of users)			
e)	Level of Education **(tick)**	Never went to school	Primary	Second-ary	College diploma/ certificate	Uni-versity degree	Others	
f)	Average monthly expenditure on food, clothes school e.t.c. **(Tick)**			<5000	5000-10000	11000-20000	>30000	
g)	Economic activities **(tick)**	Employ-ment	Agricul-ture	Livestock sales	Land rented out	Business	Gifts/ support	Others (indicate)

Section B: Land-use and change

2. For the current year, which crops/animals do you have on your **rented** land?

Crop	Tick where necessary	Livestock	
Wheat		Cattle	
Maize		Poultry	
Potatoes		Goats	
French Beans Beans		Sheep	
Tomatoes		Others (Indicate)	
Peas			
Onions			
Vegetables (cabbage, Spinach, kales...)			
Sorghum/Millet/ Cassava			
Fruits			
Trees (Indicate whether Hedge/scattered/plantation)			
Others (Indicate)			

3. For the current year, which crops/animals do you have on your **owned** land?

Crop	Tick where necessary	Livestock	
Wheat		Cattle	
Maize		Poultry	
Potatoes		Goats	
French Beans Beans		Sheep	
Tomatoes		Others (Indicate)	
Vegetables			
Peas			
Onions			
Vegetables (cabbage, Spinach, kales...)			
Sorghum/Millet/ Cassava			
Fruits			
Trees (Indicate whether Hedge/scattered/plantation)			
Others (Indicate)			

4. If you use community land, which crops do you have on community land?

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5. Change in Land-use Systems.

Are there crops you used to farm 10 years ago that you no longer farm?	Yes, Which ones? and why?
	No, why?
Are there crops that you have introduced in the last 10 year	Yes, Which ones? And why?
	No, why?
Do you have plans to add more crops	Yes, why?
	No, why?

Section C: Reference Groups

6. Which of the following groups would you say their opinion matters to you when making land-use choices. Rank from 1-8 where 1 is most important 8 is least important. **(Use cards to assist in arrangement of RGs)**

Family (F)	Ancestors (A)	Neighbours (N)	Agroexport Company (AC)	Local Traders (B)	Water Project Group (WP)	Downstream comm (DF)	Govern-ment (G)	Other (Indicate)

7. Using a scale of 1-5 rank the extent to which the indicated groups would be pleased if you adopt the indicated land-use practice. Where 5 **= most pleased, 4 = pleased 3 = neutral 2= not pleased 1 = very unpleased**.

Crop	Family (F)	Ancestors (A)	Neighbour (N)	Agroexport Company (AC)	Local market	Local traders (B)	Water Project Group (WP)	Downstream farmers (DF)	Government (G)	Other (Indicate)	If not pleased, Indicate the RG that can act against you if you choose the practice
Wheat											
Maize											
Potatoes											
French Beans											
Beans											
Tomatoes											
Vegetables											
Peas											
Onions											
Vegetables (cabbage, Spinach, kales...)											
Fruits											
Sorghum/Millet/Cassava											
Plant trees											
Cut trees											
Adopting rain fed agriculture											
Using irrigation											

*Use extra sheets for more information of RGs

A

Appendix 2: Appendices for Chapter 4 and 5

Appendix 2A: KILIMO NA MAJI game

Game design process

This section describes the designing process and application of KILIMO NA MAJI game. The designing of KILIMO NA MAJI followed steps proposed by (Etienne, 2014) (Figure 2A), i.e., model development, experts review, companion modelling, remodelling and finalization and game playing sessions.

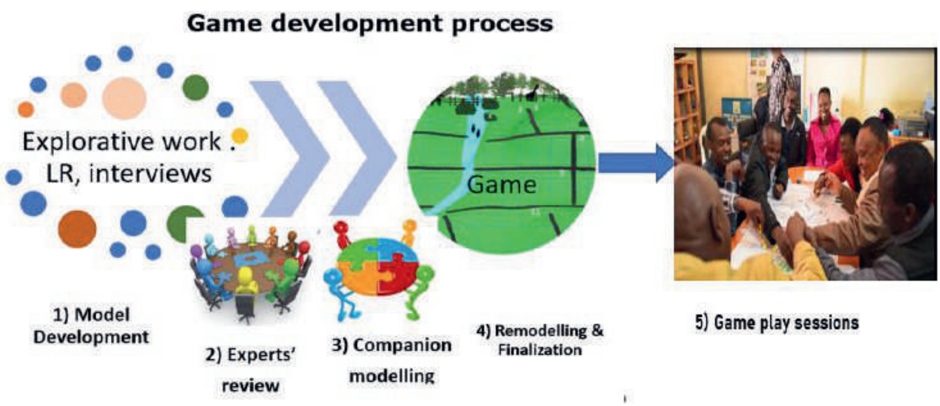

Figure 2A: Game development process.

During model development stage, we used various methods and sources to identify variables and design rules of the game (Table 2A).

We used Actors, Resources, Dynamics, and Interactions (ARDI) Framework (Etienne et al., 2011) to visualize KILIMO NA MAJI. We further expounded the framework to include social relations of the players, thus R-ARDI (Figure 2B). The Actors were farmers whose actions and/or decisions significantly impacted the landscape. Other actors were representatives from the Water Resource User Association (WRUA), playing their own role and that of government in water regulation. Resources were land, water, and finances. We tracked the impact of player actions on resources through two indicators i.e., amount of water extracted and farm-income. Dynamics were major processes that could affect the landscape or steer actions of the actors in a certain direction, for instance weather variations (dry and wet season), river flow changes, social cohesion, and collective action. Regarding Interactions players 1) Use knowledge/ rules/ relations to choose crops to farm, 2) Use money to buy seeds to plant 3) Use knowledge/ rules/ relations to decide whether to irrigate crops or not. Where, knowledge is both implicit (acquired by players over time such as crops that would produce better in their own locations), or explicit which the facilitator shares (such as amount of token required

Table 2A: Scientific Information gathering framework for KILIMO NA MAJI

Source of data	Objective	Specific variables/data
Literature review (global context)	To develop the generic components of the game	• Land-use practices • Drivers for land- and water use • Impacts on water availability, social and economic indicators
Literature review (local context)	To identify specific land-use practices in Mt. Kenya region where the game was piloted	• Commonly grown crops • Crop characteristics: investment required, market prices and variations. • Weather patterns • River flow in the region • Water use and sharing formular in the region
Interviews (local stakeholders and representatives from Water Resource Users Associations (WRUAs) and Water Management Authority)	To gain local knowledge on land- and water use in the region	• Commonly grown crops • Perceived crop characteristics • Water issues in the region • Information on reference groups
CROPWAT (Smith, 1992) (A software by Food and Agriculture Organization)	To generate crops irrigation requirements based on the region's climate, rainfall patterns, soil type, and crop type	• Crop irrigation requirements. • Data obtained was adjusted to incorporate farmer's perceived crop water requirements since this could have possible effect on their decisions in the game
Existing database (Githinji, 2023)	To get information on reference groups	• Reference groups and their perceived opinion on different crops

to irrigate different crops) or players share among themselves (such as the crops they should farm); rules include those provided by the facilitator (such as some water tokens cannot be extracted), or rules that players agree upon once they start collaborating; and relations are cases where players make decisions to sustain good relations with other players (such as avoiding to extract more water for the benefit of downstream players). Relations were interactions between players and their salient reference groups.

Rules of interaction between actors and resources were co-developed with experts and local stakeholders and referenced CROPWAT and existing databases. Rules included crop characteristics, irrigation requirement for optimal production of different crops, and amount of water that can be extracted from the river (Table 2B). Once the rules were set, KILIMO NA MAJI was calibrated, verified, and validated (Etienne, 2014) with experts and local stakeholders. The experts review session comprised of a game expert, technical expert on land-use and water dynamics and a local stakeholder. The experts assessed the game's scientific logic and played the game to assess its playability. The main outcomes from this session were simplification of the game rules, decisions,

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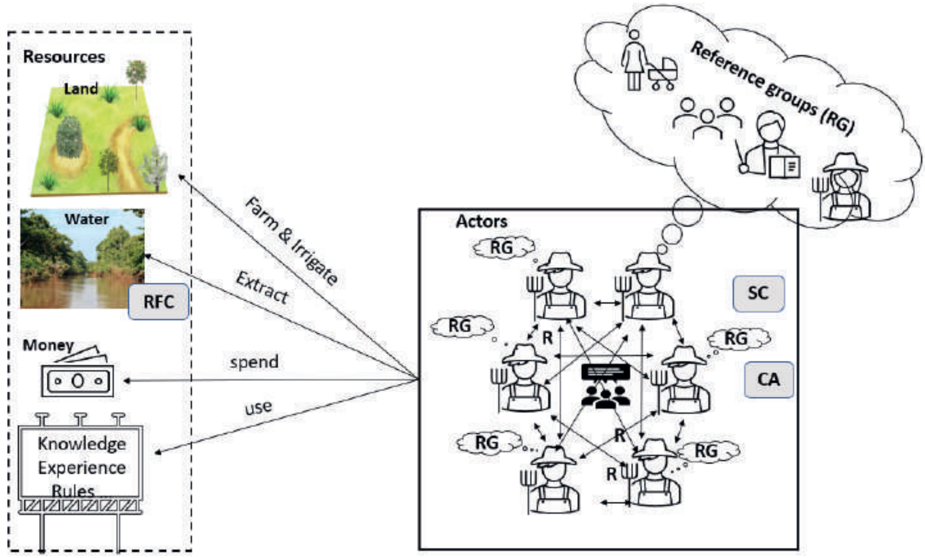


Figure 2B: KILIMO NA MAJI conceptual framework: Farmers are the strategic actors(players) interacting with resources on the left (arrows shows Interactions). Interactions among players and between players and their reference groups i.e., Relations, are on the right. Each actor interacts with resources and with own RG-reference groups that could include other actors in the room. Relations are indicated with double edged arrows indicating status-power exchanges. The round corners grey rectangles are the dynamics (SC-Social Cohesion, CA-Collective Action, and RFC- River Flow Change).

and facilitation flow of a game session. The version of KILIMO NA MAJI that emerged from the expert's review, was taken through companion modelling with a group of 16 participants comprising of farmers and WRUA representatives in the Upper Ewaso Ng'iro North River Basin. This session assessed the games representation of reality, its playability, capacity to stimulate interactions, support learning and emergence of collective action. Although the game in its first implementation provided rich discussions, the game rounds were too long. Thus, in the revised game, we reduced the number of players from 12 to 6 and crops were also classified into high-water-requirement crops (HWC), medium-water-requirement crops (MWC), and low-water-requirement crops (LWC) to hasten the decision-making process of players. Another main outcome of this session was revision of crop irrigation requirements as generated from CROPWAT. Players had their own perceived crop water need requirements. Noting that this has significant effect on choice of crops, some crop irrigation requirements were adjusted in readiness for the pilot session. For instance, potatoes irrigation requirements that needed three tokens more of water compared to French beans during the April planting season according to CROPWAT, was adjusted to zero as advised by the players who have local knowledge about water consumption of these two crops. The revised game was then played with two groups of participants in two different sessions. These two groups of participants played and rated the quality of the game in terms of its 1) playability, whether it was easy to play 2) understandability, whether it was easy to understand the rules and dynamics in the game 3) time it took to play the game 4) representation of reality 5) learning, 6) objectivity i.e., facilitating identification of solutions to water problems. Overall, KILIMO NA MAJI game was rated at 4.2 and 4.5 against a possible 5, by the 1st and the 2nd group respectively with objectivity, representation and understandability being ranked as the best qualities of the game. (Figure 2C). These three qualities ranked highly among players since they felt the game was a close reflection of their landscape, land use choices and pressures around water scarcity and water governance. Thus, it was easy to relate to the game, understand its rules and collectively explore alternative options. Some of the players felt the game took too long to play but also highlighted that this was understandable considering the complexities of the system that had to be included.

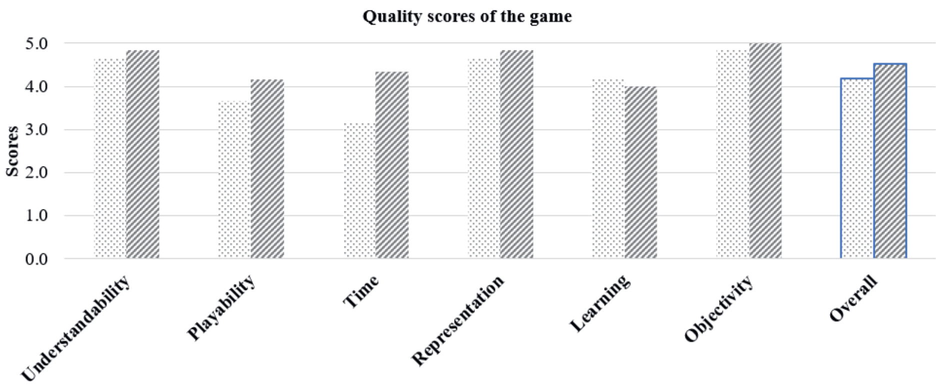


Figure 2C: Average players scores on the quality of KILIMO NA MAJI in both 1st and 2nd group. Scores range from 1 (lowest) to 5 (highest). The last 2 columns show the average rating of different qualities of the game by the two groups.

Adaptation of the game

KILIMO NA MAJI game is a generic game that can be adapted to different socioecological systems. To use this game in a specific setting the following need to be adjusted to fit the case study site.

a) Crops choices – this should feature the main crop choices in the study site.
b) Crop irrigation Requirement – with changes in the crop choices and change in ecological zone, crop irrigation requirements will have to change. CROPWAT (Smith 1992)) software can be used, but also the opinion of stakeholders on crop water requirements should be taken into account.
c) Number of water tokens – these can be estimated from a shared river (river flow data), dam, water pan, borehole, spring, or any other shared water source that a researcher wants to work with.

d) Reference groups – there are two ways of working with the reference groups: explore existing reference groups during the debriefing sessions; or identify major reference group in the study site with their respective norms then have a section of players play the role of reference groups.
e) Game board – The game board has six privately owned plots with a flowing river. Two plots for each of the three zones i.e., up-, mid-, and downstream zones. However, depending on the objective of the researcher, the board game can be adjusted to include, among other options:
   i. Have more plots to accommodate desirable number of players. For instance, during the modelling phase, the board had twelve players with the objective of eliciting rich discussions to understand the different dynamics that can be accommodated in the game.
   ii. Include unoccupied plots which can allow more players join the landscape in subsequent rounds. This can be done if a researcher wants to explore more scenarios for instance the effect of population growth.
   iii. Provide unoccupied plots for land renting to explore effects of land renting on player decisions.
   iv. Adjust land sizes to assess whether there is any difference between farmers with large farms and those with small farms.
   v. Water source can be changed to fit the case study site (e.g., a borehole, water pan). However, the water source has to a shared water source.
f) Cash currency – cash tokens are adjusted to a value more representative of money and transaction costs at the study site.

Decision tables

Table 2B: Coded River Flow

Available Water												
Month	J	F	M	A	M	J	J	A	S	O	N	D
Mean monthly flow in M^3/day	67	46	40	36	37	39	11	12	29	37	40	47
Allowable abstraction (60%) – use this for the game	40	28	24	22	22	23	7	7	17	22	24	28

Table 2C: Coded Irrigation Requirement per day for an eighth of an acre

August season												
	J	F	M	A	M	J	J	A	S	O	N	D
1. French beans	0	0	0	0	0	0	0	0	1	0	0	0
2. Maize (Grain)	0	0	0	0	0	0	0	0	1	0	0	0
3. Potatoes	0	0	0	0	0	0	0	0	1	0	0	0
4. Sorghum	0	0	0	0	0	0	0	0	1	0	0	0
5. Tomato	0	0	0	0	0	0	0	0	1	0	0	1
6. Vegetables	0	0	0	0	0	0	0	1	2	0	0	0
7. Wheat	0	0	0	0	0	0	0	0	0	0	0	0
8.Onion	0	0	0	0	0	0	0	0	1	0	0	0
April season												
	J	F	M	A	M	J	J	A	S	O	N	D
1. Green beans	0	0	0	0	0	1	0	0	0	0	0	0
2. Maize	0	0	0	0	0	1	1	0	0	0	0	0
3. Potato	0	0	0	0	0	1	1	0	0	0	0	0
4. Sorghum	0	0	0	0	0	0	1	0	0	0	0	0
5. Tomato	0	0	0	0	0	1	2	1	0	0	0	0
6. Small Vegetables	0	0	0	0	0	1	0	0	0	0	0	0
7. Wheat	0	0	0	0	0	1	1	0	0	0	0	0
8. Onion	0	0	0	0	0	1	1	1	0	0	0	0
January season												
	J	F	M	A	M	J	J	A	S	O	N	D
1. French Beans	1	2	1	0	0	0	0	0	0	0	0	0
2. Maize	0	2	2	0	0	0	0	0	0	0	0	0
3. Potatoes	1	2	2	0	0	0	0	0	0	0	0	0
4. Sorghum	0	1	1	0	0	0	0	0	0	0	0	0
5. Tomato	1	2	2	0	0	0	0	0	0	0	0	0
6. Vegetables	1	2	1	0	0	0	0	0	0	0	0	0
7. Wheat	0	1	2	0	0	0	0	0	0	0	0	0
8.Onion	1	2	2	1	0	0	0	0	0	0	0	0

Table 2D: Crop characteristics

	French Beans	Maize	Potato	Sorghum	Tomato	vegetables	Wheat	Onions	Trees
Time to maturity (in months)	3	6	5	7	5	3	7	4	84 (7 rounds)
Investment (approx. Per 1/8)	16	3	7	4	13	10	3	13	0
Labour in Kshs	15	3	8	4	30	18	21	9	84
Price fluctuation (rating)	Low	low	high	low	high	low	low	high	low
Profit margin (approx. Per 1/8)	15	1	5	1	8	9	1	9	5
Profit margin _ partial irrigation (approx. per 1/8)	12	1	4	1	7	7	1	8	5
Profit margin_ rain fed (approx. Per 1/8)	8	1	3	1	5	4	1	6	5
Profit margin for Jan season per 1/8	15	12	15	1	13	15	1	15	5
Crop characteristics Agro-forested land after 5 years									
	French Beans	Maize	Potato	Sorghum	Tomato	vegetables	Wheat	Onions	Trees
Profit margin (approx. Per 1/8)	21	1	7	1	11	13	1	13	7
Profit margin _ partial irrigation (approx. per 1/8)	16	1	6	1	9	9	1	11	7
Profit margin_ rain fed (approx. Per 1/8)	11	1	4	1	7	6	1	8	7
Profit margin for Jan season per 1/8	21	17	21	1	18	21	1	21	7

Table 2E: Predesigned rules of Reference Groups

Agro-Export company Agent • Give input subsidies – seeds and fertilizer. • Give a good market price for seeds acquired from them and crops irrigated as required.	**Local Market/Broker** • Give loan to farmers who wish to plant locally sold crops, but loaned farmers must sell to the broker, irrespective of the price. • Vary prices as he/she wishes. Ex. Provides a poor market rate for HWC and MWC crops partially irrigated. • Provides a poor market rate for crops if more than half of the farmers have similar crop.
Government representative • Give tree seedlings, input subsidies for drought resistant crops (LWC) • Give e-vouchers worth KES 10,000 • Charges KES 5,000 for deforestation of one tree • Solve any conflicts.	**WRUA Representative** • Advice on level of water that should not be abstracted. • Charge 5 tokens to all farmers who abstracted red water tokens.

Table 2F: Players' sociodemographic data collection sheet

Names of the Participant		Ward	
Contact telephone number		Village	
Player No		Age	
County		Gender	(1= Male, 2= Female
Sub-county		Marital status	(1= Single, 2= Married 3= Widowed 4= Divorced, 5= Separated
Size of land owned (acres)		Size of land rented (acres)	
Level of education	(A) No formal education (B) Primary ongoing (C) Primary incomplete	(D) Primary complete (E) Secondary incomplete (F) Secondary ongoing	(G) Secondary complete (H) Tertiary education (I) Adult education
What is your main economic activity?	Select all that apply. (A) In school (B) Housewife (C) Business or small trade (e.g., shop keeper)	(D) Farming (E) Sale of livestock (F) Formal employment (e.g., teacher, nurse)	(G) Informal employment (H) Other, specify _____
Economic status (Approx. expenditure per month in Ksh)		Position of leadership in society	
Relationship with other players (ex. family, association,)			

Table 2G: Data collection sheets during game play

Farmer Name	: ______________________								
Player No	: ______								
Season	: _____________								
Crop		**French/garden peas**	**Tomatoes**	**Onions**	**Vegetables**	**Maize**	**Potatoes**	**Sorghum/Cassava**	**Trees**
Farmed (Yes/NO)									
Irrigated (Yes/NO)									
Subsidy/ Loan, yes?	Amount/seeds								
	By whom								
Sell	To whom								
	Amount								

Table 2H: Likert scale for assessment of game's Quality

Player Number:	1	2	3	4	5
The game was simple to understand					
The game was easy to play					
The game takes appropriate time to play					
The game was a true representation of the actual land- and water use dynamics in our area					
The game has made me understand more about how my land- and water use decisions affect others					
The game has taught me how to better manage the available water while increasing production on my farm					

Table 2I: Formulae for solution space. Formulae for the solution space where HWC- High Water requirement crops, MWC-Medium Water requirement crops, LWC-Low Water requirement Crops

Season	Variable	Characteristics	Formular
Dry	Water	• HWC- needs irrigation with 4 tokens. • MWC- needs irrigation with 3 tokens. • LWC- Do not need irrigation	Total water required for irrigation (T) T = $(\sum_{i=0}^{n} HWC_i * 4) + (\sum_{i=0}^{n} MWC_i * 3)$ ---(Eq A1) where, *i* is number no of plots, total number of plots(n) ≤ 24.
	Income	• Income for both HWC and MWC depends on irrigation. • Crops that were not irrigated as required yield less income. • HWC yield maximum income of 3 coins, MWC 2 coins and LWC yields 1 coin.	If water extracted≥ water required then Income (I), I= $(\sum_{i=0}^{n} HWC_i * 3) + (\sum_{i=0}^{n} MWC_i * 2) + (\sum_{i=0}^{n} LWC_i * 1)$ -----------------(Eq A2) Else if water extracted < water required then, I = $(\sum_{i=0}^{n} HWC_i * 3 * 0.2) + (\sum_{i=0}^{n} MWC_i * 2 * 0.5) + (\sum_{i=0}^{n} LWC_i * 1)$ -----------(Eq A3)
Wet	Water	• Only HWC need to be irrigated with 3 tokens	Total water required for irrigation = $(\sum_{i=0}^{n} HWC_i * 3)$ -------------------------(Eq A4)
	Income	• only HWC are affected. • However, even without irrigation, losses are less compared to a dry season.	If water extracted≥ water required, then Income (I) = Eq A2 Else if water extracted < water required then, I = $(\sum_{i=0}^{n} HWC_i * 3 * 0.5) + (\sum_{i=0}^{n} MWC_i * 2) + (\sum_{i=0}^{n} LWC_i * 1)$ ---------(Eq A5)

Table 2J: Players' socio demographic information for the game sessions

Characteristics	Group	Average	Min	Max
Age in years	G1	41	32	51
	G2	47	40	56
	G3	41	25	70
	G4	50	32	73
	G5	55	43	65
	G6	59	45	68
		Male	Female	
Sex	G1	2	4	
	G2	2	4	
	G3	2	4	
	G4	4	2	
	G5	2	4	
	G6	2	4	
		Primary	Secondary	Tertiary
Level of education	G1	1	4	1
	G2	2	3	1
	G3	-	2	4
	G4	1	5	-
	G5	1	5	-
	G6	-	4	2
		Average	Min	Max
Expenditure per month in '000 Kenya shillings	G1	25	22	40
	G2	30	15	50
	G3	25	5	12
	G4	13	20	40
	G5	34	6	20
	G6	15	5	20
Number of players in leadership positions	G1	3		
	G2	4		
	G3	6		
	G4	2		
	G5	4		
	G6	6		
		Average	Min	Max
Land size in acres	G1	1.0	0	2
	G2	1.8	1	3
	G3	2.5	1	5
	G4	3.3	1	6
	G5	2.4	1	5
	G6	2.2	0	5

Appendix 2B: Guiding questions for debrief

After the Game, the facilitator leads a debriefing session where players discuss the game, what informed their decisions and extent to which the players were able to learn from the exercise. Questions will be around the following issues:

1. While still in their roles in the game
   i. What pleased you in the game?
   ii. What did not please you?
   iii. how did you feel as Upstream, mid, or downstream farmer?
   iv. Which decisions did you make during the game? (All those who made similar decisions can add to this answer. Why?
   v. Did you make similar decisions in subsequent rounds? Why?
   vi. If changes were done, what caused the changes?
2. From Game to reality
   i. Which components of the game represents most the actual context? Which ones does not.
   ii. Are there similarities between the game and the actual farming decisions we make as farmers?
   iii. What influences our decisions?
   iv. After explaining the concept of RG, do you think your decisions were made to please a certain group or to avoid power use? if yes, which ones and why was pleasing the group important to you?
   v. Ranking the RGs, why are some RGs more important than others?
   vi. Has the salience of some RG changed over the years?
3. Going forward
   i. What could be the ideal land- and water use practice? (Visualize by collectively placing crop, tree cards and water tokens on the game board)
   ii. Why would the ideal landscape be the way it is?
   iii. Why would it be important to us?
   iv. What can we do to differently to achieve this?
4. Improving the game
   i. Was the game easy to understand and play?
   ii. Did the game represent the actual scenario?
   iii. What can be improved?

Appendix 2C: Q-methodology statements and directions for players

You farm to increase production and income. But then this being a semi-arid region, to increase production you must irrigate using water from the shared water source. Too much irrigation would cause water stress downstream. From your own perspective, which of the 16 statements do you most agree or disagree with?

1. I farm crops that can provide enough food and income for family.
2. I farm crops that would produce within the WRUA recommended level of abstraction.
3. If my peers are made more money in the previous season from a particular crop, I will farm that crop.
4. I farm crops that are need by the agro-export market.
5. I farm crops that can be consumed by the local market/brokers.
6. I farm crops advised by government/extension worker.
7. I avoid crops that reduce water downstream, they need water too.
8. I farm crops that my family has always planted.
9. I should get a water share that is equal to everyone else.
10. I should get a water share equivalent to my money.
11. Everyone should get as much water as he/she want.
12. WRUA should determine how much each person consumes.
13. Downstream farmers should address their water shortage.
14. WRUA should address water shortage.
15. Water shortage should be addressed by all stakeholders.
16. Water is enough for everyone.

As the first step, please make 3 piles of the 16 cards, where first pile comprises of statements you agree with, second pile of those you disagree with, and third pile of those that you neither agree nor disagree with. In the second step you are provided with a board with 16 boxes spread out from strongly disagree (-3) to Strongly agree (3). Pick the first pile and spread it in the 6 boxes running from 1 to 3 depending on your level of agreement. Similarly spread out the second pile running from -1 to -3 and finally spread out the third pile across the neutral boxes with number 0. You are free to shift cards around until you reach your final decision.

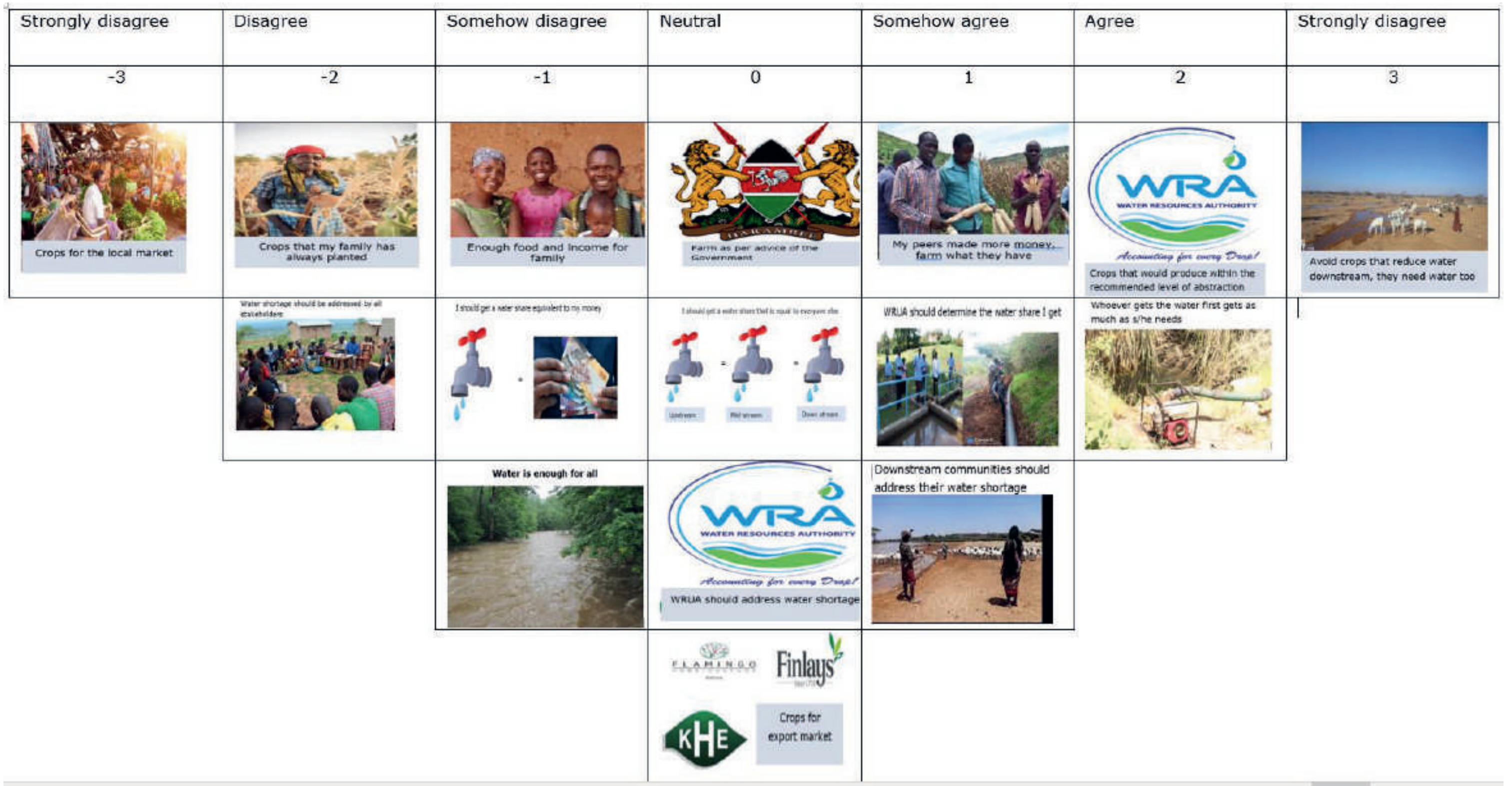
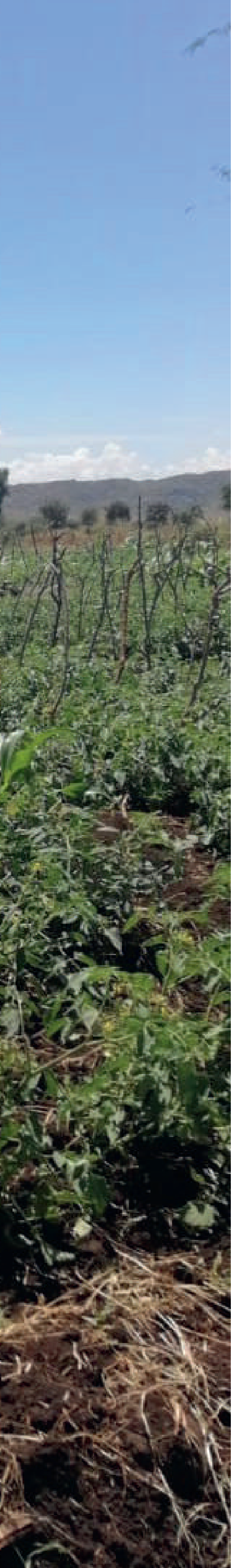


Figure 3A: Sample workout q-sort.

A



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Summary
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Summary

Farmer land- and water use decisions have significant impact on a society's social, economic, and ecological well-being. These decisions can be influenced by socio-demographic factors, economic conditions, climate, markets, and/or government policies, among others. In addition to these factors, there is the effect of social relations which has not been adequately researched. Having grown up in a highly relational farming society, I was motivated to focus my research on assessing the effect of social relations on a farmer's individual and collective decisions. In this research, I posit that nobody farms alone and their land- and water use decisions are significantly influenced by others. Besides instrumental (goal-oriented) rationality, farmers are also deemed to be relationally rational; that is, rational within the relations they have with others and in the decisions they make. From an instrumental perspective, farmers would not only wish to obtain economic, socio and/or ecological benefits from their farms and the surrounding nature, but also care about how their interactions with nature impact on their relations with others. The "others" that farmers take into consideration can be referred as reference groups. Reference groups can be important people, groups of people or other beings (for instance, neighbours, government, community elders, spiritual deities), that have significant status-power standing in the minds of farmers. Reference groups are inferred to have opinions about the desirability of various options, e.g. those in land and water use decisions. The salience of reference groups - and hence their potential influence on decisions - is measured by the amount of status they have and/or their potential to use power. Status influences decisions through respect, love, adoration and possibly through expected acknowledgement or appreciation. A reference group can influence decisions through power if the farmer believes the reference group can use power (for instance punish, curse) against him/her in response to decisions contrary to its preference.

The main objective of this thesis was to contribute to better management of scarce common water resources in a water-limited environment. To achieve this, I aimed to develop a tool that can actively engage local stakeholders in a participatory way in identification and exploring options for more sustainable land and water use management. The research was guided by four research questions. Research Question 1 (RQ1): Which theories can be used to better understand farmer land- and water use decision making? Research Question 2 (RQ2): To what extent can relational rationality (status-power and reference group theory) explain farmer land- and water use decisions in a given context? Research Question 3 (RQ3): To what extent can relational rationality help better understand the outcomes of a game that represents local land- and water use choices? Research Question 4 (RQ4): Can such serious games strengthen relational rationality to achieve collective goals? In this thesis, the Upper Ewaso Ng'iro North River Basin in Mt Kenya region was used as the case study site. The site was selected due to

its diverse land- and water use dynamics that include an up-downstream gradient of upstream water abundance and downstream water scarcity, perceived water inequalities and conflicts among multiple water users (such conflicts happen among farmers, between farmers and pastoralists, between smallholder and largescale farmers, farmers and other users for instance hydro-power producers).

Chapter 2, entitled "Farmer land-use decision-making from an instrumental and relational perspective" responds to RQ1. In reviewing the existing theories that can be used to better understand farmer land- and water use decision making, the chapter underscores the importance of social relations. The chapter presents a theoretical analysis of some of the commonly used perspectives to farmer decisions. Specifically, sociodemographic (for instance, farmer's age, gender) and contextual factors (for instance government policies and climatic conditions), expected utility theory, prospect theory, bounded rationality, theory of planned behaviour and status-power theory of relations. The chapter highlights that farmers do not only think about the financial side as would be anticipated by the expected utility theory and prospect theory, and disadvantaged by limited knowledge, time, and cognitive ability to optimize their options as indicated by bounded rationality, but they are also relationally rational. The theory of planned behaviour considers relational rationality but does not account for the influence of multiple reference groups with perceived divergent opinions. To address this, the chapter proposes use of the status-power theory of relations. The theory implies that farmers make rational choices within the realms of status-power relations that they have with their multiple reference groups with possible divergent opinions. This is the perspective that informs the rest of the thesis.

Chapter 3, titled "You never farm alone": Farmer land-use decisions influenced by social relations, responds to RQ 2 as it explores the extent to which relations can explain farmer land- and water use decisions in a specific context. Precisely, in the context of the Upper Ewaso Ng'iro North River Basin Mt Kenya. The chapter uses data collected from a random sample of respondents within selected villages, with questions about land- and water use practices, social relations, economic aspects, household size and household-level land and other resources. Using Chi-Square Automatic Interaction Detection (CHAID), the chapter notes three key findings: 1) status-power and reference groups explained land-use decisions that could not be explained by sociodemographic, and economic factors; 2) Farmers seemed more likely to choose a land-use option if they believed their salient reference groups would be pleased with the option; and 3) Reconciling social relations with other factors such as farmer's sociodemographic factors, and geographic location had significant effect on the results. This chapter experiences a limitation in conventional data collection methods (questionnaire and focused group discussions). This is because in some instances respondents could identify which reference group influenced their land-use options. The next two chapters use a different methodology in an attempt to overcome this limitation, and to nudge farmers towards more sustainable practices.

Chapter 4, titled "Collective action for sustainable farmer water management: The case of KILIMO NA MAJI serious game", responds to RQ 3 in testing the extent to which relational rationality can help explain a game's outcomes. The chapter presents design and application of a serious game, KILIMO NA MAJI (meaning farming and water in the Swahili language), in the Upper Ewaso Ng'iro North River Basin. The game is designed to engage stakeholders in exploration of land and water management options that would sustain crop production in water scarce landscapes. The game has a solution space; solution space is a set of all possible outcomes of decisions that can be made in a game session. The solution space includes a range within which trade-offs can be efficiently managed. In the solution space, presented in an x-y plane, a change in farm-income (x-axis) depends on water-extracted or used (y-axis) given the type of land- and water use. Outcomes of a game session, that is, acquired farm-income and water extracted depending on players choices, are placed within this solution space to identify options that support sustainable water use. A further analysis of the outcomes from a status-power and reference group perspective shows that social relations that participants had with their reference groups determined where their game outcomes are positioned within the solution space.

Chapter 5, titled "Exploring collective water management using serious games: The case of the Mt. Kenya region" responds to RQ 4 as it analyses how serious games can build on relational rationality to achieve collective goals. The chapter presents more experiences with KILIMO NA MAJI game and shows that the game fostered collective action among players. It focuses on detailing the impacts of individual and collective decisions on farm-income and water availability. It also analyses emergence of collective action (or lack thereof) and its impact on game outcome in different game sessions. The chapter also presents an analysis of the impact of the game on farmer decisions. In so doing, it uses Q-methodology to identify pre-game participant's opinions on land- and water management, compares this to their actions during the game session, and to their opinions at the end of the game. The analysis shows that participants shift their opinion from a family and/or market-centred discourses identified in the pre-game analysis to alternative options that considers the interests of all participants after observing the impact of upstream choices on downstream water shortage in the game.

The last chapter synthesises content from chapter 2 to 5. It provides a summary of the findings, my reflections on the findings, theories used, and data collection methods deployed in this research. The chapter emphasizes on entrenching social relations in research as an important factor in explaining and modelling farmer decisions; and leveraging (or promoting) serious games for (social) learning and fostering collec-

tive action. Further, the chapter highlights my experiences while using multiple data collection. It also presents potential future avenues of research that include applying gaming to multiple sites, post-game impact assessment to assess possible influence of the game on stakeholders' decisions in the real world, and use of an Agent Based Modelling approach to explore more alternatives for sustainable land and water management. I conclude by highlighting some ways in which findings and outputs from this research can be used. More specifically on the use of status-power theory of relations to understand effect of social relations on farmer decisions; use of solution space to identify sustainable water management option; and implementation of KILIMO NA MAJI in large scale to foster collective action and contribute to better management of the common water resources. This thesis shows that, relational rationality - as explored using status-power and reference groups - can explain heterogenous land- and water use decisions among farmers in times of changing climate, markets, policies, or other changes in Mt. Kenya region.

Muhtasari

Maamuzi ya matumizi ya ardhi na maji ya mkulima yana athari kubwa kwa ustawi wa jamii, kiuchumi na kiikolojia. Maamuzi haya yanaweza kuathiriwa na vipengele vya idadi ya watu, hali ya kiuchumi, hali ya hewa, masoko, na/au sera za serikali, miongoni mwa mengine mengi. Mbali na mambo haya, kuna athari za mahusiano ya kijamii ambayo hayajafanyiwa utafiti wa kutosha. Kwa kuwa nimelelewa katika jamii ya wakulima yenye uhusiano mkubwa, nilihimizwa kuelekeza utafiti wangu katika kutathmini athari za mahusiano ya kijamii kwa mkulima binafsi na vile vile maamuzi ya pamoja. Katika utafiti huu, ninaamini kwamba hamna mkulima anyefanya ukulima peke yake na maamuzi ya matumizi ya ardhi na maji yanaathiriwa sana na wengine. Mbali na mantiki ya msingi (yenye malengo), wakulima pia wana mantiki kimahusiano; yaani, busara ndani ya mahusiano baina yao na wengine katika maamuzi wanayofanya. Kwa mtazamo muhimu, wakulima hawanuii tu kupata manufaa ya kiuchumi, kijamii na/au kiikolojia kutoka kwa mashamba yao na mazingira wanamoishi, bali pia wanajali jinsi mwingiliano wao na mazingira asili unavyoathiri mahusiano yao na wengine. Wengine ambao wakulima huzingatia wanaweza kutajwa kama vikundi vya kumbukumbu/marejeleo. Vikundi vya marejeleo vinaweza kuwa watu muhimu, vikundi vya watu au viumbe vingine (kwa mfano, majirani, serikali, wazee wa jamii, miungu ya kiroho), vyenye shawishi mkubwa wa hadhi kwenye fikira za wakulima. Vikundi vya marejeleo vinakisiwa kuwa na maoni kuhusu uhitajikaji wa chaguzi mbalimbali, kwa mfano, maamuzi ya matumizi ya ardhi na maji. Sifa kuu ya vikundi vya marejeleo - na ushawishi wao katika maamuzi - hupimwa kwa kiwango cha hadhi walicho nacho na/au uwezo wao wa kutumia mamlaka. Hadhi huathiri maamuzi kupitia heshima, upendo, kuenzi na pengine kupitia sifa zinazotarajiwa au shukrani. Kikundi cha marejeleo kinaweza kushawishi maamuzi kwa nguvu iwapo mkulima ataamini kuwa kikundi hicho chaweza kutumia nguvu (kwa mfano kuadhibu, kulaani) dhidi yake kutokana na maamuzi yasiyoambatana na matakwa yake.

Lengo kuu la tasnifu hii lilikuwa kuchangia katika usimamizi bora wa rasilimali adimu ya maji ya kawaida katika mazingira yenye uhaba wa maji. Ili kufanikisha hili, nililenga kubuni chombo ambacho kinaweza kushirikisha wadau wa ndani kikamilifu kwa njia shirikishi katika kutambua na kuchunguza chaguzi za simamizi endelevu zaidi za matumizi ya ardhi na maji. Utafiti ulielekezwa na maswali manne ya utafiti. Swali la 1 la Utafiti (RQ1): Ni nadharia gani zinaweza kutumika kuelewa vyema maamuzi ya mkulima kuhusu matumizi ya ardhi na maji? Swali la 2 la Utafiti (RQ2): Ni kwa kiwango gani ambapo busara ya kimahusiano (nadharia ya hadhi-nguvu na kikundi cha marejeleo) inaweza kuelezea maamuzi ya mkulima ya matumizi ya ardhi na maji katika muktadha fulani? Swali la 3 la Utafiti (RQ3): Ni kwa kiwango gani ambapo busara ya kimahusiano inaweza kusaidia kuelewa vyema matokeo ya mchezo unaowakilisha uchaguzi wa eneo la ardhi na matumizi ya maji? Swali la 4 la Utafiti (RQ4): Je, michezo mikuu kama hii yaweza imarisha busara ya kimahusiano ili kuafikia malengo ya pamoja? Katika

tasnifu hii, nyanda ya Juu ya Mto Ewaso Ng'iro Kaskazini katika eneo la Mlima Kenya ilitumiwa kama tovuti ya kifani. Maeneo hayo yalichaguliwa kutokana na mienendo yake mbalimbali ya matumizi ya ardhi na maji ambayo ni pamoja na kushuka kwa kiwango cha juu-chini cha maji mengi ya mto na uhaba wa maji kutoka chini ya mto, hali ya kutokuwepo kwa usawa wa maji na migogoro kati ya watumizi wengi wa maji (migogoro kama hii hutokea miongoni mwa wakulima, kati ya wakulima na wafugaji, kati ya wakulima wadogo na wale wakubwa, wakulima na watumizi wengine kama wazalishaji wa nishati ya umeme kwa maji).

Sura ya 2, yenye kichwa "Uamuzi wa matumizi ya ardhi kwa mkulima kutoka kwa mtazamo muhimu na wa uhusiano" inajibu RQ1. Katika ukaguzi wa nadharia zilizopo zinazoweza kutumika kuelewa vyema maamuzi ya mkulima kuhusu matumizi ya ardhi na maji, sura hii inasisitiza umuhimu wa mahusiano ya kijamii. Sura hii inawasilisha uchanganuzi wa kinadharia wa baadhi ya mitazamo inayotumika kwa maamuzi ya wakulima, hasa, demokrasia ya kijamii (kwa mfano, umri na jinsia ya mkulima) na vipengele vya kimuktadha (kwa mfano sera za serikali na hali ya hewa), nadharia ya matumizi tarajiwa, nadharia ya matarajio, upatanishi wa mipaka, nadharia ya tabia iliyopangwa na nadharia ya hadhi ya mahusiano. Sura hii inaangazia kwawakulima hawawazii tu upande wa kifedha kama inavyotarajiwa na nadharia ya matumizi tarajiwa na nadharia ya matarajio, na kupungukiwa kwa ujuzi mdogo, wakati, na uwezo wa utambuzi wa kuboresha chaguzi zao kama inavyoonyeshwa na busara iliyowekewa mipaka lakini pia wana uhusiano wa kimantiki. Nadharia ya tabia iliyopangwa inazingatia busara ya uhusiano lakini haizingatii ushawishi wa vikundi vingi vya marejeleo vilivyo na maoni tofauti. Ili kutatua hili swala, sura hii inapendekeza matumizi ya nadharia ya hali-nguvu ya mahusiano. Nadharia hii inadokeza kwamba wakulima hufanya maamuzi ya busara ndani ya nyanja za mahusiano ya hadhi-nanguvu waliyo nayo na vikundi vyao vingi vya marejeleo vyenye maoni tofauti yanayoweza kutokea. Huu ndio mtazamo unaofahamisha tasnifu iliyosalia.

Sura ya 3, yenye kichwa "Haupo Peke yako Katika Kilimo": Maamuzi ya matumizi ya ardhi ya mkulima yanayoathiriwa na mahusiano ya kijamii, inajibu RQ 2 kwani inachunguza ni kwa kiasi gani uhusiano unaweza kueleza maamuzi ya mkulima kuhusu matumizi ya ardhi na maji katika muktadha wa ainafulani. Kwa usahihi, katika muktadha wa nyanda za juu za Kaskazini mwa Mto Ewaso Ng'iro katika Bonde la Mlima Kenya. Sura hii inatumia takwimu zilizokusanywa kutoka kwa sampuli nasibu ya wahojiwa katika vijiji vilivyochaguliwa, zenye maswali kuhusu mazoea ya matumizi ya ardhi na maji, mahusiano ya kijamii, hali ya kiuchumi, ukubwa wa boma na kiwango cha ardhi ya boma na rasilimali nyinginezo. Kwa kutumia Utambuzi wa Mwingiliano wa Kiotomatiki wa *Chi-Square* (CHAID), sura inabainisha matokeo matatu muhimu: 1) nguvu za hadhi na vikundi vya marejeleo vilielezea maamuzi ya matumizi ya ardhi ambayo hayangeweza kuelezewa na mambo ya kijamii na idadi ya watu, na kiuchumi; 2) Wakulima walionekana kuwa na uwezekano mkubwa wa kuchagua chaguo la matumizi ya ardhi ikiwa wanaamini kuwa vikundi vyao vya marejeleo vitafurahishwa na chaguo hilo; na 3) Uoanishaji wa mahusiano ya kijamii na mambo mengine kama vile mambo ya kijamii na hali kijamii ya idadi ya wakulima, na eneo la kijiografia vilikuwa na athari kubwa kwa matokeo haya. Sura hii inakumbwa na upungufu wa mbinu za kawaida za ukusanyaji wa takwimu (hojaji na mijadala ya vikundi lengwa). Hii ni kwa sababu katika baadhi ya matukio wahojiwa hawakuweza kutambua ni kikundi kipi cha marejeleo kilichoathiri chaguzi zao za matumizi ya ardhi. Sura mbili zinazofuata zinatumia mbinu tofauti katika jaribio la kutatua upungufu huu, na kuwahimiza wakulima kuegemea shughuli endelevu zaidi.

Sura ya 4, yenye kichwa "Hatua ya pamoja ya usimamizi endelevu wa maji ya mkulima: Suala la mchezo mzito wa KILIMO NA MAJI", inajibu RQ 3 katika kutathmini kiwango cha majaribio ambacho uwiano wa kimahusiano unaweza kusaidia kueleza matokeo ya mchezo. Sura hii inawasilisha muundo na matumizi ya mchezo mzito uitwao KILIMO NA MAJI katika nyanda za Juu za Mto Ewaso Ng'iro Kaskazini. Mchezo huu umeundwa kushirikisha wadau katika amuzi wa chaguzi za usimamizi wa ardhi na maji ambazo zingedumisha uzalishaji wa mazao katika mazingira yenye uhaba wa maji. Mchezo una nafasi ya suluhisho; nafasi ya suluhisho ni mkusanyiko wa matokeo yote yanayowezekana kuibuka katika kipindi cha mchezo huu. Sura hii inawasilisha nafasi ya suluhisho ambayo inajumuisha anuwai ambayo ubadilishanaji unaweza kudhibitiwa kwa ufanisi. Katika nafasi ya suluhisho, iliyowasilishwa katika nafasi ya X-Y, mabadiliko ya mapato ya shamba (Mhimili-X) inategemea maji yaliyotolewa au kutumika (Mhimili-Y) kutokana na aina ya matumizi ya ardhi na maji. Matokeo ya kipindi cha mchezo, yaani, mapato ya shambani na maji yanayotolewa kulingana na chaguo la wachezaji, yamewekwa ndani ya nafasi hii ya suluhisho ili kubainisha chaguo zinazohakikisha matumizi endelevu ya maji. Uchambuzi zaidi wa matokeo kutoka kwa mtazamo wa uwezo wa hadhi na kikundi cha marejeleo unaonyesha kuwa mahusiano ya kijamii ambayo washiriki walikuwa nayo na vikundi vyao vya marejeleo yalibaini mahali ambapo matokeo ya mchezo wao yamewekwa ndani ya nafasi ya suluhisho.

Sura ya 5, yenye kichwa "Uchnguzi wa usimamizi wa pamoja wa maji kwa kutumia michezo mizito: Sala la eneo la Mlima Kenya" inajibu RQ 4 inapochanganua jinsi michezo makini inaweza kujengwa juu ya upatanisho wa kimahusiano ili kufikia malengo ya pamoja. Sura hii inawasilisha uzoefu zaidi wa mchezo wa KILIMO NA MAJI na inaonyesha kuwa mchezo wa KILIMO NA MAJI ulikuza hatua ya pamoja miongoni mwa wachezaji. Inaangazia kuelezea kwa kina athari za maamuzi ya mtu binafsi na ya pamoja juu ya mapato ya shamba na upatikanaji wa maji. Pia inachanganua kuibuka kwa hatua za pamoja (au ukosefu wake) na athari zake kwa matokeo ya mchezo katika vipindi tofauti vya mchezo. Sura hiyo pia inatoa uchanganuzi wa athari za mchezo. Kwa kufanya hivyo, unatumia mbinu ya Q kubainisha maoni ya washiriki wa kabla ya mchezo kuhusu usimamizi wa ardhi na maji, inalinganisha hii na matendo yao wakati wa kipindi cha mchezo, na maoni yao mwishoni mwa mchezo. Uchanganuzi unaonyesha kuwa washiriki hubadilisha maoni yao kutoka kwa familia na/au mazungumzo yanayohusu soko yaliyobainishwa katika uchanganuzi wa kabla ya mchezo kwenda kwa chaguo mbadala zinazozingatia maslahi ya washiriki wote baada ya kuona athari za uchaguzi wa mito kwenye uhaba wa maji katika mchezo.

Sura ya mwisho imekusanya maudhui kutoka sura ya 2 hadi 5. Inatoa muhtasari wa matokeo, tafakari yangu kuhusu matokeo, nadharia zilizotumika, na mbinu za kukusanya data zilizotumika katika utafiti huu. Sura inasisitiza juu ya kuimarisha mahusiano ya kijamii katika utafiti kama jambo muhimu katika kueleza na kutoa mfano wa maamuzi ya mkulima; na kutumia (au kukuza) michezo mikubwa kwa ajili ya kujifunza (kijamii) na kukuza hatua za pamoja. Zaidi ya hayo, sura inaangazia uzoefu wangu ninapotumia ukusanyaji wa data nyingi. Pia inawasilisha njia zinazowezekana za baadaye za utafiti ambazo ni pamoja na kutumia michezo ya kubahatisha kwenye tovuti nyingi, tathmini ya athari za baada ya mchezo ili kutathmini uwezekano wa ushawishi wa mchezo juu ya maamuzi ya wadau katika ulimwengu halisi, na kutumia mbinu ya Uigaji Kulingana na Wakala ili kuchunguza njia mbadala zaidi za uendelevu. usimamizi wa ardhi na maji. Namalizia kwa kuangazia baadhi ya njia ambazo matokeo na matokeo ya utafiti huu yanaweza kutumika, hasa zaidi juu ya matumizi ya nadharia ya hadhi-nguvu ya mahusiano kuelewa athari za mahusiano ya kijamii juu ya maamuzi ya mkulima; matumizi ya nafasi ya suluhisho ili kutambua chaguo endelevu la usimamizi wa maji; na utekelezaji wa KILIMO NA MAJI kwa kiasi kikubwa ili kukuza hatua za pamoja na kuchangia katika usimamizi bora wa rasilimali za maji za pamoja. Tasnifu hii inaonyesha kwamba, busara ya kimahusiano - kama inavyochunguzwa kwa kutumia uwezo wa hadhi na vikundi vya marejeleo - inaweza kueleza maamuzi tofauti ya matumizi ya ardhi na maji miongoni mwa wakulima wakati wa mabadiliko ya hali ya hewa, soko, sera, au mabadiliko mengine katika eneo la Mt.Kenya.

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About the author

Margaret Githinji was born in Nyandarua, Kenya on 29th April 1984. Her academic background is in statistics having graduated with a Bachelors of Science in Mathematics and Computer Science in 2005 and later on a Master of Science in Applied statistics in 2008. After her graduation, she spent the next couple of years teaching at Jomo Kenyatta university of Agriculture and Technology and other Kenyan Universities as a part-time lecturer of statistics and applied mathematics.

In her quest to understand how the rest of the world works (besides academia), she joined the Government of Kenya as a Statistician/Economist in September 2010. At the time, she was attached to the National Treasury and Economic Planning, later on to the Ministry of Investment, Trade, and Industries, and currently in the Office of the Prime Cabinet Secretary. In her position, she uses her knowledge and expertise to develop economic policies, coordinate implementation, monitor, and evaluate government projects, programmes, and policies, among other related roles.

During her tenure in government, Margaret encountered many development challenges that could not be explained by conventional factors. One of those were lack of resilience of some communities to impacts of drought compared to other communities. Noting a possible explanation could be emanating from social and cultural orientation of the communities aroused her interest in researching the impacts of social and cultural factors on adaptation to climate change. This pushed her to seek an admission to Wageningen university due to its renowned interest in interdisciplinary research. In 2020, she got selected to pursue her PhD within the Scenario Evaluation for Sustainable Agro-forestry Management (SESAM) programme funded by the Interdisciplinary Research and Education Fund (INREF) of Wageningen University. She joined Wageningen University and Research where she conducted her research work under an interdisciplinary and multicultural SESAM team.

After her PhD research, she plans to delve more into interdisciplinary research. Also noting the richness of participatory approaches, she wishes to embrace and do more of related research with different institutions and disciplines. For future engagements, Margaret can be reached through her email githinjimargaret@gmail.com.

List of publications

1. **Githinji, M**., van Noordwijk, M., Muthuri, C., Speelman, E. N., & Hofstede, G. J. (2023). Farmer land-use decision-making from an instrumental and relational perspective. *Current Opinion in Environmental Sustainability*, 63. https://doi.org/10.1016/j.cosust.2023.101303

2. **Githinji, M.**, van Noordwijk, M., Muthuri, C., Speelman, E. N., Kampen, J., & Hofstede, G. J. (2024). "You never farm alone": Farmer land-use decisions influenced by social relations. *Journal of Rural Studies*, 108, 103284. https://doi.org/10.1016/j.jrurstud.2024.103284

3. **Githinji, M.,** Speelman, E.N., van Noordwijk, M., Muthuri, C., & Hofstede, G. J (2024). Collective action for sustainable farmer water management: The case of Kilimo na maji serious game. *(Under review)*

4. **Githinji, M.,** Speelman, E. N., van Noordwijk, M., Muthuri, C., & Hofstede, G. J (2024). Exploring collective water management using serious games: The case of Mt. Kenya region. *(Under review)*

5. Tanika, L., Wamucii, C., Best, L., Lagneaux, E.G., **Githinji, M.**, & van Noordwijk, M. 2023. Who or what makes rainfall? Relational and instrumental paradigms for human impacts on atmospheric water cycling. *Current Opinion in Environmental Sustainability* 63. https://doi: 10.1016/j.cosust.2023.101300.

6. Hakim, A., Saputra, D., Tanika, L., Kusumawati, I., Sari, R., Andreotti, F., Bagbohouna, M., Abdurrahim, A., Wamucii, C., Lagneaux, E., **Githinji, M**., Suprayogo, D., Speelman, E., & van Noordwijk, M. (2023). Protected spring and sacred forest institutions at the instrumental—relational value interface. *Current Opinion in Environmental Sustainability*, 62, Article 101292. https://doi.org/10.1016/j.cosust.2023.101292.

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8. van Noordwijk, M., Speelman, E., Hofstede, G. J., Farida, A., Abdurrahim, A. Y., Miccolis, A., Hakim, A. L., Wamucii, C. N., Lagneaux, E., Andreotti, F., Kimbowa, G., Assogba, G. G. C., Best, L., Tanika, L., **Githinji, M**., Rosero, P., Sari, R. R., Satnarain, U., Adiwibowo, S., … Teuling, A. J. (2020). Sustainable agroforestry landscape management: Changing the game. *Land*, 9(8). https://doi.org/10.3390/LAND9080243.

Margaret Ngunju Githinji
Wageningen School of Social Sciences (WASS)
Completed Training and Supervision Plan

Name of the learning activity	Department/Institute	Year	ECTS*
A) Project related competences			
A1 Managing a research project			
WASS Introduction Course	WASS	2021	1
Research Proposal	WUR	2020	6
SESAM kick-off meeting (3 days)	PE&RC	2020	0.9
SESAM discussion group	PE&RC	2020-2023	2
Scientific writing	Wageningen In'to Languages	2021	1.8
'SESAMSIM: understanding dynamics in tropical agro-forestry'	Social Simulation Conference 2021, Kraków, 20-24/09/2021	2021	1
A2 Integrating research in the corresponding discipline			
Research Methodology: from topic to proposal	WASS	2020	4
Participatory and cross-scale modelling of social-ecological systems	Leiden University	2021	1.5
Agent Based Modelling for Resilience - Making it happen (summer School)	PE&RC and WIAS	2023	1.5
Organizational Culture	PE&RC	2020	0.1
Research design and methodology for the study of social phenomena relevant for research on serious games	PE&RC	2020	0.3
International SESAM workshops	PE&RC	2021-2023	3.9
B) General research related competences			
B1 Placing research in a broader scientific context			
Scientific Integrity	WGS	2020	0.6
Ethics for Social Sciences Research	University of Leeds	2021	0.5
Policy and Governance theories for analysing water issues	WASS	2020	2
Companion Modelling	WASS, PE&RC and WIMEK	2020	1.5
Q-Methodology	PE&RC	2020	0.3
Fuzzy Cognitive Mapping (FCM)	PE&RC	2020	0.3
B2 Placing research in a societal context			
Stakeholders consultation forum		2021	1
C) Career related competences/personal development			
C1 Employing transferable skills in different domains/careers			
Scientific Publishing	WGS	2020	0.3
Effective and efficient communication	WGS	2023	0.9
Searching and Organising Literature	Wageningen Library	2023	0.6
Total			**32.0**

*One credit according to ECTS is on average equivalent to 28 hours of study load.

Colophon

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