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Constraints and capacities for novel livelihood adaptation: lessons from agricultural adoption in an African dryland pastoralist system

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Abstract

Climate change, land use change, and sociopolitical and institutional transitions in African drylands have resulted in the loss, fragmentation, and degradation of environmental resources that pastoralists rely upon to sustain their livestock-based livelihoods. Diversification into irrigated agriculture is a potential strategy to increase food security. However, successful livelihood adaptation depends on access to key forms of natural, human, social, financial, and physical capitals, which may be lacking or unequally distributed in pastoralist communities. In two dryland pastoralist communities in Kenya, an international relief organization introduced irrigated farming in 2010. Nearly 200 individuals began farming, but within 4 years, all had quit. This study investigated the role of household access to different forms of capital in decisions to adopt agriculture, and how adaptive capacities, environmental conditions, and farming as a new livelihood practice interacted to shape household vulnerability. We found that decisions to farm were largely decoupled from access to assets that would afford greater adaptive capacity. The analysis also identified critical constraints that households encountered once they adopted farming. This study highlights the importance of more nuanced understandings of local capacities in the dynamics of adapting to environmental change. We recommend that prior to introducing interventions that promote new livelihood activities, development organizations should assess local capacities and pursue targeted strategies to increase household-level access to the forms of assets that will facilitate successful adaptation.

Keywords Adaptation · Diversification · Pastoralism · Semi-arid · Sustainable livelihoods

Introduction

Africa's dryland ecosystems are home to over 100 million rural pastoralists, whose livelihoods are derived wholly or substantially from subsistence-level livestock husbandry (Notenbaert et al. 2009). Despite historically resilient adaptations to water-limited environments, today, many of Africa's dryland pastoralist systems are undergoing complex suites of sociocultural and environmental changes, which feed back on one another to increase ecological and social vulnerability (López-i-Gelats et al. 2016). Loss of land, restrictions on mobility, and increased human and livestock populations have led to increased year-round pressure on smaller tracts of rangelands (Hobbs et al. 2008). Current and projected climate trends show increasing drought frequency and rainfall variability across most African dryland areas (Thornton et al. 2006; Sheffield and Wood 2008), which exacerbate vegetation degradation and increase environmental sensitivity to drought (Hobbs et al. 2008). Strong customary dependence on rangeland resources, few available livelihood alternatives, and

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political marginalization limit pastoralists' capacity to cope with the resulting harsher environmental conditions (López-i-Gelats et al. 2016).

In search of diversified or alternative livelihoods to meet human needs, recent decades show increased novel adoption or reliance on irrigated crop farming among dryland pastoralists (McCabe et al. 2010; Homewood et al. 2009; Fratkin 2013), with numerous examinations of these trends from nutritional (e.g., Fratkin and Roth 2005), institutional (e.g., Angassa and Oba 2008; German et al. 2017), development economics (e.g., Barrett et al. 2005), sociopolitical equity (e.g., Snorek et al. 2014), and environmental sustainability (e.g., Greiner et al. 2013) perspectives, to name a few. From the perspective of livelihood vulnerability, the prudence of irrigated agriculture in African dryland development is a hotly debated issue (Little 2013; Sandford 2013). While crop production presents an opportunity to adapt livelihood strategies to regain food security (Eneyew 2012; Headey et al. 2014), it may instead increase vulnerability due to the following: unreliable water availability, lack of farming experience and knowledge, high uncertainty regarding costs and benefits, conflicts with customary pastoralist land use, and erosion of social exchange networks (Davies and Bennett 2007; Thompson and Scoones 2009; Fratkin 2013). Whether, and under what conditions, agricultural adoption in pastoralist systems may either increase or alleviate vulnerability is an urgent development issue (Little 2013; Sandford 2013; López-i-Gelats et al. 2016), as climate change and water management crises increasingly threaten dryland food security (Wang et al. 2012).

The sustainable livelihoods framework (SLF) is used widely in rural development studies (Carney 2003) to evaluate livelihood adaptations to environmental change and their influence on vulnerability (Scoones 1998; Fraser et al. 2011). The approach focuses on local-level actors and dynamics vis a vis access to different kinds of assets—in the form of natural, human, social, financial, and physical capital—that enable or constrain adaptive capacity (Chambers and Conway 1992; Bebbington 1999). The adaptation framework of Nelson et al. (2007) is complementary to the SLF, but adds explicit consideration of adaptation to environmental change as a sequential process: assets and adaptive capacities are preconditions that influence *decision-making*, which then enables the *enactment of adaptation* itself, and the interplay of capacities and adaptation strategies generate *outcomes*. Concepts from both frameworks can be drawn upon to investigate how household access to various forms of capital may play different roles in the sequential stages of adaptation: decisions to adopt agriculture, enactment of a new livelihood practice, and outcomes for household vulnerability. We applied this approach to the recent adoption of irrigated crop farming in two pastoralist communities in north-central Kenya. Following a period of rapid and widespread initiation of farming activities, we conducted interviews in 2 successive years to understand the circumstances that influenced farmers' decisions to enter into farming and factors that discouraged others from trying, the concerns and limiting factors they encountered once they began, and reasons for quitting. We related the reported factors to access to different forms of capital that influenced the adaptation process at each stage.

Methods

Study system

The study sites were two adjacent group ranches, Koija and Il Motiok, located in Laikipia County, Kenya, which are collectively owned by Maa-speaking pastoralist and receive approximately 450 mm of annual precipitation (Franz et al. 2010). Koija Group Ranch is 7605 ha with 2267 residents; Il Motiok is 3651 ha with 999 residents (in 2009; Kaye-Zwiebel 2011). Both are bounded on their west side by the Ewaso Nyiro River and two large unfenced private wildlife conservancies.

Households tend to keep mixed herds of mostly cattle, goats, and sheep. In 2009, average livestock per capita at Koija and Il Motiok were 1.91 and 1.43 tropical livestock units (TLU)/per capita, respectively (1 TLU = 1 cattle = 10 goats/sheep) (Kaye-Zwiebel and King 2014), which is lower than commonly cited benchmarks of 2 to 5 TLU considered sufficient for pastoralist subsistence (Potanski 1999; Lesorogol 2008). Historically, these communities were semi-transhumant, with men taking cattle to distant grazing areas during dry seasons. Today, distant grazing access is highly curtailed, so household dry season and drought grazing strategies are more variable, depending on families' social networks, herd sizes, drought severity, and current levels of land use conflict outside the group ranch (Letai and Lind 2013). For most households, selling livestock (particularly small stock) is the primary source of cash for purchasing food and other livelihood expenses and making investments (Kaye-Zwiebel 2011). Other income-generating activities practiced at Koija and Il Motiok include petty trade, beekeeping and honey sales, and external employment.

In 2009 and 2010, the area experienced one of the worst droughts on record (Letai and Lind 2013). Livestock herds were decimated, and hunger affected nearly every household. In late 2010, World Vision, an international humanitarian organization, conducted a 2-day outreach workshop at Il Motiok, advocating crop farming along the riverfront at Koija and Il Motiok to an estimated few dozen participants. Verbal accounts of the event indicated that the charity made a one-time donation of seeds, a few mechanical water foot pumps, hoes, and machetes to attendees, with no subsequent follow-up.

Following that instigating event, many residents began river-irrigated maize farming on narrow alluvial plains and hillslopes extending 7 km along the river. Some also planted beans, tomatoes, cabbages, and other vegetables. Although all group ranch lands are owned communally, the elected group ranch committee, which governs land and resource use decisions, permitted individuals to claim exclusive use rights to plots of land to farm, typically 0.25 to 1 ha in size. Claims were initially made on a first come, first served basis, but when later adopters objected to some early claims of large plots on the best sites at Koija, some farmers were directed to divide and share their claimed areas (see German et al. 2017 for more details on the governance of allocation). Both group ranches had zoning plans that prohibited permanent residences near the river. Thus, each farmer and their household (defined as an extended family and occasional non-relatives that share a residential compound) resided in the interior of the group ranch.

Data collection

In June and July 2012, we mapped the boundaries and farmers' names for all farming plots in Koija and Il Motiok. Teams of trained Kenyan enumerators and translators from Koija and Il Motiok interviewed each farmer encountered along the entire length of the farming area ($n = 35$ at Koija, $n = 24$ at Il Motiok, total $n = 59$). The structured interviews included yes/no, quantitative, and free-response questions, and documented livestock holdings, initial motivations to farm, input costs, sources of information about farming practices, and challenges related to farming that they were experiencing. These interviews, collectively referred to as the "2012 survey" in the Results and discussion, coincided with the growing season following the long rains in April; many farmers also planted during the short and less reliable rains in November/December.

In June 2013, we updated the active farm and farmer lists and conducted a full community-wide survey ("2013 survey" in the Results and discussion) on Koija Group Ranch, interviewing one adult in every household (residential compound). The survey captured 35 current farmers, 84 ex-farmers, and 106 never-farmers, for a total of 225 interviews. This included households of the farmers interviewed in the 2012 survey, but in each case, the available respondent did not happen to be the farmer interviewed in 2012. One local, trained enumerator, fluent in Maa, Swahili, and English, conducted all interviews and recorded responses in English. The survey instrument asked yes/no, quantitative, and free-response questions to ascertain household composition, livestock holdings, the respondent's reasons for farming, quitting farming, or never beginning to farm, and other experiences and perceptions related to their own farming or others' farming. Because of logistical constraints, Il Motiok was not included in this or later fieldwork. In 2014 and 2015, we revisited the farming areas on Koija to record active farms and farmers.

Analyses

Survey responses were entered into spreadsheets. Reasons volunteered by respondents for farming/quitting/never trying and day-to-day concerns were categorized by topic and coded according to the forms of capital they related to. Household livestock holdings were aggregated into tropical livestock units (TLU) as a proxy for access to financial capital. This measure of livestock wealth does not represent the multiple roles that livestock can play in household well-being and does not account for households' other sources of financial capital, but is a common approximating metric of access to financial capital used in societies with low levels of diversification (BurnSilver 2016). We grouped households into four livestock wealth categories: households without livestock, low-, intermediate-, and high-wealth terciles of household TLU. We used chi-square analyses to compare the frequency with which different reasons and concerns were cited by individuals from different livestock wealth terciles. Analyses were performed using JMP 11 statistical software (JMP 2013).

Results and discussion

Trends in farm establishment and abandonment

Except for one Koija farmer who began in 2007, all farms were initiated between late 2010 and April 2012, following the 2009–2010 drought and the World Vision outreach event in late 2010. In June 2012, we identified 95 farm plots at Koija, with 133 farmers managing or co-managing them, and 26 farm plots at Il Motiok. About half of households at Koija (107 out of 225 households in the 2013 survey) had at least one member who attempted farming. In June 2013, we found 45 active farms at Koija and less than 8 active plots at Il Motiok. In June 2014, only seven farms were still being tended at Koija. There were no active farms in June 2015, yet some households expressed interest in trying again (German et al. 2017).

Assets, adaptive capacity, and decisions to begin farming

The major pressure incentivizing adaptation was chronic loss of forage resources and recent catastrophic losses of livestock to drought. The adaptation strategy taken was to attempt crop farming for the first time. Given that rainfall is low, erratic, and divided between two annual rainy periods, the Ewaso Nyiro River afforded the critical form of natural capital to allow

farming as a potential livelihood adaptation. We examined whether decisions to adopt farming as a livelihood innovation were related to households' access to technical knowledge about farming and financial capital for input costs, two assets that we hypothesized would influence adaptive capacity, given the prevailing economic hardships and lack of prior farming experience in the study communities. Then, by evaluating non-adopters' reasons for not attempting to farm, we inferred how access to other forms of capital may have influenced decisions.

Access to knowledge In the 2012 surveys, none of the 59 farmers interviewed reported any prior personal experience with farming. To acquire initial information on farming practices, 81% reported that they relied only on visual observations of other farms; 48% observed farms outside the group ranches (respondents who specified mentioned farming areas around the towns of Nanyuki and Rumuruti, where annual rainfall is greater than 700 mm); and 38% reported observing other farms within the two group ranches. Only 11 farmers (19%) reported getting advice by talking to other people; two Il Motiok farmers cited World Vision's outreach event, and one cited the Ministry of Agriculture. Thus, while the World Vision event was broadly viewed as a catalyst for the wave of farming efforts that arose, it provided minimal training and information to farming adopters. Knowledge and learning are widely recognized as forms of human capital that afford greater adaptive capacity (Armitage 2005); these communities were severely constrained in their access to such capital, and may have even been misled by information inappropriate for the local environmental context.

Access to financial capital Financial capital is also a critical asset for adaptive livelihood transformations (Olsson et al. 2014). World Vision's initial donations of farming inputs were reportedly very limited in their quantity and distribution. Of the 59 farmers in the 2012 survey, six from Il Motiok and five from Koija received seeds, six Il Motiok farmers received a hoe, three also received a machete and a slasher, and two received water pipes (but no pump). No Koija farmers reported receiving any equipment. Thus, farmers were predominantly self-reliant for their input costs, and 84% of farmers in the 2012 survey sold livestock to cover the initial costs of farming. In the 2013 survey, only one of 12 respondents with no livestock had attempted farming. Comparing the low-, intermediate, and high-livestock wealth terciles, wealth was a very weak predictor of likelihood to try farming, explaining less than 2% of the uncertainty ($R^2 = 0.018$, $p = 0.078$). However, when we asked non-farmers why they decided not to farm, reasons related to input costs were more frequently reported by those with less livestock (100% of livestock less, 78% of low-wealth, 44% of intermediate wealth, and 17% of high-wealth respondents, $\chi^2_{3,106} = 37.33$, $p < 0.001$). In summary, households without livestock were unlikely to try farming; for those with livestock assets, herd size had almost no explanatory power regarding decisions to begin farming. Yet, input cost was a reason that many people decided *not* to try farming, especially those with less livestock.

Households of different wealth levels may have viewed risks differently, with poorer households more willing to try farming out of need, despite having fewer resources to invest (Fratkin 2013). Alternatively, because households had little or no access to economic or agro-ecological information, costs, and risks were essentially unknowable (Tversky and Kahneman 1992). Thus, it may not have even been possible for households to meaningfully weigh their own financial assets as part of decision-making. Indeed, Barrett et al. (Barrett et al. 2005) found that risk assessment was often secondary to other constraints and incentives in pastoralist income diversification decision-making.

Reasons why some did not try farming Lack of financial capital to cover costs of farming equipment was the most common reason reported for not starting to farm (57% of non-farmers, Table 1a). Lack of interest in farming was cited by 27% of respondents, more commonly by wealthier households, but not significantly so ($\chi^2_{2,95} = 3.00$, $p = 0.223$). Labor demands were reported by 19% of non-adopters, more commonly by wealthier households ($\chi^2_{2,95} = 6.07$, $p = 0.048$). Of those citing labor constraints, 68% specifically mentioned inadequate labor to both farm and tend livestock. Lack of knowledge was cited by 9% of respondents, while 7% perceived farming as too hard or physically demanding. Thus, limited access to financial and human capital (knowledge and household labor) were key constraints on the capacity of many households to diversify into farming, while environmental factors such as wildlife damage and water availability were rarely cited (Table 1a).

Interplay of constraints, assets, and farming practice for farmers

Once households had begun to farm, the most salient day-to-day concern was wildlife conflict, reported by 80% of farmers in the 2012 survey, half of whom mentioned elephants specifically. Wildlife destroys crops and, in the case of elephants, endangers human lives. Some farmers had a single-wire strand or thorn branches around their farms, but many had no barrier. Inadequate fencing was mentioned specifically by 21% of farmers who identified wildlife as a challenge. Since fencing is expensive, locally unavailable, and of limited effectiveness for the main pests, the dominant coping strategies relied on human and household capital: chasing away monkeys, birds, and squirrels by day and policing fields to deter elephants at night.

Table 1 Summary of interview responses from 2013 survey of members from each household in Koija, regarding (a) reasons why those who had never farmed ($n = 106$) decided not to attempt farming and (b) reasons for quitting explained by those who had tried farming but quit ($n = 84$). Free-response answers were categorized by general reason, then each general reason was categorized according to the form of capital that pertained to the reason. Chi-squared tests were used to determine whether the frequency of responses differed between low-, mid-, and high-livestock wealth terciles (based on aggregate household TLU)

(a) Reasons why never-farmers *decided not to farm* [and related form of capital]	% of never-farmers ($n = 106$)	% by household TLU category			
		None ($n = 11$)	Low ($n = 40$)	Mid ($n = 32$)	High ($n = 23$)
*Cannot afford input costs [F]	57	100	78	44	17
Lack of interest [H]	27	0	23	31	43
*Household labor demands [L]	19	0	10	25	35
Lack of knowledge [H]	9	0	10	13	9
Too physically demanding [L]	8	0	15	6	4
Human-wildlife conflict [N]	3	0	3	4	3
Land use conflicts [S]	2	0	3	0	4
Unreliable rainfall [N]	1	0	3	0	0
(b) Reasons why ex-farmers *decided to quit farming* [and related form of capital]	% of ex-farmers ($n = 84$)	% by household TLU category			
		None ($n = 1$)	Low ($n = 24$)	Mid ($n = 29$)	High ($n = 30$)
Input costs and equipment [F]	74	100	67	83	70
*Wildlife [N]	29	0	42	34	13
*Household labor/herding conflicts [L]	19	0	4	10	40
Cooperation and sharing problems [S]	4	0	0	4	0
Drought [N]	2	0	0	1	1
Too physically demanding [L]	2	0	1	1	0
Lack of knowledge [H]	0	0	0	0	0

*Varied significantly ($p < 0.05$) between low/mid/high household TLU categories

Key to forms of capital pertinent to cited reasons: *F* financial/physical capital, *H* human capital: knowledge/attitudes, *L* human capital: labor, *S* social capital: community-level, *N* natural capital: environmental factors

The second most common concern was cost and access to irrigation, cited by 63% of farmers. Though a few mechanical foot pumps were donated by World Vision, none of the farmers in the 2012 survey reported owning one, 11 farmers mentioned using them, and only one farmer used a foot pump as their sole source of irrigation. Petrol irrigation pumps were used by 55 of the 59 farmers, yet only five respondents owned their own pump. Everyone else had to share or rent pumps and supply petrol and pipes themselves. Due to high demand, variable rental arrangements, and frequent breakdowns, 80% of farmers said they had less frequent or consistent access to pumps than they would like, and 98% said it was hard to afford petrol. However, farmers' reports of limited access to irrigation and fuel costs were not explained by household livestock wealth (2013 survey: $\chi^2_{1,42} = 0.036$, $p = 0.849$ and $\chi^2_{1,42} = 1.132$, $p = 0.287$, for irrigation access and fuel costs, respectively). The capacity to irrigate adequately appeared to depend on access to multiple forms of capital—financial, physical, and social.

Farming also altered the ways that household human capital was allocated. All 59 farmers interviewed in 2012 owned livestock; for 78% of them, farming was changing the way they managed their livestock, and 64% reported that farming took attention or labor away from livestock. Social capital, in the forms of strong norms of reciprocity, labor pooling, and food sharing are salient adaptive characteristics in many pastoralist societies (Lesorogol 2008), including the study communities (Kaye-Zwiebel and King 2014). In the 2013 survey, 43% of farmers received farming labor and/or crop protection help from others outside their household, suggesting that existing social capital, in the form of cooperative relations among families, proved valuable in the new farming endeavor. Yet, 100% of farmers reported giving farm produce to extra-household families, neighbors, or friends, which may indicate that customary sharing norms imposed economic costs on individual household farming efforts.

Outcomes

Nearly everyone had quit farming by 2014, and all had quit by 2015. The most common reasons for quitting, cited by 74% of ex-farmers in the 2013 survey, fell in the category of input

costs and equipment (Table 1b), often expressed as input costs relative to harvested food. The likelihood of citing input costs did not differ among wealth categories ($\chi^2_{2,83} = 2.12$, $p = 0.35$), suggesting that access to financial capital did not allow wealthier farmers to overcome the discouraging cost-benefit relationship that other farmers experienced. Only two respondents mentioned drought as a reason for quitting. This suggests that people may have generally perceived the problem of crops receiving inadequate water as a limitation associated with lack of access to financial and physical capital, not as a limitation of the ecosystem itself.

Wildlife was the major day-to-day concern for 80% of farmers and was cited as a reason for quitting by 45% of ex-farmers—more often by those with less livestock wealth ($\chi^2_{2,83} = 6.31$, $p = 0.042$). The burdens associated with allocating household labor to farming were cited by 19% of ex-farmers, significantly more frequently by farmers in the highest livestock wealth tercile ($\chi^2_{2,83} = 13.39$, $p = 0.0012$). The difference in dominant constraints for poor versus wealthy households may reflect the different bundling of assets and vulnerabilities in (a) poorer families, who have fewer animals thus more labor for farming, yet are less able to absorb the cost of crop losses to wildlife, versus (b) wealthier families that are less sensitive to animal-caused crop loss, but have greater demand for herding labor given larger livestock holdings, and thus less household human labor capital to allocate to farming.

Related to social capital, three ex-farmers (4%) quit because of cooperation and sharing conflicts; two had disagreements with someone with whom they shared a plot, and one had issues with people borrowing their equipment. When discussing our findings with local project staff, their consensus was that interpersonal conflict over labor sharing, food sharing, and food theft were in fact frequent additional contributing factors in farmers' decisions to quit, but such matters are considered private and thus underreported in interviews.

Conclusion

The feedbacks between local environmental and sociocultural change have led to increasingly marginal herding livelihoods, creating incentives for adaptive transformation. A severe drought heightened the pressure to adapt at the time when World Vision introduced the idea of farming. Yet, despite the availability of untapped natural capital for farming—arable land and a river—every household gave up farming within 4 years of commencing. Using concepts from the sustainable livelihoods and adaptation frameworks allowed us to make some key inferences about how lack of access to multiple forms of capital, at both decision-making and enactment phases, can undermine livelihood adaptation.

While potent incentives may have encouraged decisions to begin farming, none of those who tried farming reported any prior experience, and they received little to no information from sources beyond their own community, where farming had never been practiced before. Except for people with no livestock, households of all other wealth levels were equally likely to decide to try farming. Thus, the amount of accessible financial capital did not appear to affect household decision-making in a systematic way across the community. There were no reported steps taken by World Vision to increase access to economic or technical knowledge that would facilitate informed decision-making.

Likewise, there were no reported efforts to help households build capacity to cope with the many grave challenges of farming in their particular context, and no households managed to do so, regardless of levels of financial capital. The greatest challenges to new farmers were access to irrigation, threats posed by wildlife, limited household labor, and perhaps social conflicts. The predominant form of financial capital is livestock, yet this asset simultaneously limits household labor availability for farming. If irrigated dryland agriculture is advocated as a livelihood adaptation, communities will need holistic solutions to reduce or mitigate wildlife threats, improve market and equipment access, and navigate labor constraints. These challenges require innovative and context-specific capacity building and innovation—in terms of knowledge, learning, and financial and social capital—to avoid exacerbating vulnerabilities. Even if these issues can be tackled successfully, it is still uncertain whether economic benefits from farming in this drought-prone, wildlife-rich region will ever outweigh costs.

Sustainable livelihoods studies of pastoralist transitions can afford insights into the differential outcomes that result from household access to key capacities (e.g., Tsegaye et al. 2013). Maasai pastoralist communities in Tanzania utilized adaptive capacities to adopt agriculture and reduce vulnerabilities (McCabe 2003), yet in northern Kenyan and Ethiopian pastoralist areas, similar adaptations have yielded more equivocal outcomes (Fratkin and Roth 2005; Davies and Bennett 2007). In this case, it appeared that no household had access to the requisite bundles of assets and capacities for farming adoption. Instead of highlighting the *relative* importance of different forms of capital as assets, this study points out the *absolute* importance of considering these factors in conceiving and implementing development interventions. When they are not considered and addressed, a well-intentioned development initiative can motivate vulnerable populations to take considerable risks, without means to overcome those risks in practice, further undermining livelihood security (Kirkbride and Grahn 2008). Unsuccessful adaptation processes are discussed anecdotally in the field, at conferences, and within development

agency offices, but are rarely formally analyzed (Bruce and Mearns 2002). This case study offers a valuable cautionary example.

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