

Migrant decision-making in a frontier landscape

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LETTER

Migrant decision-making in a frontier landscape

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**Abstract**

Across the tropics, rural farmers and livestock keepers use mobility as an adaptive livelihood strategy. Continued migration to and within frontier areas is widely viewed as a driver of environmental decline and biodiversity loss. Recent scholarship advances our understanding of migration decision-making in the context of changing climate and environments, and in doing so it highlights the variation in migration responses to primarily economic and environmental factors. Building on these insights, this letter investigates past and future migration decisions in a frontier landscape of Tanzania, East Africa. Combining field observations and household data within a multilevel modeling framework, the letter analyzes the explicit importance of social factors relative to economic and environmental factors in driving decisions to migrate or remain. Results indeed suggest that local community ties and non-local social networks drive both immobility and anticipated migration, respectively. In addition, positive interactions with local protected natural resource areas promote longer-term residence. Findings shed new light on how frontier areas transition to human dominated landscapes. This highlights critical links between migration behavior and the conservation of biodiversity and management of natural resources, as well as how migrants evolve to become integrated into communities.

1. Introduction

Rural farmers and livestock keepers in developing countries make migration decisions as part of complex livelihood strategies. Recent scholarship advances our understanding of migration in and around natural resource and biodiversity areas specifically (Scholte and de Groot 2010, Hoffman *et al* 2011), and in the context of changing climate and environments more generally (Adamo and Izazola 2010, Black *et al* 2011, Adger *et al* 2015, Hunter *et al* 2015). Conceptual models predict migration behavior from how environmental change differentially shapes household livelihoods (e.g., Black *et al* 2011). For example, inadequate farmland or insufficient rainfall causes some households to out-migrate for various destinations while others remain. Migration decisions are largely driven by access to productive natural resources and economic assets, and while social capital and local community ties may moderate decisions their role has

been viewed as less causal (Curran 2002, Doevenspeck 2011, Adams and Adger 2013).

This study addresses three specific and less-studied features of migration-environment dynamics, namely the importance of social factors relative to environment and economy (Doevenspeck 2011), the explicit consideration of immobility (Hunter *et al* 2015), and the links between migration decision-making and ongoing changes in frontier communities (Lopez-Carr 2012). I focus on internal, rural-to-rural migration within the transitional frontier, defined here to encompass sparsely populated forests and grasslands along with areas undergoing rapid deforestation and clearing to become human-dominated rural landscapes.

Close examination of migration-environment dynamics uncovers diverse and context-specific factors affecting migration as an adaptive response (Black *et al* 2011, Warner and Afifi 2014). For example, declining environmental conditions (e.g., available land, soil fertility, rainfall) often trigger decisions to

out-migrate, and the response may be patterned by access to alternative local natural resources (Hunter *et al* 2014), household wealth (Warner and Afifi 2014), social capital provided by kin in both origin and destination areas (Massey *et al* 1993, Curran 2002), or by past migration experience (Massey and Espinosa 1997, Gray 2009, Nawrotzki *et al* 2015). Empirical work focuses on rural-urban and international migration, while relatively little research examines permanent migration within the frontier as it becomes increasingly settled (Carr 2008). Moreover, even as deterministic land- and climate-driven models of migration are rethought, the barriers to migration that result in immobility remain understudied (Warner and Afifi 2014, Adams 2015), along with the implications of immobility for resource institutions and governance in rural communities (Charnley 1997, Curran 2002). Testing more comprehensive models is necessary to determine why frontier mobility persists and how households make decisions to move or remain based on perceptions of environmental, economic, and social conditions (Hunter *et al* 2015).

Continued migration to and within frontier areas poses an environmental challenge, most directly through deforestation and land clearing for agriculture (Galaty 1988, Painter and Durham 1995). Where significant areas of the landscape are designated for biodiversity protection, in-migration can contribute to increasing population densities at protected area borders and consequent isolation effects of protected ecosystems (Joppa *et al* 2009, Estes *et al* 2012, Salerno *et al* 2014). Furthermore, migration into frontier communities increases local demand on environmental resources such as shared forests and pastures. These changes are understood to negatively impact local resource management institutions by weakening social bonds and diluting knowledge of rules and resource use practices (Charnley 1997, Katz 2000, Ostrom 2000; but see Atran *et al* 1999).

As frontier areas transition into human-dominated agricultural landscapes, migration may continue into further, less-settled areas of the forest or grassland frontier (Galaty 1988, Katz 2000). However, there is a gap in forward-looking research linking migration decision-making with how migrant-resident communities change, for example, as length of residence increases and time horizons shift (Holmes 2005), and former migrants make decisions to stay or move again. This has significant implications for managed natural resources and protected biodiversity (Curran 2002, Hartter *et al* 2015).

This letter investigates past and future migration decisions in the transitional frontier landscape of western Tanzania (figure 1). It focuses on Sukuma agropastoralists, whose persistent expansion is associated with widespread environmental change. Agropastoralist mobility is typically explained by access to available land to maintain extensive farming and livestock keeping practices (Galaty 1988, Brockington 2001). I

test this assumption by considering livelihood decisions as the result of a diverse set of resources and assets (Chambers and Conway 1992, Ellis 2000), and by building on a more comprehensive model of mobility from the migration-environment literature (e.g., Black *et al* 2011). I ask two related questions about the drivers of rural-rural migration using quantitative household surveys and observational data: (1) which factors drove past decisions to move, and (2) how do multiple factors differentially contribute to households' expectations of future out-migration from their present location?

2. Conceptual approach and methods

2.1. Livelihoods and migration in rural Tanzania

The livelihoods framework conceptualizes household decision-making through adaptation strategies given available capital assets (Chambers and Conway 1992). It has been effectively applied to explain migration decisions in varying contexts (Black *et al* 2011, Hunter *et al* 2015), particularly in developing countries where natural resources are critical for how households access and use different forms of assets (Nawrotzki *et al* 2012). Migration is costly, and decisions to move may be facilitated by existing forms of capital such as cash reserves, local family ties, or kin networks present in destination areas.

The agropastoralist study population engages in a limited set of livelihood activities (e.g., few households work as or hire wage laborers, few possess physical assets such as tractors, few hold bank accounts or access credit). However, social capital is particularly important and exists through ties or embeddedness within a local community as well as through networks in a potential destination (Massey *et al* 1993). Such spatial features of social capital can facilitate household adaptation through both immobility and out-migration (Nawrotzki *et al* 2015). Therefore, livelihood capital factors predicting migration are categorized as access to environmental resources, social capital, and household productive assets.

Frontier migration of agropastoralists in Tanzania has been associated with large-scale environmental change since the mid-1900s (Galaty 1988). Continued expansion into the frontier results in extensive forest clearing, overgrazing, soil degradation, and social conflict in destination communities (Charnley 1997, Brockington 2001, Borgerhoff Mulder *et al* 2007). This study focuses on the agropastoralist Sukuma, the largest ethnic group in Tanzania, whose mobility is characterized by multiple, successive migration events over time (Galaty 1988). Households typically settle in a frontier area and clear land for pasture and rainfed agriculture (e.g., rice, maize, sesame, sunflower, sweet potato, cotton, tobacco). When increasing population densities limit agricultural expansion and central-place livestock keeping practices, households migrate

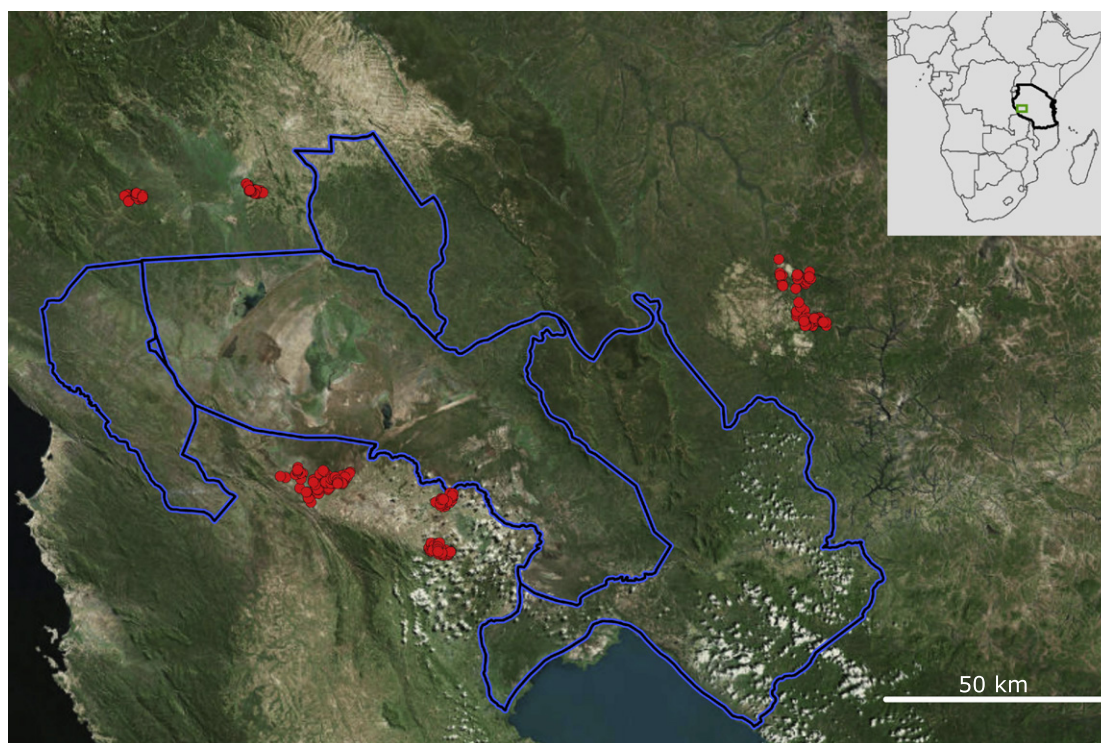


Figure 1. Katavi–Rukwa study site, western Tanzania. Sample households in seven study villages (red points) were visited 2012–2013. Villages are located in close proximity to strict protected area borders (blue polygons). Significant forest clearing is evident near the study villages (e.g., adjacent to north-eastern villages) and in other areas adjacent to protected area borders. Study site extent: 6.110 333°S–7.647 705°S, 30.484 913°E–32.790 203°E. Data sources: IUCN & UNEP-WCMC 2014; Esri DigitalGlobe (July 2011).

again as a single unit and avoid sending temporary or labor migrants (Coppolillo 2001). Mobility patterns result in a transitional frontier of increasing human and livestock densities and decreasing land and natural resource availability, described as a ‘cascade effect’ of slow-onset environmental change (Charnley 1997).

2.2. Study system, data collection, and analysis

Large-scale migration of Sukuma agropastoralists to the Katavi–Rukwa study system (figure 1) began in the 1970s following repeated droughts in northern and central Tanzania (Brockington 2001). Katavi Region currently experiences the highest rural population growth rate in the nation (3.2, URT 2013). The study system was selected because it includes mixed migrant-resident communities experiencing varying degrees of both in- and out-migration, along with land clearing and resource use pressures (Borgerhoff Mulder *et al* 2007). The study area is representative of population-environment dynamics ongoing throughout the country; however, official census data do not exist to allow for direct comparison of features of the sample population with those of the nation, which represents a limitation in generalizability. Study communities are located in a landscape alongside multiple protected area types and ongoing community-based natural resource management initiatives. Katavi National Park is of critical conservation importance, protecting 4471 km² of mixed savannah and miombo woodland and exceptional populations of wildlife.

Forest reserves and village resource areas function as buffers to the core biodiversity areas as well as constitute productive managed lands for timber, fuelwood, and grazing (Holmes 2005, Salerno *et al* 2015). Prior to the mid-1900s, the resident population included Pimbwe, Fipa, Bende, and Konongo ethnic groups at relatively low population densities (Willis 1966). While state authorities and international donors recognize the vast extent of agropastoralist expansion, it is the local village governments that manage local forests, farmland, and pastures, often without support from higher administrative levels (Brockington 2001).

Fieldwork was conducted between 2011 and 2013 in seven villages bordering Katavi National Park and adjacent conservation areas. Study villages were identified through interviews with region and district officials during pilot work in 2011. Villages were selected in the major areas of in-migrant settlement within the three distinct ethnic and agroecological areas bordering the Park; these villages define the sampling frame. In consultation with village officials, the sub-villages containing substantial Sukuma populations were identified, and sample households ($n = 232$) were randomly selected from sub-village rosters. Such stratified random sampling approaches, using sub-villages as strata, have been usefully implemented among the Sukuma study population in Katavi (Coppolillo 2001, Holmes 2003, Borgerhoff Mulder *et al* 2007). Elected sub-village chairmen provided introductions at each

household prior to surveys. Household compounds are typically comprised of the household head, married and unmarried sons, wives, and children. Compounds are located away from village centers, and it is not uncommon for them to include 30 or more family members and hundreds of livestock. Following verbal consent, surveys were conducted with household heads in Kiswahili or translated to Kisukuma when necessary.

Household surveys yielded qualitative migration narratives along with two quantitative migration outcome measures and household-level predictor variables. Household heads were asked to recall their family migration histories, which were recorded as narratives. Next, household heads were asked to free-list and rank the primary factors they thought were important in driving past migration decisions (number of reasons stated ranged from 1–5, mode = 3; see Doeveenspeck 2011). Responses were coded through emic categories: agriculture (e.g., land for farming, pasture for grazing), environment (e.g., rainfall, climate), family-community (e.g., proximity to kin, peaceful community, household health), business (e.g., access to roads, cash crop markets), and development (e.g., health centers, schools).

Respondents then quantified their expectation of future migration through a simple activity. Respondents were given 20 maize kernels and, following multiple example rounds, asked to demonstrate the chances that they would move their family to an area outside of their current ward¹ at any point in the future. Their belief was expressed by placing a fraction of the 20 kernels in a pile. This method was adapted from experimental economics as an effective tool for measuring respondent perceptions of probability or expectation of future events and was useful in the low literacy study population of Katavi–Rukwa (Luseno *et al* 2003, Delavande *et al* 2011, McKenzie *et al* 2013). While acknowledging that this outcome variable measures only perceptions of future migration behaviors, these perceptions reflect the cognitive process through which certain households self-select to make the decision to migrate (de Haas 2010, Adams and Adger 2013, Koikkalainen and Kyle 2016). Respondents within the Sukuma study population were predominantly experienced migrants, having made previous decisions to move their family multiple times based on the changing environmental, social, and economic conditions of the frontier (Brockington 2001). Koikkalainen and Kyle (2016) review the theoretical and empirical evidence for intention or expectation affecting a migration (or non-migration) outcome, including implicit assumptions of this concept in classical migration theory such as Wolpert’s stress-threshold model (see also Hunter 2005). Furthermore, ignoring future processes and examining only past migration events, which is common among the quantitative migration literature,

introduces ‘mobility bias’ and limits researchers’ understanding of migrant selectivity and immobility (Schewel 2015).

Quantitative surveys measured predictor variables to include in statistical models. Variables are organized into categories based on simplified groupings of livelihood capital assets (table 1): access to environmental resources, social capital, and household productive assets. While variables can be categorized in different ways (e.g., financial, human, physical capitals), the steps taken here are appropriate to agropastoralist livelihoods in the study system and used primarily as a meaningful organizational tool.

A multilevel regression model was fitted to test the associations between expected out-migration and the suite of predictor variables. The model treated respondent expectations of migration (indicated by the number of kernels of maize placed out of 20) as a binomial outcome using computational Bayesian methods (Plummer 2003, Gelman and Hill 2007, R Core Team 2013). Due to the hierarchical structure of the data—households clustered in sub-villages and sub-villages in villages—the model included varying intercept (i.e., random) effects for both village and sub-village. These effects control for unobserved differences in the outcome variable shared by households within different levels of clustering (McElreath 2015). The log-odds of a maize kernel response are modeled as

$$\text{logit}(p_{hsv}) = \alpha + \beta \mathbf{x}_{hsv} + S_s + V_v,$$

where p is the probability of anticipated migration; α is the intercept shared by all households; \mathbf{x} is a vector of covariates for household h in sub-village s in village v (table 1), and β is a vector of corresponding slope parameters; S and V are the varying intercepts for each sub-village and village, respectively². Model computation consisted of a 500 000-iteration burn-in and 500 000-iteration joint posterior sample³; posterior mixing and convergence were assessed by examining trace plots and kernel densities.

The two research questions—(1) which factors drove past decisions to move and (2) which factors contribute to future migration expectations—are evaluated through different approaches. The relative importance of different reasons for past migration (Question 1) is assessed through descriptive statistics of the emic categories stated above. The influence of environmental, social, and productive assets on

² Priors for coefficients of all household-level covariates are highly diffuse Gaussian densities with mean zero and standard deviation one thousand. Priors for varying village and sub-village intercepts are Gaussian with mean zero and hyperparameters for standard deviations; hyperparameters have half-Cauchy priors. For further details on model structure and prior specification see Gelman and Hill (2007, p 381, 430)

³ Models were run on the Sapper UNIX server at the UC Davis Social Science Data Service. The server is a Dell R820 32-core CPU with 512 GB of RAM running Redhat Linux Enterprise version 6 (see <http://ssds.ucdavis.edu/computing>). The complete 1 000 000-iteration model run lasted approximately eight hours.

¹ Administrative unit similar to a US county.

Table 1. Household-level factors of migration decision-making. Variables predicted to influence migration decisions are drawn from the literature and adapted to reflect agropastoralist livelihoods within the study system. Variables are organized into the three general categories (column 1, left): environmental resources, social capital, household productive assets. All variables listed (columns 2–4) are measured through surveys with household heads and included in the statistical model predicting anticipated out-migration. Sample means (column 4) from the 232-household sample are reported on observed values (not transformed).

	Predictor variable	Variable description	Sample mean (SE)
Environmental resources	Farm productivity	Household's maize yield in sacks per acre; continuous	4.48 (0.21)
	Land scarcity	Number of years since household last expanded their farm; discrete	8.23 (0.43)
	Conservation benefits	Household perceives to obtain benefits from nearby protected areas ^a or associated outreach activities (e.g., rainfall, fuelwood); binary	0.45 (0.03)
	Conservation costs	Household perceives to experience costs associated with protected areas ^a (e.g., access restrictions, conflicts with wildlife); binary	0.23 (0.03)
	Conservation knowledge	Household accurately identifies protected area ^a names and rules, boundary location, and/or outreach project activities; binary	0.43 (0.03)
Social capital	Local community kin ties ^b	Household identifies presence of additional kin living in separate households in current location; binary	0.23 (0.03)
	Local community leadership	Household head holds leadership role in local government or other institution (e.g., village council, volunteer police force); binary	0.26 (0.03)
	Non-local livelihood sharing	Household shares farm, livestock, or business activities with non-local individuals based in another place; binary	0.24 (0.03)
	Non-local kin networks ^b	Number of regions outside their present home region where household identifies kin residing; discrete	6.02 (0.20)
	Mobility networks ^b	Household's most recent migration was facilitated by kin arriving first to the current location; binary	0.65 (0.03)
	Total migrations	Number of migrations over the lifetime of the household head; discrete	2.53 (0.09)
	Years resident	Number of years household has lived in current location; discrete	10.69 (0.60)
Household productive assets	Farm size	Number of acres owned by household; discrete (sq. root transformed for binomial model)	16.70 (1.19)
	Cattle	Number of cattle owned by household; discrete (sq. root transformed for binomial model)	24.65 (2.64)
	Age of household head	Discrete	47.91 (0.89)
	Education of household head	Household head attended more than 3 years of primary school; binary	0.56 (0.03)
	Multiple wives	Household head currently has multiple living wives; binary	0.38 (0.03)
	Sons	Number of living sons fathered by the household head; discrete	3.91 (0.21)

^a Protected areas include strict non-use areas (e.g., Katavi National Park, game reserves) and village- and district-controlled reserves allowing limited use and extraction.

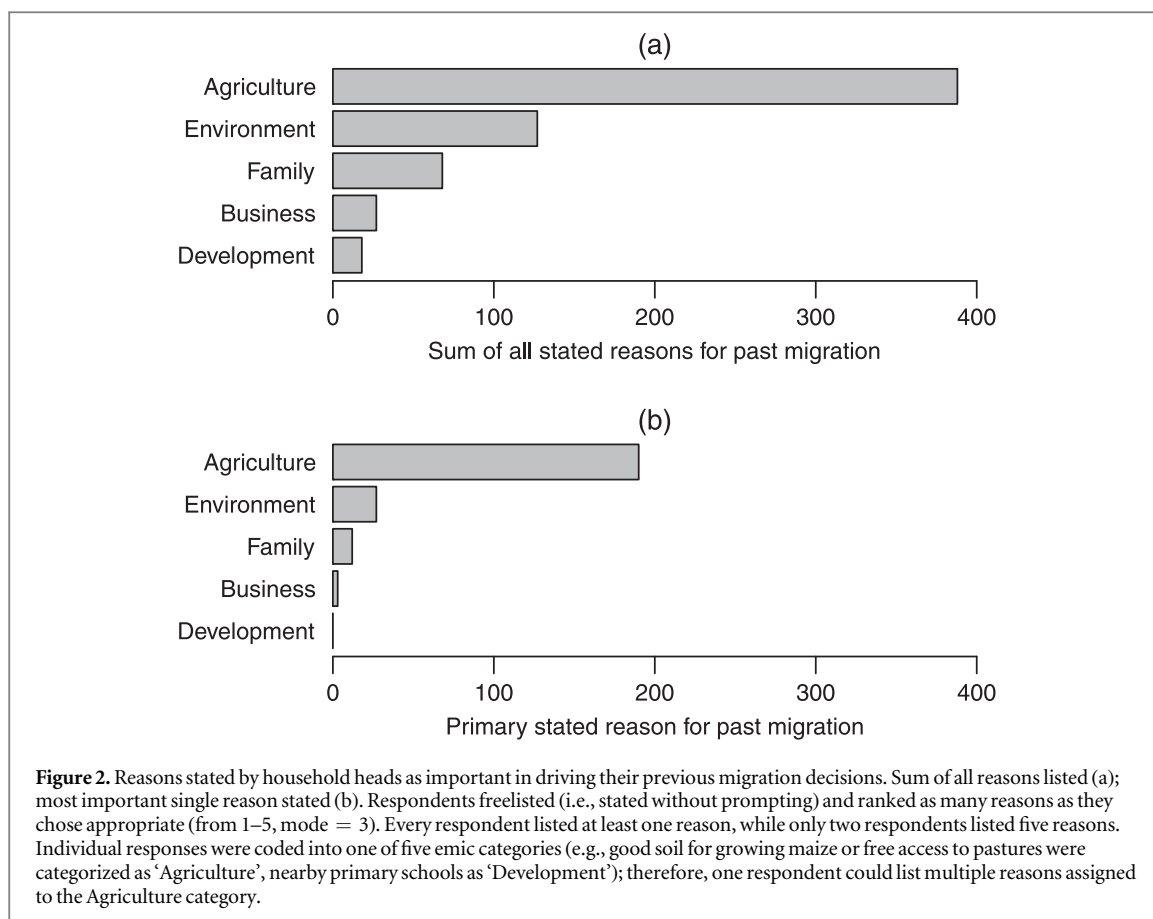
^b For consistency, kin or community *ties* describe local relationships or connectivity within the current community of residence, whereas kin or livelihood *networks* describe non-local relationships or connectivity.

anticipated out-migration (Question 2) is evaluated through coefficient estimates from the statistical model (estimates reported with 95% credibility intervals). As argued above, because of the importance of understanding migration decisions in terms of future changes in environments and communities, I focus primarily on findings of the statistical model.

3. Results

Land for agriculture was most often mentioned (figure 2(a)) and most highly ranked (figure 2(b)) by

household heads as a reason for past migration (Question 1). Within the agriculture category, when respondents chose to elaborate they cited farmland as more important and cited it twice as frequently as grazing land. Environmental reasons ranked second and were predominantly related to rainfall. Specific reasons related to family included a cooperative and peaceful community, household health, and food security. Reasons related to business and development referenced access to cash crop markets and services such as schools and roads. Though 66% of respondents knew of conservation areas and 14% knew of



conservation outreach activities prior to arriving, only two individuals cited conservation as an important reason driving their past migration decisions. One respondent moved after being evicted from a national park, while another moved to gain access to the village forest reserve (these reasons are included in the environment category in figure 2).

Estimates from the multilevel model demonstrate the relative strength of environmental, social, and productive economic factors in predicting anticipated out-migration (Question 2; figure 3). Estimates suggest that social capital assets are highly predictive of out-migration. Approximately one-quarter of households maintained strong *local community kin ties* or *leadership roles* (22% and 26%, respectively). The presence of *local kin* decreases the odds of anticipated out-migration by a factor of 0.74 (95% credibility interval: [0.60, 0.90]), and *participation in local leadership* decreases odds by 0.80 [0.67, 0.95]. Conversely, odds are increased by: *non-local livelihood sharing* (1.36 [1.15, 1.61]; e.g., cattle kept in other districts), *non-local kin networks* (1.06 [1.03, 1.09]), and previous *migration following close kin* (1.17 [1.00, 1.36]). Number of *past migrations* has no consistent association with out-migration at a 95% credibility interval.

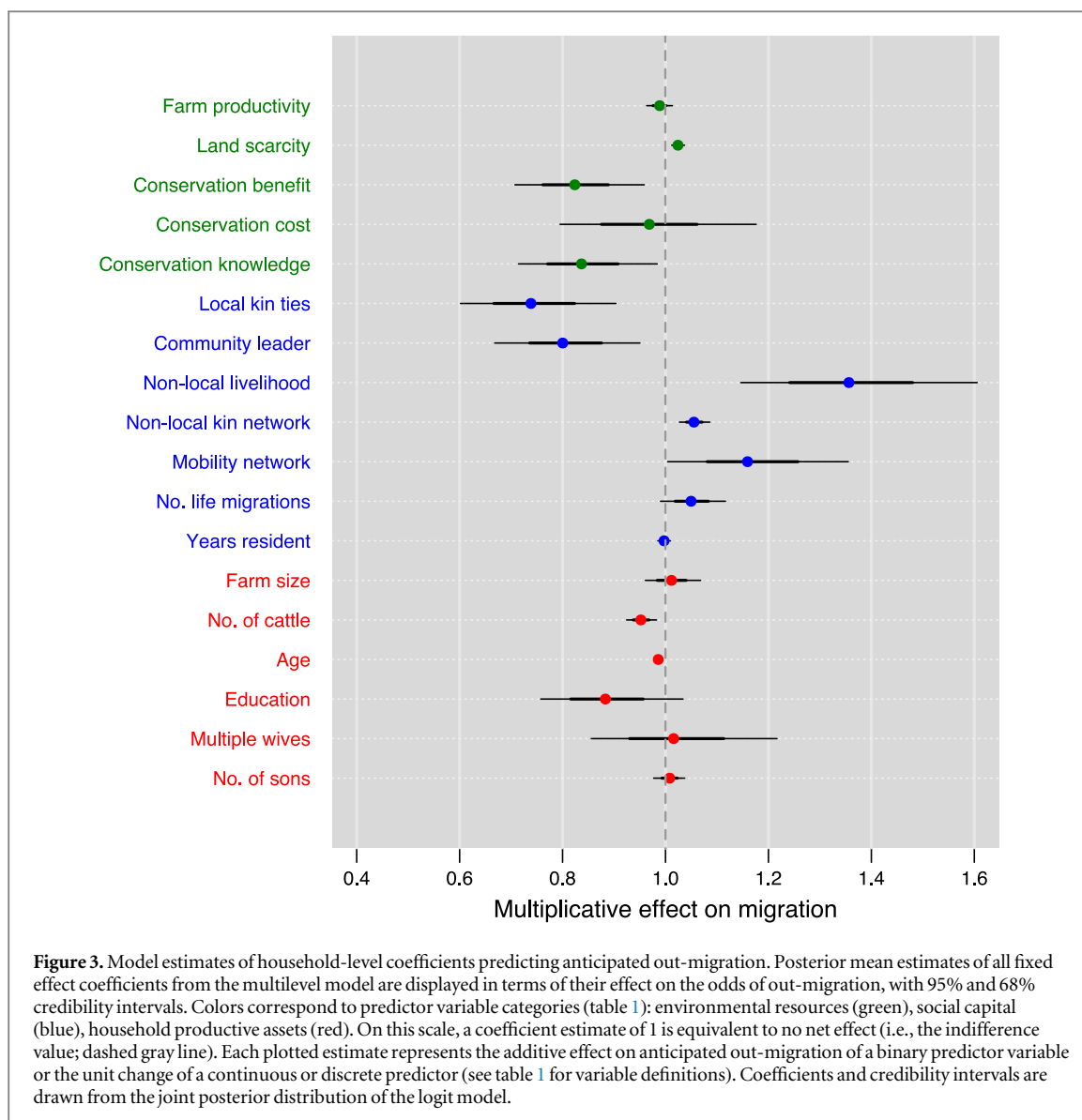
Certain predictors describing access to environmental resources are also consistently associated with anticipated out-migration (figure 3). All study communities were located adjacent to protected areas, and a substantial proportion of households experienced

conservation-related benefits (45%) and demonstrated *knowledge of conservation area* rules and ongoing outreach activities (43%). Experiencing *benefits* and demonstrating *knowledge* decrease odds of anticipated out-migration by 0.82 [0.71, 0.96] and 0.84 [0.71, 0.98], respectively. Respondents mentioned *costs* associated with conservation, such as restricted resource access or conflicts with wildlife, yet the effect of these costs is uncertain. Onfarm environmental resources are weakly predictive of anticipated out-migration: greater *land scarcity* increases odds by 1.02 [1.01, 1.04], while *farm productivity* has no consistent association.

Predictors describing household productive assets include agricultural assets and household characteristics (figure 3). Additional *cattle* holdings and years of *age of household head* decrease the odds of anticipated out-migration by a factor of 0.95 [0.92, 0.98] and 0.98 [0.98, 0.99], respectively. *Farm size* as well as *education* and *number of sons and wives* of the household head have no consistent associations.

4. Discussion

Quantitative findings demonstrate strong effects of different types of social capital on anticipated migration decisions in the presence of environmental and economic assets. Model estimates also show that environmental resources such as access to additional land and economic capital such as cattle holdings



indeed influence migration expectations, but their influence is relatively weak (figure 3). Lastly, households expect to maintain longer residence when they actively benefit from protected biodiversity and resource use areas and when they show greater knowledge of these areas and the rules governing resource use. When compared to reasons given for past migration decisions, the relative importance of different factors influencing future expectations (as estimated by the model) raises the possibility that migration decision-making may be changing.

Social capital is highly predictive of anticipated out-migration in the transitional frontier. For example, consider a comparison of two hypothetical households: model results imply that one household with assets shared through networks in other areas, with kin identified across more regions, and with a history of following kin during previous migrations is nearly three times as likely to anticipate leaving their current location than an otherwise similar household that maintains stronger local kin ties and participates in

local leadership roles. Doevenspeck (2011) found similar strong effects of social capital compared to environmental factors among migrants in rural Benin, with farmers maintaining non-local social networks and engaging in multiple migrations following kin to destination communities. The relative importance of social capital is noteworthy when considering the majority of recent research highlighting environmental factors and economic or productive factors as driving forces in migration decision-making (Black *et al* 2011, Warner and Afifi 2014). When features of social capital are examined explicitly, however, evidence demonstrates their significant influence on migration.

Moreover, findings from this letter go beyond showing that social capital matters (Gray 2009) by demonstrating distinct effects of local and non-local social capital. The maintenance of social networks in non-local potential destination areas promotes out-migration (Massey and Espinosa 1997, de Haas 2010), while engagement within migrants' present

community promotes immobility (Adams and Adger 2013, Adams 2015). Such spatial features of social networks and local ties are important factors explaining migration in various contexts of environmental and community change (Nawrotzki *et al* 2015). For example, in the drought-affected American Great Plains in the 1930s, farm families able to leverage distant networks were more likely to migrate to California's Central Valley, while those with stronger local kin ties were able to maintain residence through sharing resources and accessing credit (McLeman *et al* 2007). Results here add to the migration literature highlighting the importance of the spatial dimensions of social capital.

Environmental resources in the forms of available and productive land affect national-scale migration patterns in Tanzania (Galaty 1988, Charnley 1997, Salerno *et al* 2014), and access to land resources is indeed a principle factor shaping frontier migration elsewhere (Bilsborrow 1987, Painter and Durham 1995, Lopez-Carr 2012). Quantitative results presented in this study indicate that land scarcity consistently predicts anticipated out-migration for households in Katavi, but the effect is relatively small, and while farm productivity may suggest longer residence the effect is weak and imprecise. These results support the more nuanced understanding of land in the context of different forms of capital—clearly migrant farmers and cattle keepers consider land availability in potential frontier areas, but decision-making selects, and sometimes quite strongly, for those households with strong networks of kin already in the destination (Massey and Espinosa 1997, Curran 2002, Gray 2009, de Haas 2010).

Analyses considered household interactions with local protected areas as forms of environmental resources or natural capital. Strict and community protected areas are unlikely to attract migrants (Estes *et al* 2012, Salerno *et al* 2014, Hartter *et al* 2015), thus patterns of observed migration to borders are likely the result of protected areas being located in regions of disproportionately low population density (Scholte and de Groot 2010). Analyses addressed this claim and showed through retrospective questioning that, while the majority of respondents knew of the ongoing conservation activities prior to arriving, neither conservation areas nor associated benefits factored into their stated reasons for migrating to the Katavi study area.

However, results predicting future migration suggest that positive interactions with adjacent protected areas are associated with longer residence. Although variable, the effects of perceived benefits and greater knowledge of protected areas are quite strong. Benefits include fuelwood, timber, and grazing areas provided by local resource areas such as community forest reserves (Borgerhoff Mulder *et al* 2007). Many households also cited non-material ecosystem services of Katavi National Park, such as rainfall and keeping wild animals away from settlements, which may

significantly shape positive attitudes regarding conservation (Holmes 2003, Hartter *et al* 2014). Together, resource use and biodiversity areas constitute natural capital and contribute to how households make adaptive decisions through migration (Adams and Adger 2013, Hunter *et al* 2014). In the case of ongoing settlement in frontier areas, longer term residence has implications for migrants shifting their time horizons, perhaps adopting more sustainable resource use practices, and supporting community institutions (Charnley 1997, Katz 2000, Holmes 2005), which I address below.

Interestingly, household economic or productive capital assets do not drive migration decisions in this study, although wealth in terms of cattle is weakly associated with longer residence. Sukuma agropastoralists invest nearly all cash crop profits in cattle, and cattle wealth has principally characterized their hypermobility in the past (Galaty 1988). In terms of household assets considered here, it appears now that the younger, perhaps less-educated, and poorer households are moving, which may indicate vulnerability induced out-migration, but again these effects are relatively weak, and the data do not allow for an explicit test of vulnerability- versus opportunity-driven mobility. More generally, these findings support the growing consensus that environmental decline, as is ongoing in Katavi, precipitates different migrant streams making different decisions to both leave and remain based on accessible livelihood assets (Gray 2009, Black *et al* 2011, Warner and Afifi 2014).

Comparing results of past and future migrations suggests that mobility decisions may be changing. Explicit statements by respondents demonstrate that available farmland was the primary driver of their past migration decisions (figure 2), and other factors such as available pastures, rainfall, and family health were important but secondary. These factors were not constrained into the same categories applied to predictors in the anticipated migration model (table 1), but past reasons clearly indicate that acquiring land (household productive assets) was viewed as more important than other environmental resources or social factors such as rainfall for crops or community relations. In contrast, the model demonstrates local social ties that support longer residence for some, along with non-local social networks that promote mobility for others, play critical roles in anticipated future migration decisions (figure 3). Factors affecting past and likely future moves were measured using different methods. This was done primarily to allow respondents to generalize reasons from the past across their multiple migrations and elicit the most accurate responses. While acknowledging the different methods of questioning, the contrasting past and future reasons may be explained by the increasing population and changing environment of the transitional frontier.

Rural households in Tanzania have historically used mobility to avoid adopting more intensive

livelihood practices (Galaty 1988, Brockington 2001). Shorter time horizons may explain the environmentally-destructive behaviors of in-migrants and their lack of investment in natural resource management (Charnley 1997, Katz 2000, Holmes 2005). Yet household heads in Katavi repeatedly stated during interviews that the land was filling up, that families were squeezed, and that many would not continue to move as they had done in the past. That is, some households may view what was previously an unsettled frontier as having since transitioned into a more densely populated rural landscape. Such settled areas may be less attractive destinations. It is therefore unsurprising that the evident changes in demographic and environmental resource conditions coincide with the changing migration behaviors suggested by this study's findings. These changes pose a potential counter-narrative to the hypermobile, 'leapfrog' characterization of agropastoralist mobility (Galaty 1988, Charnley 1997, Brockington 2001).

Finally, I briefly discuss the implications for changing mobility behaviors in terms of the environment and local institutions managing natural resources. If migrant decision-making is changing in ways that promote longer residence and greater engagement with institutions, then this presents a possible alternative to the widespread prediction that migration into rural areas negatively affects community cooperation and natural resource management (Ostrom 2000, Curran 2002). Although this study did not examine migrant resource use practices explicitly, findings demonstrate that necessary precursors may be evolving for improved natural resource management. Where communities themselves govern the use of farmland, pastures, and forests, individual participation in rule-making and enforcement is more likely to result in healthy resource systems supporting local livelihoods (Persha *et al* 2011). Indeed, at the time of this research in-migrant families were cooperating to enforce village forest reserve boundaries and investigating illegal timber harvest (pers. comm. P Genda; see also Genda 2012). Additional evidence from the study site suggests that migrant-led institutions are beginning to combat the illegal killing of lions in and around Katavi National Park (Fitzherbert *et al* 2014).

Future empirical efforts are necessary to directly examine how migrants affect local institutions (Curran 2002) and whether these dynamics can help explain the potential emergence and persistence of cooperative behavior for improved natural resource management (Waring *et al* 2015). Subsequent work should employ longitudinal data that allow for testing expectations against observed events, incorporating quantitative measures of environmental and institutional change. This study is limited to modeling expectations and employing only descriptive information from past migrations.

In sum, this study contributes to a more comprehensive understanding of how rural people make adaptive decisions through mobility within changing frontier environments. Findings demonstrate the importance of migrant social capital in shaping future decisions, as well as how protected natural resource areas can affect these decisions. For East Africa, simple assumptions of persistent frontier migration in response to continued population growth and environmental degradation must be viewed with caution. Developing local social ties and accessing managed natural resources may be key to how former migrants adapt to future constraints on mobility as unsettled arable land becomes exhausted. Findings also highlight the utility of novel field methods for quantifying migration decisions, which can support analyses to tease apart the differential effects of factors influencing mobility behaviors. In regions where within-state rural mobility continues to be a dominant force shaping social and environmental outcomes, migration research should investigate future decisions and the implications for changing migrant-resident communities. Such approaches will be instrumental in understanding how communities adapt and how improved local management of natural resource systems can arise and persist.

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