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Savanna Life – evaluating board game players' revealed preferences to inform conservation and development planning in the Greater Serengeti-Mara Ecosystem

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Introduction: Conservation and development planning is complex and can involve trade-offs and conflicts of interest. Games are an increasingly popular approach to exploring such conflicts and facilitating discussion and future planning. However, few studies have compared the preferences of different stakeholders in such games.

Methods: The board game Savanna Life was played in 12 communities (24 games with 96 players, resulting in 2,889 observations) in 2018 and 2019 within the Greater Serengeti-Mara Ecosystem, characterised by sharp conservation-agropastoral livelihood trade-offs. The game was designed to capture the challenges experienced by communities and provide a safe space for exploring alternative livelihood and investment strategies. We explore how players of different genders, ethnicities, and nationalities maximise their payoffs within the game's logic, allocate preferences across the conservation-development nexus, and change preferences under growing constraints during the game.

Results: Using revealed preferences for game moves as an indicator, we found that, particularly men, prioritised maximising individual benefits over the game's primary objective of winning collectively. We also found that players generally preferred moves representing agro-pastoral production over moves aligned with Western development objectives. Moves with negative conservation implications were least preferred. Players also clearly adapted their preferences to increasing

constraints. Preferences varied among players based on gender, ethnicity, and nationality, with development and conservation planning implications.
Discussion: Post-game follow-up revealed that players considered the game realistic, and they stated planning real-life changes to how they make livelihood decisions based on insights gained while playing the game, suggesting that the game can motivate behavioural change through cognitive transfer. These results support the usefulness of games, such as Savanna Life, in providing insights for a sustainable future. However, the main benefit may be facilitating community debates after the research team departs.

KEYWORDS

bushmeat, social simulation game, revealed preference, East Africa, local community relations, protected areas, conservation-development trade-offs

1 Introduction

Protected areas in the Global South restrict livelihood activities and impose costs on adjacent communities through wildlife crop damage, livestock depredation, and wildlife attacks, causing injuries and casualties (Pulin et al., 2013; Green et al., 2018). On the other hand, adjacent communities engage in land encroachment, illegal grazing, and bushmeat hunting that can compromise conservation objectives (Veldhuis et al., 2019; Mbanze et al., 2021). Ensuing conflicts are complex, involving multiple stakeholders with different interests, values, experiences and aspirations that, over relatively short distances, may also include different political, cultural, and historical contexts (Redpath et al., 2013). Stakeholders may disagree about the nature of the problems and fail to understand the constraints and objectives of other actors, the possible consequences of actions for different stakeholders, or the complexity of the problem and available solutions (Barreteau et al., 2007; Garcia et al., 2016).

Games can illustrate the feedback loops within which stakeholders are embedded and the consequences of game players' actions (Barreteau et al., 2007; Redpath et al., 2018). The constructed reality of games also provides space to safely explore different strategies and their outcomes without suffering the consequences in real life (Bots and van Daalen, 2007; Redpath et al., 2018; Fjællingsdal and Klöckner, 2020). Being fun and different from conventional research approaches, particularly lengthy questionnaire surveys at the centre of much development and conservation management research, games allow stakeholders to immerse themselves in the constructed reality, making them a powerful tool for stimulating subsequent debate (Garcia et al., 2016). This may account for their growing popularity in conservation and development planning (Ponta et al., 2019; Kok et al., 2020). Specifically, so-called serious games, including role-play and board games, have been shown to help reveal complex socio-ecological dynamics, capture decision-making, improve stakeholder engagement and facilitate awareness and adaptive learning in a range of natural resource management contexts in the Global South (Edwards et al., 2019; Andreotti et al., 2020; Dahdouh-Guebas et al., 2022; Wamucii et al., 2025). However, few studies have compared the actions of different stakeholders in such games to identify the preferences guiding decisions – preferences that (insofar as they correspond to likely real-world behaviours) can facilitate conservation and development planning (Gelcich et al., 2013; Lamarque et al., 2014; Rakotonarivo et al., 2020). Similarly, the extent to which games contribute to real-world outcomes is still debated (DeSmet et al., 2014; van der Kooij et al., 2015; Douglas and Brauer, 2021), with few studies evaluating the effects on knowledge acquired or behavioural change (e.g. Dunn et al., 2021; Tsai et al., 2021, Wamucii et al., 2025).

This study examines players' moves in the board game Savanna Life (www.savannalife.no) by evaluating the determinants of preference for game activities that, in real life, have important implications for development and conservation management. To this end, we analyse data obtained from playing the game in communities bordering protected areas in the cross-border Greater Serengeti-Mara Ecosystem (GSME) in Tanzania and Kenya to examine various questions. Specifically, we assess the extent to which players try to maximise individual versus group payoffs within the logic of the game, how players allocate preferences across the conservation-development nexus (including how these are influenced by various demographic indicators, i.e. gender, ethnicity and nationality), and how preferences change under growing constraints during the game. Finally, players were asked how they viewed the game's realism, what they learned from it, and whether this experience created motivation for change.

More generally, we consider the relevance of games such as Savanna Life in revealing valuable insights for conservation and development planning and stimulating discussions to promote behavioural change in these domains.

2 Methods

2.1 Study area

The GSME (Figure 1) covers about 32,000 km^2, incorporating several protected areas, including the Serengeti National Park in northwestern Tanzania and Maasai Mara National Reserve in Narok County in Kenya. The GSME is of international conservation importance, hosting one of the world's largest and most well-known wildlife migrations of wildebeests and zebras. Outside PA boundaries lie agricultural and pastoral areas, home to people from diverse ethnic groups (e.g. Maasai, Sukuma, Ikoma, Kuria), where the human population is rapidly growing and pressure on the ecosystem boundary is high, particularly on the western side (Dybas, 2011; Estes et al., 2012). Poverty is prevalent (Jiao et al., 2019), and scarce alternative income options drive bushmeat hunting, the intensity of which is expected to increase as the human population grows (Estes et al., 2012; Rentsch and Damon, 2013). Illegal livestock grazing in the PAs further threatens conservation objectives (Veldhuis et al., 2019). Climate change may drive further changes in savanna environments with negative consequences for biodiversity and local well-being (IPCC, 2021).

Relationships between communities, park staff, and government authorities are strained with efforts to enforce existing legislation and PA expansion (Mittal and Fraser, 2018; Weldemichel, 2020). Despite a diversity of initiatives, including outreach programs with protected area benefit sharing (Kaaya and Chapman, 2017) and decentralised natural resource governance, relatively limited efforts have been made to assess communities' preferences for the future or the implications of their livelihood aspirations (but see Walelign et al., 2019; Kariuki et al., 2022). These characteristics prompted the selection of the GSME for this study.

2.2 Game design

Savanna Life is a serious board game designed to stimulate discussion about shared challenges and future planning at the community level and beyond, exploring the potential value of using games in conservation and development planning (e.g.,

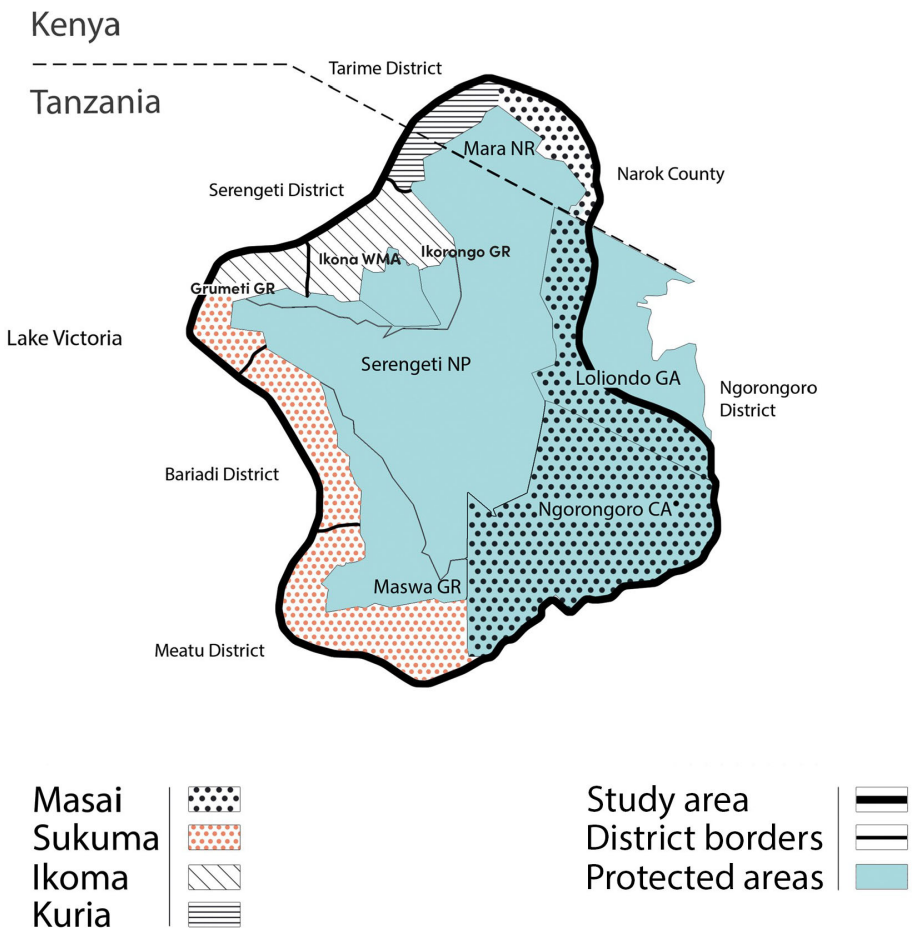

FIGURE 1
Schematic map of the Greater Serengeti-Mara Ecosystem in Tanzania and Kenya, indicating protected areas and areas dominated by the four main ethnic groups.

Ponta et al., 2019; Kok et al., 2020). The game was developed to engage communities in planning for sustainable development by enabling them to evaluate the consequences of their livelihood strategy choices and investments, safely explore alternative strategies, and facilitate discussions about solutions at the community level. Savanna Life is a social simulation game characterised as a multiplayer activity with a role-playing component that includes either quantitative or qualitative models representing particular problems according to the framework developed by Bakhanova et al. (2020). Choosing a board game format promotes physical and tactile elements facilitating engagement (Fjællingsdal and Klöckner, 2020). Savanna Life is furthermore not based on a computer model to avoid overwhelming players (Garcia et al., 2016), making environmental management more salient and understandable to the relevant stakeholders. However, going beyond increasing awareness and motivating behaviour change, by simulating livelihood strategies and revealing preferences, places Savana Life in the social simulation game category rather than the category of non-model-based games (Bakhanova et al., 2020).

The game was developed through an iterative process (as recommended, e.g., Alegria et al., 2020) by an interdisciplinary team with diverse backgrounds, including ecology, development economics, political science, and psychology, working with a professional game designer. The game was tested, and its philosophy was discussed with regional scientists, managers, and local community members, leading to the development of its final version. While we acknowledge that the Western concept of sustainability has multiple dimensions (Brooks et al., 2012), which may align neither with one another (Ferraro and Hanauer, 2014) nor with local values (Woodhouse and McCabe, 2018), we stress that Savanna Life through its coproduction aims to combine the local understanding of sustainable livelihoods with modern conservation philosophies, under the constraints of game design principles.

Savanna Life follows a constructivist approach to simulating life in the GSME, involving players living out livelihood strategies and making investments of their choice consistent with the options available in the GSME. Hence, the game incorporates elements of role-playing game mechanics and collective interest conflict to facilitate knowledge acquisition (Arnab et al., 2014). The extent to which moves in the game reflect preferences in non-gameplay contexts, or indeed real life, is largely unknown. We, therefore, use the neutral term "moves" when referring to players' decisions in the game wherever possible and use the term "revealed preference" to reflect the extent to which players choose a tile compared to the basic probability of a tile being chosen if the selection was random. We analyse moves concerning demographic indicators (gender, ethnicity, and nationality) to explore preferences across the conservation vs development nexus. Focusing on moves as revealed preferences provides insights into complex socio-ecological dynamics and offers a methodological advancement beyond general decision-making analysis.

The game is played by four players taking the role of household heads to create a sustainable community determined by individual players' combined happiness scores. A household head was defined as the person making the day-to-day decisions. Women functioning as household heads is common, including when one or more wives in polygamous relationships maintain separate households, although some tribes only recognise women as household heads when widowed or divorced (Marty et al., 2023). Players face challenges commonly experienced in the GSME, including population growth, depletion of natural resources, and droughts, causing food insecurity. The game revolves around the annual seasonal cycle of livelihood activities and events – with seasons labelled Short Rain, Short Dry, Long Rain, and Long Dry, spanning five cycles referred to as years.

The game starts in the Short Rainy season (Figure 2), with players taking turns placing household member tokens on activity tiles on two boards – the commons board and the private board (Figure 3). Tiles differ in payoffs (i.e., food or money tokens generated) and risks, and players compete against each other for the most profitable options (i.e. monopolising tiles on the common board with the highest food productivity, livestock carrying capacity and tourism income). The common board (Figure 3A) contains tiles representing two production systems – agriculture ("maize field") and pastoralism ("grazing land" requiring livestock tokens) – as well as "tourism" (described as working in the tourism sector), tiles that generate food and money tokens, respectively. Occupying these tiles monopolises this resource and generates private payoffs. The Protected Park (PP) tile on the common board, on the other hand, cannot be monopolised. Up to four players can place household member tokens on this tile, representing engaging in illegal livestock grazing or poaching (see Figure 3A). These moves generate private payoffs but incur risks determined by drawing a park card imposing sanctions (e.g., loss of happiness score or a household member token) or garnering rewards (food or money tokens), enabling evaluation of player risk aversion. The private board (Figure 3B) offers players the opportunity to engage household member tokens in education, healthcare (at a cost), building business, breeding livestock, or trade (i.e. exchanging money, livestock, and food tokens). The tiles "children in school" (described in the game as sending children to school) and "buy healthcare" (described as a preventive investment) generate happiness scores on the happiness tracker (Figure 3C). The value of food and money tokens, as well as the specification of the payoff structure, is not based on empirical analysis but instead on discussion with stakeholders and represents a simplification to facilitate game dynamics. However, despite simplifications, games can reveal initial preferences and induce non-random changes in those strategies through a learning process (Laterra et al., 2023).

In the Short Dry season, household members and livestock tokens are returned to the private board. Food deficiency is assessed by balancing food and household member tokens, and a number is subtracted from the happiness score equivalent to any food deficiency. Livestock not grazed in the Short Rainy season (described as starved) are removed. Sustainable use of common resources can be assessed through the number of grass and wildlife tokens remaining in the PP.

Reproduction occurs in the Long Rainy season (Figure 2), adding grass and wildlife tokens in the PP up to a limit of twelve

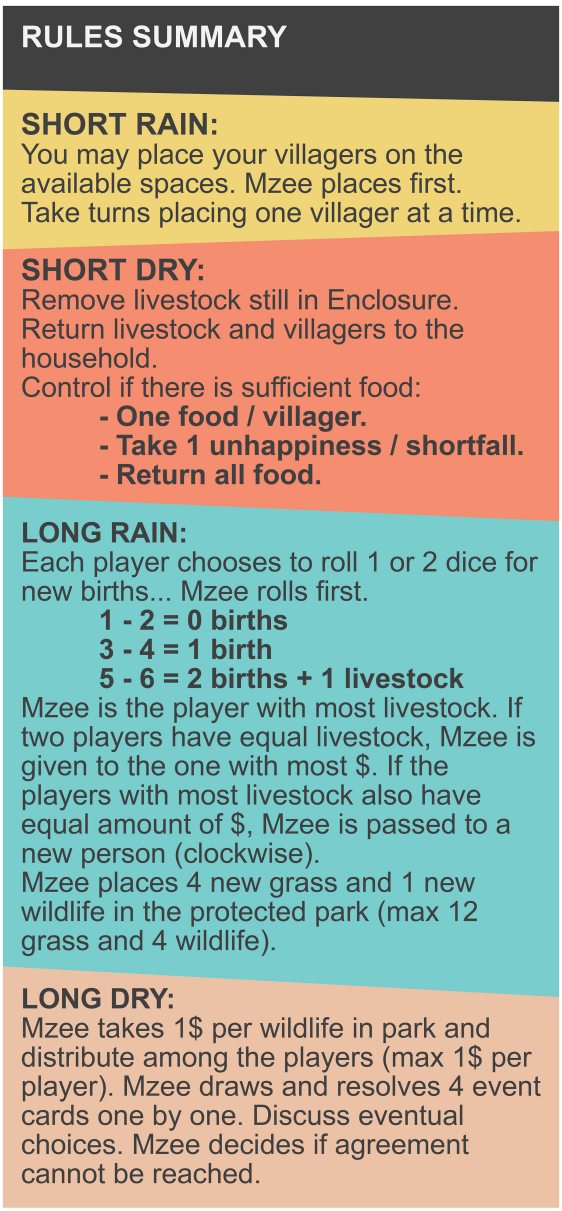

FIGURE 2
Summary of the rules of Savanna Life handed out to each player.

and four, respectively, representing carrying capacity. Population growth is determined by each player rolling a choice of one or two dice to determine the number of household members added. Population growth enables an assessment of players' responses to increasing constraints. The number of household members is the primary constraint on food security and, hence, the happiness score in the game. It also increases the pressure on players to enter the PP, affecting sustainability.

In the Long Dry season (Figure 2), four event cards are drawn, representing challenges (e.g., droughts, disease and wildlife damage that may cause loss of assets) or opportunities (out-migration, aiding poachers and auctions for tractors, or converting land, and increased tourist revenues) to individual players or the group. PP revenue sharing occurs by distributing money tokens between players equivalent to the number of wildlife tokens remaining in the PP. This feature of the game reflects communal benefits and hence promotes collaborative management.

Recurring seasonal events are repeated, and a game is won after five years by the player with the highest score on the happiness track (Figure 3C), provided that all players end with a positive happiness score. Otherwise, the game is collectively lost. This condition was explained before starting the game and was introduced to emphasise the necessity of joint planning for a shared future.

Three final points: First, the game involves the role of "mzee" (the Kiswahili word for elder and respected community member). The oldest player starts as the Mzee. After each round, this role is transferred to the player with the most livestock (Figure 2). This feature was introduced to ensure some variation in who held the Mzee status, whereas the reality is more gerontocratic, male-biased, and not necessarily determined by wealth. Being the first mover (i.e., placing the first household member token) makes the Mzee status attractive. The Mzee also decides on the distribution of PP revenue and has the last word in disputes. Second, by restricting collective wins to situations when all players end happy, the game incentivises but does not enforce cooperation between players to avoid food deficiencies by trading or gifting extra food tokens, which otherwise are removed (described as spoiled). Third, the separation between the common and the private boards distinguishes private livelihood strategy decisions (e.g., investments in education and health) from those that depend on the choices of others (i.e. the availability of jobs in the tourism sector, grazing land, and agricultural fields – through the monopolisation of tiles on the common board). Note, however, that all benefits are private, except PP revenue. This feature was added to promote discussion about the link between sustainable use and community benefits, in this case, through park revenue sharing.

The game was developed in full consultation with stakeholders, but necessarily simplifies reality. A significant departure from the contemporary situation is to classify all land (i.e., grazing areas and agricultural fields on the common board) as a common pool resource that cannot be owned (beyond cultivating or grazing for one year). Land privatisation is becoming prevalent in many pastoralist areas (including the GSME), but this design was selected to facilitate game dynamics through recurring decisions and situate players in a social dilemma. Additional features differing from the real world are more diffuse. Access to tourism employment, health care, and education is highly variable between communities and households, as are the costs of human-wildlife conflict and risks associated with poaching and illegal grazing. Hence, payoffs and risks may vary in accuracy across sites. Finally, the requirement for all players in a winning game to have positive happiness scores does not reflect reality. Contemporary agro-pastoralists' lives are characterised by inequality within communities (Borgerhoff Mulder et al., 2010; Nkedianye et al., 2019) that is increasing as norms of mutual aid among kin and clans erode (McCabe, 2020) and novel economic opportunities emerge (Lesorogol, 2008). See the Supplementary Material (SM1) for a complete game description.

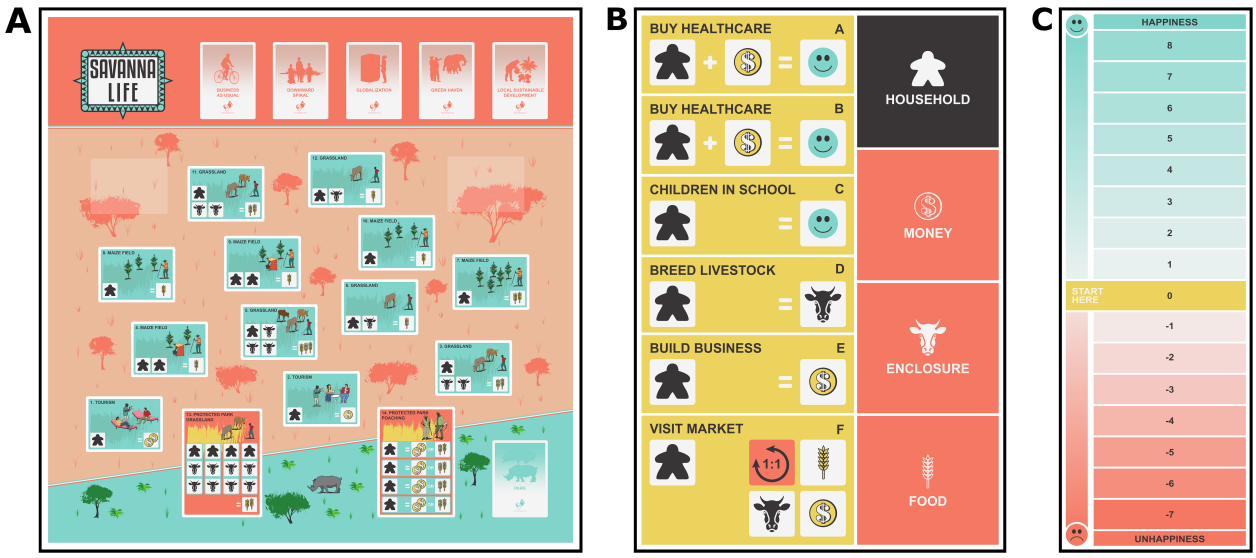

FIGURE 3
Savanna Life board game components. **(A)** Common board showing numbered actions, household member tokens required to occupy the tile, accommodated livestock, and food or money tokens generated from the activity. **(B)** Private board (one for each player), showing actions represented by the letters A-F, and placeholders for the players' household members, money, livestock, and food tokens. **(C)** Fortune track-each player will have a token placed on the fortune track to signify the player's happiness score at any time during the game.

2.3 Data collection

The game was played in twelve communities, eight in Tanzania (Meatu, Bariadi, Serengeti and Ngorongoro districts) and four in Kenya (Narok county), between April 2018 and March 2019. Communities were selected based on the criteria: adjacency to protected area boundaries, two in each of the relevant districts in Tanzania and four in the applicable county in Kenya and representing the main ethnic groups in the area. Hence, communities included pastoralist Maasai and agro-pastoralist Sukuma, Ikoma, and Kuria tribes. In each community, one game was played by men, and another simultaneously by women. This design was chosen to facilitate comparison, as the highly gender-segregated nature of some communities makes it difficult for women to speak in the presence of men (Smith, 2015; Goldman and Little, 2015). Village leaders identified players based on willingness and aptitude. Players, mainly younger community members, were paid a nominal fee equivalent to a day's casual labour salary and provided lunch and tea. All sessions started with a thorough introduction to the game. All aspects of the rules were explained, and a trial game was played by each group, overseen by a game facilitator, who corrected any breaches of the rules. The trial game continued until proficiency was achieved.

The actual game was played under the oversight of the game facilitator, who led the game's progression, answered any questions from the players, and ensured that the game's rules were observed. Numbers were assigned to tiles on the common board and letters on the private boards (Figures 3A, B) to record players' moves and their outcomes. We also recorded food balance in the Short Dry season, the number of wildlife and grass tokens remaining before each Long Rain, and player, livestock and money tokens, and happiness score after each Long Dry season (see Figure 2). The data were recorded using an Open Data Kit (ODK) survey form through a tablet interface.

Finally, players completed a debriefing questionnaire, focusing on the game's perceived relevance to real-life circumstances, insights gained, and how the game would influence future livelihood activity choices and investment strategies. Fieldwork was conducted after Maasai bomas (i.e. a compound of several houses encircling a cattle enclosure) were forcefully evicted from the Serengeti boundary in Loliondo by SENAPA in 2017, but before the more recent efforts to remove people from the Ngorongoro Conservation Area (Mbise, 2022).

2.4 Analysis

Descriptive statistics are presented comparing the basic probability of choosing each move in the Short Rain season (i.e., placing tokens on tiles on the private and common board) selected by a player, calculated by adjusting for the number of remaining options left at that point. Hence, a low average probability, when selected, represents a high revealed preference for that tile compared to a random choice. We, therefore, invert the probability as an indicator of revealed preference (henceforth simply preference), acknowledging that this measure may not directly reflect players' intrinsic utility ranking outside the game. The benefit derived from each tile was calculated as the tokens generated per household member required to occupy that tile. Tokens (food, livestock, money and happiness) have equivalent values according to game mechanics (i.e. in the "visit market" tile). Similar tiles in terms of activity and value were combined (i.e. tiles

3 + 11, 6 + 12, 8 + 10 on the common and tiles A+B on the private boards (see Figures 3A, B).

Beyond initial descriptive statistics, we focus on moves with more immediate and tangible conservation and development implications, recognising that neither game moves nor real-world actions can be exclusively classified as negative, considering the complexity of short vs long-term impacts of economic decisions and the interactions between conservation and development outcomes. We class moves with conservation implications as those with generally negative direct impacts on wildlife or habitat, including "illegal grazing" (tile 13) and "poaching" (tile 14) (Figure 3A) and "breeding livestock" (tile D) (Figure 3B). "Breeding livestock" was categorised as having negative conservation implications due to the scarcity of grazing areas and the currently high level of illegal grazing in the PAs (Veldhuis et al., 2019), although, arguably, livestock rearing can contribute to development and potentially reduce poaching (livestock is though mainly seen as a source of status and savings rather than a source of protein (Quinlan et al., 2016)). Moves with development implications are those most likely to enhance households' short to medium-term economic wellbeing. This includes "buy healthcare" (tiles A+B) and "education" (tile C) (Figure 3B), "build businesses" (tile E), "visit market" (tile F) (Figure 3B) and "tourism" (tiles 1 + 2) (Figure 3A), which are conceived as alternatives to more environmental extraction-dependent livelihood strategies and broadly consistent with several of the UN sustainable development goals incl. mainly SDG 4 (education), 3 (good health), and 8 (full and productive employment).

Partial multilevel models were specified for each tile to explore the determinants of preferences for that move clustered within game, year, and player, where relevant, to capture differences between games, across years, and between players. Dummy variables reflecting players' gender (male vs female), ethnic group (Maasai vs non-Maasai), and nationality (Tanzanian vs Kenyan) were included to explore the effect of these aspects on preferences. While age is an important determinant of social organisation in pastoralist societies, it is particularly intertwined with gender roles and ethnic institutions in Maasa communities (Maghimbi, 2024). Furthermore, most of our sample were young (77% below the age of 40 years, mean = 30.29, 95% CI ±2.57). Hence, in our experimental context, age is not analytically separable from gender and ethnic identity. Moreover, the competitive framing of a board game encourages strategic behaviour that transcends and may even reverse traditional age role expectations (Rodela et al., 2019). As such, we chose not to treat age as an independent predictor of preferences in the game. We included move number (i.e. the number in the sequence of moves within the year at which the tile was chosen), and the year if this was not included as a hierarchical level (cf. below) to capture the effect of tiles becoming successively occupied during the year and as more household member tokens are added across the years of the game (Supplementary Figures S1-3, SM).

Models (see Table 1) also included relevant variables representing household members, livestock, and money tokens or happiness scores at the end of the previous year (consistent with the data collection strategy, cf. Section 3.2). These variables were included to reflect whether a player had the resources to occupy a tile or was playing a specific strategy. This includes money tokens in the "buy health care" model because occupying this tile requires an investment of a money token. Similarly, we included livestock and money tokens in the "visit market" model because this tile requires a trade object. In models predicting education, breeding cattle, building businesses, and tourism, we included happiness scores, livestock, and money tokens to test for specific strategies. In the model predicting "poaching", we also test for the number of household members and wildlife tokens in the PP. Similarly, we include livestock and grass tokens in the model predicting "illegal grazing". In these last two models, the effect of sanctions (i.e., the park card) in the form of the effect of negative consequences in the same year and all previous years of the game for the individual player was also examined. The effect of the player having experienced no sanctions when choosing these fields was examined by substituting these variables. For simplicity, we did not consider the effect of other players being sanctioned.

Interactions were explored between year and the variables gender, ethnicity, and nationality to reveal whether these groups adapt differently to increasing constraints. If year was included as a hierarchical level, these variables were instead tested as random slopes (cf. below).

We tested for a hierarchical structure using log-likelihood ratio tests by consecutively including game ID, year, and player ID as random intercepts, as we expect that games differ, that there is a progression across the years of a game in how it is played, and that players play differently. Where no support for a hierarchical structure was found, a fractional Generalized Linear Model (GLM) was specified instead. The explanatory variables included in individual models are outlined in Table 1.

The number of wildlife and grass tokens remaining in the PP was further assessed as a measure of preferences for sustainability.

In the players debrief, responses to questionnaire items focusing on the realism and relevance of Savanna Life in terms of engendering behavioural change were coded based on themes identified in the responses. These themes include family planning, food security, investment in education and healthcare, non-farm livelihood strategies and illegal activities. Descriptive statistics identifying patterns in the data are presented.

The analysis was conducted in STATA v.17.0.

3 Results

3.1 Games played

Of 24 games, 20 were played to an end, half of which were collectively lost. Strikingly, seven out of ten games played by women were collectively won, whereas the outcome was exactly the opposite for men. Outcomes also differed by ethnic group and nationality, with non-Maasai games more often collectively won (7 out of 10) than Maasai (4 out of 10) and Tanzanian games won more often (seven out of 12) than Kenyan games (3 out of 8). All

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TABLE 1 Variables and their coding in models predicting preference for game moves with conservation and development implications.

		Conservation			Development				
Variable	Coding	Illegal grazing (Tile 13)	Poaching (Tile 14)	Breeding livestock (Tile D)	Buy healthcare (Tile A&B)	Children in school (Tile C)	Build business (Tile E)	Visit market (Tile F)	Tourism (tile 1&2)
Gender	Male=1, Female=0	✓	✓	✓	✓	✓	✓	✓	✓
Ethnicity	Maasai=1, Non-Maasai=0	✓	✓	✓	✓	✓	✓	✓	✓
Nationality	Tanzania=1, Kenya=0	✓	✓	✓	✓	✓	✓	✓	✓
Sanction	Negative outcome of park card drawn the same year or in any previous time in the game	✓	✓*						
Positive outcome	Positive outcome of park card drawn the same year or any previous time in the game	✓*	✓						
Wildlife	Wildlife tokens left at the end of last year		✓						
Grass	Grass tokens left at the end of last year	✓							
Mzee status	First mover at year start coded 1=mzee, 0=regular player.	✓		✓					
Household members (t-1)	Number of household members at the end of the previous year		✓						
Livestock (t-1)	Number of livestock units at end of the previous year	✓		✓				✓	
Money (t-1)	Number of currency units at end of the previous year				✓			✓	
Year	Year of the game (1-5)	✓	✓	✓	✓	✓	✓	✓	✓
Move number (mean centred)	Number in the sequence of moves made by all players during a year	✓	✓	✓	✓	✓	✓	✓	✓

The * symbol signifies variables that were tested by replacing it with another multicollinear variable, which were not included in the final model. The hierarchical levels of game, year and player were tested in all models and included based on log-likelihood ratio tests.

games ended with many grass tokens in the PP (7–12 tokens out of 12 maximum), with no discernible differences between demographic groups. However, 9 out of 20 games exhausted PP wildlife. Games played by women were less likely to end with no wildlife (2 out of 10 games) compared to men (7 out of 10). Also, games played by non-Maasai (5 out of 10) were more likely to end with no wildlife than those played by Maasai (3 out of 10). Differences between nationalities were minimal.

3.2 Descriptive statistics on gameplay

The distribution of preferences within and between tiles, ranked from highest to lowest median, is presented in Figure 4 to evaluate players' choice of game moves. Direct comparison reveals several significant differences ($F=113.40$; $P<0.01$, ANOVA with Bonferroni test). Tiles with high benefit (i.e., tiles 5, 3 + 11 and 7 – see Figure 3A) were preferred above lower benefit tiles, suggesting

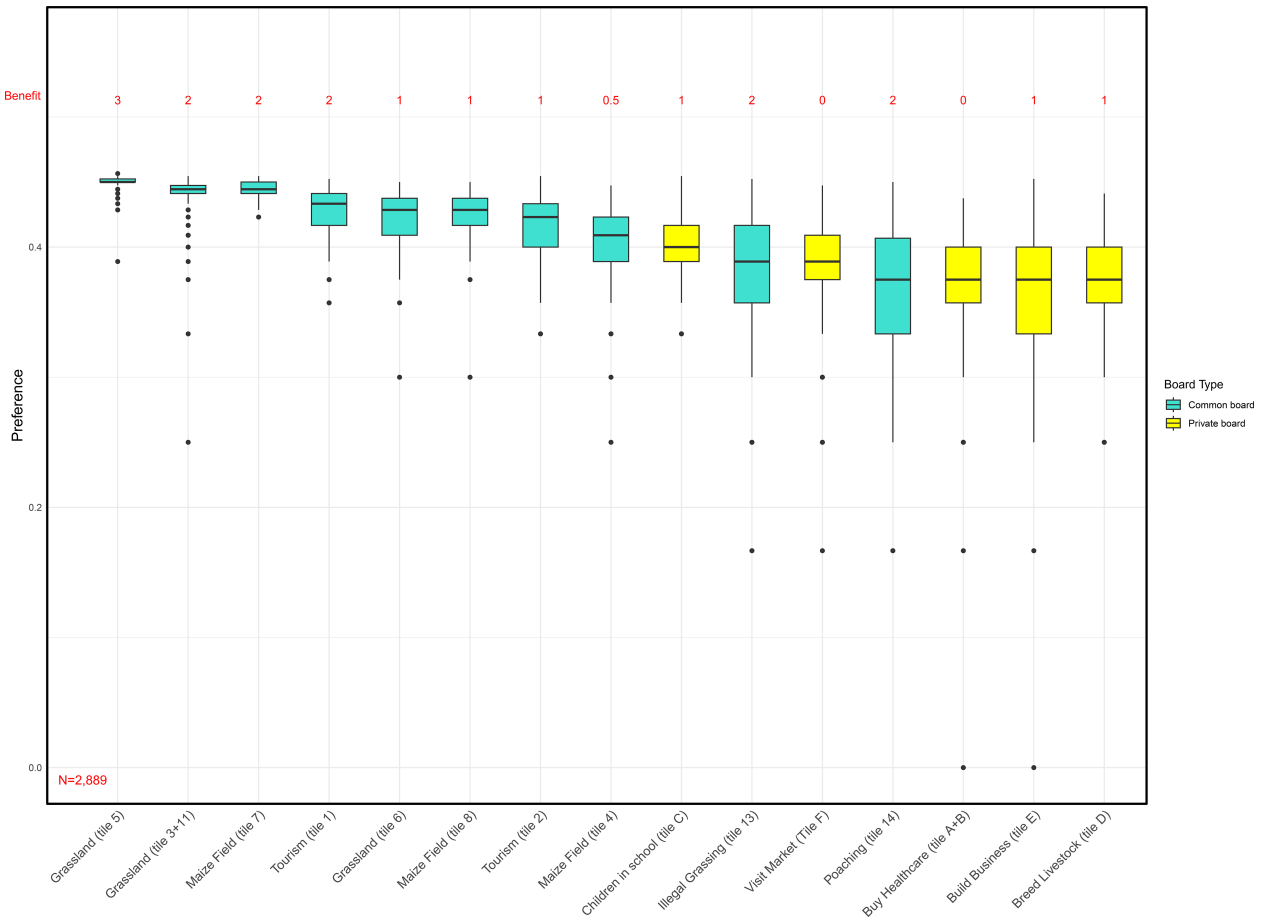

FIGURE 4
Boxplot of revealed preference for each activity, sorted by decreasing median value. Numbers and letters in parentheses on the X-axis refer to the tile on the common and private board, respectively (see Figure 3). Red numbers reflect the value of each tile in terms of food or money tokens generated, minus the costs per household member token required to occupy that tile. Whiskers are 95% confidence intervals.

that players maximise individual benefits (i.e., more profitable moves) within the game. However, tiles with development implications were less preferred than tiles with similar benefits representing agro-pastoral production activities, although few differences were significant – "tourism" (tile 1, value=2) was less preferred than "maize fields" (tile 7, value=2. t=0.017; P<0.05) and "education" (tile C, value=1) was less preferred than "maize field" (tiles 8 + 10, value=1. t=0.027; P<0.01). Tiles on the private board were generally less preferred than tiles on the common board, suggesting that players competed over open-access resources first. Exceptions include "illegal grazing" (tile 13, value=2) and "poaching" (tile 14, value=2), which were less preferred than "education" (tile C, value=1, t=0.025; P>0.01 and t=0.035; P>0.01, respectively) and "poaching" that was less preferred than "visit market" (tile F, value=0, t=0.02; P<0.01) on the private board. This suggests that players avoided moves with negative conservation implications, even when this incurred a cost (i.e., lost benefit). The least preferred fields were "breed livestock" (tile D, value = 1) and "build business" (tile E, value = 1) on the private board (for complete tests, see Supplementary Table S1 and a fractional logistic model showing rank order in the Supplementary Table S2). Descriptive statistics, differentiated by gender, ethnic group, and nationality, are presented in Supplementary Figures S4–6 in the SM and show broadly similar patterns, with some differences across these demographic categories.

3.3 Factors influencing selected game moves

Table 2 presents partial multilevel models predicting preferences for game moves with immediate and tangible conservation and development implications (cf. above). Focusing on significant results, we first consider how the game design affects gameplay by evaluating support for hierarchical model structures before exploring the associations between preferences and demographic variables, increasing constraints and risks.

There was strong support that games are played differently through tests for random intercepts of game ID (i.e. including game ID as a second level) in all models except the model for "illegal

TABLE 2 Partial multilevel models predicting revealed preference for selected tiles with generally negative conservation and generally positive development implications.

	Conservation			Development				
	Illegal grazing (Tile 13)	Poaching (Tile 14)	Breeding livestock (Tile D)	Buy healthcare (Tile A&B)	Children in school (Tile C)	Build business (Tile E)	Visit market (Tile F)	Tourism (Tile 1&2)
Gender (1=male, 0=female)	1.1383 (0.0671)	-0.0191 (0.0077)**	-0.0228 (0.0279)	-0.0062 (0.0053)	-0.0048 (0.0030)	-0.0065 (0.0051)	-0.0096 (0.0036)***	-0.0042 (0.0017)**
Ethnicity (1=Maasai, 0=non-Maasai)	0.9670 (0.0687)	0.0303 (0.0118)**	0.0248 (0.0308)	0.0120 (0.0074)	0.0041 (0.0047)	0.0191 (0.0081)**	0.0100 (0.0054)*	-0.0001 (0.0025)
Country (1=Tanzania, 0=Kenya)	0.9772 (0.0743)	0.0274 (0.0126)**	0.0257 (0.0332)	0.0170 (0.0074)**	0.0028 (0.0048)	0.0167 (0.0084)**	0.0098 (0.0055)*	0.0019 (0.0026)
Sanction (t-1)	0.7685 (0.0417)***							
Positive outcome (t-1)		0.0208 (0.0091)**						
Wildlife (t-1)		-0.0009 (0.0091)						
Grass (t-1)	1.0637 (0.0352)*							
Mzee status (1=Mzee, 0=not)			-0.0134 (0.0055)**					
Household members (t-1)		-0.0008 (0.0029)						
Livestock (t-1)	0.9196 (0.0487)						-0.0010 (0.0009)	
Money (t-1)				0.0016 (0.0018)			0.0001 (0.0011)	
Benefit								0.0009 (0.0011)
Year	1.0176 (0.0234)	0.0001 (0.0039)						0.0019 (0.0004)***
Move number (mean centred)	1.0618 (0.0036)***	-0.0055 (0.0004)***	-0.0055 (0.0005)***	-0.0061 (0.0003)***	-0.0035 (0.0001)***	-0.0045 (0.0096)***	-0.0001 (0.0002)***	-0.0035 (0.0001)***
Constant	0.0669 (0.0240)	0.3780 (0.0235)***	0.3746 (0.0381)***	0.3938 (0.0096)***	0.4017 (0.0054)***	0.3814 (0.0096)***	0.3975 (0.0067)***	0.4010 (0.0037)***
Random Intercepts								
Game ID		Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year				Yes	Yes	Yes	Yes	
Player		Yes	Yes					Yes
Performance measures								
Wald chi-squared		236.17***	132.97***	372.24***	942.54***	239.36***	464.19***	1238.12***
Observations	54	121	71	345	383	198	301	199
Groups		22/63	21/46	23/102	23/107	22/86	23/105	23/75

See results with random intercepts in Supplementary Table S4, interactions in Supplementary Table S5 and random slopes in Supplementary Table S6, SM.
Numbers in parentheses are standard errors. Random intercepts and slopes are included when supported by likelihood ratio tests (see Supplementary Table S3). *, ** and *** signify significance at the 0.1, 0.05 and 0.01 level.

grazing" (Supplementary Table S2). There was also strong support that preferences increase across years (i.e. including "year" as a third level) in models predicting preference for "buy healthcare", "education", "breeding livestock", "building business", and "visit market" and for preferences differing between players in the model's predicting "tourism" and "poaching" (i.e. including player ID as a third level). This suggests that preferences evolve as players, and in some models, certain players learn and adapt more than others to increasing constraints throughout the game. Where "year" was included as a fixed effect (as opposed to a random intercept), it had a significant positive effect in the model for "tourism", suggesting an increasing preference as games progressed.

Looking at player characteristics (i.e. gender, ethnicity and nationality), women had a higher preference for "poaching", "visit market", and "tourism" than men. Maasai players had a higher preference for "poaching" than non-Maasai. Tanzanian players had a higher preference for "poaching" and "build business" than Kenyans. Interactions between these categorical variables reveal negative modifying effects of gender on nationality (β = -0.0394; $P<0.01$) in the model for "poaching", indicating that being a male Tanzanian is associated with a lower preference for "poaching".

Further exploring the effect of increasing constraints through interactions between the categorical variables and "year" (in the models where year is not a random intercept), we find a negative modifying effect of ethnicity (β = -0.0018; $P<0.05$) on "year" in the model for "tourism" indicating that Maasai preference for "tourism" increases less through the game than non-Maasai. In models where "year" was included as a random intercept, support for player characteristics was tested using random slopes. Hence, the interpretation differs, but in the model for "breed livestock", we find support for a random slope of gender on the hierarchical level of "year" (χ^2 = 11.55; $P<0.01$) (Supplementary Table S3), indicating that males have a lower preference for "breed livestock" in "years" with a higher average preference. Similarly, we find support for a random slope of gender in the model for "buy healthcare" (χ^2 = 11.55; $P<0.01$), indicating that males have a higher preference for "buy healthcare" in "years" with lower average preference. Similar support for a random slope of ethnicity (χ^2 = 5.39; $P<0.05$), indicates that Maasai players have a higher preference for "buy healthcare" in "years" with a lower average preference.

Finally, the effect of sanctions and mzee status was examined. A positive association with successful outcomes (i.e., no sanctions) the same "year" was found in the model for "poaching", but we also found a positive effect of sanctions received in the model for "illegal grazing", which appears counterintuitive. This may be explained by the sanction – loss of a household member – which may reduce household food security constraints and, therefore, be perceived as a benefit. We found no effect of exchanging these variables between the two models or, instead, including the lagged effect of previous years' experience. Hence, players logically have a higher preference for "poaching" if they have been successful (i.e. not sanctioned) in the same "year" but not in previous years. However, we did not test how other players' sanctions influenced preferences. The number of grass tokens remaining positively affected the preference for "illegal grazing", but the number of wildlife tokens had no effect on predicting preference for "poaching". The status as mzee was the only variable associated with preference for "breed livestock" reducing it.

3.4 The players' debrief

All 96 players found the game realistic and mentioned aspects of the game that replicate real-life livelihood problems faced in their community. The most frequently mentioned aspect reflected food insecurity in various ways (34%), and the second most frequent was illegal hunting or grazing. Some players (36%) found the decision to enter the PP to poach or graze livestock unsettling or unrealistic. However, several players acknowledged involvement in such activities and highlighted the risk of being killed in attacks by wildlife or PP rangers.

Statements about the most relevant real-life insights gained revolved around the importance of balancing family planning and food production (45%). Others highlighted the importance of education and healthcare (19%), the potential consequences of trespassing in the PPs (8%), the need to try alternative income-generating opportunities (8%), and the possibility of destocking to avoid overgrazing and cattle dying during droughts (8%).

All 96 players mentioned at least one real-life change they would like to make based on insights from playing the game. Priorities were diverse but included increased attention to family planning, ensuring a better balance with food production ability, investment in education and healthcare, testing business and other non-farm livelihood strategies, and abstaining from poaching or grazing livestock in protected areas in the future.

4 Discussion

Several relevant findings emerge from this analysis of games played with communities in the GSME. First, Savanna Life was considered realistic, facilitated learning, and, according to players, created insights motivating change. Second, while players maximised individual game returns, the games revealed a higher preference for moves reflecting agricultural and pastoral production activities over moves broadly aligned with development objectives, i.e., education and tourism jobs, whereas players were averse to higher benefit moves with negative conservation implications. Third, preferences differed between genders, ethnicities and nationalities. In the following sections, these results are discussed in more detail.

4.1 Real-world game relevance

We found high acceptance of Savanna Life as realistically reflecting the current livelihood problems experienced in the GSME. Its realism for other parts of Maasailand, and pastoralists more generally, is an empirical question. Post-game discussions stimulated a lively debate about solutions to these challenges and how to chart a path towards sustainable development. Moreover, all players mentioned at least one real-life change they would like to

make, having played the game. Research shows that games, as real-life simulations, can function as a safe testbed for exploring behavioural strategies that would be too risky in the real world (Fjællingsdal and Klöckner, 2020). However, the fact that players preferred established real-life practices over less practised but equally beneficial gameplay alternatives reflects the game's realism.

4.2 Player self-interest and game moves

Preferences were aligned with players maximising self-interest. Tiles of higher benefit were preferred over those of lower benefit, and tiles on the private boards-that others cannot occupy and for which there is therefore no competition-were less preferred than tiles on the common board. This suggests that players play competitively to win the game individually and only secondarily attend to winning collectively, despite the rules requiring positive happiness scores for all players to constitute a win. The fact that half the games were collectively lost supports this interpretation. Several possible explanations exist for this phenomenon, including insufficient explanation of rules. However, there was no connection between collectively lost games and specific game facilitators. Winning collectively represents a social dilemma, and game theory predicts that non-cooperative outcomes may arise from a lack of trust and if players assume that other players will also maximise individual payoffs (Abbass et al., 2018). Loss aversion may further predispose players to avoid personal loss, which feels more tangible than the more abstract risk of collective loss (Henrich et al., 2005). Playing competitively, however, may serve both objectives. It ensures players are protected against unforeseen events in the game, including household growth (i.e., the role of the dice) in the Long Rain season and random shocks (i.e. the event cards) in the Long Dry season (Figure 2). However, it also allows the player to accumulate and distribute surplus food tokens to players with negative scores during the Short Dry season. In addition, above a certain level of individual happiness score, players could be shifting to playing more cooperatively by giving players with negative happiness scores access to high-benefit tiles (although we found limited support for this explanation (see Supplementary Appendix 4)). The reason several games were collectively lost, despite some players achieving high individual happiness scores, is unclear. Social comparison theory (Buunk and Gibbons, 2007) predicts that players may become fixated on out-performing others, ignoring collective goals, particularly when scores are openly displayed, as in the happiness track (Figure 3C). Alternatively, the theory of mind and perspective-taking suggests the possibility of overconfidence in others' altruism, prompting players to postpone intervening until it is too late. Possible support for this interpretation is the greater probability of collective game winning among women than men. Some evidence (albeit contested; Cassar et al., 2016) suggests that men are more competitive, whereas women are more likely to weigh the risks of non-cooperation (Balliet et al., 2011).

We found a few examples where preferences appear sub-optimal. This includes that the higher return "illegal grazing" and "poaching" tiles, with negative conservation implications were less preferred than "education" and "visit market". However, this may be explained by the sensitivity of these moves and the research team's presence, that overexploitation reduces or curtails group-level benefits, and a 0.63 probability of experiencing sanctions when selecting these tiles. Alternatively, this indicates the (at least partial) successes of decades of conservation interventions in the GSME in both supporting traditional conservation practices and instilling new norms (Andrews and Borgerhoff Mulder, 2024).

The results also revealed higher preferences for moves representing agro-pastoral production activities. A choice experiment in the GSME found similar preferences (Walelign et al., 2019). In Savanna Life, these preferences often align with higher benefits and, thus, self-interest. However, despite yielding the same benefit score, some moves, such as "tourism", are less preferred than agro-pastoral production strategies. This discrepancy may, however, be explained by how game payoffs are structured, reflecting that grazing is required to avoid losing livestock tokens at the end of the Short Rainy season. Furthermore, the tiles "maize field" produce food tokens that are more immediately useful in avoiding lost happiness scores than money tokens, which require trade (i.e. "visit market") to be converted into food tokens. These production moves are thus essential in the game.

4.3 Player strategies and learning

The hierarchical structure of the models predicting preferences reveals that games are played differently for most of the selected tiles. Furthermore, preferences change over the game, particularly for private tiles ("buy healthcare", "education", "breeding livestock", "build business", and "visit market"), indicating learning or adaptation to increasing constraints throughout the game. Evidence was also found suggesting that demographic groups adapted differently (i.e., through interactions and random slopes on "year"). However, only for the tiles "tourism" and "poaching" did we find evidence that preference differed between individual players (i.e., a random intercept on Player ID-irrespective of the demographic group), suggesting specific game strategies.

Playing Savanna Life involves making decisions that maximise individual benefits while ensuring that other players remain with positive scores (cf. above). Hence, to be successful, players must engage in cognitive processes, including evaluating options, predicting outcomes, and learning from past experiences within the game (Stevens and Slavin, 2021). The results indicate that players are applying this learning, and cognitive transfer theory suggests that the skills and insights gained in a game through cognitive transfer can be used in real-life situations (Barnett and Ceci, 2002). The fact that all players mentioned at least one real-life change they would like to make as a result of playing the game supports the possibility that the game can shape players' real-life behaviour (Nass, 2020; Serrano et al., 2025). These findings highlight the usefulness of games in conservation and development planning.

4.4 Differentiated preferences along demographic variables

Exploring the determinants of preferences for selected tiles, we identified several commonalities attributed to player demographics, with implications for designing effective conservation and development interventions.

Compared to men, women showed higher preferences for "visit market"- a tile with zero benefit (reflecting an exchange of goods of equal value). Typically, money or livestock tokens were exchanged for food tokens to avoid food deficiency. Women also showed a higher preference for "maize field", "buy healthcare", and "children in school" than men (see Supplementary Figure S4). These findings are consistent with ethnographic evidence showing women's engagement in the household economy (Smith, 2015; Mwaseba and Kaahus, 2015) and likely reflect their immediate concerns with food security in the area (Lawson et al., 2014). However, men's preferences for "buy healthcare" increase throughout the game.

Although preferences for "poaching" were generally low, women had higher preferences than men. This may reflect a lower likelihood of condemning commercial poaching than men as observed elsewhere (Lowassa et al., 2012; Sundström et al., 2020). In Savanna Life, as in real life, poaching is often conducted in the face of food and financial insecurity, albeit typically by men (Loibooki et al., 2002; Mfunda and Røskaft, 2010). However, these results suggest that reducing poaching may require more attention to addressing women's concerns about household finances and food security. Alternatively, women players may be less concerned than men about the stigma associated with poaching in the game, having neither experienced such sanctions in real life nor suffered the consequences of arrest, and perhaps they even admire poachers as paying the cost to provision their families and the village, as suggested in one debrief session. Furthermore, women's games retained higher-end game wildlife numbers than male games. This effect may be driven by a few male players consistently choosing "poaching," resulting in the depletion of PP wildlife. This scenario also occurs in real life, where typically a relatively small subset of men poach (Knapp et al., 2010; Nuno et al., 2013).

Maasai players had higher preferences for "poaching" than non-Maasai players. Historically, the Maasai have not consumed game meat, but this appears to be changing (Ceppi and Nielsen, 2014). The traditional practices and cultural views of the Maasai that have accommodated coexistence between livestock and wildlife are dwindling and being replaced by new values and aspirations, leading to more conflicting attitudes towards wildlife (Western et al., 2019), no doubt partially exacerbated by the loss of their rangelands in adjacent areas (McCabe and Woodhouse, 2022).

Direct comparison revealed that Maasai had lower preferences for "maize field" and "visit market" but higher preferences for "children in school" than non-Maasai (see Supplementary Figure S5). Maasai preferences for "buy healthcare" also increased more over games than non-Maasai. The Maasai are characterised by low primary school enrolment and high dropout rates (Vimefall et al., 2017). This result suggests that investment in educational infrastructure in Maasai areas would be attractive, although further dialogue is required on the modality and how to incorporate traditional knowledge (Pesambili, 2020).

Tanzanian players show stronger preferences for "build business" than those from Kenya. This may reflect the fact that Kenyans have had more prolonged exposure to a liberal and capitalist environment than Tanzanians, because of a political divergence in the 1970s, so that Tanzanians are more attracted to business opportunities now. Direct comparison also revealed that Tanzanians had a higher preference for "maize field", "tourism", and "buy healthcare" than Kenyan players (see Supplementary Figure S6). However, in our sample, all Kenyan players were Maasai. Comparing only Maasai players in both countries shows that preferences for "buy healthcare" and "tourism" remain higher for Tanzanian Maasai and that preferences for "breed livestock" were also higher for Tanzanian Maasai. This may reflect the high livestock densities and more common involvement in tourism through conservancies in Narok County (Ogutu et al., 2016), as well as the generally better access to healthcare in Kenya (Kruk et al., 2017).

Tanzanian players had a stronger preference for "poaching". Illegal bushmeat hunting is widespread in the Tanzanian part of the GSME, with some estimates suggesting that between 52,000 and 60,000 people participated in illegal hunting within protected areas in the early 2000s (Loibooki et al., 2002). However, the notion that poaching is less common in Kenya may be due to the fact that wildlife is already severely depleted (Ogutu et al., 2011).

4.5 Other insights for conservation and development planning

The game also revealed insights of conservation relevance. This includes the fact that the preference for "poaching" overall was low compared to even less profitable game moves. Furthermore, the effect of a successful poaching move did not extend to the next game year. However, preferences for "poaching" were stronger if this strategy had been successful the same year. The remaining wildlife tokens (i.e. sustainability) did not affect this preference. These and other findings suggest that poaching might diminish in real life if households experienced food security (perhaps women in particular) or a higher likelihood of being sanctioned for poaching.

4.6 Limitations

As mentioned initially, certain simplifications were made to facilitate game mechanics, which potentially affect external validity. Other limitations are more likely to have implications for internal validity. This includes the fact that the game design can force or provoke players to choose activities they might not have done in real life, including illegal grazing and poaching. However, debriefing revealed that players found the dilemmas presented in the game to

be largely realistic. Another potential limitation is interviewer bias, where the player's judgment is affected by expectations about the interviewer's opinions or values. Although our observations are based on gameplay, rather than survey questions, such effects are still likely. The presence of outside researchers may have primed players to think that the investigators were interested in wildlife conservation in the GSME. Countering this concern, several players admitted to engaging in technically illegal behaviour, suggesting that such biases were minor. Finally, we acknowledge that the data were collected almost 7 years ago. We do not view this as limiting the inferences we can draw from this study, nor its external validity, because Savanna Life is designed to address enduring challenges to pastoralists' livelihoods under conditions of land alienation, climate change, population increase and poverty-conditions that appear not to have changed substantially over this period (Kegamba et al., 2023), although they may have subsequently slightly intensified, as a result of evictions in the area.

5 Conclusion

The board game Savanna Life was played to reveal preferences for game moves with conservation and development implications by simulating increasing constraints on local livelihoods in the GSME. Players considered the game realistic, reflecting current problems in the GSME. Participants, and particularly males, played competitively, maximising individual benefits with less attention to the game's primary goal of creating a happy community. This highlights the importance of promoting the inclusion of women in development planning in these often patriarchally dominated communities. Players learned and adapted to increasing constraints throughout games. All players stated planned real-life livelihood and investment strategy changes, laying the foundation for the possibility that playing the game can promote real-life behaviour change through cognitive transfer.

Players preferred game moves representing agricultural and livestock production over those aligned with the UN SDGs, including education, healthcare and formal employment. Moves with negative conservation implications were least preferred. Preferences for game moves varied among players based on their gender, ethnicity, and nationality. The revealed preferences suggest a need for investment in healthcare and education facilities in Tanzanian Maasailand. This should follow a culturally sensitive modality. Preferences for the game move "poaching" were higher among women, Maasai and Tanzanian players, which coincides with higher levels of bushmeat hunting in Tanzania, reported cultural change among the Maasai, and women being responsible for household food security, while not experiencing the potentially harsh real-life consequences of sanctions.

Overall, this study supports the use of board games like Savanna Life to generate relevant insights for development and conservation planning, as they enable players to test alternative livelihood strategies safely and reveal their preferences. However, more research is needed to determine the degree of alignment between game and real-life behaviour and the extent to which the insights gained lead to behaviour change. Unfortunately, the COVID-19 pandemic prevented planned follow-up studies to address this. However, based on the player debrief and discussions, we believe that the statements reflect real-world intentions and aspirations for change. Perhaps the game's real force is sparking discussions that will likely continue after the research team has left.

Data availability statement

The data presented in the study are deposited in the Mendeley Data repository, accession number 10.17632/2k96x83686.1 (https://data.mendeley.com/datasets/2k96x83686/1).

Ethics statement

Permission for this study was granted through COSTECH research clearance No 2017-299-NA2011-21 in Tanzania and permission No KWS/BRM/5001 issued by Kenyan Wildlife Service in Kenya. Procedures for collecting information from human subjects were approved by the Tanzanian National Health Research Ethics Committee (ID: NIMR/HQ/R.8a/Vol. IX/2609). In Norway, ethical evaluation was conducted, and approval was granted by "Norsk senter for forskningsdata AS" – reference number 247641. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in the study.

Author contributions

MRN: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. MBM: Writing – review & editing, Writing – original draft. GS: Writing – original draft, Writing – review & editing. CAK: Writing – original draft, Writing – review & editing. EM: Writing – original draft, Writing – review & editing. HM: Writing – original draft, Writing – review & editing. HH: Writing – original draft, Writing – review & editing. BG: Funding acquisition, Project administration, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fcosc.2025.1604967/full#supplementary-material

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