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Research

Grazing game: a learning tool for adaptive management in response to climate variability in semiarid areas of Ghana

Grace B. Villamor [1] *and Biola K. Badmos* [2]

ABSTRACT. In West Africa, the most extreme predicted effects of climate change are expected to occur in desert and grassland areas. It is crucial for local populations in this region to better understand what such projections signify to them to identify sound adaptation policies and interventions. We developed a game, called the "grazing game," and conducted trials with local farmers at multiple study sites as a learning tool to better understand their behavior in response to climate variability under semiarid conditions in West Africa and to facilitate social learning. The grazing game was designed to reveal the processes that lead to overgrazing and desertification based on the players' interactions with environmental conditions and their resulting decisions. We conducted a total of 23 game trials around the Vea catchment of the Upper East Region of Ghana involving 243 individual farmers. From the games, local farmers exhibited a very positive response to how the game replicated rainfall fluctuations that they currently experience and led to the identification of coping strategies, such as selling cows, seeking government assistance, and engaging in alternative livelihood means. Participating farmers tended to avoid uncertain situations and sought to simplify their decisions, and the game provided insight into the rich local ecological knowledge of environmental indicators. Based on the game trial results, we found that the game facilitated instrumental and communicative learning among the players and facilitators. Further, the game served as a platform where players could share their views, knowledge, and perceptions of climate-related issues.

Key Words: *anticipatory learning; coping strategies; dry lands; local ecological knowledge; overgrazing; rainfall fluctuations; role-playing games*

INTRODUCTION

In West Africa, the most extreme predicted climate change effects are expected to occur in desert and grassland areas. According to Heubes et al. (2011), grassland is projected to expand into the desert over an area of 2 million km² by 2050. However, uncertainty about future rainfall patterns is a major challenge because there is a wide range of estimates projected from different interclimate models (Adger et al. 2003). What do these projections mean for West Africans? For agricultural and water sector actors in many parts of Africa, interclimate model differences in rainfall variability often remain a barrier to the effective use of climate change information by farm managers and other stakeholders. For local populations, this uncertainty is greater, especially when traditional methods of predicting rainfall, e.g., phenology of local trees, have also become unreliable. For African researchers and extension services, the understanding of climate processes, driving forces, and meaningful coping and adaptive strategies remains insufficient (Twomlow et al. 2008, Tschakert and Dietrich 2010).

In dealing with this climate-related uncertainty, implementing well-designed experiments with local populations using an adaptive management approach (Holling 1978) is one of the suggested strategies (Pahl-Wostl 2007). Increasing the adaptive capacity of the actors includes learning based on a more inductive approach, e.g., learning by doing, and anticipation of, or a forward-looking stance toward, the possible implications of extreme effects of climate change, e.g., collective learning improves when actors become aware of how to prepare for unexpected events. However, this also requires an in-depth exploration of the perceptions and reactions of the affected stakeholder groups and the public (Berkes and Folke 1998). Consequently, there are very few published efforts to address such uncertainties in which social constructions and related subjective perceptions of the affected people are explicitly included (Pahl-Wostl 2006). If they are included, this type of knowledge is often only considered in a shallow way because most research efforts are narrowly confined within specific disciplines. At the same time, learning tools exploring anticipatory adaptation are still limited, especially in places and populations that have low levels of adaptive capacity such as in West African countries (Tschakert and Dietrich 2010, d'Aquino and Bah 2013, 2014).

In many ecosystems, unsustainable resource management may result from farmers' management decisions, their choice of practices, and their ability to respond appropriately to current and future threats (Bernard et al. 2014). Typically, there are multiple actors operating within social-ecological systems who often have distinct specific interests that may be contrasting or competing (Villamor et al. 2014). Hence, participatory adaptive approaches to land-use conflict prevention are needed that facilitate learning among stakeholders (Folke et al. 2002, Cundill et al. 2012). According to Reed et al. (2010), social learning is a change in understanding that extends beyond individuals to become established within broader social units or communities of practice through social interactions among actors by means of their social networks. Because our interest is to explore the possible adaptive strategies and behavior of farm households to future unpredictable rainfall patterns together with demographic and policy trends, we also applied the concept of anticipatory or future-looking learning, which serves as a framework and develops skills to understand future possibilities and the ability to collaborate in creating a preferred future (McGray et al. 2007, Shostak 2009). Accordingly, the latter type of learning involves cycles of discovery, integration, and renewal that keep the actors

[1]Department of Ecology and Natural Resources Management, Center for Development Research, University of Bonn, [2]Kwara State University, Malete, Nigeria

thinking forward in an ever-changing environment (Shostak 2009). Anticipatory learning assumes that if learning outcomes look to the past (memory) too much, what becomes important is mastering a body of knowledge, i.e., local ecological knowledge, whereas if learning focuses forward, knowledge moves into new possibilities, i.e., emergent. We relied on these definitions of two types of learning throughout our research. Although these types of learning are gaining increasing attention for their application in coping with complexity under climate change, determining how social learning might be better facilitated for this purpose and with what tools is a challenge (Garmendia and Stagl 2010, Reed et al. 2010, Tschakert and Dietrich 2010, Cundill et al. 2012).

Games, particularly role-playing games (RPGs), have become well-recognized as natural resource management tools for better understanding the behavior of human actors (Barreteau et al. 2007). RPGs, especially with game boards, have been used to simulate and help human actors visualize and react to potential future uncertainties based on their existing knowledge and experiences (Vieira Pak and Castillo Brieva 2010, Villamor and van Noordwijk 2011). With respect to land-use decisions in the face of climate change, RPGs can help stakeholders identify options for resilience-building responses to extreme climate change impacts. According to Schelling (1961), games rapidly generate complex interactions and dynamics among decision centers that must reflect the reality of the system being represented. RPGs, especially board games, are like mirrors of the social-ecological systems they represent, in which roles simulate key actors in the real world. Players can interact in a collective and iterative way that improves their understanding of the processes that link the social and ecological systems (Bousquet et al. 2001, 2003, Barreteau et al. 2007). They may reflect on their experience with and their understanding of these systems, while acquiring new knowledge as a result of the interactions that may emerge, as well as imposed scenarios, and subsequently modify their perspective of these systems. Moreover, integrating uncertainties into such games may facilitate change in the way players respond to potential negative impacts, which may in turn stimulate social learning. Self-design RPGs are examples that facilitate social learning both for scientists and local people by incorporating new rules, e.g., collective rules or land-use zoning, in the games (d'Aquino and Bah 2014).

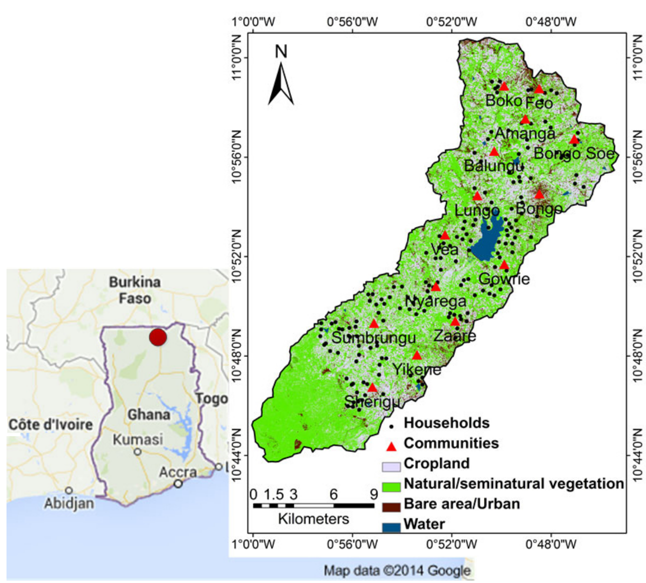
We explored, through the development and application of an RPG board game, the adaptive strategies of local farmers collectively in response to anticipated unfavorable conditions that might result from climate uncertainties. Individuals often tend to be negative or avoid responding to questions about pessimistic future scenarios, e.g., drought, deluge, or extreme sea-level rise. If, collectively, people engage in a game setting with their neighbors and/or colleagues, these issues can be dealt with in an entertaining way that encourages individual participation. Through a game, we emphasized climatic uncertainty, i.e., erratic rainfall patterns, that allowed us to explore how local farmers perceive threats, identify possible coping strategies, and respond in a collective way. The RPG board game is one of the tools identified under the work package (WP) 6.2 of the West African Science Service Center on Climate Change and Adapted Land Use (WASCAL) program (http://www.wascal.org). The goal of WP 6.2 is to identify resilient landscapes under climate change impacts. Among the other tools that are simultaneously tested and implemented are agent-based models and scenario-building exercises (Badmos et al. 2014, 2015, Villamor et al. 2015). Because RPGs are useful tools for envisaging the behavior and responses of farm households to the negative effects of climate variability, we explored whether RPGs can facilitate social and anticipated learning both with the researchers implementing the game and the target stakeholders as players, by addressing the different modes of learning. Our hypothesis is that games can contribute to a better understanding of the resilience of human and environmental systems to climate change and increased variability in a dynamic and collective way. We explored the following questions: (1) How do games facilitate social and anticipated learning? (2) What knowledge, e.g., coping strategies, experiences, and/or changes of understanding of the involved actors are elicited through the games?

METHODS

Study area

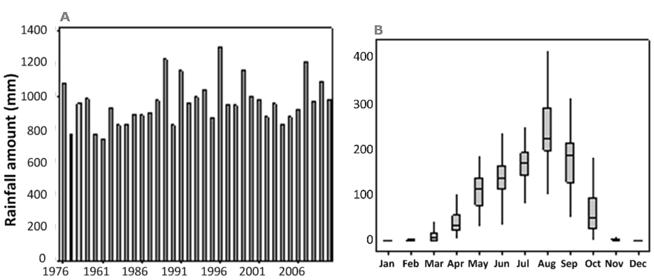
We conducted participatory field trials of a grazing management game in the Vea catchment of the districts of Bongo and Bolgatanga, Upper East Region (UER) of Ghana (Fig. 1). The study area is directly bordered by Burkina Faso to the north and Togo to the east. Most of the region belongs to the semiarid West African Guinea savanna belt, with the exception of a small swath of land in the very northeastern part of study area that belongs to the Sudan savanna (Adu 1972). With a total land area of 8842 km², this region represents 3.7% of Ghana's territory (GSS 2012). Bolgatanga Municipal District has a population of 131,550 with an average household size of 5, approximately 50% of which is rural. Bongo District has a population of 84,545 with an average household size of 6, approximately 94% of which is rural (GSS 2012).

Fig. 1. Study area map of Vea catchment in the districts of Bongo and Bolgatanga, Upper East Region of Ghana, West Africa. The red dots are the locations of the households that participated in the game.



Rainfall in the study area is unimodal with a rainy season peak (60% of annual total) between July and September (Fig. 2). Over the past 40 years, mean annual rainfall has been 1044 mm, which is suitable for a single wet-season crop (IFAD 2007). The rainy season in the UER is relatively short and marked by variations in its onset, duration, and the intensity of rainfall. This creates interannual variation in agricultural production potential (IFAD 2007). Mean annual temperatures are approximately 28°C to 29° C, and the absolute minimum temperatures are approximately 15° C to 18°C (Mdemu 2008). The hottest period of the year is around March and April, and the coolest period occurs around August.

Fig. 2. Annual rainfall (A) and monthly variation in rainfall (B) of Bolgatanga (1976-2010). Source: Ghana Meteorological Services Department.



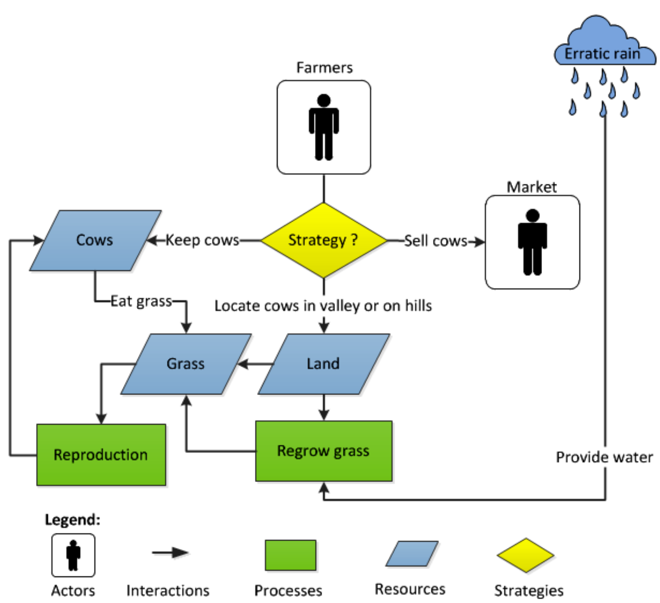
The communities in this region practice agropastoralism (Eguavoen 2013, Yembilah and Grant 2014). Agricultural activities are the main source of income in the area and are carried out both during the rainy season (rain fed) and the dry season (irrigated), but most agricultural work is concentrated during the rainy season. Within the immediate farmer's environment, traditional cereals are the basis for the agricultural system. The traditional cereals are cultivated around the compound, whereas groundnut (*Arachis hypogaea*), mixed or monoculture, may be cultivated within the compound or at some distance from the house. Other crops that are traditionally cultivated include guinea corn, millet, and rice. The cropping system practiced by the local farmers is mostly for subsistence. In terms of livestock production, the most common include cattle; sheep; goats; poultry, primarily guinea fowl (*Numida meleagris*) and ducks; swine; and donkeys. In the region, cattle ownership is a measure of wealth and social status (Yilma 2005). Together with smaller livestock, cattle are often used to pay bridal dowries. During periods of extreme stress, the smaller livestock are more easily liquidated to address immediate household needs.

Grazing game: a conceptual model

The grazing game we employed is a modified version of the "overgrazing game" developed by Van Noordwijk (1984) as a teaching method for university students in the context of the Sudan savanna. The objective of the game is to reveal the processes that lead to overgrazing and desertification. To apply the game for exploring the coping strategies of local farmers, we modified the game to match our study area and research objectives. The modified settings of this game simulate dryland conditions where agricultural production is highly dependent on rainfall with additional factors that introduce flexibility and complexity into the game. We based this assumption on several studies conducted in the region regarding the lack of reliability of rainfall, including the timing, associated to interannual variability of both distribution and total amounts of rainfall (Dietz et al. 2004, Van der Geest and Dietz 2004, Amikuzino and Donkoh 2012).

Figure 3 depicts the conceptual model of the modified game. It involves the actors, i.e., farmers and market; resources, i.e., cows, grass, patches of land, and rainfall; processes, i.e., reproduction and regrow of grass; and strategies, i.e., keep the cows, sell the cows, or locate the cows in the valley or on hills. The basic setting is that the rainfall patterns that farmers rely on for their livelihoods become more unpredictable, and the land degradation process is influenced by rainfall and the number of grazers. The farmers' livelihoods are dependent on cattle raising, and crop production is limited to household subsistence use in a restricted area. The basic processes in the game involve grass development cycles based on rainfall: less rainfall limits grass growth, and more rainfall increases bush development and cow reproduction. The resources conceptualized in the model are indicators to be monitored, such as total produced, total sold, and reproductive increases in herd size. The arrows depicted in Figure 3 describe the interactions among causes and effects, including, but not limited to, simple decision strategies such as selling cows, maintaining cows, and grazing management. To make the game handy, we used the term "cows" in the game and assumed that a bull was available for reproduction; the term "cattle" refers to both cows and their calves.

Fig. 3. Conceptual model of the grazing game.



Materials

The game board representing all available land is organized by a grid of 8 × 8 cells, each of which measures 5 × 5 cm, for a total of 64 cells or "patches" of land on the game board. A total of 16 patches at the center of the game board represents a "valley," where water is assumed to be available throughout the year.

A six-sided die is used to determine the amount of rainfall and grass production before each round of the game (Fig. 4). Herd indicators, e.g., pebbles, are used to represent herds of cows. Each herd is composed of five cows as a starting herd size.

Fig. 4. Game board and die with the local farmers during the pretest.

Land patches are colored coded according to land cover type: red patches represent desert, and green patches represent bush. Colored pins are used to indicate the quantity of grasses and crops. A score sheet (see Appendix 1) is provided to monitor the status of individual players, such as the number of cows produced (yield) and the number of cows sold, and an observer cross-checked the conversations of the players.

Game rules

Round/time step
Each time step or round of the game represents 1 annual cycle. Each year is divided into 2 seasons: a rainy season and a dry season. The rainy season begins in April and lasts for a period of 7 months. Afterward, the dry season begins in November and ends in March. In northern Ghana, the rainy season is also referred to as the growing season.

Rainfall and vegetation
In dryland areas, rainfall is low and erratic. In the game, the die is used to determine the amount of rainfall once a year for each land patch on the board. The amount of grass growth varies along a range from 1 to 6 markers. For example, if the die indicates the number 1, then each field of the board will have a unit of grass during that round of the game.

Grazing
Every month, each cow in a herd requires 1 unit of grass. The herd can move through 2 neighboring patches per month. If the full requirements of the cows are not met, they can be fed at half a ration, but this will affect both reproduction and sale value. If individual cows are not fed at all, they perish. The crop residues remaining after the harvest of corn, millet, peanut or groundnut (*A. hypogaea*), and rice can be used to feed cows, but only during the month that crops are harvested.

Reproduction and sale
At the end of each dry season, the cows that have been fed full rations for the past 6 months give birth to a calf. At the end of each rainy season, cows can be sold at the discretion of the player. If cows have not been fully fed over the previous 6 months, their value (count) is reduced by one-half. If a herd consists of 6 cows or more, it may be split into 2 subherds that graze separately. Subherds must be reunited if they are reduced to fewer than 3 cows.

Regrowth of vegetation
After the first year, there are the following additional rules for determining the vegetation on the basis of rainfall:

- If there is no vegetation remaining in a patch of land at the end of each round, nothing will grow, i.e., it becomes desert, in the subsequent round.
- If the vegetation in a patch of land is reduced to 1 unit, the vegetation will recover slowly. The rainfall determined by the subsequent roll of the die will only produce half (rounded down) of the quantity of grass that would grow under normal conditions (1 = 0 markers, 2 and 3 = 1 marker, 4 and 5 = 2 markers, and 6 = 3 markers).
- If the vegetation marker for a land patch is 6 at the end of a round and the next roll of the die results in a 6, the vegetation changes from grass to bush and no longer has any forage value.

Players
In terms of players, each game included 5 to 15 players. Each game had a game master, an observer to document the conversation each round, and a recorder to maintain scores and facilitate the process. The games were also facilitated by 2 additional research assistants who were locals and native speakers in each of the study sites. The game trial locations were selected based on the results of an initial household survey conducted within the study area (Badmos et al. 2013). A total of 23 game trials involving 243 individual farmers, excluding children and other bystanders, were conducted from August to October 2013. These individual farmers were also part of the initial household survey, and we asked if they were willing to participate in the game. Table 1 presents the key characteristics of the surveyed households. Each of the games represents the subvillages in the catchment study area. Typically, 1 or 2 female players participated in each game.

Session steps and reflection
Before the beginning of each game, the players were asked to locate 4 patches with their choice of crops, e.g., 1 unit of millet, 1 unit of corn, 1 unit of rice, and 1 unit of groundnut. Each player began with a herd of 5 cows that would graze in one of the suitable patches. The objectives were to manage the herd, maximize the production of cows, and avoid desertification. The game master explained the objectives and the rules of the game, including the

score sheets (see Appendix 1). The score sheets were used to track the indicators, e.g., primary production of grass, amount of grass used, number of calves produced, number of desert patches, number of bush patches, number of cows sold, and amount of fertilizer bought, during each round.

Table 1. Descriptive statistics of households in the study area (source: 2013 survey).

Household Variable	Minimum	Maximum	Mean	Standard Deviation
Age of household head	18	90	56	17
Household size	2	18	8	3
Size of labor (≥15 years)	1	13	5	2
Number of bicycles	0	9	2	1
Number of hoes	2	20	6	3
Number of mobile phones	0	10	2	2
Total land area cultivated (ha)	0.14	4.48	1.22	0.78
Number of cattle	0	21	3	4
Number of donkeys	0	8	1	1
Total income (USD/yr)[†]	31	2595	468	421
Per capita income (USD/yr)[†]	6	448	68	64

[†]Note: At the time of writing.

A pretest was conducted before each full game trial to make certain that the rules of the game were clearly understood by the players. Each full game consisted of 5 rounds. Each round was composed of 12 months. Depending on the number of players per game, players rotated turns per month or per year to graze (move) on the game board. Each herd began grazing inside the valley, i.e., central 16 patches on the board, for the first month of year/round 1 before the herd could be moved to graze outside the valley. The game master would score the result after each round and announce the status of achieving the players' goals, i.e., the number of calves produced and the number of desert or bush patches created. During the course of each annual round, the game master would also announce the beginning and end of the rainy and dry seasons and ask whether players wanted to sell cows. At the end of each game, a reflection exercise was conducted to clarify and verify the strategies/decisions made by the players and for them to assess the overall game. Typically, we asked multiple-choice and open-ended questions regarding the quality of the game, i.e., playability, perceived value as a learning tool, and so forth; reflection of reality; cooperation; role of the government; local ecological knowledge; and ways to improve the game (see Appendix 2).

Game scenarios

We used the game scenarios that were identified during the participatory scenario exploration exercise before the grazing game implementation (Badmos et al. 2014). During the game, the game master announced scenarios for the following years:

- At the beginning of year 3, a new household with a new herd, i.e., 5 cows, was added as a population-increase scenario. The new household would select 4 new blocks for the crop production, i.e., millet, corn, rice, and groundnut. The purpose of this scenario was to understand the players' responses to competition for available patches of grasses.
- At the beginning of year 4, a fertilizer subsidy was offered to restore grass in desert patches in exchange for a cow. One cow could replenish the units of grasses depending on the rainfall as well. This scenario explored players' perceptions on fertilizer subsidies of the local government in the study area. The fertilizer subsidy was introduced in the region in 2008 to make fertilizer affordable for farmers and increase the use for the improved maize varieties (Angelucci 2012).
- At the beginning of year 5, the game resumed the original scenario.

Analysis

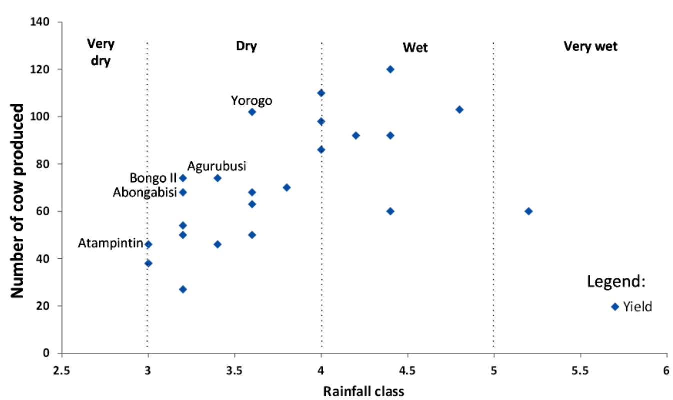
We compared results of the games by plotting key indicators, i.e., the number of desert patches against accumulated yields or the total number of cows produced, throughout the game. From these indicators, we determined the best performers on the following (1) subvillages that had above-average yields under limited rainfall conditions and (2) subvillages that had the smallest number of desert patches under limited rainfall conditions. For simplification, we categorized the average rainfall generated by the die, i.e., the average die value of the farmers per year, as follows: 1.0-2.5 as very dry, 2.6-3.0 as dry, 3.1-4.5 as wet, and 4.6-6.0 as very wet.

RESULTS

Overall response

Yields and average annual rainfall values generated from 23 game trials are presented in Figure 5. Approximately 14 (61%) games had mean annual rainfall values between 3 and 4, which fall under the dry and wet categories. Eight games had mean annual rainfall values in the wet category, and only 1 game had values in the very wet category. Among the games that had mean annual rainfall values in the very dry and dry categories, 5 subvillages had above-average yields, i.e., in terms of the number of cows produced. Among games with mean annual rainfall values in the dry category, the best cow producer was the subvillage Yorogo, with a total of 110 cows.

Fig. 5. Yields by mean annual rainfall category among grazing game trials in Ghana (N = 23).



The mean percentage of patches that were classified as desert, i.e., degraded land, by the end of the game was approximately 11%. Figure 6 presents a summary of the final percentages of desert patches. Only 7 of the games (30%) with mean annual rainfall in the dry category had below-average percentages of desert patches.

The top performer among these games was the subvillage of Bongo II, which finished the game with only 2 desert patches. There were multiple cases of games ending with higher percentages of desert patches despite higher rainfall, underlining the fact that the causes of desertification can be unrelated to climatic factors (see case 3 of Fig. 7). Only 1 game was completed without any desert patches.

Fig. 6. Prevalence of desertification among grazing game trials in Ghana (N = 23).

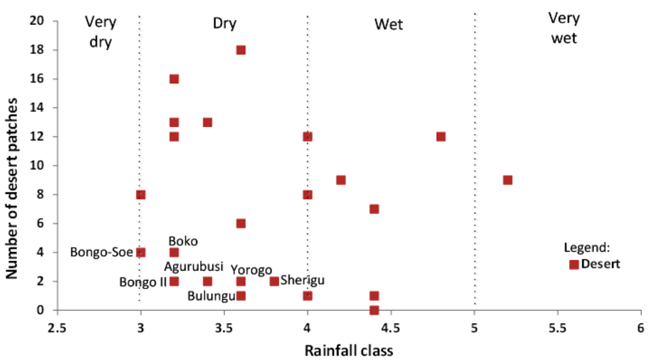
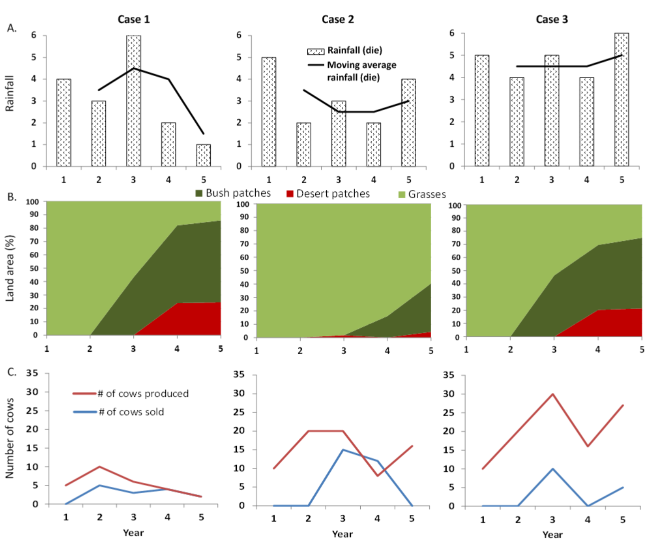


Fig. 7. Grazing game trial results in Ghana with rainfall patterns reflecting dry conditions with decreasing rainfall (case 1), dry conditions with increasing rainfall (case 2), and wet conditions with increasing rainfall (case 3): (A) pattern of average rainfall, (B) land-use trajectories, and (C) yields from cow production.



From the 23 games that were conducted, we selected 3 games that are representative of the resulting rainfall trends. Figure 7 presents a summary of land-use trajectories (Fig. 7B) and yields from cow production (Fig. 7C) according to rainfall categories. In case 1, the pattern of average rainfall (Fig. 7A) shows a concave shape with decreasing trend, case 2 has a moving average rainfall in a convex shape with increasing trend, and case 3 has a moving average with a stable but increasing trend. In cases 1 and 2, the land-use trajectories and yields from cow production mirrored the rainfall patterns, suggesting that as rainfall decreased the process of desertification intensified and yield from cow production decreased. However, in case 3, the percentage of desert patches increased even though rainfall was relatively abundant. Because the yields from cow production were high in case 3, this appears to be an example of anthropogenic land degradation or overgrazing.

Game and coping strategies

During the course of the games, we observed the players' strategies under decreasing rainfall conditions. Some of the farmers were adept at strategizing their cattle movements with respect to timing and ration levels (Table 2). The most common decision-making process was that farmers would wait until after the rainfall was determined, by the die, before deciding on a coping strategy, i.e., selling or keeping cattle. This suggests that farmers would prefer to make decisions based on relevant information.

Table 2. Strategies identified from observations of the best performers of the grazing game in Ghana.

Strategies of Best Performers during Low Rainfall
Dividing herd and distributing livestock to different patches
Feeding cows half rations
Buying fertilizer to improve cropland productivity
Keeping cattle when pastures are in good condition and selling them during the dry season
First throw the die before selling cows

The most common coping strategy for rainfall variability/uncertainty was selling livestock (Table 3). In fact, the participants commented on the importance of paying attention to the condition of their livestock. One comment that summarized the reaction of many participants was that "though cows are quite expensive to acquire, we let them graze around the place and we don't notice them until we realized that they were already dead." Some of the women players opted to sell their livestock and save the money for coping with the dry seasons, or drought events, whereas other women proposed seeking alternative livelihoods, i.e., basket weaving. Among males players, many opted to seek migrant labor jobs.

Another coping strategy identified was the cultivation of new drought-resistant crop varieties. Maize is a relatively new crop in the study area. Farmers expressed a preference for maize because it only requires 4 months rainfall and matures before the end of the rainy season; crops that require longer periods to mature can present problems.

Observed behavior and perception

Approximately 98% of the players perceived the game as a reasonably good reflection of reality. The time required to introduce the game and conduct the pretest typically ranged from 30 to 45 minutes. As the game boards were designed to simply represent the landscape in the study sites, where the inner patches (4 × 4 central areas) represent the valley and the outer patches

(8 × 8) represent the hills or uplands, we allowed players to locate their crops according to their customary practices. For example, the corn and rice were cultivated in separate patches, whereas millet and peanut were always cultivated together. Rice was always cultivated in the valley because water is available there throughout the year. The overlapping arrangement of millet and peanut on the game board matched our observations of the farmers' plots.

Table 3. Coping strategies identified under extreme rainfall variability, grazing game

Coping Strategy	Percent of the Cases
Sell the livestock	39
Call for government help	13
Seek a new job	13
Cultivate new crop requiring less water	10
Apply fertilizer to degraded areas	7
Cut bushes to feed livestock	3
Plant more trees in degraded areas	3
Relocate to forested area	3
Relocate near the dam	3
Revive irrigation canals	3

When we introduced scenarios in years 3 and 4 of the game sequence, we observed that at first, inconvenience was felt by all the players, especially the older ones. In year 3, we introduced the population increase by adding a new household as a newcomer. As observed, the newcomer was always played by a younger farmer in the group and always followed the suggestions of the older households. During the course of the games, households would compete for available resources while we observed how they cooperated with each other. The following are some of the direct statements from the farmers:

> *If he has one bull and another farmer also has [one], we can combine them to plough for each other.*
>
> *Giving my herd to another farmer helped me keep [some] animals for me.*
>
> *Allowing the household to settle in my farm plot to let his land restore new grasses*
>
> *To live in peace and consult for information with my neighbors especially when the rain is delayed*
>
> *Plan together and respect each other's views.*
>
> *Asking a neighbor for food support and money to buy food*

The erratic rainfall patterns generated through the games were one of the features that players considered realistic. For instance, some participants explained that the rainfall in 2013 was delayed by more than a month compared to the typical annual pattern. For this reason, some farmers were reluctant to plant early millet, a traditional crop. Every time a desert was "created," it was immediately recognized as a serious problem. Some participants shouted, "Disaster!" when this occurred, or else they paused and laughed at each other and expressed that the person who threw the die had bad luck. During the game, some players expressed their desire to shift their traditional cultivation practices to maize production to secure their harvest. Some participants, particularly women, also suggested restoring irrigation canals to allow them to continue cultivating crops during the dry season. To secure the production of at least 1 calf every year, the players kept at least 1 cow at full rations for the required 6-month period. There were many instances of players using crop residues to feed their cows to maintain grass availability in other patches. Other behaviors observed during the games are presented in Table 4.

Table 4. Observed coping strategies and behavioral responses to rainfall variability among grazing game players in Ghana.

Observed Behavior	Strategies	Situation
Cooperation	The players agreed to sell the cows from both of the households. They sought suggestions from one another.	Dry months with less rainfall
Leadership/ dominance	The older household showed a strong dominance in dictating where the new household should graze.	Less available grass
Ego and reputation	When there was no way out, the majority of the players were shouting, "Disaster!" One player even stated that "not feeding the cows for some months is like a process of abortion." "We really need to talk after this game; I don't like the way you manage your cows."	Presence of peer pressure
Ecological awareness	Using guinea fowl as indicator for fresh grasses. Keeping bushes to allow soil to recover.	Wet months
Competition	Directing the new household (because of population-growth scenario) to areas with less grass available. Leaving the patch overgrazed so the other household's cow would not reproduce.	When available grasses are limited

Local ecological knowledge for coping with climatic uncertainty

Based on a very abstract representation of the dryland social-ecological system, one of the main findings was how the local people relied on their ecological knowledge, which affirmed some prior ecological knowledge of the facilitators, i.e., researchers. During the course of the games, players often shared specific ecological insights that indicated means for coping with uncertainty.

1. Presence and behavior of guinea fowl (*N. meleagris*): Although small animals were not represented in the game, several farmers reflected on the role of the guinea fowl as an environmental indicator. Guinea fowl are native to sub-Saharan Africa. They are free-ranging and ground-nesting birds that eat insects and seeds, making them sensitive to rainfall conditions. Local farmers observe these birds as indicators of the quality of the rainy season. This might be related to the availability and quality of insects that they feed on during the onset of the rainy season. Some game participants explained that guinea fowl reproduction can be adversely affected if there is a significant interruption in rainfall. Guinea fowl typically lay their eggs at the onset of the rains and may lay daily once the rains have begun in

Table 5. Assessment of grazing game as a social-learning tool.

Forms/Modes of Learning†	Role-Playing Game as a Tool for Learning	
	Case: Grazing Game	Specific Example
Instrumental: Does the game involve acquiring new knowledge or skills?	Yes: For the players, the game enabled the players, i.e., local farmers, to view the system outside the box. Integrating an element for visualizing uncertainty further helped them to view the processes and interactions, including the possible effect of their decisions on their welfare. For the researchers as facilitators of the game, it allowed them to understand the system interactions and gain the local perspectives.	Erratic rain produced by the die mimics the rainfall pattern in the study area. The spatial land-use arrangement produced by the players; local ecological knowledge and coping strategies identified (Table 3).
Communicative: Does the game allow understanding and reinterpreting knowledge through communication with others?	Yes: The game is a multiplayer game that allows communication between players.	Both the players and game facilitators exchanged their views on the concept of cooperation and the role of government support in coping with climate uncertainties.
Transformative: By reflecting on the assumptions that underlie actions:		
Single loop: Learning about the consequences of specific actions? Refinement of actions to improve performance without changing guiding assumptions?	Yes: Improvement of their established practice; correcting errors from routines.	Players appreciated the value of their livestock and cooperation as a coping strategy during lean months.
Double loop: Reflecting on the assumptions that underlie actions? Is there a change in frame of reference and calling into question?	Yes: Correcting errors by examining values and policies, e.g., water management during drought events/delayed rains.	Proposed revival of irrigation canals and construction of new dams.
Triple loop: Learning that changes the values, norms, and higher order of thinking processes that underpin assumptions and actions?	No: That is, structural change, such as shifting to integrated landscape planning from optimal adaptation strategies.	

†Adapted from Pahl-Wostl (2009).

earnest. Many players, mostly women, suggested including guinea fowl in the game.

2. Multistrata vegetation structure: Multistrata vegetation supports the guinea fowl in the dryland ecosystem. Because of the fact that local people place great value on these birds, having multistrata vegetation structure is deemed important for protecting chicks from predators, e.g., wild hawks and eagles.
3. The role of bushes in soil fertility: Aside from the protective role of trees (e.g., *Vitteria* sp. and *Parkia globusa*) and shrubs for animals that are important for subsistence purposes, the trees also create microclimates that provide services such as shade for local people during the dry season. Although bush development was treated as an unproductive land use in the game, farmers did not view this as negative. Rather local farmers recognize the progression of plant community succession as a natural way of restoring productivity of the soil.
4. The role of water bodies: Water bodies are important components of dryland ecological systems; however, the grazing game did not explicitly consider them in the game board. Almost 90% of the players mentioned the importance of dams or irrigation canals for watering their crops, especially during the dry season, and as a water source for their livestock.

DISCUSSION

In the context of the drylands and climatic uncertainty, how do games contribute to better understanding of the resilience of human and environmental systems to climate change and increased variability, as well as facilitate social and anticipatory learning? Furthermore, what knowledge, experiences, and/or changes of understanding of the actors involved are elicited through the games?

Role-playing game as a tool for facilitating social and forward-looking learning

Basically, the grazing game is instrumental for eliciting the players' subjective perceptions, goals, and expectations within the specific context described. It is a simple and straightforward tool for better understanding the perceptions and behaviors of the local people in a relatively realistic context. Moreover, this tool facilitates social learning particularly for the scientists involved. The key aspects for assessing the degree to which the grazing game is an effective tool for facilitating social learning are summarized in Table 5. This information was generated during the reflection sessions of each game, in which the players exchanged information with the facilitators/game master, i.e., researchers and modelers, and it was considered the most important part of the entire process. The facilitators and researchers investigated the reasons behind participants' reactions more deeply and, at the same time, verified and validated the behaviors and perceptions of the players observed during the game. Although most of the local ecological knowledge listed previously was not that new to scientific ecological knowledge, the integration of the two knowledge systems harnessed an understanding of the system (Stringer and Reed 2007) that may be useful for the development of management plans, e.g., provision of maps of various water bodies to communities. For example, a study conducted in the savannas of northern Nigeria on traditional knowledge for predicting rainfall variability also found that local people identified guinea fowl as a climatic condition indicator (Sanni et al. 2012), which concurs with the local farmers in the region. In addition, our results support the outcomes of the participatory scenario exercises (Badmos et al. 2014), such as consideration of water availability over the lifetime of a selected crop before deciding whether to cultivate it, as well as consideration of other varieties of crops and land suitability.

However, fully addressing the definition of social learning of Reed et al. (2010) is not possible in the current implementation design of the RPGs, and we considered this a limitation. One reason is that transformative forms of learning (see Table 5, one of the three social learning modes) are hard to achieve because they involve changes in the underlying values, belief systems, norms, higher order thinking processes, and worldviews of the individuals. Although RPGs, if well designed, can facilitate double-loop learning (Schelling 1961), according to Pahl-Wostl (2009) this kind of societal learning involves transitions of entire regimes, e.g., from optimal land-use planning to integrated landscape planning. In fact, belief systems or core normative beliefs may be so deep that changing them may require time and specific perturbations (Sabatier 1988, Villamor 2006).

On the other hand, in terms of anticipatory learning, the farm households' behavior and patterns observed in the game provide a different insight. As mentioned previously, some of the local ecological knowledge from the game overlaps with the existing scientific ecological knowledge (Hesse and MacGregor 2006, Flintan et al. 2013). This suggests that either the local respondents have mastered strongly their local knowledge (Shostak 2009) or that scientific knowledge is also reliant on the local existing knowledge. Because the average farmer in the study area depends largely on farming (Table 1), by anticipating more erratic rainfall patterns in the future the players saw the importance of their small animals, i.e., guinea fowl, during extreme drought events for immediate cash (as reflected in Table 2).

In addition, as expressed by the players, the dynamic consequences of human decision making in response to unpredictable rainfall patterns made the game more realistic and engaging. The players who generated unpredicted rainfall patterns through the use of a die made the game more exciting. Thus, they were more reactive to the rainfall while being proactive in terms of strategizing cow production efforts. In comparison, another study used RPGs to integrate seasonal climate forecasts into the context of the livelihoods of small-scale producers in the environment of southern Africa (Ziervogel 2004), with a design based on suggestions about how to respond to different rainfall patterns. In that case, each game was composed of three rounds: the first round reflected a weather forecast of normal rainfall, the second round included above-normal rainfall, and the third round included below-normal rainfall. In each round, the players, i.e., small-scale farmers, were asked to reassess their decisions. The game provoked suggestions about how to adapt to those scenarios; however, the author commented that there were not many suggestions because it was hard for the players to relate to the impacts of climate change, especially in terms of their livestock.

We aimed, through the use of RPGs, to explore the adaptive strategies of the local farmers and their responses to highly unpredictable rainfall patterns and not to make decisions for them. Unlike self-design RPGs, participants were not involved in the formulation of the model; rather, we used this simple game for them to refine and improve the tool for further replications in other WASCAL pilot sites. It was so simple that the players easily related to the game concept, and it was favorable especially if the end target was the integration of different knowledge systems (Villamor et al. 2014). With respect to representing actual complex systems using soft system tools, the debate, i.e., simplification versus realism, remains and is understudied (Voinov and Bousquet 2010). Nevertheless, Barreteau et al. (2013) suggested the following indicators to assess the quality of the tools used, which we considered in the RPG:

1. Diversity, i.e., individual player characteristics, breadth of knowledge, experiences, and perspectives, including status in the human system: The game and trial results examined emerged from the interactions of a total of 243 individuals around the study area with different ages, genders, and status in the community (Badmos et al. 2013).
2. Involvement of multiple decision centers: According to Schelling (1961), reproducing settings with multiple independent centers (players) improves the quality of the representation of complexity. The grazing game is a multiple-player game that requires about 3 hours to complete. During this time frame, the players freely exchange their ideas to arrive at particular decisions.
3. The model's intended use: As stated previously, the goal of the game is to dynamically explore the processes that lead to land degradation, e.g., overgrazing and desertification, in the context of an agropastoral system. The game settings and rules are a simplification of the landscape of the Sudan savanna, which is similar to the socio-environmental context of the UER of Ghana. In this region, the main driver of land degradation is the interaction of grazing activities and erratic rainfall, which are both captured in the game.

CONCLUSIONS

We designed the grazing game and conducted field trials to explore the perceptions and coping strategies of the local people in the drylands of the UER of Ghana under climate variability. The game enabled us to examine farmers' behavior under unpredictable rainfall patterns with clear targets for their livelihoods with consequences such as land degradation. Through the game trials, we identified coping strategies and local ecological knowledge for increased climatic variability. Furthermore, the game provided the farmers with an opportunity for observing the implications of their land-use decisions on their livelihoods. The replication of the game around the study area enabled us to assess whether the game can facilitate social learning. We found that the game was instrumental for eliciting the players' subjective perceptions, goals, and expectations within the specific context described but was limited in facilitating social learning, particularly the transformative form of learning.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/issues/responses.php/8139

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Appendix 1. Score sheet of grazing game.

Year: _	**Rainy season**							**Dry season**				
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Cow 1												
Cow 2												
Cow 3												
Cow 4												
Cow 5												
Cow 6												
Cow 7												
Cow 8												
Cow 9												
Cow 10												
Total												

No. of cows sold: ___ No. of cows reproduced: ___ No. of desert patches: ___ No. of bush patches: __
Amount of grass used: __Total number of cows: __ Amount of fertilizer used: ___
No. of cows used to buy fertilizer: ___

Appendix 2. Game reflection guide.

1. How did you find the game?
   Boring / Fun / Educational / Hard / Easy
   Others (pls. specify)

2. Does it reflect the reality?
   - ☐ Yes: what aspect does the game appears to be real?
     (e.g., rainfall pattern, feeding habits of the animals in the valley, neighbors competing for resources, fertilizer availability, etc.)
   - ☐ No: the game is not real at all.

3. If rainfall pattern will be much less in the coming 5 years, what plans or strategies can you do to survive or solve the problem?

4. Will cooperation with your neighborhood assist you to survive?
   - ☐ Yes, example of cooperation activities:
   - ☐ No, why?

5. Are there other common problems in the area that needs to be captured in the game?

6. Would you play this game again?
   - ☐ Yes
   - ☐ No

7. Any suggestion to improve the game?