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Exploring risk related to future climates through role-playing games: the African Catchment Game

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***Abstract*— Risk is the result of two interacting components: hazard and vulnerability. Climatic hazards are related to extrinsic factors such as drought or severe storms. Vulnerability is the result of intrinsic factors that often arise from the socio-political-economic context. The interplay of risk and vulnerability is difficult to predict. Although computer models have been widely used to forecast climate related risk, albeit with considerable uncertainty, they can never capture sufficiently the vulnerability of human systems to these hazards. Role-playing games can be used more realistically to simulate possible outcomes of different climate change scenarios, and allow players to reflect on their significance. The authors have developed the African Catchment Game to simulate a water scarce African country. Risk can be modelled mechanistically by changing the nature of the annual rainfall input. Vulnerability can in part be modelled by changing the starting parameters (such as access to land and resources) and, secondly, through the unpredictable response of players to game dynamics. Players' reflections demonstrate that through the game they become more aware of the concept of risk and the complex response of individuals and societies that determine their vulnerability to climatic hazards. This paper reflects on the potential for developing the game further as a tool for participatory learning around climate change, based on the authors' experience of playing the game with participants from South Africa.**

INTRODUCTION AND BACKGROUND

There are now strong indications that global climate change is a future reality[1], while climatic variability and extreme weather events are self-evident at the present time. The IPCC[1] predicted that climate variability and climate related extreme events would become more prevalent, putting increasing stress on the world's ecosystems and human population. According to Thomalla et al.[2] climate related events accounted for 90% of people killed by disasters between 1970 and 1999; these numbers could well increase in the future.

Southern Africa's climate is presently characterised by great variability, with drought and flood cycles. Although the IPCC[1] reported in 2002 that no clear trends had as yet been identified for the southern hemisphere, and, in 2006, Thomalla and co authors warned that there is much uncertainty around climate change, especially at the local scale[2], Hoerling[3] indicated a probable increased drying over southern Africa, linked to sea surface temperature changes. In 2000 Kiker[4] reported predictions of a warming of 1-3℃, a general reduction in regional rainfall of 5-10% and a possible reduced frequency but greater intensity of summer convective storms, with an increased flood risk. Concomitant changes are expected in terms of streamflow, agricultural production, fire risk and disease prevalence[4]. Other South African researchers have predicted that the biggest economic impacts would be on the existence value of biodiversity, the subsistence value of ecosystems, tourism and health[5].

It is clear that the human population of Africa is already exposed to a high level of climate-related risk, which is likely to increase

in the future if climate change predictions are correct. Development policies for the region must therefore take account of these risks and their impacts on society.

Pyle, in his study of severe storms in the Eastern Cape of South Africa, saw risk as being made up of two components – hazard and vulnerability[6]. Hazard is the external element of risk to which an individual or society is exposed – severe weather events, drought, disease vectors. Vulnerability is a measure of the degree to which the individual or society is protected (or not) from the hazard. This relates to factors such as economic wellbeing and stability, demographic structure, institutional stability and strength of public infrastructure, global interconnectivity and dependence on natural resources[7]. Some authors distinguish physical from social vulnerability[7 8], physical vulnerability being a measure of exposure to a hazard and social vulnerability being a measure of resilience to withstand that hazard.

Assessment of future climatic hazards[6] or physical vulnerability[7 8] normally takes a positivist approach, based on physical science. Assessment of social vulnerability needs to take a different, more constructivist approach that takes account of the complex, dynamic and individualistic response of people.

Vulnerability and the human response to climate change vary with geography and with scale [8 2]. Researchers working at the village scale in Kenya and Tanzania, distinguished short term coping from longer-term adaptation[8]. They stressed the place-specific and individualistic nature of coping strategies and concluded that climate change adaptation policies should focus on empowerment before the event rather than intervention after the event. Such policies must encourage dynamism through diversification and flexibility. Interconnectivity at all scales is an important aspect of vulnerability. Other researchers have stated the need to facilitate urban-rural linkages, or links between humid areas and drylands[9].

Vulnerability is clearly an example of the outcome of a complex adaptive system[10]. Eriksen et al. express this succinctly as "A complex mesh of interactive processes creates an ever-evolving distribution of vulnerability, differentiated within the community, as households fail to identify, or succeed in identifying and implementing, effective responses to environmental stress, within a socio-economic and political context that is itself constantly changing." They go on to say "Describing and explaining this dynamism represents one of the main challenges of developing the theoretical framework of vulnerability" (Eriksen et al. 2005 p.302)[8].

While real-world case studies such as used by Eriksen et al.[8] are essential to meet this challenge, role-playing simulation games provide an alternative way of giving both students, researchers and policy makers an experience of vulnerability that can help them understand its complex nature. In this paper we look at the African Catchment Game as a means to expedite understanding of climate related risk. We start by demonstrating how the game models the interaction between external hazards and internally determined vulnerability, before analysing one game run that was used specifically to engage South African students through active learning with the nature of climate risk and the possible longer term impacts of climate change. We conclude by reflecting on whether or not this game could be used to explore risk scenarios relating to future climate change.

THE AFRICAN CATCHMENT GAME

The African Catchment Game is a role-playing simulation that is underpinned by the social constructivist approach to learning[11 12]. Through this approach game participants experience for themselves what it is like to be vulnerable to environmental and societal challenges within a complex system. The pedagogical approach adopted requires the players to connect their game experience to their pre-existing knowledge and understanding of the process that the game models. This is done through reflection in pre and post

game questionnaires and focus group debriefing.

The game simulates a small Africa country that consists of urban and rural sectors that are presided over by a government. The urban sector includes industrialists, labour, a banker, buyer, seller and trader. The government resides in the urban sector and comprises a president and two ministers. The rural sector in our game consists of two commercial farms and a number of smallholder farms.

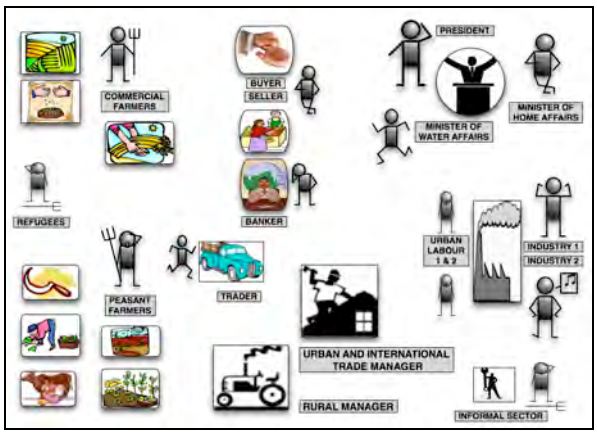

Figure 1. Players' roles and layout of the room[13].

The room is divided into two sections, separated by the trading sector (Figure 1). No one is allowed to pass between sectors without some form of transport, which at the start of the game is restricted to the trader, one member of the government and one commercial farmer.

At the start of the game each player is given a number of assets and liabilities, some of which have an element of chance in their distribution between players, and has a family of variable size. For example, a smallholder farmer has three fields and a garden (all of which are used to grow the staple food - rice) and may have a bull or cows (Figure 2).

Cows are used for ploughing fields and provide fertilizer in the form of manure, calves grow up into either bulls or cows; excess stock can be sold. A commercial farmer has nine fields, some of which have irrigation infrastructure (water pumps), and either a tractor or a light truck for transporting farm produce. At the start of the game one field on each farm is planted with sugar cane. The commercial farmers are in debt to the bank for the tractor and vehicle. Family size for each farm is determined by chance cards and can vary from two adults and three children to six adults and four children.

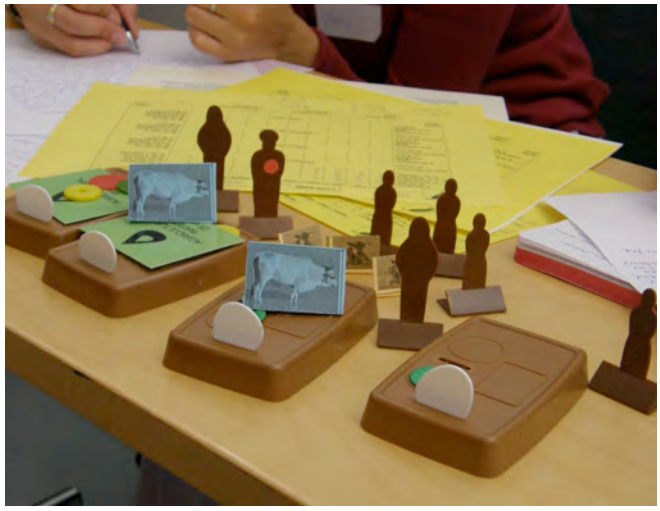

Figure 2 A small holder farm, three fields and garden planted with rice, two field irrigated (see green water tokens), two bulls. Family size is three adults and four children.

The game runs through a series of hourly cycles (normally five). The main aim for the players is to make sure that all family members receive enough food (in the form of rice) and water to survive each year of the game cycle. Rice is grown in the fields, water for domestic consumption, irrigation and industry is provided by a reservoir. The rains and availability of water in the reservoir determine productivity. Each is the outcome of chance. There are three rainy seasons in the lower catchment (the farming area). These simulate early growth, middle growth and flowering of rice. Each season has a four in six chance of drought, a one in six chance of good rains and a one in six chance of floods. The reservoir lies in the upper catchment and receives more rainfall, with a four in six

chance of good rain and a two in six chance of drought.

The game is thus able to simulate climatic hazards in the form of drought and floods. A further hazard is pests. These are farm specific and increase during wet years according to chance cards. Each year more children are born, and some people die, normally as a result of insufficient food or water.

What can a farmer do with his or her produce? First it must be used to feed the family - ten maunds per adult and five per child. In a good year a smallholder with no additional investments can produce 139 mounds of rice, enough to feed a family of six adults and four children with a significant surplus. The rice can be sold to other families, to the urban sector, or for export. It can be stored in a granary (if available). Some must be kept back for planting.

In a bad year the same farm will only produce 55 maunds of rice, which can only feed four children and three adults. In order to survive, and prevent a death (which adds a further burden of an expensive funeral) the farmer has to develop a coping strategy. This may rely on immediate actions, such as using social networks or asking for government aid, or on longer term adaptations such as investing in irrigation, buying a granary to store surplus crops, buying pesticide, buying fertilizer, diversifying into cattle. A bank loan can supply cash to get an enterprise underway.

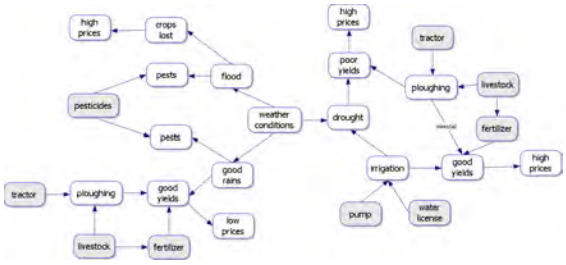

Figure 3 Outcomes of variable weather conditions and farmers' possible response options (grey boxes).

The various ways in which a farmer can mitigate against the outcomes of variable weather conditions (hazards) is illustrated in Figure 3. Small holders' gardens provide a safety net because they are protected to a large extent from weather events, but this was not so for commercial farmers. Investing in water pumps and buying water every year can afford drought protection, but there is no protection available against floods.

The game is therefore able to simulate the complexities of risk associated with climatic variability and, by extension, with climatic change. Climate related hazards are simulated through the use of chance cards, whereas social vulnerability depends on both the initial entitlements and the development of individual coping strategies. By asking players to reflect on what they learnt, we can analyse the game dynamics[14].

We have played this game with participants from South Africa, the USA, Sweden and Finland. Every game has been different, depending on the combination of chance and the actions of individual players, but the learning process was found to be similar. In this paper we present the outcomes of a game played with final year undergraduates students from Rhodes University in February 2009. Through their three-year curriculum the students had already been exposed to ideas around climate variability and climate change, and had been encouraged to think holistically about the societal response.

In this particular game we assessed their learning about climate-related risk through a questionnaire and reflection exercise. Students were asked the following questions.

1. What was your role in the game?

Given this role:

2. What were the main climate-related risks that affected you and how did they affect your livelihood?
3. What factors affected your vulnerability to these risks?
4. Did you do anything to decrease your vulnerability and, if so, what? Was it effective?
5. How would you expect climate change to affect both the risk and your vulnerability?

As a more general post-game reflection exercise they were asked:

What have you learnt about environment and development in Africa through playing the African Catchment Game? Relate this learning to specific activities or incidents in the game.

The questionnaire answers and reflections of the 31 students were analysed using a qualitative content analysis. Eight key themes relating to coping mechanisms were identified after an initial reading of their responses: investment in farm infrastructure, cash income, bank loans, social handouts, employment, diversification, social networks, rural-urban linkages. Two other themes that emerged as having an important influence on game outcomes were governance and chance events. Each student response was then categorised according to these themes.

In the analysis that follows we focus on the responses of players from the rural area – the two commercial and seven small holder farms, as it is farm productivity that is affected most directly by climate related hazards. The analysis of responses of urban players will focus on governance and urban-rural linkages.

GAME OUTCOMES

The sequence of weather events and pests for each game year of the February 2009 game run is given in Table 1. The probability of having either a drought or flood was high and there were no good years. Pests were also a problem, exacerbated on those farms that chose to plant high yield rice. Some protection against pests is afforded by applying pesticides.

The farmers' responses to these hazards are outlined below. These are considered with respect to the themes identified above.

Investment in farm infrastructure

There was limited investment in farm infrastructure due to a general shortage of cash income in the rural area. At the start of the game only the commercial farms had irrigation infrastructure; by the end of the game two more farms had invested in irrigation. Inability to purchase water limited the extent of irrigation in some years, despite having pumps. One farm bought a granary (for grain storage), another a water tank and another a bicycle (for access to the urban area).

Table 1. Rains and pests

Year	Season R=good rain D = drought F = flood			Final crop state before pests & without irrigation	Pests (no. of farms affected)
	1	2	3		
1	D	D	D	Low	0
2	F	F	R	Low	5
3	R	R	D	Medium	4
4	R	D	F	Low	6
5	F	D	R	Low	2

Cash income

Cash in the game is required to purchase short-term needs - rice for consumption, water for domestic use and irrigation - and to invest in farm inputs that can reduce longer-term vulnerability. The main sources of cash income were sales of rice, cattle and water. Income from rice sales was generally low due to the poor weather conditions, but cattle were more reliable because the game rules made them less vulnerable to weather. No one reported receiving cash for labour. Low incomes in the rural areas were seen to be an impediment to farm investments.

Bank loans

Two farms reported taking out bank loans to help solve short-term problems, one to buy a water tank and one to purchase seed. Commercial farmers were heavily indebted from the start of the game; this left little spare cash for further investment in their farms and made planning ahead difficult.

Social handouts

Only one farm reported receiving a handout from government.

Employment

All smallholder farms had excess labour and commercial farms started with a labour shortage. Employment could also be found in the urban area. Five out of the six farms reported labour issues. A shortage of employment opportunities was caused by the poor urban economy, refugees adding to labour pool. Issues included low wages and inability of commercial farmers to pay wages.

Diversification

A number of farmers mentioned the importance of diversification as a means of reducing vulnerability. Four farms mentioned the importance of cattle as these were used to plough fields, provided cash income and fertiliser, and were required for funerals. Three farms specifically mentioned diversity as being important in reducing vulnerability

Social networks

All but one farm mentioned social networks as being important. Six farms mentioned exchange of favours or barter and three the importance of friendly relationships. Two farms received outside investment and the formation of partnerships. Most social networking was done within the rural area whereas the lack of interaction with the urban area or a lack of knowledge of what was happening in urban areas was noted by three farms. Knowledge of the markets was important to optimise profits. One commercial farmer noted the negative impacts of a poor urban economy as this limited the availability of industrial farm inputs.

Rural-urban linkages

Rural-urban linkages are an important part of the game as urban families rely on farm produce for food and the agro-industrialist supplies farmers with agro-chemical inputs and processes farm outputs (sugar cane). Industry can manufacture farm infrastructure such as water pumps, granaries, water tanks and bicycles. A thriving industry also provides employment. The government is also located in the urban area. Its policies (or lack of) influence the direction that a game takes.

The poor crops arising from frequent drought and floods resulted in food shortages and high prices in the urban sector. Low farm profits meant that farmers were often unable to repay bank loans and lacked necessary cash to buy farm inputs. This impacted negatively on industry; the agro-chemical industry went bankrupt early in the game. As a result, there was little demand for labour in the urban areas, reducing employment opportunities for rural families as well as those in urban areas. Thus as the population grew, so did unemployment.

The most successful people in the urban areas were the banker, buyer and trader. Other players saw this trio as being in a position of power from which they could exploit others. The banker and buyer worked closely together and with the farmers. The buyer brought granaries to store grain so that he could benefit from market fluctuations, but was disadvantaged when the export price dropped markedly. The trader had the advantage of mobility between sectors and played the market to his advantage, but he could never afford the bribe needed to get a trading license for export. The seller was not successful. This was possibly due to a lack of market for farm inputs, but also due to poor communication with the farmers, a black market that was operating, and competition from the buyer, who usurped his role.

Governance

The government was weak and did little to mitigate adverse effects of weather hazards. The President noted that he was a puppet of the other two ministers and there was a lack of consultation and information within the government. The lack of transparency led to corruption within the government and a seeming lack of concern for the country at large. When HIV/AIDS spread through the

game the Minister of Home Affairs decided it was cheaper to allow people to die, despite the cost of funerals, than to provide anti-retrovirals or feed unproductive people. The Minister of Water Affairs admitted that he had no interaction with farmers; he gave the government free water and thereafter was not overly concerned by what happened as long as he survived. The domestic water was sold to a consortium in the rural area, who charged high prices, made a quick profit, and caused much suffering in the rural areas.

The government had no effective policy for raising income through taxation and was always in debt due to a bank loan taken out to build the dam. The reservoir water was one of the main sources of government income; this income was reduced during droughts. As a result it was difficult to import food to make up for production deficits due to lack of money. Being in constant debt, the government was open to corruption.

The President noted that the variable climate made planning difficult. The Minister of Home Affairs said that drought and floods in rural areas caused "chaos" in urban areas due to people looking for jobs. This was exacerbated by a lack of information as to what was happening in the rural area. Other players also commented on the poor communication between urban and rural areas. It was interesting that the government thought that disasters were less of a problem to the government than were ongoing shortages because external agencies take over and provide aid.

Later in the game the urban sector was taken over by an NGO manager who encouraged cooperation in place of competition and corruption. This turned the urban area around, improved industrial production and increased employment opportunities. Positive spin-offs for the rural areas were not noted, but would have undoubtedly been felt, especially if the game had continued longer.

The importance of chance

Whether or not a farm or other enterprise was successful was often the result of some chance event - not only the initial entitlements, the run of drought, rain of flood events and pests, but also bad luck or “lucky breaks”. Theft of a major asset such as a cow could break a farm, whereas in the case of one farm "one lucky break got the ball rolling" when the refugee decided to invest his surplus income in the farm.

DISCUSSION AND CONCLUSIONS

The above responses indicate how farmers attempted to reduce their vulnerability in the face of variability. One player commented that "One of the main points taken away from the game is that, as a Third World farmer, it is hard to come up with a game plan as the variables are always changing”. Successful farmers were those who managed to accumulate cash that could be used to invest in strategies to further increase their income or protect themselves against shortages. Without cash, farmers were highly vulnerable to any hazards. Neighbourly goodwill was their only remaining resource, making social networks important.

Games are simplifications of the real world, but to the players the problems faced in trying to survive and prosper in difficult circumstances are genuine[15]. Through participatory learning, the game described here provided players with insight into what it is like to live with climatic hazards. It also highlighted a number of factors that affected either an individual’s or society’s vulnerability to these hazards. Individual farmers adopted a range of coping mechanisms as described above and illustrated in Figure 4. These are similar to those identified for example by Eriksen et al.[8] and Vincent[7], indicating that the imaginary world of the game did reflect a microcosm of the real world.

Chance events – good and bad – were seen to be important in changing the fate of an individual family. Participants were also able to see the importance of the higher-level structures that allow or impede the flow of goods and information. In this game a lack of government policy, poor information flows and corruption negated against either urban

or rural development. In the rural areas strong social networks provided a safety net, but in the urban areas players were more self-seeking. It was only after the NGO stepped in that cooperation led to a more stable structure.

Figure 4 Hazards and vulnerability as experienced in the African Catchment Game. Grey boxes indicate inputs determined by game parameters, rectangular boxes indicate coping mechanisms and adaptations that are determined by the players.

How can this game, and the participatory learning that it promotes, be used as a tool for looking at climate change scenarios? We have already changed the game significantly from that first developed by Graham Chapman[15 16] for the Indian context. In order to better model twenty-first century South Africa we have changed the distribution of farm sizes to create two farming classes – commercial and smallholder – and have introduced cattle. HIV/AIDS has also been added.

Other changes have also been made to target certain aspects of climate change within particular contexts. We have changed the hazard component by altering the probability of rain and drought and added floods as an additional hazard. In recent games we have added a reservoir to supply water for irrigation, industry and households, which affects the vulnerability of players and the role of water managers and other policy makers in the game.

The outcome of a game can be analysed at two levels. The first is at the level of the player who, through a debriefing immediately after the game and a post-game exercise is able to reflect subjectively on his or her experience within the game. This can be contextualised within the player's personal experience of the real world or relevant academic literature. This level of analysis is aimed at increasing an individual's level of awareness and may lead to more empathetic decision-making. The second level is to objectively analyse the game dynamics on a more holistic or 'global' level through examining game managers' records of inputs and transactions and compiling player's individual reflections. The material presented above, like that discussed by Fraenkel and Fox[12], takes an holistic approach and may present conclusions of relevance to policy makers.

To date we have played the African Catchment Game only with University students, within the context of a theoretical curriculum on Africa. Other role playing games have been used with some success as a negotiating tool with local water users[17 18], but we have not as yet used the African Catchment Game with local policy makers. This is an important next step if indeed we as educators believe in the power of simulation games in facilitating effective policy making for an uncertain future.

The African Catchment Game captures the dynamism and complexity of vulnerability to climate change as identified by Eriksen et al.[8]. It also captures the time and place-based singularity of vulnerability, as all games are different. This means that it is difficult to draw generalities from one game. Games cannot be used as positivist experiments, as the outcomes are so game specific and depend as much on the responses of the actors as on externally imposed inputs. Their value lies in their experiential and constructivist nature that can contribute to meeting the challenge thrown down by Eriksen et al.[8] of describing and explaining the dynamism that must be incorporated into the theoretical framework of vulnerability.

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