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Coupling Nile Basin 2050 scenarios with the IPCC 2100 projections for climate-induced risk reduction

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Abstract

Scenarios are valuable tools that could support decision making under deep uncertainty, nevertheless, their potential remains untapped. The paper explores whether participatory scenario construction in the form of stories coupled with the Intergovernmental Panel on Climate Change (IPCC) 2100 projections may contribute to increased utility of the scenarios and projections for climate-induced risk reduction, in the Nile Basin. The Nile River is 6,695 kilometres long and covers a basin area of 3.18 million square kilometres (one-tenth of the African land mass). The basin is highly susceptible to climate-change induced disasters. According to the IPCC, there is high confidence that the Basin will suffer from severe shifts in biome distribution, compounded water stress, degradation of marine life and reduced crop productivity. There is also medium confidence that the Nile Basin will experience: severe decline in livestock, significant increase in vector and water-borne diseases, undernutrition, increased migration and sea level rise. The basin is already experiencing some of these key risks, on the other hand, their impact in the next 30 to 35 years is deeply uncertain. The findings of this paper are based on four scenarios, namely: Kazuri, Miskeen, Umoja and EjoHeza and data collected from two forums that were held in Jinja, Uganda and Nairobi, Kenya. The forum participants were a multi-disciplinary team of national and international stakeholders. The paper concludes that coupling Nile Basin storylines with the IPCC 2100 projections, proved to be an effective tool in increasing the utility of the scenarios and projections, for purposes of disaster risk reduction. Future work will entail analysing the uptake of the scenarios to resolve deadlocks and enhance cooperation.

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Keywords: Scenarios; Climate Change; Disaster, Risk Reduction; Risk Transfer; Adaptation; Decision Support; Futures; Deep Uncertainty; Nile; Water Management

1. Introduction

The Nile is derived from the Greek word Neilos: Neilos was the River God of Ancient Egypt. The lives of the Nile Basin citizens are woven around the Nile and it is a source of their economic, social and cultural well-being. Being the longest river in the world, with a length of 6,695 kilometres, it is located between the coordinates -4°S to 31°N and 24°E to 40°E. Its basin area occupies one-tenth of Africa in the Central, East, North and Horn of Africa regions. The basin area is 3,176,543 km^3. Its mean annual flow is 84 billion cubic meters per annum at the Aswan High dam. Though it is the longest river in the world, it does not have a very high annual flow because its main source of water is highly seasonal. The basin's highest point is 5,110 meters (Rwenzori Mountains in Uganda) whereas its lowest point is -133 meters (Qattara Depression in Egypt). In 2012, the Nile countries population was 437 million and 54 per cent of this population (238 million) lives in the basin area. The land use in 2009 comprised of shrublands and woodlands (37.3 percent), bare soils (30.8 percent), agricultural land (11.6 percent), grasslands (10.6 percent), forests (6.9 percent), water bodies (3.0 percent), and built-up areas (0.1 percent). The main Nile water use is agriculture (78 percent of the peak flow at the Aswan high dam). Due to climate change, the future of the basin is becoming

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increasingly uncertain. As a consequence, Nile decision-makers are constantly looking for tools and approaches that would support their decision-making process under deep uncertainty.

Scenarios (a set of plausible long-term futures) are useful in supporting decision-making under deep uncertainty [1]. Despite the growing acceptance of the importance of scenarios, their potential has barely been tapped. In this paper, we explore whether the development of the Nile Basin climate-change risk scenarios and coupling them with IPCC model-based projections [2] may increase knowledge on climate-induced risk reduction. Scenarios were selected because they can facilitate change of mind-frames from business as usual towards targeted solutions to the current climate change challenges [3]. Scenarios also have the potential to bridge the gap between scientists, water managers and policy makers. Thereby, increasing their uptake by the decision makers. However, to increase their uptake, as explained by Enserink et al. (2013), the scenario developers have to embrace uncertainty and thereafter communicate this to the decision makers [4]. Thissen et al. (2015) furthers the argument by stating that current uncertainties are downplayed when a political decision is urgently needed or overemphasized when avoiding political action. As a way forward, Thissen et al. (2015) proposes "a tailored combination of different approaches … combining more top-down measures with bottom-up approaches" [5]. In this paper, we have applied Thissen's recommendation through the coupling of the IPCC projections, with the Nile Basin storylines.

We selected the storyline form of scenario construction which describes how a particular future may unfold in the form of a consistent story. Storylines are an effective tool that can guide decision makers in the policy making process and provide a basis for modellers to make numerical estimates. Storylines can also be coupled with existing climate-change environmental models so as to increase the impact of both. Garb et. al (2008) states that "scenarios are social objects," yet in practice more attention is paid to the numerical results that are derived from the storyline rather than the story and process of scenario construction. Garb et. al (2008) adds that there has been insufficient coupling of the environmental models and storylines. The two are meant to strengthen one another so as to build a strong case for climate change risk reduction. Unfortunately, they have been disseminated and used separately, with very limited interweaving. He further stresses that scenarios are powerful tools of influence and this influence occurs not only when there is a knowledge change but also when there is a change in problem framing. Locally understood metaphors, phrases, names, images and even language can significantly increase the uptake of already existing environmental models [6]. Linking IPCC to local names like Umoja, Kazuri, Miske en and Ejo Heza, easily communicates the message to the Nile Basin policy makers, in a language that they are familiar with. In addition, a Nile Basin policy maker would pay more attention to scenarios developed by his or her constituents rather than scenarios developed by a panel of experts, even though both could be containing the same message. On the basis of these considerations, we selected storyline scenarios and interweaved them with the IPCC climate change projections 2000 to 2100 (for Africa), so as to increase the utility of both, as decision support tools.

2. The Scenario Development Process and Results

2.1. The Scenario Development Forum

The scenarios were developed according to the RAND Corporation methodology, also known as the 'Shell-scenarios' methodology [7]. The RAND methodology is a step by step process of working with key stakeholders to develop scenarios. In this methodology, the first step is the determination of the core question and then the contextual factors and thereafter clustering the contextual factors. The clustering of the contextual factors leads to the group determination of the driving forces. The driving forces are then ranked and based on the ranking, some driving forces are selected to develop the scenario logic. After the scenario logic is constructed, the stakeholders develop storylines around various scenarios. The refinement of the storylines takes a longer period and involves an iterative process where the storylines are subjected to existing data on the subject-area so as to ensure that they are plausible. After the completion of the storyline development process, the storylines are subjected to a validation process before being considered complete. This process is illustrated in Fig. 1 and explained, in detail, in this sub-section.

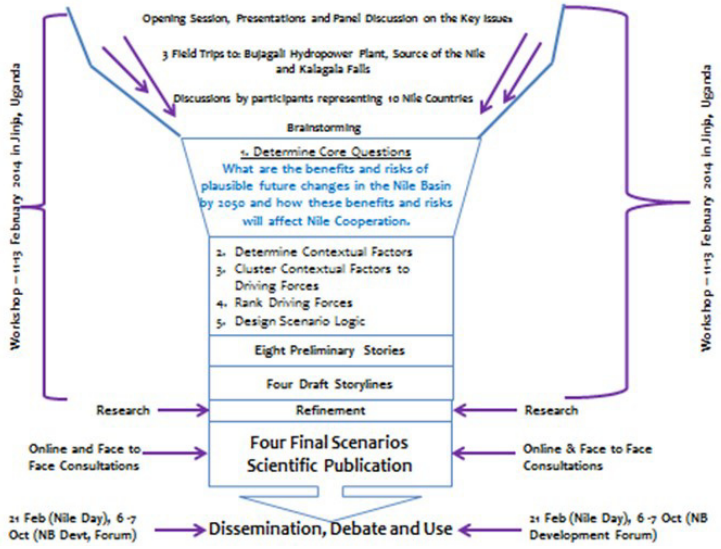

Fig. 1. The scenario development process.

The scenarios are known as the Nile Basin scenarios by 2050. They were developed in a scenario workshop titled "Futures Planning for The Restoration of Ecosystem Services through Participatory Nile Basin Scenario Construction." The workshop was held in Jinja Uganda on the 11 to the 13 February 2014. The specific workshop objective was to develop storylines of plausible futures for the Nile Basin by 2050. The Workshop participants were 24 persons, who represented the ten riparian states and formed a multi-disciplinary group of experts and stakeholders from basin, sub-basin, national and international organizations. After the workshop, there was a process of refining the storylines. Thereafter, the scenarios were presented to Nile Basin policy makers and other stakeholders during the Nile Day celebrations held in Kampala, Uganda on the 21st of February 2014 and the Nile Basin Development Forum held on 6 and 7 October 2014. During the Nile Basin Development Forum, the scenarios were presented to all the Ministry of Water Ministers from the Nile Basin riparian states, their water managers and over 400 Nile Basin stakeholders.

The main question identified by the participants was: What are the plausible future changes in the Nile Basin by 2050. Determining the question took longer than we had envisaged. This is because we had a multi-disciplinary group from all over the basin and other development actors. To determine the question, we organised brief sessions for Nile Basin expert presentations on what in their opinion are the main issues. Thereafter the participants deliberated and integrated their knowledge, experience and the information they had received from the Nile Basin experts, so as to determine the core question.

After determining the core question, the participants brainstormed in four groups and developed a list of factors that are impacting the Nile Basin system, leading to a joint list of contextual factors that influence Nile basin. Then the contextual factors were clustered into driving forces. Through different sequential steps, and reaching consensus after each step, the list of contextual factors were scrutinized, reduced and grouped. Consequently, groups agreed, based on the clusters, on the driving forces behind the changes in these factors. As a result, causal relations were distinguished and sources of change identified. From the list of contextual factors, six main driving forces were agreed upon. The six main drivers for change were: Governance; Population growth; Information/capacity/knowledge; Socio-economic development needs; Climate variability and change and Energy. Fig. 2 elaborates on the causal linkages identified between the contextual factors and the six main drivers of change.

Fig. 2. Deconstruction of the scoping process: 89 factors >38 clusters of factors > 6 forces driving change.

After reaching an agreement on what were the driving forces, the participants ranked these driving forces, according to their importance, relative impact on the Nile Basin system and their level of uncertainty. The ranking was done through an individual voting system (Fig. 3).

Fig. 3. Ranking driving forces - development needs, climate change, energy, governance, population and information.

Based on the ranking, the participants agreed to focus their scenario logic on these three key driving forces: governance, climate change and information. Climate change was preferred over socio-economic development needs because of the uncertainty of its impacts. Based on the three driving forces, a scenario logic was constructed. Thereafter, the participants developed a table (Table 1) that illustrates all the different plausible futures. From the table, the participants selected the candidate scenarios that they will detail out, from the group of eight plausible futures. The best and worst case scenarios were not selected because the participants wanted to further define a consistent and plausible future. Two other scenarios that were eliminated incorporated responsive governance and weak information sharing. This was found, by the participants, not to be consistent because one key component of responsive governance is a strong and functional information management system.

Table 1. Selection of the candidate scenarios.

Governance	**Non Responsive Not Adaptive**				**Responsive Adaptive**			
Climate change resilience	Non-resilient		Resilient		Non-resilient		Resilient	
Information sharing	No	Yes	No	Yes	No	Yes	No	Yes
Decision	Worst case OUT	IN	IN	IN	Implausible OUT	IN	Implausible OUT	Best case OUT

By having short pitches during the story writing the groups were able to come to a set of matching names and rudimentary storylines. The four scenarios were named: Kazuri, Miskeen, Umoja and EjoHeza. Thereafter, the group agreed on the terminology and the three axis for the scenario logic: “Governance” (from non-responsive/non-adaptive to responsive and

adaptive), “Information sharing and knowledge” (from not shared/restricted to shared and applied); and “Climate change:” (from high variability to low variability). Based on the above decisions, the scenario logic was constructed (Fig. 4)

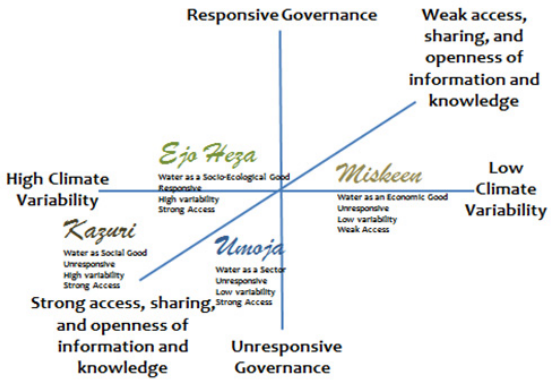

Fig. 4. The scenario logic.

The detailed scenarios are structured around the rationale, methods and drivers that we have already described earlier, in this paper. The four scenarios are not the best or the worst case scenarios; they represent some emerging potential opportunities, strengths, weaknesses and even threats that the Nile Basin may face in the near future. The initial storylines were edited and detailed by the workshop facilitators in cooperation with the workshop participants. Based on the detailed storylines, the feedback received during the Nile Day celebrations and the Nile Basin Development forum, we were able to assess the contribution of the Nile Basin scenarios to the reduction of risks that may result from future climate induced disasters.

3. Coupling Nile Basin 2050 Scenarios with the IPCC 2100 Scenarios

Each of the four Nile Basin scenarios is an illustration of the potential benefits and the potential negative consequences of pursuing a particular trajectory (Fig. 5). Two scenarios are proactive in nature (Ejo Heza and Kazuri). What triggers the stakeholders to action, in the two scenarios, are climate-change induced disasters. What differentiates the two scenarios is the governance mode that is adopted to address the social problem. In one the collective action is at all levels, but engineered using top down approaches (Ejo Heza), whereas the other governance mode focuses on horizontal networks with limited bottom up and top down interventions (Kazuri). In Miskeen, the states are not cooperating, because non-cooperation enables them to maximize their outcomes [8]. However, these outcomes are maximized in the short-term and ultimately diminish. In Umoja, the 11 riparian states unite into one supra-national institution known as the United Nile Republic, to address the climate induced risks and jointly manage the Nile Basin water resources.

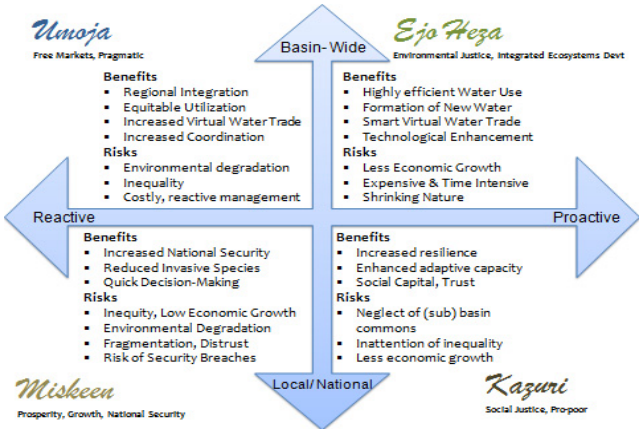

Fig. 5. The benefits and risks of the 4 scenarios.

Upon completion, the four scenarios were presented during the Nile Day celebrations in Kampala, Uganda on the 22nd of February 2014 and over 2000 printed copies of the scenarios were distributed. On October 6th 2014, the scenarios were presented to over 400 participants in the 2014 Nile Basin Development Forum (NBDF) in Nairobi, Kenya. From the outcome of the NBDF, it was evident that storylines are a very powerful policy influencing tool. We reached this conclusion because during the NBDF deliberations, the then Uganda Minister for Water and Environment, used the storylines to urge other Ministers to take action so as to enhance cooperation. He stated that he would prefer the Ejo Heza future and he is certain that none of the Water Minister's present would want Miskeen to be the Nile Basin future. He therefore urged all the water ministers to convene a diplomatic mission to Egypt to inculcate Egypt to resume cooperation. All the other Ministers of Water present agreed and it was noted in the meeting minutes [9]. The storylines led to an agreement for joint action by the policy makers to resolve the long-standing issues. This was not achieved by the IPCC projections that had been concluded earlier.

The IPCC projections may not have the same influence as the Nile Basin scenarios, because they are not tailored to the special needs of the Nile Basin. However, they are useful in increasing the utility of the storylines since they have undergone a rigorous development process involving climate change experts. The IPCC working group II's contribution to the Fifth Assessment Report (WGII AR5) identified nine key risks for climate change, in Africa, as explained in table 2. The table also provides the potential for risk reduction through adaptation and mitigation, for the above-mentioned climate-induced risks [10]. To couple the Nile Basin scenarios with the IPCC projections, we analyzed each scenario against the IPCC key risks, adaptation issues and prospects (Table 2).

Table 2. Table showing the IPCC key risks from climate change and the potential for risk reduction through mitigation and adaptation in Africa. Each key risk is characterized as very low, low, medium, high, or very high. The four Nile Basin scenarios are enumerated for every key risk and its subsequent IPCC adaptation issues and prospect. The content in the Nile Basin scenarios is derived from the storylines that were developed by the Nile Basin stakeholders in Jinja, Uganda and validated during the 2014 Nile Basin Development Forum in Nairobi, Kenya. (Source, modified IPCC Table 22-6 [2] and Nile Basin Scenarios [11]).

Key Risks	*IPCC Adaptation Issues and Prospects*	*Miskeen (Poor)*	*Umoja (Unity)*	*Kazuri (Small but Beautiful)*	*Ejo Heza (Tomorrow is bright)*	*Climatic Drivers*
1. Shifts in biome distribution, and severe impacts on wildlife due to diseases and species extinction (high confidence)	▪ Very few adaptation options; migration corridors; protected areas; better management of natural resources	▪ To address water scarcity issues, the water sector is fully privatised leading to overuse of the water without regard to the environment. ▪ This leads to a rapid decline in flora and fauna and some are becoming extinct. ▪ In response, the riparian states develop national strategies to slow down the extinction of endangered species. ▪ However, poor governance, overuse of the water without regulation and the destruction of the forests leads to a significant decline of flora and fauna despite the present of national strategies to combat this.	▪ The shifts in biome distribution is also caused by the high increase of fertiliser and chemical usage (that contaminate water) due to the low food productivity occasioned by droughts and the construction of large dams. ▪ There is an over-reliance on the Nile Decision Support System (Nile-DSS). ▪ However, the countries are surprised that despite having the Nile-DSS, they were ill-prepared for ecological surprises when their crops and livestock are severely threatened.	▪ Climate change leads to so much suffering and as a result, Kazuri emerges. ▪ Kazuri resolves the challenge of shifts in biome distribution through strong horizontal networks, self-organisation and community management of natural resources. ▪ The communities build small water reservoirs at the local level so as to ensure that the portion of water for the environment is not depleted, rear their own livestock and rear fish in fish ponds to avoid over poaching and over fishing. ▪ Through Kazuri the original balance is regained leading to preservation of biome.	▪ At the end of 2020, the Greening the Nile Commission is established to combat the severe effects of climate change. ▪ The basin is depleted and is at risk of becoming largely a desert. ▪ Greening the Nile Commission works with the governments and the communities to restore the original biome distribution thus saving many species from extinction. ▪ The Commission establishes the ecological balance to how it was in the 1800s.	▪ warming trend ▪ sea level rise ▪ precipitation ▪ sea surface temperature rise
2. Compounded stress on water resources facing significant strain from overexploitation and degradation at present and increased demand in the future, with drought stress exacerbated in drought-prone regions of Africa (high confidence)	▪ Reducing non-climate stressors on water resources ▪ Strengthening institutional capacities for demand management, groundwater assessment, integrated water-wastewater planning, and integrated land and water governance ▪ Sustainable urban development	▪ The Nile River Basin Commission is established without the agreement of all the riparian states. ▪ This leads to divisions within the basin. ▪ Countries result to unilateral actions. ▪ Private sector is given autonomy to manage national water resources. ▪ Private water boards monopolise the water sector. ▪ Water becomes a very expensive commodity that the poor can barely afford. ▪ This leads to civic unrest. ▪ There is no basin organisation to regulate water use. ▪ There is fear that the countries will go to war over the scarce resource.	▪ In 2029, the Nile riparian states established the United Nile Republic (UNR), a supra-national body. ▪ To effectively manage the Nile river resources, the UNR established the Nile River Basin Commission. ▪ The Commission focused on downstream water supply. Industrial users were given the largest share of water because the priority of UNR was economic development. ▪ This h led to inequity and a significant strain on the water resources	▪ Climate change induced water stress leads to droughts and loss of confidence in the government to resolve the challenges. ▪ As a last resort communities start to manage their own natural resources through water boards with no state regulation. ▪ Indigenous knowledge is used to build small reservoirs and harvest rainwater. ▪ Due to weak state regulation, resource rich regions remain rich while the poor ones become poorer.	▪ Establishment of the Greening the Nile River Basin Commission in 2020, for the joint management of the shared water resources. ▪ Joint water project include construction of joint multi-purpose dams, water condensation, reuse of waste water and desalination of the water from the Mediterranean Sea, the Red Sea and the Indian Ocean.	▪ warming trend ▪ extreme temperature rise ▪ sea level rise ▪ precipitation ▪ extreme precipitation
3. Degradation of coral reefs results in loss of protective ecosystems and fishery stocks (medium confidence).	▪ Few adaptation options; marine protected areas; conservation and protection; better management of natural resources	▪ In Miskeen, by 2050 there is a significant loss of marine life. ▪ The natural resources are not managed well – there is no basin body to manage the water resources and the riparian states deplete the natural resources within their territory.	▪ The basin water is contaminated by chemicals and fertilisers. ▪ There is an annual build-up of toxicity and salinity levels that is threatening marine life.	▪ Kazuri focuses on small scale community actions to address the effects of climate change. ▪ In the process, the role of the state is significantly diminished that regulatory and marine protection issues are barely addressed. ▪ The communities around the Indian Ocean, Mediterranean Sea and Red sea manage their own land resources but the marine life is forgotten.	▪ In 2020, the basin was experiencing high temperatures, sea level rise and salt water intrusion. ▪ Greening the Nile Commission addressed all this challenges through better water resources management. ▪ By 2050 marine life was no longer endangered.	▪ sea surface temperature rise ▪ ocean acidification ▪ damaging cyclone ▪ sea level rise
4. Reduced crop productivity associated with heat and drought stress, with strong adverse effects on regional, national, and household livelihood and food security, also given increased pest and disease damage and flood impacts on food system infrastructure (high confidence)	▪ Technological adaptation responses ▪ Enhancing smallholder access to credit and other critical production resources; Diversifying livelihoods ▪ Strengthening institutions at local, national, and regional levels to support agriculture and gender-oriented policy ▪ Agronomic adaptation responses	▪ Reduced crop productivity led to the cutting down of trees and cultivation of land designated for forests. ▪ This led to significant land degradation, especially in the upstream countries. ▪ The streams and rivers that were once permanent became seasonal and slowly dried up. ▪ The forest cover reduced drastically. ▪ By 2030, the Nile Basin is characterised by soil loss,	▪ The Nile River Basin Commission (NRBC) invests in large-scale agricultural projects that lead to the production of enough food for the entire basin. ▪ NRBC also hosts the Nile DSS which acts as an early warning advisory. ▪ However, since climate change issues are very uncertain, the Nile-DSS does not sufficiently prepare the decision	▪ Through the Kazuri citizen-based collective intelligence knowledge hub, individual learn how to grow drought resistant crop varieties, water harvesting, reuse of the water, small scale irrigation systems and small reservoirs, safe fertilizers to use and how to compost. ▪ This has led to increased crop productivity despite the unfavourable climate. ▪ Kazuri is a market hub where excess agricultural produce is	▪ In 2020, the Nile Basin was experiencing salt water intrusions, loss of our ground water resources, increased level of water scarcity and our desert area cover was increasing at a very alarming rate. ▪ The crop productivity in the Northern parts of the Nile Basin (Egypt and Sudan) had immensely decreased. ▪ Greening the Nile	▪ warming trend ▪ extreme temperature rise ▪ precipitation ▪ extreme precipitation

Key Risks	IPCC Adaptation Issues and Prospects	Miskeen (Poor)	Umoja (Unity)	Kazuri (Small but Beautiful)	Ejo Heza (Tomorrow is bright)	Climatic Drivers
		massive flood events and long spells of drought.	makers for ecological surprises. ▪ Increased use of fertilisers and chemical leads to the production of enough food but at a very high cost to health.	sold. ▪ Kazuri also acts as an early warning advisory on floods and droughts and other weather conditions.	Commission was established at the end of 2020 and it worked very hard and reversed the climate change effects. ▪ By 2050, the Nile Basin is food secure.	
5. *Adverse effects on livestock linked to temperature rise and precipitation changes that lead to increased heat and water stress, and shifts in the range of pests and diseases, with adverse impacts on pastoral livelihoods and rural poverty (medium confidence)*	▪ Addressing non-climate stressors facing pastoralists. ▪ Natural resource-based strategies such as reducing drought risk to pastoral livelihoods through use of forest goods and services hold potential.	▪ By 2050, there is no water. The rivers and streams have dried up. ▪ The pastoralists are highly affected because their livestock die and they have no other source of livelihoods. ▪ By 2050, pastoralists are in despair because their leaders have not addressed the climate stressors facing them.	▪ With the United Nile Republic in place, there were extensive irrigation schemes all over the basin and most of the basin population had moved to the cities. ▪ Therefore the pastoralists changed their livelihood because they had no land to herd their livestock.	▪ The pastoralists have formed their own group within the Kazuri knowledge hub where they learn from each other how to address the non-climate stressors facing them as their livestock are adversely affected. ▪ Through Kazuri they replace their current herds with more resistant breeds. ▪ They also start communal projects for planting trees and building water points.	▪ By 2020 the livestock had significantly diminished. ▪ By 2050, the quality and quantity of Nile waters had improved. ▪ This is because of the great leadership of the Greening the Nile Commission. ▪ Agriculture, livestock, have been effectively managed. ▪ The Nile Basin protected are secured.	▪ warming trend ▪ extreme temperature rise ▪ precipitation ▪ extreme precipitation
6. *Changes in the incidence and geographic range of vector- and water-borne diseases (medium confidence)*	▪ Achieving development goals ▪ Vulnerability mapping and early warning systems ▪ Coordination across sectors ▪ • Sustainable urban development	▪ Miskeen barely addresses the challenges of vector and water borne diseases.	▪ With the increased usage of fertilizers and chemicals the basin's surface and ground water is contaminated. ▪ The basin also suffers from very high salinity and toxicity levels. ▪ Unknown water –related infectious diseases seem to be emerging that the Nile DSS never forecasted.	▪ Through the Kazuri knowledge hub citizens learn how to use safe farming practices that do not affect water quality. ▪ They also have citizen sensors that they use to check water quality so that they act as early warning advisories on emerging vector and water borne diseases. ▪ Diseases are detected early and managed.	▪ The Commission also focused on green agricultural practices, such as post-harvest loss reduction, organic farming, and fish farming. ▪ In the Energy sector, the Commission changed focus towards targeted clean energy solutions ▪ This has significantly reduced diseases.	▪ warming trend ▪ extreme temperature rise ▪ precipitation
7. *Undernutrition, with its potential for life-long impacts on health and development and its associated increase in vulnerability to malaria and diarrhoea diseases (medium confidence).*	▪ Early warning systems and vulnerability mapping (for targeted ▪ interventions); diet diversification; coordination with food and ▪ Agriculture sectors; improved public health functions to address underlying diseases	▪ By 2050, the citizens cannot afford water and food, they are in despair. ▪ Lack of a long-term perspective led the basin into this disparate state. ▪ The riparian states have become so inward looking, compartmentalized and very short-sighted. ▪ The food security and nutrition of the Nile citizens is in grave danger.	▪ Food security is assured for the Nile Basin for the next century. ▪ However, with the increase the usage of fertilizers and chemicals so as to increase production and fight agricultural pests, these chemicals and fertilizers have contaminated the basin's surface and ground water.	▪ Kazuru knowledge hub has an early warning and vulnerability mapping that helps reduce a number of climate change induced risks. ▪ Through Kazuri citizens learn what the best crops to grow and buy to address the undernutrition challenge. ▪ Through Kazuri communities plan to grow diverse crops depending on their comparative advantage and trade their excess produce.	▪ Reduced crop productivity led to large import of food, malnourishment and millions dying due to lack of food. ▪ The Commission also focused on green agricultural practices, such as post-harvest loss reduction, organic farming, and fish farming. ▪ It also encouraged public-private partnerships to address undernutrition.	▪ warming trend ▪ extreme temperature rise ▪ precipitation ▪ extreme precipitation
8. *Increased migration leading to human suffering, human rights violations, political instability and conflict (medium confidence)*	▪ Adaptation deficit to current flood and drought risk; effective adaptation includes sustainable land management and modification of land use, drought relief, flood control and effective regional and national policy and legislative environment that allows for flexible adaptation responses.	▪ Water scarcity causes many Nile Basin citizens to migrate to water secure places. ▪ Floods force some of them to leave their homes. ▪ The citizens are not prepared for the disasters. ▪ Migration leads to suffering of the citizens, political unrest and conflicts for the scarce resources.	▪ The Nile Basin citizens are enjoying the benefits of having a single currency, one Government managing the entire basin and one passport. ▪ There are no restrictions on movement and the borders have been dismantled. ▪ At the end of 2050, there are extensive irrigation schemes in the Basin. ▪ Most of the Nile basin population has been moved to the cities to pave way for large scale agricultural investments.	▪ Kazuri focuses on local management of resources and through its success migration is reduced significantly. ▪ People are closer to their community and these strong networks sustain them and encourage them to stay within their localities. ▪ Subsequently, when the issue of equity is not addressed, Kazuri starts to experience a migration of people from the resource poor areas to the resource rich areas.	▪ Ejo Heza has been successful in restoring the basin, reducing the impacts of floods and droughts and introduced sustainable land management practices. ▪ The Nile Basin citizens have their basic needs met and they can make a living out of the Nile Basin resources. ▪ This the Commission has curbed the migration challenge.	▪ Sea level rise ▪ extreme temperature rise ▪ precipitation ▪ extreme precipitation
9. *Sea level rise and extreme weather events disrupt transport systems, production systems, infrastructure, public services (water, education, health, sanitation), especially in informal areas (flooding) (medium confidence)*	▪ Limited options for migration away from flood prone localities Enhanced urban management and land use control would reduce both vulnerability and exposure to risks; would require policy review, significant capacity development and enforcement.	▪ Miskeen barely addresses the challenges of sea level rise.	▪ To address the challenge of sea level rise, Umoja focuses on hard infrastructural options that are expensive, need technical knowledge and are not always environmentally sustainable.	▪ Through Kazuri, communities at the coastal areas focus on developing low-cost soft protective coastal infrastructure options could reduce risk of sea level rise.	▪ Greening the Nile Commission's first assignment was to reduce risks of sea level rise and sat intrusion at the Nile Delta. ▪ It was successful in addressing this because of its community led approaches and enhanced public-private partnerships.	▪ damaging cyclone ▪ sea level rise

4. Discussion

At the start of the coupling process, we were not certain that the two products could be combined. This is because they were developed at different timeframes, with different stakeholders for completely different purposes. In addition, one approach led to the development of qualitative scenarios in the form of storylines and the other led to projections. Another concern was the scale and focus area, one was developed for the entire world with a focus on Africa and the other one for a river basin. The projections were developed exclusively on climate change whereas the Nile Basin scenarios focused on three driving factors. Climate change was only one of these factors. Combining the two, we thought, would be a great challenge. However, we were surprised at how the two pieces fitted so well together. The storylines seemed to be addressing the key risks, in two ways. First, they gave a very detailed governance and information context within which the key risks may be embedded, in the future. This was completely lacking in the IPCC projections. In addition, it was surprising how the two seemed to communicate the same message. Second, the IPCC adaptation issues and prospects were also addressed in great detail in the storylines.

From the coupling exercise four key findings emerged. First, we realised that from coupling, you can easily identify a recurrent theme, which may form a basis for prioritising further action. In this current coupling exercise, the significance of climate governance became apparent to us. As we analysed the table, governance was the central theme that mainstreamed in all the scenarios. It was striking that the scenarios seemed to be substantiating the IPCC projections and there seemed to be no conflict in regard to the plausible futures. The same risks identified in the IPCC projections were the same risks identified in all the four scenarios. What was missing in the IPCC projections was plausible futures in regard to the governance structure that may be adopted, to address the climate induced disasters. Different governance structures yielded different results. The storylines combined with the IPCC projections communicate a consistent and strong message on the dangers of weak governance and its impact on the adaptation to climate induced disasters. The projections alone could not communicate this message. Before coupling the Nile Basin scenarios and the IPCC projections, it was not clear what the core problem was. But with the combination of the two, the storyline was very clear - good governance is key to the effective climate change risk reduction.

Secondly, we realised that coupling of scenarios may be used to check for consistency and plausibility. One of the major challenges that storylines face is the test of consistency and plausibility. We recall, during the NBDF, one of the Ministers of Water asked how we developed the storylines, with what data, with whom and how can we establish that they are plausible. In our response, we explained that the scenarios were developed by a multi-disciplinary team of experts, who checked for consistency and plausibility through an iterative process. It was hard to determine that the scenarios were credible, consistent and plausible, to policy makers who have been accustomed to data and quantitative information. IPCC projections also face credibility concerns because the world is becoming increasingly uncertain that many predictions fail the test of accuracy. If there is one inconsistent projection, the credibility of the entire IPCC projections is questioned. Hence coupling the two, increased the credibility of both products. Since one product was reinforcing another and did not contain conflicting information, it was a strong indicator of consistency and plausibility. Different products, on the same subject-matter that are developed in different contexts, may be compared through coupling, so as to check for consistency and plausibility.

Third, coupling brings to light some of the emerging issues that may be lost in projections or not emphasised in the storylines. With the storylines, we realised that based on how the story was written, there was a danger of emerging issues being construed, downplayed or lost. For example, the emerging issue on human migration was depicted in the following lines of the Umoja scenario: “The Nile Basin citizens are enjoying the benefits of having a single currency, one Government managing the entire basin and one passport.” It is not easy to drawn the linkages between a single passport and migration problems, when reading the excerpt, at the first instance. However, when reading the same story against a backdrop of the IPCC projections on increased human migration that will result in human suffering, the story is contextualised and is better understood. Some of the emerging issues that were mentioned in the storylines but were not that apparent were: the impact of climate change on human security, the contribution of climate change to violet conflicts in the Nile Basin and the issue of human migration (whether internal or cross-boundary). The coupling exercise led to more clarity, in regard to the emerging issues.

Lastly, coupling helps to ascertain the causal effect connections. The projections by themselves failed to communicate the causality. From the original table it seemed that the causal relationships were very simple. However, as we combined the stories and the projections it became apparent that the causal effect relationships are extremely complex. For instance, the cause of shifts in biome distribution was global warming, sea level rise, sea surface temperature and precipitation, according to the original IPCC table. However, when you couple the scenarios and the projections you realise that the shifts in biome distribution is also caused by construction of large dams to address the food productivity and undernutrition challenge, which lead to trapping the silt upstream, and leads to poor soils downstream and decline in productivity, that leads to the increase in use of chemicals and fertilisers which filter into the water system therefore causing severe impacts on plants and animals. Projections by themselves cannot tell this complex story. However, they help to develop a framework through which the story can be effectively communicated, thereby increasing the utility of the scenarios and the projections.

5. Conclusions

At the beginning of this paper, we argued that scenarios are powerful tools for influencing decision making on climate-change induced risk reduction. Unfortunately, this potential has barely been tapped. In addition, we argued that the Nile Basin decision

makers rarely take account of scenarios in their decision making processes. Thereafter, we explained why projections that are applied in isolation or storylines that are applied with no projections, might not be effective in influencing decision-making. We also argued that coupling of scenarios in the form of storylines and climate change projections, is essential in increasing the utility of both outputs. Based on our analysis, IPCC projections were considered the best scenarios to be coupled with the Nile Basin 2050 scenarios.

The findings we have presented suggest that scenarios coupled with projections hold a promise in increasing the utility of both the scenarios and the projections. Our findings are important in supporting scientists, water resources managers and policy analysts who develop scenarios to influence decision making. Our findings are also important for decision makers as policy influencing and decision support tools when dealing with deep uncertainty. This study offers an innovative solution to the aspiration by the developers that the scenarios and projections they develop are consistent, plausible and will eventually influence policy. Our study also raises important questions and suggestions on how to couple scenarios and projections. Since this is a very new area and very few researchers have coupled scenarios in the past, we did not find an existing framework to guide the process. As a result of conducting this research, we propose more emphasis on the social perspectives of scenario development. It would be fruitful if future scenarios do not focus only on projections but also the story that supports the projections and the process that led to the development of the scenarios. Future research should focus on developing a framework to support coupling of scenarios with system models and projections.

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