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Participatory analysis of water-related conflict risks in complex adaptive systems – the case of the Inner Niger Delta in Mali

Karen S. Meijer[a*], Rozemarijn ter Horst[b], Euan Mackway-Jones[c], Luca Ferrini[d], Beteo Zongo[e], Mori Diallo[f], Ibrahima Sado Fofana[e] and Karounga Keïta[e]

[a]Climate Change and Risk Programme, Stockholm International Peace Research Institute (SIPRI), Solna, Sweden; [b]Water Resources Management Group, Wageningen University & Research, Wageningen, The Netherlands; [c]Social and Human Sciences Sector, UNESCO, Paris, France; [d]Global Programs, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ GmbH), Niamey, Niger; [e]Sahel Office, Wetlands International Sahel, Bamako, Mali; [f]Sevare-Mopti Office, Wetlands International Sahel, Sévaré, Mali

ABSTRACT

To avoid negative societal implications from water management actions, the complex interrelations between water and conflict need to be understood. Assessment of such links in complex adaptive systems, characterized by various factors which mutually influence each other, is challenging. This paper explores how the use of participatory methods can support the identification of water-related conflict risks in one such complex adaptive system: the Inner Niger Delta in Mali. We find that participatory analysis not only facilitated the identification of systemic risks in a complex adaptive system, but also shapes the perceptions of these interlinkages.

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water-conflict nexus; complex adaptive systems; systemic risk; participatory identification of risks; Inner Niger Delta; Mali

Introduction: participatory analysis of human behaviour in complex adaptive systems to address the water-conflict nexus

Research on the water-conflict nexus has shown that whether tensions around water issues result in violence depends on local social, economic and political factors, and is therefore largely context specific (Meijer & Kim, forthcoming). Similarly to findings on the links between climate and security (Kim & Garcia, 2023; Mobjörk et al., 2020) it is possible to identify different mechanisms through which such water-conflict links can play out. For example, increased scarcity of water and water-related resources can result in clashes between different communities who use these resources for their livelihoods. When people migrate in search of better living conditions, they may increase pressures on resources and services in host communities, resulting in conflicts. At the same time, armed

CONTACT Karen S. Meijer karen.meijer@sipri.org
*At the time of the research: Water Resources and Delta Management Department, Deltares, Boussinesqweg 1, 2629 HV, Delft, The Netherlands

groups may exploit such deteriorating livelihood conditions, particularly in situations where people feel marginalized by government. Whether changes in water result in violent conflict not only depends on water quantity, but also on access to water (Audu, 2013; Keskinen et al., 2007), and the options people have to respond. In addition, pre-existing grievances, tensions between communities and negative feelings towards government, influence how easily tensions can escalate to conflict (Cederman et al., 2013; Gurr, 1993).

Such interactions of multiple factors, where effects can feed back to enhance causes and where factors link across subsystem boundaries, are characteristic of complex adaptive systems. Complex adaptive systems-thinking builds on insights from system dynamics, adjusted to analyse complex, unpredictable, uncertain and conflictual situations where cause and effect are difficult to discern (Brincat, 2017). In the next section we introduce the concept of complex adaptive systems in more detail, with specific attention for its application to the water-conflict nexus.

In order to develop effective water management measures that do not inadvertently contribute to tensions and violence, it is important to get a better understanding of how intervening in a complex adaptive system may play out. Moreover, a better understanding of underlying causes of existing conflict and violence could be used to design water management in such ways that could reduce such risks. Although the literature, as mentioned above, discusses various factors that influence whether changes in water systems and management of such systems can result in conflict, context specific analysis of system linkages are needed to understand how people respond to changes in the system they depend on.

However, gaining such an understanding of complex adaptive systems, which is challenging, in itself, due to its complexity, is further challenged if it includes violent conflict. Conflict zones are typically difficult to access and assess, often making data collection, observation and interaction with the individuals and groups involved in violent conflict not possible, or highly limited. In situations where insecurity hampers fieldwork, we argue that employing participatory methods with stakeholders that represent or have knowledge of different elements of the water-society system supports the identification of water-related conflict risks. Through participatory methods, highly complex situations can be discussed in a structured way with a larger group of stakeholders who may each have only a partial understanding of the system, within a timeframe of several hours (which can be extended to increase the quality of results), with results that can be shared with others for further scrutiny and discussion. Moreover, we emphasize that to identify sustainable solutions to conflicts, it is important that relevant stakeholders are actively and dynamically engaged in the analysis of a specific situation.

In this paper, we explore how the use of participatory methods can support stakeholders in the identification of water-related conflict risks in one such complex adaptive system: the Inner Niger Delta in Mali. The Inner Niger Delta is a large wetland (around 15–20 km^2 depending on river inflows) where the livelihoods of the two million inhabitants strongly depend on wetland ecosystem services (Madgwick et al., 2017). The area is experiencing increasing levels of violent conflict. As we elaborate in the method section, during a three day workshop with stakeholders in Bamako, Mali, in July 2019, we used different participatory methods and participant surveys to understand how the

participants perceived the links between water and conflict in the Inner Niger Delta, and how this thinking changed during the workshop as a result of the exercises.

In the Results section we use both the outputs of the participatory exercises and the feedback provided by the participants to assess the value of our approach to analyse the water-conflict nexus. In the Discussion section we reflect on the usefulness and limitations of approaching the water-conflict nexus and related systemic risks in the Inner Niger Delta as a complex adaptive system, and the value of participatory approaches to its analysis.

Theoretical framework: complex adaptive systems and the water-conflict nexus

Complex adaptive systems

A system, at its most basic, can be seen as 'any group of interacting, interrelated or interdependent [elements] that form a complex and unified whole that has a specific purpose' (Kim, 1999, p. 4). The performance of the system thus depends on how the different elements of a system are arranged and organized. For analytical purposes, system-thinking identifies a boundary as conceptual frontier beyond which elements can no longer be determined as influencing/being part of a system. The distinguishing factor between general (linear) systems and complex adaptive systems, is that the latter are constantly evolving, adapting and self-organizing; they interact with and are shaped by interactions with other systems, resulting in both unpredictability and emergence (the realization of behaviours or properties which only emerge when interactions across the system(s) occur in a wider whole (Brincat, 2017; De Savigny & Adam, 2009)). As a result, cause and effect patterns are difficult to unravel (Arnold & Wade, 2015).

Complex adaptive systems exhibit emergent properties which give rise to unexpected behaviours. These include; i) self-organization, which entails that system dynamics arise from the internal structure of the system, ii) constant changes, meaning that systems are constantly adapting to internal and external stimuli, often in a way that is unpredictable, iii) systems are controlled by feedback loops, moderating behaviour as elements 'react and back react' on one another, iv) non-linearity, relationships within a system cannot be arranged along a simple input-output model and v) different systems are tightly linked, meaning there are high levels of connectivity between and across systems: changes in one sub-system affect others (negatively or positively) (Brincat, 2017). In the Methods section we explain how we assess the presence of these emergent properties in the Inner Niger Delta in Mali.

The concept of complex adaptive systems guides decision-making on how to influence hyper-connected, complex, unpredictable, uncertain and conflictual situations. Although attempts to understand system links could quickly result in an oversimplification of the situation, building up on ideas of linearity, boundaries, rational choice and causal relations, a complex adaptive systems-based analysis helps to gain understanding of the interplay between different factors, and in understanding that the impact of certain changes is contingent on the presence of other factors. A complex adaptive systems-based analysis gives complexity and uncertainty a central role, opening the door for

additional knowledge to be added, assumptions to be verified or contested, and greater priority afforded to micro-level interactions within the system(s).

Complex adaptive systems, water-conflict nexus and systemic risk

Recognizing systems as complex adaptive systems can also support the identification of systemic risks, which are central to research on the water-conflict nexus. Systemic risks, at their most basic, can be understood as the transference of 'instability and shock across network linkages' (Wyrwoll et al., 2018), which can in turn cause a major breakdown in the achievement of systemic purpose, and induce other unintended consequences. For example, these systemic risks can cause a collapse of financial systems in case of a bank crash, or of a river ecosystem when animals or plants can no longer survive in its waters and affect other species dependent on these animals and plants. Systemic risks are therefore these interdependencies in the system that mean that changes in a certain element result in such changes in other elements, causing tipping points to be crossed and preventing the system to return to its original state. The system will remain permanently changed, which can cause collapse. The analysis of systemic risks therefore places emphasis on identifying the ways these risks can 'travel' through a system, identifying dependencies and connections between humans and non-humans, sectors and places. For various system factors, their future value is unknown. The system outcomes are therefore contingent upon variations or development in these factors. Similar observations have been made regarding the complex interlinkages between water availability, cooperation and conflict (Benjaminsen & Ba, 2009; Schmeier et al., 2019; Selby et al., 2017).

We include here an example of a systemic risk in relation to water and conflict to clarify: lack of water, in combination with social, economic and political factors, can result in tensions. In the absence of effective dispute resolution mechanisms these tensions can result in violence. Violence in turn can result in further livelihood deterioration when insecurity limits access to certain pastures or markets. Such a vicious cycle of livelihood deterioration, tensions and violence forms an example of a systemic risk where drought or poor water resources management contribute to insecurity. Of course, these consequences are contingent on other factors (the previously mentioned social, economic and political factors), for example, significant population growth which increases the need for food production and water, cultural rules that determine that only men who own land have a say in the community, grievances against the state for not coping well (or fairly) with scarcity and influences of religious extremist ideas from surrounding areas. Identifying these dependencies helps to understand the possible consequences of drought or water management actions. In addition, it gives insight into what other types of action, i.e., those to address the relevant social, economic or political factors, could reduce the societal impacts of drought or water shortage.

System level versus human behaviour

Human behaviour is central to the way in which the system responds to influences from both within or outside the system. Despite the importance of human behaviour, most complex adaptive systems analyses focus on the system level and do not assess, in detail,

why and how human behaviour changes (Holland, 2006). Understanding human behaviour is of critical importance when addressing the water-conflict nexus: 'What leads people to pick up arms and engage in violent behaviour?' And as important, 'Why do others facing the same circumstances refrain from violence?' For instance, due to the construction of a dam, the flow regime of the downstream river changes, and fish resources decline. A fisherman perceives this as a threat as he foresees he will not be able to catch enough fish to sustain his current way of life. He would like to change jobs to become a truck driver, for which he is very motivated. However, he is not able to change jobs, since he does not have a driver's licence nor a truck.

Case study: the Inner Niger Delta

With its more than four million hectares (Ramsar Convention, 2004), the Inner Niger Delta is the third largest Ramsar wetland in the world and the largest in West Africa. Natural floodplains such as the Inner Niger Delta provide a large variety of socio-ecological services, such as flood regulation, aquifer recharge and provision of food, feed, fibre and building materials. The Inner Niger Delta is fed by the rivers Niger and Bani of the Upper Niger catchment and located in central Mali (see Figure 1). Selingue is one of the major dams in the upstream catchment, and another large dam near Fomi is

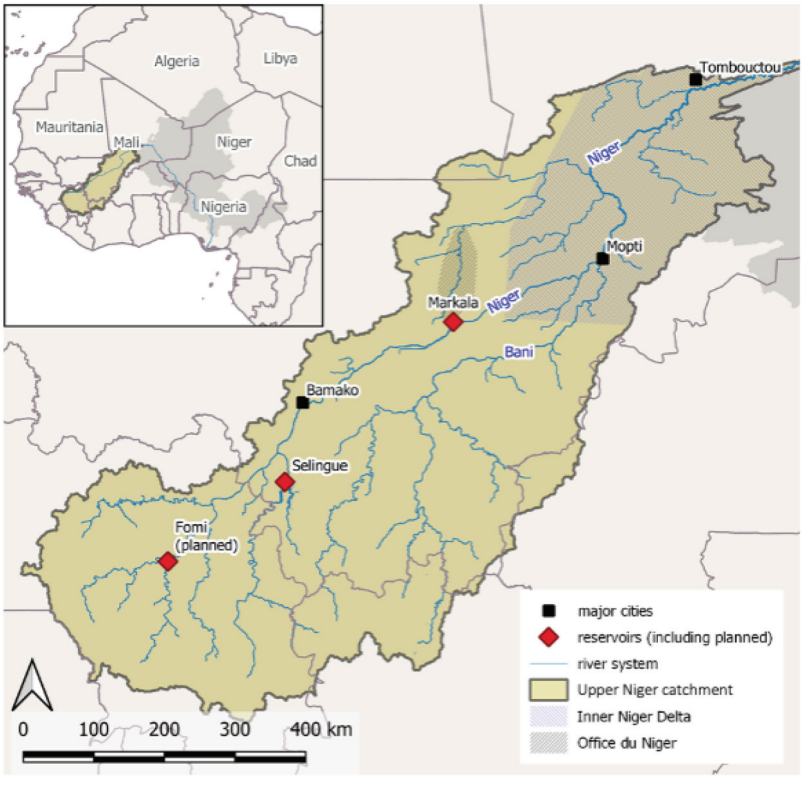

Figure 1. Overview of the Niger Upper catchment which discharges into the Inner Niger Delta (top right) (reused with permission from Meijer et al., (2021)).

planned. In addition, a weir at Markala diverts part of the Niger discharge to the irrigated area of Office du Niger. The delta includes three major ecosystems: river-lake systems, swamps and plains and is home to two million people, broadly represented by herders, farmers and fishermen/women, all of whom depend directly on the Delta's natural resources (De Noray, 2003).

Fulani herders (also known as Peul), Bozo and Somono fishermen and Dogon and Bambara farmers have long been in conflict over land use (grazing vs. farming land, land tenure issues, etc.) and, during the dry season, also over access to water resources (Mitra, 2017; Sandor, 2017). These conflicts have deepened since the end of the 1980s. A reduction in the river's discharge has been observed, as well as a decline in the extent and duration of wetland inundation, which is essential for maintaining fish stocks and ecosystem health (De Noray, 2003; Zwarts et al., 2005). Fish populations are diminishing since the beginning of the century (Food Security Cluster, 2018). Data show a concentration of violence against civilians in central Mali, around the city of Mopti, which is in the middle of the Inner Niger Delta (Nsaibia, 2023).

Within the context of an armed conflict, natural resource management becomes more difficult and at the same time more important. Infrastructure maintenance, production support programmes or land use monitoring are important instruments to react to the conflict and limit the depth of its consequences. Furthermore, the impacts the conflict has had on fishermen and breeder's movements, along with a weakening of legal institutions in the region (Sandor, 2017; Ursu, 2018), have heightened and radicalized natural resource-related conflicts, already exacerbated by frequently extreme climatic conditions. The population of the Inner Niger Delta region possesses deep-rooted knowledge for the peaceful and balanced management of these types of complex problems. A way that used to effectively bring these experiences and knowledge together is the annual '*conference des bourgoutières*'. In these annual conferences Inner Niger Delta users agreed on the date at which cattle are allowed to enter the Inner Niger Delta. However, nowadays these agreements seem no longer to be respected, resulting in overgrazing and conflicts between herders and farmers.

Methods

Participatory methods to analyse the water-conflict nexus in the Inner Niger Delta as a complex adaptive system

As explained above, the objective of the study presented here is to assess whether participatory methods can support stakeholders in the identification of system risks related to water and conflict in a complex adaptive system, based on the case of the Inner Niger Delta. The participatory methods were conducted during a workshop in Bamako in July 2019.

This workshop was organized in the framework of the Water, Peace and Security partnership (Water, Peace and Security partnership, 2023), with the purpose to involve stakeholders in an analysis to better understand the linkages between water-related risks and security challenges, and the potential actions that can be taken to address them. The invited participant organizations were identified through mapping the level of responsibility and the interest of the different

actors that can influence or may be influenced by changes in the Inner Niger Delta. These organizations include local communities, local and regional decision-makers, civil society and socio-community organizations. The individual participants are chosen by the leaders of the above-mentioned actors with reference to an invitation letter which emphasizes the importance of representing vulnerable groups, such as women and young people. Although the exact selection of stakeholders was thus not fully within our control, the workshop was attended by a mix of men and women, of different ages, representing both government authorities and NGOs.

Of the 20 participants, three identified themselves as working in the security or resilience sectors, including defence, and all others (17) as working in the water and/or environment sector(s). All were working in the capital of Mali, mainly in relation to national policies and programmes. One participant had specific experience working in the Inner Niger Delta at local level. The full duration of the workshop was two and a half days, starting with an introduction to Water, Peace and Security by the facilitators and an introduction of the participants, followed by two half days of participatory analysis.

Two participatory exercises were conducted during which the participants jointly analysed the Inner Niger Delta as a case of water-conflict nexus. Complex adaptive systems analysis generally focuses on system level. We assert that human behaviour at individual or group level is important to understanding system level change. For this reason we conducted two participatory activities, the first focused on the water-conflict nexus at system level, the second on human responses to changes in availability of water and water-related ecosystems services. This relates to calls for applying multiple methods to understand complex situations (Ide et al., 2020; Mingers, 2001), providing a middle ground between deductive and inductive approaches.

Activity 1: participatory analysis of the water-conflict nexus at system level

The participatory analysis of the water-conflict nexus at the systems level was based on the activities proposed in the group model building approach (Vennix, 1996, 1999). This method is a problem structuring method that supports outcomes to be shared with, and understood by, others. This is done by developing a qualitative system dynamic model, also referred to as a causal-loop diagram, in which causal links between factors are made explicit by visualizing how various factors interact. To analyse the water, peace and security aspects at play in the Inner Niger Delta, the groups were invited to follow the following steps; 1) identification of the central issue of concern, 2) discuss how this issue has changed over time, 3) identify causes and consequences of this trend and 4) map the links between the central issue, causes and consequences. The groups were not fully moderated, but moderators were present to ask probing questions, such as 'how do variables influence each other' and 'are additional variables needed to understand the influence of one variable on another'? The participants worked in two groups of 10 persons, and subsequently presented their analysis to the other group, resulting in further discussion and elaboration of the analysis. Although we based the session on the group model building approach, groups discussed amongst themselves, and only loosely applied group model building-conventions. The main aim was to encourage a structured

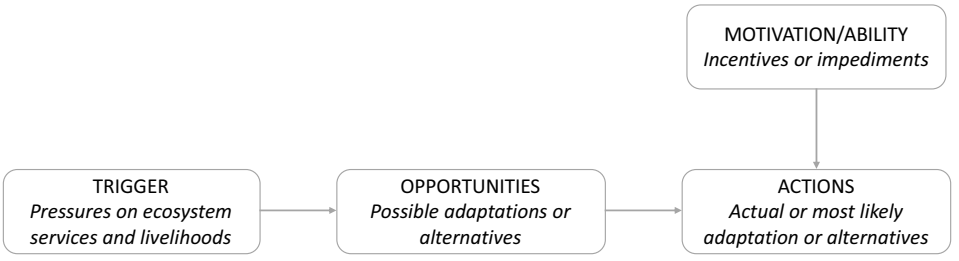

Figure 2. Conceptual model to represent the Motivation-Ability framework applied to situations of environmental conflict.

and constructive discussion between participants of how changes in the system caused or were caused by changes in other factors. The results would perhaps be labelled a 'mind map' rather than a 'causal loop diagram'.

Activity 2: participatory analysis of human responses to changes in availability of water and water-related ecosystems services

The second participatory exercise moved from system level to behaviour of specific societal groups. A simplified version of the Motivation-Ability framework (Phi et al., 2015) was introduced as a concept model to facilitate the joint analysis of human behaviour, explained below and shown in Figure 2. This framework explains human behaviour as a combination of an individual or group being motivated to do something, in combination with being able to change towards a certain behaviour or action in response to perceived opportunities or threats resulting from a trigger (e.g., environmental pressures).

The participants were randomly divided into two groups, in a different composition than during the group model building exercise. Each group was invited to focus on one socio-economic group active in the Inner Niger Delta: cattle herders, fishers or farmers, and imagine themselves to be in the shoes of one of these stakeholder groups. Participants were then asked to choose one risk factor identified in the group model building as a 'trigger' in this framework, in Figure 2 included as 'Pressures on ecosystem services and livelihoods'. The participants then identified how this trigger would be perceived by their socio-economic group, what possible ways to act upon this trigger existed for this group (adaptations/alternatives) and what incentives or impediments would affect the motivation and ability to pursue one or more of these options in reality (actual or most likely adaptation or alternatives).

On a poster the participants added their reflections on post-its, and jointly identified the lines of thought that they largely agreed upon. The analysis was undertaken with the full involvement of all participants and was rapid and non-comprehensive, and should be considered a first step in the development of a shared perception of water-security links in the Inner Niger Delta. The Motivation-Ability analysis and participatory systems analysis do gain explanatory power in conjunction.

Research questions and approach

Three sub-questions guide our research on the whether participatory methods can support stakeholders in the identification of system risks related to water and conflict in the Inner Niger Delta as a complex adaptive system.

(1) Can the Inner Niger Delta be characterized as a complex adaptive system?
(2) Can systemic risks be identified from the results of the participatory methods?
(3) Have the participatory methods contributed to a changed understanding of the links between water and conflict, and related systemic risks?

Research question 1. Can the Inner Niger Delta be characterized as a complex adaptive system?

To identify the extent to which the Inner Niger Delta qualifies as a complex adaptive system, we compare information on links between water and security in the Inner Niger Delta with the following complex adaptive system characteristics as developed by De Savigny and Adam (2009).

- Self-organization: System dynamics arise from the internal structure of the system – in other words, it is the dynamics between the different agents within the system, and the interaction of the system to other related systems, which come to determine the nature and characteristics of a system.
- Constant changes: Systems are constantly adapting to internal and external stimuli, often in a way that is unpredictable – in other words systems can react to the same stimuli (inputs) in adaptive and sometimes unpredictable ways, determined by the particular configuration of interactions and feedback loops within and between the system(s) at a given time.
- Governed by feedback: Systems are controlled by feedback loops, moderating behaviour as elements 'react and back react' on one another. Such feedback could result in oscillations or exponential growth over time and can result in changes to the expected results emerging.
- Non-linearity: Relationships within a system cannot be arranged along a simple input-output model. In other words, the effects or consequences emerging from systems level interventions are often only vaguely related to the intentions of original interventions/inputs.
- Tightly linked: High levels of connectivity between and across systems: changes in one sub-system affect others (negatively or positively). In other words, because of the interconnectedness between systems and sub-systems within a complex adaptive system, it can be expected that changes in the dynamics/functioning of one area will have profound consequences on the dynamics/functioning of another.
- History dependence: Effects may not be evident immediately and very often are subject to time-delays due to the complex make up of a complex adaptive system; short term effects may be insufficient to generate continued support for an intervention.

- Counter intuitive: Cause and effect within a complex adaptive system is very difficult to determine, and the functioning of one intervention at a particular moment may generate different effects than the functioning of the same intervention at a different moment owing to the different dynamics within the complex adaptive system at any particular moment.
- Resistant to change: Interventions may not generate desired outcomes if the bottlenecks and barriers are too entrenched and the dynamics of the system are not understood well enough.

Data collection for research questions 2 and 3

The results from the participatory activities formed part of the collected data. In addition, we collected data on how the perception of the causes and consequences of changes in water-related issues changed during the workshop. As shown in Figure 3, the participants received a questionnaire at the beginning of the workshop, to establish a baseline of how they perceived water-security linkages in the Inner Niger Delta. The questions asked were:

(1) According to you, what is the central problem related to water and security?
(2) Can you describe the most important causes of this problem?
(3) Can you describe what are, according to you, the most important effects of this problem?
(4) Can you think of three options to resolve this problem?

Question 1 is posed in a general manner to avoid directing answers in a certain direction, while being aware of the influence the selection of participants and the communication on the topic of the workshop already has. We expect some overlap in answers to the different questions because some people may interpret 'problem' as a 'cause' and others as an 'effect'. We included a separate question about the problem to allow participants to consider the same issue from different angles.

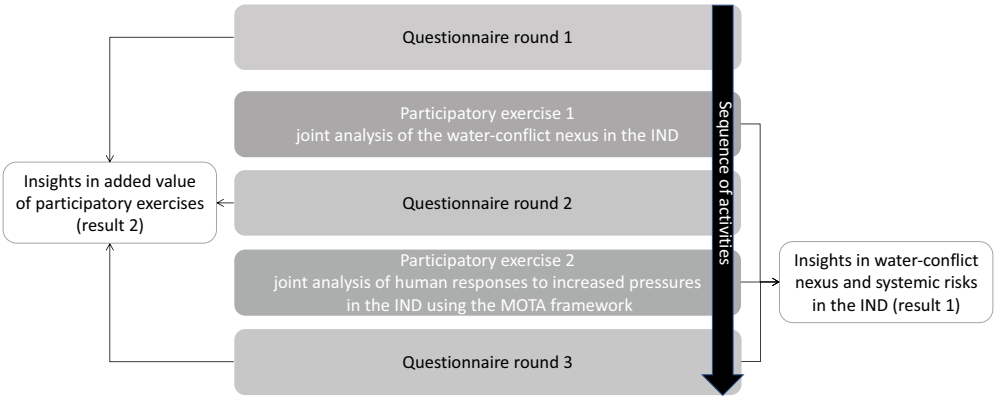

Figure 3. Structure of the research.

The participants were asked to fill out the same questionnaire after the participatory systems analysis session and a third time after the Motivation-Ability session, to be able to identify whether the answers of participants changed as a result of workshop activities. Questionnaires were anonymous and marked by a number chosen by participants themselves to ensure grouping of the three questionnaires corresponding to one participant. As a result, 54 forms from 20 people were made available to us as facilitators for analysis. Eighteen people provided three filled out questionnaires each. Two participants provided only one questionnaire and were therefore left out of further analysis.

Research question 2. Can systemic risks be identified from the results of the participatory methods?

To answer research question 2 we analysed the outputs of the participatory exercise and the answers from the third round of the survey. We identify as 'systemic risks' all factors that have the potential to travel across sub-system (e.g., water, security) boundaries to affect the functioning of the interlinked water-society system.

Research question 3. Have the participatory methods contributed to a changed understanding of the links between water and conflict, and related systemic risks?

To analyse the evolution in the answers, which we attribute to the participatory activities, we considered the change in the content of the answers between the different survey rounds.

Results

Identifying the Inner Niger Delta as a complex adaptive system

As the conflicts over resources in the Inner Niger Delta have several root causes as well as effects that in turn create more conflict, it is challenging to unravel causes and consequences. In Table 1 we analyse to what extent characteristics of complex adaptive systems, as identified by De Savigny and Adam (2009) apply to the Inner Niger Delta.

The analysis does not do full justice to the complexities of the Inner Niger Delta, but serves to show how the Inner Niger Delta demonstrates the characteristics of a complex adaptive system. Based on the analysis, we can conclude that the integrated water-society system of the Inner Niger Delta can be considered a complex adaptive system, in which conflict risks can have links to water.

Table 1. Application of complex adaptive system characteristics on the Inner Niger Delta.

Characteristics of a complex adaptive system	Relevance in the Inner Niger Delta
Self-organization: System dynamics arise from the internal structure of the system	The Inner Niger Delta´s large wetland ecosystem is home to thousands of species (including migratory ones) and directly provides sources of livelihood for over two million people, of both sedentary and nomadic lifestyles. The economic activities in the Delta provide agricultural produce (fish, rice, meat) to other regions in Mali and beyond. The natural seasonal flooding of the Delta makes it and its inhabitants highly vulnerable to fluctuations in rain patterns, river flow and climate change (Dickens et al., 2018; Haque et al., 2020; Schep et al., 2019). The large variety of ethnic groups, coupled to the region´s attractiveness to nomadic populations seeking pastures for their cattle during the dry season, results in frequent confrontation of groups, and adjustment to new socio-economic dynamics, especially in the (perceived) absence of national government (representatives; Adekola & Mitchell, 2011).
Constant changes: Systems are constantly adapting to internal and external stimuli, often in a way that is unpredictable	Intensifying agricultural practices and population pressures on land and forests are internal stimuli (Schep et al., 2019). Increasing water withdrawals, dam construction and dam management upstream are external stimuli (Haque et al., 2020). All are only partly predictable and quantifiable, particularly those like dam construction taking place beyond national borders (e.g., in Guinea; Seidou et al., 2020). Climate change, migration, armed conflict and state-society relationships (e.g., presence/absence and rent-seeking behaviour of state officials, police, gendarmerie, eaux et forets, etc.) can also be internal and external stimuli. 'Three structural factors are the main drivers behind conflicts: agricultural encroachment that obstructed the mobility of herders and livestock, opportunistic behavior of rural actors as a consequence of an increasing political vacuum, and corruption and rent seeking among government officials' (Benjaminsen et al., 2012).
Governed by feedback: Systems are controlled by feedback loops, moderating behaviour as elements 'react and back react' on one another	The Inner Niger Delta is experiencing changes in rainfall patterns, increasing soil erosion, deforestation and sedimentation, as well as loss of biodiversity and changes in its ecosystem (Schep et al., 2019). In addition, the presence of armed rebel groups and non-state governance structures (traditional or imposed by rebel groups) causes submission, reactionary behaviour, migration or changes in economic and cultural practices by certain socio-economic groups (Benjaminsen et al., 2012). Natural and human changes affect the choice of human settlement, create conflict on hotspots of resource availability and local migration to make up for changes in pressure on resources.
Non-linearity: Relationships within a system cannot be arranged along a simple input-output model	Tensions around access to water for different uses, cultural-religious pressures on populations to shift towards specific agricultural practices (e.g., growing *bourgou*) and conflicting governance systems for obtaining access to land and pastures create uncertainty and overlapping policing systems. The presence of rebel groups, societal tensions around belonging and allegiance form new categories of identity and conflict. Changes in access to areas, to markets, to decision-makers and to the justice system create new hierarchies and networks (Pérouse de Montclos, 2018).
Tightly linked: High levels of connectivity between and across systems: changes in one sub-system affect others (negatively or positively)	This is the core of the water-conflict nexus. The worsening security and stability situation in central Mali is itself a dimension of vulnerability, strongly connected to many aspects of human and natural life. Dynamics in the water system, its management and its link to socio-economic activities based on the natural resources of the Inner Niger Delta are inextricably linked to the conflict system (Tobie, 2017).

(*Continued*)

Table 1. (Continued).

Characteristics of a complex adaptive system	Relevance in the Inner Niger Delta
History dependence: Effects may not be evident immediately; short term effects may be insufficient to generate continued support for an intervention	A reduction in the rate of deforestation can have a positive long-term impact on limiting soil erosion and sedimentation. But immediate pressure for biomass and firewood most often prevail, particularly for the poorest and most vulnerable (Benjaminsen et al., 2012; Ursu, 2018). Another example is the deterioration of social contracts between different communities, for instance, based on reduced access to water and pastures that leads to competition over natural resources between societal groups.
Counter intuitive: Proven or effective interventions in one setting fail to deliver when transposed into a different context	Measures addressing conflict and instability and strengthening climate resilient development sometimes have unintended negative effects, deteriorating the security situation even further or simply shifting the problem elsewhere. Efforts to channel water to communities having water access problems, to restore land and improve its productive use, have, in some cases, resulted in conflict with surrounding communities and other resource users, such as herders and cattle breeders, often belonging to different ethnic groups or communities, who have attempted to benefit from the improved infrastructure for their own economic activities (Mitra, 2017).
Resistant to change: Interventions may not generate desired outcomes if the bottlenecks and barriers are too entrenched	Some scholars have argued that the militarization of the conflict by the Malian army and its international allies has entrenched the resistance of the armed non-state groups who find in the rent-seeking behaviour of state representatives (including the army, but also state official and police forces) the very justification of their battle (Pérouse de Montclos, 2018).

Identification of systemic risks on water and conflict through participatory analysis – contents of the results

Systemic risks are identified by finding those factors, that, if changed, would result in changes in other factors that could propagate through the system and result in system 'collapse' (Wyrwoll et al., 2018). Identifying systemic risks thus starts by understanding (causal) links, and possible reinforcing or balancing feedback loops. Therefore, we assessed the water-conflict links identified by the participants in the participatory system analysis exercise (exercise 1) and the Motivation-Ability exercise on understanding human behaviour in the context of water and security (exercise 2). We also compare this with what participants identified as main risks in the questionnaires.

The two groups chose different starting points for their analysis. Group 1 chose 'insecurity in the Inner Niger Delta' (Figure 4), and group 2 ´poor water management´ (Figure 5). Despite these different starting points, two similar clusters of factors are identified by both groups. Cluster 1 is the cluster ´natural resources – climate change – water availability´: natural resources are the source of livelihoods for all groups in the Inner Niger Delta (farmers, fishers, cattle herders) and climate change and human activity change access to these natural resources, thus changing equilibria between socio-economic groups and therefore bringing tension.

Cluster 2 is the ´insecurity – violence – state presence – governance´ cluster. Here starting points are different: in some cases insecurity and violence are considered to make it difficult for the state to be present and ensure law enforcement effectively; in other cases (arguably deeper-looking) a lack of clear and effective governance gives rise to alternative and parallel systems of governance and law enforcement (religious or non-religious). In a multiplicity of

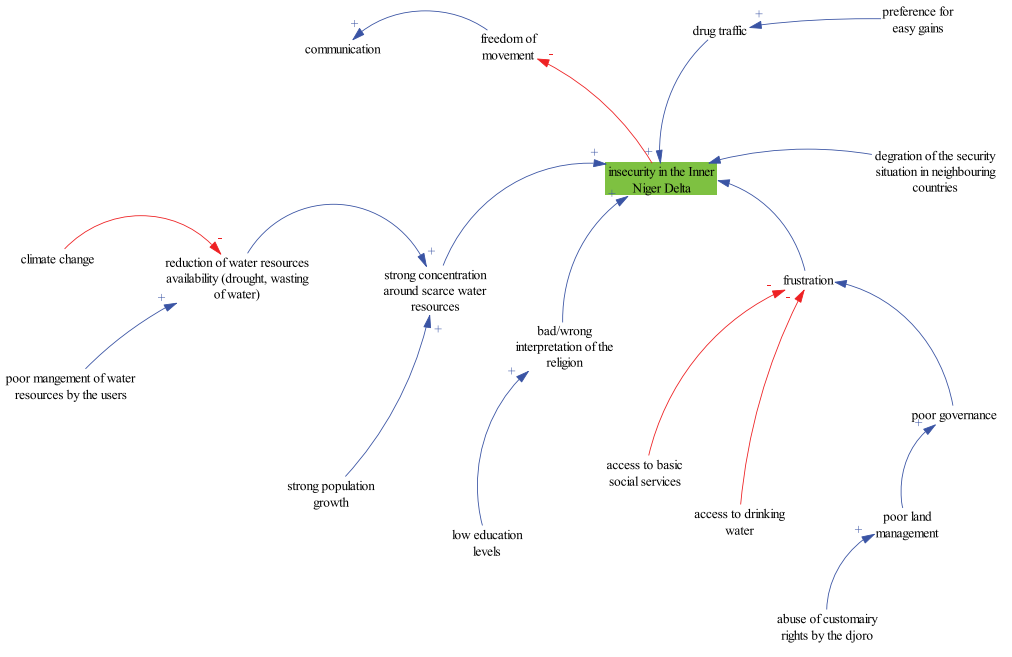

Figure 4. Result of water-security system analysis – group 1. Red arrows with minus signs represent a negative relationship between factors (an increase in one factor results in a decrease in the other). Blue arrows with plus signs represent a positive relationship between factors (an increase in one factor results in an increase in the other).

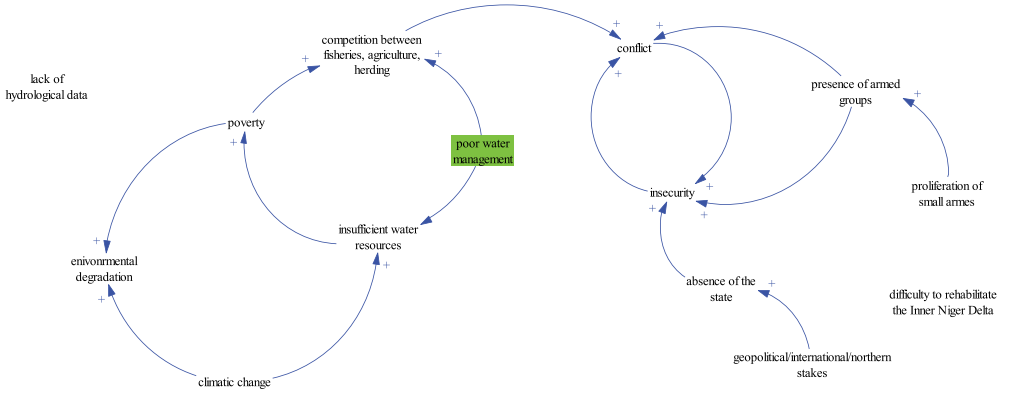

Figure 5. Result of water-security system analysis – group 2. Red arrows with minus signs represent a negative relationship between factors (an increase in one factor results in a decrease in the other). Blue arrows with plus signs represent a positive relationship between factors (an increase in one factor results in an increase in the other). The group did not identify how two factors that were identified in the discussion (lack of hydrological data; difficulty to rehabilitate the Inner Niger Delta) were connected to the rest of the system.

governance structures the state is weak and is not able to ensure its presence, and this gives rise to violence where governance systems are in conflict (access to land, right to access water points).

Although the two clusters have various separate factors, participants connected 'strong concentration around scarce water resources' and 'competition between fisheries, agriculture, herding' to 'insecurity' and 'conflict'. The two diagrams identify similar important underlying causes such as 'poor governance', 'absence of the state' or 'poor water management'.

The second exercise which focused on behavioural analysis based on the adapted Motivation-Ability-framework identified similar factors and added an additional dimension; the possible actions of actors and the potential factors that are conducive to this behaviour. After identifying various options for the broad groups of farmers (Figure 6) and herders (Figure 7) in the Inner Niger Delta, participants discussed, for some adaptation actions or alternatives what could be motivations to engage or not in these activities.

From the system and the behavioural analyses a number of driving factors, or small causal chains, can be derived that participants perceived as important to water and

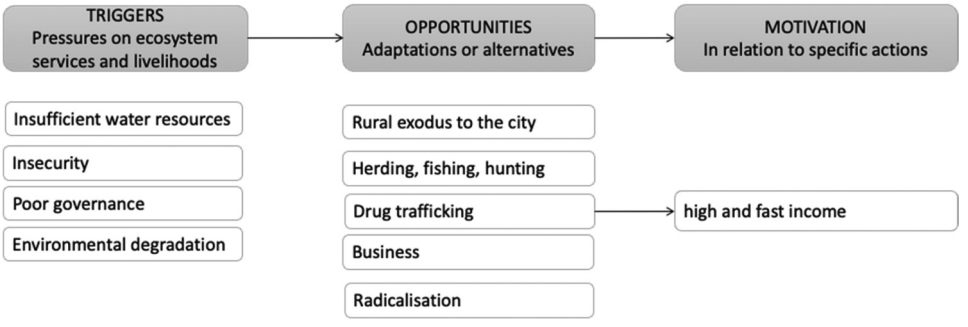

Figure 6. Analysis of farmer's response to reduced livelihood opportunities.

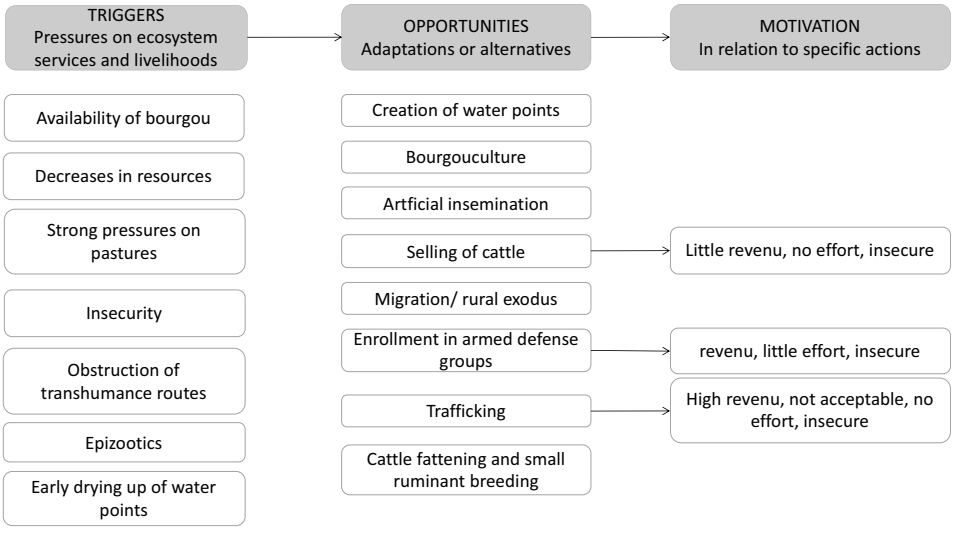

Figure 7. Analysis of herder's response to reduced livelihood opportunities.

Table 2. Overview of main factors driving (water-related) insecurity as perceived by the participants of the workshop.

Factor/causal (sub-)chain	Causal loop diagram 1 (security)	Causal loop diagram 2 (water management)	Motivation-Abilitity1 (farmers)	Motivation-Ability 2 (herders)	Questionnaires
Climate change, resulting in higher competition for scarce resources	X	X			X
Poor management of water resources by users, resulting in higher competition for scarce resources	X	X			X
Strong population growth, resulting in higher competition for scarce resources	X				X
Reduced resource availability			X	X	
Obstruction of transhumance (seasonal migration of herders) routes				X	
Cattle diseases (epizootics)				X	
Poor governance			X		X
Low education levels, followed by wrong interpretation of religion	X				
Abuse of customary rights, resulting in poor governance	X				
Lack of basic services, both social and utilities	X				
Degradation of the security situation in neighbouring countries, Geopolitical influences, resulting in absence of the state	X	X			X
Preference for easy gains	X		X	X	
Proliferation of small arms		X			
Economic instability					X
Insecurity			X		

security in the Inner Niger Delta. The answers to the three rounds of questionnaires allow the ability to see where participants identified systemic risk. The systemic risks identified through the various exercises are summarized in Table 2, without yet providing an indication of which of these form the main systemic risks. The three methods; participatory systems analysis, human behaviour analysis and a questionnaire, resulted in lists of factors, which had overlaps, but which were also different.

What can we now say about the identification of systemic risks? The realization that social and resource systems are connected is a first step in the identification of systemic risks, because it shows that perturbations in one sub-system can result in changes in the other sub-system, for instance. This can result in reinforcing feedbacks which can exacerbate both competition and insecurity. The identification of whether and how specific systemic risks outweigh others in the system requires an additional analysis. The analyses done by the participants all included relations between climate and water-related factors and security. These could form starting points for deeper participatory analyses of thresholds and quantitative evaluation of systemic risks.

Identification of systemic risks on water and conflict through participatory analysis – evolving perceptions of the water-conflict nexus

Based on the questionnaires we observe three developments in the answers from the first to the third round of filling in the questionnaire. Because the answers to question 1

(central problem) and question 2 (main causes) were similar – 'central problem' was mainly interpreted as 'main cause' – the answers to these questions were analysed together (the answers to questions 3 (effects) and 4 (solutions) are summarized in Tables 4 and 5 respectively.

First, perhaps unsurprisingly, but interestingly, the answers in the subsequent surveys become more complex, mentioning multiple causes, and combining especially social, political and physical causes.

Second, in the second and third round, participants formulated the central problem in terms of underlying causes. For example, instead of mentioning a reduction in water availability as the central issue, as was done during the first round of questionnaires, in the second round participants refer to underlying causes, such as climate change or too much water extraction. Similarly, instead of referring to increased violence as they did in the first round, in the later rounds participants refer to increased availability of arms on the black market that itself leads to the increased violence and insecurity.

Third, we observe that the focus of the answers of the participants moves from water-related factors to conflict- and governance-related factors and indicates increased awareness between water, social dynamics and conflict, as the inventory of answers between round 1 and round 3 shows (see Tables 3, 4 and 5).

The general emphasis in answers to question 1 on the central issue/cause of conflict changed from the first to the third survey, from issues related to water to issues related to the combination of water and social or security aspects (see Table 3). The results to the question of main effects of the central issue/causes identified are summarized in Table 4. They show a general move, between the first and third questionnaire, towards effects in the social and governance sphere. In particular, participants who in the first round identified mainly effects focused on water, shift in round 3 to effects focused on social and governance-related aspects. For participants who already mention a combination of social and water effects, no change is registered. This confirms the finding for questions 1 and 2 that the participatory exercises framed around the complex adaptive system led participants to adopt a broader systemic view of the combined factors from different sub-systems.

The results to the question on possible solutions for the central issue/causes identified are summarized in Table 5. They show the exact same trend as for questions 1, 2 and 3: a general move, between the first and third questionnaire, towards solutions in the social and governance sphere. Participants who identified solutions that referred to both social/governance aspects and water aspects in round 1, still do so in round 3.

Table 3. Summary of answers in rounds 1 and 3 in response to the question of the central issue and/or most important cause.

	Round 1	Round 3
Answers focused on water-related aspects, including water governance	6	1
Answers focused on social or general governance-related aspects	2	2
Answers combining water and social/security aspects	6	11

Table 4. Summary of answers in rounds 1 and 3 in response to the question of the most important effects of the identified central issue/main cause.

	Round 1	Round 3
Answers focused on water-related aspects, including water governance	4	0
Answers focused on social or general governance-related aspects	7	10
Answers combining water and social/security aspects	3	3

Table 5. Summary of answers in rounds 1 and 3 in response to the question of possible solutions for the issue.

	Round 1	Round 3
Answers focused on water-related aspects, including water governance	6	3
Answers focused on social or general governance-related aspects	4	7
Answers combining water and social/security aspects	3	4

Discussion

Can participatory analysis support the identification of systemic risks in the complex adaptive system of the Inner Niger Delta

Did the participatory analysis of the Inner Niger Delta help participants to identify additional factors and systemic risks related to the water-conflict nexus? Our results suggest that a joint analysis of the water-conflict nexus, applying different methods by stakeholders from different backgrounds, was useful to identify interrelated risk-factors, and gain an understanding of the complexity of the water-security-nexus in the Inner Niger Delta. The questionnaires show that participants were able to identify more factors throughout the workshop, which is an indication that new insights were gained by the participants through learning from other participants. Although these factors may not be new from a scientific point of view, they seemed new to some of the participants and to their description of the water-conflict nexus in the Inner Niger Delta.

In particular, the change observed in the identification of factors/risks that the analyses became less 'sector-specific', notably with water experts integrating elements beyond the water sector in their visualizations and including factors linked to insecurity, conflict, presence of arms in the system and general governance problems which go significantly beyond water towards the rule of law and trust in authority and the state. This is in line with findings that group model buildings support exchanges of opinions and participant learning (Rouwette et al., 2016, 2002; Scott et al., 2016).

The system approach served to understand how changes in one factor could, potentially only in combination with the presence of other factors, result in changes elsewhere in the system. Without further looking into the magnitude of the factors or thresholds of impacts, it is not possible to identify which of the many factors identified in the participatory sessions can potentially result in large changes affecting the system as a whole. The exercise analysed in this paper should therefore be considered as a first step, to be followed by an evaluation, qualitative and/or quantitative, of the magnitude and thresholds related to the risks that could lead to system collapse and, in the case of the water-conflict nexus, to conflict.

Participatory analysis to increase understanding of complex adaptive systems

The open character of the participatory exercises was found to be suitable for the analysis of a complex adaptive system, since it allowed for the identification of any factor deemed relevant by the participants, as is recommended for semi- or ill-structured decision situations (Vennix, 1999). Although we acknowledge the relevance of group model building and causal loop diagram conventions, and the importance of identifying feedbacks on the system by 'closing loops', for our short workshop our aim was to stimulate a structured discussion with the possibility for all to give inputs. The method allowed for stories to be shared and told, and for questions to be posed and answered in a dialectically open fashion. While the resulting diagrams will always demand further explanation, discussion and scrutiny, this process facilitated social learning and improved system understanding of the participants themselves, potentially directly affecting outcomes of the system itself since participants have an active role in the very system they analyse. The assumption is that a more participatory, shared understanding of the system by stakeholders leads to better reactions to risk in the system and therefore to better system outcomes. In addition, it can serve as a group memory for following sessions (Vennix, 1996).

The fact that different exercises (see Table 2) identified different factors or risks, shows that using multiple methods to identify perceptions of the behaviour of a system and of groups or individuals helps to get a more complete picture, as well as to identify possible incoherences or gaps that can be followed up on. It confirms that using a multiple method approach to analyse conflict is preferable (Ide et al., 2020).

Analysing human behaviour as a key element in the water-conflict nexus

In our theoretical section, we identified the water-conflict nexus as a complex adaptive system. Here we would like to reflect on what lessons can be drawn from our analysis that can serve to further develop complex adaptive systems thinking. One thing stood out for us – the connection between system functioning, including the propagation of systemic risks, and the behaviour of individuals, or groups of actors, within this system. The underlying purpose of looking at the water-conflict nexus is to find entry points to reduce water-related security risks, and we argue that to identify suitable measures to reduce this risk, insight in the behaviour of actors is pertinent.

Understanding actor's motivations and abilities to alter behaviour, steered by triggers and opportunities, helps to understand why certain measures may or may not have been successful in the past, and can lead to the identification of new measures, that can focus on taking away triggers, providing opportunities, motivating people or enabling them to undertake sustainable and legal livelihood activities. The fact that a conflict may be water-related does not mean that water management is the solution. In the case of the Inner Niger Delta, solutions could also be found in reinstating formal government and the rule of law, in better agreements between farmers and herders on who can use which land when, or in providing emergency food supplies or income support in extremely dry years, while supporting people to develop new skills and ways of living. The participants in our workshop also indicated as insightful that they had to 'place themselves in the shoes of specific social groups'. Resulting in statements such as 'before, I never understood why someone would join a jihadist group, but now I understand they have only

very few options when their livelihoods decline'. The ultimate purpose of analysing complex adaptive systems is not the increased system understanding, but the joint identification of feasible solutions to reduce undesirable system risks. We argue that this requires attention for human behaviour. Analysing human behaviour with policy stakeholders can be a first step towards implementation of these solutions, and an important aspect of analysing and influencing complex adaptive systems, which could receive more attention in complex adaptive systems research.

Limitations – role of the participatory method in a short workshop led by international researchers

The results of a participatory method depend on various factors: the combined knowledge of the participants, the way the workshop is facilitated, the time available to participants to work on the analysis, and the possibilities to access additional information, test the information shared and dig deeper into the assumptions made. Moreover, due to time constraints we focused on the broad groups of herders, farmers and fishermen, and did not make explicit distinctions between the different ways a trigger may affect women and men, richer and poorer, or people in different geographical locations in the large Inner Niger Delta. Despite the coarse analysis, we especially saw the value of this exercise in the way it provided the participants with a methodology to start to untangle why certain people potentially undertake certain activities, and to start to see 'herders', 'farmers' and ´fishers´ as individuals with certain needs and opportunities, and to reflect on what could be required to support people in dealing with potential risks.

The workshop involved a range of actors from different background and disciplines, which contributed to developing a broad understanding of interactions between subsystems. However, while most of these participants professionally dealt with a different aspect of the Inner Niger Delta, they were not themselves the water users or the parties involved in the conflict. While this is partly an inherent problem of analysing a system in violent conflict (with the above-described problems of physically accessing the geographical zone and the socio-economic groups active there), it is clearly also a hindrance to a deeper understanding of the system under analysis. The results reported here can therefore only be considered a first and limited effort.

We nevertheless consider it an effective method to facilitate amongst stakeholders a process of collective social learning and building a common understanding of connections between sub-systems and the systemic risks at play, and to identify at which level and on which causal links there is a need for action or for additional participatory analysis. Indeed, missing links between elements require further discussion or possibly further factual research if they can be identified as knowledge gaps.

Moreover, as facilitators we have to be critically aware of the bias that we may insert in such 'understanding' that may derive from the worldview and framing we are putting forward. Simply by linking water and conflict in the announcement of the workshop, and through the background of the people we chose to invite, we more or less subconsciously steer the development of system understanding. Despite this, we observed and received written anonymous feedback from the participants that the facilitation of the workshop, including open discussions led by participants themselves, allowed for independent learning and opinion-building. Needless to say, our own was a learning process: we

conscientiously avoided projecting on the exercises our own understanding and expectations, and the results and outcomes of the participatory discussions were in no way intended to match with pre-conceived ideas we may have had of the factors at play.

Conclusion and recommendations

The research presented in this paper aimed to explore how the use of participatory methods can contribute to an understanding of water-conflict links and the identification of systemic risks in the Inner Niger Delta, a complex adaptive system. Identifying a system as a complex adaptive system implies awareness of interlinkages between various factors across sub-systems, for example, factors related to water and ecosystems, to poverty, to the role of government and/or to conflicts. Feedback between factors in this system can create non-linear behaviour. Understanding how such systems respond to changes in some of the factors, is important for the design of water management measures that do not inadvertently increase conflict, or miss out on opportunities to contribute to peace. Because little information on individual and system level responses was available, we used participatory methods to analyse system links, human behaviour and water-related conflict risks.

We found that participatory methods supported the identification of links between water and conflict and related systemic risks. Moreover, we observed that through participating in these methods, which facilitated conversations between actors with various backgrounds, participants broadened their perception of causes and effects of these risks. Gaining such a broader understanding, is an important prerequisite for consciously designing policies and measures that can influence the system to improve livelihoods and reduce conflict risks.

Based on our findings, we derive two recommendations: one for those involved in addressing water-conflict links in practice, one for the academic community:

(1) We observed an evolution in system understanding during the course of the workshop. The broader view on the links between water, existing governance mechanisms, livelihood opportunities and conflict will hopefully support participants in their future work in the Inner Niger Delta. Participants took the initiative to form a WhatsApp group to keep a link to each other. To really reap the benefits of such a group interaction, it would be helpful if the interaction is facilitated over a longer period of time, and if one actor (e.g., a local NGO) would be enabled to play a moderating role, to regularly convene the group, or share information through the WhatsApp group or other platforms, to build a 'community of practice'.
(2) We found that the combination of methods and exercises that focused on the system or on the individual level gave complementary insights and propose that future research on the functioning of complex adaptive systems in general, and on water-conflict links in particular, pays attention to both levels.

Approaching the Inner Niger Delta as a complex adaptive system and analysing, through participatory analysis, how various hydrological, social, economic and political factors influence the behaviour of its population and, subsequently, the wider system, can

contribute to a broader understanding of both current and future conflict risks. Despite complex adaptive systems being continuously in flux, self-organizing, unpredictable and adapting to shocks we perceive the identification of factors and risks by local actors as a key stepping stone towards reducing such risks.

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Author contribution statement

Conceptualization of the research paper: Karen Meijer, Rozemarijn ter Horst, Euan Mackway-Jones and Luca Ferrini. Data collection: Beteo Zongo, Mori Diallo, Ibrahima Sado Fofana, Karen Meijer, Rozemarijn ter Horst and Luca Ferrini. Workshop organization and stakeholder contacts: Beteo Zongo, Mori Diallo, Ibrahima Sado Fofana and Karounga Keita. Data analysis: Karen Meijer, Rozemarijn ter Horst and Luca Ferrini. Writing: Karen Meijer, Rozemarijn ter Horst, Euan Mackway-Jones and Luca Ferrini. Review: Beteo Zongo, Mori Diallo, Ibrahima Sado Fofana and Karounga Keita.

Disclosure statement

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ORCID

Karen S. Meijer http://orcid.org/0000-0002-6135-4131

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