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Three Points Approach (3PA) for urban flood risk management: A tool to support climate change adaptation through transdisciplinarity and multifunctionality

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Urban flood risk is increasing as a consequence of climate change and growing impervious surfaces. Increasing complexity of the urban context, gradual loss of tacit knowledge and decreasing social awareness are at the same time leading to inadequate choices with respect to urban flood risk management (UFRM). The European Flood Risk Directive emphasises the need for non-structural measures aimed at urban resilience and social preparedness. The Three Points Approach (3PA) provides a structure facilitating the decision making processes dealing with UFRM. It helps to accept the complexity of the urban context and promotes transdisciplinarity and multifunctionality. The 3PA introduces three domains wherein water professionals may act and where aspects valued by different stakeholders come into play: (1) *technical optimisation*, dealing with standards and guidelines for urban drainage systems; (2) *spatial planning*, making the urban area more resilient to future changing conditions; and (3) *day-to-day values*, enhancing awareness, acceptance and participation among stakeholders. Based on in-depth interviews conducted in The Netherlands and Denmark, we describe the complexity of decision making in practical UFRM and explain how the 3PA can be used when organising participatory processes. We introduce a theoretical framework characterising the large range of aspects involved in decision making related to UFRM and evaluate the usefulness of the 3PA in dealing with it. We conclude that the 3PA offers water managers and operators an efficient communication tool and thinking system, which helps to reduce complexity to a level suitable when organising strategy plans for UFRM and urban adaptation to climate change.

Keywords: complexity; decision making; resilience; spatial planning; process management; water aspects; social values.

1. Introduction

1.1. *Urban flood risk management in the context of climate change*

Flooding in Europe is recognised as the most common and costly natural disaster in terms of damage (WHO 2002). Urban flood damage has increased during the past decades and is expected to increase even more due to more frequent heavy rain storms potentially caused by climate change as well as growth of impervious surfaces and increased property value in urban areas (Jensen 2008, Tait *et al*. 2008, Larsen *et al*. 2009, Nie *et al*. 2009, Arnbjerg-Nielsen 2012). In 2007, the European Flood Risk Directive (EFRD) was published, stating that flood risk management plans should favour non-structural measures aiming at resilience of urban infrastructures and preparedness of the social system (EU 2007). The EFRD promotes the use of a holistic approach to flood risk management, and it also creates new opportunities for development of the urban water sector as it attracts the attention of society and thus politicians to the issue of urban flood risk in connection with climate change.

The EFRD defines flooding as ''the temporary covering by water of land not normally covered by water'' (EC 2007). In the urban context this includes fluvial flooding from water courses, flooding from sea surges in coastal areas, and pluvial flooding when the capacity of sewerage systems is exceeded. ''Flood risk'' is defined as ''the combination of the probability of a flood event and of the potential adverse consequences for human health, the environment, cultural heritage and economic activity associated with a flood event'' (EC 2007). However, in the context of climate change, risk management is not only concerned with hazards and probability, but also with the social, natural and technical vulnerability of the urban context (Füssel and Klein 2006, Hauger *et al*. 2006, Fussel 2007). As a consequence, we define urban flood risk management (UFRM) as the measures that need to be undertaken

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to minimise vulnerability associated with a certain flood hazard and its probability.

UFRM has traditionally focused mostly on the underground infrastructures that are part of classical urban drainage engineering. ''Dual drainage'' or ''major and minor systems'' are used in countries like Australia with typically moderate but occasionally very intense rainfall events; here the underground (minor) piped drainage systems are intended only for moderate flows whereas the runoff in connection with heavy rain storms is allowed to discharge above the ground utilising topography and streets (major system) (e.g. Butler and Davies 2000). Such an approach has not generally been used in e.g. Europe, where most national UFRM guidelines until recently have only considered designs of separate or combined sewer systems for surcharge return periods in the range of 5–10 years as defined in the European standard for planning, design and operation of drain and sewer systems outside buildings (EN 752:2008 2008), and where local implementations of the EFRD have sometimes not fully addressed pluvial flooding. Water professionals have however lately realised that in order to deal with increasing urban flood risk, it is necessary to combine underground and above ground systems (Ashley *et al.* 2007b, Geldof and Kluck 2008, Price and Vojinovic 2008, Tait *et al.* 2008).

In the white paper on climate change adaptation, the Commission of the European Community (2009) states that: ''evidence suggests that working with nature's capacity to absorb or control impact in urban and rural areas can be a more efficient way of adapting than simply focusing on physical infrastructure. Green Infrastructure can play a crucial role in adaptation in providing essential resources for social and economic purposes under extreme climatic conditions''. However, when designing area-based solutions within the urban space particular attention should be given to public amenities (Brilly 2007), like traffic, energy supply, media, water supply, health care, food supply, safety and other aspects directly involving the inhabitants of the specific urban area. Responses to climate change cannot solely be technological, but will require changes in lifestyle and expectations in the social environment (Ashley *et al.* 2007a). In particular, several studies have proven that the management of urban flood risk in the context of climate change requires more attention to urban planning and social participation than is currently the case (Brown 2005, Rauch *et al.* 2005, Price and Vojinovic 2008).

1.2. *Functional and relational complexity in UFRM*

Urban flood risk management exhibits a lot of complexity (Abebe and Price 2005, Levy *et al.* 2007). Geldof (1995a, 1995b) introduces the concept of complexity in relation to the many uncertainties characterising ''integrated water management'' and argues that it is necessary ''to adapt water management to the ever changing surroundings''. Engineers need to look at problems not only considering the sole technical relation among system components but also taking into account the uncertainties generated by the influence of nature and society. According to Rauch *et al.* (2005), recent studies on urban water management have increasingly advocated the need for more ''integrated'' approaches and asserted that ''integration is being pursued and implemented predominantly at two conceptual levels: 1) integrating the technical system with the receiving waterway environment, and 2) considering the interactions and influence of the human system with the technical system''. Healey (2006) argued that ''places and their qualities, both social and physical, are thus double creations (...) planning activity can be understood both as part of an effort of collective imagination about place qualities, and as a set of relational webs which, intersecting with other relations, can produce substantial resources and constraints on other relational dynamics''. In a study about the cooperation between municipalities and water boards in the Netherlands, Geldof *et al.* (2007) examined how water professionals cope with complexity and uncertainty, and they distinguished two dimensions in complexity. Based on these premises it appears logical to distinguish between two kinds of complexity:

- Functional complexity, when complexity is related to the physical dimensions of the urban space and to the range of functions assigned to technical objects (e.g. infrastructures).
- Relational complexity, when complexity is related to humans and in particular to the different views and perspectives of the actors involved in the decision making process.

1.3. *Multifunctionality and transdisciplinarity in UFRM*

Addressing functional and relational complexity requires different skills and approaches. To cope with functional complexity and create multifunctional urban spaces that can deliver the range of functions required, water professionals need to use their technical knowledge in cooperation with other professionals not focusing solely on water infrastructures. The term ''multifunctionality'' has been used in studies regarding agricultural development since the 1990s (Renting *et al.* 2009), and in connection with the promotion of sustainable development (UNCED 1992, FAO 1999, OECD 2001). Wolf and Meyer (2010) used it in the context of spatial planning and referred to "three main groups of landscape functions, i.e. economic (production-oriented), ecological (regulatory) and social (cultural, aesthetic, ethical, psychological and recreational)". Lately, the term multifunctionality has been used with approximately the same meaning in relation to complex and intensively used space and planning of green infrastructures for increasing resilience and adaptive capacity (Bomans *et al.* 2010, Ahern 2011, Madureira *et al.* 2011) and in connection with flood defence structures (Miguez *et al.* 2007), and we therefore also adopt it here.

Multifunctional solutions ideally address the needs of a range of different actors. To cope with the relational complexity involved, water professionals thus need to organise interactions between people who value different aspects in relation to the urban space in order to include the local values in future strategies. In other words, they need to organise transdisciplinary processes. Transdisciplinarity is an approach to team work that implies a mutual and joint learning process between the stakeholders and the experts involved (Wiek and Walter 2009). It is meant to meet the complex challenges of society through cooperation and knowledge exchange among society and academia (Klein *et al.* 2001), and it is considered particularly valuable when dealing with the transition of complex socio-technical systems toward a more sustainable development (Scholz *et al.* 2009). Transdisciplinarity can therefore be seen as a prerequisite for developing successful multifunctional solutions.

1.4. Research aim

The need for transdisciplinary processes make communication a key element for project success in the UFRM area, but communication is often difficult due to the functional and relational complexity involved especially under changing conditions (climate change, urban growth). A new approach is therefore needed to improve communication between stakeholders and allow the complexity of UFRM to be acknowledged. This paper will present and discuss the Three Points Approach (3PA) as a method to cope with the functional and relational complexity characterising UFRM in the context of climate change. The 3PA introduces three domains wherein water professionals may act and where a large range of aspects valued by different stakeholders come into play: (1) *technical optimisation*, dealing with standards and guidelines for urban drainage systems; (2) *spatial planning*, making the urban area more resilient to future changing conditions; and (3) *day-to-day values*, enhancing awareness, acceptance and participation among stakeholders.

The 3PA was presented for the first time at the 11th International Conference of Urban Drainage in 2008 (Geldof and Kluck 2008) and has subsequently been presented and discussed at several national and international meetings, which has contributed to corroborating and refining the approach. This paper, for the first time, presents a comprehensive study on the 3PA based on a thorough literature review and analysis of selected case studies. The overall aims of the paper are to:

- introduce the 3PA to the scientific environment related to UFRM providing a theoretical background for this practical method,
- explore and assess the functional and relational complexity characterising decision making in UFRM,
- evaluate how the 3PA can be used as a practical tool by water professionals to facilitate transdisciplinary processes aiming at urban adaptation to climate change through multifunctional implementations.

To do so, we introduce the 3PA as a conceptual model in Section 2 and the theoretical concepts, frameworks and methods behind this study in Section 3. In Section 4, we explore and assess the functional and relational complexity characterising UFRM in the context of climate change (Sections 4.1 and 4.2) and investigate the value of the 3PA in dealing with it (Sections 4.3 and 4.4). Finally, Section 5 summarises the conclusions of the study.

The term "water professional" will be used throughout the paper as a general term for engineers, scientists and managers dealing with stormwater, urban drainage and UFRM in their daily work. The authors of this paper are all water professionals and the perspective undertaken to carry out this analysis is thus that of the water professionals involved in decision making processes in relation to UFRM.

2. The Three Points Approach

Per Bak (1996) observed a fixed relation between the size of a natural crisis and its frequency on a logarithmic scale. He defined this pattern "Self Organised Criticality". This pattern suggests that in complex systems like urban areas that are continuously evolving, the risk related to extreme hydrologic events can be represented by a roughly straight frequency-damage line on a log-log depiction. Reducing the risk of flooding might first result in less damage but then people and nature adapt to the new equilibrium and vulnerability and, thus, risk increases again. So in the end the frequency-damage line remains more or less the same (Geldof 2005). In the 3PA, the pattern defined by Bak has been re-elaborated to facilitate the analysis of flood occurrence (Figure 1). The magnitude (vertical axis) is expressed in term of costs and instead of frequency the exceedance return period is shown on the horizontal axis.

In the case of medium return period events (Point 1 on Figure 1), the runoff produced over the urban surfaces can damage urban infrastructures and private properties if not properly drained, and this is why (minor) drainage infrastructure is put in place. When a large return period event occurs (Point 2 on Figure 1), damage occurs within the urban area, sometimes even putting human life in danger. The more rigid and unprepared the urban area is, the greater the damage and danger to life will be. On a daily base (Point 3 on Figure 1) rain however represents a resource for life and daily practices of the inhabitants of the urban area. Wastewater and stormwater is drained, transported, treated and finally released into nature again. To maintain service quality it is necessary to use financial and human resources to keep the urban drainage system up to date and make the users aware of its vulnerabilities.

The aim of the 3PA is not to calculate the effects of flooding mathematically and then perform a cost benefit analysis (Geldof and Kluck 2008). The idea is to provide both managers and operators dealing with flood prevention with a tool to communicate, discuss and reflect about the possible future scenarios and directions and the effects of different possible solutions. For example, the 3PA can clearly visualise that the effects of climate change produce an increase in the frequency and magnitude of floods thus shifting the return period-cost line in an upwards direction on the graph in Figure 1. The important thing is that the 3PA represents urban flooding as persistent and self-organised-critical, i.e. that flooding cannot be eliminated, and that it visualises three essential pro-active domains wherein decisions in relation to UFRM in the context of climate change are made (Figure 1):

(1) *Domain of technical optimisation*: where design standards for sewers and other drainage infrastructures apply. Here professionals discuss technical solutions to deal with defined design storms in order to prevent damage and meet the service level established politically.
(2) *Domain of urban resilience and spatial planning*: where urban water managers, in order to deal with extreme events, have to interact with urban planners and architects. Here the aim is to mitigate the effect of possible future extreme rains, but also to create the technical basis for adaptation to future changing scenarios. The idea is to make the urban area more resilient to future changes by finding new spaces for water conveyance and storage within the urban area.

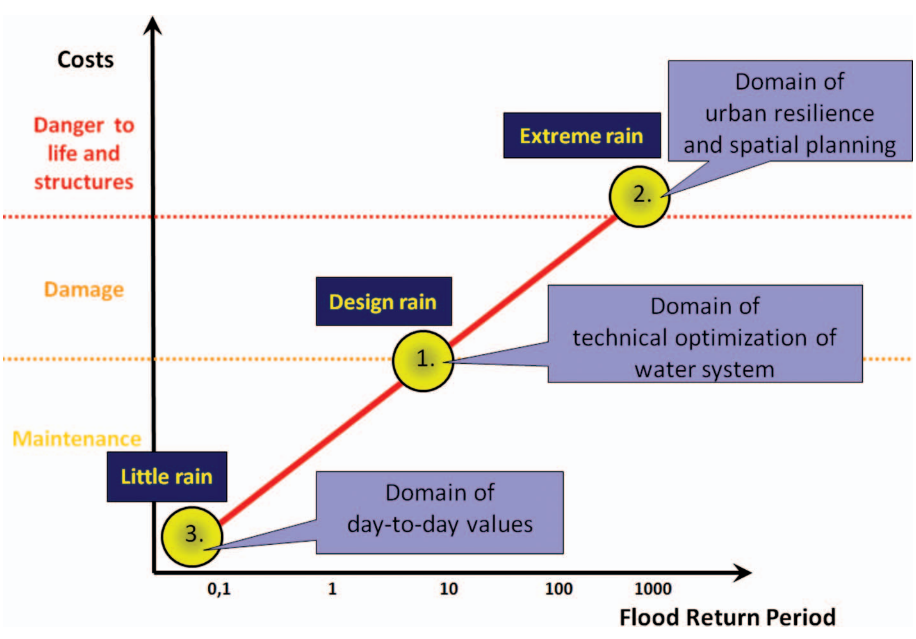

Figure 1. The Three Points Approach scheme. Both the axes are on a logarithmic scale. The horizontal axis represents the flood return period and the vertical axis represents the magnitude of the rain event in terms of costs of maintenance and damage of the urban infrastructure.

(3) *Domain of day-to-day values*: where particular attention is given to the way urban space is perceived and used on a daily base by its inhabitants. This domain suggests that projects hold strong day-to-day values when they are able to improve the quality of life within the area in focus. Such considerations are expected to create a solid base for political and public support and thus ask for a higher participation in the decision making process. Social participation is considered important in order to enhance awareness of flood risk and acceptance of the new urban development towards a more resilient city. When the social system is involved in all fields, a strong base for the maintenance of urban infrastructures is furthermore created.

Currently designs of drainage systems are such that they meet a certain standard for sewer surcharge (Point 1). The requirements are set locally but in Europe they are influenced by a common standard (EN 752:2008 2008). For example, in Denmark the surcharge return period generally used for design of combined sewer systems is 10 years, and the national design guidelines (Harremoës *et al.* 2005) do not require evaluating the potential adverse consequences associated with flooding for larger return periods. The main message of the 3PA is that in addition to this first point, the second point (functioning at extreme events) is also important and should be evaluated in order to make the urban areas more resilient to flood risk. Finally, prevention against flooding at the second point usually requires above ground measures, and these need to be incorporated into the daily functioning of the urban space (Point 3) in order to be successful. The message of the 3PA is that addressing all three points in parallel is important, providing the possibility to adapt to climate change while making public areas better places to live in because the extra space required for water can result in more space for play-grounds, parks, or rehabilitation of an area improving the local quality of life.

3. Methodology and theoretical background

3.1. Research approach

We conducted 35 semi-structured qualitative interviews in order to fully comprehend the complexity characterising UFRM in practice, and to understand how the 3PA may be used to cope with such a complexity.

The interviews were conducted in two countries and three different case study areas following the multiple-case replication design according to Yin (2003): Egmond aan Zee and Dordrecht in the Netherlands and Greve in Denmark. Egmond aan Zee and Greve are both located in coastal areas that recently experienced floods due to extreme rain events and a critical physical location of the city area. Dordrecht was included because the municipality was in the middle of developing a new water plan for the city, which was largely dedicated to flood management due to the critical physical location of the city regarding this matter. In all three cases the 3PA was used to communicate with the stakeholders involved about the problems and the action to be taken. In Dordrecht and Egmond aan Zee the 3PA was also used to organise the decision making process.

In the Netherlands, the interview campaign was conducted in the spring of 2008 by the first author of this paper while working as an intern in a consultancy company, Tauw b.v., directly involved with projects in the two Dutch case studies. This allowed to interview professionals, citizens and shop-owners from the urban area of interest. In Denmark, the interviews were performed in the autumn of 2008 again by the first author, acting this time merely as an observer not directly involved in the process and interviewing only the professionals involved.

The total number of interviewees was 35, some of whom were interviewed more than once. Among those, 21 were professionals working for municipalities, institutions and private companies directly involved in the decision making process. The remaining 14 were citizens and shop owners defined as lay persons because their knowledge about the technical issues involved was considered limited. Among the professionals, more than 16 were water professionals, mostly managers or operators from the municipality or from the private companies hired to propose solutions to deal with the flood issues that had arisen. For a more precise list of the stakeholder categories represented by the interviewees, see Table 1.

The interview approaches used for this campaign were a mixture of the following semi-structured qualitative interview forms inspired by Kvale (2007):

- *Factual interviews* were used to obtain an overview of each study case. Usually different stakeholders have different points of view on the same problem. For this reason, information about each stakeholder was usually first collected through contacting and interviewing the water manager or project leader of the particular case area. During the interview campaign the interview network was usually enlarged as the presence of new aspects was discovered. To obtain a complete overview, the network circle needed to be closed. This meant that the

Table 1. Number of stakeholder categories and sub-categories and number of interviewees associated with them.

Stakeholder category	Number of interviewees
Water Professionals	16
✓ Consulting companies	6
✓ Municipality	5
✓ Regional water management	2
✓ Research institutions	3
Urban planners	2
Natural Scientists/biologists	2
✓ Consulting companies	1
✓ Regional agency – regulator	1
Insurance companies	1
Lay persons	14
✓ Local representatives	5
✓ Directly involved in local projects	5
✓ Experienced flooding	3
✓ NGOs volunteers	1

interview campaign stopped when repetitions and thus validation of contents started to arise by including additional interviewees.

- *Conceptual interviews* were used to obtain "conceptual clarification" of the approaches to urban flood risk management used in practice. This approach was necessary to clarify the purposes of the projects under study but also to get a personal overview of the subject. This interview type was mainly used as a learning process; interviewees were asked to express their knowledge, experiences and their point of view on the subject. Sometimes this interview approach turned into a soft form of *confrontational interview* where confrontation between the interviewee and the interviewer was naturally created. The result was always a better understanding of the topic for the interviewer.
- *Narrative interviews* focused on capturing experiences and "lived meanings" (Kvale 2007) from the everyday world of the inhabitants of the urban area. This methodology mainly focused on the stories told by the interviewees. These stories could come up spontaneously or at the request of the interviewer through bringing an example of a previously expressed concept. The idea is that examples give validity to theories and create the narrative that builds up experience.

The interviews were completely transcribed, analysed and coded in relation to the studied topics. Then the extracts considered most relevant were identified, compared and finally reported. The final outcome of this interview campaign was a better understanding of the complexity characterising UFRM from the perspective of different stakeholders, and a working document containing narratives in the subjects' own words. In this working document, the different points of view, experiences and ideas were maintained in the form of storytelling without attempted interpretation by the interviewer. Due to the quantity of data, we could not report all the narratives in this paper. As a consequence, we decided to report (in Section 4) only the reflections coming from the analysis of the working document and the citations essential to the discussion carried on in this article.

3.2. *Aspects and values of water infrastructure and services*

The real innovation of the 3PA is that it visualises the need for taking a range of perspectives related to the management of water in the urban area into account when dealing with UFRM. On one hand, Point 2 suggests that more space for water within the urban area is needed to deal with large flood volumes. On the other hand, Point 3 suggests that additional aspects related to the daily functions of urban areas need to be taken into consideration when aiming to successfully implement new above ground infrastructures within the urban space. But, which are those aspects that need to be taken into account within projects to benefit society and nature on a daily basis? And why are they so important?

The design of water infrastructure where above ground and below ground structures are integrated requires a lot of technical expertise; combining models of rainfall, infiltration, groundwater, sewage, treatment and impacts on the receiving waters is a rapidly evolving field (e.g. Mark *et al.* 2004, Schmitt *et al.* 2004, Rauch *et al.* 2005, Smith 2006, Sto Domingo *et al.* 2010). Still, to deal with the technical challenges (functional complexity) in practical UFRM, water engineers are trained to find manageable solutions based on reductionism. This reduction of complexity is needed in order to be able to make choices and decisions. However, to successfully implement water infrastructures it is necessary to design them as an integrated part of the local urban development (Brown 2005, Rauch *et al.* 2005, Price and Vojinovic 2008) and to do so, technical expertise alone is usually not enough: water professionals are dependent on other stakeholders to achieve their goals. Reductionism sometimes becomes excessive so that cooperation among people from different disciplines is hindered and many relevant aspects are not taken into consideration (Geldof 1995a, 1995b, Lems 2008).

Urban development is a process that requires the consideration of a large range of aspects to unravel the meanings assigned to the living environment (Gehl

1987, 2010). Lems (2008) defines ‘‘meaning’’ as ‘‘the consciousness-raising and utilisation of a value (. . .) by an individual or an organisation’’. The city area often has multiple meanings and the inhabitants use it as a social area, business area, recreational area, cultural area etc. As a consequence ‘‘people continuously and intensively plan, build, demolish, mix and staple’’ (Lems 2008). In this case conflicts are a consequence of creative processes and different opportunities for development occurring at the same time (McClymont 2011). When designing green infrastructures aiming at climate change adaptation it is therefore important to understand the meaning stakeholders attribute to the urban area in focus and then create the opportunities that allow the new urban water infrastructures to disclose those meanings as part of the local urban development.

Based on Lems (2008), Dooyeweerd (1953), Lems and Valkman (2003) and Geldof (2005), we identified 11 aspects listed in Table 2, defining the wide range of

Table 2. 11 aspects defining the values stakeholders involved in decisions related to UFRM may assign to water infrastructure and services within the urban area. Adapted from (Lems, 2008; Dooyeweerd, 1953; Lems &Valkman, 2003; Geldof 2005)

Symbol	Aspect	Meaning	In relation to Urban Water
	Biotic	Related to life processes and nature	Water is the first condition for the life of all species. Its quality and quantity have a strong influence on the quality of life of humans within the urban area. The presence of nature and a variety of species is a fundamental value for humans' health.
	Sensitive	Related to perception	Water can stimulate positively or negatively all human's senses: sight, taste, hearing, smell and physical contact. When water stinks, its presence becomes unpleasant. When water is fresh and clean, people can bath in it.
	Logical	In relation to the physical, chemical and mathematical functions	Urban water is part of the water cycle. It has chemical and physical characteristics that can be represented with the use of mathematics. Nowadays water behaviour can be modelled, monitored and partially controlled.
	Historical	In relation to history, traditions and origins. In this sense, pedagogical to new generations	Humans have always needed water and tried to control it. Sometimes historical water structures remain within the urban environment. New generation can always learn from the past. Tourism usually appreciates the presence of historical structures.
	Linguistic	In relation to symbols and communication of values	Language is a fundamental tool for communication of feelings and opinions but also rules. Communication about water can occur by road signs but can also be tacit, unwritten. Unwritten symbols are not always easy to detect. They are part of the local culture. They are maintained alive by storytelling. Communication is also an important tool to find agreement. In order to communicate, people need to share the same language or linguistic tool and have a shared understanding about them.
	Social	Dealing with people and the way they meet and communicate with each other	The urban area is a place where people socialize. Water usually attracts people. Its presence can increase the opportunity of meeting the others. People usually like to walk along a river or sit in front of a lake.
	Economic	In relation to costs and efficiency	The costs of water are related to space, resources and development. Thus efficiency is important. Costs versus benefits have to be considered. On the other hand some benefits can be: 1) not easily countable at present because their benefits relate to possible risks in the future whose level of uncertainty is very high; 2) not tangible, as the increase in quality of life and in environmental quality
	Aesthetic	In relation to beauty and that which is desired.	Water can improve the aesthetics of the urban area in two directions: increasing the presence of water and nature within the urban space; enhancing the representation of art through harmonic architecture in the urban landscape.
	Legal	Related to laws and official rules	Water quality and quantity in the urban area is regulated by laws and guidelines.
	Ethical	In relation to what is morally ‘‘good’’ and to responsibility	‘‘Good’’ water management is not the sole responsibility of the municipal management. Citizen should be aware of their responsibility for the maintenance of water structures and resources.
	Ideal	In relation to convictions and beliefs, the opinion of the group, religion, and to what is desirable	Water is part of the community. It is used for common rituals related to cultural habits. As a consequence each stakeholder has inevitably his/her own idea of what should be the desirable management of water resources within the urban area.

values stakeholders involved in decision making may assign to urban water infrastructures and services within the urban space. These defined aspects have been used as a theoretical framework to analyse our empirical data and then assess and describe the functional and relational complexity characterising decision making in UFRM.

4. Results and discussion

4.1. A conceptual description of the urban area as the context of analysis

The analysis performed on the case studies focused on the urban area, defined as the context where the decision making process in UFRM takes place. After a general reflection on the analysis of the three case studies in the Netherlands and Denmark, a conceptual description of the urban area and the stakeholders involved in the decision making process of UFRM emerged.

Three main systems and their sub-systems interacting and overlapping each other within the urban context are identified in Figure 2. The *natural system* and the *natural water cycle* consist of all the natural processes involving life and water respectively. The *technical system* and the *water system* consist of the urban infrastructures humans have created to adapt the natural system and water cycle to fulfil their needs (buildings, streets, water supply, urban drainage facilities, etc.). Finally, the *social system* is composed of all the people living and working in the urban area, who may be directly or indirectly involved in the decision making process related to UFRM. On one hand they may be affected by flood occurrence. On the other hand, their behaviour and decisions play an important role to the degree of risk that flood occurrence may represent for the urban area.

The systems illustrated in Figure 2 are interrelated. However, despite some of the interrelations have been largely analysed by different academic and professional disciplines, they are not yet completely understood and taken into account in theory and practice. The consequence of the lack of understanding of the interrelations between the natural and the technical systems is referred in this paper as the functional complexity characterising decision making in UFRM.

4.2. Stakeholders and values in UFRM

To explore the relational complexity characterising decision making in UFRM, we defined specific stakeholder categories in relation to each of the physical systems part of the urban context, as illustrated in Figure 2. These categories are listed and characterised in Table 3, where we also highlight the aspects valued by each stakeholder category. It is noted that Table 3 covers a larger range of stakeholder categories than the ones directly covered by our in-

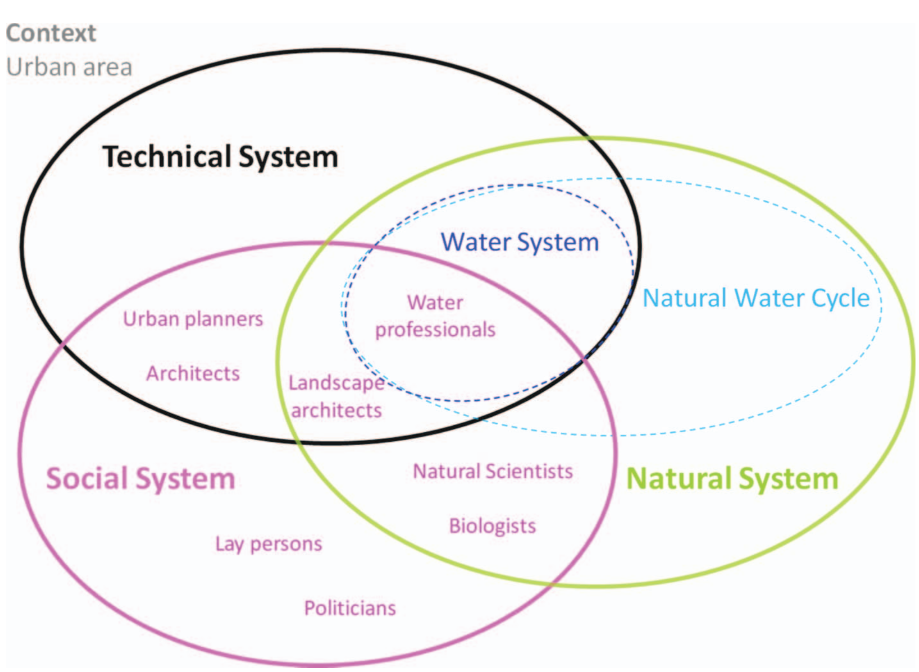

Figure 2. A conceptual description of the urban area as context of the decision making process in UFRM. This is just a representation of the complexity characterising an urban context where the technical, social and natural systems interact. However, the characteristics of the context change from project to project and from location to location.

Table 3. Overview of the key stakeholder categories identified in the analysed case studies and the aspects they prioritised during the interviews.

Stakeholder category	Characteristics	Prioritised water aspects
Water professionals	• Manage public or private organisations working with urban water facilities • In charge of finding solutions • Maintain service level and functionality of water infrastructures • Modellers/practitioners directly operating present water infrastructures • Work in municipality or private company	• Assessing solutions: **Logical, Economic, Legal** • Presenting options to the project sponsors: **Logical, Economic** • Cooperating with other professionals: **Logical, Linguistic Economic, Legal** • Discussing solutions with stakeholders: **Logical, Linguistic, Economic, Ethical**
Urban planners	• Manage municipal departments in charge of urban infrastructure not directly related with water • Organise urban space • Responsible for new plans and visions	• New planning: **Logical, Economic, Social, Historical, Aesthetic** • Communicating with stakeholders: **Lingustic, Social**
Architects/ Landscape architects	• Design urban infrastructures and green areas • Create visions • Major driver is creativity	• Creating visions: **Aesthetics, Social, Sensitive, Historical, Ideal, Ethical** • Communicating with stakeholders: **Linguistic**
Natural Scientists/ Biologists	• Knowledgeable about natural processes in relation to environmental quality and human health • Prevent new infrastructure implementations from impacting the environment and human health negatively.	• Assessing impacts: **Biotic, Legal, Logic, Sensitive, Ethical, Ideal, Legal** • Controlling and maintaining: Linguistic, **Legal, Ethical, Ideal**
Lay persons	• Live and work in the urban area • Have diverse drivers depending on many aspects (education, knowledge, wealth, interests, etc.) • Pay to receive services • Can vote to change political goals • Use urban infrastructures daily • Major driver: improving their own quality of life	• Prioritise aspects related with their life quality: **Sensitive, Historical, Social, Economic, Aesthetic** • Parception depends on cultural background: **Ethical, Ideal** • The **Linguistic** aspect is very important when involving them in decision making
Politicians/ Municipality	• Comply with national guidelines • Work under financial constraints • Comcerned about citizen's happiness and safety • Seeking social support and power • Eager to maintain their prestige within the same mandate, want to be re-elected	• Setting constraints: **Legal, Economic, Ethical, Ideal** • Seeking social support: **Sensitive, Historical, Social, Ideal, Aesthetic** • The **Linguistic** aspect is central for them

depth interviews (i.e. architects/landscape architects, politicians, cf. Table 1). The additional categories were identified and characterised indirectly through analysing the empirical interview data, interpreting interactions between participants in meetings arranged in the case studies, and corroborating this with grey literature.

A major challenge for water professionals is that they need to communicate (Linguistic aspect) and strongly motivate (Logical and Economic aspect) future implementations to politicians who do not usually take as much interest in the logical aspects (meaning technical issues) as they do. A politician seeking social support will prioritise those aspects that are most attractive for the inhabitants of the urban area (Sensitive, Historical, Social, Economic, Aesthetic). As a result, urban planners whose prioritised aspects are more in line with those of the politicians tend to have greater influence in the physical planning of the urban space than the water professionals (cf. Table 3).

As highlighted by one of the water professionals interviewed in Denmark, communication in decision making is not so easy and a strained relation is sometimes created with the other stakeholders:

> "It is sometimes difficult to make people accept that the solution you give is not definitive. People always expect you to remove the problem completely but this is impossible. The notion of flood return periods is hard for them to understand. They think it is not acceptable to have flooding at all. (...) It is quite difficult to communicate with the urban planners of the municipality. Sometime you simulate the situation of the area and find the optimal solution, but then the city planners want a different design, and so you have to come back and do the simulation again. In this way you waste a lot of time".

Public opinion is usually very influential on political decisions, and it is formed by the local citizens defined as lay persons in Figure 2. Citizens live and work in the urban area, but they tend to be less knowledgeable and aware of the technical issues than the professional stakeholders involved in decision making. Their drivers may differ depending on their education, their knowledge of the issue, their personal interest and most of all their cultural background (Hofstede and Hofstede 2005). In general, lay persons tend to prioritise all the aspects that improve their quality of life according to their perception of reality (i.e. Sensitive, Historical, Social, Aesthetic, Ethical, Ideal and Linguistic). To communicate with lay persons is a challenge for water professionals, which are typically not particularly used and thus skilled to address most of the values not belonging to the technical sphere.

For example, the municipality of Egmond aan Zee implemented a pervious pavement with underground storage, combining a solution aimed to reduce flood risk with one already planned to improve the city's aesthetic and logical values, promoted by the local urban planners. Assigning multifunctional aspects to the newly implemented urban infrastructures was a good choice from a cost-benefit perspective and facilitated the cooperation with the urban planners. However, pervious pavements require a lot of attention by the inhabitants crossing the streets on a daily basis and their daily habits and rituals (Ideal and Ethical aspects) had not been properly considered. As an example, the project manager and water professional in Egmond aan Zee described his difficulties involving citizens in the project as follows:

> "(...) some of the people use little old tractors to go from their houses to the sea, also for fishing. These tractors release oil and even if the water engineers tried to explain the problem in respect to the pervious pavement to them they do not care and keep using those tractors. (...) They don't like to do what the municipal management says; sometimes, it seems they do the opposite things on purpose"

This perspective of a water professional, prioritising the Logical aspect, is in direct contrast to that of a typical citizen living in the area, who prioritises the Linguistic, Ethical, Ideal and Social aspects:

> "(...) civil engineers. They are doing their job but they do not take part in our meetings, they don't get in contact with the people and thus they are not able to implement the municipal orders in a proper way. They cannot understand the feelings of people living here. This is the biggest problem: they are clever guys but they do not think about people's emotions (values, Ed.)".

A Danish water professional gave us more insight on how difficulties arise in decision making and how she believes they should be handled:

> "In the case of flood risk we usually design a traditional solution with open detention basins to store the exceeding water and then we send an application to the authorities. The authorities may not accept it because the city planners have decided to have a certain percentage of green areas in this part of the city and so we cannot use those areas for building a detention basin. So we go back and we have to do something underground and we have to make the wall in concrete and huge pipes and so on. Everything becomes more expensive and at the end the price of the project goes from 5 million to 100 million DKK just because the city planners decided not to implement the first solution. (...) Well, I would say, you could use the 95 million to improve the living area in the city. So if you explain to the city planners what the citizens are experiencing today and what they will experience in the future, in the end they will understand. We need to start to work together because this problem is crossing boundaries and we have common interests in the way we are going to develop the urban area".

As suggested by the interviews reported above, water professionals need to work together with the urban planners because the technical innovation needed in UFRM is crossing boundaries and the two stakeholder categories may find common interests in the way they are going to develop the urban area.

The water professionals need to learn to develop more attractive projects where more aspects are considered than in typical urban drainage projects based on pipes. They need to find the space for the necessary storage and conveyance elements within larger projects involving the urban space using multifunctionality, and they need to cooperate with other municipal sections using transdisciplinarity as a tool to create shared ownership of proposed solutions. Only in this way can the projects become cost-effective and attractive at the same time for the politicians and the other stakeholders involved. The water professionals need to extend their area of action in order to become part of the future urban planning vision. They need to learn to consider a larger variety of aspects if they really want to obtain the support of a larger number of stakeholders (Stahre 2008).

The examples and the description (Table 3) of the stakeholders involved in UFRM shows how communication in decision making is really central and most of all, that the common understanding of terms and concepts brought into the discussion is very important for successful cooperation among the involved stakeholders. In particular, among the aspects introduced in Table 2 the "Linguistic aspect" is the only one common to all stakeholders, as shown in Table 3. Unfortunately, water professionals are not used to prioritising the Linguistic aspect and they don't generally have proper tools to communicate concepts in a language that allows them to reach the different stakeholders involved in decision making.

4.3. The 3PA in practice

At the start of the project in Egmond aan Zee, the water professionals were very pro-active in approaching Point 2 of the 3PA, finding synergies with the urban planners to implement a solution to flood risk mitigation that combined a pervious pavement with new major above ground conveyance elements that reduces the damage costs of flooding by transporting critical runoff water to less vulnerable areas. However, due to their lack of skills in communication with the citizens and the regional agency for groundwater quality and nature protection, the water engineers were not very successful in fulfilling Point 3. At the time of the interview campaign the municipality had not yet succeeded in obtaining permission for storing and infiltrating runoff water on the citizens' properties and within two natural areas surrounding the city. This is an issue because the designed system took the storage and the infiltration capacity of those areas into account. Thus by failing to address Point 3 in a timely manner they might risk compromising the successful implementation of facilities addressing Point 2.

Interacting with the citizens about flood risk reduction measures on their properties is crucial but not easy, as the local project manager affirmed:

> "(. . .) it is difficult to ask people to do something if they do not have the problem directly. The flood problem only involves the people living around the Voorstraat [the downstream area of the sewer system, Ed.] but one of the causes of the flood problem is that the people upstream have decided to pave their gardens and connect their runoff and the water coming from their roofs to the sewer system".

Social awareness and acceptance requires a lot of effort. In Dordrecht much more has been done to increase awareness and enhance social support, while at the same time enhancing storage, reuse of storm water from the roofs and groundwater infiltration. Dordrecht Municipality managed to combine Points 2 and 3 of the 3PA really well. They pro-actively encouraged the citizens to install facilities in their gardens that allow storing and infiltrating water in the soil instead of connecting the runoff to the sewage system. Two water professionals from the municipality of Dordrecht reported:

> "20 citizens living in critical areas for water management in the city have been participating in a course where they learned how to deal with their gardens and use storm water to make their living place more pleasant. They followed the course and then they had the opportunity to design their own garden and to get suggestions from the technicians teaching the course. The course was free, while any expense on the gardens would have been the owners'. The result was impressive. It had great success among the people participating. Now the municipality is willing to run another session involving more people".

Another example was described by the local project manager:

> "Here in Dordrecht there is a neighbourhood that is quite densely built up. They have a green area where people usually walk their dogs. We needed to create storage there but we couldn't use the only green area they had. So we asked the citizens to design the storage area in collaboration with the technicians. We told them the size we needed, and we also told them: 'It does not need to be blue, but can also be green [meaning that it does not need to contain water all the time, Ed.]. It should only be able to get flooded when it rains intensively'. It worked: people were very happy and now they enjoy their common green area even more".

A first comparison between the analyses performed in the Netherlands and in Denmark showed that there is a basic difference in the way UFRM is approached in the two countries, due to the difference in physical characteristics and history of the two countries with respect to water management. Large parts of the Netherlands are below sea level and the country is therefore very used to dealing with flood risk. Everybody more or less understands what flood risk means and agrees that this has a high priority. So the authorities and the rest of the social system tend to be open to new approaches to UFRM involving the urban space. As a consequence water managers have the freedom to experiment more. In Denmark, urban flooding is perceived as a relatively new challenge brought into focus by numerous pluvial flooding incidents over the past 5–10 years. Stakeholders therefore have a very different perception of flood risk and tend to be more resistant to new approaches. As a consequence, water professionals need stronger tools to support decision making and motivate their choices.

A water professional with a long experience in local water management and with the development of advanced water engineering software affirmed:

> "In Denmark we have a problem with the definition of the service level. A water manager in charge of the urban drainage system must only be sure that this system will comply with the national standards, nothing more (. . .) People do not realise the existence of the second point of the 3PA in Denmark, they don't

plan on it, they don't do anything about that at the moment''.

The lack of focus on Point 2 in Denmark is a critical issue in the context of climate change where the frequency of large rain storms is expected to increase. The 3PA may represent a useful communication tool for water professionals to enhance social acceptance of the necessary implementations to deal with flood risk. A water manager and engineer working in the department of water infrastructures in the municipality of Greve affirmed:

> ''I used the 3PA approach in the municipality with the politicians. After the first half hour they were already discussing the actions to be taken in terms of Points 1, 2 or 3. The 3PA responds to the politicians who want a definition of the domains where actions needs to be taken. Furthermore, this method is a good way to explain to ordinary people what is going on and why we can't do everything for them. It has a strong communicative power. (...) You can tell them that Point 1 is what they are paying for and then you can explain them that at the moment they are not paying for the other two points''.

According to another water manager and engineer with a relevant professional experience in the Danish urban water sector:

> ''The 3PA is a good communication tool. Sometimes it is not enough. But I think it is an extremely efficient tool to say to the city planners, to the urban drainage guys and to the risk guys that they need to work with each other. You have so many specialists working with urban drainage that are only interested in the size of the pipes and they do not care about the rest. So you need a very simple way of looking at the world''.

In each of the three case studies analysed, the 3PA has shown to be a good tool to stimulate discussion in projects where multiple stakeholders are involved and to facilitate the introduction of different values in the decision making process. However, it is not yet able to make a proper connection with specialists who work with economic assessment of flooding; a utilitarian evaluation of the day-to-day values (Point 3) seems to be too complex in practice. Nevertheless, the aim of the 3PA is not to make a pure economic evaluation of the project but only to visualise the arenas in which to discuss and act in UFRM in the context of climate change. Even if the economic evaluation of flooding is a relevant part of UFRM, it is not the only one. The aim of the 3PA is to make visible and clear to the stakeholders that all the points indicated in Figure 1 are important, and that different perspectives and aspects are involved and necessary to consider in the three arenas defined by the three points.

4.4. The 3PA in the decision making: organising transdisciplinary processes to achieve multifunctionality

The strength of the 3PA is that, because it is understandable and easy to grasp by all stakeholders including the non-experts, it can help in communicating and understanding the complexity characterising reality without over-simplifying it. In a transdisciplinary process organised using the 3PA as backbone, multifunctionality is the desired outcome of a process that addresses the functional and relational complexity characterising decision making for UFRM. To include multiple aspects in the new implementations the water professionals need to enhance their creativity and communication skills in order to organise processes that will enable them to design solutions in cooperation with other relevant stakeholders.

When dealing with the complexity of urban flood risk management, the 3PA becomes a thinking system that does not exclude the aspects characterising complex systems, but instead groups them. For example, ''having an area where children can play safely'' is a day-to-day need (Point 3), just like having constructions that can be maintained well (Point 3) while at the same time reducing the negative effects of flooding (Point 2); whereas issues concerning structures that meet the technical standards can be grouped under Point 1. When all the different drivers and values are considered, each stakeholder becomes aware and thus agrees to assume his/her own responsibilities in both maintenance and protection from risks.

A transdisciplinary process is achieved when water professionals organise interactions in the three domains of the 3PA in an iterative process, as illustrated in Figure 3. In a case where the decision making process only focuses on one or two of the three points, something in the final outcome will be missing and the project will fail even before any solution is implemented.

The 3PA pattern illustrated in Figure 1 is mathematically and technically understandable at Point 1 (Logic and Economic aspects) but unravels a larger variety of aspects valued by a broader range of stakeholders in Points 2 and 3. The holistic goal to flood risk management set out in the EFRD cannot be achieved by solely focusing on Logical and Economic aspects and the 3PA makes this clear in a way that can be easily communicated. Decisions made with the use of the 3PA facilitate taking into account the interrelation among the technical, the natural and social systems characterising the urban context. The key is to employ a transdisciplinary working method aimed at implementing multifunctional structures able to increase the resilience of the urban context to flood risk.

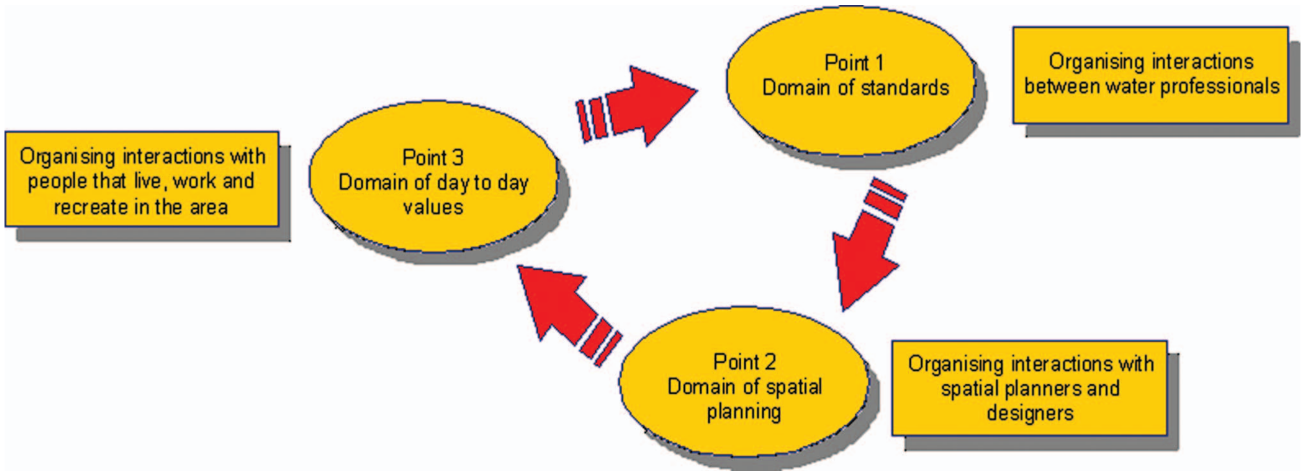

Figure 3. The iterative process of UFRM when using the 3PA. The boxes list (non-exclusively) the main stakeholders that are important to include in the three domain discussions.

5. Conclusions

The European Flood Risk Directive (EFRD) requires consideration of the complexity involved in urban flood risk management (UFRM), including that urban adaptation to climate change requires measures that combine underground and above ground measures and processes. Above ground measures are inevitably area based, so their implementations involve multiple actors and multiple systems. As a result, given the functional and relational complexity involved in UFRM in the context of climate change, more aspects need to be taken into account than in the traditional approach to UFRM based solely on below-ground sewers. Given the space constraints characterising already developed urban areas, the identification of relevant aspects valued by the multitude of stakeholders active in an urban context unveils opportunities for multifunctional solutions that create value in addition to managing flood risk.

The Three Points Approach (3PA) poses that water engineers should take into account three domains for action in UFRM: (1) *technical optimisation* dealing with standards and guidelines for urban drainage systems; (2) *spatial planning* making the urban area more resilient to future changing conditions; and (3) *day-to-day values* enhancing support and awareness among stakeholders and thus creating a solid base for social preparedness and maintenance of urban infrastructures. Each domain has its own characteristics, and in each of them different aspects play main roles and thus different stakeholders need to be involved.

The 3PA tool emerged from practical experiences with UFRM and was designed to fill the communication gap existing between the water engineers, in charge of the management of urban flooding, and the multitude of other stakeholders involved in the urban decision making processes. The 3PA enables water professionals to communicate about options for managing flood risk by organising the discussion in three arenas represented by each of the domains introduced by the 3PA. As a result, each stakeholder is more likely to participate and support the project without necessarily denying their own values and expectations. This potentially increases awareness, objectivity and flexibility, and facilitates mediation and knowledge transfer among the stakeholders involved in developing effective strategies for local adaptation to climate change.

The use of the 3PA in practice has proven it to be a communication tool that allows a direct connection to be maintained with the complexity characterising reality in UFRM. It allows water professionals to address the relational complexity characterising UFRM in the context of climate change in a pedagogic manner, thus facilitating the organisation of decision making with the use of transdisciplinarity. Multifunctional solutions for UFRM are an expected outcome of transdisciplinary processes organised with the 3PA. Multifunctionality and transdisciplinarity address the functional and relational complexity of the urban area and thus creates opportunities for consensus in a decision making process where many stakeholders are involved.

As a conclusion, the 3PA is an efficient communication tool that can be used to give form and content in practice to the European Flood Risk Directive when designing local strategies for urban adaptation to climate change.

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