ID 1630 | PARTICIPATORY MODELLING TO SUPPORT GROUP DECISION MAKING PROCESSES IN CLIMATE RESILIENT URBAN DESIGN

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1 INTRODUCTION

Interest in climate resilience is growing worldwide among policy makers, urban planners, citizens and scientists. Climate Resilient Urban Design (CRUD) relates to the (re-)design of urban areas in such a way that cities and citizens become less vulnerable to climate change. Weather phenomena like heat stress, droughts and floods impact the lives of city dwellers, villagers, and rural residents all over the globe. The making of policies dealing with climate resilience in urban environments is a process that inevitably involves stakeholders from various disciplines, each with their own interests, constraints and goals.

Group Model Building (GMB) (Vennix, 1999) is known to facilitate the decision making processes by modelling important variables and their causal relations in a Causal Loop Diagram (CLD). This participatory group modelling process creates a shared understanding of the problem, incorporating the views of all stakeholders, and it improves the support for the final decisions taken.

The GRACeFUL (Global systems Rapid Assessment tools through Constraint Functional Languages) project aims at supporting decision making in complex problems by connecting participatory processes (using GMB) to scientific evidence through novel tools. Rapid Assessment Tools typify causal factors and linkages with concrete data from other system layers and produce a set of viable and acceptable alternative solutions to be used in decision making. Simulation tools will simulate the alternative scenarios over time and visualization tools will show the results of the different CRUD solutions on maps. The case study area is a neighbourhood in the city of Dordrecht, the Netherlands. The municipality is planning to redevelop the public space in this neighbourhood taking into account climate resilience and involving different stakeholders, including citizens.

The aim of this paper is to identify important variables, their causal relations and feedback loops which are generally involved in Climate Resilient Urban Design problems. These factors, relations and loops help us to develop the GRACeFUL Rapid Assessment Tools. Student workshops were held in which six groups of Urbanism and Water management students represented different stakeholder roles. Each group created a Causal Loop Diagram (CLD) on the Dordrecht case study neighbourhood and used this participatory modelling process as an exercise to create a better Climate Resilient Urban Design.

This paper is organized as follows. First, the participatory modelling method Group model building will be explained. This is followed by a description of the workshop on climate resilient urban design. Section 4 represents the analyses of the CLDs and the paper ends with a discussion.

2 GROUP MODEL BUILDING

The participatory modelling method Group model building is particularly useful for problem structuring and diagnosis in decision making processes (Vennix, 1999). It is known to include all stakeholders' views, input and explanations and thereby the method guides the participants to an improved and shared understanding of the problem and a stronger support for the final decisions made.

Group model building is a facilitated participatory modelling method which implies that an independent facilitator will guide the group of six up to 15 different stakeholders through the process, often assisted by a modeller/recorder. The participants are generally seated in a semi-circle or U-shape with the facilitator and a whiteboard (or projection screen if the model is created using system dynamics modelling software) in front (Rouwette and Vennix, 2017).

Group model building consists of a divergent as well as a convergent phase. The creative divergent phase is typically covered by using an existing method like brainstorming, in order to elicit as many variables associated with the problem as possible. In the convergent phase those variables will be related to each other, creating a causal diagram or system model. This so-called Causal Loop Diagram (CLD) represents the variables that (in)directly affect or are affected by the problem variable, and the causal relations between the variables. As an illustration, figure 1 shows a picture of a part of the causal loop diagram created by group 2 of the 2017 CRUD workshop. A positive causal relation means that both factors change in the same direction. For instance, according to group 2017_2, an increase in damage caused by floods will lead to an increase in climate awareness. Negative relationships between factors indicate a change in opposite directions (Rouwette and Vennix, 2017). For example, an increase in climate awareness will decrease household consumption (right-hand side of figure 1). Furthermore, feedback loops within the diagram (e.g., between climate awareness and climate policy in figure 1) are important indicators for balancing or escalating behaviour.

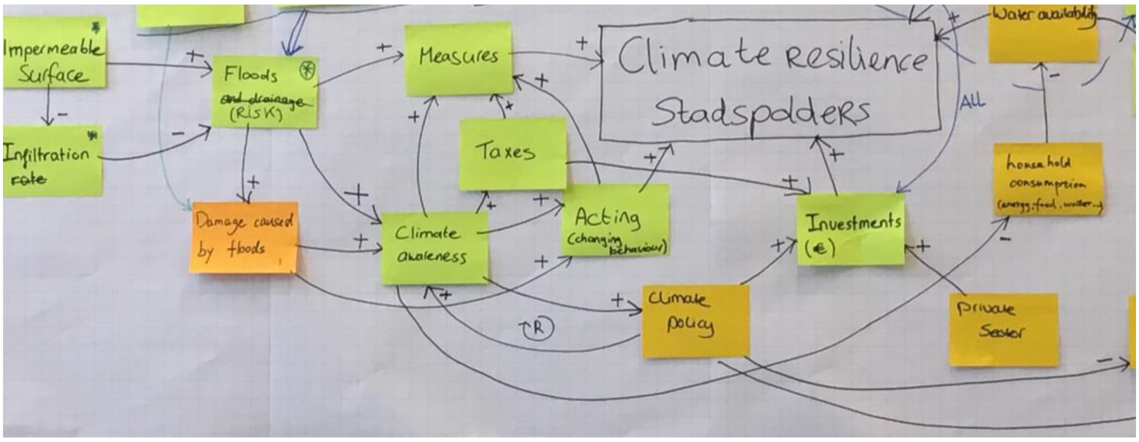

Figure 1 - Causal loop diagram made by group 2017_2

Related to the urban planning field, issues regarding specific projects on topics like tourism development in a coastal area (Vugteveen et al., 2015), neighbourhood safety (Rouwette et al., 2016) and coastal flooding were addressed by using Group model building. To the best of our knowledge, this method has not been applied to climate resilience at the urban design level taking into account pluvial flooding, drought and heat stress.

3 CRUD WORKSHOP

As part of a one-day workshop on Climate Resilient Urban Design (CRUD), in May 2015, 2016 and 2017 two student groups, each consisting of six students, worked on a Causal Loop Diagram (CLD). The remaining five to six groups used other methods/tools in preparation of the design phase. The students were master students Urbanism (Faculty of Architecture and the Built Environment) or Water management (Faculty of Civil Engineering and Geosciences) at Delft University of Technology. Each student was assigned a stakeholder role. The following roles were divided: 1) local residents representative; 2) local businesses representative; 3) city of Dordrecht – spatial planning & development; 4) city of Dordrecht – water; 5) environmentalist; 6) recorder. Their task was to create a climate resilient urban design for the Stadspolder neighbourhood in Dordrecht. As a problem structuring exercise each year two groups of students participated in a Group model building (GMB) session. In these GMB sessions first factors related to Climate Resilient Urban Design were elicited. Subsequently, the students created a CLD by linking the factors that were causally related.

3.1 STADSPOLDER NEIGHBOURHOOD

Stadspolder in a neighbourhood in Dordrecht located in the east part of the city (see Figure 2). The neighbourhood was built in the 1980s and 1990s. Nowadays the public space is in need for reconstruction and therefore the municipality of Dordrecht seized this opportunity to not only renew the streets, sewage system, parking lots and green space, but to redesign the public space and making it more climate resilient. The Stadspolder neighbourhood has a so-called cauliflower structure, which was typically applied to Dutch neighbourhoods designed in the 1970s and 1980s. These cauliflower neighbourhoods are characterised by a maze-like grouping of cul-de-sacs or small courtyards intended to encourage social bonding by facilitating spontaneous encounters among neighbours (Wekker, 2016), to improve intimacy and to reduce through traffic. Main problems in the Stadspolder neighbourhood concern parking (limited parking space, parking in front gardens), dwellings with low doorsteps and accessibility.

Figure 2 - Stadspolder's location in Dordrecht (in red)

4 ANALYSES

This section describes the analyses of the six CLDs constructed by the groups of students at the CRUD workshop. The first thing that catches the eye is that all six models are different even though the Master students have similar knowledge and the project case is exactly the same. Another observation, which often is noticed when analysing GMB sessions on the same topic, is that the different groups use different words to indicate the same thing. Furthermore, it should be noted that the CLDs are not perfect after only 1.5 - 2 hours of modelling.

The analysis starts with identifying general causal relations to and from 'climate resilience'. This is followed by a specific focus on the climate resilience aspects flooding and heat stress. The respondents did not consider drought to be a problem to the Stadspolder case. Finally, other important themes in the causal diagrams, safety, awareness, liveability and costs, will be evaluated.

4.1 CLIMATE RESILIENCE

The GMB groups worked with 'Climate resilient Stadspolder' as the central variable in the CLD. This implies that 'Climate resilient Stadspolder' was the first factor written in the centre of the empty board and subsequently, the variables elicited in the brainstorming phase which had a causal relation to the factor(s) on the board were added to create the causal diagram. As a consequence, all groups have connected factors to this central variable. Table 1 shows per topic which factors were causally related to it, both ingoing and outgoing arrows, and whether the arrow had a plus or minus sign. When looking at the incoming arrows, the most frequently connected factors to 'climate resilience' deal with flooding and heat stress on the negative side (i.e., the more flooding the less climate resilient), whereas measures, water management factors (like vegetation, green/blue space, drainage/storage capacity, permeable surfaces), sustainability related factors and safety show a positive causal relation. The outgoing arrows from climate resilience head towards living quality, different forms of sustainability and safety holding a plus sign and flooding and heat stress having a negative causal relation.

4.1.1 FLOODING

In the causal diagrams this dimension of climate resilience is indicated by flood risk, floods, flooding and flood events return period. Group 16_2 connects flood risk to floods by an arrow with a positive sign which implies that a higher flood risk leads to more floods. Other factors with a positive link towards flooding concern rainfall (events), impermeable surfaces, groundwater level, maintenance issues, drought dikes risk and run-off. On the other hand, infiltration/permeable surfaces, water drainage, water storage, green space, quality of sewage, quality of water management, (measures and emergency preparedness) are factors which reduce the flood risk when improved. Regarding the outgoing arrows of flooding, variables like damage, hazards and costs, but also measures and awareness are linked with a plus sign (the more flood events, the more damage or the more awareness). Whereas safety, living quality and accessibility are negatively affected by flooding.

4.1.2 HEAT STRESS

Urban heat stress or heat risk was mentioned by four out of six groups. Their causal diagrams show that increasing the space for buildings and roads raises heat stress levels. On the other hand, urban heat stress declines due to an increase in green/blue space, water availability, citizen initiatives and sun reflection. Factors caused by heat stress concern energy cost for cooling and heat stress business opportunity, holding a plus sign (the more heat stress, the higher the costs for cooling) and water quality, safety and native biodiversity are connected with a negative arrow (the more urban heat stress causes poorer water quality).

		Incoming arrow		Outgoing arrow	
-	group	+	-	+	-
Climate resilience	17_1	vegetation	flood risk		
		area for water	ground water fluctuation		
			consumption		
	17_2	measures			
		acting (changing behaviour)			
		investments			
		water availability			
		green/blue space			
	16_1	adaptivity	flooding (extreme)	living quality	flooding (extreme)
		energy transition	urban heat stress		
	16_2	space for green/ water/nature	impervious areas		heat stress
		open water availability (surface)		flood risk	open water availability (surface)
	15_1	CRUD measures		amount of vegetation	
		drainage capacity			
		permeable surfaces			
		green housing			
		storage capacity			
	15_2	quality of water management		economic sustainability	flood risk
		adaptive measures		environmental sustainability	
		social sustainability		safety	
		biodiversity			
		safety			
Flooding/floods	17_2	impermeable surface	infiltration (rate)	damage caused by floods	
			measures	climate awareness	
				measures	
	16_1	management groundwater	water storage		climate resilience
		drought dikes risk	climate resilience		living quality
		block in sewer/ maintenance issue	landscape permeability/ infiltration		
	16_2	flood risk		hazards open water	accessibility
flood risk	17_1	run-off	infiltration capacity	costs for business	climate resilience
			quality of sewage		
	16_2	impervious areas	climate resilience	damage during flood	
		groundwater level	water drainage	floods	
	15_2	extreme rainfall events	emergency preparedness		safety
			quality of water management		
			climate resilience		
			green space		
flood events return period	15_1	rainfall	amount of permeable surfaces	quality of life	

		Incoming arrow		Outgoing arrow	
	group	+	-	+	-
(urban) heat stress	17_2	space for buildings/ roads	water availability	energy cost for cooling	
			water storage		
			green/blue space		
	16_1		citizen initiatives	HS business opportunity	climate resilience
			vegetation/green-blue infrastructure	water quality	vegetation/green-blue infrastructure
			albedo roofs		native biodiversity
	16_2	space for buildings	climate resilience		
			space for green/water/nature		
			open water availability (surface)		
heat risk	15_2		green space		safety
Liveability	16_1	aesthetics	flooding (extreme)		
living quality		water quality	densification		
		native biodiversity	subsidence		
		urban farming			
		climate resilience			
		citizen initiatives			
		green mobility/parking			
		infrastructure			
		attractiveness recreational areas			
quality of local living environment	16_2	water quality		healthy environment	
		interaction with nature		population	
quality of life	15_1	amount of vegetation	quality of life		
		safety			
		environmental quality			
		CR measures			
		return period flood events			
social sustainability	15_2	social cohesion		climate resilience	
		public awareness			
		urban farming			
wellbeing residents	17_1	welfare of residents	housing density	support for initiatives	
		vegetation			
		area for water			
		biodiversity			
		water recreation			
Awareness	17_2	floods		measures	household consumption
(climate)		damage caused by floods		taxes	
		climate policy		acting (changing behaviour)	
				climate policy	
(collective)	17_1	support for initiatives		support for initiatives	consumption
(public)	16_1			citizen initiatives	
(public)	15_2	education		social sustainability	
Safety	15_1	accessibility in crisis		quality of life	safety
		water available for fires			

		Incoming arrow		Outgoing arrow	
	group	+	-	+	-
Safety (continued)	15_2	climate resilience	flood risk	climate resilience	
			heat risk		
			health risk		
Cost	17_1	flood risk			local business
money/ subsidy	16_1	subsidence		green roofs	
		HS business opportunity		energy transition	
maintenance costs	15_1	maintenance			CR measures
taxes	17_2	climate awareness		investments	
				measures	
water taxes	16_1		landscape permeability/infiltrati on	landscape permeability/infiltrati on	
investments	17_2	taxes		climate resilience	
		climate policy			
		private sector			
economic development	16_2	development of area		population	
economic sustainability	15_2	job opportunities			
		available funds			
		climate resilience			
		urban farming			

Table 1 - Factors in CLDs by theme and their causal relations

4.1 OTHER IMPORTANT CRUD THEMES

The six Causal Loop Diagrams show some other topics that are part of a climate resilient urban design system model. Liveability, awareness, safety and costs are often mentioned. Furthermore, ‘measures’ in general or specific measures are frequently part of the causal diagram. This subsection describes the causal relations regarding those themes.

4.1.1 LIVEABILITY

Liveability is chosen as a blanket term for the factors living quality, quality of local living environment, quality of life, social sustainability and wellbeing residents. This theme appears in five out of the six CRUD system models. Group 16_1 really puts an emphasis on their living quality factor since they identified twelve ingoing arrows, making it the most prominent factor. According to them aesthetics, attractiveness recreational areas, native biodiversity, water quality, climate resilience, urban farming, green mobility, infrastructure and citizen initiatives contribute to a better living quality. On the other hand, flooding, densification and subsidence negatively affect the liveability of the Stadspolder neighbourhood. Group 16_2 adds that interaction with nature positively influences the quality of the local living environment. Furthermore, they indicate that increasing liveability leads to a healthy environment and a growing population. Group 15_1 focusses on quality of life which according to them is affected by more vegetation, safety, environmental quality, measures for climate resilience and a longer return period of flood events. In the case of social sustainability (group 15_2), social cohesion, public awareness and urban farming are positively connected. Finally, the wellbeing of Stadspolder’s residents (group 17_1) is influenced by welfare of the residents, vegetation, biodiversity, area for water and water recreation and housing density. The latter factor is in this CLD the only negative causal link (i.e., the higher the housing density the lower the wellbeing).

4.1.2 AWARENESS

Compared to the presentations of groups using other tools/methods at the CRUD workshop, the GMB groups often come up with ‘raising awareness’ and ‘involving local residents’ as measures for increasing the climate resilience of the Stadspolder neighbourhood. These are actions which are not directly related to maps (compared to technical measures like bio swales or green roofs). Collective, climate or public awareness turns up in four causal loop diagrams. Regarding the incoming arrows, we see that support for initiatives, climate policy, education, floods and damage caused by floods are factors raising awareness. Whereas awareness causes more support for initiatives, measures, taxes, acting, climate policy, citizen initiatives and social sustainability. Some direct feedback loops show up here. A decrease in household consumption an effect of increased awareness as well.

4.1.3 SAFETY

Another theme that can be distinguished is safety. This factor is described in half of the CLDs and for this analysis it also includes hazards open water and emergency preparedness. Regarding ingoing arrows, accessibility in crisis, water available for fires and climate resilience show a positive causal relation (the more water for fires the greater the safety), while flood risk, heat risk and health risk negatively affect safety (the higher the risk the lower the safety level). Safety, in its turn, has positive causal effects on quality of life and climate resilience. Hazards open water are increased by more open water availability and more floods, whereas improved water quality decreases the exposure to hazards. Finally, emergency preparedness grows when available funds increase and education on this topic improves. On the other hand, preparedness for emergencies causes a reduced flood risk.

4.1.4 COST

Inevitably costs are involved in restructuring neighbourhoods when applying measures to make them more climate resilient. All of the groups had factors in their CLD that deal with this theme. Costs for business, money/subsidy, maintenance costs, taxes, investments, economic development and economic sustainability were mentioned. With regard to investments, the factors taxes, climate policy and private sector positively affect the number of investments made. 'Investments' is also directly connected to climate resilience (i.e., the more investments the more resilient the neighbourhood is). CRUD measures in general and some specific measures are linked with cost as well. For example, the higher the taxes, the more measures will be adopted, the higher the maintenance costs the lower the number of measures implemented, the more money/subsidy the more green roofs and the more urban farming the more economic sustainability. This economic sustainability is positively influenced by job opportunities, available funds and climate resilience as well.

4.2 DISCUSSION

Six causal loop diagrams were obtained from workshops on climate resilient urban design of the Stadspolder neighbourhood in Dordrecht. Analysis of the causal diagrams shows that all system models seem to be very different even though the case study area is exactly the same and the Master students had a similar background in education. Furthermore, also the wording used to indicate the same factor differs between groups. This is often noticed when evaluating causal diagrams on the same topic. A general explanation is that a causal loop diagram represents how the group thinks about the problem. Other stakeholder groups might create a different model based on the exact same problem.

Another observation is that the CLDs are more focused on flooding than on heat stress or drought. The students might consider pluvial flooding as the main problem, however this could also be caused by an overrepresentation of water management students in the groups (usually five water management students and one urbanism student). This also explains why typical urban design variables, like aesthetics and attractiveness, are not frequently mentioned.

Finally, the group model building sessions in the CRUD workshops were quite short (1.5 – 2 hours) compared the usual GMB process, which covers at least two sessions of 3 to 4 hours with opportunities for reconsideration and improvement. Hence, the final CLDs created by the student groups are not absolutely perfect.

ACKNOWLEDGEMENTS

This research is funded by the EU GRACeFUL (Global systems Rapid Assessment tools through Constraint Functional Languages) project, www.graceful-project.eu, Horizon 2020, grant 640954 EU-GRACeFUL. We thank all students who participated in the CRUD workshops for their valuable contributions.

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