	Theme 3. Fresh water availability and access
SC 3.3	**Improving fresh water availability: measures under climate change**
Chair	Gualbert Oude Essink, Deltares, the Netherlands
Rapporteur	Emilie Buist, Delft University of Technology, the Netherlands
Presenters	Koen Zuurbier, KWR Watercycle Research Institute, the Netherlands Amir Haider, Malik Comsats IIT, Pakistan Josep Osorio, Climate Service Center Germany, Germany Anuradha Maharaj, Centre for Resource Management and Environmental Studies (CERMES), Barbados

The chair presents himself and the topic: how to improve fresh water availability, taking into account climate change, sea level rise, changes in precipitation, etc. The topic is very relevant, not just for the Netherlands, but also other areas around the world where water scarcity is a serious threat. Some of the presentations in this session will be about small islands in developing states like in the Caribbean and the Pacific. With their intrinsic small fresh groundwater availability these islands benefit from measures even more and are thus interesting case-studies.

Freshwater supply: the subsurface to the rescue
Koen Zuurbier, KWR Watercycle Research Institute, the Netherlands
Often there is a mismatch between water availability and water shortage. The central research question is: how can dedicated hydrogeological solutions in the subsurface contribute to bridge periods of water availability and demand, as well as be of help in future climate adaptation? Using the subsurface has several benefits; it has a large capacity, it can prevent evaporation and contamination and it can work as a water buffer in times of floods. The difficulty is to get the fresh groundwater out without extracting salt groundwater at the same time. Three case studies in the Netherlands were presented and compared, that use different techniques. Aquifer storage and recovery, the Freshkeeper (prevent salt water intrusion into freshwater fields) and the Freshmaker (injection of freshwater with horizontal directional drilled wells). One conclusion is that it is important to build flexible and dedicated systems. The importance of ICT is stressed, which can help to make it more convenient for the end user. Further research should involve how to deal with stakeholder participation, market scans, regulations and life cycle analysis. More information on www.subsol.org.

Flood water conservation underground – Case Study: Indus Basin to improve water quality & quantity
Amir Haider, Malik Comsats IIT, Pakistan
Pakistan is facing serious water challenges in terms of water quantity and water quality, such as floods and droughts. It is close to using all its water resources and future demand is projected to grow with 30%. At the moment, 25 million acre feet (MAF) of (fresh) flood water drains into the sea, unused. The idea presented in the presentation regards this unused water, and describes different aspects of a strategic water plan. It is proposed to divert the flood water in order to recharge over mined and contaminated aquifers. The water can then be used during droughts, and will be prevented from evaporation. This also implies more resilience against floods. The water can also be used for food and electricity production. Gravity can be used for the diversion of the water and natural sand dams offer storage capacity. To implement the plan, a selection of sites should be made and modelling should be done to divert the water most optimal. The Ministry of Water & Power should be convinced to implement this project to improve the quality and quantity of water.
A question is raised whether dams and barrages are the only ways to infiltrate the water, or whether other methods can also be used. This might be a good point for further discussion.

Water poverty in small islands: natural laboratories for global water management
Josep Osorio, Climate Service Center Germany, Germany
Water poverty was researched in small coral islands in the Indonesian Archipelago. On small islands there often is no surface water, and they rely on precipitation and fresh groundwater storage. Small islands are considered as semi-enclosed labs, because water related problems occur in a condensed way.
Water poverty is not just about the physical component, but also involves socio-political and economic issues.

As such, the Water Poverty Index (WPI) has been developed. WPI is an indicator for the water resource availability and includes the criteria resources, accessibility, capacity, use and environment. The WPI was used to evaluate the water resources of six islands. From this it was concluded that water poverty is pressing on the six islands, however despite the common geographical position there are differences between the indexes. The preferred sources of water also differs, due to availability and pricing differences. Measures should be taken to make maximum use of the 3000 mm of rainfall per year and the extraction rates should be limited. Desalination might be another source of water.

Quantifying present and future water availability in selected Caribbean catchments
Anuradha Maharaj, Centre for Resource Management and Environmental Studies (CERMES), Barbados
The project deals with four Caribbean islands: Jamaica, Trinidad, Barbados and Carriacou that are expected to be impacted by climate change, including sea level rise. On average, 90% of the water comes from the aquifer system. A decrease in precipitation is expected, and small changes in precipitation can already have a big influence which can severe influence on the overall water availability. As part of the project, climate projections and project precipitation changes are used to model the future water availability on the islands. For this, the Water Evaluation and Planning Tool (WEAP), that is a good choice because it can handle data scarce areas: e.g. WEAP can still give a good understanding of the trends. In the first runs only the precipitation was a variable. The preliminary results show an increase in unmet demand and this could imply a high risk for severe droughts. In the current models the socio-economics have been assumed constant, but in future models this should also be included as a dynamic parameter.

Discussion
Three questions: What is the challenge? What did we contribute? What are the next steps?
A first point to come up during the discussion: creating future water availability is not just a technical issue, there are many more obstacles to overcome, such as corruption and mismanagement.
Then a remark was made. To be able to change this we have to make water everybody's business. Water awareness is very important. This is also the responsibility of the researcher. In this regard, knowledge transfer is very important. The complex science should be made insightful to for example farmers.
Along with that goes the challenge to minimise unwanted side-effects of the interventions. For example, by making irrigation more efficient, aquifer recharge goes down at the same time. This should be taken into account, to complete the analysis.
Another topic addressed in the discussion is model quality and uncertainty of data. A first problem is the lack of data, for example on Barbados. On the other hand, most models are made for developed countries, using them for undeveloping countries does not always correspond. The model should always be validated in the field.
A remark is made about the importance to look at future scenarios within the models and then look what measures would be best in what point in the future. Depending on what happens, you can decide what measure to apply when; meaning adaptive strategies should be considered. Stakeholders are also more comfortable with this. Another point made in this regard is that sometimes you don't need that much detail in your model if you already have an idea about core issues (e.g., about subsurface: if it is a sandy setting, the permeability of the system van relatively easily be determined). Often, accurate and necessary data are more essential than quantity, though this does not always true for quite some parameters.
Communication is mentioned as a way forward: there is a lot of knowledge on specific pilots and it should be brought together in more than just a paper. And researchers can learn from other areas; knowledge transfer between young scientists and front runner stakeholders might be the key to successful measures.