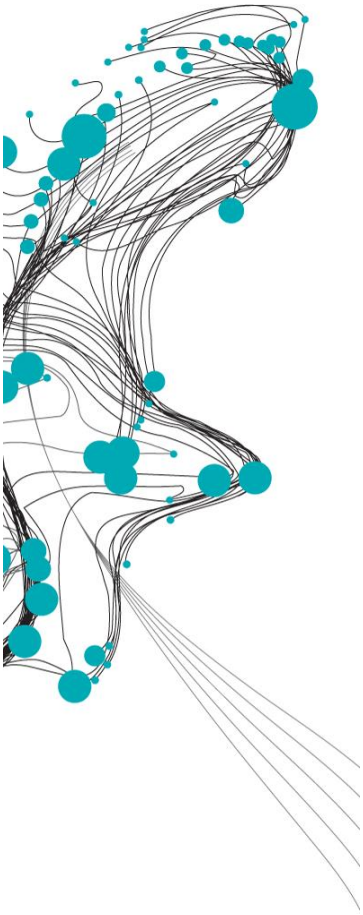
Ethical water allocations based on water footprint caps: a case study for the Yellow River Basin



To determine the amount of water which can be used in a sustainable manner is key to reduce water scarcity. The amount of water which can be used in a sustainable manner is highly dependent on the distribution of water over the sub-catchments. Authorities implement water allocation strategies, which allocate water to sub-catchments based on their respective characteristics. However, it is often unknown on which characteristics an allocation strategy is based, including the role of reservoirs, and what the role is of an underlying principle of fairness in allocation. This study determines allocation strategy based on several principles of fairness and considers the role of reservoirs in achieving fair distributions. To create the allocation strategies based on fairness a literature study has been conducted in several ethical domains and allocation strategies have been proposed based on these findings. This resulted in six allocation strategies, based on population, area, GDP, inverse GDP, irrigation demand and industrial demand respectively. These six allocation strategies were implemented in a model of the Yellow River Basin in China using a genetic algorithm and evaluated. The case study described a period of five years from 2010 to 2014 which contained wet and dry periods to extensively evaluate the impact of these periods on the actual availability of water in the basin. The area was divided into sub-catchments each with their specific characteristics both geographically and socio-economically. After the allocation strategies have resulted in actual allocations for each sub-catchment each allocation is evaluated, resulting in a fairness score for each sub-catchment over time.

The most relevant result from the model is the final water allocation over the sub-catchments. Each sub-catchment had a preferred allocation strategy, where the achieved fairness of allocation over time was highest. The second finding is on the achievement of fairness itself; several sub-catchments which are located on the tributary streams of the main river have specific characteristics which severely impact the achievable fairness of the entire model. This is due to several reasons, firstly the overall water availability in these sub-catchments is low, secondly population in some of these tributaries is large inhibiting positive fairness scores. To achieve a maximum fairness in the spatial distribution, the sub-catchment with lowest water availability is found to be dominating. For to achieve a fair distribution, abundantly available water in other sub-catchment may still not be allocated to those sub-catchments as it would reduce the fairness of the overall system.
Overall, the implementation of ethics in water allocation is not a straightforward process requiring further research into the topic to get a better understanding of its deliberations in water allocation.

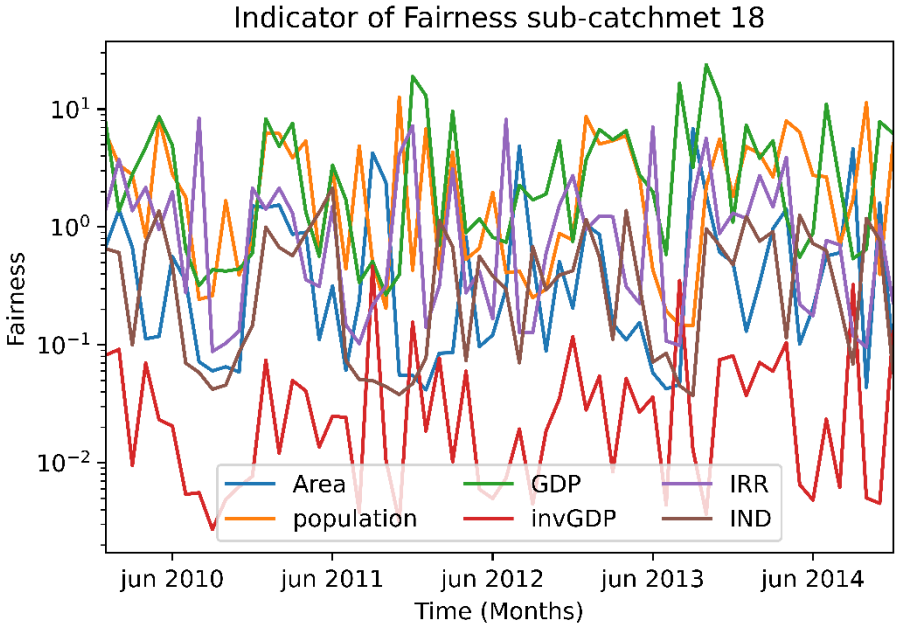


Figure: Indicator of fairness for each Allocation strategy in time. For this particular sub-catchment the Area based allocation strategy resulted in the best solution: for this solution the fairness score is closest to the optimal score of 1.

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