

WATER RESOURCES PERSPECTIVE OF CONFLICTS

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1. INTRODUCTION

Climate change is expected to alter the future water availability conditions drastically around the world. The spatial inequality of the future river discharge distributions is anticipated to rise even with rising total river discharge availability for the whole world under IPCC A1B (Gunasekara, N.K. et. al., 2009). This confirmed the findings of IPCC (2007) for increased possibility of occurrences of extreme hydrological events as draughts and floods, with increased intensities. Gunasekara et. al. (2009) revealed rapidly escalated inequalities compared to the surrounding years, around 2050. We argue that these widened inequalities in the water availability would likely result in increased tensions in populations sharing the international river waters, creating high risks for the ignition of water conflicts and for the escalation of the existing ones.

This inter-connection between inequality in water resources distributions and water conflicts was tested in the global scale. As the water resources available, only the surface water resources were considered in this phase of the research, as it constitutes as much as 80% of all fresh water abstractions in the world. Therefore, for all the regions other than the major groundwater dependent regions as the Middle-East, India, Mexico and South-Western USA, the result of this study is expected to be applicable.

2. METHOD OF ANALYSIS

The inter-relationship of spatial inequalities in surface water distributions and water conflicts was tested in this research. Only river discharges were considered as surface water resources at this phase.

(1) Inequality measurement in the river discharge distributions

The global river discharges of 0.5°x0.5°resolution produced by Total Runoff Integrating Pathways (TRIP1) routing scheme utilizing runoffs from 5 GCMs (CCSM3, MIROC3.2, ECHAM5-OM, CGCM2.3.2, and UKMO) for 1990 were employed for the analysis. The 5 GCM average

river discharges were obtained in order to minimize the possible effects of model biases. Inequalities of the discharge distributions were calculated for 4.5°x4.5° grids and the resulting inequality values were assigned to the middle 0.5°grid to produce the inequality map (**Fig. 1**) for 1990.

The Gini Coefficient was occupied as the inequality measurement tool (Litchfield, J. A., 1999), which is used to measure inequality distributions of in welfare indicators of society in Economics.

$$Gini = \frac{1}{2n^2\bar{y}} \sum_{i=1}^n \sum_{j=1}^n |y_i - y_j| \quad (1)$$

As applied in this research, n is the number unit areas (1km²) in each 0.5°grid in the sample, y_i and y_j are the discharges out of unit areas i and j , while $i, j \in (1, 2, \dots, n)$ and $\bar{y} = (1/n) \sum y_i$ is the arithmetic mean discharge (Gunasekara, N.K. et. al., 2009). The Gini coefficient varies from 0 to 1. The closer the Gini is to 1, the more is the inequality.

(2) The inter-relation of inequality in water resources and water conflicts

In order to relate the above calculated inequalities in river discharge distributions to water conflicts, a conflict intensity scale was required. The Water Event Intensity Scale (or BAR scale) (Yoffe, S.B. et. al., 2002) was modified (**Table. 1**) to suit our purpose, to interpret only conflict intensities. It assigns intensities from -7 to +7 based on the inter-country relations of the basin countries. Its cooperation scale was disregarded. The water conflicts in the Mekong basin were not solved by 1990 even with prior water agreements, although they are included as cooperation events in the above scale. The risks exist of the prevailing debates on sharing the resource to exacerbate in the future as well. Therefore, two more intensity groups were introduced (0.1 and 0.2), to overcome this.

An unbiased sample region (Marked in blue in **Fig. 2**) analysis was done to explore the inter-relationship of river

Table. 1 The adopted international water conflict intensity scale.

Intensity	Event description
1.0	Formal declaration of war.
0.8	Political-military hostile actions.
0.5	Diplomatic-economic hostile actions.
0.4	Strong verbal expressions displaying hostility in interaction.
0.3	Mild verbal expressions displaying discord in interaction.
0.2	The dispute tempting country not having any existing or historical water agreements / An adequately appropriate solution is not given by the existing agreements. Nevertheless, the present interactions are cooperative.
0.1	The tempted country not having any existing or historical water agreements / An adequately appropriate solution is not given by the existing agreements. Nevertheless, the present interactions are cooperative.
0.0	Neutral or non-significant acts for the inter-nation situation.

Key words: River discharges, unequal spatial distribution, Gini, water conflicts, global scale.

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discharge inequalities and water conflicts. Conflict intensities were assigned to countries in the international river basins of the sample, judged based on the international relations on sharing the same international river 1990. News releases by various sources assigned with BAR scale values to each news item, available as a collection in the Transboundary Fresh Water Dispute Database of the Oregon State University were used judge the conflict intensity values.

Conflict intensities were assigned to river discharge inequality values for all the land grids in **Fig. 1**, using the derived inter-relationship of river discharge inequality and conflicts to test the applicability of this inter-relationship to other regions of the world (**Fig. 2**).

3. RESULTS AND DISCUSSION

In **Fig. 1**, inequalities of discharge distributions are higher along the rivers, along the Nile, the Indus, Ganges, the Amazon for example, than in desert areas as Sahara, or in Central Australia. This is due to the natural concentration of water along the river valleys. Nevertheless, in two regions on a desert, the availability of water is almost comparable. Hence, those regions do not exhibit high inequalities.

It is noticeable that all the islands do not exhibit any inequalities. This could be partly due to the fairly distributed precipitations caused by the effect of the surrounding oceans, and to some extent, it could be due to the inability of the chosen scale (4.5°x4.5°) to convey such details as well.

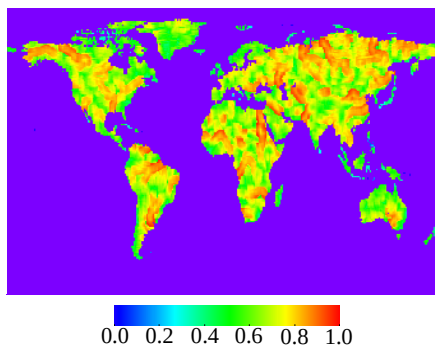


Fig.1 Inequalities of potentially available water in 1990 measured by Gini, varying from 0 to 1.

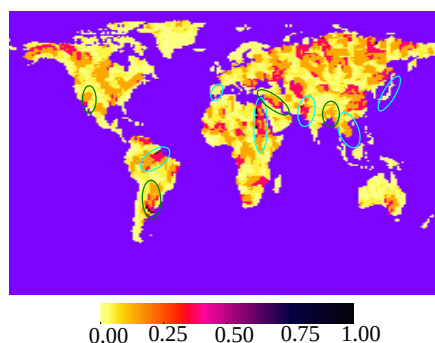


Fig.2 The Conflict Proneness Scale; varying from minimum 0 to maximum 1 (For year 1990).

Comparative to the inequality map (**Fig. 1**), the resulted conflict proneness map (**Fig. 2**) very high possibilities for international water conflicts in the Nile, Indus, Amazon (Marked in blue in **Fig. 2**), and The La Plata (Green markings in **Fig. 2**) basins. It doesn't show higher conflict proneness in the Euphrates Tigris, Ganges, Colorado and Mekong basins (Green markings in **Fig. 2**), despite of the

well-known water conflicts in these basins. In addition, the low populated, northern most territories of North America (Alaska) and Russia are displaying comparatively high proneness for water conflicts. These observations correspond to the high and low inequalities in the inequality map (**Fig. 1**). The areas with highest inequality display the highest conflict possibilities, while low inequality areas are shown free of conflicts. Nevertheless, population is an important factor which decides the proneness of conflicts, although lacking in this stage of the study. The Middle East, Mexico and European countries also seem to be not explained well enough. If ground water resources were considered, these regions could have been modeled more accurately.

If focused only on the African continent in **Fig. 2**, in spite of all the above observations, its water conflicts are modeled fairly well. The Nile, the Sahelian region, Zambezi and the small basins around it, Orange and Congo basins are shown complying with the conflict situations prevailing in 1990. This deems that inequality could be used as an indicator of water conflicts in such arid regions.

4. CONCLUSIONS

The inequalities in river discharge distributions were related to water conflicts by a sample region analysis in the global scale. Then this relationship was utilized to model the conflicts in rest of the world in 1990.

The inequalities in river discharge distributions modeled the African water conflicts well in the global scale, indicating that in such arid climates, water resources inequalities could be used to identify conflict prone regions. The failure in this method in the other regions of the world deems that population distribution is a vital factor for conflict proneness as well.

This method is expected to be applied in the village or local scale in the future with population considered. A robust indicator of water conflicts is expected as the outcome.

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