論 文 の 内 容 の 要 旨

論 文 題 目　　Valuing Water Use at Different Sectors with Considering Socio-Economic Development: Global Scale Assessment（経済開発水準を考慮した複数セクターにおける水利用価値の全球評価に関する研究）

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Water plays an essential role in our economic and social activity. Demographic and climatic changes will increase pressure on water resources in the future. Therefore it is crucial for Managers, whether in the government or private sectors, to make the right decisions on water allocation. Nowadays, many countries are finding that supply-side solutions alone are not enough to overcome to meet ever-increasing demand, thus other solutions, such as demand management are being addressed to overcome insufficient available water.

Water allocates between different sectors and user based on the economic improvement in hydro-economic models. Considering the economic value of water is essential for water planner and manager for water allocation. Also, this kind of estimation enables them to find the costs of water scarcity with estimating the economic benefit of water use in different sectors, and calculating missing amount of water that can't meet demand as a unrealized economic value. With understanding water value in various sectors, a policymaker can mitigate the financial costs of water scarcity with managing the available water in the right way. Maximize the economic benefits of the allocated water can help reduce the costs of future water scarcity under global changes in the world.

The aim of current framework is how much benefit we can gain from using the unit amount of water in each sector (Irrigation, domestic, and industry). The present work focuses on the demand side of water scarcity assessment.

In the agriculture sector, the shadow price of water as an economic benefit of agriculture water uses for four major crops; maize, rice, soy, and wheat is calculated on the global scale from 1980 to 2010 over grid cells. Since water withdrawal in agriculture is for irrigation proposes, therefore this assessment estimates the shadow price of irrigation water by applying the yield comparison method. This work defines the shadow price as a potential marginal added value by irrigation. The result shows that in terms of global annual average rice has the highest, and wheat and rice have the lowest shadow price with more than five times difference. Shadow price varies region by region and year by year for all crops.

Estimation of industry water quantity assessment is carried out by following H08 methodology, and economic value of the industrial sector on the global scale is estimated based on comparison with desalination technology as the most energy intense technology of water production. The result shows that IWW (km^3/year) is increased 1.5 times, and it reaches almost 913 km^3 in 2010 compared to nearly 610 km^3 in 1980, although industrial water intensity (m^3/MWh/year) decreases, and it halved during the same time as expected, industrialized countries withdraw more water than developing countries, although in Europe and North America IWW declines after 1990 and 2000 respectively as a result of efficiency growth. Expansion of Asia IWW during time is substantial. The global average of IWW economic value is increased more than 1.5 times and from almost 1.1 to 1.7 (USD/m^3) during 30 years. The total global IWW value is increased more than 2.3 times with the average annual growth rate of 4.4% and it reaches almost 1538 billion USD in 2010 compared to 660 billion USD in 1980. As an application of industrial sector, we assess impact of hydro power and renewable energy on IWW economic value. Our result shows that with applying hydro power and renewable energy, economic value is increased 13% and 1% from 1980 to 2010 respectively.

Domestic water withdrawal is estimated on the grid. We construct both domestic water withdrawal (DWW) and domestic water intensity on the grid level globally from1980 to 2010. DWW is increased 2.3 times from 201 to 469 km^3 between 1980 and 2010 with an annual growth rate of 4.4%. The highest growth rate is captured in Asia and South America. Our result shows that in 1990, 1.43 billion people suffered to access basic human required amount, although this number is decreasing to almost 660 million in 2010. The global average economic value of domestic water use is just increased 2.6% from 4025 to 4129 $yr-1yr-1 with 0.1%yr-1 growth rate from 1980 to 2010. Oceania and High-income countries have the highest and Asia, and low-income countries have the lowest economic value of domestic water use, since the economic value in Africa and Asia as continental scale, and low and lower middle income countries as income category, is smaller than the global average value.

The economic value of the domestic sector is far above the industry and agriculture sector, and agriculture water value is minimum (agriculture =0.1 USD/m^3, IWW = 1.3 USD/m^3 and DWW = 124.7 USD/m^3 for long term average). Among DWW components, the first par has the highest (330 (USD/m^3) for long term average), and other parts value is less than 10 (USD/m^3) in terms of 30 years average. IWW economic value is less than 2nd and 3rd part of DWW; also, the economic values of agriculture products are meagre in comparison to IWW and DWW. Within countries, in general, developed countries have the highest value. Human activities in all water sectors make almost 30 trillion benefits globally in 2010, although this value is still 2.3 times less than the global GDP in 2010, it shows the importance of water for human life. Total economic benefit increases 1.6 times during 30 years.