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# 主　論　文　の　要　旨

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| 論文題目 | National Water Footprint and Water Management Policy in Thailand |
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## 論　文　内　容　の　要　旨

Due to the water shortage problem and water pollution in Thailand, every government has tried to alleviate these problems by focusing on supply-side management, but the water problem continues up to today. Nevertheless, demand-side policy, such as water pricing policy, which collects water fees in the agricultural sector in particular, were formerly proposed in Thailand but found to be impractical. When water pricing is an ineffective method, indirect measures should be imposed instead to establish more efficient water markets. Taxation on water-intensive sectors should be selected in order to increase the relative price of water-intensive products. This will cause the quantity of production of water-intensive products to decrease and lead to savings in water. In order to identify water-intensive sectors which should be targeted for taxation, information on the water usage of each sector is required as an input for consideration. The national water footprint (NWF) will be employed for the water consumption measurement of each sector. Hence, the objectives of this study were:

1. To investigate patterns of water usage and problems related to water resources in Thailand.

2. To calculate the amount of water usage and water discharge for each production sector.

3. To find the results of water saving caused by changing water-related taxation and import duty.

4. To suggest an appropriate water management policy for Thailand.

The major findings of this study are the amount of water consumption of each sector in terms of water input and treatment water, and NWF intensity. The main contribution of this chapter is the inclusion of water used for producing export goods in the NWF calculation, which is different from most previous literature. The pollution aspect which is considered in this study has also not been studied much in the past literature. However, the results for pollution-related aspects have to be used with caution since they were calculated based on many assumptions and limited data availability.

The NWF comprises two components, which are 1) the amount of water used in production for domestic consumption and production for export, and 2) virtual water consumption derived by treatment of water polluted due to production process. Therefore, this calculated NWF reflects the pattern of water consumption of Thailand, and also shows the source of water pollution. Results of the water input part of NWF show that the agriculture sector water footprint accounts for 33% of NWF, which is almost three times as much as the industry with the second highest water footprint. However, the high-level footprints of several industrial sectors contradict the belief that the agriculture sector is the only one with high water demand. The government to ensure fairness of water allocation and prevent disputes between agriculture and industrial sectors should scrutinize this pattern of water usage.

According to the result concerning water use derived by water treatment, the top four sectors which require the highest amount of treated water are all industrial sectors. This reflects how much industry pollutes the water, which is an indirect obstacle to the process of providing fresh water to meet everyone’s demand. When water is polluted, the quality of the water source will deteriorate, which means additional treatment steps are required to convert the polluted water to become usable. It means that the cost of water input will unavoidably be higher, or in some areas that lack treatment facilities, water shortage problems may occur.

The NWF shows that the agriculture sector has the highest national water footprint. Nevertheless, there is an issue with the NWF calculation because it cannot indicate whether a sector is a consumption-intensive sector. The finding that is more useful for further analysis is NWF intensity. Calculation of the NWF intensity has taken into account how much water is used to generate a particular amount of total final demand. It means that the intensity can be used for comparing the worth of water use for each sector. We can identify that the water-intensive sectors are (1) paper and printing industries (2) agriculture (3) trade and (4) rubber, chemical and petroleum. The government should implement some domestic policies for these water-intensive sectors in order to economize their water use. Thus, chapter 5 examined the impact of the domestic policies by creating policy simulations that are divided to three main simulations: (A) output taxation on water-intensive sectors simulations; (B) water tax simulations; and (C) technological improvement simulations.

Due to the findings of the output tax simulation, when all water-intensive sectors were taxed separately at the same rate of 1 percent of output price, the highest saving in virtual water consumption was the trade sector, with 0.25 percent of the NWF. Imposing tax on the trade sector will result in relative changes in the output of other sectors because the trade sector has many linkages with other sectors.

The water tax in the simulations B-1 to B-5 levied on the direct water use of each respective sector. Therefore, the amount of water saved depends on value of direct water used and value-added of the sector. The water tax on the agriculture sector can save the highest amount of water about 1.59 percent of NWF. Another simulation is taxation on waterworks and supply as to achieve the full-cost pricing of tap water. The output of the economy decreased and water consumption decreased by about 3.2 percent of the NWF. The amount of water saving of this simulation, which mainly comes from the trade and services sectors is because these two sectors have the highest payment records to waterworks sector.

The finding from the last domestic policy, technological improvement simulation, shows that when the water requirements for agricultural production and the wastewater treatment process of the paper sector decrease by 1 percent and 6.9 percent, water footprint savings are 0.33 percent and 2.2 percent of the NWF, respectively.

Another strategy for demand-side water management is reducing import duty in the water-intensive sectors, which are the paper and rubber sectors, so as to decrease domestic production and substitute domestic products with imported product. Results from simulation show that this can reduce domestic production and the amount of water used by 0.46 percent of the NWF in the case of the paper sector, and 1.03 percent of the NWF in the case of the chemicals sector.

For policy implication for this study, at the first step, central government should legislatively determine and clarify the right to water use. Water rights should be based on a particular water resource, i.e. a canal should be used for agriculture only, while other canals in other areas should be used only for industrial purposes (similar to water zoning). Water rights should be determined depending on economics value. Sectors with high economic value should first obtain the right to use. Additionally, the government should charge an output tax on inefficient water users, based on their water intensity. The tax rate should be decided by considering the water saving target of the country. Moreover, the government should promote technological improvement by formulating policy such as reducing import tariff or granting soft-loan for new treatment equipment to support their technology projects. Finally, both taxation and promoting technological change can be done simultaneously.