因應氣候變遷水源供應與經濟影響研究(1/2)

The Adaptation to Climate Change Impact on Water Supply and Economy (1/2)

主管單位：經濟部水利署

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摘要

本計畫重點為評估可能水文情境下水源枯旱風險與經濟影響，並依據分析結果(缺水率與經濟影響)進行調適策略評估，以提供水資源政策推動參考。因臺南降雨集中發生於梅雨季與颱風季，故本計畫主要針對兩季研擬偏少、無雨、延遲以及正常之情境，針對水文情境定義簡單說明如下：(1)偏少情境：降雨總量累分布函數之值小於 30%、(2)無雨情境：降雨總量累分布函數之值小於 10%、(3)延遲情境：首月降雨總量累分布函數之值小於 30%以及(4)正常情境：排除上述 3 種情境之資料。

為評估氣候變遷對水源供需可能帶來之負面影響，本計畫參考「氣候變遷降雨量情境差異對洪旱衝擊評估(2/2)」(經濟部水利署，民國 106 年)選擇臺南地區水源供需之最劣情境 A2-CSMK35 進行衝擊分析，藉由比對基期與未來水文情境特徵線之差異，瞭解氣候變遷對臺南地區主要降雨來源之可能影響。基期與未來之情境特徵線比對結果顯示：(1)在水文情境平均值之部分，A2-CSMK35 最劣情境下梅雨偏少、無雨、延遲以及正常情況之降雨總量平均值皆有減少，其又以延遲情況之減少幅度最大；而颱風雨偏少、無雨、延遲以及正常情況之降雨總量平均值則有增有減，偏少與無雨情況呈現略為減少，而延遲與正常情況則有較顯著增加；(2)在水文情境邊際機率之部分，A2-CSMK35 最劣情境下梅雨偏少與無雨之發生機率皆有增加情形，而梅雨延遲與正常之發生機率則皆有減少情形；颱風雨偏少與無雨之發生機率則皆有減少情形，而颱風雨延遲與正常之發生機率則分別為持平與增加情形。

針對水文高度不確定性下之調適策略決策問題，參考決策理論中期望值準則(expected value criterion)，整合機率概念進行水源枯旱風險之計算，提供決策者合理且客觀之量化風險值，以作為後續水資源政策推動參考。本計畫將水源枯旱風險定義為缺水率或經濟影響之期望值：

$$\text{水源枯旱風險} = \sum_{i=1}^{N} \text{缺水率}_i \times \text{水文情境發生機率}_i$$

其中，i 為水文情境之編號，而 N 則為水文情境之總數量。

調適策略效益評估結果指出：臺南高雄水源聯合運用(S2)與山上淨水場改善工程(S8)於減緩缺水上有較高之效益，而效益次高之策略則為永康安平再生水(S3)與白河水庫後續更新改善(S4)，以上調適策略若能順利推動，每個策略皆可減緩公共用水缺水率約 2.1%至 3.0%。

關鍵詞：氣候變遷、枯旱風險、經濟分析

Abstract

This project aims to build up an economic analysis and policy assessment system for water under various hydrological scenarios. The project evaluated the drought risk from the perspective of both water shortage and economic impact. With taking economic analysis into account, a more valuable information for water policy assessment or decision making can be provided.

First of all, the project investigated hydrological characteristics of the project area and proposed various hydrological scenarios (e.g., below normal, few, delay and normal mei-yu conditions) based on the local hydrological characteristics of mei-yu and typhoon. Then, the project focused on drought risk assessment and economic analysis to quantifying possible water shortage or economic loss caused by drought events under various hydrological scenarios. Moreover, the project also focused on water policy assessment to rank the benefits of adaptation strategies. Various adaptation strategies such as reclaimed water or water saving will be implemented and examined under worse hydrological scenarios.

Since the major rainfall seasons in Tainan are mei-yu (May to June) and typhoon (July to September) seasons, this project designs some hydrological scenarios to study potential drought risk. The designed hydrological scenarios are composed of below normal, few, delay and normal conditions for both mei-yu and typhoon seasons. The definition of proposed hydrological scenarios are given below: (1) the below normal condition: the cumulative probability of total rainfall amount is less than 30%. (2) the few condition: the cumulative probability of total rainfall is less than 10%. (3) the delay condition: the cumulative probability of the first month rainfall is less than 30%. (4) the normal condition: the exclusion of above conditions.

Besides, the project also took climate change scenarios into consideration. The impact assessment shows that: (1) under the A2-CSMK35 scenario (the worst scenario), all the average values of below normal, few, delay and normal mei-yu conditions decrease, while the delay mei-yu condition decreases most significantly; the average values of below normal and few typhoon conditions slightly decrease, but the average values of delay and normal typhoon conditions increase significantly. (2) under the A2-CSMK35 scenario (the worst scenario), the occurrence probabilities of below normal and few mei-yu conditions increase but the occurrence probabilities of delay and normal

mei-yu conditions decrease; the occurrence probabilities of below normal and few typhoon conditions decrease but the occurrence probabilities of delay and normal typhoon conditions plateau and increase, respectively.

The expected value theory was used to quantify the drought risk of a water supply system under both hydrological and climate change scenarios. The drought risk is defined as the expectd value of water shortage and economic impact, which is calculated as follows:

$$drought\ risk = \sum_{i=1}^{N} water\ shortage_i \times occurrence\ probability_i$$

where i represents i-th hydrological scenario and N represents the total number of hydrological scenarios.

In this project, the benefit of a strategy is evaluated by the increase in drought risk (i.e., expected water shortage or expected economic impact) due to a failure in strategy implementation. A larger increase in expected water shortage indicates the benefit of a strategy is higher. Eight different combinations of adaptation strategies were examined and then ranked. The evaluation results show: (1) the benefits of S2 and S8 strategies are relatively higher than others. (2) S3 and S4 strategies are of medium benefits in reduction of water shortage.

Keywords：climate change, drought risk, economic analysis.