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AN APPROACH TO ESTIMATING THE POTENTIAL BENEFITS FROM IMPROVED IRRIGATION WATER MANAGEMENT FOR RICE**

BY

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Introduction

Economic evaluation of efforts to improve the management of irrigation systems is often limited by the twin difficulties of identifying (1) the effect of the change in management procedures on the resulting pattern of irrigation water deliveries, and (2) the effect of changes in water deliveries on production. A common approach used to circumvent these difficulties is to compare yields before and after a change in management is made. Alternatively, comparisons of yields may be made between a project area and some nearby "reasonably comparable" area. In either case, the difference in yields, perhaps adjusted for differences that can be attributed to variables not related to irrigation, are assumed to be due to the improvement in irrigation. Effects of unmeasured variables may cause a bias of unknown magnitude and direction in the resulting estimate of the effect of the irrigation improvement.

In this paper we present an alternative approach to dealing with the second of the two difficulties noted above.[1] The approach, which is applicable where flooded paddy rice dominates the cropping pattern, also permits an *ex ante* estimation of the potential for increasing production through improvements in allocation of a given water supply. The results of our attempt to apply this approach to a Philippine irrigation system are reported.

[1]This paper does not deal with the problem of identifying the effect of an improvement in management on the deliveries of irrigation water, which is largely one of hydraulic modelling and of data collection.

Conceptual Framework

From the perspective of economic theory, the value of irrigation water can be conceptualized by means of a production function in which water is one of the inputs with a functionally defined effect on production. Translating this concept into operationally useful methods for evaluating actual irrigation projects requires both empirical estimates of the water-output functional relationship and field measurements of the amount of water input. Several researchers have investigated the nature of the production function for water for various crops (Hexem and Heady; Hogg and Vieth; Minhas et al). But the ability to obtain appropriate measurements of the actual water input under the field conditions that prevail in most LDC irrigation projects designed for flooded paddy rice production is severely limited.

These measurement problems are of two general types. First, several practical difficulties associated with the instrumentation necessary to obtain field measures of water flows limit the availability of such measurements to a small number of points within an irrigation system. The water that is measured at any one of these points serves a relatively large area (generally 30 hectares or more). Such meausrements do not permit the identification of the amount of water delivered to any individual field for which data on other inputs and outputs are obtained.

The second type of measurement problem relates to the potential for the existence of large differences between the amount of water delivered to an individual field and the amount of water available to the plants. Under field conditions, especially when significant amounts of rainfall may occur during the cropping season, a substantial proportion of the water delivered to an individual field may not be available to the plants because of surface runoff. In contrast to the situation with an input such as fertilizer, the amount of water which can be stored on the field for future use by the plant is very small relative to the total amount of the input which is needed for unstressed plant growth during an entire cropping season. Thus even if it were feasible to measure the amounts of water delivered to individual fields, these measurements would not necessarily correlate well with the actual water input into the biological production process.

Given these difficulties, much of the research dealing with functional relationships between water and yield has followed an approach that incorporates into the production function one or more variables reflecting the degree of moisture adequacy or moisture stress encountered by the crop. Such a variable may be called a moisture-related growth index, or a moisture stress index. Many of these indices are based on some modification of the concept, introduced by van Bavel, of "drought days." Although early work focused on moisture stress indices for crops grown under dryland conditions, Wickham and his colleagues at the International Rice Research Institute developed a similar index applicable to "wetland" rice production (Wickham; International Rice Research Institute, pp 60-61). This index was further modified by Small et al.[2]

Several studies have successfully incorporated a moisture stress index into production functions for wetland paddy rice (Herdt and Mandac; Small et

[2]See Small et al for a more detailed review of the literature on the development of moisture stress indices.

al; Wickham). In these functions, the coefficient of the stress index has a negative value, indicating that the greater the amount of moisture stress, the lower the resulting yield. Although a non-linear relationship between yield and moisture stress would be expected, the empirically estimated production functions do not generally show a statistically significant non-linear term.

In this study, we use the water shortage index (WSI) developed by Small et al. This index is calculated by summing daily water shortage factors from the time that the crop is transplanted until 20 days before harvest, which is about when flooded fields are drained in preparation for harvest. The daily water shortage factors reflect both the environmental demands on the crop (measured by pan evaporation) and the availability of water in the soil (measured by the depth below the soil surface to the free standing water associated with the perched water table). As with other moisture stress indices, the larger the value of the WSI, the greater the degree of water stress.

Given the utilization of a water shortage index in the production function, estimation of the effect of irrigation water on yield requires that a relationship between the amount of water available and the amount of moisture stress be established. We postulate the existence of a functional relationship between weekly water supplies to a given area and the corresponding amount of moisture stress in this area. We expect the relationship to be non-linear, with the water shortage index approaching some maximum value at extremely low levels of water supply, and approaching zero with abundant supplies of water (Figure 1).