Optimization of design of on-farm channel network in an irrigation area

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Abstract. Lack of suitable technical criteria to find out the optimal design of on-farm channels leads to poor efficiencies of many irrigation schemes. It is desirable to design a channel network which is economical and the seepage loss is minimum. In this paper three network models viz. Minimal Spanning Tree, Shortest Path and out-of-kilter algorithms are used to find an optimal layout. In addition to the continuous supply, the results of the models are checked for their usefulness in a rotational irrigation system. All the three models were applied to three different areas of the Mae Klong Irrigation Project, in Thailand.

Introduction

In general, efficiency of canal irrigation projects in Asia is very low. One of the causes recognized widely is the improper irrigation water utilization. However, the basic layout of the on-farm channel network could be an important factor. Unfortunately, in spite of the importance of the layout of the on-farm channel network it is left to the farmers to decide on how to draw the water supplied by irrigation authorities from the main canal. A well laid-out network of channels not only allows efficient distribution of water to different fields but also helps in increasing the command area of the outlet. It is therefore essential to find a generalized approach to the design of terminal networks in new irrigation systems as well as rehabilitation of old schemes.

The conventional water course routings are based solely on engineering judgment rather than on scientific or mathematical methods. In practice, engineers generally utilize previous experience and direct configuration evaluation to establish the best layout, while designing a water distribution system. The designer, however cannot guarantee that the selected route obtained will give the most economical system, since only a few alternatives are studied in detail.

Due to the above reasons, in some of the canal command areas, the water courses from outlets run in a random manner without much consideration of
the local topographical features. In some cases, many fields do not have access to the field channels.

For the successful operation of any water distribution system, each holding should have access to a channel. Since the seepage loss below a channel outlet is a direct function of the total length of the water course, consideration of the length is essential. In addition to length, the capacity of the channel and its cross-sectional area influence the seepage loss. Cost being a direct function of length and capacity of a channel, the minimum length of a channel and its optimal capacity should be determined, keeping in view the economic feasibility of the channel network.

Although mathematical programming techniques have been used to design pipe networks, very few works are available on the optimal design of an open channel system.

The Minimal Spanning Tree (MST) method considers only lengths between the nodes and not the elevations of the nodes. It is therefore essential to make necessary changes in the available MST algorithm. This study is an attempt to develop an approach based on certain considerations and parameters for practical purposes. The design problem considered in this study is limited to the evaluation of the construction of channels to their ultimate flow capacities without consideration of a capacity expansion. Also, a fixed cropping pattern has been considered, as change in the cropping pattern may demand different layout of the channels. For this study, the channels have been designed for rice crop. As rice has the maximum water requirement, the same layout of channels can be used for other crops also. Rotational Irrigation is also a very important factor in water distribution systems as far as channel capacity and seepage losses are concerned. Two typical rotational methods viz. fixed channel capacity, variable time of application and fixed time of application, variable channel capacity are considered. The variable channel capacity means that the channel size together with its length is a design variable.

Methodology and theoretical considerations

The optimal channel network layouts are determined by the modified MST algorithm, as well as using the Shortest path and out-of-kilter algorithms. The results of these models are compared.

For the design of a channel network system, one should first find out the flow direction (elevation of the nodes), required supply to each plot (possible outlet), cost of the network (length between two outlets, total length of the network, channel capacity), seepage (length, channel capacity) and water distribution (channel capacity and governing area).