LINKAGES OF AQUACULTURE WITHIN WATERSHEDS AND CONCURRENT DESIGN OF HILLSIDE PONDS

Ninth Work Plan, Appropriate Technology Research 2 (9ATR2)
Final Report

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ABSTRACT

The hillsides in Latin America cover about one million square kilometers and provide livelihood for some 200 million people. Nearly one-half of this population is classified as “poor.” There is a possibility of introducing tilapia production to the hillside regions in Latin America for improving nutrition of farm families and local communities and for providing a means of additional income. The objective of this paper is to present a levee pond design model for NGO personnel to use as they assist local producers. The model resides on the Excel® platform. The model is based on a monthly volume balance. The model enables iterative computation of the inflow needed to balance seepage and net evaporation. One can also determine the pump-in and pump-out rates needed to reach a target volume change rate per month. The model also includes an empirical spillway design.

INTRODUCTION

The hillsides in Latin America cover about one million square km and provide livelihood for some 200 million people (Verma et al., 2000). Nearly one-half of this population is classified as “poor.” The typically hilly landscape is heterogeneous, and populated segments consist largely of small plots. Farming on hillsides has resulted in progressive deterioration of natural resources due to a combination of overgrazing, poor tillage and farming practices, deforestation, and poor water management.

There is a possibility of introducing tilapia production to the hillside regions in Latin America for improving nutrition of farm families and local communities and for providing a means of additional income. NGO organizations have effectively stimulated the production of tilapia by residents in a few localities of Honduras where water is plentiful. In most regions where water is not as plentiful, design tools are necessary for properly evaluating pond designs in order to make optimal use of the available water. The objective of this paper is to present a levee pond design model for NGO personnel to use as they assist local producers.

METHODS AND MATERIALS

The levee pond model is an Excel® spreadsheet that computes a volume balance on a levee pond. The model is organized into the following pages: Directions and Overview, Table of Contents, Input, Pond Model, Results, and Principal Spillway. The design is based on answers to 16 key questions on the Input page. Each question has guidance in the form of a comment that becomes visible when clicked upon. The model is designed to assist competent NGO personnel in helping small- to medium-scale producers. Input questions are shown in Figure 1. Each of the six regions selectable on the Input page has monthly precipitation and evaporation data built into the model. The Input page provides all inputs necessary to evaluate the volume balance, shown in Figure 2, on a monthly basis. The model allows one to iteratively compute the pumped inflow required to offset seepage and net evaporation. Knowing that value, one can then determine the inflow and outflow rates to change the levee pond volume a set number of times per month, based on management targets.

A spillway design is also provided based on an empirical spillway design approach. The riser diameter is based on the circumference acting as a weir. The circumference required for the flow through the levee to pass over a weir with a 5 mm head is computed.

RESULTS

After completing the initial inputs, one proceeds to the Results page, exemplified in Figure 3. Maximum, average, and minimum pond volume changes are computed based on net inflow and net outflow.

The recommended procedure for using the levee pond model is to first set the output pump rate to zero. One may then determine the inflow pump rate necessary to balance seepage, rainfall, and evaporation in a given climatic region, based on monthly net outflow as shown on the Pondmodel page. Monthly rainfall and evaporation are used in the monthly balances. A soil seepage field is included in the model, and it should be determined by soils analyses or seepage tests. Volume balances on net input should be near zero to have a sustainable pond. Next, one may determine the pump-out and pump-in rates needed to meet the volume change target. This process begins by entering a trial pump-out rate. To do this, enter the initial pump-in rate determined above, plus the trial pump-out rate for the new trial pump-in value. The volume balance based on net output should be near the volume change target. Maximum, average, and minimum volume ratios are reported based on monthly ratio computations. The principal spillway design is included. There is no watershed supply; therefore, an emergency spillway was not included.

Volume changes based on net inflow should approach the volume change target based on the level of management anticipated. After achieving the initial water balance, one adjusts both the pump-in and pump-out rates to achieve the desired volume change targets. The pump-in rate exceeds the pump-out rate by the pump-in rate found with the initial volume balance, which preserves the initial volume balance. Adjust these inputs until the desired volume changes are achieved based on net inflow. One may then proceed to the Principal Spillway page for a pipe-riser spillway design. The equivalent sharp-crested weir length is given for those who may prefer to use other spillway styles.

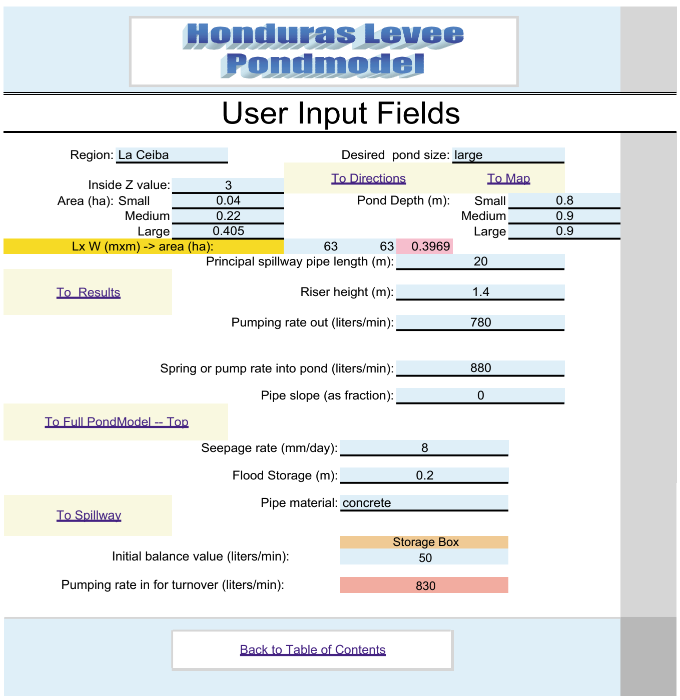

Figure 1. Input page for the levee pond model.

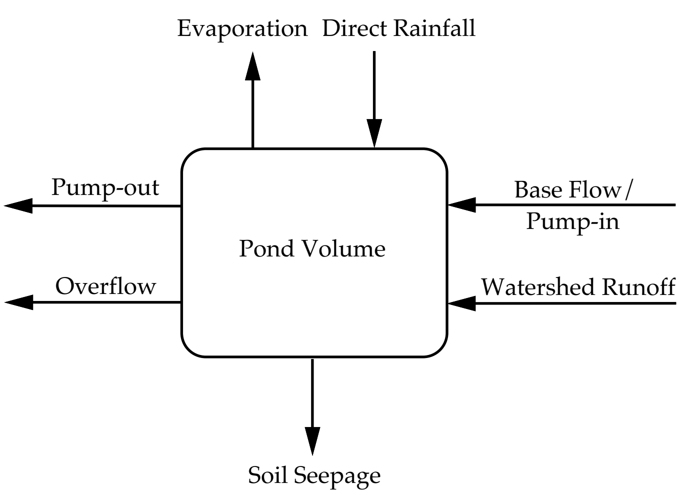

Figure 2. Volume balance for the levee pond model. Worst case overflow is zero.

DISCUSSION

Suppose a levee pond, with 0.4 ha surface and 0.9 m deep, is to be constructed in the La Ceiba region of Honduras. The spillway pipe is made of concrete and is 20 m long on a flat slope with a 1.4 m riser. The soil has a seepage rate of 8 mm d^{-1}. Pond managers have set a volume change rate of 10 per month.

On the Input page, choose the large pond size and select the La Ceiba region. Enter the 20 m spillway pipe length, concrete material, 1.4 m riser height, zero pipe slope, and 8 mm d^{-1} seepage rate. Initially, enter a pump rate out of the pond as zero. Enter a trial pump-in rate of 20 l min^{-1}. On the Results page, one will find the minimum volume change per month based on net outflow is negative. This implies that the pond will lose volume and not be sustainable. Increase the pump-in rate to 30 l min^{-1}. This brings the minimum monthly volume change per month to zero. One can manage the 30 l min^{-1} flow rate throughout the remainder of the year so as not to overflow the pond. The distribution of rainfall and evaporation throughout the year cause the variation. In the case of small levees, the design is usually complete after specifying a standard spillway of 101 mm diameter pipe and riser.

Slightly larger, more intensively managed ponds typically specify a volume change target per month. To do this, place the initial input rate of 30 l min^{-1} in the Storage Box on the Input page. Next, propose a pump-in rate of 500 l min^{-1}. To maintain the pond, the pump-in rate is 500 + 30 = 530 l min^{-1}. Go to the Results page and find that the net volume change based on inflow is 7.1 volume changes per month, below the target of 10. Therefore the pump-in is increased to, say, 780 l min^{-1}, and the pump-out rate is changed to 780 + 30 = 810 l min^{-1}. This raises

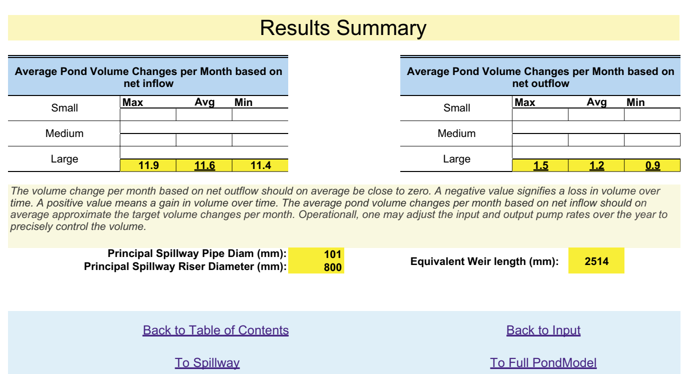

Figure 3. Results summary of the levee pond model.

the volume change based on net inflow to a value in excess of 10. Pump-in and pump-out rates are decreased to 730 and 760 l min^{-1}, respectively, yielding an average volume change rate of near 10. This outflow requires a 101 mm diameter pipe with a 0.7 m diameter riser. The equivalent weir length of 2,171 mm is useful to those desiring a principal spillway style other than the pipe riser. Other structures such as a drop-inlet or box-inlet should contain an effective weir length of the reported equivalent weir length.

If springs or stream flow are not adequate for the desired pond size and management, one may wish to consider a watershed pond or a hillside pond for water harvesting. Water harvesting is dependent on diverting runoff from a watershed collection zone to the pond. The design of the watershed pond or hillside pond is very site-specific. Hillside pond developers are strongly encouraged to seek the help of competent pond designers.

Experience suggests that valleys with available springs are the best levee pond candidates. Valleys frequently have soils of adequate clay for sealing purposes. Elevations above 1,000 m become problematic for finding springs. In Latin America there seems to be a correlation between both coffee and rice production and water availability. Areas with nearby hardwood forests tend to bode well for water availability.

CONCLUSIONS

The model is currently in verification and testing.

ANTICIPATED BENEFITS

The levee pond model is a useable tool for pond designers and managers. The feasibility of locations previously determined to possess desirable market potential and other promise of supporting tilapia production may be determined based on soil and terrain properties and water availability.

ACKNOWLEDGMENTS

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