Inflow calculation for on-farm ponds in northeast Thailand

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- More than 85% of agricultural land is rainfed agriculture
- Erroneous rainfall pattern
- Unfertile soil-sandy texture
- Poor farmers.
On-farm pond

- the most suitable technology for water harvesting
- collecting rain water in rain season and use in dry season
- easily construction
- environmentally sound
- economically sufficient
Benefit from on-farm is several. Such as upland crops and horticulture.
Irrigation supplementary
Fisheries
Number of on-farm ponds in northeast is tremendous

- increasing rapidly
- only one third are fully utilized
- the rest are inefficient or even useless
Number of on-farm ponds is tremendous
Amount of inflow is very critical for usability and sustainability

- too much inflow
  - can damage the pond by erosion
  - increase silting and sediment deposition

- too small inflow
  - not enough water for utilization
Not enough inflow makes the pond useless
Too much inflow damage the pond
Our objective is to study inflow to on-farm pond

- Inflow into a pond is a function of
  - precipitation
  - catchment characteristics
Two types of on-farm ponds

- **Dammed pond**
  - To build a dam across a valley
  - cheaper, easier to manage
  - difficult to find suitable place

- **Dug-out pond**
  - To dig a pit, add embankment, and equipped with inlet and/or outlet facilities.
  - suitable for flat area
  - more popular in the Northeast
Hydrologic concepts

On-farm ponds fill up during rainy season from
- rainfall
- catchment runoff
- groundwater inflow

The ponds lose water during dry season through
- water usage
- evaporation
- seepage loss
Two on-farm ponds were selected near Ban Wang Wa about 20 km south of Khon Kaen city.

The two ponds are near by each other

- the North pond and the South pond
  - dimensions: 20 x 30 x 4, 17 x 33 x 4 m³
  - elevations of the bottoms 194.4 m, 195.0 m
Equipments installation

- Weather station
- Piezometers with water table recorders
- Pond water level recorders
- V-notch weir with a water level recorder for inflow measurement
Plan view of the equipments

South pond

North pond

Weather station

Barometer

Piezometer for measurement water table

Surface water measurement
Set up equipments
Catchment areas of the two ponds

- North pond: 10643 m$^2$, 6.7 rai, butterfly shape
- South pond: 12618 m$^2$, 7.9 rai, elongated shape
To compare two methods of inflow calculation

- Watershed routing
  - using the concept of outflow from a catchment varies nonlinearly with storage

- Synthetic unit hydrograph
  - Unit hydrograph is direct runoff hydrograph causing by 1 cm of rainfall of specific duration
  - Synthetic unit hydrograph to be constructed from catchment characteristics
Watershed routing technique

Assuming that outflow varies linearly with storage

\[ s = kq \]

At two time steps \( t_1 \) and \( t_2 \), we obtain

\[ q_2 = \frac{k - 0.5\Delta t}{k + 0.5\Delta t} q_1 + \frac{\Delta t}{k + 0.5\Delta t} i \]

That is by knowing \( q_1 \), \( \Delta t \), and \( i \) then \( q_2 \) can be estimated.
Synthetic unit hydrograph for small watershed

- **Time of concentration**
  \[ t_c = 0.0195C_k \left( \frac{L}{S^{0.5}} \right)^{0.77} \]

- **Lag time**
  \[ t_1 = 0.6t_c \]

- **Time to peak**
  \[ t_p = t_1 + \frac{D}{2} \]

- **Peak discharge**
  \[ u_p = \frac{C_p A}{t_p} \]
Assuming unit hydrograph shape follows

Probability distribution function of gamma function as

$$u = u_p \left( \frac{t}{t_p} \right) \exp \left( 1 - \left( \frac{t}{t_p} \right) \right)^{n-1}$$

where $n = f(C_p)$

From unit hydrograph and rainfall we obtain inflow hydrograph
We compare the two techniques

- watershed routing
- synthetic unit hydrograph

to the data of rainfall and inflow into the two on-farm ponds for the events of 30 Aug 06, 17 Sep 06, and 19 Sep 06
Comparison results for 30 Aug 06
Comparison results for 17 Sep 06

North pond 17-Sep-06

South pond 17-Sep-06
Comparison results for 19 Sep 06

North pond 19-Sep-06

South pond 19-Sep-06
Suitable values of $k$ for watershed routing and $C_p$ for unit hydrograph

<table>
<thead>
<tr>
<th>Rainfall event</th>
<th>North pond</th>
<th>South pond</th>
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<tbody>
<tr>
<td></td>
<td>$k$</td>
<td>$C_p$</td>
</tr>
<tr>
<td>30 August 2006</td>
<td>0.6</td>
<td>0.65</td>
</tr>
<tr>
<td>17 September 2006</td>
<td>1.2</td>
<td>0.26</td>
</tr>
<tr>
<td>19 September 2006</td>
<td>1.1</td>
<td>0.37</td>
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Variations in $k$ and $C_p$ show nonlinearity in the rainfall-runoff systems
Conclusions

- Variation in \( C_p \) is less than in \( k \)

- Unit hydrograph technique gives better agreement with the data than watershed routing technique in peak discharge and runoff volume

- Appropriate value for \( C_p \) is 0.4 - 0.6 for Khon Kean area