TD 603 Problem Set

1. Consider the regional water systems lecture and study the KT bandhara used to irrigate farms. Suppose that there is a free-flowing river and a sequence of interventions happen in the following sequence:

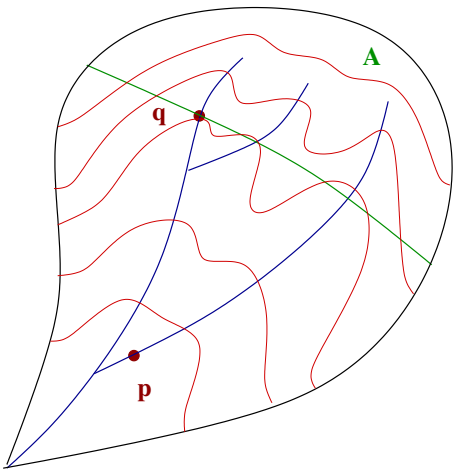
   - 1955: A KT bandhara is built across the river which creates a lake in the river.
   - 1960: farmers start using the water in the reservoir and also well water from wells near the lake, for irrigating their farms.
   - 1970: Ghodegaon, a nearby large village, which used to depend on wells, starts using the lake water for their drinking water supply. The waste water flows back to the river.

   Use the above timeline and consider how you will construct a waterbalance. Argue for each stock and flow in the water and how it changes through the years.

2. Consider the Papagni watershed maps and look at slide 9 on *Groundwater Potential*. How do you think was this constructed? If you were given the datasets in preceding slides and asked to compute "groundwater potential", how would you do it? Use an exmaple to illustrate your answer.

3. A region has soil of depth 10m. However, half the region has soil of $S_y = 2\%$ while the other half has $S_y = 5\%$. The region is covered with loamy soil so that the infiltration rate is constant at 30%. How much will the groundwater rise when it rains 100mm?

4. Consider the watershed in the figure below. What fraction of the total water falling the watershed will flow through p? The area A lies in village V_1 and the area below in V_2. If V_1 decides to build small dams where the streams cross from V_1 to V_2, what fraction of the water falling on area A will be available to V_1?



5. Suppose next that a DBI has to be started at q on the right (as the water comes down) with half the slope of the river, mark the area in the command area of the DBI.

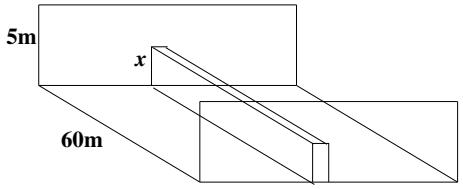
6. An hectare-day (*had*) is roughly the amount of water needed by a hectare of crop for one day. It depends on the temperature and stage of crop, but for simplicity, let us assume that this is a constant of 40cu.m., i.e., about 4mm of ET. See the following table:

Crop	Duration (days)	Extra *hads*	Costs	Revenue/Ha Rs. 1000×
K. Jawar	100	10	3	15
K. Jawar	100	0	0	10
K. Tomato	100	30	20	50-150
K. Cotton	240	100	30	60-80
R. Tomato	100	100	60	80-150
R. Onion	100	100	30	50-70
Sugarcane	365	280	100	180-200

In the above table, a profit-range implies that the chance of getting the lower or the higher is 50%.

Suppose you had d *hads* available (say 100 *hads*), in addition to the monsoon, $1000 \times x$ rupees and 1 hectare of land. Moreover, an investment of Rs. 5×1000 is needed to try and get 1 extra *had*, with a chance of success of 50%, with zero if you fail. What would you do?

7. A river is 60m wide and has banks of height 5m. The slope is $1m$ per km. A KT weir is being considered with height x. Assuming that the effective depth of the river due to the KT weir becomes $5-x$, compute the maximum flow in the river without it overflowing its banks. If $100mm/hr$ is peak rainfall, how much area can this river safely drain?



8. As in Ghodegaon, the river has a dam upstream and the river is fed by a gate of capacity 10 cubic meters per second. Assuming that the KT weir is of height 2m and that there are 20 of them, one every 2km, how much time will it take to fill up the system?

Assuming an ET load of 5mm/day, how much can the canal irrigate? What would be the thickness of the strip of fields along the river which would benefit?

Supposing that a thickness of 8km around the first 10km of the river start utilizing the water, what would be the area may be irrigated by the farmers downstream in the remaining water?

Assuming that the dam can provide about 100 days of flow and that the area received about 600mm of rainfall, with 50% infiltration, how do you think the canal should be operated?

9. A top-soil has thickness 50cm with $S_y = 0.2$. Thus the maximum soil moisture is 0.2. A crop needs 5mm every day which it must obtain from soil-moisture. Moreover, if the moisture is above 0.1, it loses water to the ground at 5mm/day, and if the moisture falls below 0.05, the plant is unable to extract it. Given that the soil is fully saturated and receives no additional rainfall, plot the soil moisture for the next few days.

10. Recall that to estimate the total flow in a stream, we (i) took a cross section and k equally-spaced (with spacing Δ) locations $x_0, \ldots, x_k$ on this cross section, with x_0 on this bank and x_k on the other bank and (ii), if the depth at x_i was d_i, then we measured the flow at $0.6d_i$, say v_i. We then estimated the total flows as:

$$\Delta \cdot (\sum_{i=1}^{k} d_i v_i)$$

Argue for the correctness of this formula. *Hint*: Suppose that if the surface velocity is v then the velocty at depth D is given by a function $f(x)$, where $f(0) = v$ and $f(D) = 0$, then at what depth d should this flow be sampled? Consider the function $f(x) = v \cdot \frac{D-x}{D}$. For this f, at what depth should the sample be taken?