Water and Development

Part 3a: Watersheds

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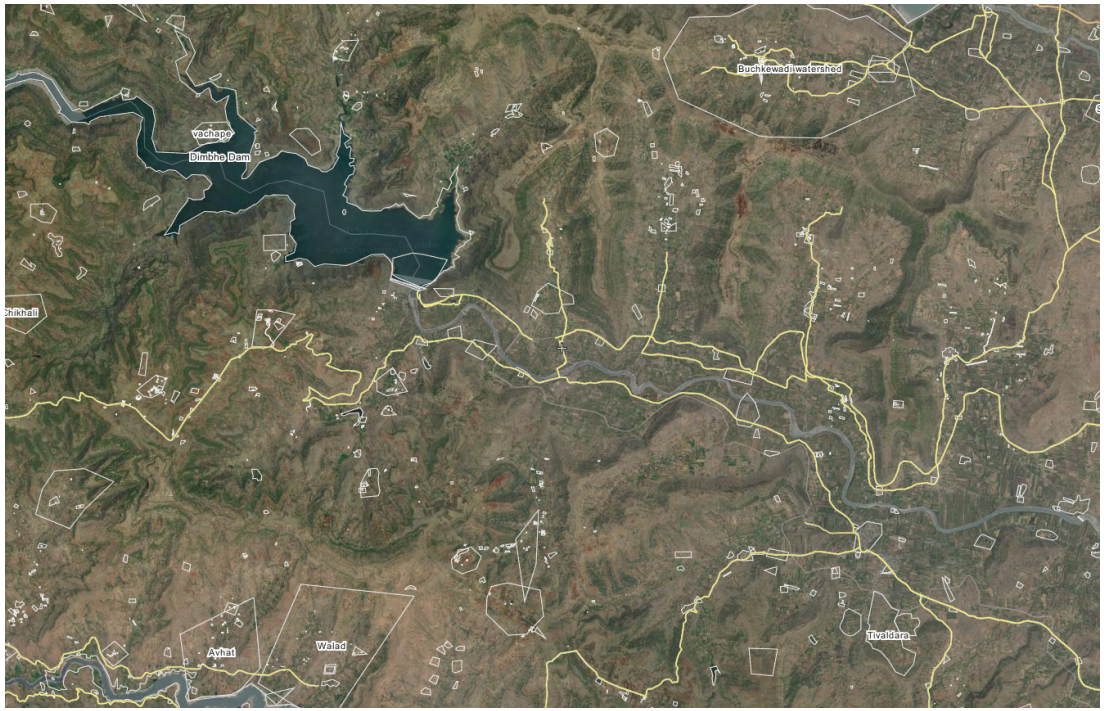
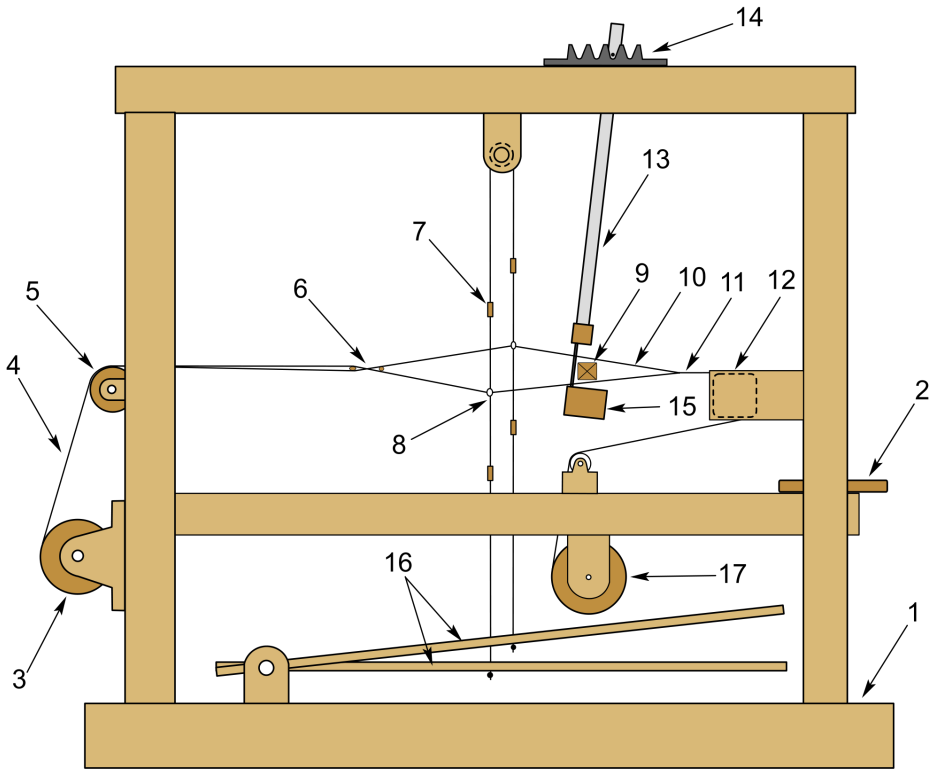
Objective

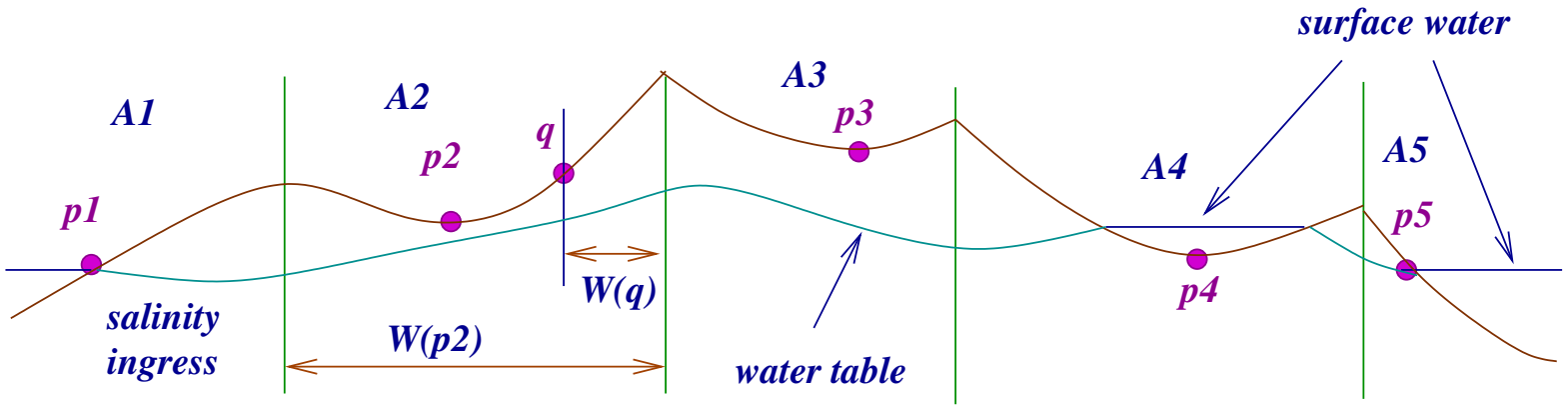


- Supply, demand and Allocation
- Surface water, groundwater, reservoirs and other structures.
- Complex domain with multitude of interactions.
- How do we simplify the domain for better analysis?

Structural decomposition



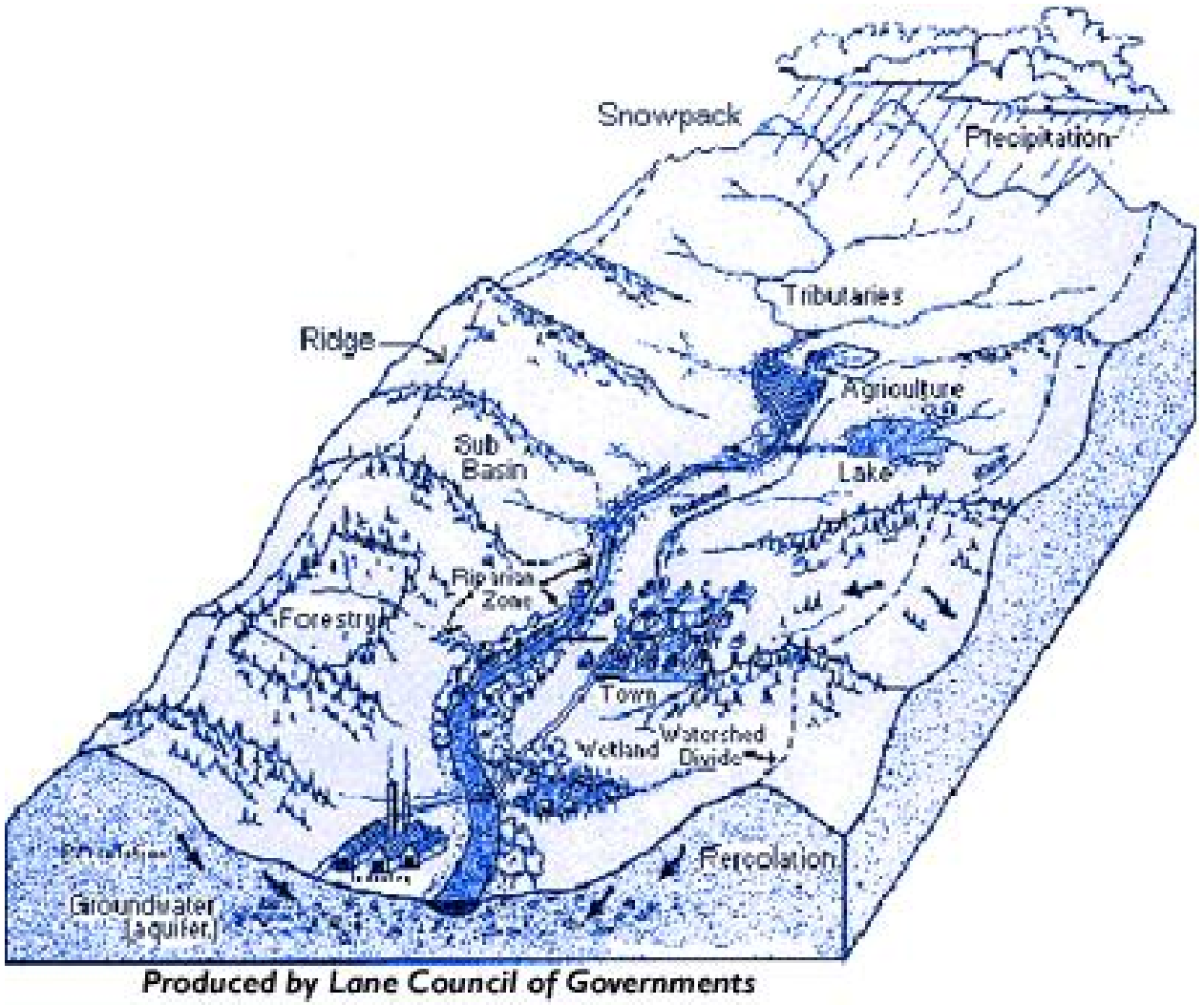
Domain Decomposition-*By surface flows*



- The watershed $W(x)$ of a point x is $W(x) = \{\text{all points } y \text{ from where } \textit{surface} \text{ water flows to } x\}$.
- For any two points x, y either $W(x) \subseteq W(y)$ or $W(x) \cap W(y)$ is a thin set.

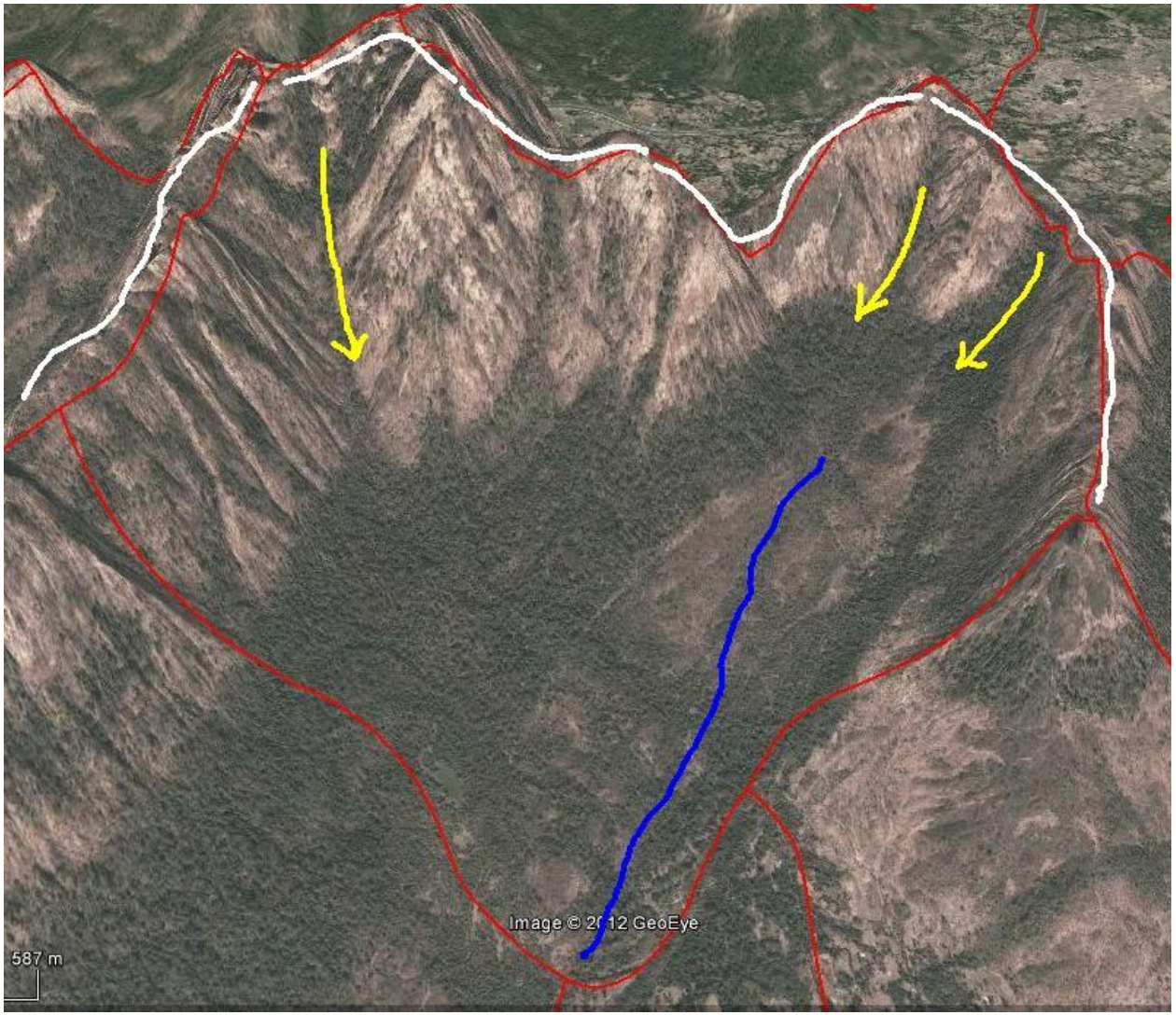
- **Decomposition of Domain into disjoint union of watersheds.**

The Watershed

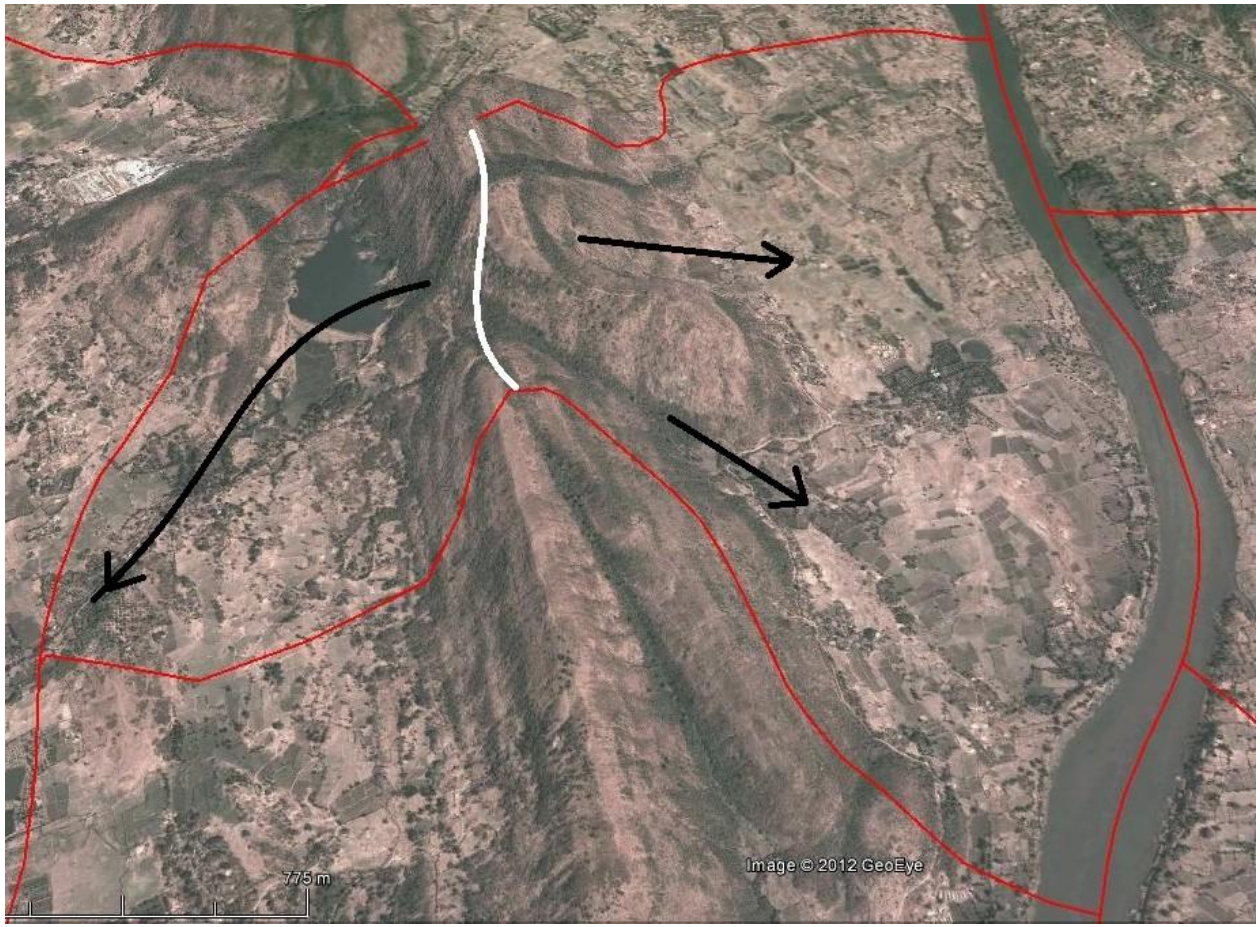


source:albanywater.org

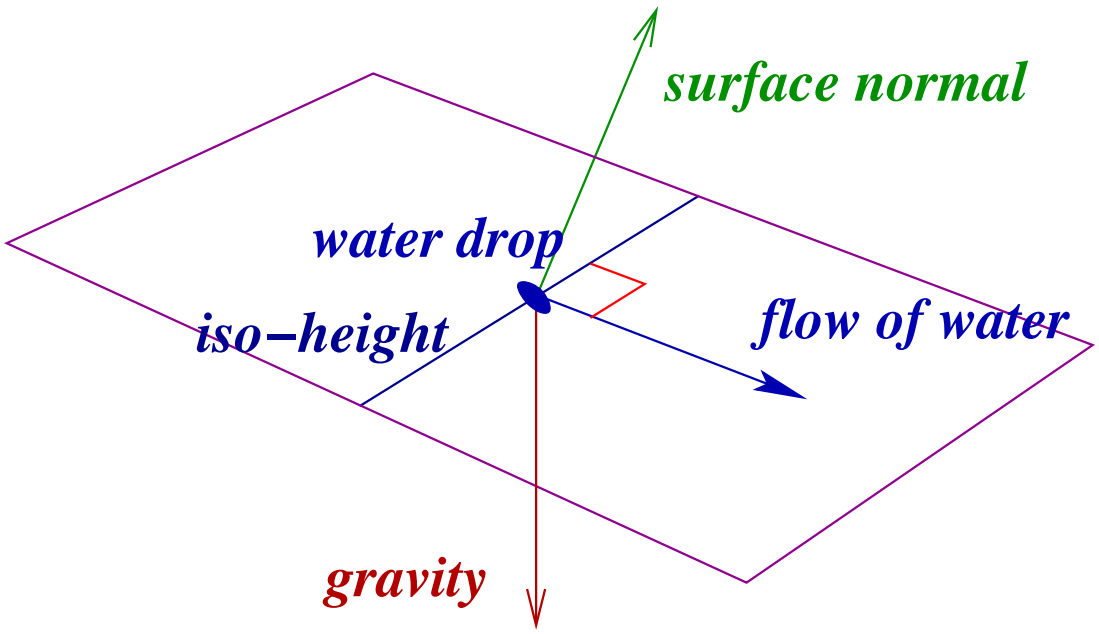
Thane Watersheds



Ridgelines, flowlines, drainlines



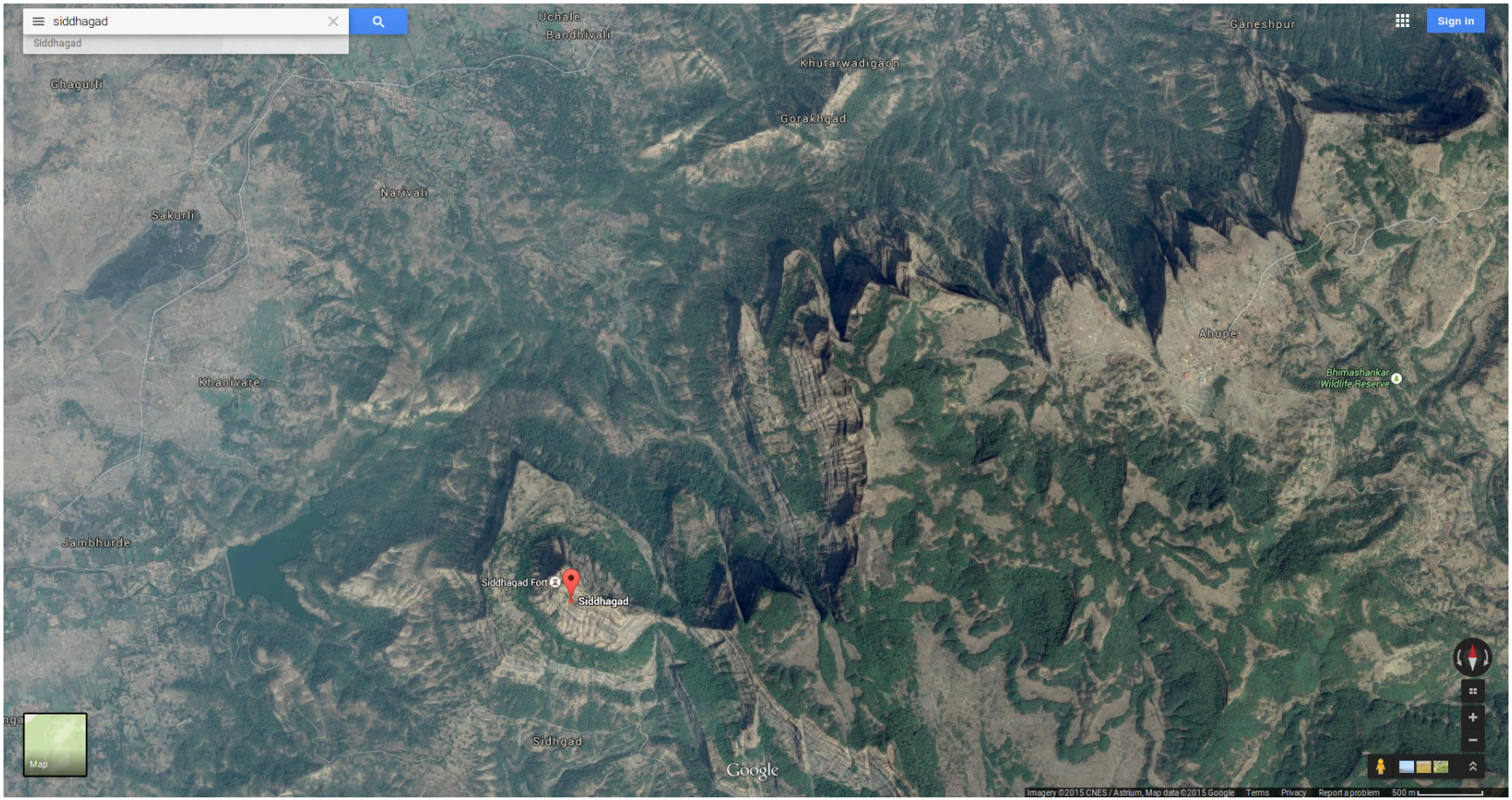
How does water flow on a slope?



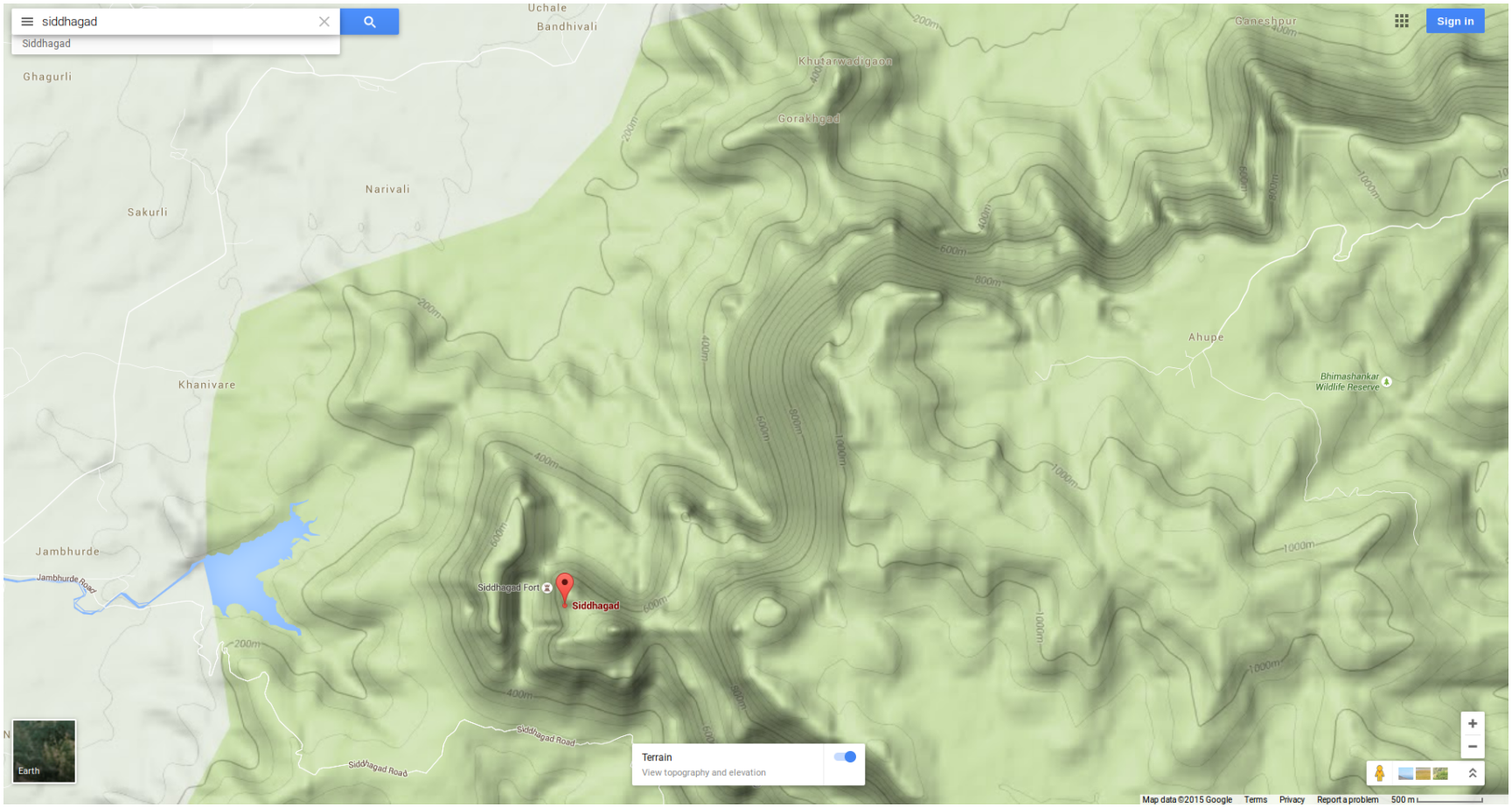
Elevation $e(x, y)$, then flow direction is $\nabla e = (-\frac{\partial e}{\partial x}, -\frac{\partial e}{\partial y})$ and normal is $[-\frac{\partial e}{\partial x}, -\frac{\partial e}{\partial y}, 1]$. Direction of steepest descent.

Enough to check when $e(x, y) = ax + by + c$

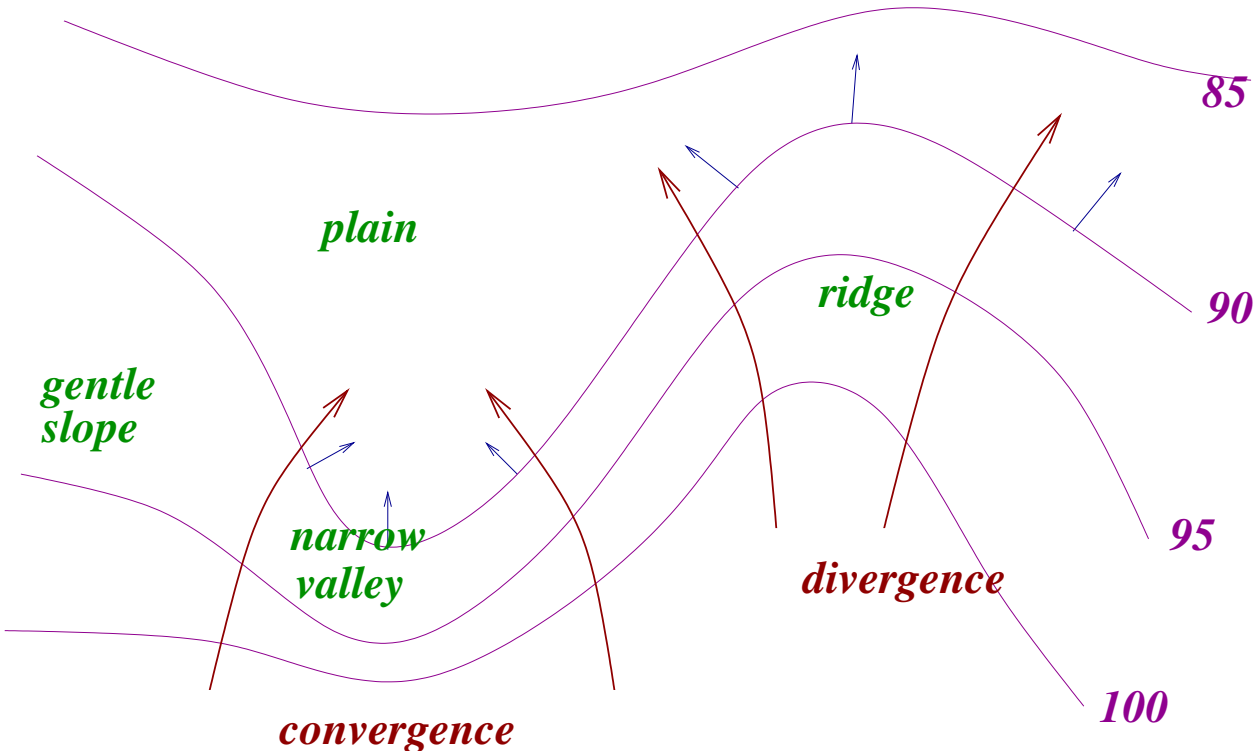
The Siddhagad Area



Its Contour Map

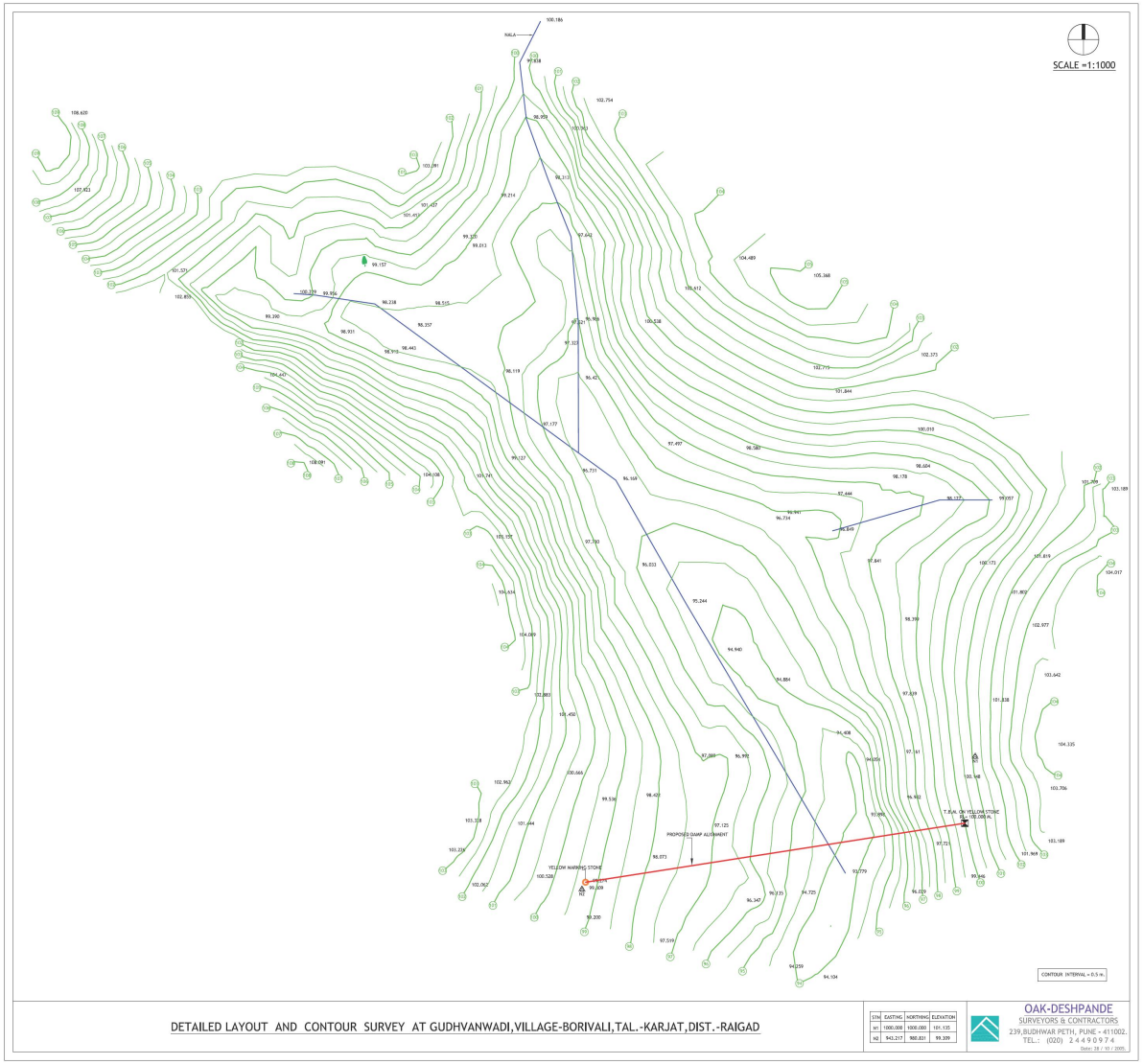


Contours and contour-flows

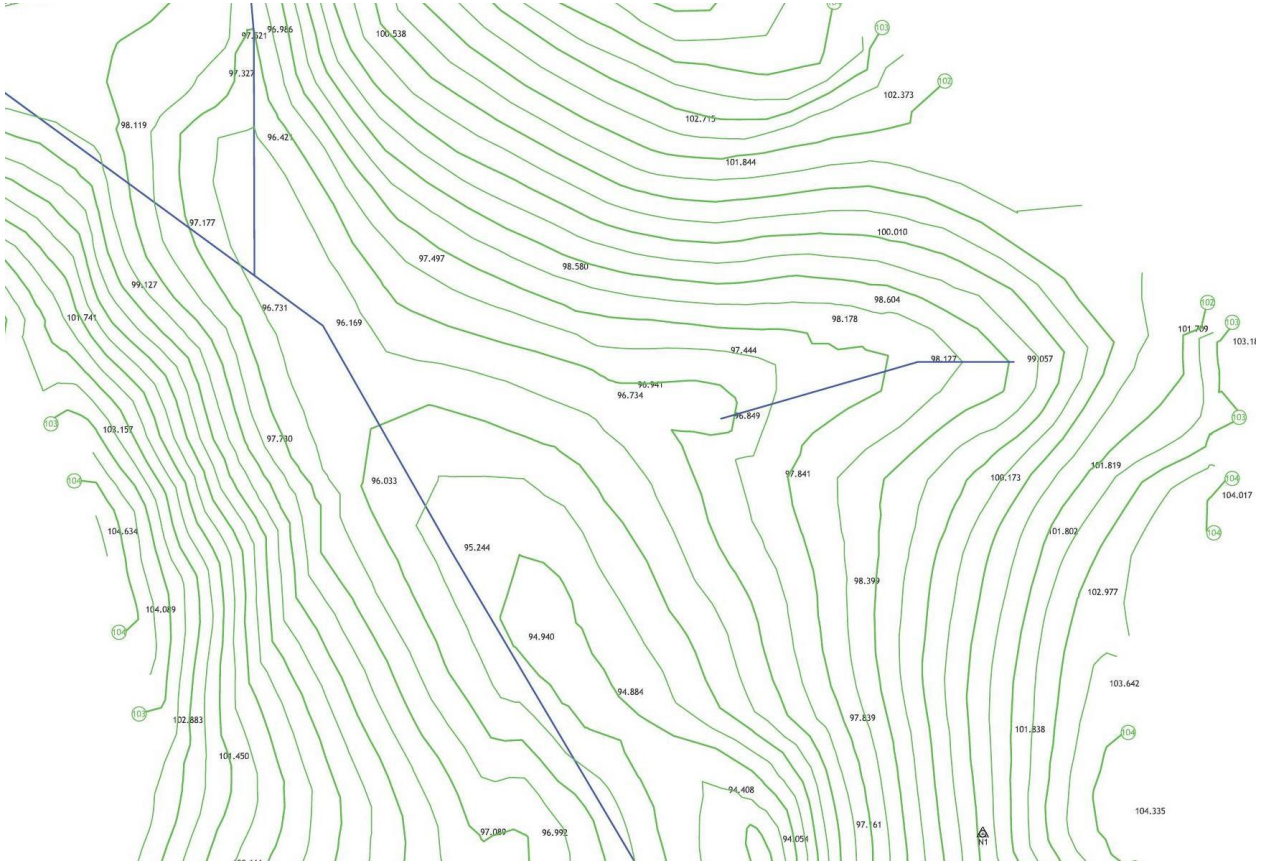


A sample Topo-sheet

Gudwanwadi reservoir.

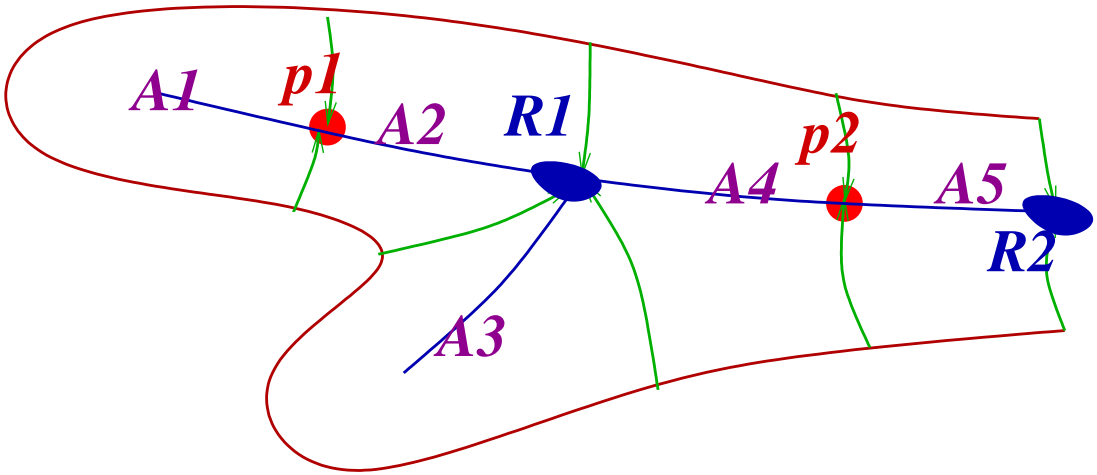


A close-up



Notice (i) the point data which is used to build the curves, and (ii) the drainage lines.

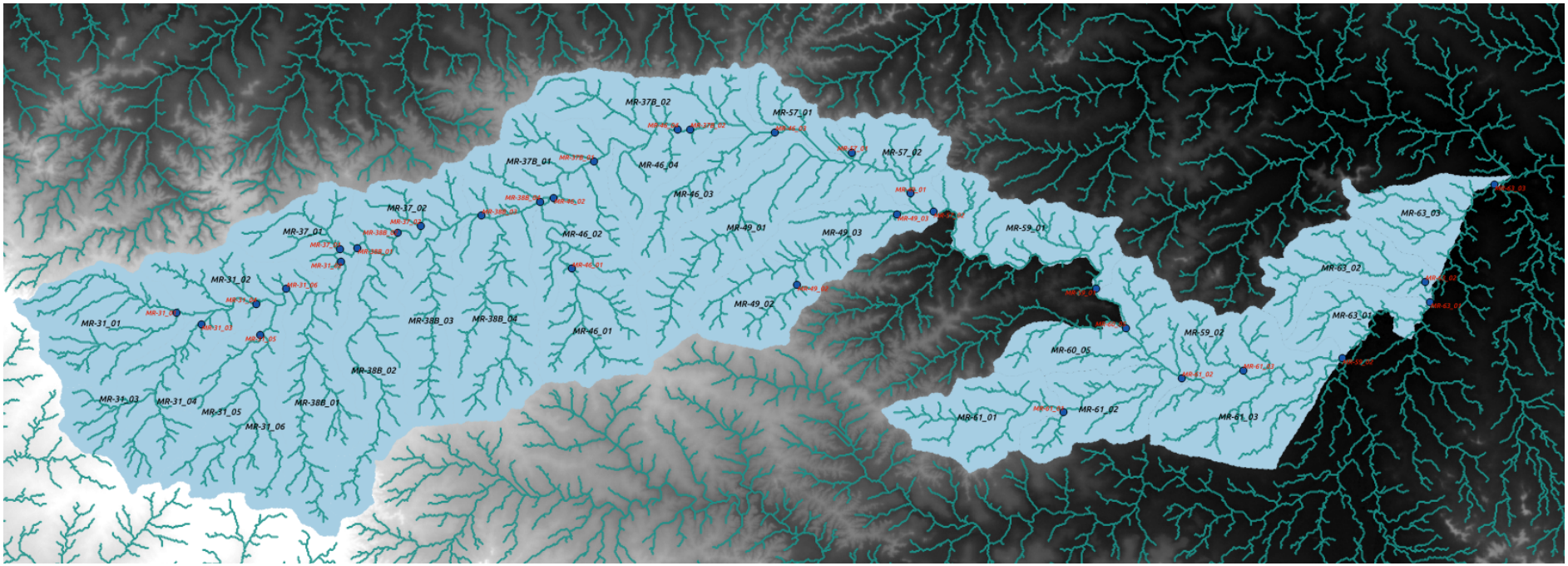
Decomposition



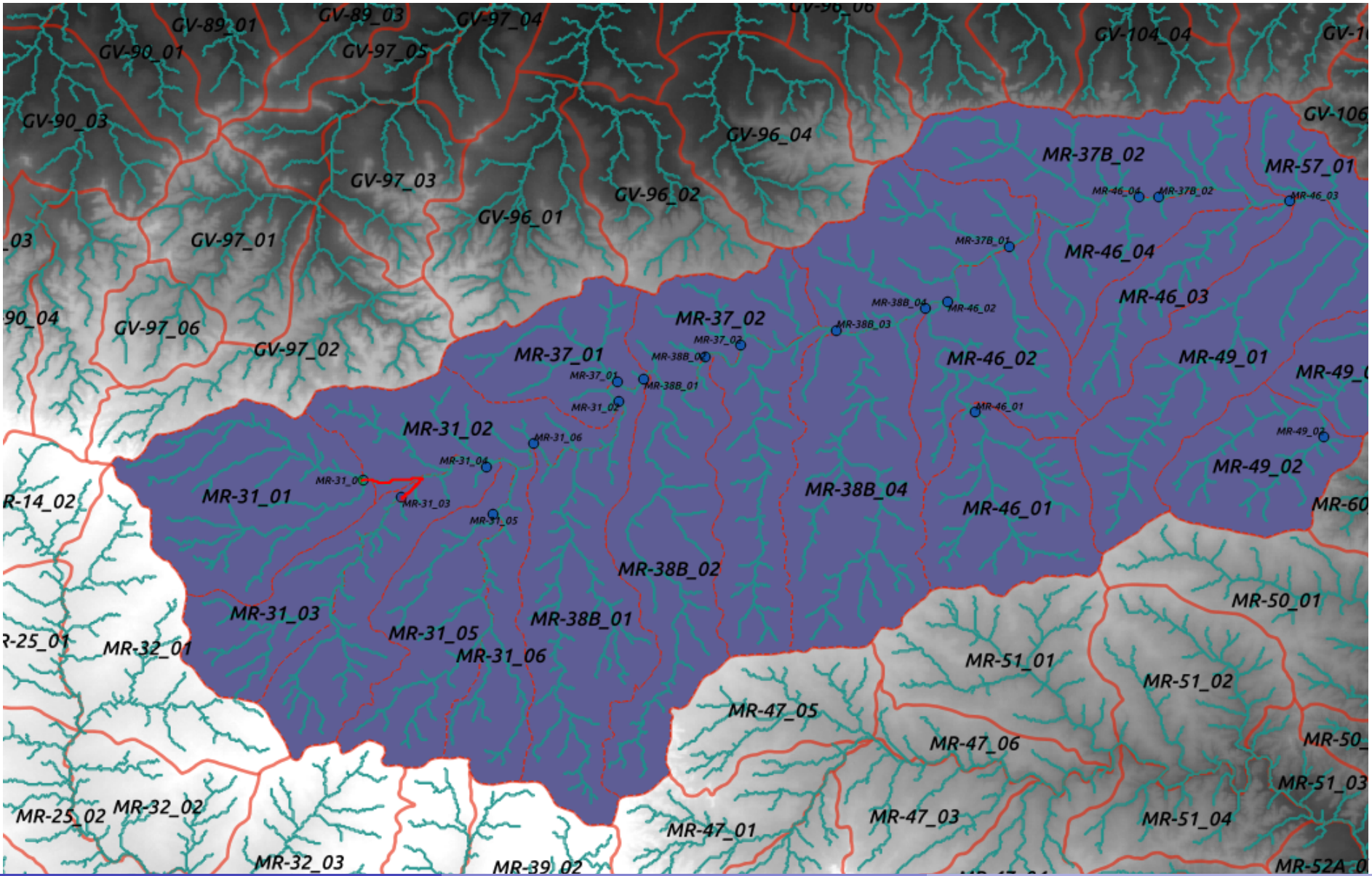
- Objective: Divide the domain into sub-domains, each of reasonable size.
- Select suitable points and prepare differential watersheds.

- Reservoirs R_1 and R_2. Special points p_1 and p_2.
- $A_1 = WS(p_1)$, $A_2, A_3 = WS(R_1) - A_1$ and so on.
- Catchment of $R_1 = A_1 + A_2 + A_3$. Catchment $R_2 = WS(R_2) - Catchment(R_1)$.
- Attributes of each A_i area, crops, soil, rainfall and so on.

Manar in Hingoli



Watersheds


GV-89_01
GV-89_03
GV-97_04
GV-90_01
GV-97_05
GV-104_04
GV-90_03
GV-96_04
GV-97_03
GV-96_02
GV-96_01
GV-97_01
GV-97_06
GV-97_02
MR-37B_02
MR-57_01
MR-46_04
MR-46_03
MR-37_02
MR-37_01
MR-46_02
MR-49_01
MR-31_02
MR-31_01
MR-38B_04
MR-46_01
MR-49_02
MR-38B_02
MR-31_03
MR-38B_01
MR-31_05
MR-31_06
MR-50_01
MR-51_01
MR-51_02
MR-47_05
MR-47_06
MR-51_03
MR-32_01
MR-32_02
MR-47_03
MR-51_04
MR-47_01
MR-32_03
MR-39_02

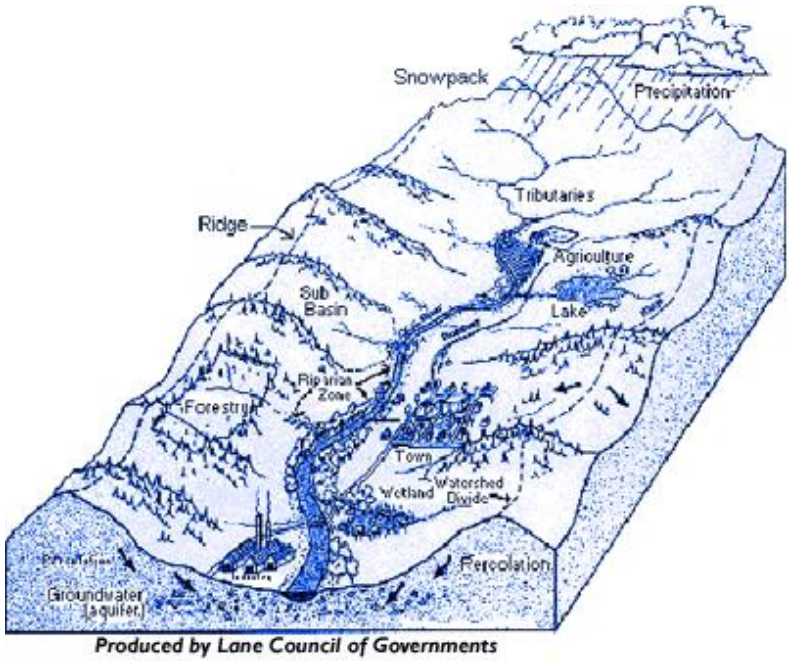
A Watershed decomposition

The Watershed

- a small *volumetric* unit for analysis.
- includes static data such as
  - geology
  - wells and discharges
- dynamic data such as:
  - weather data
- land and water use.
  - farms, factories, wells etc.

Demarcation

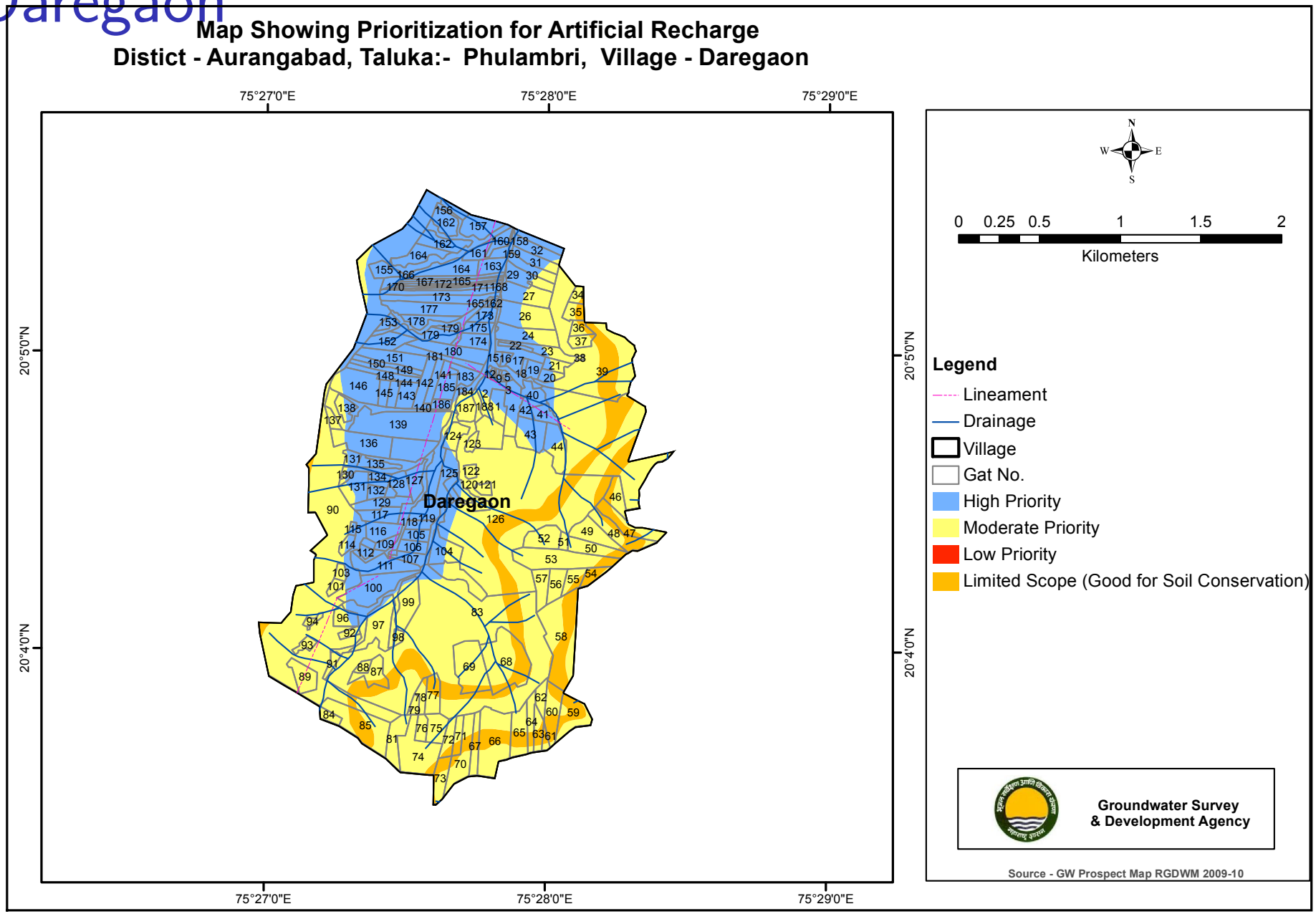
- Along *ridge lines*
- enclosing surface water flow.



Objective

Water Balance, Sustainable use, Planning Intervention design.

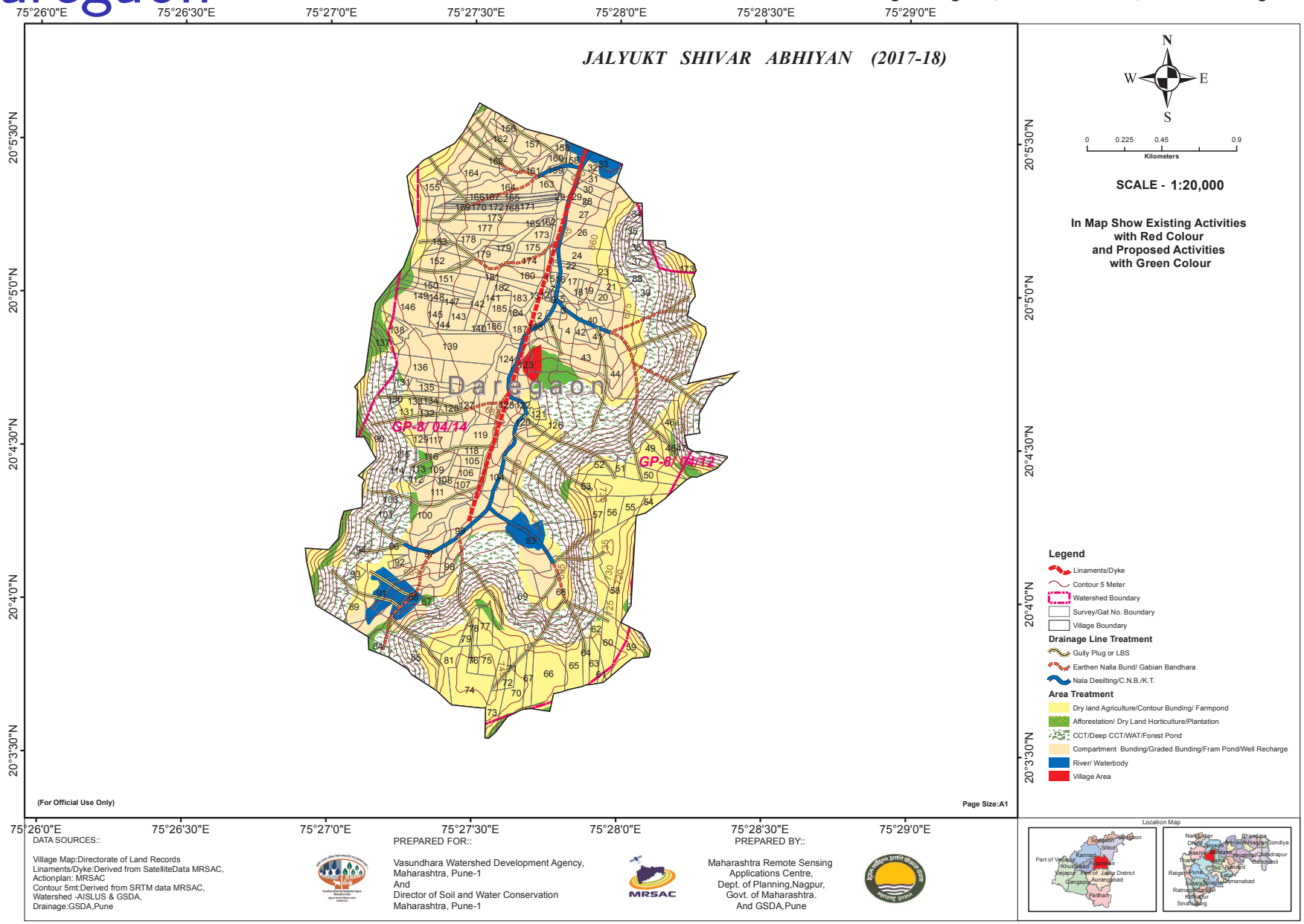
Daregaon


Map Showing Prioritization for Artificial Recharge
Distict - Aurangabad, Taluka:- Phulambri, Village - Daregaon
75°27'0"E
75°28'0"E
75°29'0"E
20°50'0"N
20°4'0"N
Daregaon
N
W
E
S
0 0.25 0.5 1 1.5 2
Kilometers
Legend
Lineament
Drainage
Village
Gat No.
High Priority
Moderate Priority
Low Priority
Limited Scope (Good for Soil Conservation)
Groundwater Survey & Development Agency
Source - GW Prospect Map RGDWM 2009-10

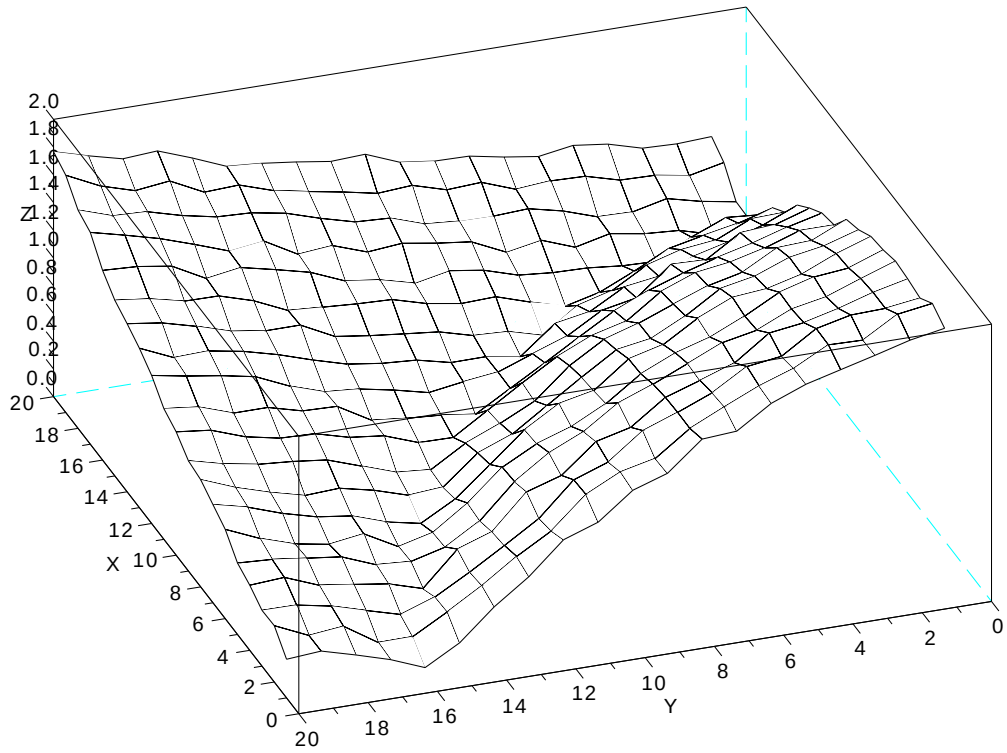
Daregaon

ACTIONPLAN MAP (Watershed No:- GP-8/4/14)

Village-Daregaon ,Taluka -Fulambari, District -Aurangabad

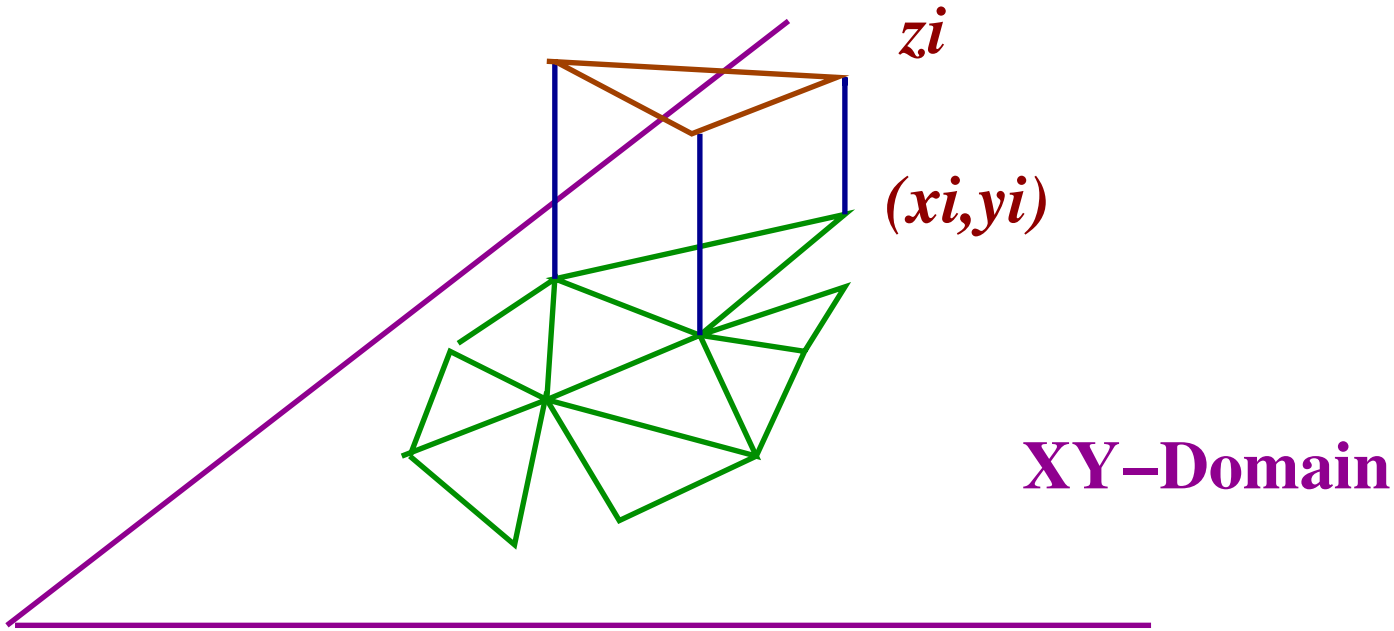


The mathematics, data, entities and quantities



- The DTM or DEM: terrain model/elevation model is a representation of the terrain in a particular area.
- Grids are where the base division in 2D is a grid of squares/triangles with a certain resolutions.

The Digital Terrain/Elevation model



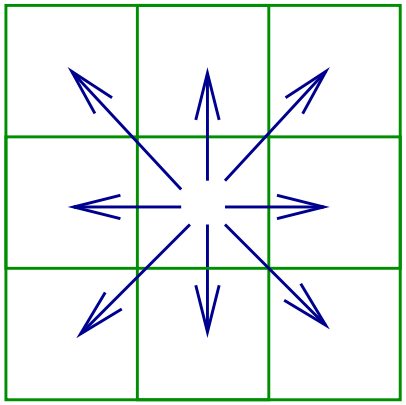
- Basic grid in the 2D-plane as an index set, *with adjacency*
- association of z-values for each point, to define 3D points, edges, triangles and adjacency.

The Attributes and Computation

- The DTM or DEM: terrain model/elevation model is a representation of the terrain in a particular area.
- Attributes of the DTM-soil, geology, land-use, land-cover.
- Regions-subsets of the DTM, to represent watersheds, flows, etc.
- Functions and Computations: to simulate various physical quantities and their dynamics.
  - Infiltration : the process of rainwater moving down to groundwater.
  - Drainage lines : The development of streams due to rainfall.
  - Surface flow : a composite model of surface flow of water and infiltration which may include time to flow, movement of solids etc.

Lets Compute Drainage

- If a drop falls at point (i, j) then how does it move?
- We consider the 8-neighbours of the point.



8–way adjacency

- The flow gets distributed relative to the height differences.

- Here is an example:

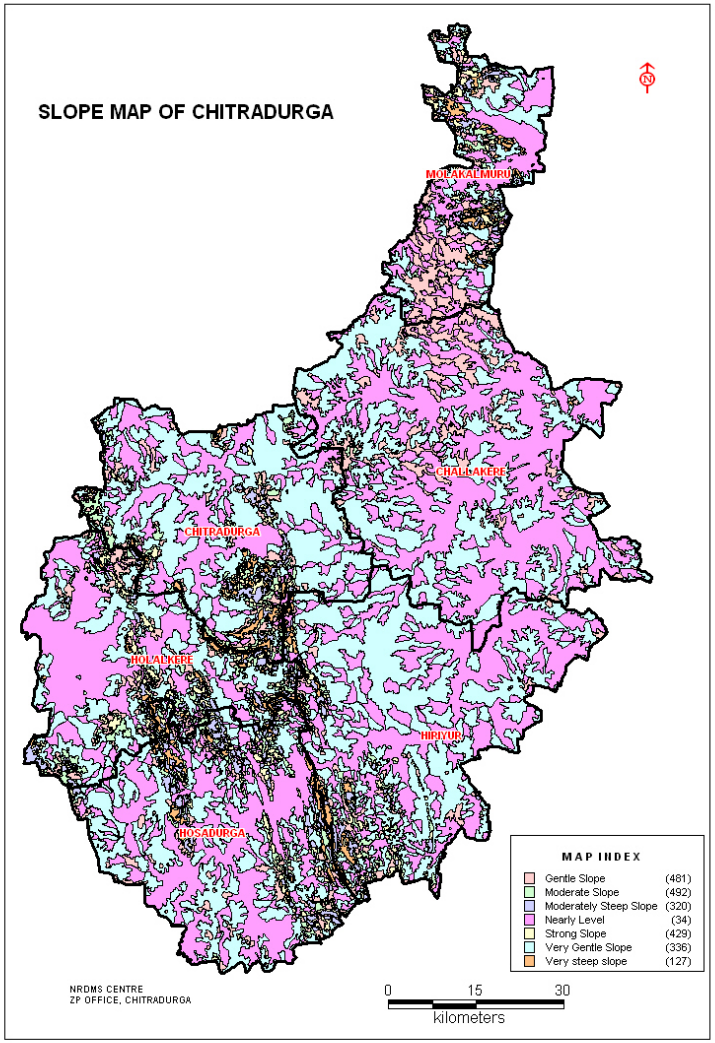
1.1	1.5	1.6
1.3	1.4	1.7
1.3	1.3	1.5

- Hypothesis: Only lower, and in proportion to the height differences.

3/6	0	0
1/6	0	0
1/6	1/6	0

- And this continues recursively downwards.

and Infiltration



- The slope values ($\times 10^{-3}$).

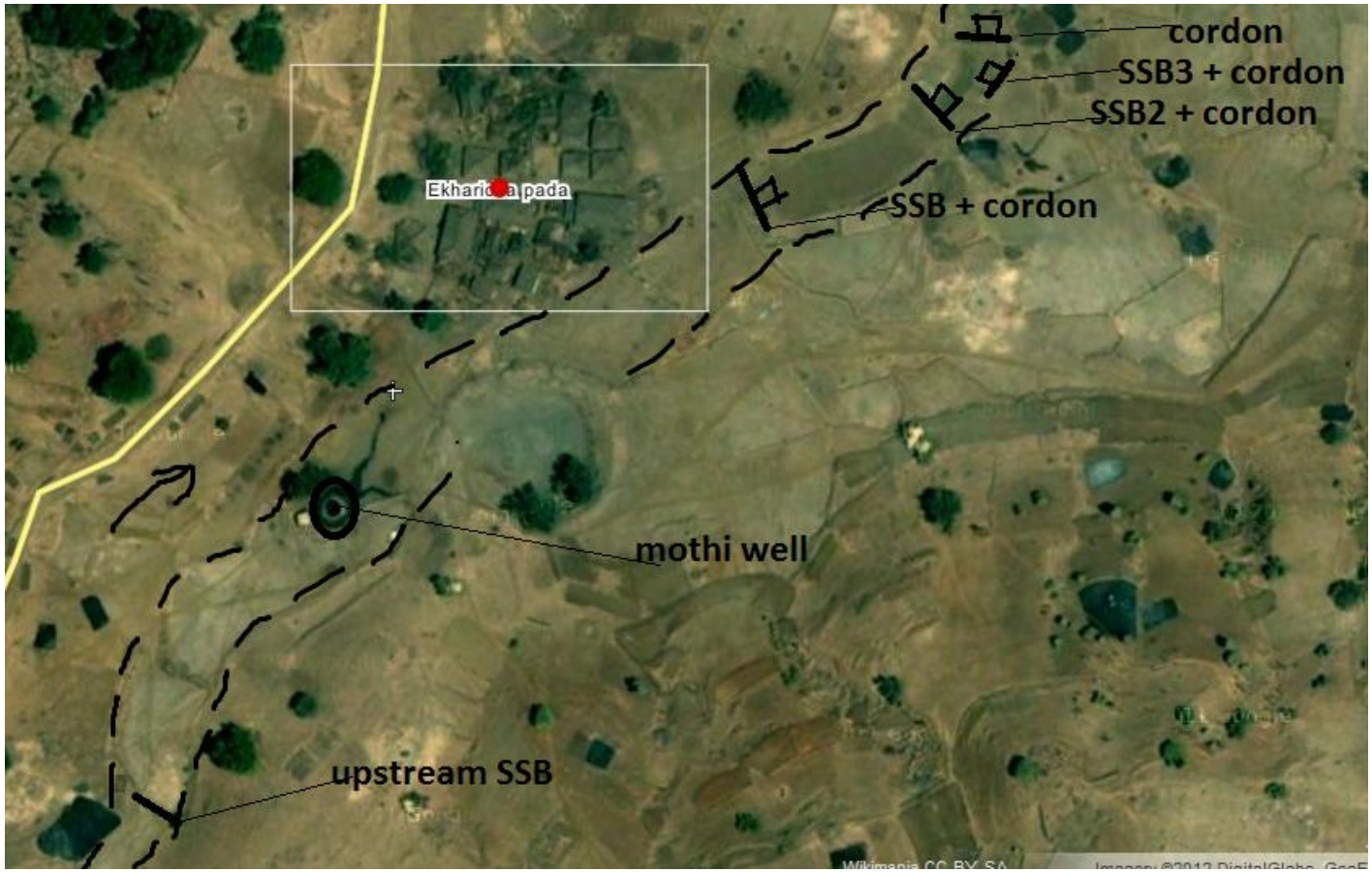
2.1	2.5	2.6
7.3	9.1	8.0
1.3	1.3	1.5

- Hypothesis: Infiltration depends on slope.

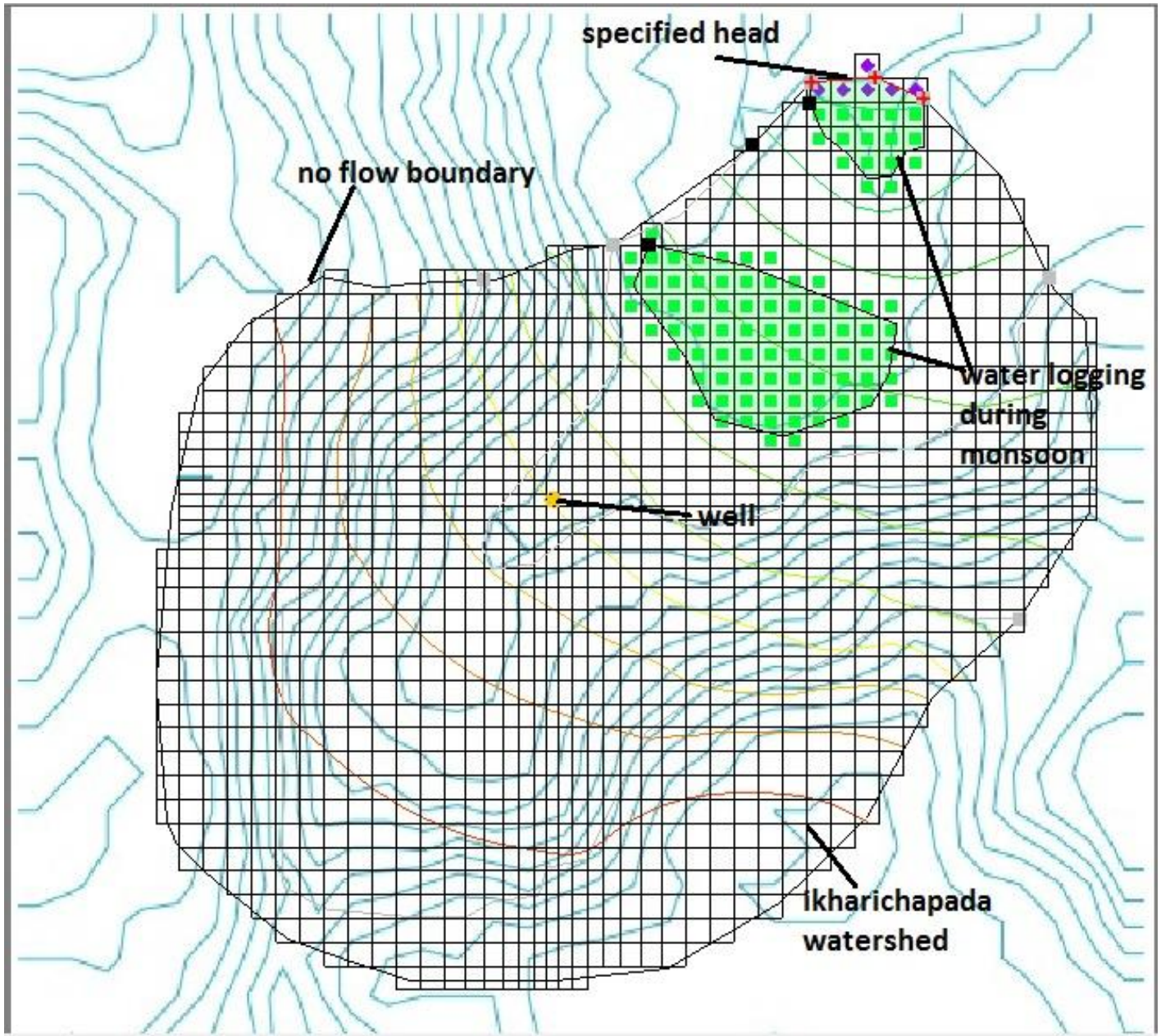
0.1	0.09	0.09
0	0	0
0.2	0.2	0.15

- More complicated models: moisture, daily rainfall, soil-thickness.

Ikharicha pada

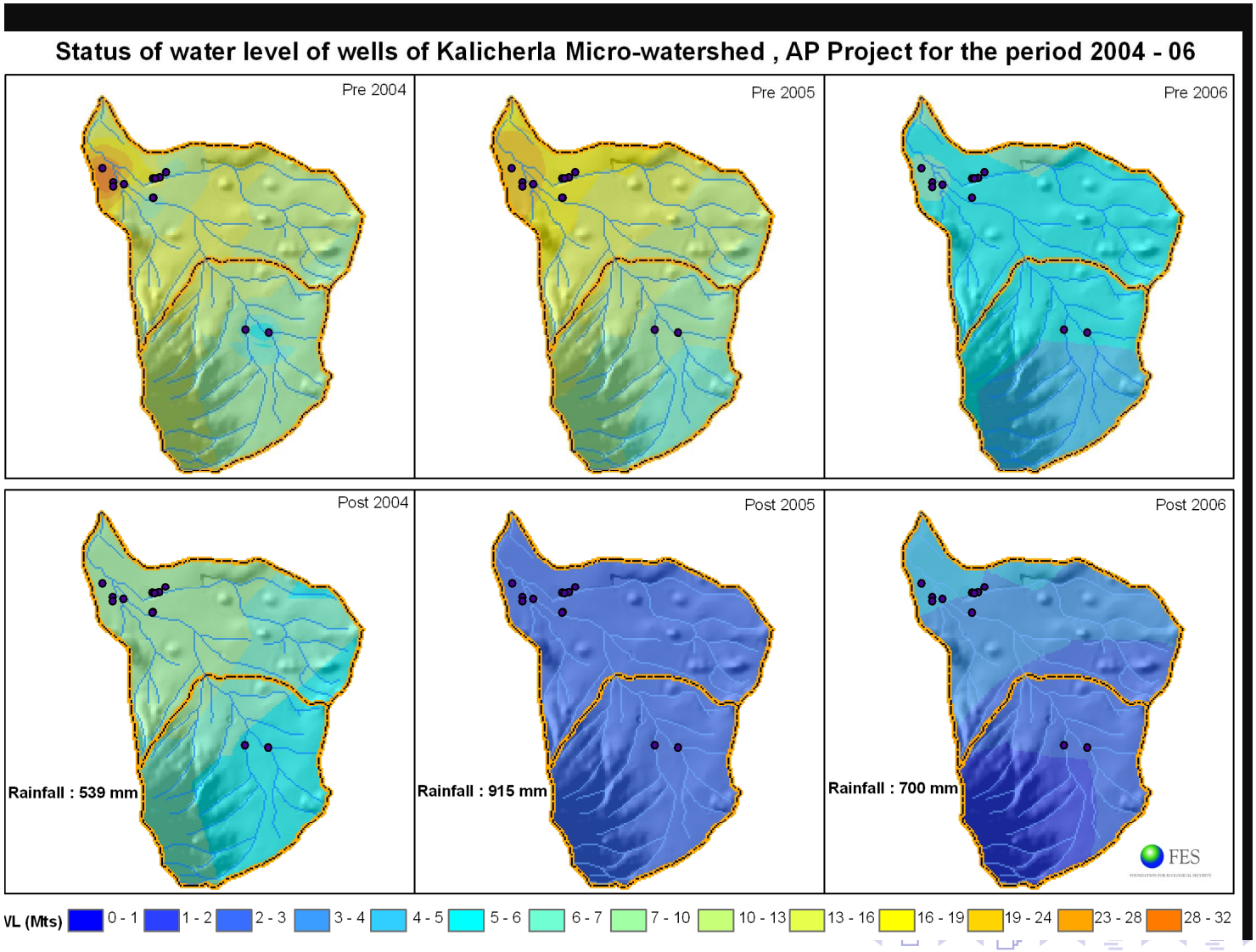


Ikharicha pada

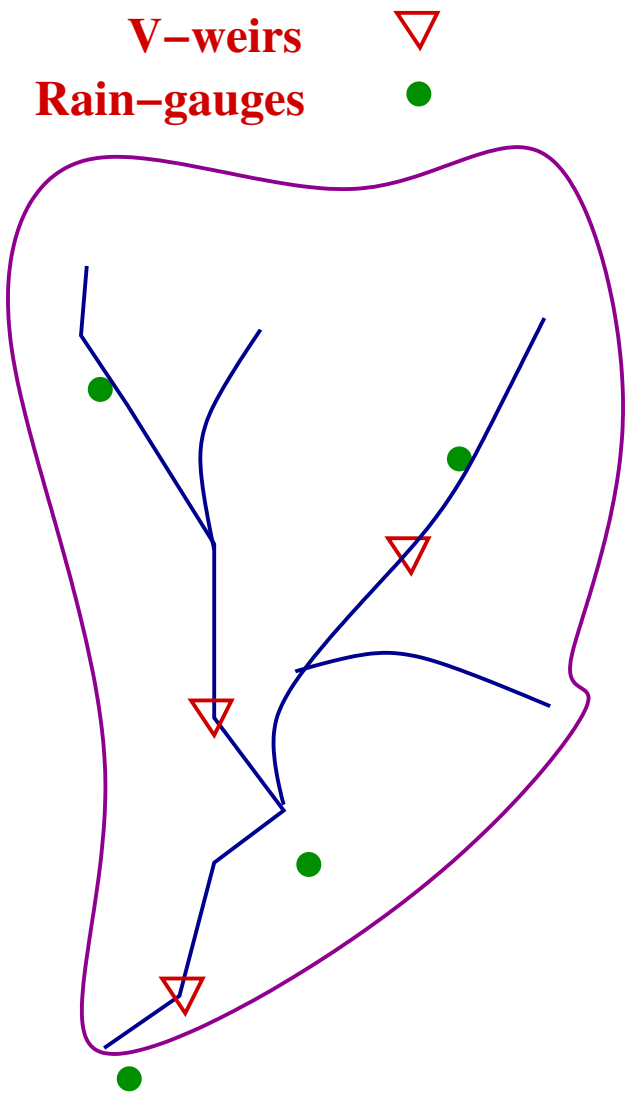


A watershed*

*Thanks to FES.org



Coming back-mywatershed



- Suppose that we have installed appropriate rain-gauges and V-notch weirs.
- Suppose that we have good geological and GW data.
- Can we achieve stating a water-budget for mywatershed?
- Likely not. Most natural phenomena too complicated to model.

A good model will always have predictive value.

- Short-term: floods, crops. Long term: health of watershed.

Thanks