Using ArcSWAT for Evaluation of Water Productivity and Economics of Crops in Canal Irrigation Command

R.T.Thokal
Head, Dept. of Irrigation and Drainage Engineering
College of Agril Engg. And Tech., Dr.BSKKV, Dapoli
Maharashtra State, INDIA

rtt1966@yahoo.com

S.D. Gorantiwar
Head, Dept. of Irrigation and Drainage Engineering
Dr. A. S. College of Agril Engg., Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar,
Maharashtra State, INDIA

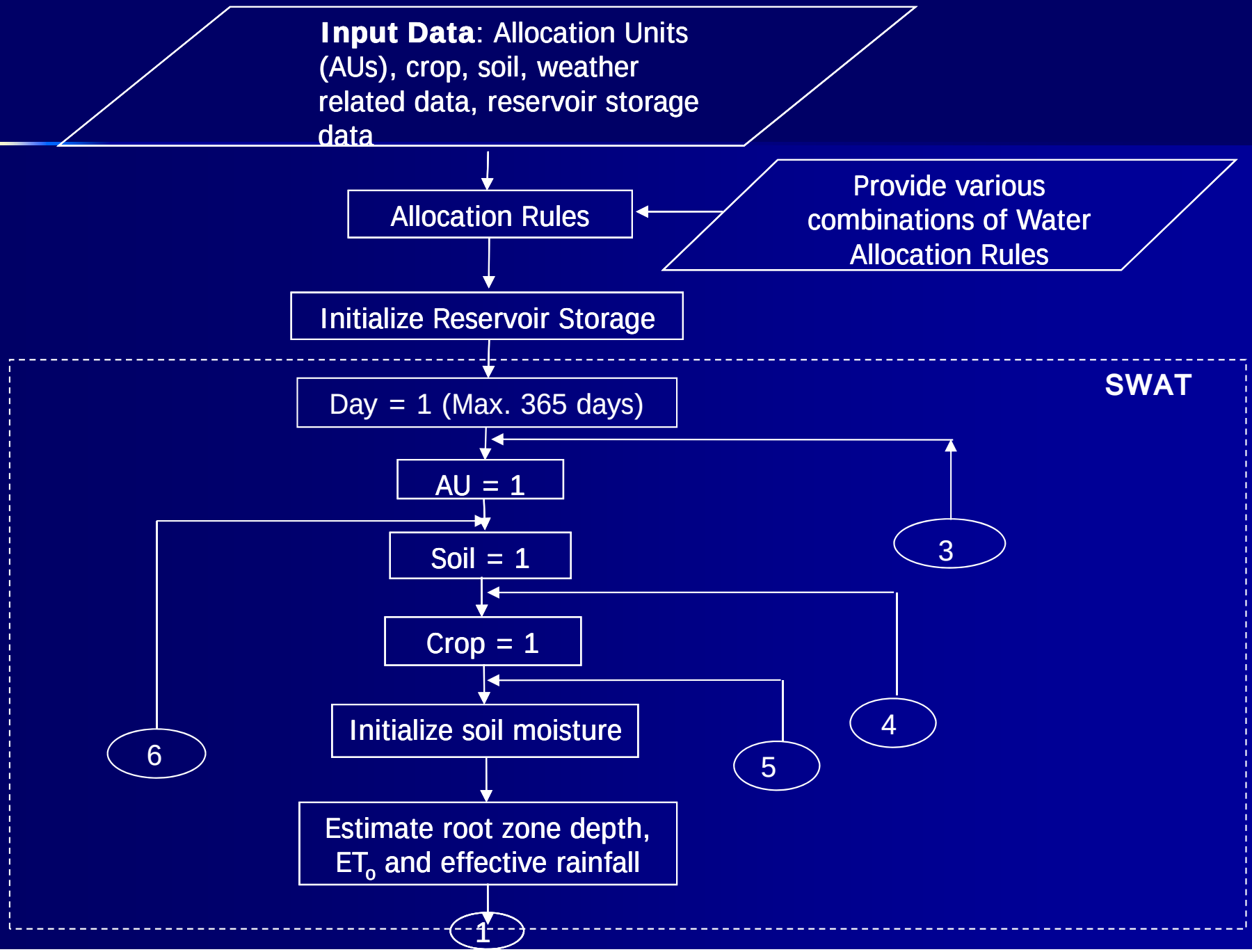
- Importance of Irrigation Water Management in Water Scarce Regions
- Development of framework using SWAT for irrigation water management of command area
- Case study
- Application: Root zone moisture status, Crop Net benefit and Water Use Efficiency

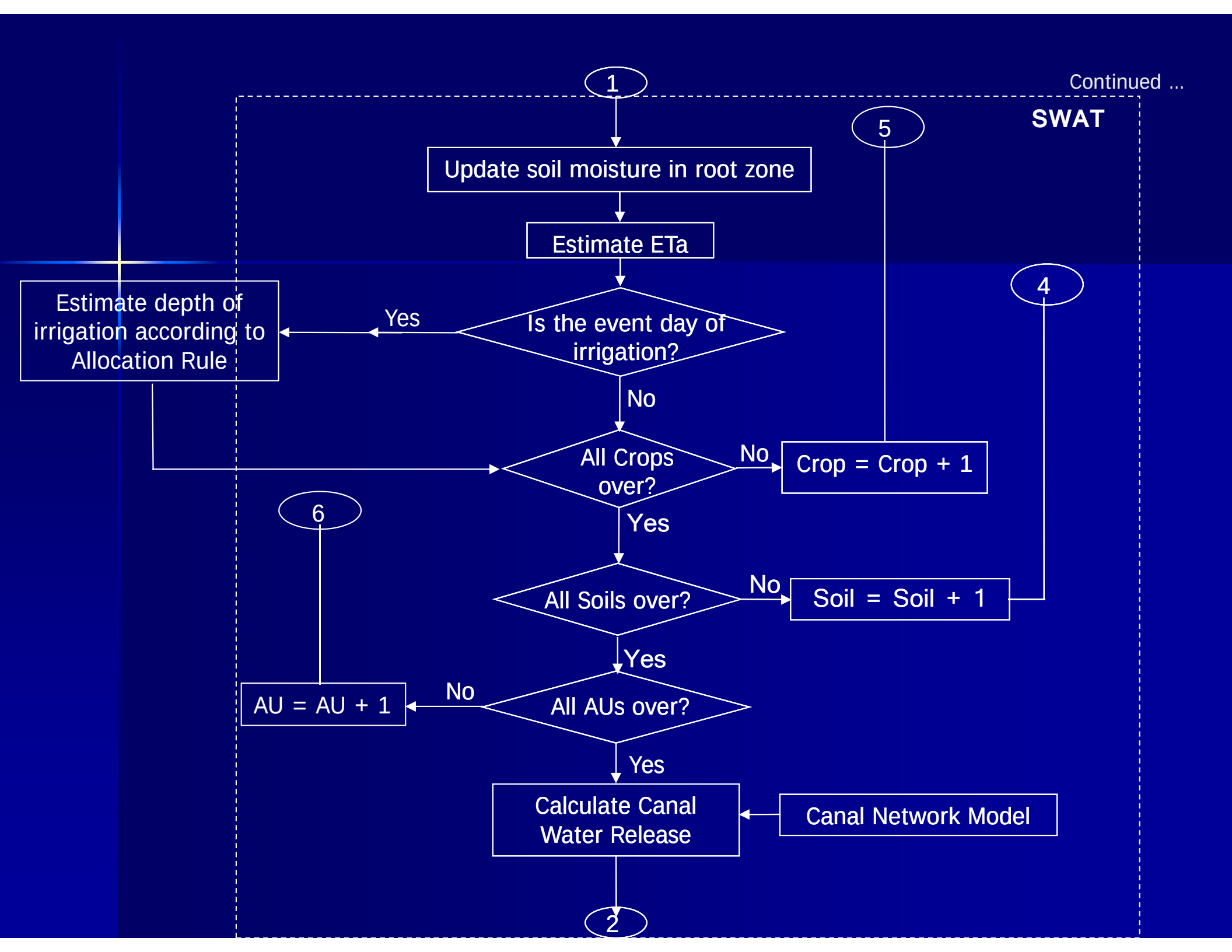
- Water - most critical natural resource for agriculture in the twenty-first century
- Use of water for irrigation is by far the greatest consumer of fresh water globally
- Irrigated regions globally consume more than 70% of the world's water resources
- Saving just a small amount of water destined for irrigation and using it for drinking purpose instead, could improve the living conditions of millions of people
- Increasing irrigation efficiencies seem to be the practical way to save water
- Deficit irrigation strategy - application of water below full crop-water requirements
- Deficit irrigation can lead to greater economic gain in case of drought and water scarce condition

Components of Framework

- Tool framework mainly comprises three modules:
  - Allocation rules module
  - SWAT modules
  - economic module
- Framework also has a facility to use crop growth module externally
- Water allocation rules can be given as input according to water availability in reservoir
- Soil water balance is done through SWAT module
- External crop growth model uses output of ETp and ETa from SWAT
- Economic module computes cost of cultivation of crops, gross and net benefits of individual crop as well as project net benefit for respective allocation rule
- Tool framework is able to estimate daily updates of reservoir storage

Development of Conceptual Framework

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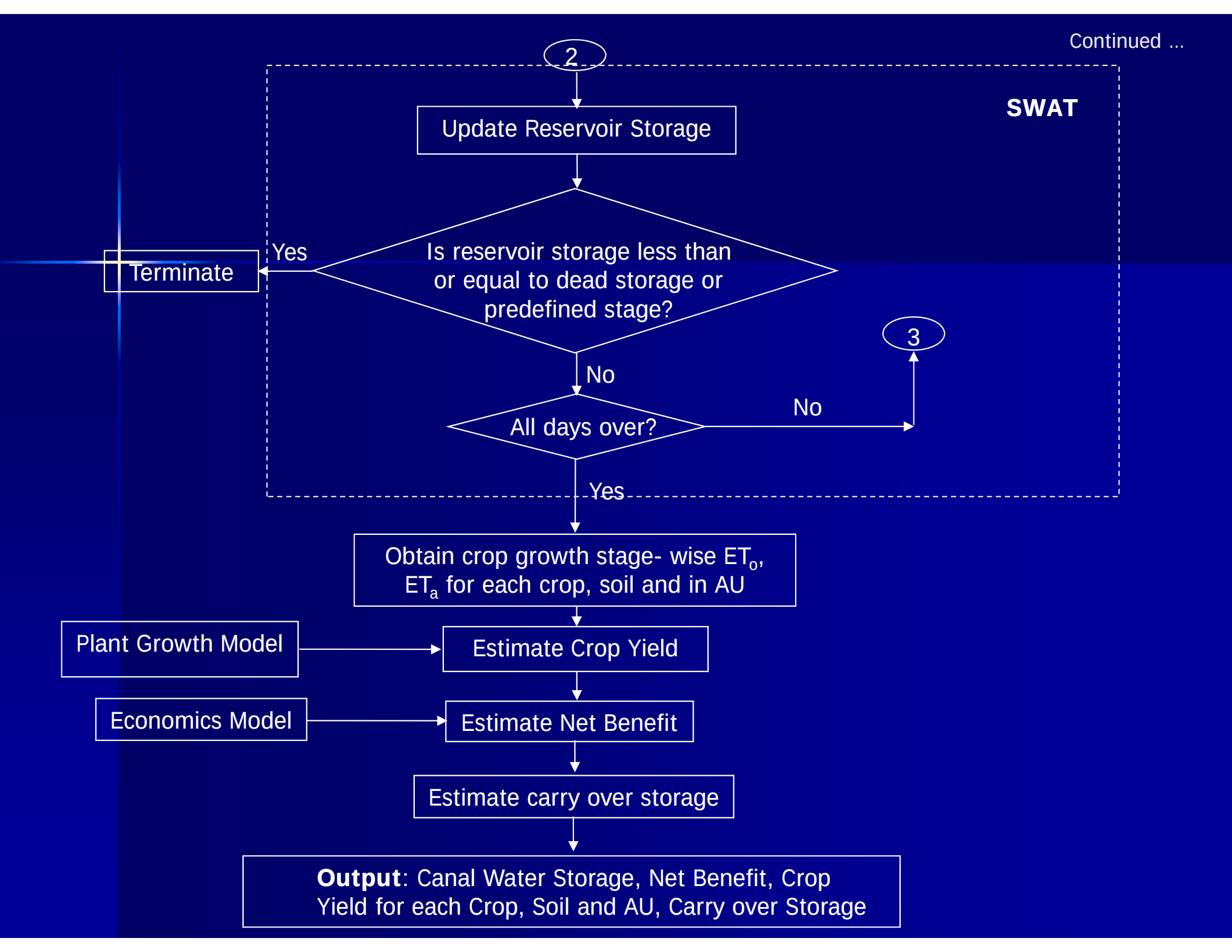
SWAT
1
Update soil moisture in root zone
Estimate ETa
Is the event day of irrigation?
Yes
Estimate depth of irrigation according to Allocation Rule
No
All Crops over?
No
Crop = Crop + 1
5
4
6
Yes
All Soils over?
No
Soil = Soil + 1
Yes
All AUs over?
No
AU = AU + 1
Yes
Calculate Canal Water Release
Canal Network Model
2

Continued ...

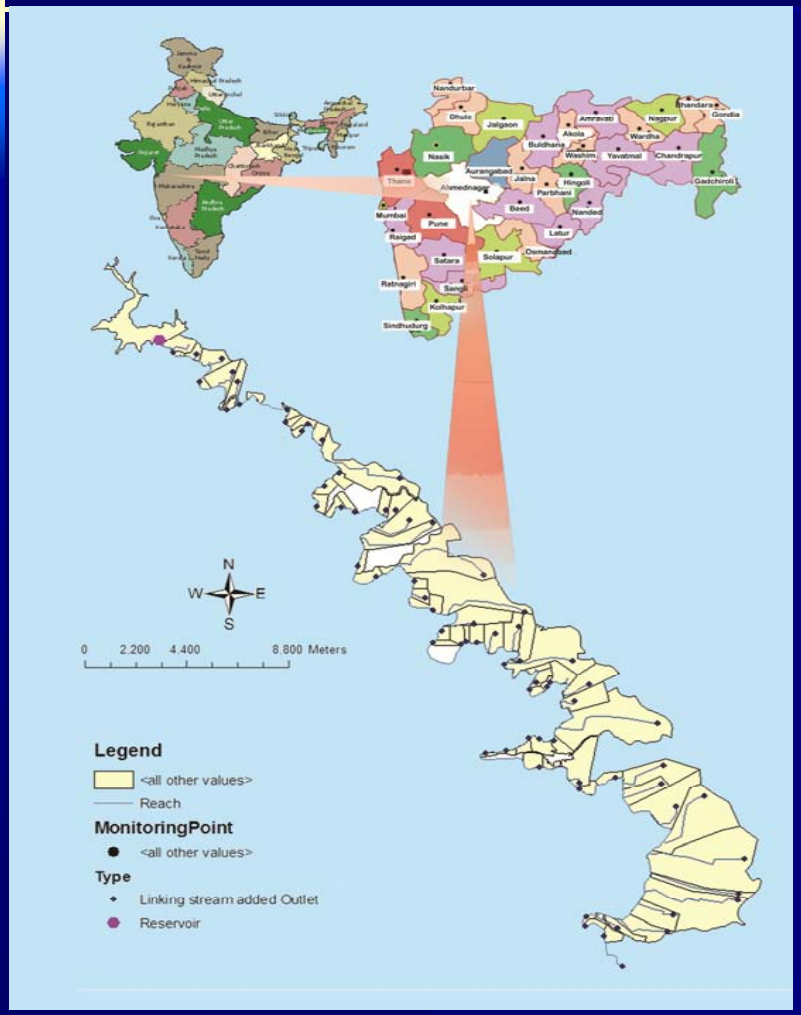

2
SWAT
Update Reservoir Storage
Is reservoir storage less than or equal to dead storage or predefined stage?
Yes
Terminate
No
3
All days over?
No
Yes
Obtain crop growth stage- wise ET_o, ET_a for each crop, soil and in AU
Plant Growth Model
Estimate Crop Yield
Economics Model
Estimate Net Benefit
Estimate carry over storage
Output: Canal Water Storage, Net Benefit, Crop Yield for each Crop, Soil and AU, Carry over Storage

External Crop Growth Model

- Stewart water production function (or any other suitable model)

$$\frac{Y_a}{Y_m} = 1 - \sum_{s=1}^{ns} K_{y_s} \left(\frac{ET_{o_s} - ET_{a_s}}{ET_{o_s}} \right)$$

Location of Study Area



Location of Sina Irrigation Project

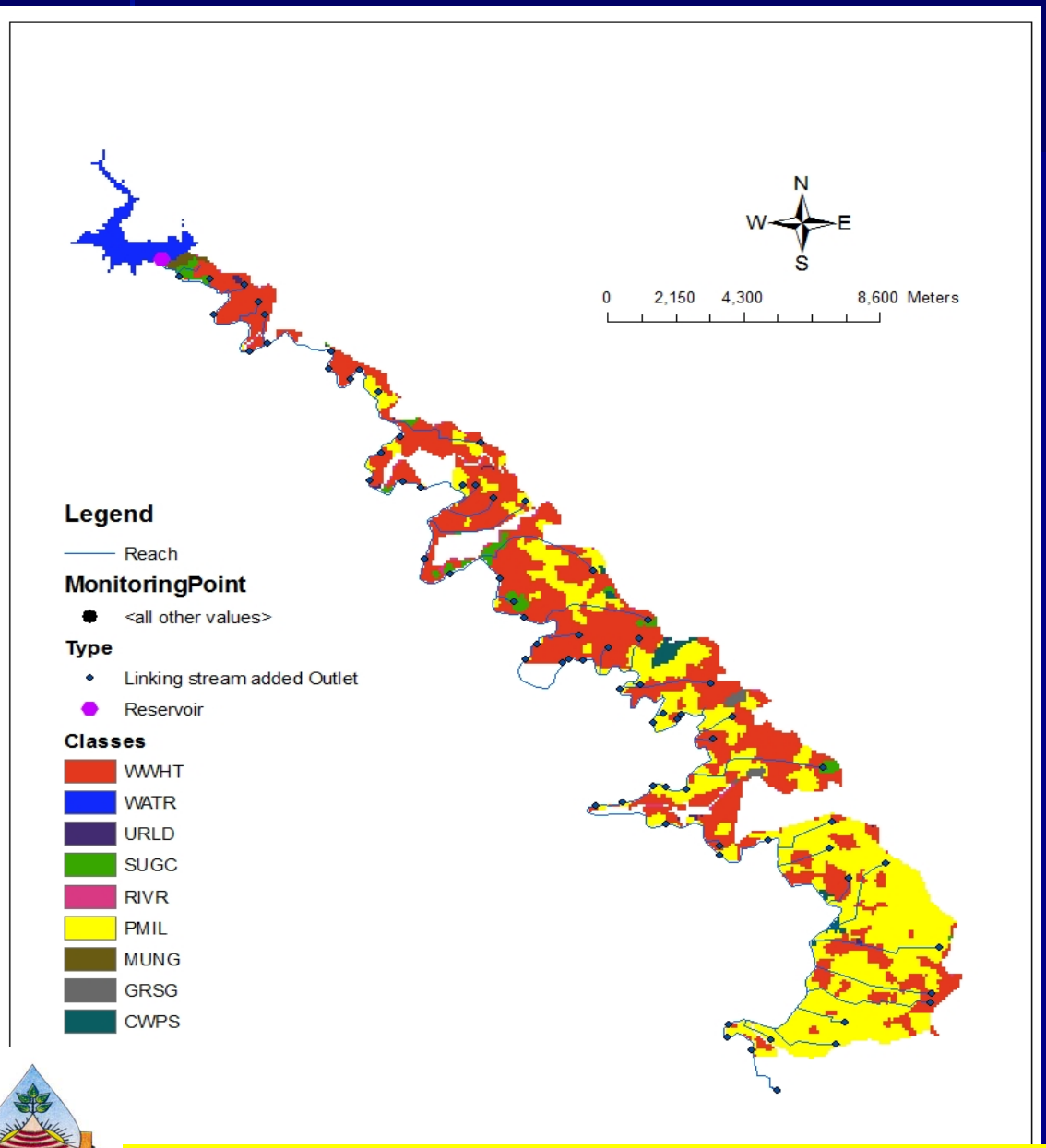
- **Sina Medium Irrigation Project**
- Tributary of river Bhima in Krishna basin
- Location: Nimgaon Gangarda village, Tal. Karjat, Dist. Ahmednagar
- Location: Latitude 18o49'0"N Longitude 74o57'0"E
- Topo-sheets No.: 47 J/13, 47 J/14, 47 N/1 and 47 N/2

Features of Study Area

- Annual rainfall: 503.80 mm
- Reservoir gross capacity: 67.98 M cum
- Live storage: 52.33 M cum
- Dead storage: 15.65 M cum
- Observed percentage of live storage in reservoir over a period of 25 years is **69.92** (36.57 M m^3)
- Culturable Command Area (CCA): 9677 ha
- Irrigable Command Area (ICA): 8445 ha
- ICA under Right Bank Canal: 7656 ha

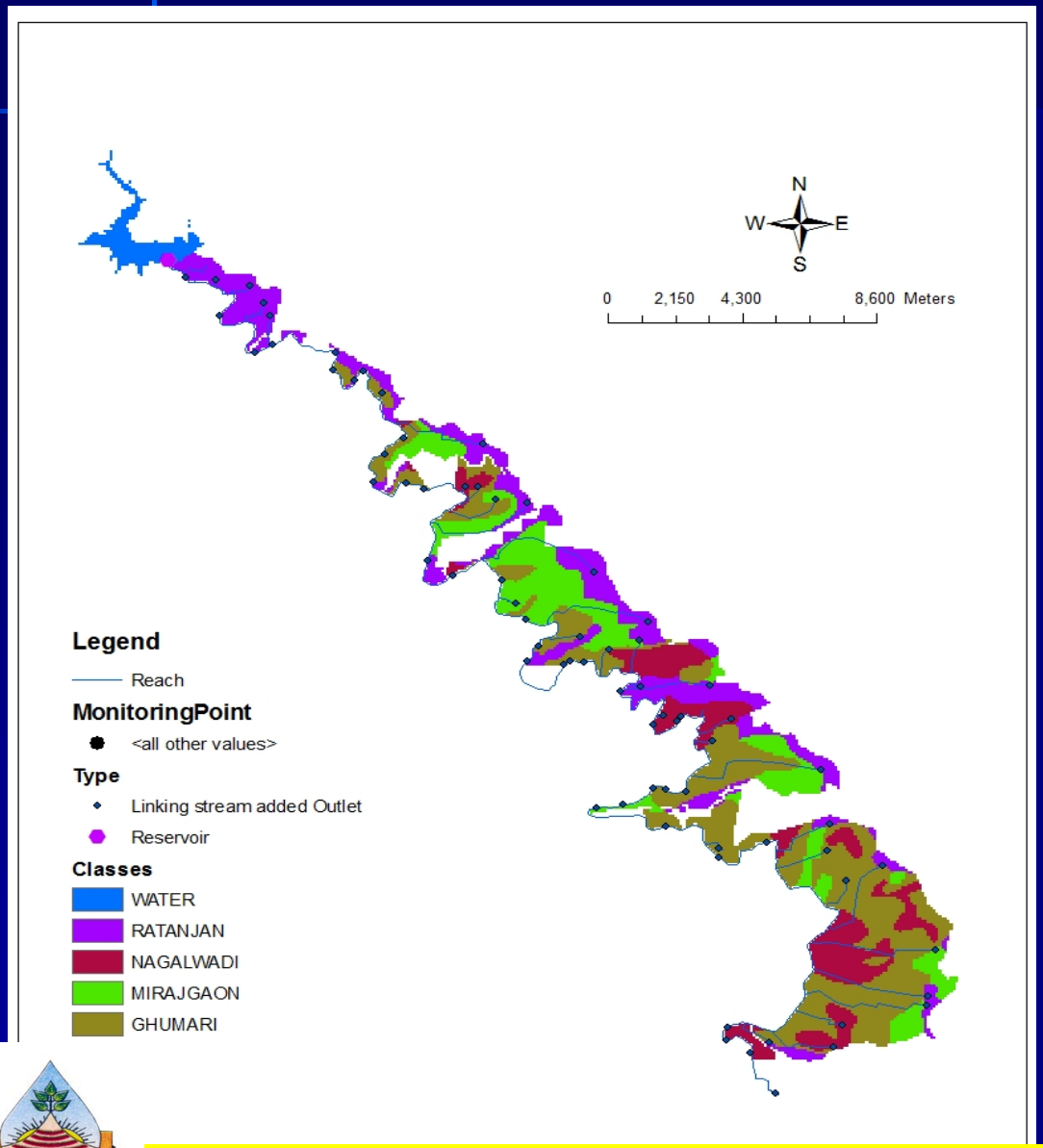
- SRTM images (SRTM_51_091 and SRTM_52_091) were mosaiced and used for preparation of DEM
- Pre-defined stream definition option was selected for watershed delineation
- User-defined canal network (stream) and outlet command (sub-basins) were linked with each other and input to SWAT

Cropping pattern in study area



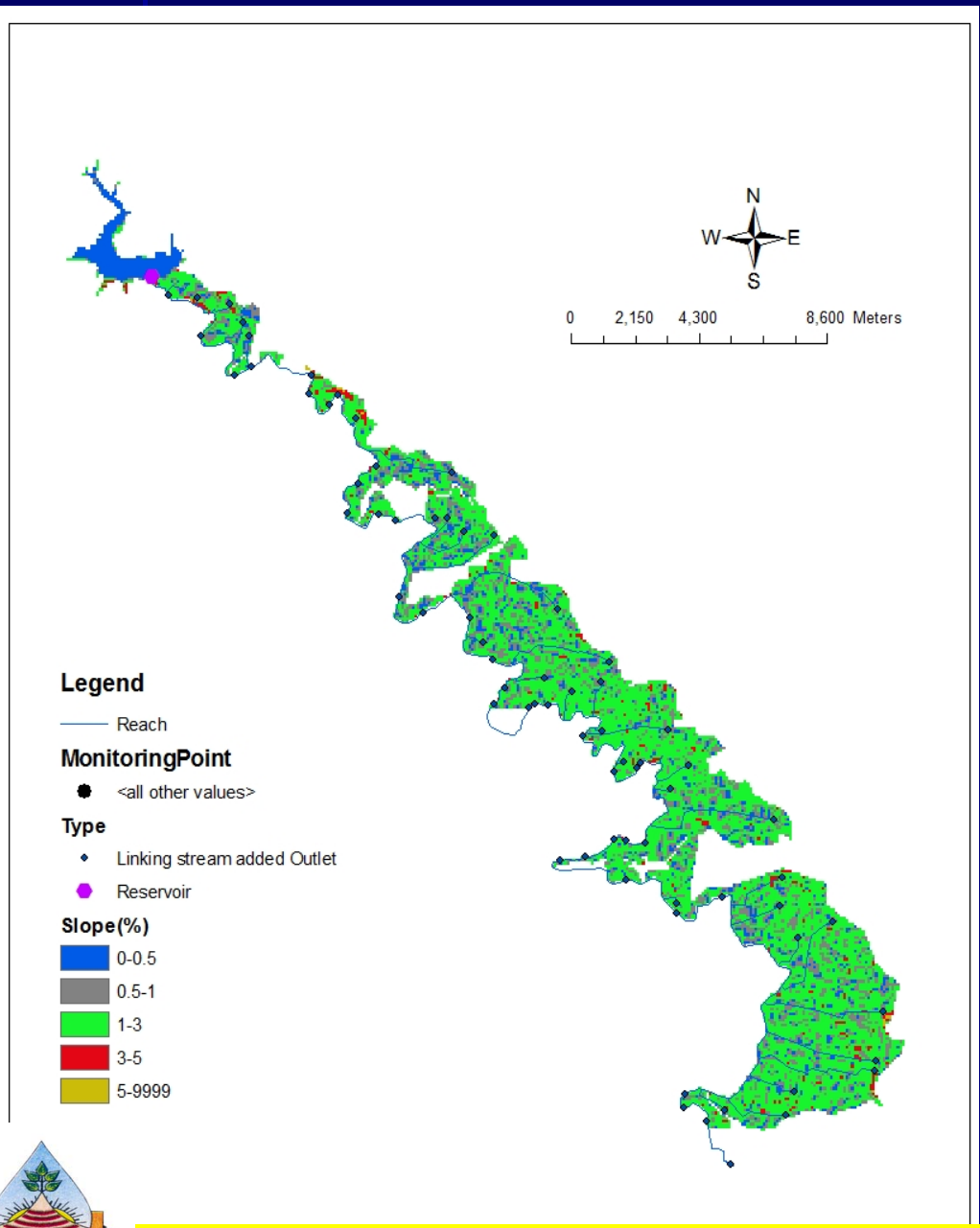
- *Kharif* season (June to October) crops:
  - Sunflower (4154 ha)
  - Pearl millet (3320 ha)
  - Mung bean (89 ha)
  - *Kharif* sorghum (14 ha)
- *Rabi* Season (November to March) crops:
  - Wheat (4154 ha)
  - Groundnut (3320 ha)
  - *Rabi* sorghum (89 ha)
  - Onion (14 ha)
- Annual crops:
  - Sugarcane (78 ha)

Soils of study area



- Mirajgaon series (Clay): 1566 ha
- Ratanjan series (Silt clay): 1820 ha
- Ghumari series (clay loam): 3084 ha
- Nagalwadi series (Silt loam): 1185 ha

Soil Slope in study area



- 0-0.5% slope: 75 ha
- 0.5-1% slope: 1276 ha
- 1-3% slope: 6265 ha
- 3-5% slope: 38 ha
- Above 5% slope: 2 ha

Water Allocation Rules

- Percentage of area to be irrigated
  - 100% ICA
  - 80% ICA
  - 60% ICA
  - 40% ICA
  - 20% ICA
- Release rate from reservoir
  - 5 m^3/sec
  - 4 m^3/sec
  - 3 m^3/sec
  - 2 m^3/sec
  - 1.5 m^3/sec
- Irrigation depth
  - 90 mm
  - 70 mm
  - 50 mm

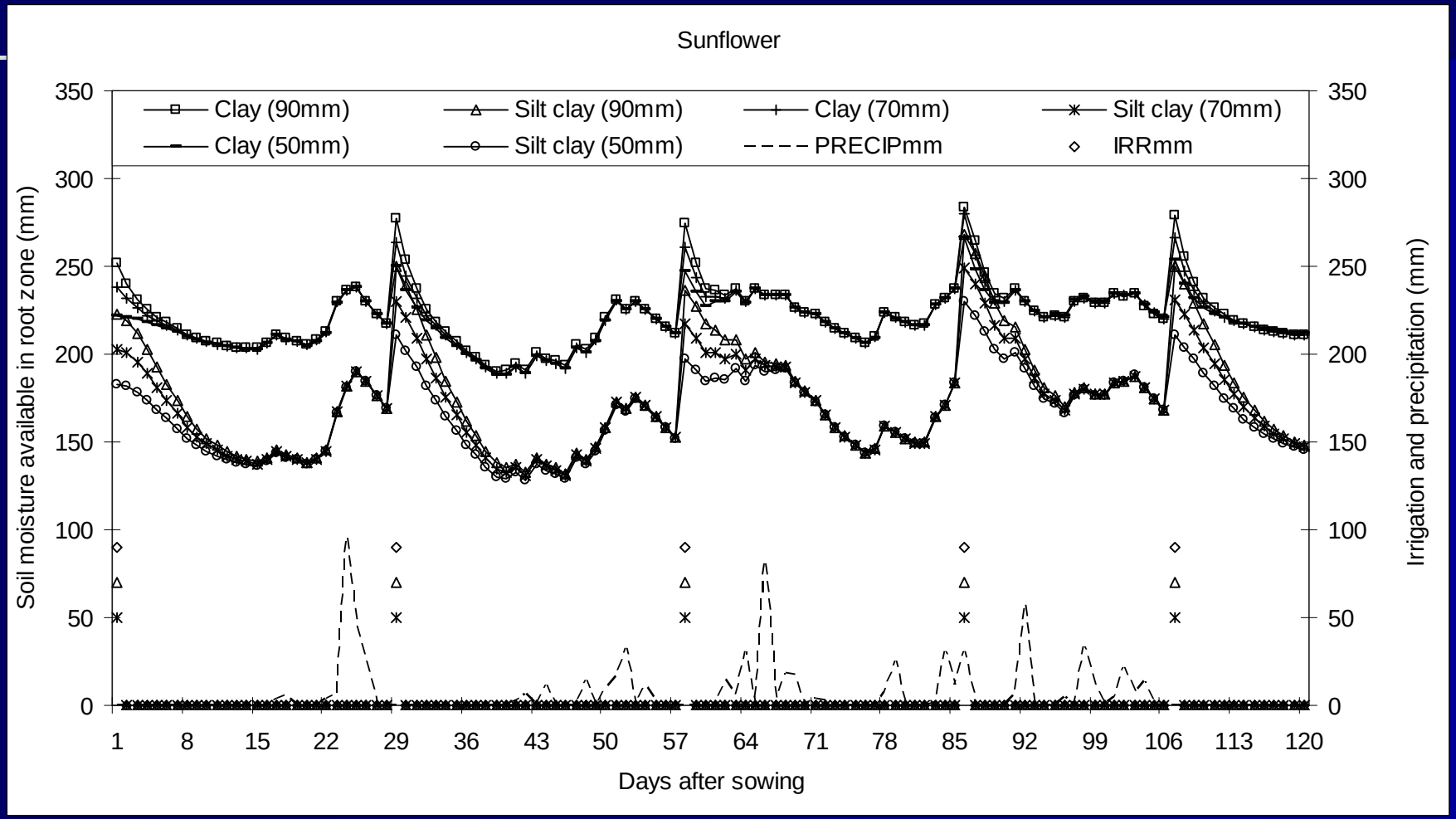
Irrigation Rotations

- Kharif season (June to October): 28 days
- Rabi season (November to February): 21 days
- Summer season (March to May): 14 days

Allocation Units Analysis

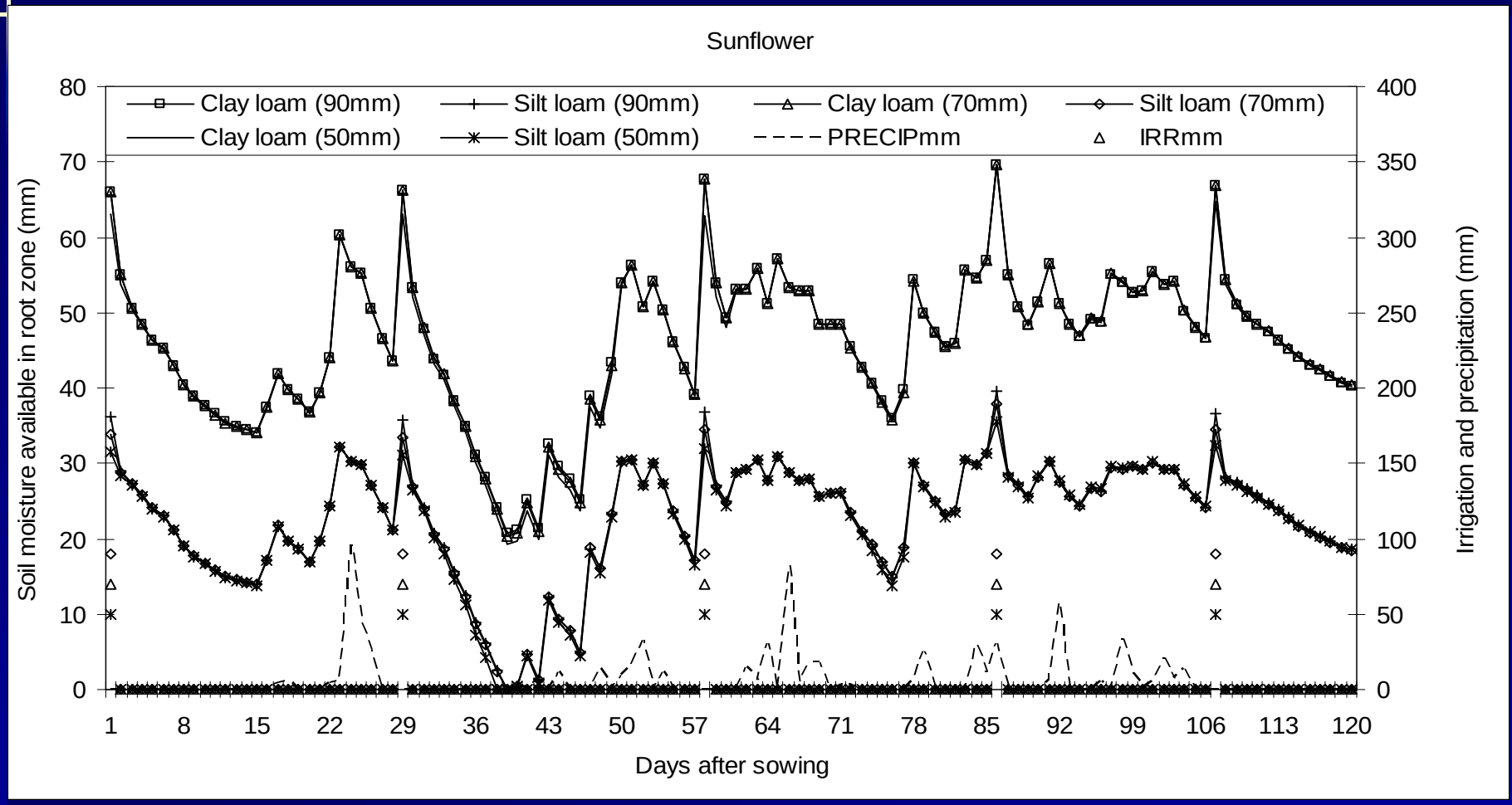
- SWAT sub-divided irrigation command area (7656 ha) of 72 units in 305 AUs
- First unit was allocated as Reservoir
- Most of the crops are concentrated in 0.5 to 1% followed by 0 – 0.5% slope category

Soil moisture status in root zone of sunflower due to water application



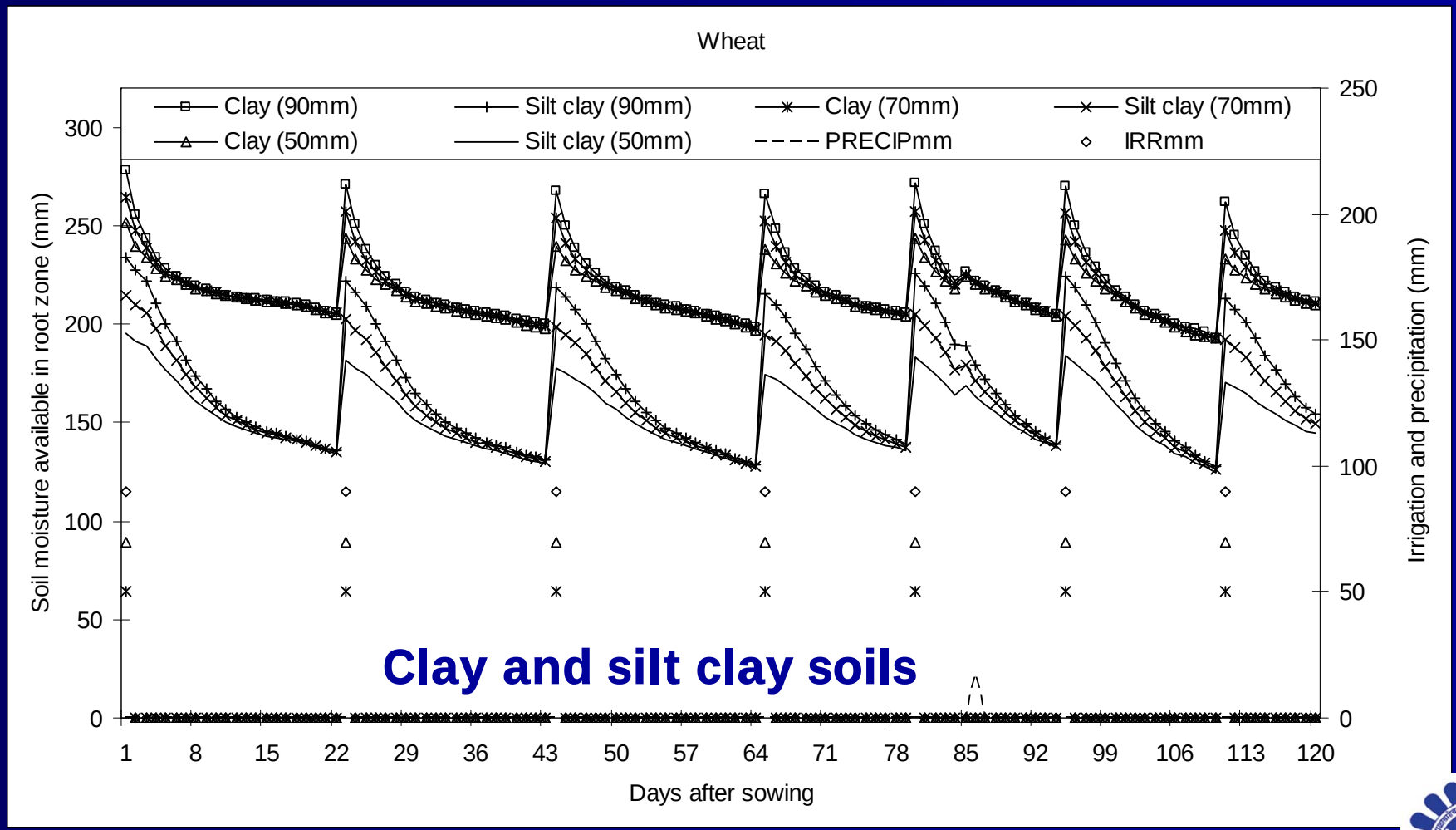
Clay and silt clay soils

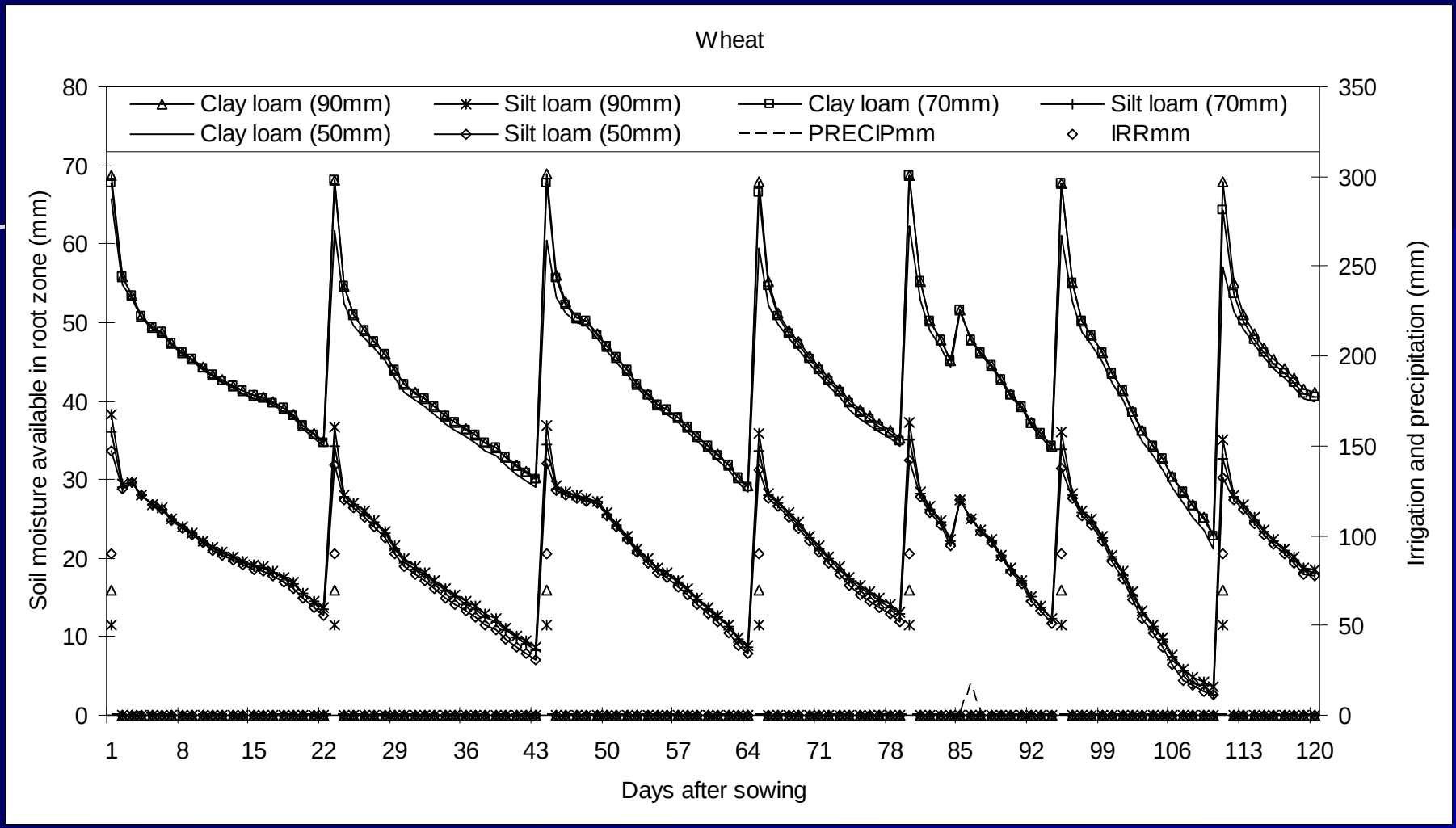
Soil moisture status in root zone of sunflower due to water application



Clay loam and silt loam soils

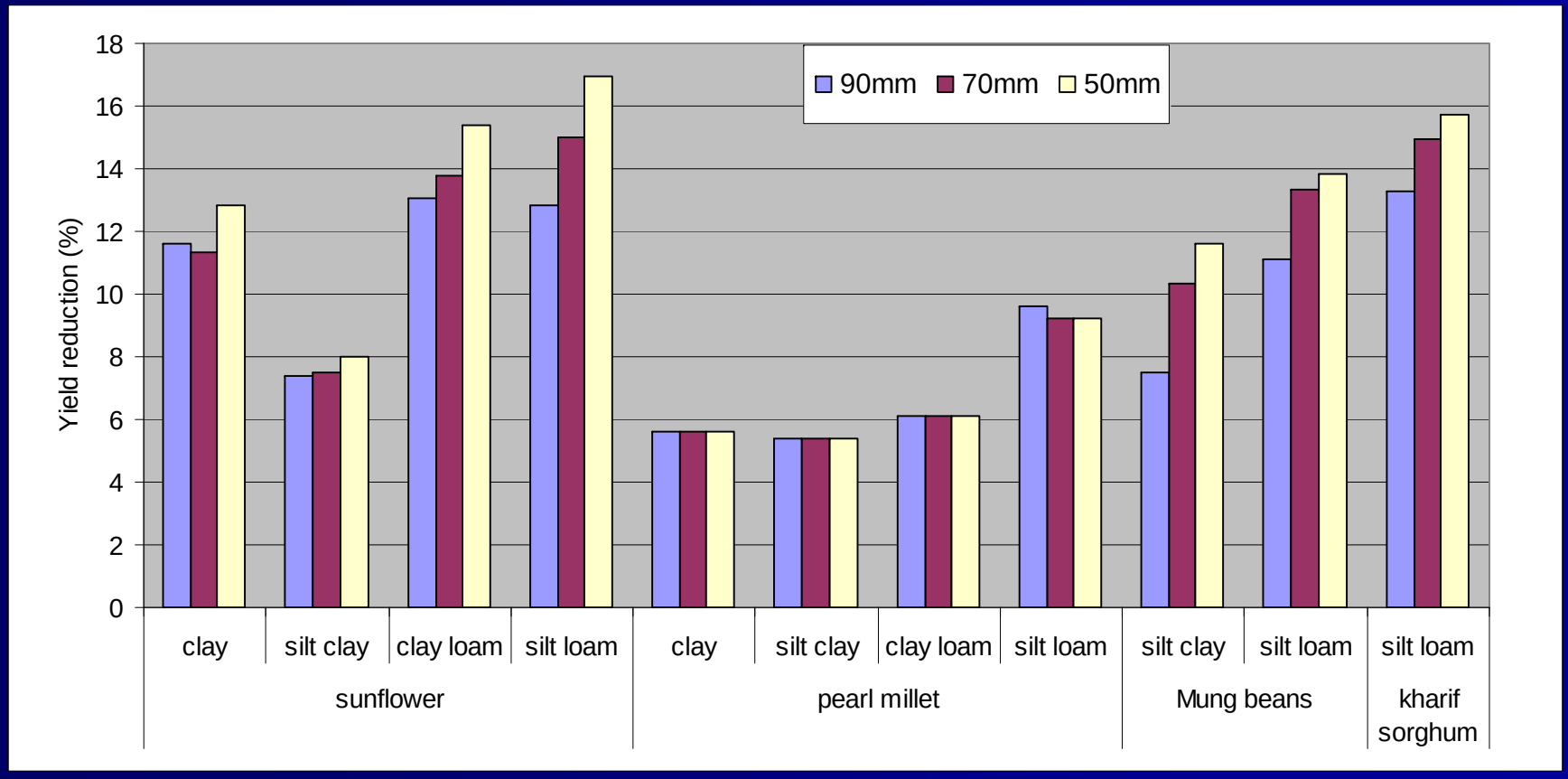
Soil moisture status in root zone of wheat due to water application



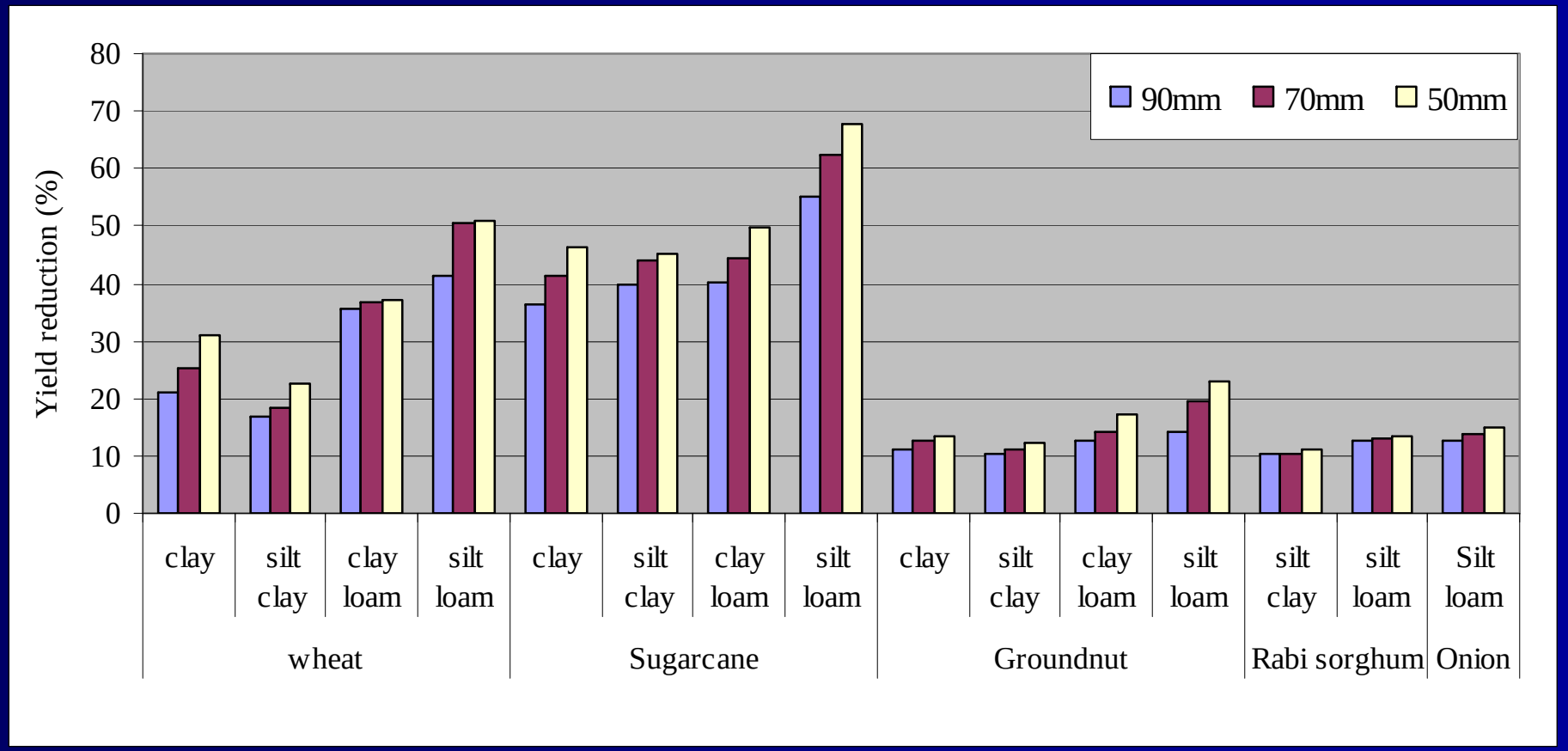


Clay loam and silt loam soils

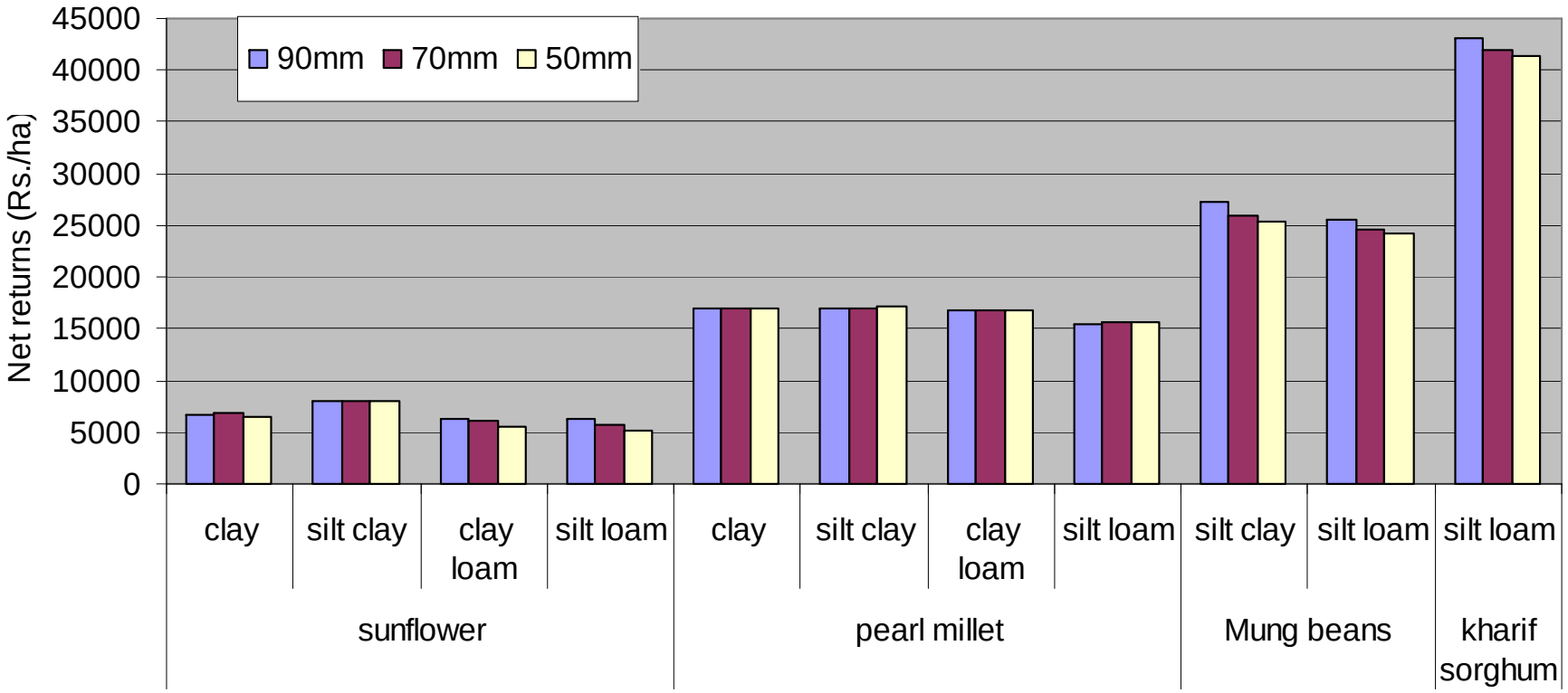
Percent yield reduction in *kharif* season crops



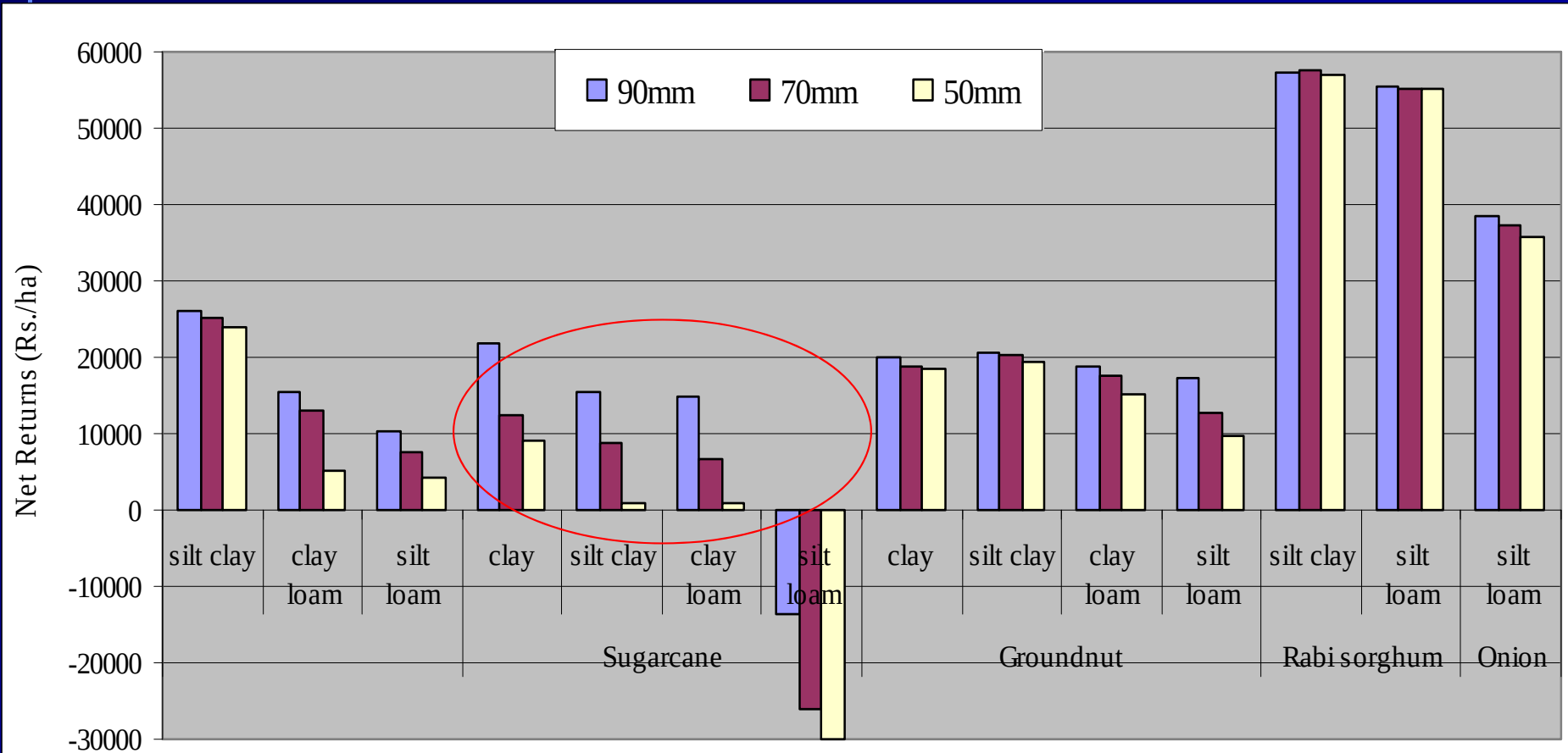
Percent yield reduction in annual and *rabi* season crops



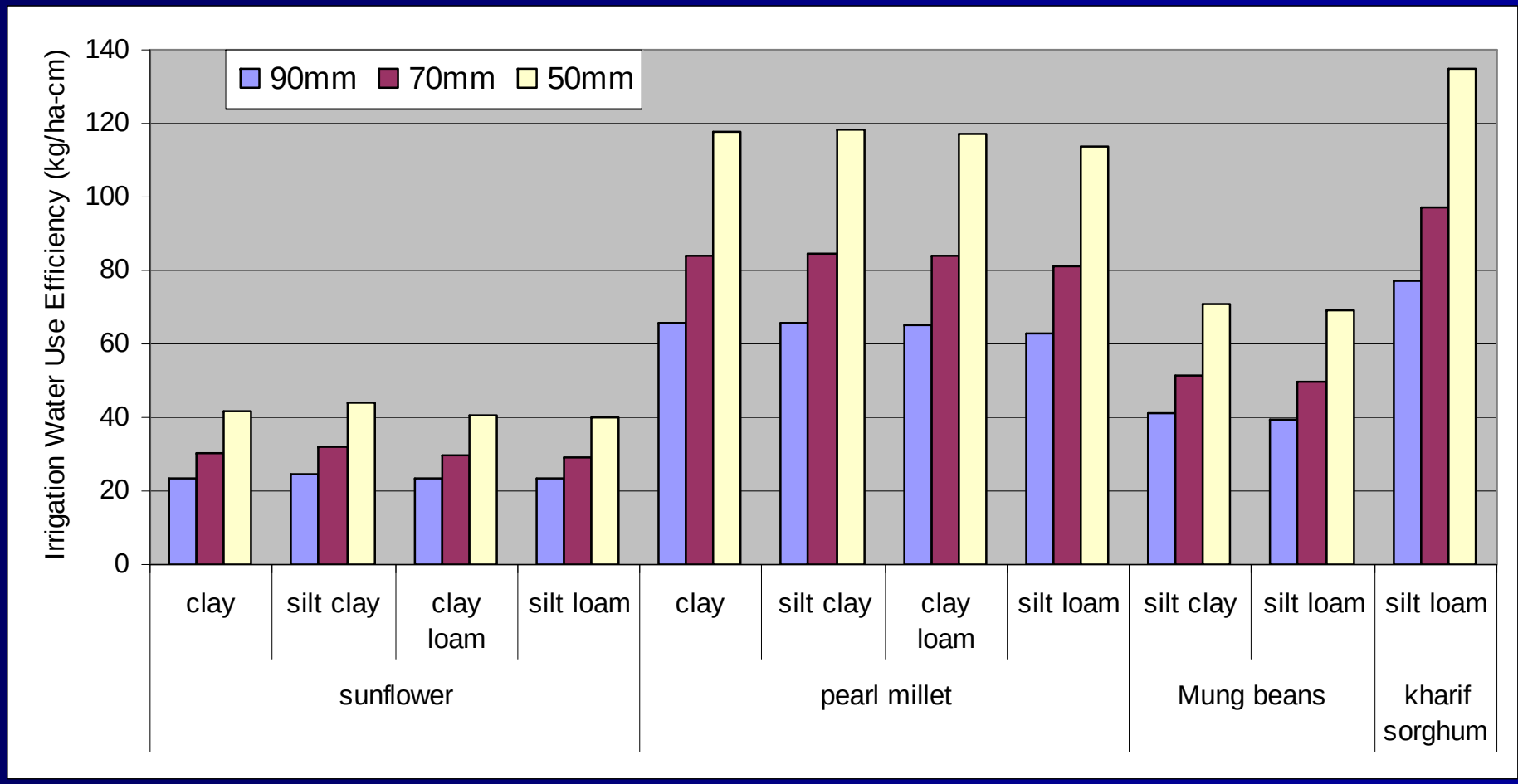
Net Returns from *kharif* season crops



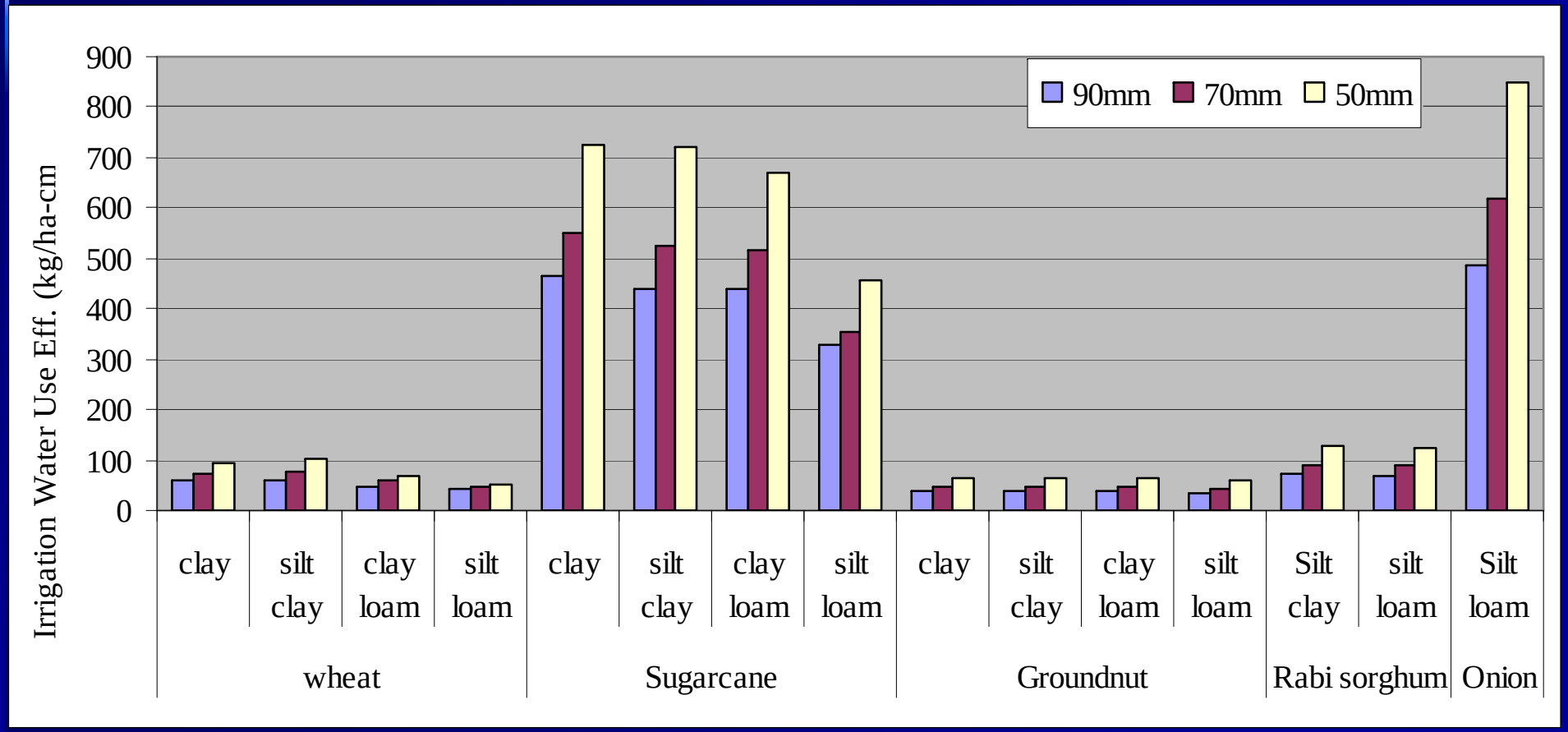
Net Returns from annual and *rabi* season crops



Irrigation water use efficiency for *kharif* season crops



Irrigation water use efficiency for annual and *rabi* season crops



Thank you !