Using an agent-based model to inform equitable water usage amongst stakeholders in the Koue Bokkeveld catchment

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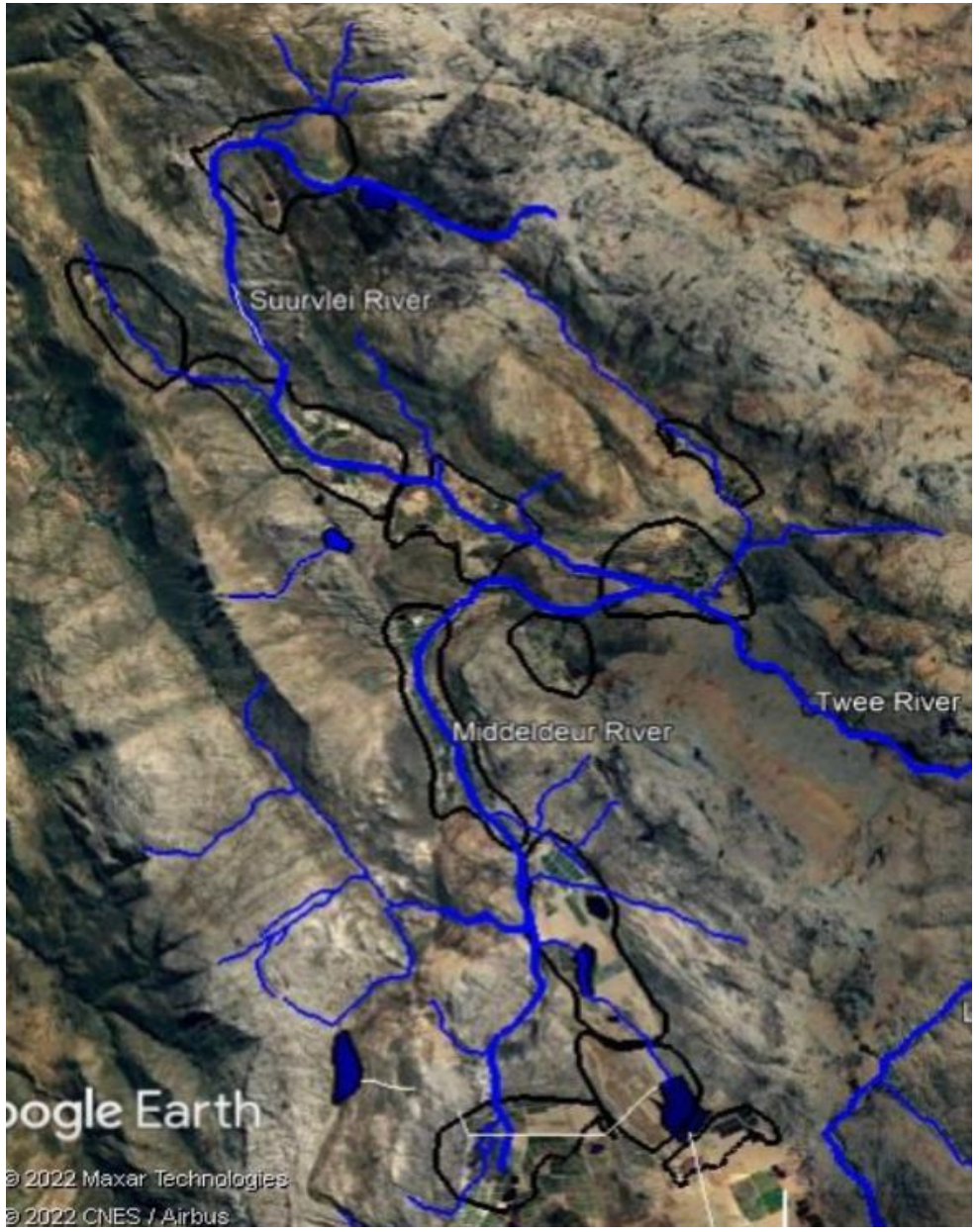
Problem Context

- Koue Bokkeveld (KBV) located in the Western Cape

- Irrigated fruit production by corporate farmers upstream
- Several large family farms, but also small emerging farmers and some residential plots

- Region has many endemic fish species (Skelton et al., 1995)
- Ecological reserve not being met

- Water scarcity in summer causing conflict between stakeholders



Koue Bokkeveld Region
(Google Earth 7.3, 2022)

Implemented solution

- Develop an Agent-based Model (ABM) of the KBV catchment to model water use of stakeholders
- Domain knowledge gathered through collaboration with the stakeholders in the region
- Validate the ABM from historic data and current knowledge

- Use model simulations to better understand how climate variability affects water availability for the various stakeholder groups
- First step in helping the stakeholders create a water management strategy

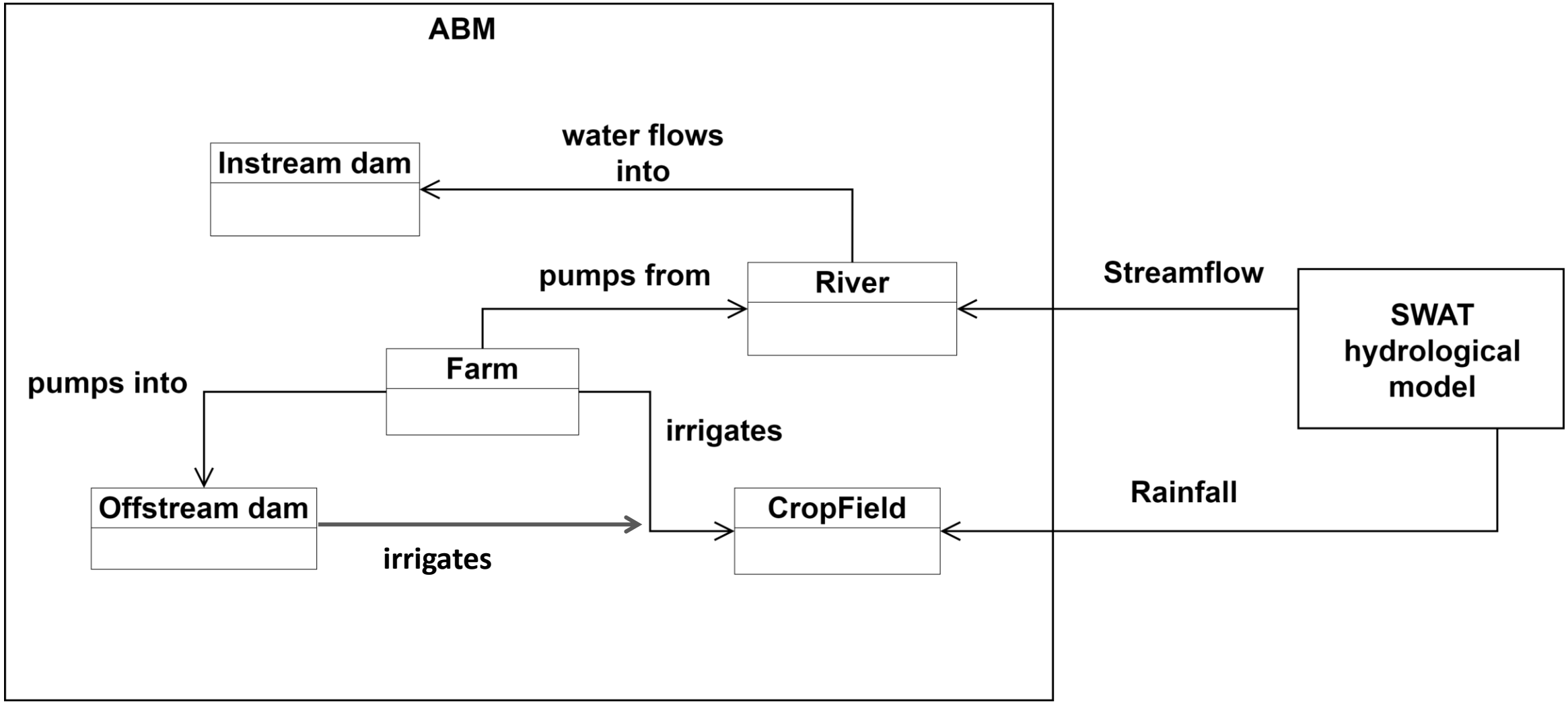
What is an Agent-based Model?

- Modelling technique that uses agents that behave autonomously and interact with each other and the environment (Macal and North, 2010)
- Agents act independently and decide what to do depending on their current state and what is happening around them (environment)
- Statistical models rely on data and equations, whilst ABMs make use of autonomous agents with programmed behaviours

Conceptual model of the catchment

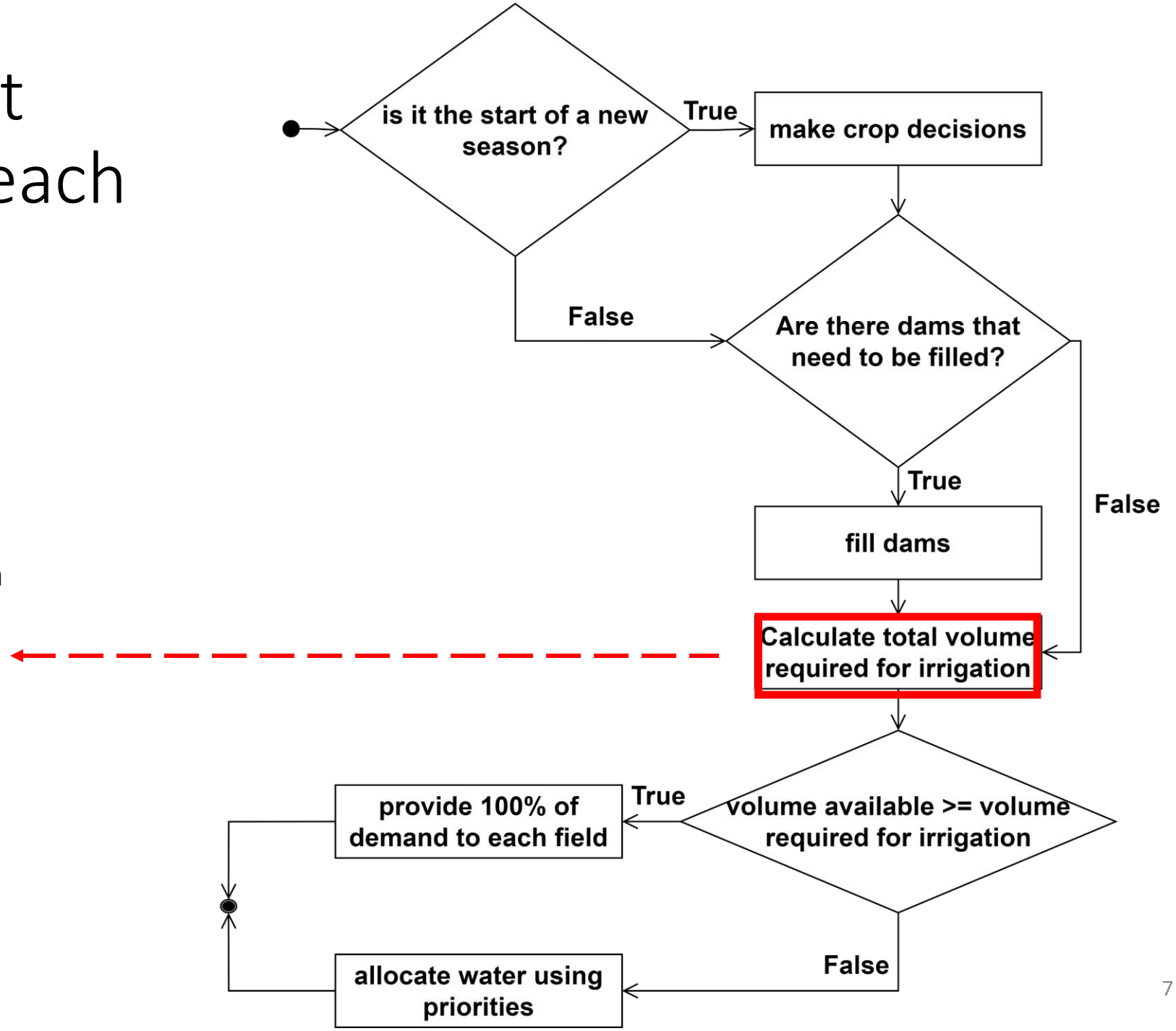
Note: Ground water not considered in this version

Links between agents & other models



Farm agent behaviour at each timestep

Irrigation is dependent on the type of crops, hectarage, A-Pan evaporation, rainfall and the farm's irrigation strategy

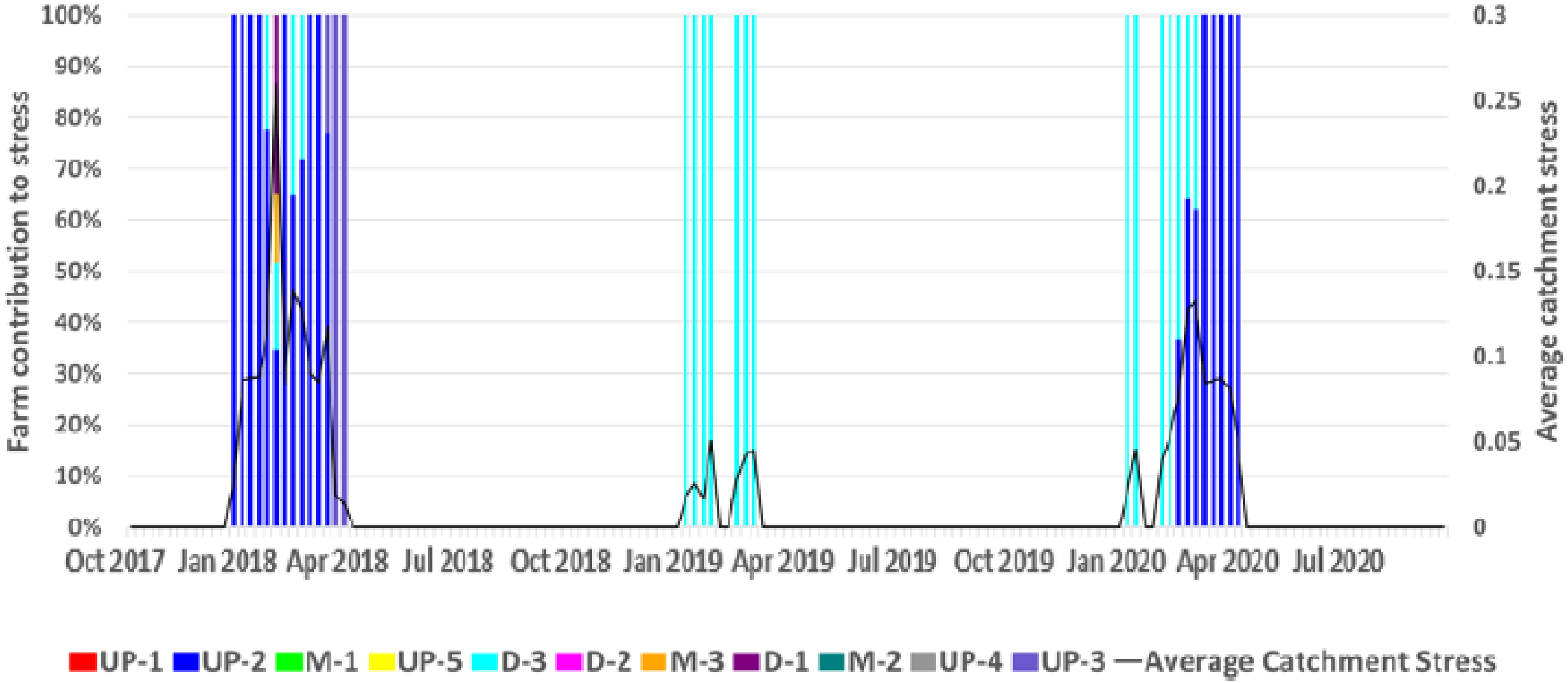


Model Verification and Validation

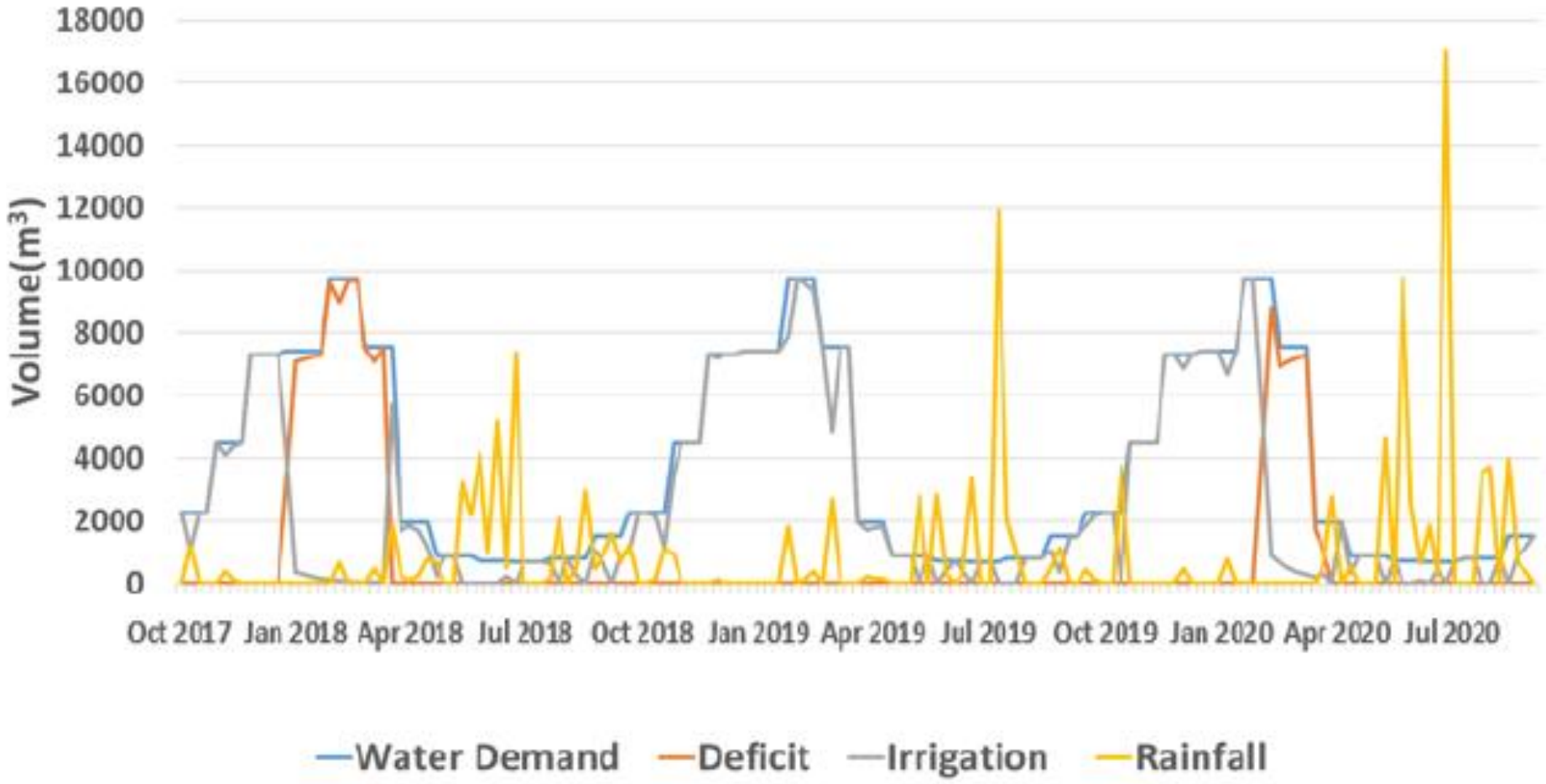
- Verified by comparing flow output values from the ABM and SWAT for
  - Natural setup
  - Irrigation setup
- And by checking the water balance

- Validation done through consultation with catchment experts
- And by comparing irrigation demand with survey data from stakeholders

Visualisation of average catchment stress and contribution of each farm (2017-2020)

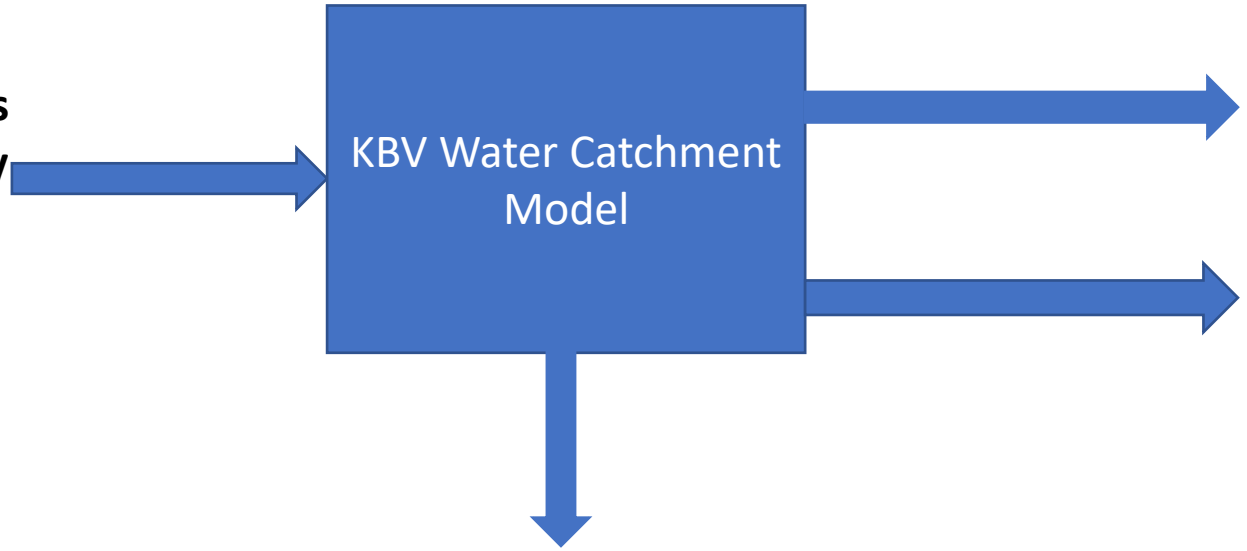


Water demand, deficit, irrigation and rainfall for farm UP-2 (2017 to 2020)



Computer simulation of scenarios

Data about farms e.g., types of crops cultivated, hectarage, farm strategies (irrigation, etc.) and many more



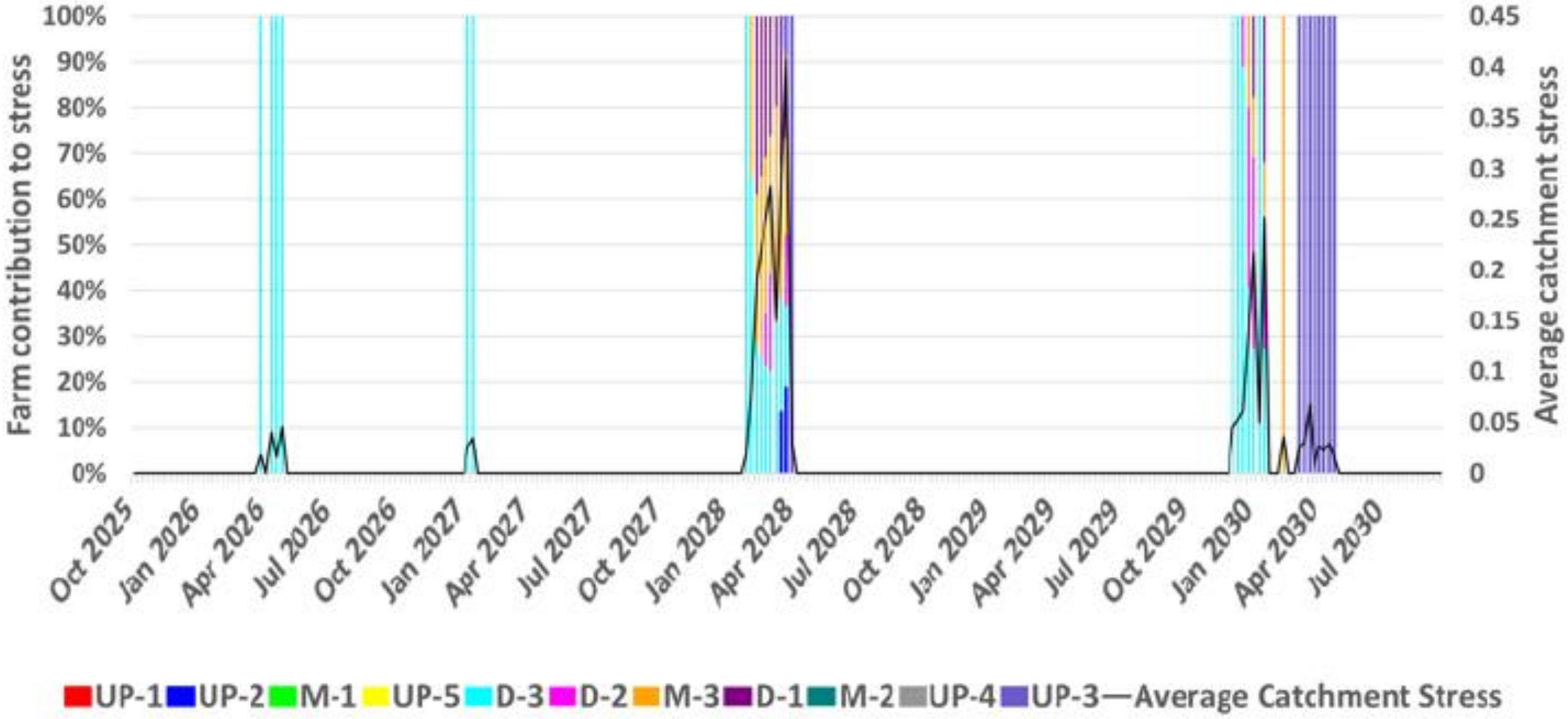
What happens to the river flow

Crop field status. Water requirements vs. what was applied

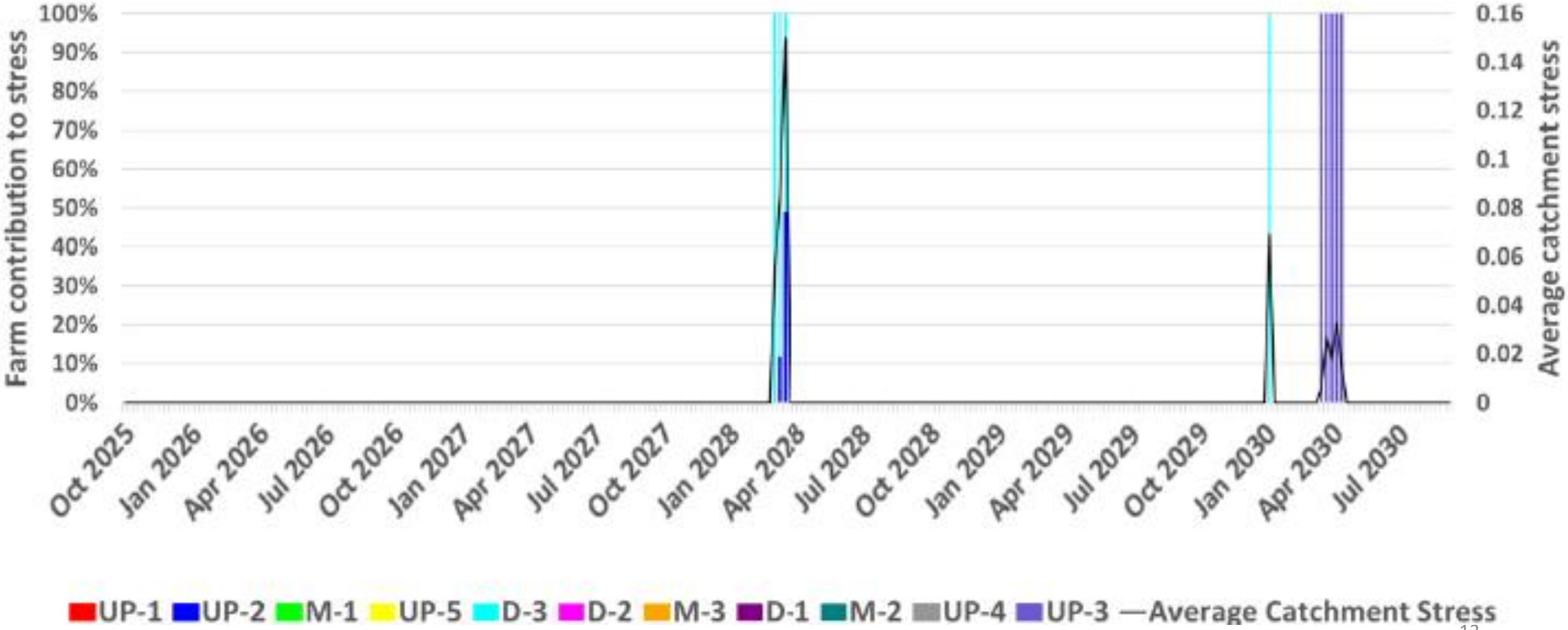
Different scenarios:

- **Climate change**
- **Different crops**
- **Increase in hectarage**
- **Increase in dam capacities**
- **Shared dam**

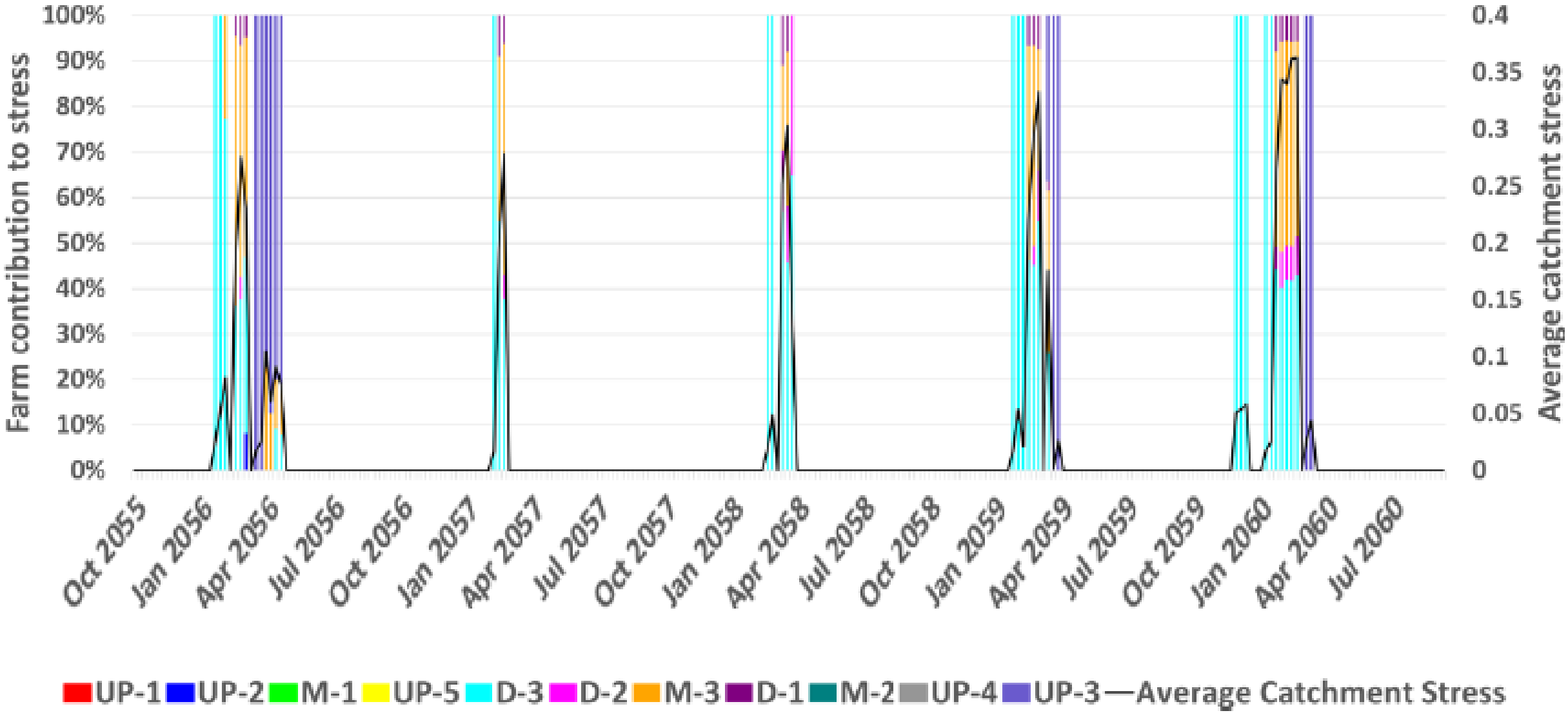
Avg. catchment stress (RCP 4.5) 2025 to 2030



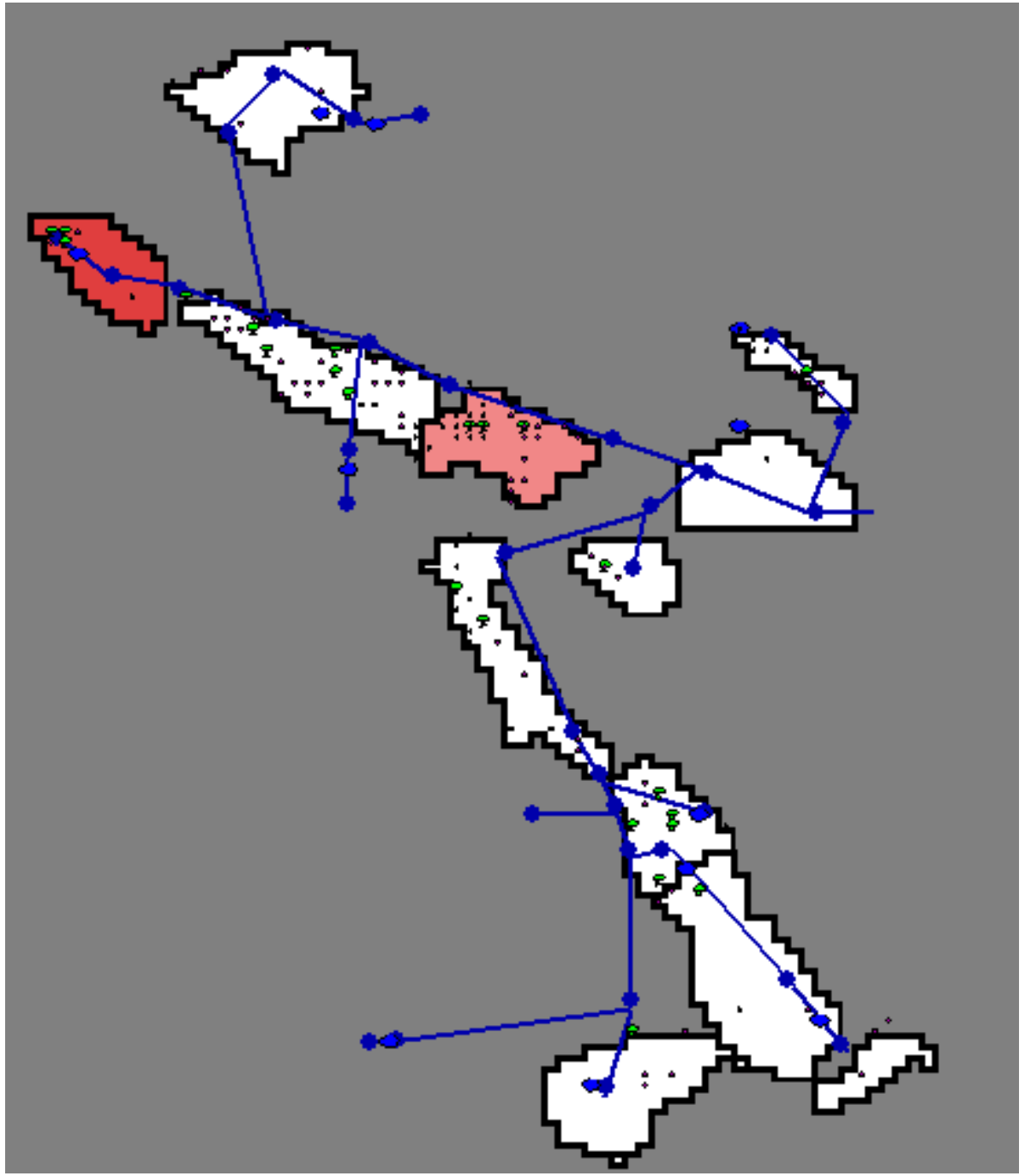
Avg. catchment stress (RCP4.5) 2025 to 2030 with new shared dam



Avg. catchment stress (RCP 8.5) 2055 to 2060



Visualization of water stress per farm



References

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- **Skelton, P., Cambray, J., Lombard, A., and Benn, G.** Patterns of distribution and conservation status of freshwater fishes in South Africa. *South African Journal of Zoology*, 30(3):71–81, 1995.

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