PhD-project Louise Malmquist

Potential and boundaries for resilient water management in agricultural landscapes under climate change and extreme weather

Quantitative catchment hydrology and water balances has long been on the agenda and is even more in the spotlight due to climate change impacts on the water balance. Various scales are considered from individual catchments under different dominating land use, to national basins as well as studies of the global water cycle. However, which is clear from above review, knowledge of quantitative water balance in agricultural dominated catchments in Sweden is lacking behind. Especially linked to hydrological flows other than discharge and evapotranspiration. This knowledge is essential to inform on impacts of mitigation and adaptive measures towards climate change, and extreme weather events. Moreover, to elucidate competitiveness between sectors and required support for water supply in the agricultural sector. Thus, this project aims to explore current water balance in selected Swedish catchments and impacts on water allocation due to extreme weather events. The objectives are to firstly quantify water allocation in agricultural catchments and distinguish variation in water allocation and water availability for crop production as a cause of a) change in historical climate, and b) due to implementation of best management practices (BMPs) for water retention. The second objective is to explore how the water allocation is affected by implementation of BMPs during extreme weather events in the individual catchments.

The aims will be achieved by setting up catchment properties with the model Soil and Water Assessment Tool (SWAT) (Arnold et al., 1998). SWAT has been widely used globally in agricultural catchments and evaluated in relation to other hydrological models. In comparison SWAT has shown good representation of annual water dynamics, yet limitation in representing flow variation on shorter time scale (Farkas et al., 2016; Piniewski et al., 2017) and possibly peak flows (Grusson et al., 2020; Zhang et al., 2014). SWAT has been used for several model setups of extreme flows both high- and low flows, yet there is a concentration to larger basins and in USA and China, thus there is a scope to explore the model at more northern latitudes and for development of uncertainty analysis in extreme event modellation (Tan et al., 2020).

Study catchments are selected from catchments included in the project Local Engagement for Water (LEVA)[1], to make use of collective efforts to improve water status from both quantitative and qualitative point of view. Thus, there is a common interest for a full overview of the catchment hydrology. Current weather conditions and weather-related problematics is the main character for selection of catchments, due to higher precipitation in west and more risk for drought in east. This sets the scene for exploring BMPs effects under different climate- and weather impact yet under somehow otherwise similar landscape conditions. The preliminary selection is Tidans åtgärdsområde, Saxån-Braåns avrinnignsområde, Tjust kustområde and Enköpingsån-Örsundaåns avrinningsområde.

Input data for the model will be obtained from national statistical databases, national authorities, county administrative boards, the Swedish mapping, cadastral and land registration authority, water councils (sv. vattenråd & vattenvårdsförbund), discussions with representatives for LEVA-areas, scientific publications and grey literature. A pilot overview study search on available information in the LEVA catchments to use for hydrological modelling, indicates that there is a limitation in discharge data available for calibration and validation within the catchments. Furthermore, data on drainage systems are important for accurate determination of flows and flow impact in the catchment. This data also varies between catchments in terms of availability and quality. Thirdly, observed data on soil moisture from arable land is limited and the stream delineation from most detailed maps

[1]LEVA – Lokalt engagemang för vatten. Available: https://www.havochvatten.se/planering-forvaltning-och-samverkan/program-projekt-och-andra-uppdrag/leva---lokalt-engagemang-for-vatten.html [2021-04-01]

available - Fastighetskartan - does not cover streams and moist land to full extent (Ågren and Lidberg, 2020). Additional remote sensing data from international space agencies is under exploration as additional input data for calibration and validation of the model, to complement limited national observation data. The lack in available observed data will be clustered and possibilities to complement the data with measurement on site will be further explored.

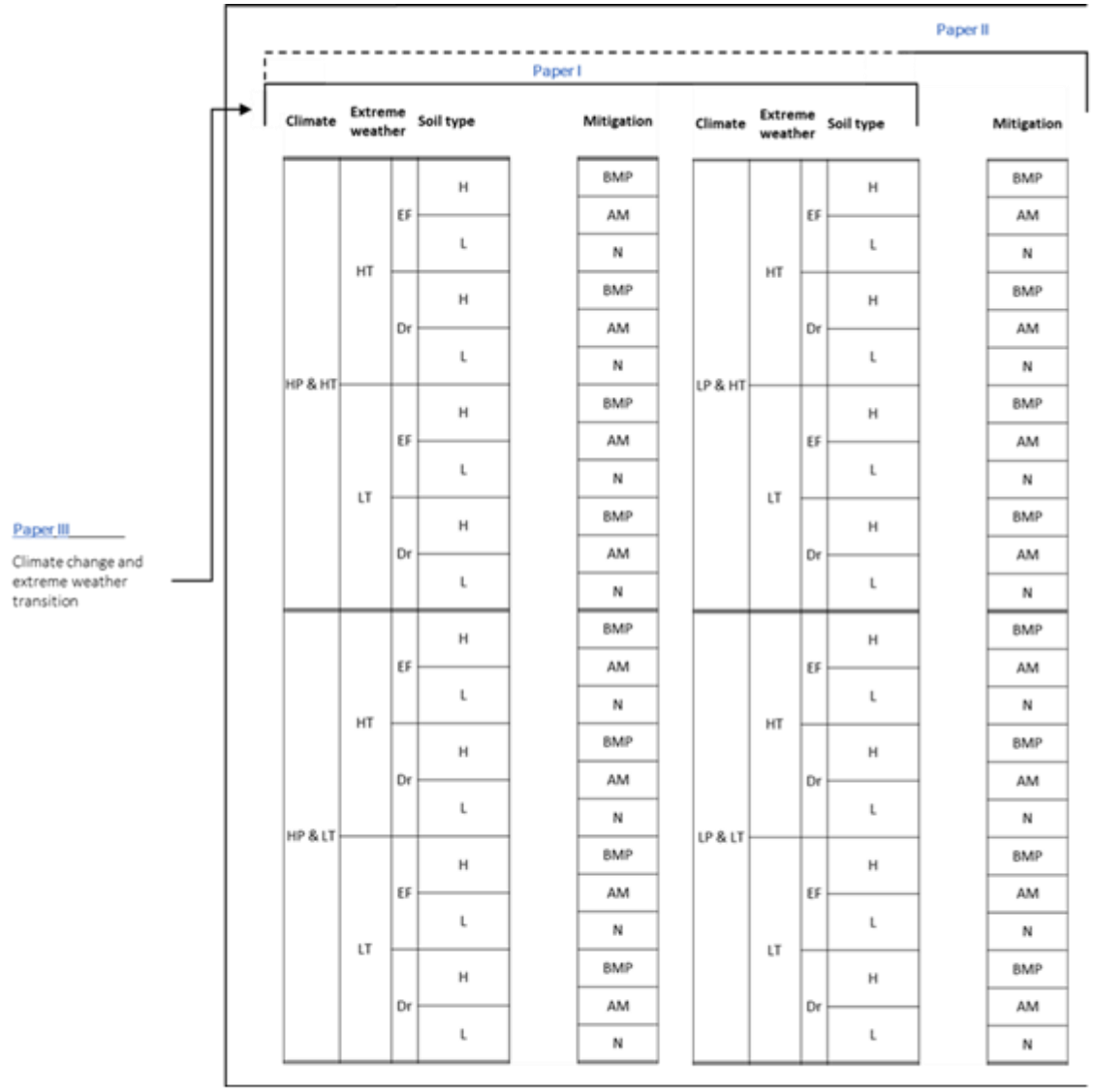
The priorities in this study are effects of climate and extreme weather events; effects of implementation of BMPs. This study will be limited to hazards in terms of droughts and soil saturation (i.e. flooding), frost- and heatwave damages (due to impact on evapotranspiration and thus indirectly on soil moisture), due to the drivers of precipitation excess, snowmelt event, heatwaves and cold waves. As these are the parameters that are essential for crop production but also have a large limiting potential (see Zscheischler et al., 2020 for definitions). Effects of soil type will also be explored as it has important impact on infiltration and water retention capacities. Yet these are traits that are easier to modify as "synthetic" properties in the hydrological model. Thus, these variations are secondary in the choice of catchment to set up the model for.

To be able to generalize results landscape effects from climate effect and extreme weather, following clustered comparisons will be explored and separated from soil properties as following pairwise set-ups:

- Similar climate - different catchment properties
- Different climate - Similar catchments properties

The explored contrasts between catchments will be:

- Climate properties/cropping zone, i.e. effects of spatial placement and meteorological property variation between catchments and impact on water allocation.
- Extreme weather impact – temporal variation within same catchment of meteorological events
- Soil types by either add additional catchments with varying soil types in the same area concerning meteorological characteristics, OR by alternate the properties of the same catchments with hypothetical soil properties.
- Implementation of BMPs and alterations to hydro-morphology will be explored after the principle of before after impact, i.e. by exploring water allocation before and after implementation of mitigation measures. The effects will be studied by exploring modelled historical water allocation with allocation after the implementation of BMPs.
- Characteristics for the catchments that will be kept similar to exclude impact are catchment area and land-use distribution – as focus is on agricultural catchments, the catchments are selected with a major share of land-cover under agricultural management.



Category	"Impact	Acronym	Comparison
Climate	High precipitation	HP	Between catchments – dependent on spatial climatological conditions
	High temperature	HT	
	Low precipitation	LP	
	Low temperature	LT	
Extreme weather	High temperature	HT	In same catchment – event dependent
	Low temperature	LT	
	Extreme precipitation and flooding	EF	
	Drought	Dr	
Mitigation	Implemented BMPs	BMP	In same catchment – Variation over temporal Scale – historical comparison
	No BMPs: Antropogenically modified catchments	AM	
	"Natural" hydromorphology/ water bodies	N	
Soil type	Clayey soils	H	Between catchments under same climate – spatial conditions
	Lighter soils	L	

Figure 1. Schematic block-design for comparing catchments in Paper I, II and III using hydrological modelling

Ågren, A., Lidberg, W., 2020. Dokumentation nya hydrografiska kartor – vattendrag och SLU Markfuktighetskartor.

Arnold, J.G., Srinivasan, R., Muttiah, R.S., Williams, J.R., 1998. Large Area Hydrologic Modeling and Assessment Part I: Model Development1. JAWRA J. Am. Water Resour. Assoc. 34, 73–89. https://doi.org/10.1111/j.1752-1688.1998.tb05961.x

Farkas, C., Kværnø, S.H., Engebretsen, A., Barneveld, R., Deelstra, J., 2016. Applying profile- and catchment-based mathematical models for evaluating the run-off from a Nordic catchment. J. Hydrol. Hydromech. 64, 218–225. https://doi.org/10.1515/johh-2016-0022

Grusson, Y., Wesström, I., Svedberg, E., Joel, A., 2020. Influence of climate change on water partitioning in agricultural watersheds: Examples from Sweden.

Piniewski, M., Meresa, H.K., Romanowicz, R., Osuch, M., Szcześniak, M., Kardel, I., Okruszko, T., Mezghani, A., Kundzewicz, Z.W., 2017. What can we learn from the projections of changes of flow patterns? Results from Polish case studies. Acta Geophys. 65, 809–827. https://doi.org/10.1007/s11600-017-0061-6

Tan, M.L., Gassman, P.W., Yang, X., Haywood, J., 2020. A review of SWAT applications, performance and future needs for simulation of hydro-climatic extremes. Adv. Water Resour. 143, 103662. https://doi.org/10.1016/j.advwatres.2020.103662

Zhang, X., Xu, Y.-P., Fu, G., 2014. Uncertainties in SWAT extreme flow simulation under climate change. J. Hydrol. 515, 205–222. https://doi.org/10.1016/j.jhydrol.2014.04.064

Zscheischler, J., Martius, O., Westra, S., Bevacqua, E., Raymond, C., Horton, R.M., van den Hurk, B., AghaKouchak, A., Jézéquel, A., Mahecha, M.D., Maraun, D., Ramos, A.M., Ridder, N.N., Thiery, W., Vignotto, E., 2020. A typology of compound weather and climate events. Nat. Rev. Earth Environ. 1, 333–347. https://doi.org/10.1038/s43017-020-0060-z