Agent-based socio-hydrological model to analyse human-drought feedbacks

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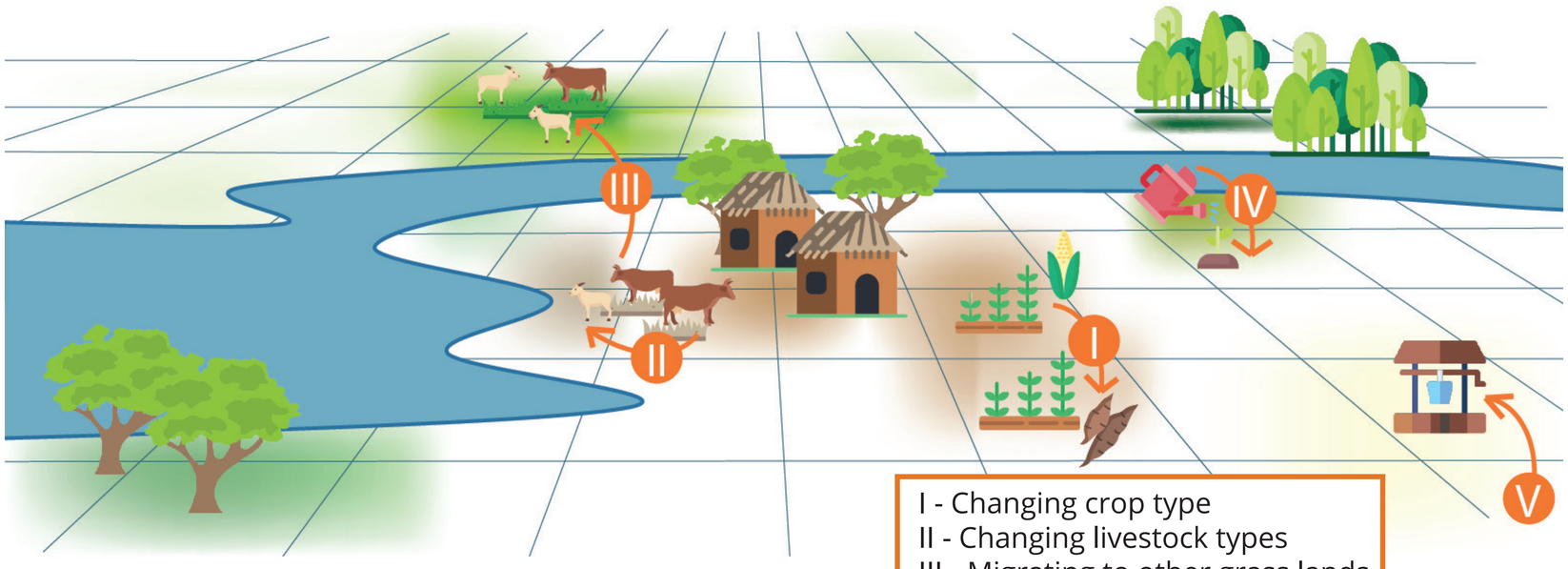
Motivation

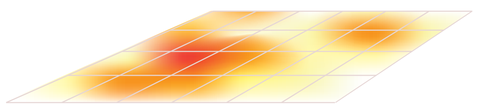
The rural livelihoods of countries in the Horn of Africa Drylands (HAD) region are highly dependent on rain-fed agriculture and livestock herding (agro-pastoralism), which is extremely sensitive droughts. Adaptation choices made by agro-pastoralists influence drought hazard, yet few drought models incorporate the adaptive behaviour and feedbacks in drought propagation and analysis (Van Loon et al., 2016). In this research we present a dynamic drought adaptation modelling framework that combines socio-hydrological and agent-based modelling approaches.



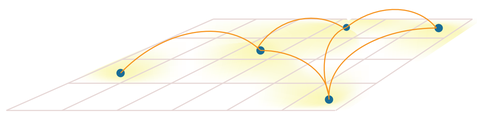
I - Changing crop type
II - Changing livestock types
III - Migrating to other grass lands
IV - Irrigation
V - Installing water point

Examples of data layers in each component:

Population density



Social network



SOCIO-ECONOMIC

HUMAN DECISION-MAKING

Protection Motivation Theory (PMT)

Risk Appraisal
- Drought
- Damage
- Memory

Coping Appraisal
- Self Efficacy
- Adaptation Efficacy
- Adaptation Costs

Wens et al. (2020)

POLICY SCENARIOS

Agro-pastoralists are represented in the model as household agents that make adaptation decisions over time (depending on livelihood profile). In this research we adapt the Protection Motivation Theory (PMT), as applied by Wens et al. (2020). Policies can influence decision factors in the PMT.

Adaptation measures

- Household size
- Number/type of livestock

Losses crop & livestock production

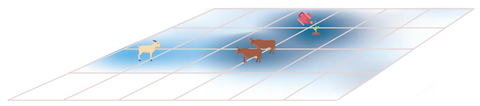
WATER, LIVESTOCK & LAND CHANGE

Grass (yield) → Livestock → Crop (yield) → Water demand

Domestic → Livestock

Expected crop & livestock production

Water demand



Land use

Adaptation decisions lead to changes in water, livestock and land. The interactions between these changes and the hydrological model are established through existing (socio-hydrologic) equations available in literature. In this way, we simulate the dynamic feedbacks between drought adaptations and hydrological processes.

Drought (*SPEI*)

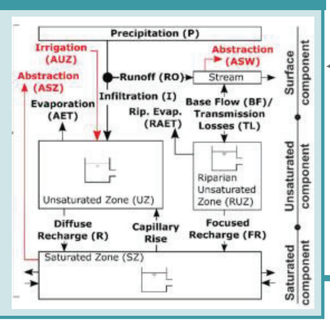
AET, PET

- Land use (crop factor)
- Water demand

ENVIRONMENT

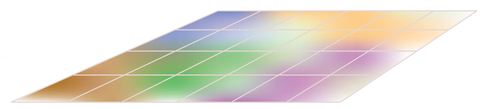
DRYP: hydrological model

Quichimbo et al. (in review)

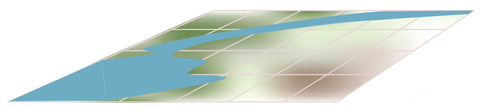


OTHER USERS

Soil properties



River network



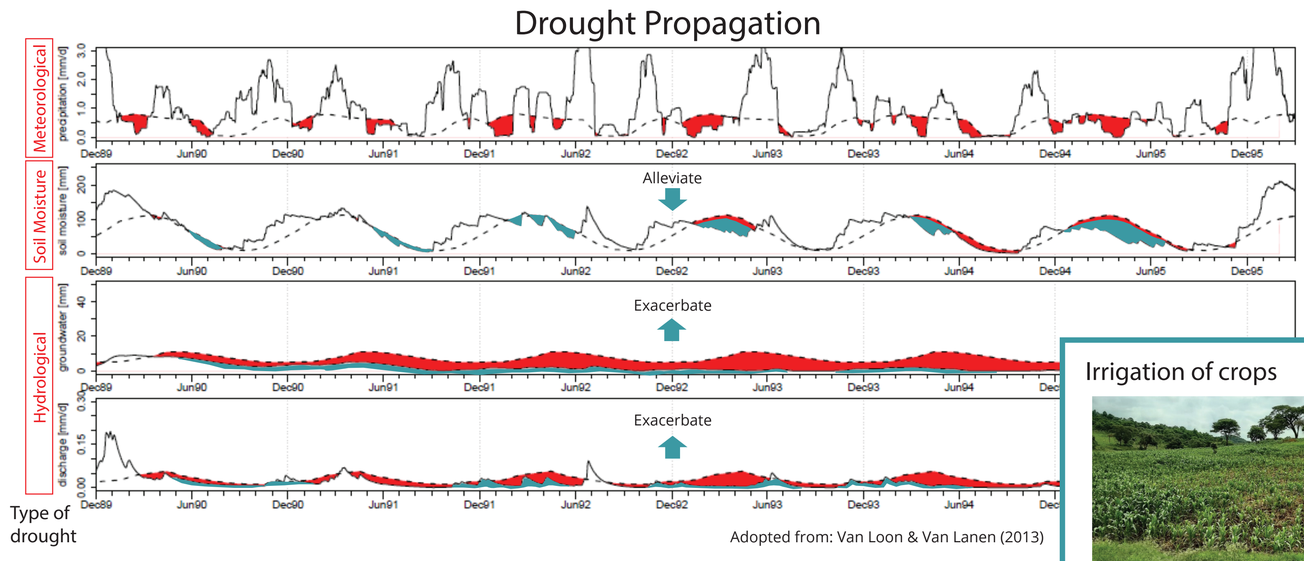
CLIMATE SCENARIOS

The environment is represented by the hydrological model Dryland Water Partition model (DRYP) (Quichimbo et al., in prep). DRYP captures the main and relevant hydrological processes in dryland regions. The outcome of the model are hydrological variables that are used in characterisation and propagation of drought.

Expected Results

Effect of adaptation on drought propatation
- Running hydro vs socio-hydro model
-Alleviation or exacerbating different types of drought
- Per (type of) adaptation measure

Drought Propagation



Adopted from: Van Loon & Van Lanen (2013)

Irrigation of crops

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