Irrigation Elasticities and Shocks for SIMPLE-G derived by mrwater

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Introduction

Here, we assess the data from mrwater for an analysis of environmental flow protection with SIMPLE-G. We further prepare all mrwater output data for further processing in SIMPLE-G. The first part of this document visualizes the outputs from mrwater at gridded level. The second part processes the data to derive elasticities for SIMPLE-G and transforms the data to netcdf files.

```
## Warning: Something went wrong in the committed agricultural iteration of mrwater.
##        Please check.
```

Water Availability

We distinguish renewable water availability (surface and shallow groundwater) and fossil groundwater and provide the volume in terms of cubic meters per hectare to SIMPLE-G (so that it can be combined with the area that is used in SIMPLE-G).

Environmental Flow Requirements

In the version/setting of mrwater that was used for this analysis, environmental flow requirements are calculated based on the the Variable Month Flow (VMF) Method following Pastor et al. (2014).

The following graph shows the share of discharge per grid cell around the year 2010 that has to be reserved for the environment to keep aquatic and riverine ecosystems in a fair condition. The value ranges between 30% and 40% of discharge to be preserved for the environment.

This is the underlying data that we want to apply as shock to SIMPLE-G. It indirectly affects the price elasticity of surface water through a reduction of potential irrigation water withdrawals (PIWW), i.e. the asymptode of the surface water supply function.

Not every location would be affected by the water limitation because many areas have plenty of water available that could be used for irrigation without violating environmental flows. However, in some local hotspots water withdrawals would have to be reduced to maintain a functioning acquatic and riverine ecosystem.

Here are summary statistics on gridded PIWW (in mio. m3):

```
## [1] "Without environmental flow protection:"
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    0.00    0.00    0.00   63.71   26.70 5354.89
```

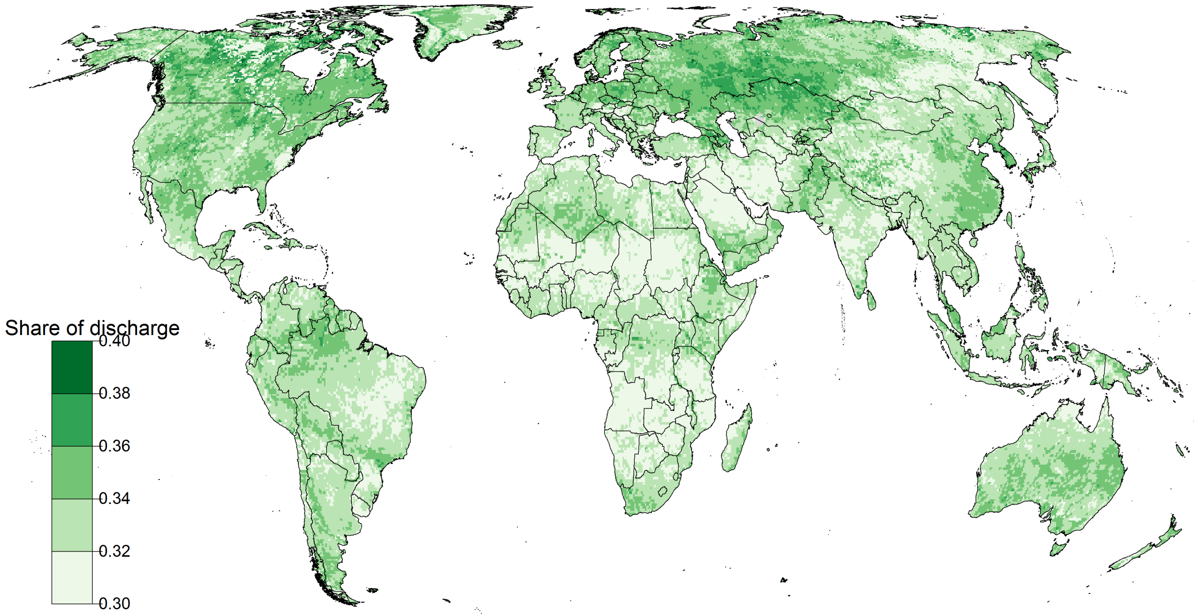

Figure 1: Share of Discharge that has to be reserved for the Environment

```
## [1] "With environmental flow protection:"

##     Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##     0.00    0.00    0.00   59.97   23.28 4886.40
```

The following two maps visualize the volume of PIWW for the two scenarios:

The difference between the two scenarios (reflecting the change in the maximum water withdrawal volume) is shown in the following figure:

For SIMPLE-G, the EFP shock is calculated as the difference of PIWW under environmental flow protection and PIWW without limits on withdrawals as a percentage change.

Note: Some areas see an extreme (up to 52577%) increase in PIWW. I have capped them to 100% (for visualization purposes). In SIMPLE-G, the positives are actually not included. The shock is only negative.

The percentage change is displayed here:

Groundwater Shock

Additionally to constraining surface water use to maintain environmental flow requirements surface water bodies, non-renewable groundwater use would have to be reduced to achieve sustainable water use.

The percentage change in total water usage required in particular locations is shown here:

Price Elasticity of Surface Water

We derive the price elasticity of surface water using PIWW on current cropland (without environmental flow protection), i.e. the maximum volume of surface water that can be withdrawn in a certain grid cell and the current withdrawal for irrigation using the following formula:

Figure 2: Potential Irrigation Water Withdrawal (without EFP)

Figure 3: Potential Irrigation Water Withdrawal (with EFP)

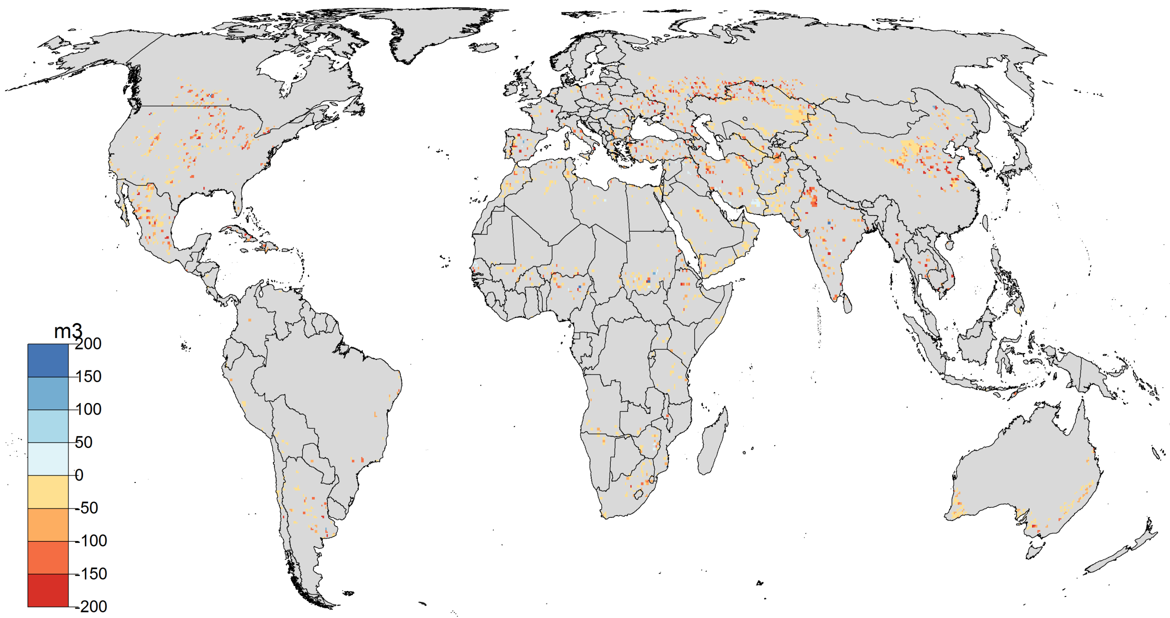

Figure 4: Change in PIWW through EFP

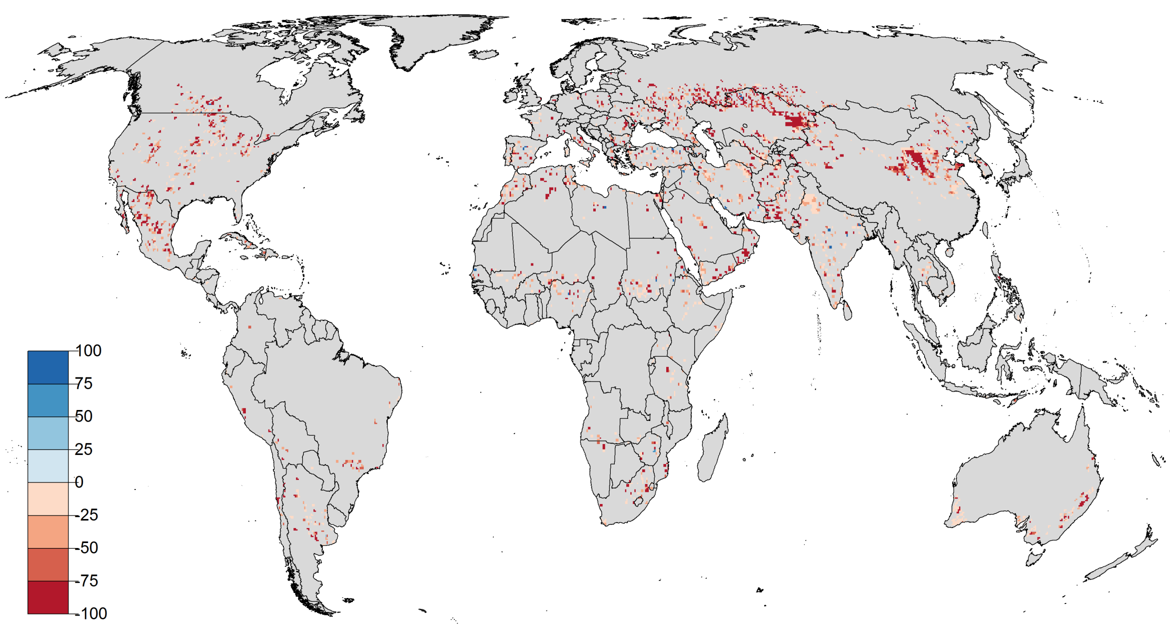

Figure 5: Percentage Change in PIWW through EFP

Figure 6: Percentage Change in PIWW through EFP

Values of 0 indicate that there is no further potential to withdraw more water beyond the current level (perfectly inelastic). Values of 1 indicate that plenty of water is still available and more water can be used. The following graph visualizes the values on a global map:

The price elasticity changes when water withdrawals are restricted in line with Environmental Flow Protection (EFP).

Transformation Elasticity of Rainfed to Irrigated Land

The proxy for the gridded transformation elasticity of rainfed to irrigated land should give an indication of how easy it is to transform rainfed to irrigated area. This depends on both the distance of the currently irrigated area to the maximum potentially irrigated area as well as on the yield gain through irrigation.

Note: Include calculation and visualization here.

Generation of Inputs for SIMPLE-G

The main outputs for a first analysis are:

- surface water elasticity for baseline case (`swElasticity.nc`)
- environmental flow policy shock as percentage change (note: capped) (`efpShockpc.nc`)
- groundwater conservation shock as percentage change (`gwShockpc.nc`)

The secondary outputs (depending on how we choose to implement it) are:

- surface water elasticity for environmental flow protection case (`swElasticityEFP.nc`)
- the asymptode (maximum) for the two scenarios (`PIWW.nc` and `PIWWefp.nc`)
- current irrigation water withdrawal (`currentWW.nc`)