

## THESIS Agricultural Spatial Downscaling Tool

This tool is used to generate a time series of gridded global agricultural land use maps from annual iPETS regional targets for crop and pasture area. The tool integrates economic theory and observed land use history, with data on the socioeconomic and biophysical determinants of land use change to develop relationships found in the long-term historical data. These relationships can then be used to meet the annual regional aggregate totals provided by the targets through a time series of regionally downscaled crop and pasture maps. The details of these methods can be found in (Meiyappan, Dalton et al. 2014). A description of the application of tool as well as the iPETS model and regions can be found in (Ren, Weitzel et al. 2016).

This documents the use of the tool from generating the required input files for a land use time series to configuring the model to processing the regional output from the tool into global netcdf files. The input and output data for the tool are shown in Figure 1.

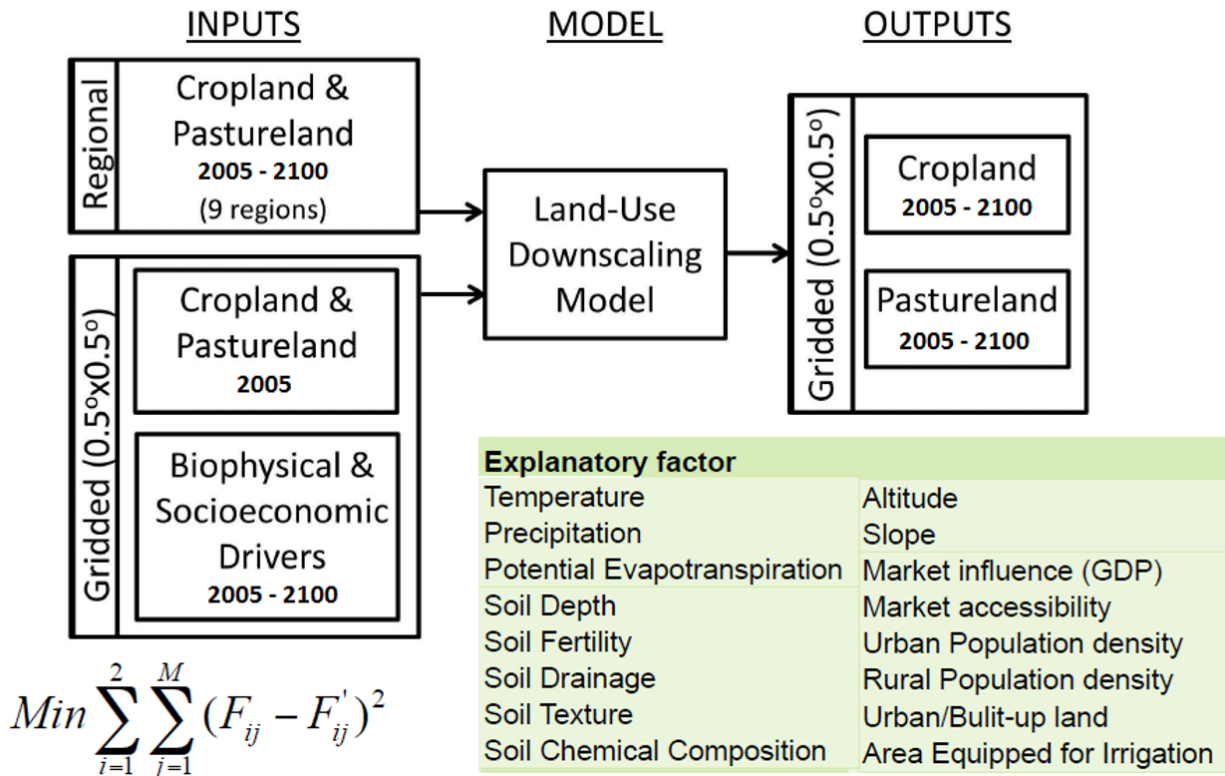


Figure 1. Schematic of Agricultural Spatial Downscaling Tool.

Input data for the Agricultural Spatial Downscaling tool currently resides in THESIS Database on the NCAR CGD servers. The model parameters and the input data are specified through a namelist file that needs to be generated for each region of a time series downscaling run. An example of the namelist file is provided with the code when downloaded from the SVN repository and is shown in Figure 2.

```

&inparm
  dataroot_dir = "/project/iams/thesis/data/agriculture_spatial/global_development/version0.1/ "
  paramestimate_dir = "paramestimate_output/GLM_CESM_141212/ "
  sc_fra1 = 1.04,1.04,1.01,1.08,1.12,1.05,1.19,1.12,1.05
  landuse_regional_dir = "landuse_input/SSP3_RCP45_160602/ "
  landuse_gridcell_dir = "landuse_input/GLM_141215/spatial/ "
  biophysical_dir = "biophysical_input/BASELINE_141215/FAO_AEZ/ "
  socioecon_urban_dir = "socioeconomic_input/BASELINE_141215/urban_area/ "
  socioecon_popul_dir = "socioeconomic_input/BASELINE_141215/population/ "
  socioecon_market_dir = "socioeconomic_input/BASELINE_141215/market/ "
  climate_raw_dir = "climate_input/CESM_RCP4.5/ "
  climate_proc_dir = "climate_input/CRUTS_3.1/ "
  output_dir = "./SSP3_RCP45_160602/"
  reg_no = 1
  year_start = 2006
  year_end = 2100
  lFixed_socioecon_urban = .true.
  lFixed_socioecon_popul = .true.
  lFixed_socioecon_market = .true.
  lFixed_climate_proc = .true.
/

```

Figure 2. Example Namelist File

The Namelist file specifies the location where the input data resides as the `dataroot_dir`. Within the `dataroot_dir` there are directories associated with the different input data sources. The first option is the location of the downscaling parameters to be used with the run. These parameters have been generated using the Agricultural Parameter Estimates tool in MATLAB. The output of this tool is generated prior to using the Agricultural Spatial Downscaling tool.

The next option in the Namelist file is `sc_fra1`, which is a series of hand selected parameters that prescribe the relative weights of the various explanation variables in the downscaling process. These are provided by expert opinion, in this case by Prasanth Meiyappan. The next option is `landuse_regional_dir`, which provides the location of the time series regional targets files for crop and pasture area. Within this directory there is a single `landuse_targets.dat` file which has a single line for each year and region specifying the area of crop and pasture to be downscaled over the region.

The iPETS regions specified in the Downscaling tool differ from those used in the most recent version of iPETS which needs to be accounted for in the regional targets file before starting a downscaling run. Downscaling regions:

- |                                   |                       |                               |
|-----------------------------------|-----------------------|-------------------------------|
| 1. United States                  | 2. European Union     | 3. Transition Countries       |
| 4. Other Industrialized Countries | 5. China              | 6. India                      |
| 7. Latin America                  | 8. Sub-Saharan Africa | 9. Other Developing Countries |

As the targets file is typically generated from an iPETS simulation the format and region numbering need to be recoded into the region ids of the Downscaling tool before starting the downscaling tool.

The next option is `landuse_gridcell_dir`. This is the location for the historical time series of gridded crop and pasture maps to be used as the baseline for the downscaling run. The gridded maps are specified through ascii files for each region and year with each line representing a single grid location with latitude, longitude, grid cell area, crop area, pasture area, and remaining area available for allocation to crop or pasture.

The next option is the `biophysical_dir`. This is the location for all of the biophysical data used in the downscaling tool. The files in this directory describe grid cell level soil texture, fertility, depth, drainage and chemical composition along with terrain from global ascii grids. The biophysical data is time invariant with a single value for all years run with the downscaling tool.

The `socioecon_urban_dir`, `socioecon_popul_dir` and the `socioecon_market_dir` variables which follow contain the locations of annual global maps of urban fraction, rural and urban population density, and market influence. Like the biophysical data these grids are represented as global ascii files with each line representing a single grid cell value. The usage of these files is modified by the `IFixed_socioecon_urban`, `IFixed_socioecon_popul`, and `IFixed_socioecon_market` variables. If these are false, then the downscaling tool uses the calendar year files that correspond with the year of the target crop and pasture values. If they are true however the downscaling tool holds these values constant using the year prior to the `year_start` value which is the first year of the downscaling process.

The next option is `climate_raw_dir`. This is the location for the annual climate time series data corresponding with the calendar years of the downscaling crop and pasture targets. The files in this location contain grid cell values for temperature and precipitation for winter, spring, summer and fall for each year of the time series. Like the biophysical and social input data, these files are global ascii grids with a single grid cell value for each line. The raw climate data files always correspond with the calendar year of the target crop and pasture values.

The `climate_proc_dir` variable specifies the location of processed climate data. This is again an annual climate time series, but of the derived input variables of annual heat waves, seasonal Palmer Drought Stress Index (PDSI), and seasonal Potential Evaporation (PET). Like the socioeconomic data, the usage of the processed climate data is modified by the `IFixed_climate_proc` variable. If the value is false, then the downscaling tool uses the calendar year files associated with the corresponding year of the target crop and pasture values. If this value is true however, then these values are held constant at the year prior to the first year of the downscaling process.

The final options are the `reg_no` which specifies the downscaling region to be processed. The downscaling tool only processes one region at a time, although multiple regions can be run independently at the same time with their own unique Namelist files. The other options are the `year_start` and the `year_end` which specify the start and end of the downscaling process. Each year of the downscaling produces a specific set of files for optimization and allocation of crops and pasture to the region being downscaled. The downscaling in each region is done independently without dependency across regions.

## Running Instructions

1. Download Downscaling Tool from THESIS website and build the executable file.
2. Create the Downscaling time series directory for the output and Namelist files to reside.
3. Generate an annual crop and pasture regional target file and register it in the THESIS database.
4. Create a Namelist file for each region in the Downscaling time series directory.
5. Run the Downscaling tool for each region with the Namelist file specified.
6. Generate a global time series netcdf file with crop and pasture variables from the annual regional crop and pasture files. The netcdf file is dimensioned by latitude, longitude and year.

## References

- Meiyappan, P., et al. (2014). "Spatial modeling of agricultural land use change at global scale." Ecological Modelling **291**: doi:10.1016/j.ecolmodel.2014.1007.1027.
- Ren, X., et al. (2016). "Avoided economic impacts of climate change on agriculture: Integrating a land surface model (CLM) with a global economic model (iPETS)." Climatic Change: in review.