



**Chris Mutel :: Paul Scherrer Institut**

# Regionalized life cycle assessment in Brightway2

**LCA Discussion Forum 69**

**Sept. 13, 2018**

# 1. Convert inventory information

	A	B
1	<b>Activity</b>	white rice, from dry milling
2	code	Dry milling US
3	location	US
4	production amount	
5	type	process
6	unit	kilogram
7		
8	<b>Exchanges</b>	
9	<b>name</b>	<b>amount</b>
10	white rice, from dry milling, at plant	
11	treatment of wastewater from maize starch pro	
12	rice production	
13	heat production, natural gas, at industrial furna	
14	transport, freight, lorry >32 metric ton, EURO3	
15	market for tap water	
16	market group for electricity, medium voltage	
17		
18	<b>Activity</b>	white rice, packed, at plant
19	code	Packed rice US
20	location	US
21	production amount	
22	type	process
23	unit	kilogram
24		
25	<b>Exchanges</b>	
26	<b>name</b>	<b>amount</b>
27	white rice, packed, at plant	
28	white rice, from dry milling, at plant	

# Convert names and locations to ecoinvent 3.5

# Copy/paste into “standard” BW2 template

# Import and link against ecoinvent 3.5

	<b>reference product</b>	<b>unit</b>	<b>database</b>	<b>location</b>	<b>type</b>
1		kilogram	AWARE Case Study	US	production
0.00097446		m3	ecoinvent 3.5 cutoff	RoW	production
1.3441	rice	kilogram	ecoinvent 3.5 cutoff	US	technosphere
1.0551		MJ	ecoinvent 3.5 cutoff	RoW	technosphere
0.067204		tkm	ecoinvent 3.5 cutoff	RER	technosphere
0.00097446		kg	ecoinvent 3.5 cutoff	RoW	technosphere
0.17137		kWh	ecoinvent 3.5 cutoff	US	technosphere
nt					
1					
	<b>reference product</b>	<b>unit</b>	<b>database</b>	<b>location</b>	<b>type</b>
1		kg	AWARE Case Study	US	production
1		kilogram	AWARE Case Study	US	technosphere

## 2. Label ecoinvent Rest-of-Worlds

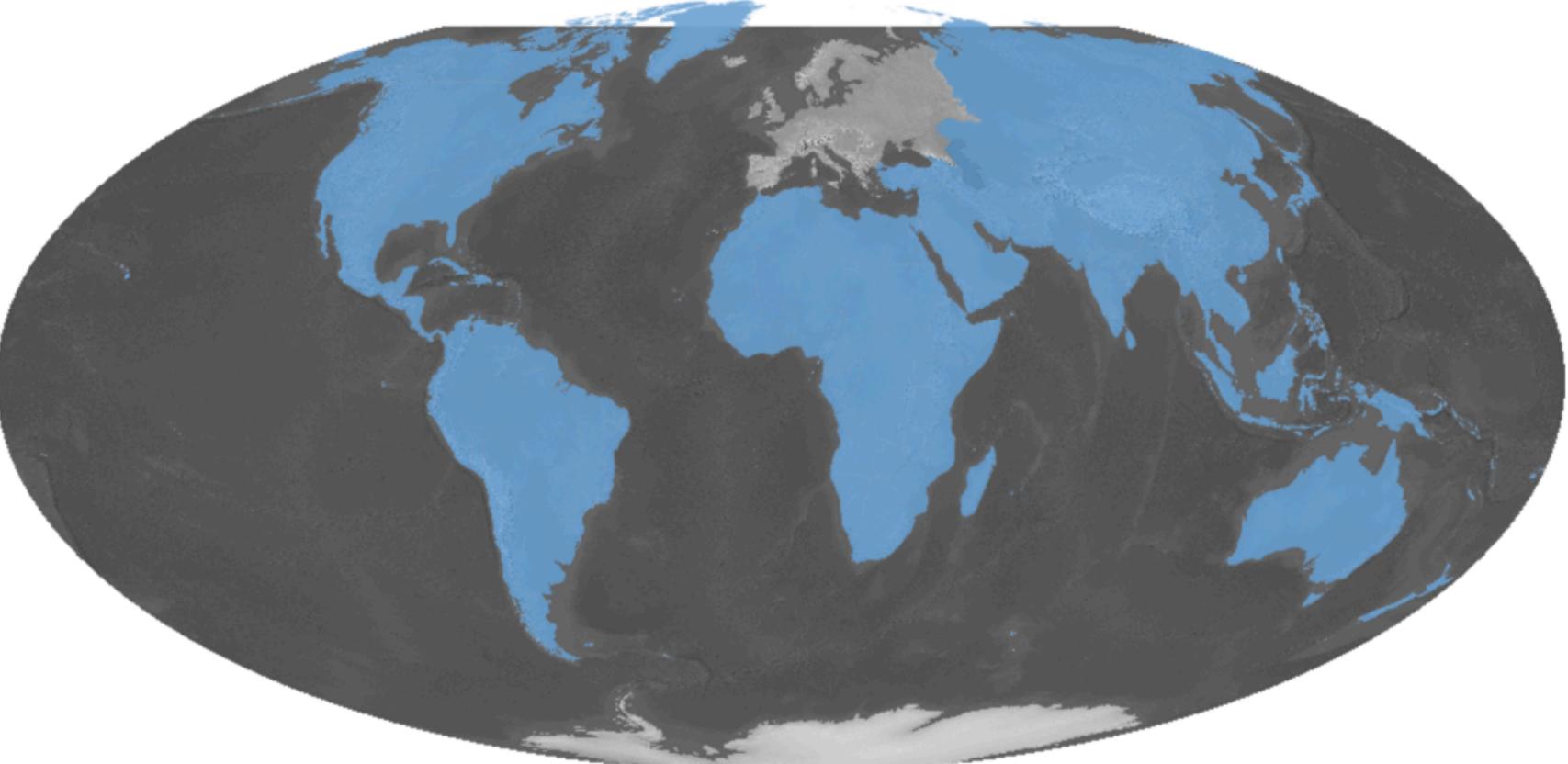
Rest-of-World: RoW\_213

[https://geography.ecoinvent.org/rows/RoW\\_213.html](https://geography.ecoinvent.org/rows/RoW_213.html)

### Rest-of-World location: RoW\_213 | [RoWs report](#)

[Rower](#) version: (0, 0, 'dev')  
[constructive\\_geometries](#) version: (0, 6, 4)

Excluded from this "Rest-of-World": AQ, AUS-AC, Bajo Nuevo, Clipperton Island, Coral Sea Islands, RER



**ecoinvent 3.3 APOS**

Activity Name	Reference Product	Unit
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<https://geography.ecoinvent.org/rows/>

### 3. Label geocollections

#### Databases

ecoinvent 3.5 cutoff

biosphere

rice foreground

#### Geocollections

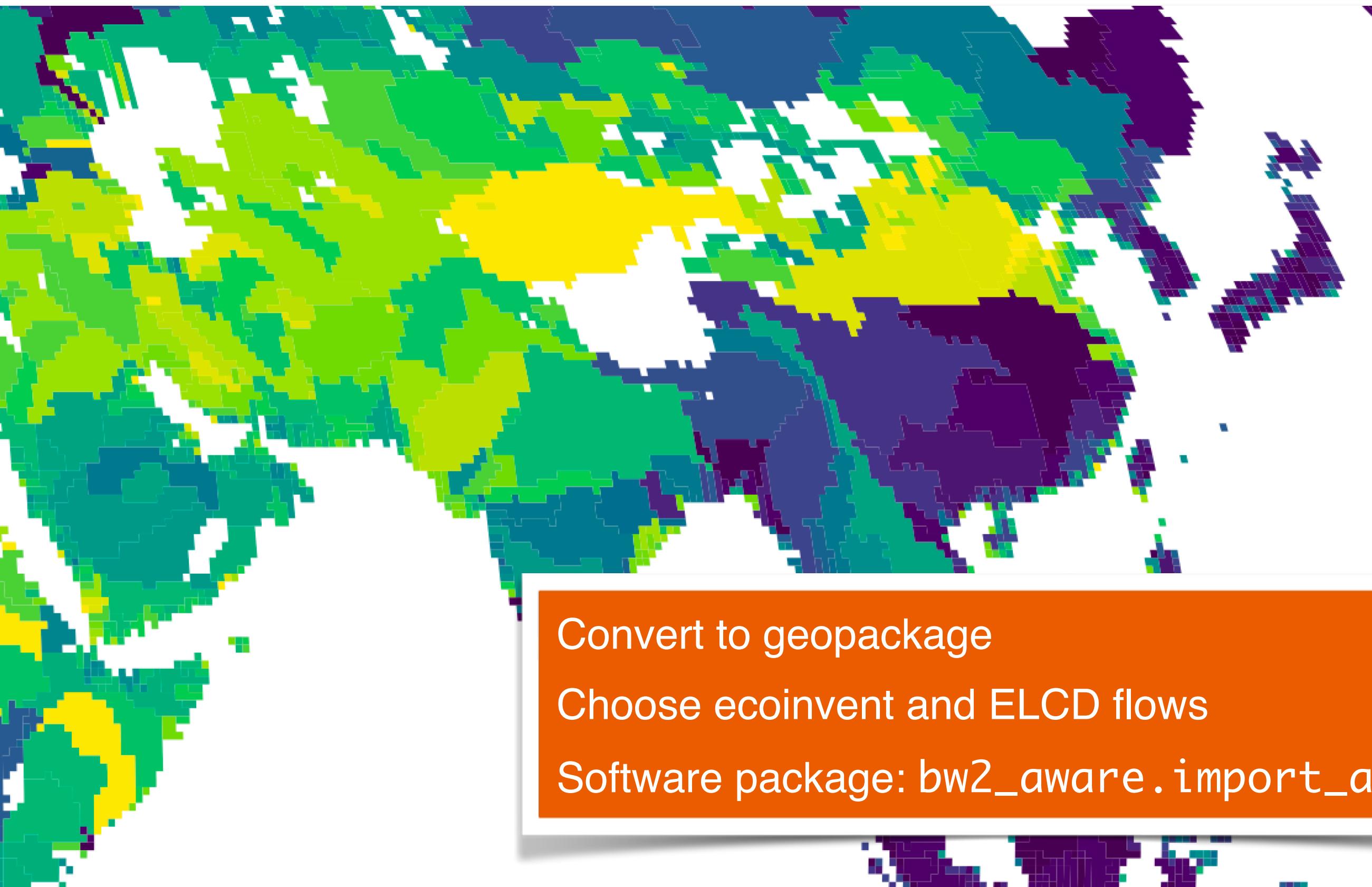
ecoinvent

world

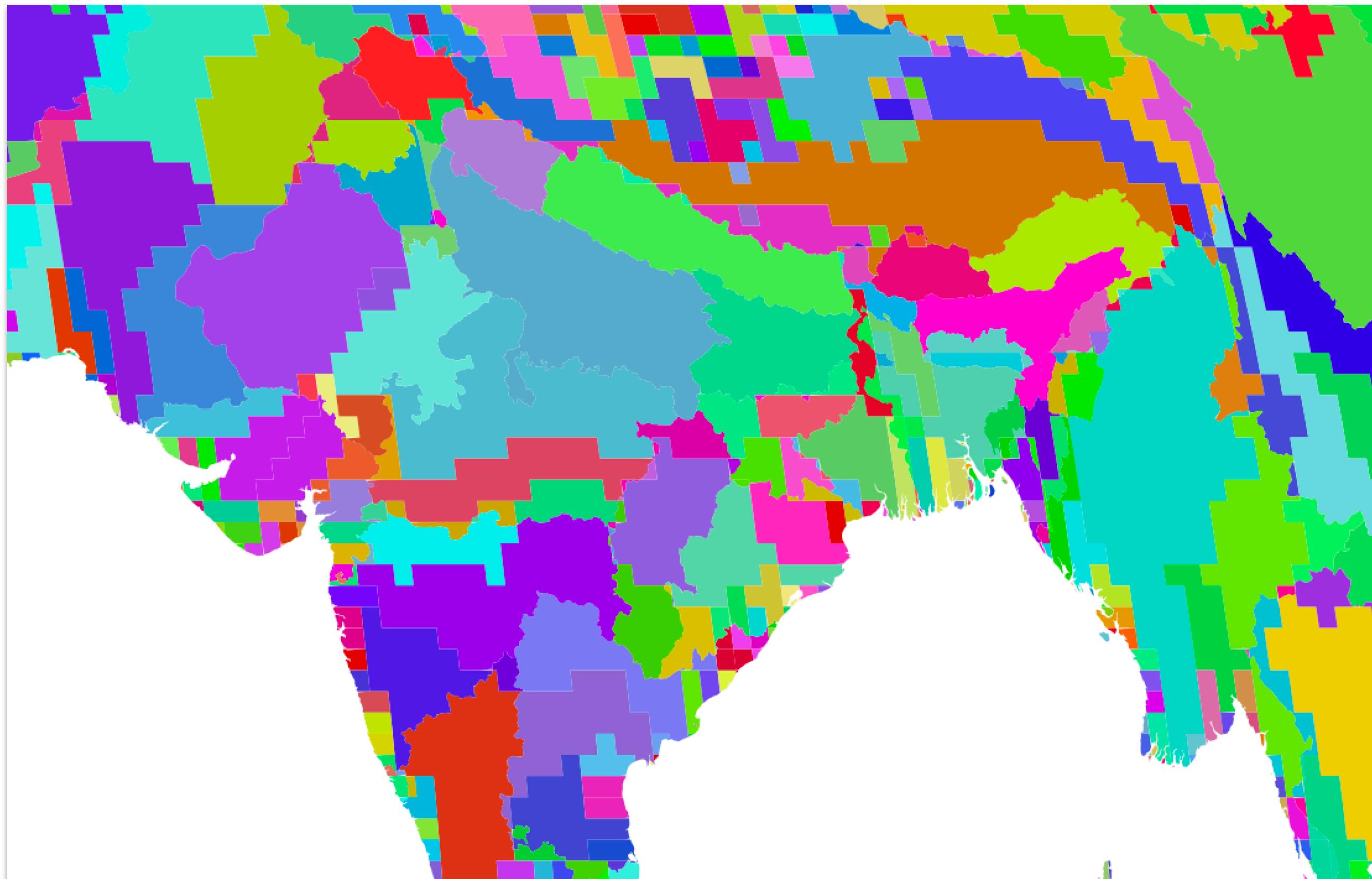
RoW

watersheds

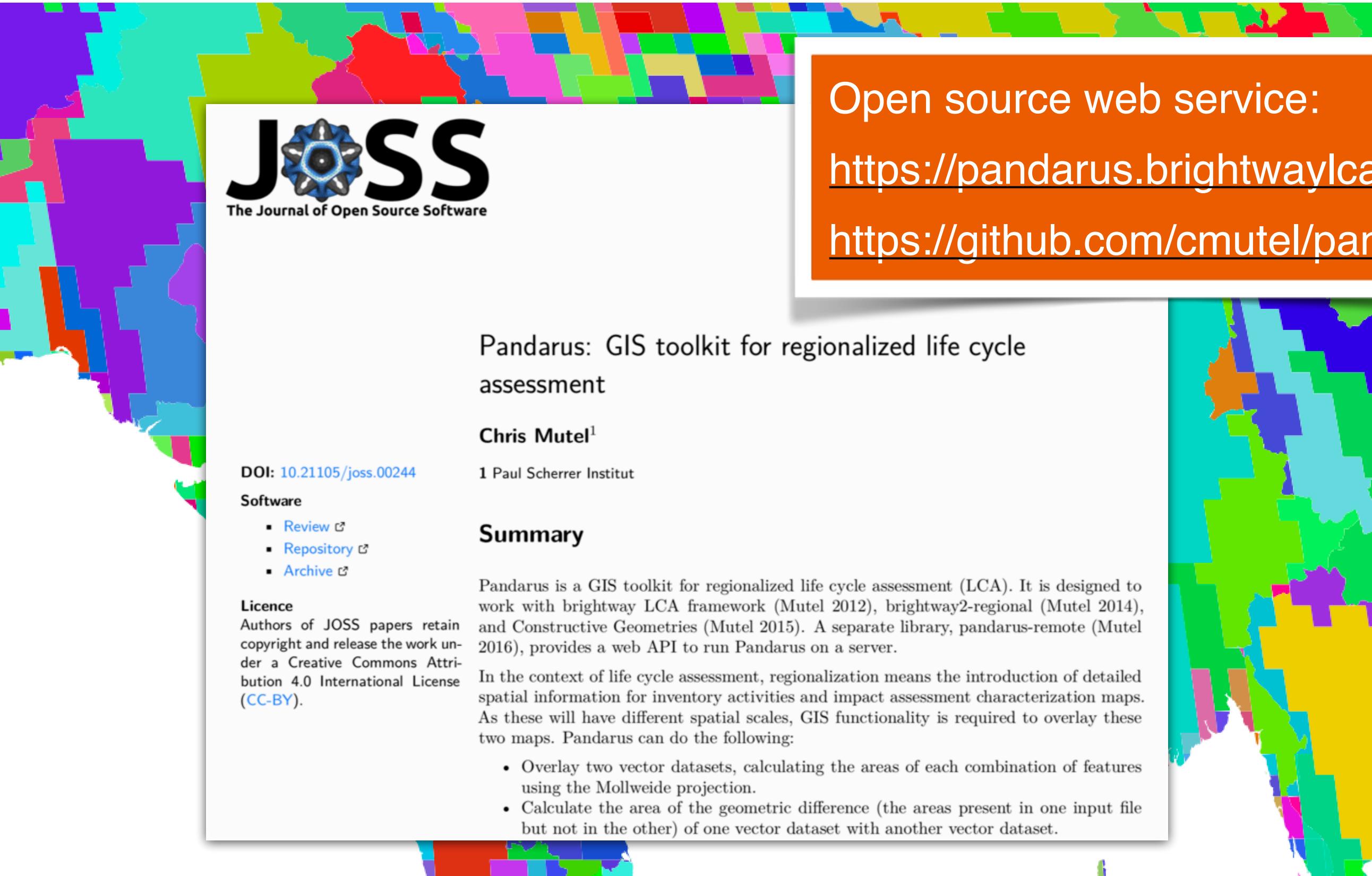
## 4. Convert and import AWARE



## 5. Calculate intersection of inventory and IA scales



## 5. Calculate intersection of inventory and IA scales



**Open source web service:**

<https://pandarus.brightwaylca.org/>

<https://github.com/cmutel/pandarus>

**Pandarus: GIS toolkit for regionalized life cycle assessment**

**Chris Mutel<sup>1</sup>**

**DOI:** [10.21105/joss.00244](https://doi.org/10.21105/joss.00244)

**Software**

- [Review ↗](#)
- [Repository ↗](#)
- [Archive ↗](#)

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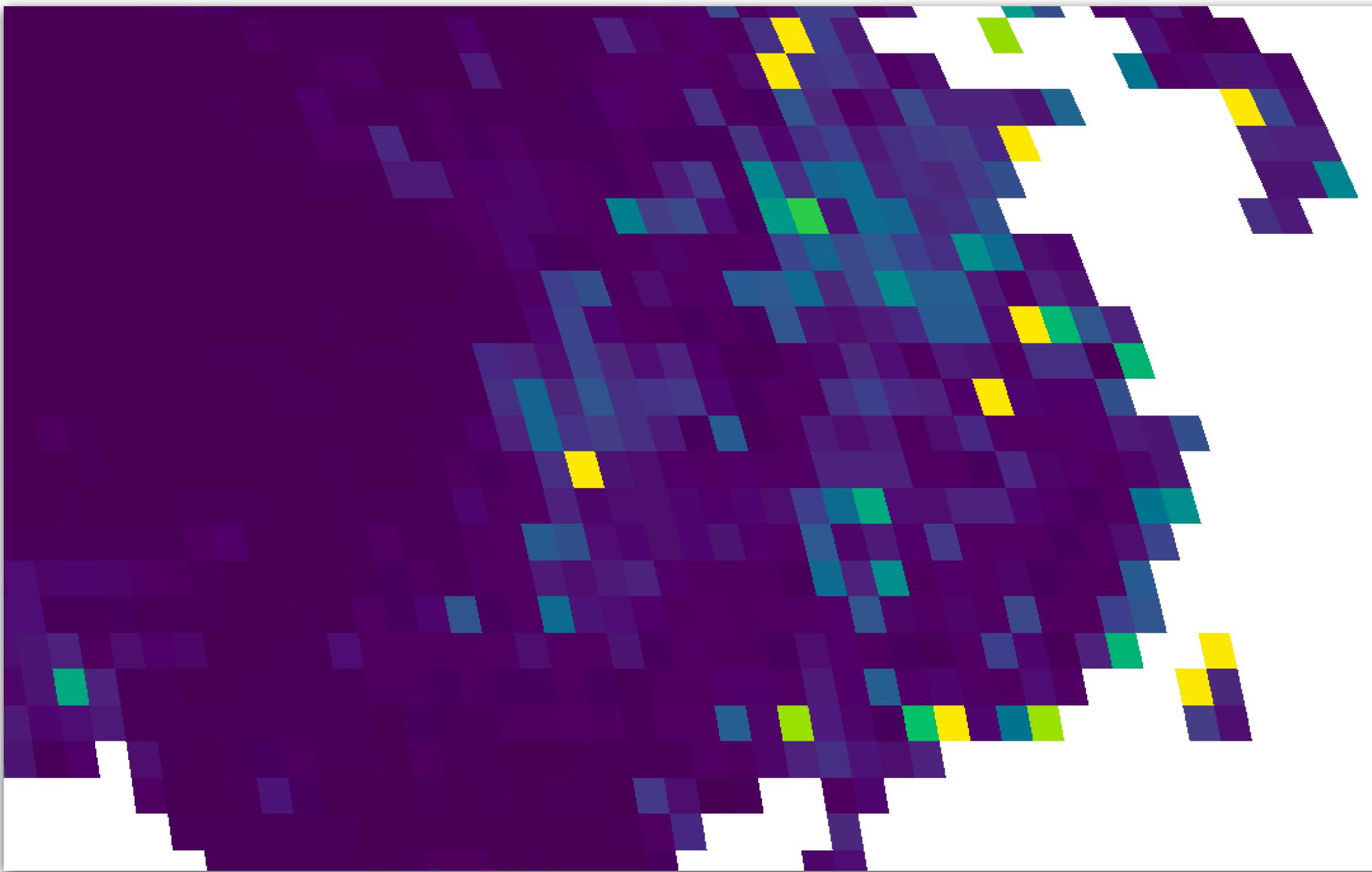
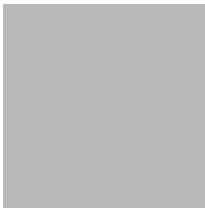
**Summary**

Pandarus is a GIS toolkit for regionalized life cycle assessment (LCA). It is designed to work with brightway LCA framework (Mutel 2012), brightway2-regional (Mutel 2014), and Constructive Geometries (Mutel 2015). A separate library, pandarus-remote (Mutel 2016), provides a web API to run Pandarus on a server.

In the context of life cycle assessment, regionalization means the introduction of detailed spatial information for inventory activities and impact assessment characterization maps. As these will have different spatial scales, GIS functionality is required to overlay these two maps. Pandarus can do the following:

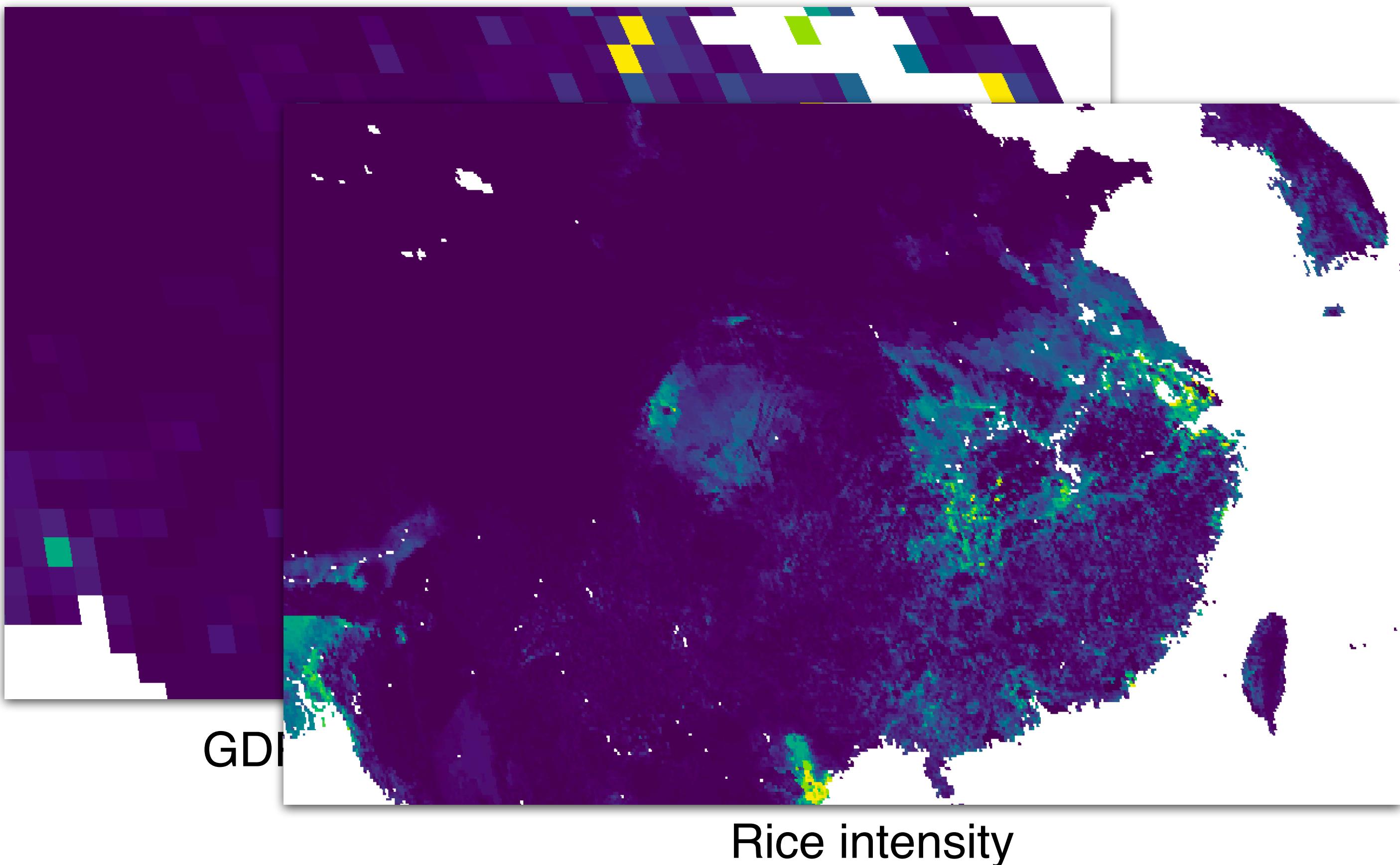
- Overlay two vector datasets, calculating the areas of each combination of features using the Mollweide projection.
- Calculate the area of the geometric difference (the areas present in one input file but not in the other) of one vector dataset with another vector dataset.

## 6. Choose detailed spatial scale



GDP-weighted population density

## 6. Choose detailed spatial scale



## 7. Map activities to different spatial scales

Include:

- Rice intensity map
- Agricultural average characterisation factors

```
irrigation = [x for x in bw.Database("ecoinvent 3.5 cutoff")
              if x['name'] == 'irrigation']

rice_production = [x for x in bw.Database("ecoinvent 3.5 cutoff")
                     if x['name'] == 'rice production']
```

Exclude:

GDP-weighted population density map

Non-agricultural average characterisation factors

## 8. Do regionalized calculations

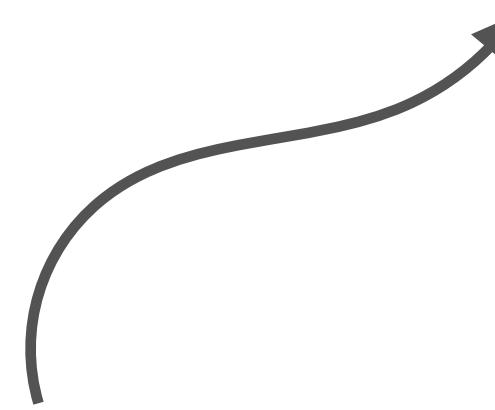
$$h_r = [\mathbf{MN}_{dx} \mathbf{DXN}_g \mathbf{GR}]^T \circ [\mathbf{B} \cdot (\mathbf{A}^{-1} f)]$$

Inventory

## 8. Do regionalized calculations

$$h_r = [\mathbf{MN}_{dx} \mathbf{DXN}_g \mathbf{GR}]^T \circ [\mathbf{B} \cdot (\mathbf{A}^{-1} f)]$$

Inventory



**Mapping**

Inventory Processes to

Inv. Spatial Units

*(1 or 0)*

## 8. Do regionalized calculations

$$h_r = [\mathbf{MN}_{dx} \mathbf{DXN}_g \mathbf{GR}]^T \circ [\mathbf{B} \cdot (\mathbf{A}^{-1} f)]$$



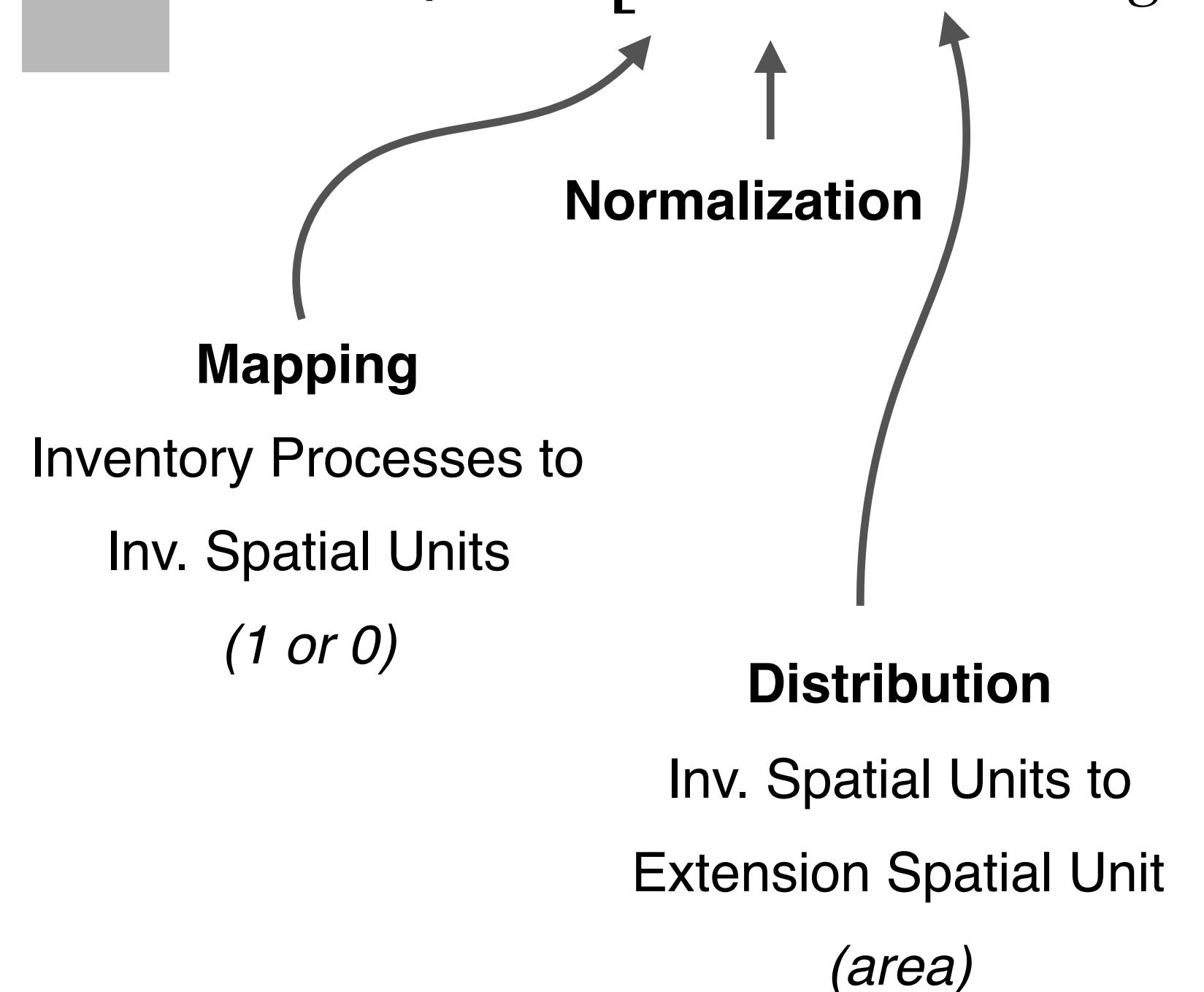
Inventory Processes to

Inv. Spatial Units

*(1 or 0)*

## 8. Do regionalized calculations

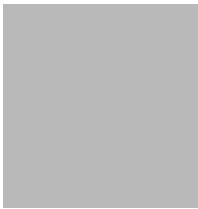
$$h_r = [\mathbf{MN}_{dx} \mathbf{DXN}_g \mathbf{GR}]^T \circ [\mathbf{B} \cdot (\mathbf{A}^{-1} f)]$$



Inventory

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$$h_r = [\mathbf{MN}_{dx} \mathbf{DXN}_g \mathbf{GR}]^T \circ [\mathbf{B} \cdot (\mathbf{A}^{-1} f)]$$



Inventory Processes to  
Inv. Spatial Units

(1 or 0)

Inv. Spatial Units to  
Extension Spatial Unit

(area)

**Mapping**

**Normalization**

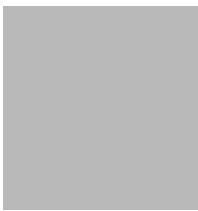
**Extension Table**

Extension tables values

**Inventory**

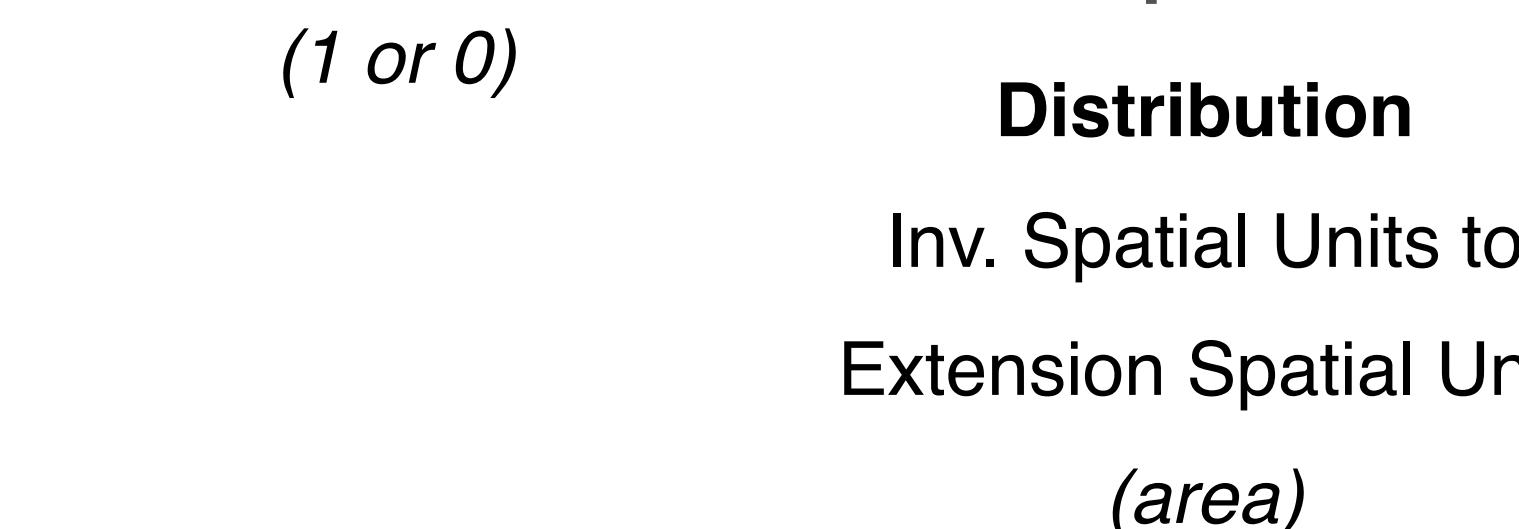
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$$h_r = [\mathbf{MN}_{dx} \mathbf{DXN}_g \mathbf{GR}]^T \circ [\mathbf{B} \cdot (\mathbf{A}^{-1} f)]$$



Inventory Processes to  
Inv. Spatial Units

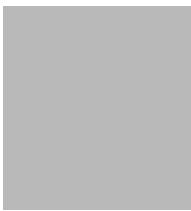
(1 or 0)



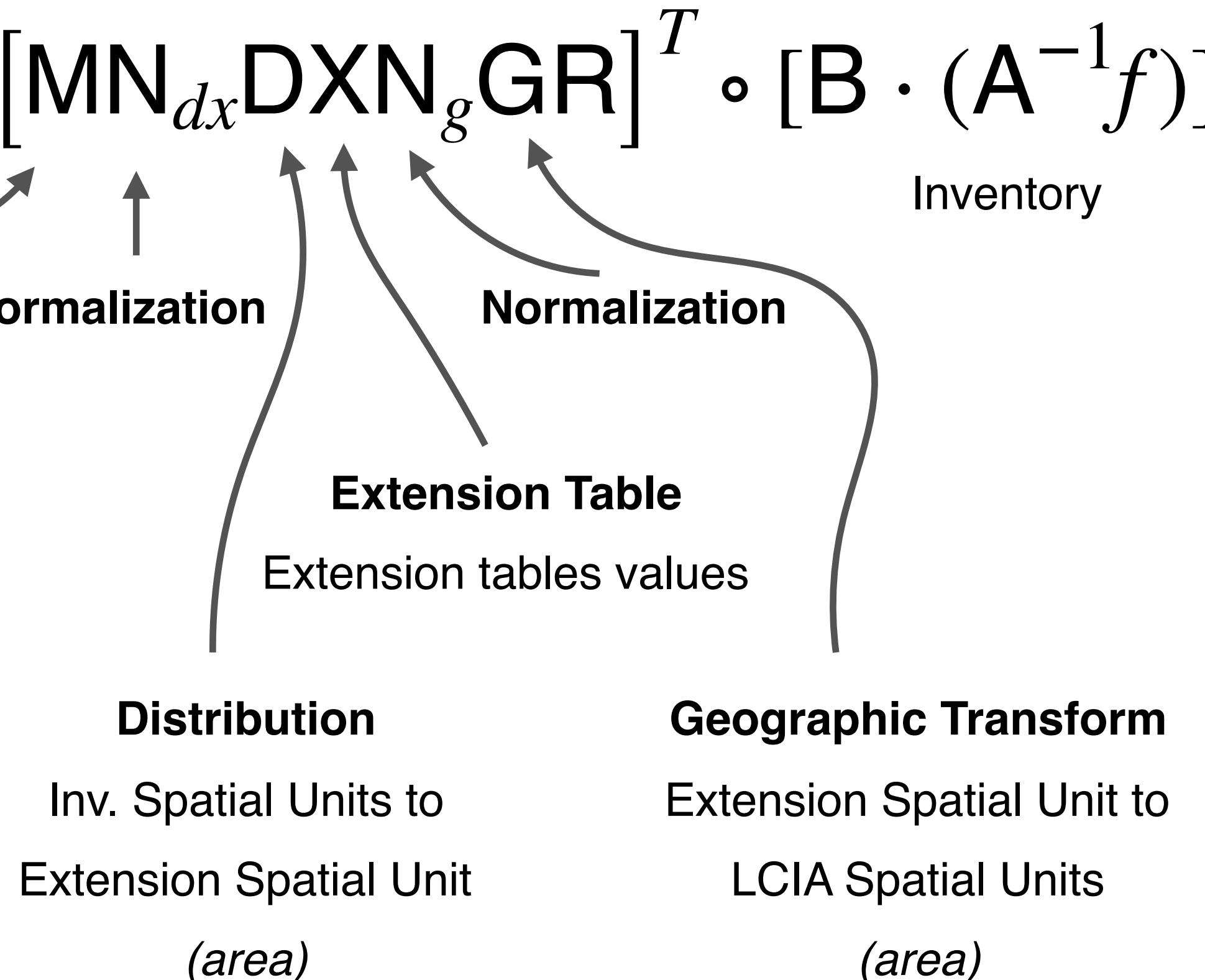
Inventory

## 8. Do regionalized calculations

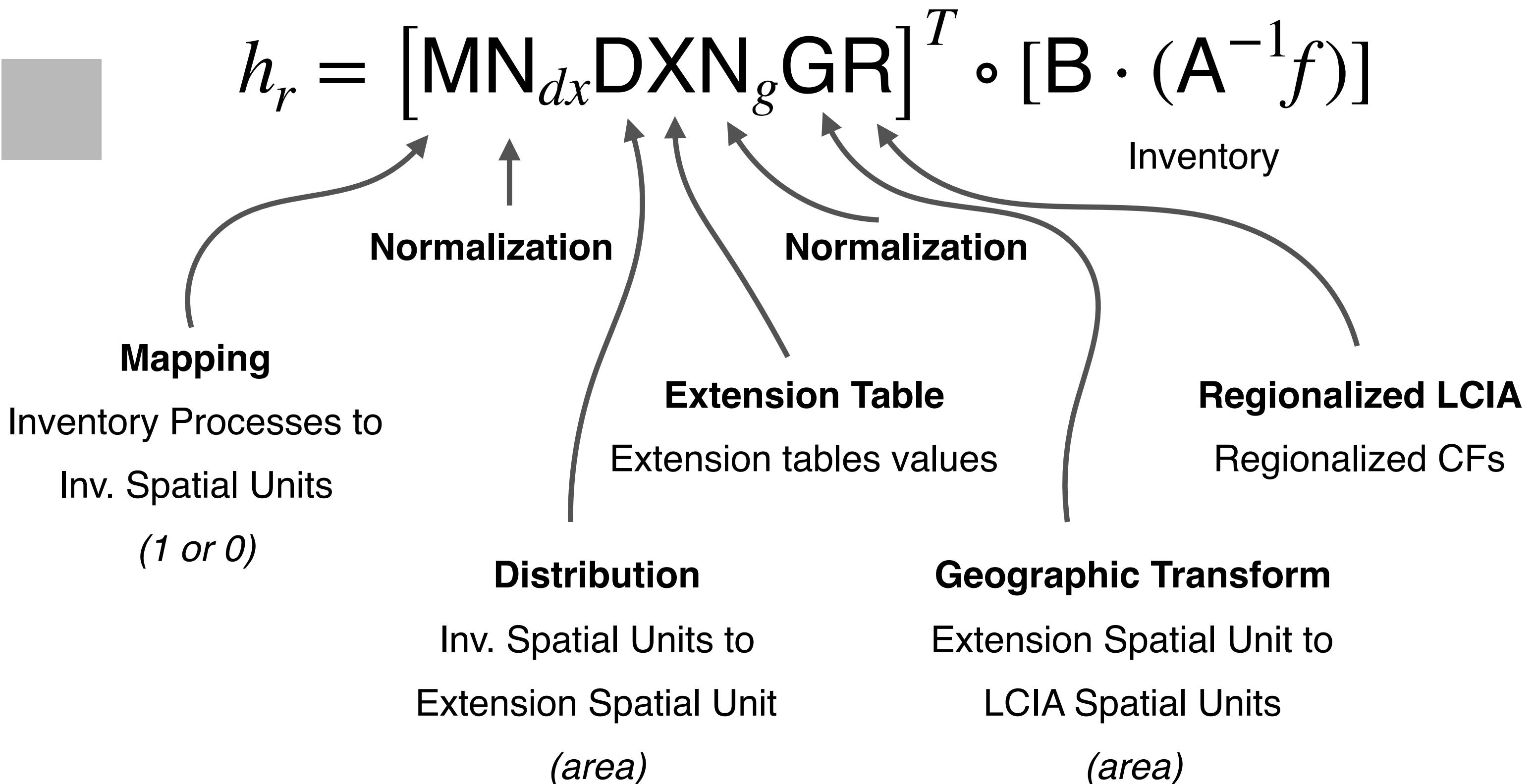
$$h_r = [\mathbf{MN}_{dx} \mathbf{DXN}_g \mathbf{GR}]^T \circ [\mathbf{B} \cdot (\mathbf{A}^{-1} f)]$$



Inventory Processes to  
Inv. Spatial Units  
*(1 or 0)*



## 8. Do regionalized calculations

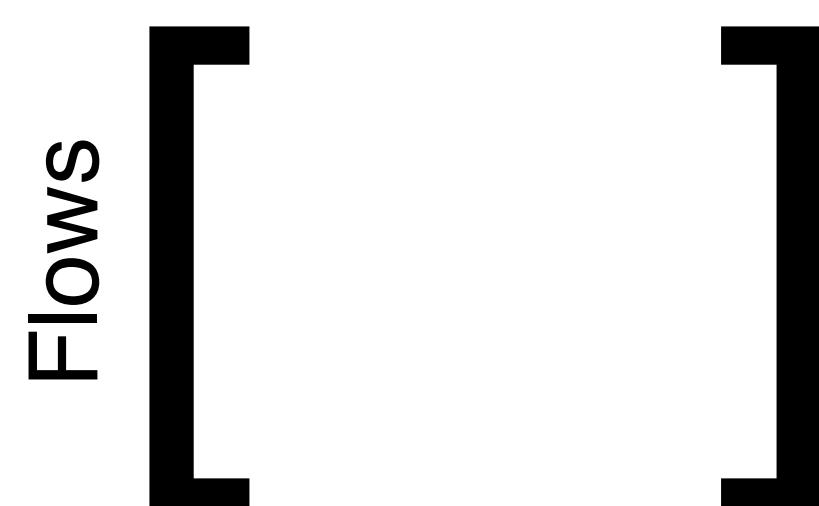


## 8. Do regionalized calculations

$$h_r = [\mathbf{MN}_{dx} \mathbf{DXN}_g \mathbf{GR}]^T \circ [\mathbf{B} \cdot (\mathbf{A}^{-1} f)]$$

Processes

Processes



## 8. Do regionalized calculations

$$h_r = [\mathbf{MN}_{dx} \mathbf{DXN}_g \mathbf{GR}]^T \circ [\mathbf{B} \cdot (\mathbf{A}^{-1} f)]$$

Processes

Processes

Flows [ ]

Flows [ ]

$$h_r = \mathbf{R}^T \circ [\mathbf{B} \cdot (\mathbf{A}^{-1} f)] \mathbf{MN}_{dx} \mathbf{DXN}_g \mathbf{G}$$

IA spatial scale

IA spatial scale

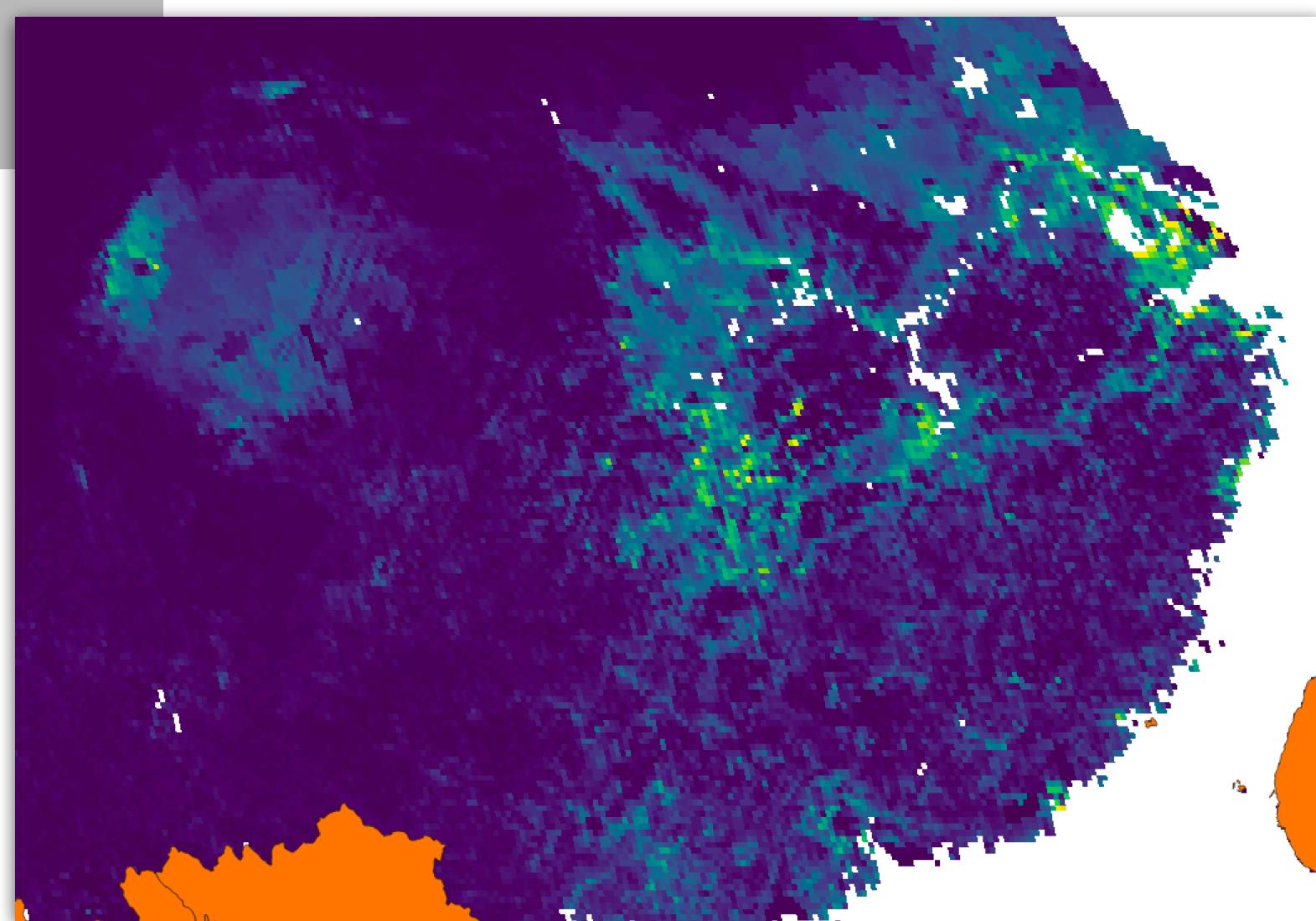
Flows [ ]

Flows [ ]

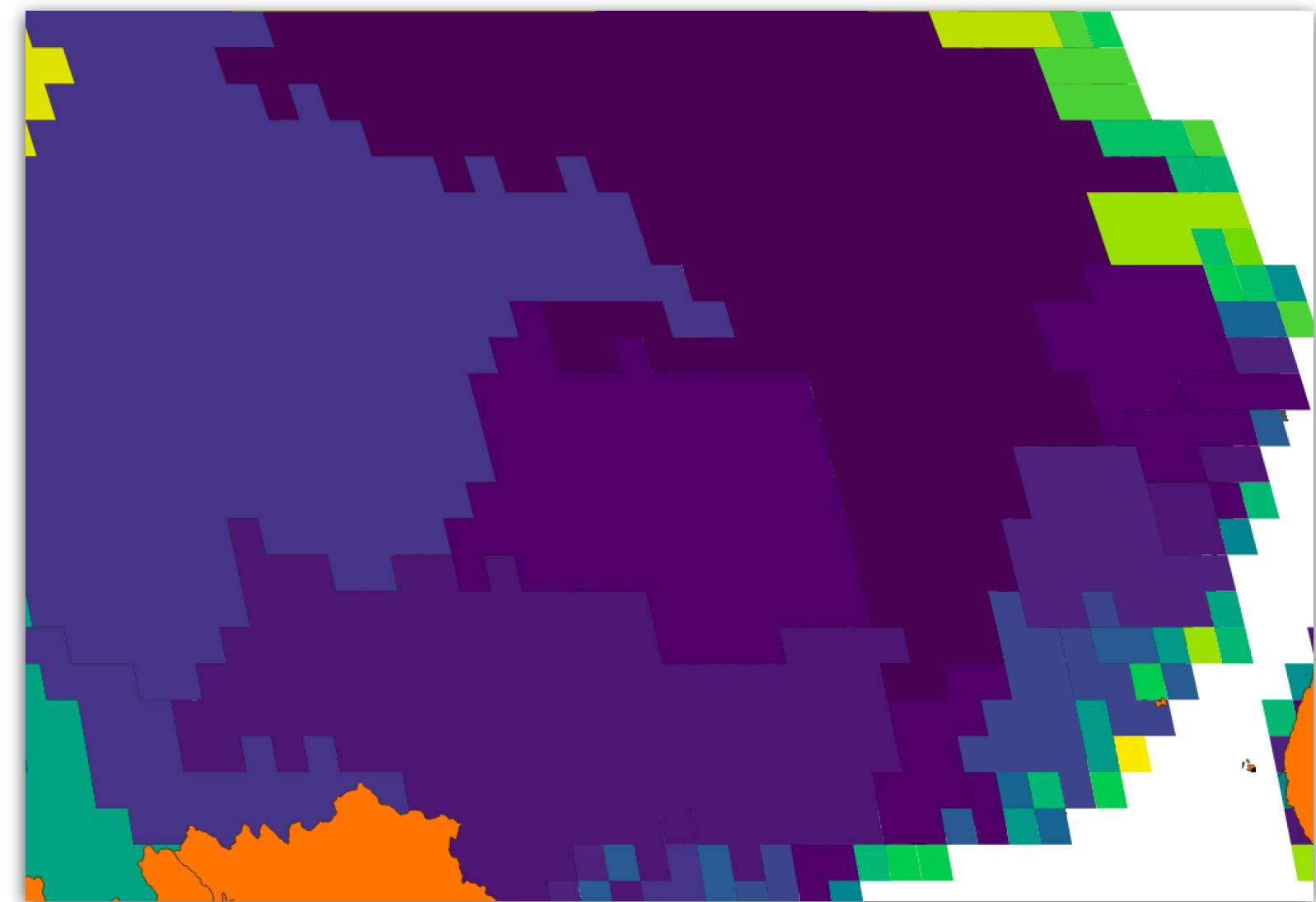
# Results

Rice consumed in China: 2.27 AMD  
Rice consumed in Switzerland: 10.1 AMD  
(Rice from USA)  
99% of impact from rice irrigation in both cases

# Results

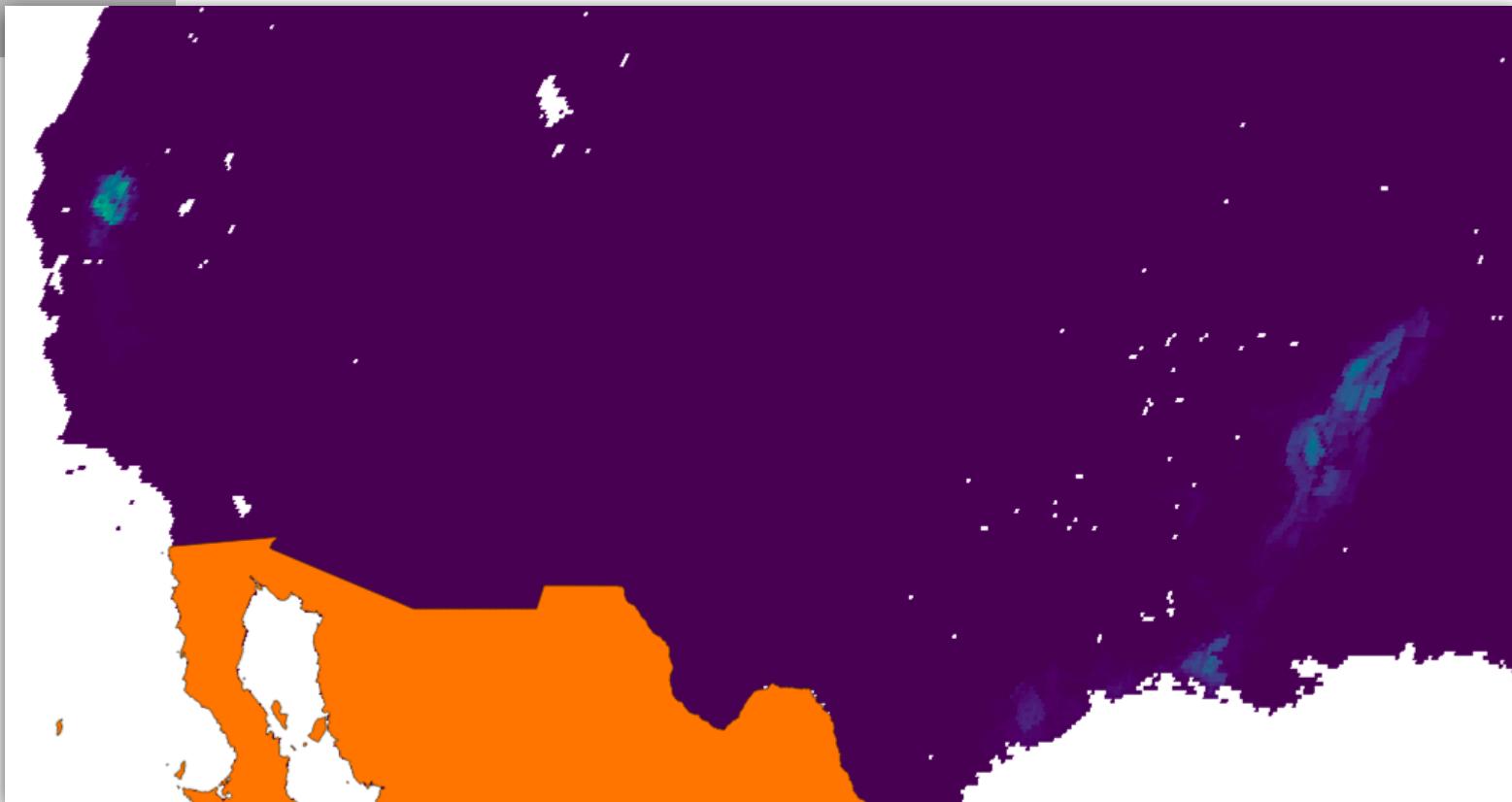


Rice intensity

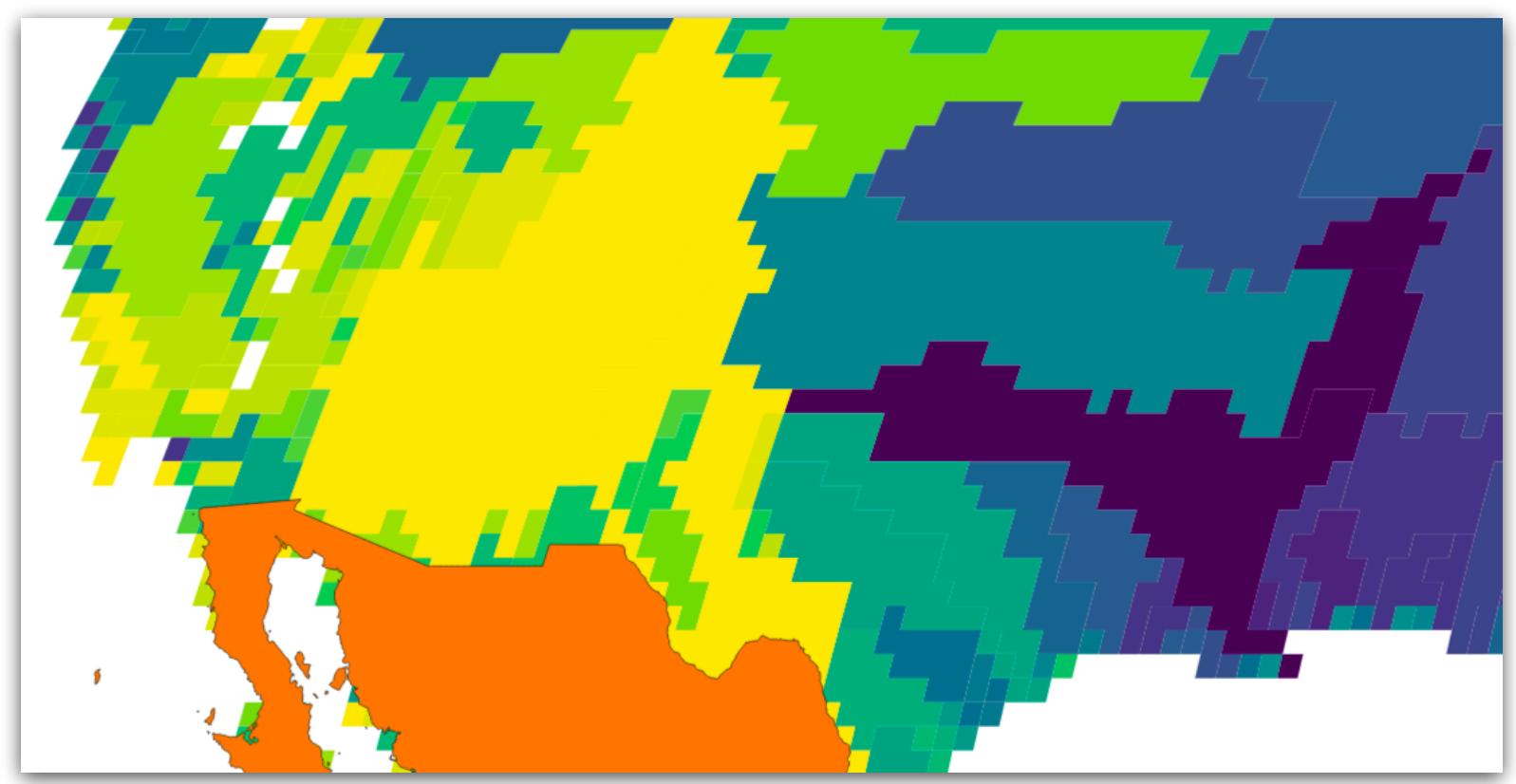


AWARE CFs (Ag.)

# Results



Rice intensity



AWARE CFs (Ag.)

# Conclusions

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  - Could also apply e.g. LC-IMPACT (many impact categories)
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- **Results could be improved**
  - Monthly CF maps
  - Spatial pattern of rice irrigation
- **Open source toolchains for (regionalized) LCA are available**
  - Complete case study calculations: [mutel.org/df69](http://mutel.org/df69)

# Regionalized LCIA data format

## Technical standards for regionalized LCIA method data interchange

*Version: 0.draft-1*

### Motivation

There is currently no standard methods. This lack of standardization results in inconsistent implementation of LCIA methods and poor uptake of regionalization in general. This document provides a specification for a software- and database-independent data format for regionalized and site-generic LCIA methods. Its guiding principles are:

- Simplicity. Use the simplest and easiest approach and format whenever possible.
- Compatibility and consistency. This standard requires elementary flows be identified in both of the major nomenclature systems (ELCD and ecoinvent).
- Reuse of existing standards. This standard builds on top of existing widely-used standards for metadata ([datapackage](#)), [CSVs](#), and GIS data ([geojson](#), [GeoTIFF](#)).

### Summary

An LCIA method is a directory with a set of files:

- `datapackage.json` : Describes the LCIA method metadata, including impact categories, elementary flows, spatial support, and uncertainty distributions.

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Metadata (JSON)

Summary

CFs (CSV)

Spatial Scale  
(GeoJSON/GeoTIFF)

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