Package: mrwater (via r-universe)

September 30, 2024

Type Package

Title madrat based MAgPIE water Input Data Library

Version 1.13.5

URL https://github.com/pik-piam/mrwater,

https //doi.org/10.5281/zenodo.5801680

License LGPL-3 | file LICENSE

Date 2024-09-30

Description Provides functions for MAgPIE cellular input data
generation and stand-alone water calculations.

Depends R (>= 2.10.0), madrat (>= 1.72), magclass (>= 6.0.0),
mrcommons (>= 1.41.0), mrlandcore (>= 1.0.0), mrland (>=
0.59.0)

Imports magpiesets, mstools (>= 0.6.0), raster, stats, stringr, utils,
withr

Suggests covr, knitr, rmarkdown, testthat

VignetteBuilder knitr

Encoding UTF-8

LazyData no

RoxygenNote 7.3.2

Repository https://pik-piam.r-universe.dev

RemoteUrl https://github.com/pik-piam/mrwater

RemoteRef HEAD

RemoteSha 52c50bd47701384c5dd01808bde7fad63dff7b08

Contents

mrwater-package	*mrwater: madrat based MAgPIE water Input Data Library*

Description

Provides functions for MAgPIE cellular input data generation and stand-alone water calculations.

Author(s)

Maintainer: Felicitas Beier <beier@pik-potsdam.de>

Authors:

- Jens Heinke <heinke@pik-potsdam.de>

- Kristine Karstens <karstens@pik-potsdam.de>

- Benjamin Leon Bodirsky <bodirsky@pik-potsdam.de>

- Jan Philipp Dietrich <dietrich@pik-potsdam.de>

See Also

Useful links:

- <https://github.com/pik-piam/mrwater>,

---

calcActualIrrigWatRequirements

calcActualIrrigWatRequirements

Description

This function calculates actual irrigation water requirements per cell given the chosen irrigation system

Usage

```
calcActualIrrigWatRequirements(
  selectyears,
  iniyear,
  lpjml,
  climatetype,
  irrigationsystem,
  multicropping
)
```

Arguments

selectyears	Years to be returned
iniyear	Initialization year (for weight by cropland)
lpjml	LPJmL version required for respective inputs: natveg or crop
climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"
irrigationsystem	Irrigation system used: system share as in initialization year, or drip, surface, sprinkler for full irrigation by selected system
multicropping	Multicropping activated (TRUE) or not (FALSE) and Multiple Cropping Suitability mask selected (mask can be: "none": no mask applied (only for development purposes) "actual:total": currently multicropped areas calculated from total harvested areas and total physical areas per cell from readLandInG "actual:crop" (crop-specific), "actual:irrigation" (irrigation-specific), "actual:irrig_crop" (crop- and irrigation-specific) "total" "potential:endogenous": potentially multicropped areas given temperature and productivity limits "potential:exogenous": potentially multicropped areas given GAEZ suitability classification) (e.g. TRUE:actual:total; TRUE:none; FALSE)

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

See Also

[calcIrrigationSystem](), [calcIrrigWatRequirements]()

Examples

```
## Not run:
calcOutput("ActualIrrigWatRequirements", aggregate = FALSE)

## End(Not run)
```

---

calcAreaPotIrrig   *calcAreaPotIrrig*

Description

This function calculates land that is potentially available for irrigated agriculture

Usage

```
calcAreaPotIrrig(selectyears, comagyear, iniyear, landScen)
```

Arguments

selectyears	Years to be returned
comagyear	If NULL: total potential croparea is used; if !NULL: already irrigated area is subtracted; year specified here is the year of the initialization used for cropland area initialization in calcIrrigatedArea (e.g. NULL, 1995, 2010)
iniyear	Initialization year for current cropland area
landScen	Land availability scenario consisting of two parts separated by ":": 1. available land scenario (currCropland, currIrrig, potCropland) 2. protection scenario (WDPA, or one of the scenarios available in calcConservationPriorities, e.g., 30by20, BH, BH_IFL, PBL_HalfEarth, or NA for no protection). For case of no land protection select "NA" in second part of argument or do not specify second part of the argument

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("AreaPotIrrig", aggregate = FALSE)

## End(Not run)
```

---

calcAvlWater   *calcAvlWater*

Description

This function calculates water availability for MAgPIE retrieved from LPJmL

Usage

```
calcAvlWater(
  lpjml = c(natveg = "LPJmL4_for_MAgPIE_44ac93de", crop =
    "ggcmi_phase3_nchecks_9ca735cb"),
  climatetype = "GSWP3-W5E5:historical",
  cells = "lpjcell",
  stage = "harmonized2020",
  seasonality = "grper"
)
```

Arguments

lpjml	Defines LPJmL version for crop/grass and natveg specific inputs
climatetype	Switch between different climate scenarios
cells	Number of cells to be returned (select "magpiecell" for 59199 cells or "lpjcell" for 67420 cells)
stage	Degree of processing: raw, smoothed, harmonized, harmonized2020
seasonality	grper (default): water available in growing period per year; total: total water available throughout the year; monthly: monthly water availability (for further processing, e.g. in calcEnvmtlFlow)

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier, Kristine Karstens, Abhijeet Mishra

Examples

```
## Not run:
calcOutput("AvlWater", aggregate = FALSE)

## End(Not run)
```

---

calcBlueWaterConsumption

calcBlueWaterConsumption

Description

This function calculates consumptive blue water use for the whole year based on LPJmL blue water consumption of crops and the difference between rainfed and irrigated evapotranspiration of grass

Usage

```
calcBlueWaterConsumption(
  selectyears,
  lpjml,
  climatetype,
  fallowFactor = 0.75,
  areaMask,
  output
)
```

Arguments

selectyears	Years to be returned
lpjml	LPJmL version required for respective inputs: natveg or crop
climatetype	Climate model (e.g., "MRI-ESM2-0:ssp370") or historical baseline (e.g., "GSWP3-W5E5:historical")
fallowFactor	Factor determining water requirement reduction in off season due to fallow period between harvest of first (main) season and sowing of second (off) season
areaMask	Multicropping area mask to be used "none": no mask applied (only for development purposes) "actual:total": currently multicropped areas calculated from total harvested areas and total physical areas per cell from readLandInG "actual:crop" (crop-specific), "actual:irrigation" (irrigation-specific), "actual:irrig_crop" (crop- and irrigation-specific) "total" "potential:endogenous": potentially multicropped areas given temperature and productivity limits "potential:exogenous": potentially multicropped areas given GAEZ suitability classification
output	output to be returned by the function: combination of crop type ("crops" or "grass") and season ("main" (LPJmL growing period), "year" (entire year)), separated by ":" ("crops:main", "crops:year", "grass:main", "grass:year")

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("BlueWaterConsumption", aggregate = FALSE)

## End(Not run)
```

---

calcCropareaAdjusted   *calcCropareaAdjusted*

Description

This returns croparea as reported by FAO and LUH for the initialization year and

Usage

```
calcCropareaAdjusted(iniyear, dataset = "LandInG", sectoral = "kcr")
```

Arguments

iniyear	initialization year
dataset	LUH or LandInG Note: once migration to Toolbox data is complete, this function can be replaced with calcCropareaLandInG
sectoral	crops to be reported: "kcr" for MAgPIE items, and "lpj" for LPJmL items

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("CropareaAdjusted", aggregate = FALSE)

## End(Not run)
```

calcCropAreaPotIrrig	*calcCropAreaPotIrrig*

Description

This function calculates croparea that is potentially available for irrigated agriculture per crop given a chosen cropmix

Usage

```
calcCropAreaPotIrrig(selectyears, comagyear, iniyear, cropmix, landScen)
```

Arguments

selectyears	Years to be returned
comagyear	If NULL: total potential croparea is used; if !NULL: already irrigated area is subtracted; year specified here is the year of the initialization used for cropland area initialization in calcIrrigatedArea (e.g. NULL, 1995, 2010)
iniyear	Initialization year for current cropland area
cropmix	Cropmix for which croparea share is calculated (options: "hist_irrig" for historical cropmix on currently irrigated area, "hist_total" for historical cropmix on total cropland, or selection of proxycrops as vector)
landScen	Land availability scenario consisting of two parts separated by ":": 1. available land scenario (currCropland, currIrrig, potCropland) 2. protection scenario (WDPA, or one of the scenarios available in calcConservationPriorities, e.g., 30by20, BH, BH_IFL, PBL_HalfEarth, or NA for no protection). For case of no land protection select "NA" in second part of argument or do not specify second part of the argument

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("CropAreaPotIrrig", aggregate = FALSE)

## End(Not run)
```

---

calcCropAreaShare *calcCropAreaShare*

Description

This function calculates the crop area share for a chosen cropmix

Usage

```
calcCropAreaShare(iniyear, cropmix)
```

Arguments

iniyear	Croparea initialization year
cropmix	Cropmix for which croparea share is calculated (options: "hist_irrig" for historical cropmix on currently irrigated area, "hist_rainf" for historical cropmix on currently irrigated area, "hist_total" for historical cropmix on total cropland, or selection of proxycrops)

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier, Benjamin L. Bodirsky

Examples

```
## Not run:
calcOutput("CropAreaShare", aggregate = FALSE)

## End(Not run)
```

---

calcCropProductionRevenue
                                calcCropProductionRevenue

Description

calculates irrigated and rainfed production quantities or revenue on given crop areas under selected management scenario. It can return quantities in terms of the sum of crop biomass produced in tDM or production revenue in terms of monetary revenue achieved in USD

Usage

```
calcCropProductionRevenue(
  outputtype,
  scenario,
  management,
  area,
  lpjml,
  climatetype,
  selectyears,
  iniyear,
  efrMethod,
  accessibilityrule,
  rankmethod,
  yieldcalib,
  allocationrule,
  gainthreshold,
  irrigationsystem,
  cropmix,
  comAg,
  transDist,
  fossilGW
)
```

Arguments

outputtype	"biomass": returns the production quantity in terms of crop biomass (in tDM) "revenue": returns the revenue in terms of price x quantity of crop production (in USD)
scenario	EFP and non-agricultural water use scenario separated with a "." (e.g. "on.ssp2")
management	management in terms of irrigation and multiple cropping practices consisting of multiple cropping scenario ("single", actMC", "potMC") and ("potential", "counterfactual") separated by ":" (e.g. "single:potential", "actMC:counterfactual") Multiple cropping practices: "single": single cropping assumed everywhere "actMC": multiple cropping as reported by LandInG data "potMC": multiple cropping practiced everywhere where it is possible Irrigation assumption: "potential": irrigation practiced where possible according to irrigation potentials or practiced according to area information (see param 'area') "counterfactual": production and revenue for counterfactual case that irrigated areas were managed under rainfed conditions
area	area scenario "actual": current cropland and currently irrigated areas or potentially irrigated areas following land availability defined in landScen scenario: consisting of two parts separated by ":": 1. available land scenario (currCropland, currIrrig, potCropland) 2. protection scenario (WDPA, or one of the scenarios available in calcConservationPriorities, e.g., 30by20, BH, BH_IFL, PBL_HalfEarth, or NA for no protection). For case of no land protection select "NA" in second part of argument or do not specify second part of the argument
lpjml	LPJmL version used

climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"
selectyears	Years for which irrigatable area is calculated
iniyear	Initialization year for initial croparea
efrMethod	EFR method used including selected strictness of EFRs (e.g. Smakhtin:good, VMF:fair)
accessibilityrule	
	Strictness of accessibility restriction: discharge that is exceeded x percent of the time on average throughout a year (Qx). (e.g. Q75: 0.25, Q50: 0.5)
rankmethod	Rank and optimization method consisting of Unit according to which rank is calculated: USD_ha (USD per hectare) for relative area return, or USD_m3 (USD per cubic meter) for relative volumetric return; USD for absolute return (total profit); Price aggregation: "GLO" for global average prices, or "ISO" for country-level prices and boolean indicating fullpotential (TRUE, i.e. cell receives full irrigation requirements in total area) or reduced potential (FALSE, reduced potential of cell receives at later stage in allocation algorithm); separated by ":"
yieldcalib	If TRUE: LPJmL yields calibrated to FAO country yield in iniyear Also needs specification of refYields, separated by ":". Options: FALSE (for single cropping analyses) or "TRUE:actual:irrig_crop" (for multiple cropping analyses) If FALSE: uncalibrated LPJmL yields are used
allocationrule	Rule to be applied for river basin discharge allocation across cells of river basin ("optimization", "upstreamfirst", "equality")
gainthreshold	Threshold of yield improvement potential required (in USD per hectare)
irrigationsystem	
	Irrigation system used ("surface", "sprinkler", "drip", "initialization")
cropmix	Selected cropmix (options: "hist_irrig" for historical cropmix on currently irrigated area, "hist_total" for historical cropmix on total cropland, "hist_rainf" for historical rainfed cropmix, or selection of proxycrops)
comAg	If TRUE: currently already irrigated areas in initialization year are reserved for irrigation, if FALSE: no irrigation areas reserved (irrigation potential)
transDist	Water transport distance allowed to fulfill locally unfulfilled water demand by surrounding cell water availability
fossilGW	If TRUE: non-renewable groundwater can be used. If FALSE: non-renewable groundwater cannot be used.

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("CropProductionRevenue", aggregate = FALSE)

## End(Not run)
```

---

calcCropYieldGain   *calcCropYieldGain*

Description

This function calculates the yield gains per crop through irrigation or multiple cropping relative to rainfed-single system production (including negatives)

Usage

```
calcCropYieldGain(
  lpjml,
  climatetype,
  yieldgaintype,
  priceAgg,
  iniyear,
  selectyears,
  yieldcalib,
  multicropping
)
```

Arguments

lpjml	LPJmL version used for yields
climatetype	Climate scenarios or historical baseline "GSWP3-W5E5:historical"
yieldgaintype	Crop yield gain through multiple cropping under rainfed conditions "multicropping_rf", multiple cropping under irrigated conditions "multicropping_ir", irrigation under single cropping conditions "irrigation_singlecropping" irrigation and multiple cropping "irrigation_multicropping"
priceAgg	Price aggregation: "GLO" for global average prices, or "ISO" for country-level prices, or "CONST" for same price for all crops
iniyear	initialization year for food price and cropmix area
selectyears	Years to be returned by the function
yieldcalib	If TRUE: LPJmL yields calibrated to FAO country yield in iniyear Also needs specification of refYields, separated by ":". Options: FALSE (for single cropping analyses) or "TRUE:actual:irrig_crop" (for multiple cropping analyses) If FALSE: uncalibrated LPJmL yields are used

multicropping	Multicropping activated (TRUE) or not (FALSE) and Multiple Cropping Suit-
	ability mask selected (mask can be: "none": no mask applied (only for devel-
	opment purposes) "actual:total": currently multicropped areas calculated from
	total harvested areas and total physical areas per cell from readLandInG "ac-
	tual:crop" (crop-specific), "actual:irrigation" (irrigation-specific), "actual:irrig_crop"
	(crop- and irrigation-specific) "total" "potential:endogenous": potentially multi-
	cropped areas given temperature and productivity limits "potential:exogenous":
	potentially multicropped areas given GAEZ suitability classification) (e.g. TRUE:actual:total;
	TRUE:none; FALSE)

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("CropYieldGain", aggregate = FALSE)

## End(Not run)
```

---

calcDischargeAccessibilityShare

calcDischargeAccessibilityShare

Description

This function calculates the share of discharge that is useable given the variability of monthly flows.
If discharge is highly variable, it is harder to bring into productive use and therefore water availabil-
ity (for human use) is reduced.

Usage

```
calcDischargeAccessibilityShare(
  lpjml,
  selectyears,
  climatetype,
  accessibilityrule
)
```

Arguments

`lpjml`	LPJmL version used
`selectyears`	Years to be returned (Note: does not affect years of harmonization or smoothing)
`climatetype`	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"
`accessibilityrule`	
	Method used: Quantile method (Q) or Coefficient of Variation (CV) combined with scalar value defining the strictness of accessibility restriction: discharge that is exceeded x percent of the time on average throughout a year is inaccessible (e.g. Q:1 all discharge accessible, Q:0.75 0.75-quantile is accessible everything that is more variable inaccessible) or base value for exponential curve, separated by : (CV:2)

Value

magpie object in cellular resolution representing share of discharge that is accessible to humans

Author(s)

Felicitas Beier, Jens Heinke

Examples

```
## Not run:
calcOutput("DischargeAccessibilityShare", aggregate = FALSE)

## End(Not run)
```

---

calcDischargeInaccessible

calcDischargeInaccessible

Description

This function calculates the discharge that is inaccessible to humans based on the variability of monthly flows and natural discharge.

Usage

```
calcDischargeInaccessible(lpjml, selectyears, climatetype, accessibilityrule)
```

Arguments

`lpjml`	LPJmL version required for respective inputs: natveg or crop
`selectyears`	Years to be returned (Note: does not affect years of harmonization or smoothing)
`climatetype`	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"
`accessibilityrule`	
	Method used: Quantile method (Q) or Coefficient of Variation (CV) combined with scalar value defining the strictness of accessibility restriction: discharge that is exceeded x percent of the time on average throughout a year (Qx, e.g. Q75: 0.25, Q50: 0.5) or base value for exponential curve separated by : (CV:2)

Value

magpie object in cellular resolution representing discharge that is inaccessible to humans

Author(s)

Felicitas Beier, Jens Heinke

Examples

```
## Not run:
calcOutput("DischargeInaccessible", aggregate = FALSE)

## End(Not run)
```

---

calcDischargeInaccessibleAdd

calcDischargeInaccessibleAdd

Description

This function calculates water that is inaccessible to humans but not part of EFRs. Reason: Inaccessible discharge is highly variable discharge that can also serve as high flow requirements (HFR) for EFRs. This has to be accounted in the Discharge Allocation Algorithm for the determination of potential irrigation.

Usage

```
calcDischargeInaccessibleAdd(
  selectyears = selectyears,
  lpjml = lpjml,
  climatetype = climatetype,
  accessibilityrule = accessibilityrule,
  efrMethod = efrMethod
)
```

Arguments

selectyears	Years to be returned (Note: does not affect years of harmonization or smoothing)
lpjml	LPJmL version used
climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"
accessibilityrule	
	Method used: Quantile method (Q) or Coefficient of Variation (CV) combined with scalar value defining the strictness of accessibility restriction: discharge that is exceeded x percent of the time on average throughout a year (Qx, e.g. Q75: 0.25, Q50: 0.5) or base value for exponential curve separated by : (CV:2)
efrMethod	EFR method used including selected strictness of EFRs (Smakhtin:good, VMF:fair)

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("DischargeInaccessibleAdd", aggregate = FALSE)

## End(Not run)
```

---

calcEconOfIrrig *calcEconOfIrrig*

Description

calculates potentially irrigated area for different gainthresholds subject to land and water constraints

Usage

```
calcEconOfIrrig(
  scenario,
  output,
  gtrange,
  selectyears,
  iniyear,
  lpjml,
  climatetype,
  efrMethod,
  accessibilityrule,
```

```
  rankmethod,
  yieldcalib,
  allocationrule,
  irrigationsystem,
  landScen,
  cropmix,
  transDist,
  fossilGW,
  comAg,
  multicropping
)
```

Arguments

scenario	non-agricultural water use scenario
output	output to be displayed: irrigated area "IrrigArea" or available water volume "wat_ag_ww" "wat_ag_wc"
gtrange	range of x-axis (gainthreshold) to be depicted on the curve
selectyears	years for which irrigatable area is calculated
iniyear	initialization year
lpjml	LPJmL version required for respective inputs: natveg or crop
climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"
efrMethod	EFR method used including selected strictness of EFRs (e.g. Smakhtin:good, VMF:fair)
accessibilityrule	
	Method used: Quantile method (Q) or Coefficient of Variation (CV) combined with scalar value defining the strictness of accessibility restriction: discharge that is exceeded x percent of the time on average throughout a year (Qx, e.g. Q75: 0.25, Q50: 0.5) or base value for exponential curve separated by : (CV:2)
rankmethod	Rank and optimization method consisting of Unit according to which rank is calculated: USD_ha (USD per hectare) for relative area return, or USD_m3 (USD per cubic meter) for relative volumetric return; USD for absolute return (total profit); Price aggregation: "GLO" for global average prices, or "ISO" for country-level prices and boolean indicating fullpotential (TRUE, i.e. cell receives full irrigation requirements in total area) or reduced potential (FALSE, reduced potential of cell receives at later stage in allocation algorithm); separated by ":"
yieldcalib	If TRUE: LPJmL yields calibrated to FAO country yield in iniyear Also needs specification of refYields, separated by ":". Options: FALSE (for single cropping analyses) or "TRUE:actual:irrig_crop" (for multiple cropping analyses) If FALSE: uncalibrated LPJmL yields are used
allocationrule	Rule to be applied for river basin discharge allocation across cells of river basin ("optimization", "upstreamfirst", "equality")
irrigationsystem	
	Irrigation system used ("surface", "sprinkler", "drip", "initialization")

landScen	Land availability scenario consisting of two parts separated by ":": 1. available land scenario (currCropland, currIrrig, potCropland) 2. protection scenario (WDPA, or one of the scenarios available in calcConservationPriorities, e.g., 30by20, BH, BH_IFL, PBL_HalfEarth, or NA for no protection). For case of no land protection select "NA" in second part of argument or do not specify second part of the argument
cropmix	Selected cropmix (options: "hist_irrig" for historical cropmix on currently irrigated area, "hist_total" for historical cropmix on total cropland, or selection of proxycrops)
transDist	Water transport distance allowed to fulfill locally unfulfilled water demand by surrounding cell water availability
fossilGW	If TRUE: non-renewable groundwater can be used. If FALSE: non-renewable groundwater cannot be used.
comAg	if TRUE: the currently already irrigated areas in initialization year are reserved for irrigation, if FALSE: no irrigation areas reserved (irrigation potential)
multicropping	Multicropping activated (TRUE) or not (FALSE) and Multiple Cropping Suitability mask selected (mask can be: "none": no mask applied (only for development purposes) "actual:total": currently multicropped areas calculated from total harvested areas and total physical areas per cell from readLandInG "actual:crop" (crop-specific), "actual:irrigation" (irrigation-specific), "actual:irrig_crop" (crop- and irrigation-specific) "total" "potential:endogenous": potentially multicropped areas given temperature and productivity limits "potential:exogenous": potentially multicropped areas given GAEZ suitability classification) (e.g. TRUE:actual:total; TRUE:none; FALSE)

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcEconOfIrrig(aggregate = FALSE)

## End(Not run)
```

---

calcEFRviolations   *calcEFRviolations*

Description

This function calculates grid cell specific violation of environmental flow requirements

Usage

```
calcEFRviolations(
  lpjml,
  selectyears,
  climatetype,
  efrMethod,
  transDist,
  accessibilityrule,
  rankmethod,
  yieldcalib,
  allocationrule,
  gainthreshold,
  irrigationsystem,
  iniyear,
  landScen,
  cropmix,
  comAg,
  multicropping,
  scenario,
  cellular = TRUE
)
```

Arguments

lpjml	LPJmL version used
selectyears	Years for which irrigatable area is calculated
climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"
efrMethod	EFR method used including selected strictness of EFRs (e.g. Smakhtin:good, VMF:fair)
transDist	Water transport distance allowed to fulfill locally unfulfilled water demand
accessibilityrule	
	Strictness of accessibility restriction: discharge that is exceeded x percent of the time on average throughout a year (Qx). (e.g. Q75: 0.25, Q50: 0.5)
rankmethod	Rank and optimization method consisting of Unit according to which rank is calculated: USD_ha (USD per hectare) for relative area return, or USD_m3 (USD per cubic meter) for relative volumetric return; USD for absolute return (total profit); Price aggregation: "GLO" for global average prices, or "ISO" for

country-level prices and boolean indicating fullpotential (TRUE, i.e. cell receives full irrigation requirements in total area) or reduced potential (FALSE, reduced potential of cell receives at later stage in allocation algorithm); separated by ":"

yieldcalib   If TRUE: LPJmL yields calibrated to FAO country yield in iniyear Also needs specification of refYields, separated by ":". Options: FALSE (for single cropping analyses) or "TRUE:actual:irrig_crop" (for multiple cropping analyses) If FALSE: uncalibrated LPJmL yields are used

allocationrule   Rule to be applied for river basin discharge allocation across cells of river basin ("optimization", "upstreamfirst", "equality")

gainthreshold   Threshold of yield improvement potential required (in USD per hectare)

irrigationsystem
                 Irrigation system used ("surface", "sprinkler", "drip", "initialization")

iniyear   Initialization year of irrigation system

landScen   Land availability scenario consisting of two parts separated by ":": 1. available land scenario (currCropland, currIrrig, potCropland) 2. protection scenario (WDPA, or one of the scenarios available in calcConservationPriorities, e.g., 30by20, BH, BH_IFL, PBL_HalfEarth, or NA for no protection). For case of no land protection select "NA" in second part of argument or do not specify second part of the argument

cropmix   Selected cropmix (options: "hist_irrig" for historical cropmix on currently irrigated area, "hist_total" for historical cropmix on total cropland, or selection of proxycrops)

comAg   If TRUE: currently already irrigated areas in initialization year are reserved for irrigation, if FALSE: no irrigation areas reserved (irrigation potential)

multicropping   Multicropping activated (TRUE) or not (FALSE) and Multiple Cropping Suitability mask selected (mask can be: "none": no mask applied (only for development purposes) "actual:total": currently multicropped areas calculated from total harvested areas and total physical areas per cell from readLandInG "actual:crop" (crop-specific), "actual:irrigation" (irrigation-specific), "actual:irrig_crop" (crop- and irrigation-specific) "total" "potential:endogenous": potentially multicropped areas given temperature and productivity limits "potential:exogenous": potentially multicropped areas given GAEZ suitability classification) (e.g. TRUE:actual:total; TRUE:none; FALSE)

scenario   Combination of EFP ("on", "off") and non-ag. water use scenario ("ssp2", "ISIMIP", ...) separated by "."

cellular   If TRUE: cellular data returned. If FALSE: aggregated to basins

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier, Benjamin Leon Bodirsky

Examples

```
## Not run:
calcOutput("EFRviolations", aggregate = FALSE)

## End(Not run)
```

---

calcEnvmtlFlowRequirements

calcEnvmtlFlowRequirements

Description

This function calculates environmental flow requirements (EFR) based on EFR share calculated from LPJmL monthly discharge

Usage

```
calcEnvmtlFlowRequirements(lpjml, selectyears, climatetype, efrMethod)
```

Arguments

lpjml	LPJmL version used
selectyears	Years to be returned (Note: does not affect years of harmonization or smoothing)
climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"
efrMethod	EFR method used including selected strictness of EFRs (Smakhtin:good, VMF:fair)

Value

magpie object with EFRs, LFRs and HFRs in cellular resolution

Author(s)

Felicitas Beier, Jens Heinke

Examples

```
## Not run:
calcOutput("EnvmtlFlowRequirements", aggregate = FALSE)

## End(Not run)
```

calcEnvmtlFlowRequirementsInaccess
calcEnvmtlFlowRequirementsInaccess

Description

This function calculates environmental flow requirements (EFR) that are inaccessible to humans based on EFRs and inaccessible discharge calculated from LPJmL monthly discharge

Usage

```
calcEnvmtlFlowRequirementsInaccess(
  lpjml,
  selectyears,
  climatetype,
  efrMethod,
  accessibilityrule
)
```

Arguments

lpjml	LPJmL version used
selectyears	Years to be returned (Note: does not affect years of harmonization or smoothing)
climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"
efrMethod	EFR method used including selected strictness of EFRs (Smakhtin:good, VMF:fair)
accessibilityrule	
	Method used: Quantile method (Q) or Coefficient of Variation (CV) combined with scalar value defining the strictness of accessibility restriction: discharge that is exceeded x percent of the time on average throughout a year (Qx, e.g. Q75: 0.25, Q50: 0.5) or base value for exponential curve separated by : (CV:2)

Value

magpie object with EFRs, LFRs and HFRs in cellular resolution

Author(s)

Felicitas Beier, Jens Heinke

Examples

```
## Not run:
calcOutput("calcEnvmtlFlowRequirementsInaccess", aggregate = FALSE)

## End(Not run)
```

---

calcEnvmtlFlowRequirementsShare
calcEnvmtlFlowRequirementsShare

Description

This function calculates environmental flow requirements (EFR) (as share of discharge) based on LPJmL monthly discharge

Usage

```
calcEnvmtlFlowRequirementsShare(lpjml, climatetype, efrMethod)
```

Arguments

lpjml	LPJmL version used for monthly discharge
climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"
efrMethod	EFR method used including selected strictness of EFRs (e.g. Smakhtin:good, VMF:fair, PB:Rockstroem)

Value

magpie object in cellular resolution representing share of discharge that is reserved for environmental flows

Author(s)

Felicitas Beier, Jens Heinke

Examples

```
## Not run:
calcOutput("EnvmtlFlowRequirementsShare", aggregate = FALSE)

## End(Not run)
```

---

calcFullIrrigationRequirement

calcFullIrrigationRequirement

Description

This function calculates the water requirements for full irrigation per cell per crop given potentially available land

Usage

```
calcFullIrrigationRequirement(
  lpjml,
  climatetype,
  selectyears,
  iniyear,
  comagyear,
  irrigationsystem,
  landScen,
  cropmix,
  multicropping
)
```

Arguments

lpjml	LPJmL version used
climatetype	Climate model or historical baseline "GSWP3-W5E5:historical"
selectyears	Years to be returned
iniyear	Croparea initialization year
comagyear	if !NULL: already irrigated area is subtracted; if NULL: total potential land area is used; year specified here is the year of the initialization used for cropland area initialization in calcIrrigatedArea
irrigationsystem	
	Irrigation system used: system share as in initialization year, or drip, surface, sprinkler for full irrigation by selected system
landScen	Land availability scenario consisting of two parts separated by ":": 1. available land scenario (currCropland, currIrrig, potCropland) 2. protection scenario (WDPA, or one of the scenarios available in calcConservationPriorities, e.g., 30by20, BH, BH_IFL, PBL_HalfEarth, or NA for no protection). For case of no land protection select "NA" in second part of argument or do not specify second part of the argument
cropmix	Selected cropmix (options: "hist_irrig" for historical cropmix on currently irrigated area, "hist_total" for historical cropmix on total cropland, or selection of proxycrops)

multicropping   Multicropping activated (TRUE) or not (FALSE) and Multiple Cropping Suit-
                 ability mask selected (mask can be: "none": no mask applied (only for devel-
                 opment purposes) "actual:total": currently multicropped areas calculated from
                 total harvested areas and total physical areas per cell from readLandInG "ac-
                 tual:crop" (crop-specific), "actual:irrigation" (irrigation-specific), "actual:irrig_crop"
                 (crop- and irrigation-specific) "total" "potential:endogenous": potentially multi-
                 cropped areas given temperature and productivity limits "potential:exogenous":
                 potentially multicropped areas given GAEZ suitability classification) (e.g. TRUE:actual:total;
                 TRUE:none; FALSE)

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("FullIrrigationRequirement", aggregate = FALSE)

## End(Not run)
```

---

calcGrassET   *calcGrassET*

Description

Calculates evapotranspiration (ET) of grassland under irrigated and rainfed conditions based on
LPJmL inputs.

Usage

```
calcGrassET(selectyears, lpjml, climatetype, season)
```

Arguments

selectyears   Years to be returned

lpjml   LPJmL version required for respective inputs: natveg or crop

climatetype   Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"

season   "wholeYear": grass et in the entire year (main + off season) "mainSeason": grass
               etP in the crop-specific growing period of LPJmL (main season)

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("GrassET", aggregate = FALSE)

## End(Not run)
```

---

calcGrowingPeriod   *calcGrowingPeriod*

Description

This function determines a mean sowing date and a mean growing period for each cell in order to determine when irrigation can take place.

Usage

```
calcGrowingPeriod(
  lpjml = c(natveg = "LPJmL4_for_MAgPIE_44ac93de", crop =
    "ggcmi_phase3_nchecks_9ca735cb"),
  climatetype = "GSWP3-W5E5:historical",
  stage = "harmonized2020",
  yield_ratio = 0.1,
  cells = "lpjcell"
)
```

Arguments

lpjml	Defines LPJmL version for crop/grass and natveg specific inputs
climatetype	Switch between different climate scenarios
stage	Degree of processing: raw, smoothed, harmonized, harmonized2020
yield_ratio	threshold for cell yield over global average. crops in cells below threshold will be ignored
cells	Number of cells to be returned (select "magpiecell" for 59199 cells or "lpjcell" for 67420 cells)

Value

magpie object in cellular resolution

Author(s)

Kristine Karstens, Felicitas Beier

Examples

```
## Not run:
calcOutput("GrowingPeriod", aggregate = FALSE)

## End(Not run)
```

---

calcIrrigAreaActuallyCommitted
                    calcIrrigAreaActuallyCommitted

Description

calculates area reserved for irrigation based on area irrigated in initialization and available water resources

Usage

```
calcIrrigAreaActuallyCommitted(
  lpjml,
  climatetype,
  selectyears,
  iniyear,
  efrMethod,
  fossilGW,
  multicropping,
  transDist
)
```

Arguments

lpjml	LPJmL version used
climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"
selectyears	Years to be returned (Note: does not affect years of harmonization or smoothing)
iniyear	Initialization year of irrigation system
efrMethod	EFR method used including selected strictness of EFRs (Smakhtin:good, VMF:fair)
fossilGW	If TRUE: non-renewable groundwater can be used. If FALSE: non-renewable groundwater cannot be used.

multicropping	Multicropping activated (TRUE) or not (FALSE) and Multiple Cropping Suitability mask selected (mask can be: "none": no mask applied (only for development purposes) "actual:total": currently multicropped areas calculated from total harvested areas and total physical areas per cell from readLandInG "actual:crop" (crop-specific), "actual:irrigation" (irrigation-specific), "actual:irrig_crop" (crop- and irrigation-specific) "total" "potential:endogenous": potentially multicropped areas given temperature and productivity limits "potential:exogenous": potentially multicropped areas given GAEZ suitability classification) (e.g. TRUE:actual:total; TRUE:none; FALSE)
transDist	Water transport distance allowed to fulfill locally unfulfilled water demand by surrounding cell water availability

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("IrrigAreaActuallyCommitted", aggregate = FALSE)

## End(Not run)
```

---

calcIrrigAreaCommitted

calcIrrigAreaCommitted

Description

calculates area reserved for irrigation based on area irrigated in initialization year and depreciation parameter (set to 0.1)

Usage

```
calcIrrigAreaCommitted(selectyears, iniyear)
```

Arguments

selectyears	select years
iniyear	initialization year

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("IrrigAreaCommitted", aggregate = FALSE)

## End(Not run)
```

```
calcIrrigatableAreaUnlimited
```
calcIrrigatableAreaUnlimited

Description

calculates area that can potentially be irrigated given chosen land scenario and gainthreshold

Usage

```
calcIrrigatableAreaUnlimited(
  selectyears,
  iniyear,
  landScen,
  lpjml,
  climatetype,
  cropmix,
  yieldcalib,
  irrigationsystem,
  unit,
  gainthreshold,
  multicropping
)
```

Arguments

selectyears	years for which irrigatable area is calculated
iniyear	initialization year
landScen	Land availability scenario consisting of two parts separated by ":": 1. available land scenario (currCropland, currIrrig, potCropland) 2. protection scenario (WDPA, or one of the scenarios available in calcConservationPriorities, e.g., 30by20, BH, BH_IFL, PBL_HalfEarth, or NA for no protection). For case of no

	land protection select "NA" in second part of argument or do not specify second part of the argument
lpjml	LPJmL version required for respective inputs: natveg or crop
climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"
cropmix	Selected cropmix (options: "hist_irrig" for historical cropmix on currently irrigated area, "hist_total" for historical cropmix on total cropland, or selection of proxycrops)
yieldcalib	If TRUE: LPJmL yields calibrated to FAO country yield in iniyear Also needs specification of refYields, separated by ":". Options: FALSE (for single cropping analyses) or "TRUE:actual:irrig_crop" (for multiple cropping analyses) If FALSE: uncalibrated LPJmL yields are used
irrigationsystem	
	Irrigation system used: system share as in initialization year, or drip, surface, sprinkler for full irrigation by selected system
unit	Unit of yield improvement potential to be returned and level of price aggregation used, separated by ":". Unit: USD_ha (USD per hectare) for relative area return, or USD_m3 (USD per cubic meter) for relative volumetric return; USD for absolute return (total profit); Price aggregation: "GLO" for global average prices, or "ISO" for country-level prices
gainthreshold	Threshold of yield improvement potential (in USD per hectare)
multicropping	Multicropping activated (TRUE) or not (FALSE)

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("IrrigatableAreaUnlimited", aggregate = FALSE)

## End(Not run)
```

---

calcIrrigationSystem *calcIrrigationSystem*

Description

This function returns the irrigation system share initialization

Usage

```
calcIrrigationSystem(datasource)
```

Arguments

datasource   Data source to be used: Jaegermeyr (irrigation system share based on FAO 2014, ICID 2012 and Rohwer et al. 2007) or LPJmL (dominant irrigation system per country)

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("IrrigationSystem", datasource = "Jaegermeyr", aggregate = FALSE)

## End(Not run)
```

---

calcIrrigCellranking   *calcIrrigCellranking*

Description

This function calculates a cellranking for the river basin discharge allocation based on yield improvement potential through irrigation

Usage

```
calcIrrigCellranking(
  lpjml,
  climatetype,
  cellrankyear,
  iniyear,
  comagyear,
  irrigationsystem,
  landScen,
  method,
  cropmix,
  yieldcalib,
  multicropping
)
```

Arguments

lpjml	LPJmL version used for yields
climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical" for yields
cellrankyear	Year(s) for which cell rank is calculated
iniyear	Initialization year for price
comagyear	if !NULL: already irrigated area is subtracted; if NULL: total potential land area is used; year specified here is the year of the initialization used for cropland area initialization in calcIrrigatedArea
irrigationsystem	
	Irrigation system used: system share as in initialization year, or drip, surface, sprinkler for full irrigation by selected system
landScen	Land availability scenario consisting of two parts separated by ":": 1. available land scenario (currCropland, currIrrig, potCropland) 2. protection scenario (WDPA, or one of the scenarios available in calcConservationPriorities, e.g., 30by20, BH, BH_IFL, PBL_HalfEarth, or NA for no protection). For case of no land protection select "NA" in second part of argument or do not specify second part of the argument
method	Rank and optimization method consisting of Unit according to which rank is calculated: tDM (tons per dry matter), USD_ha (USD per hectare) for relative area return, or USD_m3 (USD per cubic meter) for relative volumetric return; USD for absolute return (total profit); Price aggregation: "GLO" for global average prices, or "ISO" for country-level prices; and boolean indicating fullpotential (TRUE) or reduced potential (FALSE)
cropmix	Selected cropmix for which yield improvement potential is calculated (options: "hist_irrig" for historical cropmix on currently irrigated area, "hist_total" for historical cropmix on total cropland, or selection of proxycrops) NULL returns all crops individually
yieldcalib	If TRUE: LPJmL yields calibrated to FAO country yield in iniyear Also needs specification of refYields, separated by ":". Options: FALSE (for single cropping analyses) or "TRUE:actual:irrig_crop" (for multiple cropping analyses) If FALSE: uncalibrated LPJmL yields are used
multicropping	Multicropping activated (TRUE) or not (FALSE)

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("IrrigCellranking", aggregate = FALSE)
```

```
## End(Not run)
```

calcIrrigCropYieldGain

calcIrrigCropYieldGain

Description

This function calculates the yield gains per crop through irrigation (including negatives)

Usage

```
calcIrrigCropYieldGain(
  lpjml,
  climatetype,
  priceAgg,
  iniyear,
  selectyears,
  yieldcalib,
  multicropping
)
```

Arguments

lpjml	LPJmL version used for yields
climatetype	Climate scenarios or historical baseline "GSWP3-W5E5:historical"
priceAgg	Price aggregation: "GLO" for global average prices, or "ISO" for country-level prices, or "CONST" for same price for all crops
iniyear	initialization year for food price and cropmix area
selectyears	Years to be returned by the function
yieldcalib	If TRUE: LPJmL yields calibrated to FAO country yield in iniyear Also needs specification of refYields, separated by ":". Options: FALSE (for single cropping analyses) or "TRUE:actual:irrig_crop" (for multiple cropping analyses) If FALSE: uncalibrated LPJmL yields are used
multicropping	Multicropping activated (TRUE) or not (FALSE)

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("IrrigCropYieldGain", aggregate = FALSE)

## End(Not run)
```

calcIrrigSystemShr   *calcIrrigSystemShr*

Description

This function returns the share of the irrigation area under a specific irrigation system type (surface, sprinkler, drip) per crop type

Usage

```
calcIrrigSystemShr(iniyear)
```

Arguments

iniyear   Year to be used for irrigation system share initialization

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("IrrigSystemShr", aggregate = FALSE)

## End(Not run)
```

calcIrrigWatRequirements

calcIrrigWatRequirements

Description

This function calculates irrigation water requirements based on LPJmL blue water consumption of crops and considering irrigation efficiencies

Usage

```
calcIrrigWatRequirements(selectyears, lpjml, climatetype, multicropping)
```

Arguments

selectyears	Years to be returned
lpjml	LPJmL version required for respective inputs: natveg or crop
climatetype	Climate model or historical baseline "GSWP3-W5E5:historical"
multicropping	Multicropping activated (TRUE) or not (FALSE) and Multiple Cropping Suitability mask selected (mask can be: "none": no mask applied (only for development purposes) "actual:total": currently multicropped areas calculated from total harvested areas and total physical areas per cell from LandInG "actual:crop" (crop-specific), "actual:irrigation" (irrigation-specific), "actual:irrig_crop" (crop- and irrigation-specific) "total" "potential:endogenous": potentially multicropped areas given temperature and productivity limits "potential:exogenous": potentially multicropped areas given GAEZ suitability classification) (e.g. TRUE:actual:total; TRUE:none; FALSE)

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier, Jens Heinke

Examples

```
## Not run:
calcOutput("IrrigWatRequirements", aggregate = FALSE)

## End(Not run)
```

---

calcIrrigYieldImprovementPotential
calcIrrigYieldImprovementPotential

Description

This function calculates the yield improvement potential through irrigation for all grid cells given a certain crop mix

Usage

```
calcIrrigYieldImprovementPotential(
  lpjml,
  climatetype,
  unit,
  iniyear,
  selectyears,
  comagyear,
  cropmix,
  landScen,
  irrigationsystem,
  yieldcalib,
  multicropping
)
```

Arguments

lpjml	LPJmL version used for yields
climatetype	Climate scenarios or historical baseline "GSWP3-W5E5:historical"
unit	Unit of yield improvement potential to be returned and level of price aggregation used, separated by ":". Unit: USD_ha (USD per hectare) for relative area return, or USD_m3 (USD per cubic meter) for relative volumetric return; USD for absolute return (total profit); for relative return according to area and volume. Price aggregation: "GLO" for global average prices, or "ISO" for country-level prices
iniyear	initialization year for food price and cropmix area
selectyears	Years to be returned by the function
comagyear	if !NULL: already irrigated area is subtracted; if NULL: total potential land area is used; year specified here is the year of the initialization used for cropland area initialization in calcIrrigatedArea
cropmix	Selected cropmix for which yield improvement potential is calculated (options: "hist_irrig" for historical cropmix on currently irrigated area, "hist_total" for historical cropmix on total cropland, or selection of proxycrops) NULL returns all crops individually

landScen   Land availability scenario consisting of two parts separated by ":": 1. avail-
                      able land scenario (currCropland, currIrrig, potCropland) 2. protection scenario
                      (WDPA, or one of the scenarios available in calcConservationPriorities, e.g.,
                      30by20, BH, BH_IFL, PBL_HalfEarth, or NA for no protection). For case of no
                      land protection select "NA" in second part of argument or do not specify second
                      part of the argument

irrigationsystem

                      Irrigation system used: system share as in initialization year, or drip, surface,
                      sprinkler for full irrigation by selected system

yieldcalib   If TRUE: LPJmL yields calibrated to FAO country yield in iniyear Also needs
                      specification of refYields, separated by ":". Options: FALSE (for single crop-
                      ping analyses) or "TRUE:actual:irrig_crop" (for multiple cropping analyses) If
                      FALSE: uncalibrated LPJmL yields are used

multicropping   Multicropping activated (TRUE) or not (FALSE)

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("IrrigYieldImprovementPotential", aggregate = FALSE)

## End(Not run)
```

---

calcMissingWater   *calcMissingWater*

Description

Calculates difference between requested water and water that can be fulfilled in algorithm given
available surface water resources for all scenarios. This information is used to derive non-renewable
groundwater use.

Usage

```
calcMissingWater(
  output,
  lpjml,
  climatetype,
  transDistGW = 100,
```

```
  multicropping = "TRUE:actual:irrig_crop",
  selectyears,
  iniyear
)
```

Arguments

output	sector to be reported: non-agricultural sector water use ("nonAg"), (committed) agricultural water use ("comAg"), or both ("total")
lpjml	LPJmL version used
climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"
transDistGW	Water transport distance allowed to fulfill locally unfulfilled water demand by surrounding cell water availability to determine missing water that is tagged as non-renewable groundwater
multicropping	Multicropping activated (TRUE) or not (FALSE) and Multiple Cropping Suitability mask selected (mask can be: "none": no mask applied (only for development purposes) "actual:total": currently multicropped areas calculated from total harvested areas and total physical areas per cell from LandInG "actual:crop" (crop-specific), "actual:irrigation" (irrigation-specific), "actual:irrig_crop" (crop- and irrigation-specific) "total" "potential:endogenous": potentially multicropped areas given temperature and productivity limits "potential:exogenous": potentially multicropped areas given GAEZ suitability classification) (e.g. TRUE:actual:total; TRUE:none; FALSE)
selectyears	Years to be returned
iniyear	Initialization year

Value

cellular magpie object

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("MissingWater", aggregate = FALSE)

## End(Not run)
```

calcNonrenGroundwatUse

calcNonrenGroundwatUse

Description

Calculates current non-renewable (fossil) groundwater use as negative difference between water availability from renewable sources and human water use (consumption and withdrawal). The water use in the initialization year is fixed in the future as non-renewable groundwater.

Usage

```
calcNonrenGroundwatUse(
  output,
  lpjml,
  climatetype,
  transDistGW = 100,
  multicropping = "TRUE:actual:irrig_crop",
  selectyears,
  iniyear
)
```

Arguments

output	"total": total groundwater use (non-agricultural and agricultural), "nonAg": groundwater use in non-agricultural sector (industry, domestic, electricity), "comAg": groundwater use in agricultural sector (currently irrigated area)
lpjml	LPJmL version used
climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"
transDistGW	Water transport distance allowed to fulfill locally unfulfilled water demand by surrounding cell water availability to determine missing water that is tagged as non-renewable groundwater
multicropping	Multicropping activated (TRUE) or not (FALSE) and Multiple Cropping Suitability mask selected (mask can be: "none": no mask applied (only for development purposes) "actual:total": currently multicropped areas calculated from total harvested areas and total physical areas per cell from LandInG "actual:crop" (crop-specific), "actual:irrigation" (irrigation-specific), "actual:irrig_crop" (crop- and irrigation-specific) "total" "potential:endogenous": potentially multicropped areas given temperature and productivity limits "potential:exogenous": potentially multicropped areas given GAEZ suitability classification) (e.g. TRUE:actual:total; TRUE:none; FALSE)
selectyears	Years to be returned
iniyear	Initialization year

Value

cellular magpie object

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("NonrenGroundwatUse", aggregate = FALSE)

## End(Not run)
```

---

calcPotIrrigAreas   *calcPotIrrigAreas*

Description

Calculates Potentially Irrigated Areas (PIAs) per crop given available water and land

Usage

```
calcPotIrrigAreas(
  cropAggregation,
  lpjml,
  climatetype,
  selectyears,
  iniyear,
  efrMethod,
  accessibilityrule,
  rankmethod,
  yieldcalib,
  allocationrule,
  gainthreshold,
  irrigationsystem,
  landScen,
  cropmix,
  comAg,
  fossilGW,
  multicropping,
  transDist
)
```

Arguments

cropAggregation

TRUE (aggregated Potentially Irrigated Areas (PIAs)), FALSE (crop-specific PIAs)

lpjml   LPJmL version used

climatetype   Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"

selectyears   Years for which irrigatable area is calculated

iniyear   Initialization year for initial croparea

efrMethod   EFR method used including selected strictness of EFRs (e.g. Smakhtin:good, VMF:fair)

accessibilityrule

Strictness of accessibility restriction: discharge that is exceeded x percent of the time on average throughout a year (Qx). (e.g. Q75: 0.25, Q50: 0.5)

rankmethod   Rank and optimization method consisting of Unit according to which rank is calculated: USD_ha (USD per hectare) for relative area return, or USD_m3 (USD per cubic meter) for relative volumetric return; USD for absolute return (total profit); Price aggregation: "GLO" for global average prices, or "ISO" for country-level prices and boolean indicating fullpotential (TRUE, i.e. cell receives full irrigation requirements in total area) or reduced potential (FALSE, reduced potential of cell receives at later stage in allocation algorithm); separated by ":"

yieldcalib   If TRUE: LPJmL yields calibrated to FAO country yield in iniyear Also needs specification of refYields, separated by ":". Options: FALSE (for single cropping analyses) or "TRUE:actual:irrig_crop" (for multiple cropping analyses) If FALSE: uncalibrated LPJmL yields are used

allocationrule   Rule to be applied for river basin discharge allocation across cells of river basin ("optimization", "upstreamfirst", "equality")

gainthreshold   Threshold of yield improvement potential required (in USD per hectare)

irrigationsystem

Irrigation system used ("surface", "sprinkler", "drip", "initialization")

landScen   Land availability scenario consisting of two parts separated by ":": 1. available land scenario (currCropland, currIrrig, potCropland) 2. protection scenario (WDPA, or one of the scenarios available in calcConservationPriorities, e.g., 30by20, BH, BH_IFL, PBL_HalfEarth, or NA for no protection). For case of no land protection select "NA" in second part of argument or do not specify second part of the argument

cropmix   Selected cropmix (options: "hist_irrig" for historical cropmix on currently irrigated area, "hist_total" for historical cropmix on total cropland, or selection of proxycrops)

comAg   If TRUE: currently already irrigated areas in initialization year are reserved for irrigation, if FALSE: no irrigation areas reserved (irrigation potential)

fossilGW   If TRUE: non-renewable groundwater can be used. If FALSE: non-renewable groundwater cannot be used.

multicropping	Multicropping activated (TRUE) or not (FALSE) and Multiple Cropping Suitability mask selected (mask can be: "none": no mask applied (only for development purposes) "actual:total": currently multicropped areas calculated from total harvested areas and total physical areas per cell from LandInG "actual:crop" (crop-specific), "actual:irrigation" (irrigation-specific), "actual:irrig_crop" (crop- and irrigation-specific) "total" "potential:endogenous": potentially multicropped areas given temperature and productivity limits "potential:exogenous": potentially multicropped areas given GAEZ suitability classification) (e.g. TRUE:actual:total; TRUE:none; FALSE)
transDist	Water transport distance allowed to fulfill locally unfulfilled water demand by surrounding cell water availability

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("PotIrrigAreas", aggregate = FALSE)

## End(Not run)
```

---

calcPotMulticroppingShare

calcPotMulticroppingShare

Description

Calculates share of currently irrigated areas that is multiple cropped. On areas where irrigation expansion takes place, full multiple cropping is assumed.

Usage

```
calcPotMulticroppingShare(
  scenario,
  lpjml,
  climatetype,
  selectyears,
  iniyear,
  efrMethod,
  accessibilityrule,
  rankmethod,
```

```
    yieldcalib,
    allocationrule,
    gainthreshold,
    irrigationsystem,
    landScen,
    cropmix,
    comAg,
    fossilGW,
    multicropping,
    transDist
)
```

Arguments

scenario	EFP and non-agricultural water use scenario separated with a "." (e.g. "on.ssp2")
lpjml	LPJmL version used
climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"
selectyears	Years for which irrigatable area is calculated
iniyear	Initialization year for initial croparea
efrMethod	EFR method used including selected strictness of EFRs (e.g. Smakhtin:good, VMF:fair)
accessibilityrule	
	Strictness of accessibility restriction: discharge that is exceeded x percent of the time on average throughout a year (Qx). (e.g. Q75: 0.25, Q50: 0.5)
rankmethod	Rank and optimization method consisting of Unit according to which rank is calculated: USD_ha (USD per hectare) for relative area return, or USD_m3 (USD per cubic meter) for relative volumetric return; USD for absolute return (total profit); Price aggregation: "GLO" for global average prices, or "ISO" for country-level prices and boolean indicating fullpotential (TRUE, i.e. cell receives full irrigation requirements in total area) or reduced potential (FALSE, reduced potential of cell receives at later stage in allocation algorithm); separated by ":"
yieldcalib	If TRUE: LPJmL yields calibrated to FAO country yield in iniyear Also needs specification of refYields, separated by ":". Options: FALSE (for single cropping analyses) or "TRUE:actual:irrig_crop" (for multiple cropping analyses) If FALSE: uncalibrated LPJmL yields are used
allocationrule	Rule to be applied for river basin discharge allocation across cells of river basin ("optimization", "upstreamfirst", "equality")
gainthreshold	Threshold of yield improvement potential required (in USD per hectare)
irrigationsystem	
	Irrigation system used ("surface", "sprinkler", "drip", "initialization")
landScen	Land availability scenario consisting of two parts separated by ":": 1. available land scenario (currCropland, currIrrig, potCropland) 2. protection scenario (WDPA, or one of the scenarios available in calcConservationPriorities, e.g., 30by20, BH, BH_IFL, PBL_HalfEarth, or NA for no protection). For case of no

land protection select "NA" in second part of argument or do not specify second part of the argument

cropmix   Selected cropmix (options: "hist_irrig" for historical cropmix on currently irrigated area, "hist_total" for historical cropmix on total cropland, or selection of proxycrops)

comAg   If TRUE: currently already irrigated areas in initialization year are reserved for irrigation, if FALSE: no irrigation areas reserved (irrigation potential)

fossilGW   If TRUE: non-renewable groundwater can be used. If FALSE: non-renewable groundwater cannot be used.

multicropping   Multicropping activated (TRUE) or not (FALSE) and Multiple Cropping Suitability mask selected (mask can be: "none": no mask applied (only for development purposes) "actual:total": currently multicropped areas calculated from total harvested areas and total physical areas per cell from LandInG "actual:crop" (crop-specific), "actual:irrigation" (irrigation-specific), "actual:irrig_crop" (crop- and irrigation-specific) "total" "potential:endogenous": potentially multicropped areas given temperature and productivity limits "potential:exogenous": potentially multicropped areas given GAEZ suitability classification) (e.g. TRUE:actual:total; TRUE:none; FALSE)

transDist   Water transport distance allowed to fulfill locally unfulfilled water demand by surrounding cell water availability

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("PotMulticroppingShare", aggregate = FALSE)

## End(Not run)
```

---

calcPotWater   *calcPotWater*

Description

This function returns the potential water quantity (separated into withdrawal and consumption) available for different uses

Usage

```
calcPotWater(
  lpjml,
  selectyears,
  climatetype,
  efrMethod,
  accessibilityrule,
  rankmethod,
  yieldcalib,
  allocationrule,
  gainthreshold,
  irrigationsystem,
  iniyear,
  landScen,
  cropmix,
  comAg,
  fossilGW,
  multicropping,
  transDist
)
```

Arguments

lpjml	LPJmL version used
selectyears	Years for which irrigatable area is calculated
climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"
efrMethod	EFR method used including selected strictness of EFRs (e.g. Smakhtin:good, VMF:fair)
accessibilityrule	
	Strictness of accessibility restriction: discharge that is exceeded x percent of the time on average throughout a year (Qx). (e.g. Q75: 0.25, Q50: 0.5)
rankmethod	Rank and optimization method consisting of Unit according to which rank is calculated: USD_ha (USD per hectare) for relative area return, or USD_m3 (USD per cubic meter) for relative volumetric return; USD for absolute return (total profit); Price aggregation: "GLO" for global average prices, or "ISO" for country-level prices and boolean indicating fullpotential (TRUE, i.e. cell receives full irrigation requirements in total area) or reduced potential (FALSE, reduced potential of cell receives at later stage in allocation algorithm); separated by ":"
yieldcalib	If TRUE: LPJmL yields calibrated to FAO country yield in iniyear Also needs specification of refYields, separated by ":". Options: FALSE (for single cropping analyses) or "TRUE:actual:irrig_crop" (for multiple cropping analyses) If FALSE: uncalibrated LPJmL yields are used
allocationrule	Rule to be applied for river basin discharge allocation across cells of river basin ("optimization", "upstreamfirst", "equality")
gainthreshold	Threshold of yield improvement potential required (in USD per hectare)

irrigationsystem

                Irrigation system used ("surface", "sprinkler", "drip", "initialization")

iniyear	Initialization year of irrigation system
landScen	Land availability scenario consisting of two parts separated by ":": 1. available land scenario (currCropland, currIrrig, potCropland) 2. protection scenario (WDPA, or one of the scenarios available in calcConservationPriorities, e.g., 30by20, BH, BH_IFL, PBL_HalfEarth, or NA for no protection). For case of no land protection select "NA" in second part of argument or do not specify second part of the argument
cropmix	Selected cropmix (options: "hist_irrig" for historical cropmix on currently irrigated area, "hist_total" for historical cropmix on total cropland, or selection of proxycrops)
comAg	If TRUE: currently already irrigated areas in initialization year are reserved for irrigation, if FALSE: no irrigation areas reserved (irrigation potential)
fossilGW	If TRUE: non-renewable groundwater can be used. If FALSE: non-renewable groundwater cannot be used.
multicropping	Multicropping activated (TRUE) or not (FALSE) and Multiple Cropping Suitability mask selected ("endogenous": suitability for multiple cropping determined by rules based on grass and crop productivity "exogenous": suitability for multiple cropping given by GAEZ data set), separated by ":" (e.g. TRUE:endogenous; TRUE:exogenous; FALSE)
transDist	Water transport distance allowed to fulfill locally unfulfilled water demand by surrounding cell water availability

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier, Jens Heinke

Examples

```
## Not run:
calcOutput("PotWater", aggregate = FALSE)

## End(Not run)
```

---

calcRiverDischargeAllocation

                calcRiverDischargeAllocation

Description

This function distributes surplus basin discharge after the previous river routings following certain management assumptions

Usage

```
calcRiverDischargeAllocation(
  lpjml,
  climatetype,
  selectyears,
  efrMethod,
  accessibilityrule,
  transDist,
  rankmethod,
  yieldcalib,
  allocationrule,
  gainthreshold,
  irrigationsystem,
  iniyear,
  landScen,
  cropmix,
  comAg,
  multicropping
)
```

Arguments

lpjml	LPJmL version used
climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"
selectyears	Years to be returned (Note: does not affect years of harmonization or smoothing)
efrMethod	EFR method used including selected strictness of EFRs (e.g. Smakhtin:good, VMF:fair)
accessibilityrule	
	Method used: Quantile method (Q) or Coefficient of Variation (CV) combined with scalar value defining the strictness of accessibility restriction: discharge that is exceeded x percent of the time on average throughout a year (Qx, e.g. Q75: 0.25, Q50: 0.5) or base value for exponential curve separated by : (CV:2)
transDist	Water transport distance allowed to fulfill locally unfulfilled water demand
rankmethod	Rank and optimization method consisting of Unit according to which rank is calculated: USD_ha (USD per hectare) for relative area return, or USD_m3 (USD per cubic meter) for relative volumetric return; USD for absolute return (total profit); Price aggregation: "GLO" for global average prices, or "ISO" for country-level prices and boolean indicating fullpotential (TRUE, i.e. cell receives full irrigation requirements in total area) or reduced potential (FALSE, reduced potential of cell receives at later stage in allocation algorithm); separated by ":"
yieldcalib	If TRUE: LPJmL yields calibrated to FAO country yield in iniyear Also needs specification of refYields, separated by ":". Options: FALSE (for single cropping analyses) or "TRUE:actual:irrig_crop" (for multiple cropping analyses) If FALSE: uncalibrated LPJmL yields are used

allocationrule	Rule to be applied for river basin discharge allocation ("optimization" or "upstreamfirst")
gainthreshold	Threshold of yield improvement potential (in USD per hectare)
irrigationsystem	
	Irrigation system to be used for river basin discharge allocation algorithm ("surface", "sprinkler", "drip", "initialization")
iniyear	Initialization year of irrigation system
landScen	Land availability scenario consisting of two parts separated by ":": 1. available land scenario (currCropland, currIrrig, potCropland) 2. protection scenario (WDPA, or one of the scenarios available in calcConservationPriorities, e.g., 30by20, BH, BH_IFL, PBL_HalfEarth, or NA for no protection). For case of no land protection select "NA" in second part of argument or do not specify second part of the argument
cropmix	Selected cropmix (options: "hist_irrig" for historical cropmix on currently irrigated area, "hist_total" for historical cropmix on total cropland, or selection of proxycrops)
comAg	if TRUE: the currently already irrigated areas in initialization year are reserved for irrigation, if FALSE: no irrigation areas reserved (irrigation potential)
multicropping	Multicropping activated (TRUE) or not (FALSE) and Multiple Cropping Suitability mask selected (mask can be: "none": no mask applied (only for development purposes) "actual:total": currently multicropped areas calculated from total harvested areas and total physical areas per cell from LandInG "actual:crop" (crop-specific), "actual:irrigation" (irrigation-specific), "actual:irrig_crop" (crop- and irrigation-specific) "total" "potential:endogenous": potentially multicropped areas given temperature and productivity limits "potential:exogenous": potentially multicropped areas given GAEZ suitability classification) (e.g. TRUE:actual:total; TRUE:none; FALSE)

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier, Jens Heinke

Examples

```
## Not run:
calcOutput("RiverDischargeAllocation", aggregate = FALSE)

## End(Not run)
```

---

calcRiverHumanUseAccounting

calcRiverHumanUseAccounting

Description

This function calculates human uses and reserved water along the river

Usage

```
calcRiverHumanUseAccounting(
  iteration,
  lpjml,
  climatetype,
  selectyears,
  iniyear,
  efrMethod,
  multicropping,
  transDist,
  comAg,
  accessibilityrule,
  rankmethod,
  gainthreshold,
  cropmix,
  yieldcalib,
  irrigationsystem,
  landScen
)
```

Arguments

iteration	Water use to be allocated in this river routing iteration (non_agriculture, committed_agriculture, committed_agriculture_fullMulticropping, potential_irrigation,
lpjml	LPJmL version used
climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"
selectyears	Years to be returned (Note: does not affect years of harmonization or smoothing)
iniyear	Initialization year of irrigation system
efrMethod	EFR method used including selected strictness of EFRs (Smakhtin:good, VMF:fair)
multicropping	Multicropping activated (TRUE) or not (FALSE) and Multiple Cropping Suitability mask selected (mask can be: "none": no mask applied (only for development purposes) "actual:total": currently multicropped areas calculated from total harvested areas and total physical areas per cell from LandInG "actual:crop" (crop-specific), "actual:irrigation" (irrigation-specific), "actual:irrig_crop" (crop- and irrigation-specific) "total" "potential:endogenous": potentially multicropped

	areas given temperature and productivity limits "potential:exogenous": potentially multicropped areas given GAEZ suitability classification) (e.g. TRUE:actual:total; TRUE:none; FALSE)
transDist	Water transport distance allowed to fulfill locally unfulfilled water demand by surrounding cell water availability
comAg	if TRUE: the currently already irrigated areas in initialization year are reserved for irrigation, if FALSE: no irrigation areas reserved (irrigation potential). Only relevant for iteration = potential
accessibilityrule	
	(For case of iteration = "potential_irrigation" only:) Method used: Quantile method (Q) or Coefficient of Variation (CV) combined with scalar value defining the strictness of accessibility restriction: discharge that is exceeded x percent of the time on average throughout a year (Qx, e.g. Q75: 0.25, Q50: 0.5) or base value for exponential curve separated by : (CV:2)
rankmethod	Rank and optimization method consisting of Unit according to which rank is calculated: USD_ha (USD per hectare) for relative area return, or USD_m3 (USD per cubic meter) for relative volumetric return; USD for absolute return (total profit); Price aggregation: "GLO" for global average prices, or "ISO" for country-level prices and boolean indicating fullpotential (TRUE, i.e. cell receives full irrigation requirements in total area) or reduced potential (FALSE, reduced potential of cell receives at later stage in allocation algorithm); separated by ":"
gainthreshold	(For case of iteration = "potential_irrigation" only:) Threshold of yield improvement potential (same unit as in rankmethod)
cropmix	(For case of iteration = "potential_irrigation" only:) Selected cropmix (options: "hist_irrig" for historical cropmix on currently irrigated area, "hist_total" for historical cropmix on total cropland, or selection of proxycrops)
yieldcalib	(For case of iteration = "potential_irrigation" only:) If TRUE: LPJmL yields calibrated to FAO country yield in iniyear Also needs specification of refYields, separated by ":". Options: FALSE (for single cropping analyses) or "TRUE:actual:irrig_crop" (for multiple cropping analyses) If FALSE: uncalibrated LPJmL yields are used
irrigationsystem	
	(For case of iteration = "potential_irrigation" only:) Irrigation system to be used for river basin discharge allocation algorithm ("surface", "sprinkler", "drip", "initialization")
landScen	Land availability scenario consisting of two parts separated by ":": 1. available land scenario (currCropland, currIrrig, potCropland) 2. protection scenario (WDPA, or one of the scenarios available in calcConservationPriorities, e.g., 30by20, BH, BH_IFL, PBL_HalfEarth, or NA for no protection). For case of no land protection select "NA" in second part of argument or do not specify second part of the argument

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier, Jens Heinke

Examples

```
## Not run:
calcOutput("RiverHumanUseAccounting", aggregate = FALSE)

## End(Not run)
```

---

calcRiverNaturalFlows *calcRiverNaturalFlows*

Description

This function calculates natural discharge for the river routing derived from inputs from LPJmL

Usage

```
calcRiverNaturalFlows(selectyears, lpjml, climatetype)
```

Arguments

selectyears	Years to be returned (Note: does not affect years of harmonization or smoothing)
lpjml	LPJmL version used
climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier, Jens Heinke

Examples

```
## Not run:
calcOutput("RiverNaturalFlows", aggregate = FALSE)

## End(Not run)
```

---

calcRiverRoutingInputs

calcRiverRoutingInputs

Description

This function collects inputs necessary for the different river routings depending on the chosen settings

Usage

```
calcRiverRoutingInputs(
  lpjml,
  climatetype,
  selectyears,
  iniyear,
  iteration,
  transDist,
  efrMethod,
  accessibilityrule,
  multicropping,
  comAg,
  rankmethod,
  gainthreshold,
  cropmix,
  yieldcalib,
  irrigationsystem,
  landScen
)
```

Arguments

lpjml	LPJmL version used
climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"
selectyears	Years to be returned (Note: does not affect years of harmonization or smoothing)
iniyear	Initialization year of irrigation system
iteration	Water use to be allocated in this river routing iteration (non_agriculture, committed_agriculture, potential_irrigation, committed_agriculture_fullMulticropping).
transDist	Water transport distance allowed to fulfill locally unfulfilled water demand by surrounding cell water availability
efrMethod	EFR method used including selected strictness of EFRs (e.g. Smakhtin:good, VMF:fair)
accessibilityrule	
	Water accessibility rule. Available methods: Quantile method (Q) or Coefficient of Variation (CV); combined with scalar value defining the strictness of accessibility restriction: discharge that is exceeded x percent of the time on average

	throughout a year (Qx, e.g. Q75: 0.25, Q50: 0.5) or base value for exponential curve separated by : (CV:2)
multicropping	Multicropping activated (TRUE) or not (FALSE) and Multiple Cropping Suitability mask selected (mask can be: "none": no mask applied (only for development purposes) "actual:total": currently multicropped areas calculated from total harvested areas and total physical areas per cell from LandInG "actual:crop" (crop-specific), "actual:irrigation" (irrigation-specific), "actual:irrig_crop" (crop- and irrigation-specific) "total" "potential:endogenous": potentially multicropped areas given temperature and productivity limits "potential:exogenous": potentially multicropped areas given GAEZ suitability classification) (e.g. TRUE:actual:total; TRUE:none; FALSE)
comAg	if TRUE: the currently already irrigated areas in initialization year are reserved for irrigation, if FALSE: no irrigation areas reserved (irrigation potential). Only relevant for iteration = potential
rankmethod	Rank and optimization method consisting of Unit according to which rank is calculated: USD_ha (USD per hectare) for relative area return, or USD_m3 (USD per cubic meter) for relative volumetric return; USD for absolute return (total profit); Price aggregation: "GLO" for global average prices, or "ISO" for country-level prices and boolean indicating fullpotential (TRUE, i.e. cell receives full irrigation requirements in total area) or reduced potential (FALSE, reduced potential of cell receives at later stage in allocation algorithm); separated by ":"
gainthreshold	Threshold of yield improvement potential (in USD per hectare)
cropmix	Selected cropmix (options: "hist_irrig" for historical cropmix on currently irrigated area, "hist_total" for historical cropmix on total cropland, or selection of proxycrops)
yieldcalib	If TRUE: LPJmL yields calibrated to FAO country yield in iniyear Also needs specification of refYields, separated by ":". Options: FALSE (for single cropping analyses) or "TRUE:actual:irrig_crop" (for multiple cropping analyses) If FALSE: uncalibrated LPJmL yields are used
irrigationsystem	
	Irrigation system to be used for river basin discharge allocation algorithm ("surface", "sprinkler", "drip", "initialization")
landScen	Land availability scenario consisting of two parts separated by ":": 1. available land scenario (currCropland, currIrrig, potCropland) 2. protection scenario (WDPA, or one of the scenarios available in calcConservationPriorities, e.g., 30by20, BH, BH_IFL, PBL_HalfEarth, or NA for no protection). For case of no land protection select "NA" in second part of argument or do not specify second part of the argument

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("RiverRoutingInputs", aggregate = FALSE)

## End(Not run)
```

---

calcShrHumanUsesFulfilled

calcShrHumanUsesFulfilled

Description

calculates of share of current non-agricultural and irrigation that can be fulfilled given renewable water availability of the algorithm

Usage

```
calcShrHumanUsesFulfilled(
  lpjml,
  climatetype,
  transDist,
  multicropping,
  selectyears,
  iniyear,
  efrMethod
)
```

Arguments

lpjml	LPJmL version used
climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"
transDist	Water transport distance allowed to fulfill locally unfulfilled water demand by surrounding cell water availability
multicropping	Multicropping activated (TRUE) or not (FALSE) and Multiple Cropping Suitability mask selected (mask can be: "none": no mask applied (only for development purposes) "actual:total": currently multicropped areas calculated from total harvested areas and total physical areas per cell from LandInG "actual:crop" (crop-specific), "actual:irrigation" (irrigation-specific), "actual:irrig_crop" (crop- and irrigation-specific) "total" "potential:endogenous": potentially multicropped areas given temperature and productivity limits "potential:exogenous": potentially multicropped areas given GAEZ suitability classification) (e.g. TRUE:actual:total; TRUE:none; FALSE)
selectyears	Years to be returned
iniyear	Initialization year
efrMethod	EFR method used including selected strictness of EFRs (e.g. Smakhtin:good, VMF:fair)

Value

cellular magpie object

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("ShrHumanUsesFulfilled", aggregate = FALSE)

## End(Not run)
```

---

calcWaterUseActuallyCommittedAg

calcWaterUseActuallyCommittedAg

Description

This function calculates committed agricultural water uses that are used in the river routing algorithm for distributing available water across the basin

Usage

```
calcWaterUseActuallyCommittedAg(
  iteration = "committed_agriculture",
  lpjml,
  climatetype,
  selectyears,
  iniyear,
  multicropping,
  efrMethod,
  fossilGW,
  transDist
)
```

Arguments

iteration	Default: "committed_agriculture", Special case: "committed_agriculture_fullPotential". Special case should only be used for calculation of full multicropping potential committed agricultural area for case of Current Irrigation.
lpjml	LPJmL version required for respective inputs: natveg or crop
climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"
selectyears	Years to be returned

iniyear	Year of initialization for cropland area
multicropping	Multicropping activated (TRUE) or not (FALSE) and Multiple Cropping Suitability mask selected (mask can be: "none": no mask applied (only for development purposes) "actual:total": currently multicropped areas calculated from total harvested areas and total physical areas per cell from LandInG "actual:crop" (crop-specific), "actual:irrigation" (irrigation-specific), "actual:irrig_crop" (crop- and irrigation-specific) "total" "potential:endogenous": potentially multicropped areas given temperature and productivity limits "potential:exogenous": potentially multicropped areas given GAEZ suitability classification) (e.g. TRUE:actual:total; TRUE:none; FALSE)
efrMethod	EFR method used including selected strictness of EFRs (e.g. Smakhtin:good, VMF:fair)
fossilGW	If TRUE: non-renewable groundwater can be used. If FALSE: non-renewable groundwater cannot be used.
transDist	Water transport distance allowed to fulfill locally unfulfilled water demand by surrounding cell water availability

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("WaterUseActuallyCommittedAg", aggregate = FALSE)

## End(Not run)
```

---

calcWaterUseCommittedAg

calcWaterUseCommittedAg

Description

This function calculates committed agricultural water uses that are used in the river routing algorithm for distributing available water across the basin

Usage

```
calcWaterUseCommittedAg(
  lpjml,
  climatetype,
  selectyears,
  iniyear,
  multicropping
)
```

Arguments

lpjml	LPJmL version required for respective inputs: natveg or crop
climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"
selectyears	Years to be returned
iniyear	Year of initialization for cropland area
multicropping	Multicropping activated (TRUE) or not (FALSE) and Multiple Cropping Suitability mask selected (mask can be: "none": no mask applied (only for development purposes) "actual:total": currently multicropped areas calculated from total harvested areas and total physical areas per cell from LandInG "actual:crop" (crop-specific), "actual:irrigation" (irrigation-specific), "actual:irrig_crop" (crop- and irrigation-specific) "total" "potential:endogenous": potentially multicropped areas given temperature and productivity limits "potential:exogenous": potentially multicropped areas given GAEZ suitability classification) (e.g. TRUE:actual:total; TRUE:none; FALSE)

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier, Jens Heinke

Examples

```
## Not run:
calcOutput("WaterUseCommittedAg", aggregate = FALSE)

## End(Not run)
```

calcWaterUseNonAg *calcWaterUseNonAg*

Description

This function extracts non-agricultural water demand

Usage

```
calcWaterUseNonAg(
  selectyears = seq(1995, 2100, by = 5),
  cells = "lpjcell",
  datasource = "WATCH_ISIMIP_WATERGAP",
  usetype = "all",
  seasonality = "grper",
  harmonType = "average",
  lpjml = c(natveg = "LPJmL4_for_MAgPIE_44ac93de", crop =
    "ggcmi_phase3_nchecks_9ca735cb"),
  climatetype = "GSWP3-W5E5:historical"
)
```

Arguments

selectyears	Years to be returned
cells	Number of cells to be returned (select "magpiecell" for 59199 cells or "lpjcell" for 67420 cells)
datasource	Data source to be used (e.g. WATERGAP2020)
usetype	water use types (domestic, industry, electricity) and option to return withdrawals or consumption separated by ":" (e.g. "all:withdrawal") options for first argument: "total" (returns the sum over different water use types) or "all" (returns all water use types (domestic, industry, electricity)) options for second argument: "all", "withdrawal", "consumption"
seasonality	grper (default): non-agricultural water demand in growing period per year; total: non-agricultural water demand throughout the year
harmonType	Type of time smoothing: average (average over 8-year time span around baseline year) or spline (time smoothing using spline method with 4 degrees of freedom) or NULL (no smoothing)
lpjml	Defines LPJmL version for crop/grass and natveg specific inputs
climatetype	Switch between different climate scenarios for calcGrowingPeriod

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("WaterUseNonAg", aggregate = FALSE)

## End(Not run)
```

---

calcYearlyRunoff   *calcYearlyRunoff*

Description

This function calculates yearly runoff from runoff on land and water provided by LPJmL

Usage

```
calcYearlyRunoff(selectyears, lpjml, climatetype)
```

Arguments

selectyears	Years to be returned (Note: does not affect years of harmonization or smoothing)
lpjml	LPJmL version required for respective inputs: natveg or crop
climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier, Jens Heinke

Examples

```
## Not run:
calcOutput("YearlyRunoff", aggregate = FALSE)

## End(Not run)
```

calcYieldgainArea	*calcYieldgainArea*

Description

reports potentially irrigated area depending on gainthreshold and land constraint only

Usage

```
calcYieldgainArea(
  rangeGT,
  lpjml,
  selectyears,
  iniyear,
  climatetype,
  yieldcalib,
  unit,
  irrigationsystem,
  landScen,
  cropmix,
  multicropping
)
```

Arguments

rangeGT	Range of gainthreshold for calculation of potentially irrigated areas (in USD per hectare)
lpjml	LPJmL version required for respective inputs: natveg or crop
selectyears	Years for which irrigatable area is calculated
iniyear	Initialization year for cropland area
climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"
yieldcalib	If TRUE: LPJmL yields calibrated to FAO country yield in iniyear Also needs specification of refYields, separated by ":". Options: FALSE (for single cropping analyses) or "TRUE:actual:irrig_crop" (for multiple cropping analyses) If FALSE: uncalibrated LPJmL yields are used
unit	Unit of yield improvement potential used as threshold, consisting of unit and price aggregation level separated by ":". Unit: tDM (tons per dry matter), USD_ha (USD per hectare) for area return, or USD_m3 (USD per cubic meter) for volumetric return. Price aggregation: "GLO" for global average prices, or "ISO" for country-level prices
irrigationsystem	
	Irrigation system used: system share as in initialization year, or drip, surface, sprinkler for full irrigation by selected system

landScen   Land availability scenario consisting of two parts separated by ":": 1. avail-
                  able land scenario (currCropland, currIrrig, potCropland) 2. protection scenario
                  (WDPA, or one of the scenarios available in calcConservationPriorities, e.g.,
                  30by20, BH, BH_IFL, PBL_HalfEarth, or NA for no protection). For case of no
                  land protection select "NA" in second part of argument or do not specify second
                  part of the argument

cropmix   Selected cropmix (options: "hist_irrig" for historical cropmix on currently irri-
                  gated area, "hist_total" for historical cropmix on total cropland, or selection of
                  proxycrops)

multicropping   Multicropping activated (TRUE) or not (FALSE)

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcYieldgainArea(rangeGT = seq(0, 10000, by = 100), scenario = "ssp2")

## End(Not run)
```

---

calcYieldgainPotential

calcYieldgainPotential

Description

reports yield gain potential for irrigatable area under different scenarios

Usage

```
calcYieldgainPotential(
  scenario,
  selectyears,
  iniyear,
  lpjml,
  climatetype,
  efrMethod,
  yieldcalib,
  irrigationsystem,
  accessibilityrule,
```

```
    rankmethod,
    gainthreshold,
    allocationrule,
    transDist,
    fossilGW,
    landScen,
    cropmix,
    multicropping,
    unlimited
)
```

Arguments

scenario	Non-agricultural water use and EFP scenario, separated by "." (e.g. "on.ssp2")
selectyears	Years for which yield gain potential is calculated
iniyear	Initialization year
lpjml	LPJmL version used
climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"
efrMethod	EFR method used including selected strictness of EFRs (e.g. Smakhtin:good, VMF:fair)
yieldcalib	If TRUE: LPJmL yields calibrated to FAO country yield in iniyear Also needs specification of refYields, separated by ":". Options: FALSE (for single cropping analyses) or "TRUE:actual:irrig_crop" (for multiple cropping analyses) If FALSE: uncalibrated LPJmL yields are used
irrigationsystem	
	Irrigation system used ("surface", "sprinkler", "drip", "initialization")
accessibilityrule	
	Strictness of accessibility restriction: discharge that is exceeded x percent of the time on average throughout a year (Qx). (e.g. Q75: 0.25, Q50: 0.5)
rankmethod	Rank and optimization method consisting of Unit according to which rank is calculated: USD_ha (USD per hectare) for relative area return, or USD_m3 (USD per cubic meter) for relative volumetric return; USD for absolute return (total profit); Price aggregation: "GLO" for global average prices, or "ISO" for country-level prices and boolean indicating fullpotential (TRUE, i.e. cell receives full irrigation requirements in total area) or reduced potential (FALSE, reduced potential of cell receives at later stage in allocation algorithm); separated by ":"
gainthreshold	Threshold of yield improvement potential required (in USD per hectare)
allocationrule	Rule to be applied for river basin discharge allocation across cells of river basin ("optimization", "upstreamfirst", "equality")
transDist	Water transport distance allowed to fulfill locally unfulfilled water demand by surrounding cell water availability
fossilGW	If TRUE: non-renewable groundwater can be used. If FALSE: non-renewable groundwater cannot be used.

landScen   Land availability scenario consisting of two parts separated by ":": 1. avail-
                    able land scenario (currCropland, currIrrig, potCropland) 2. protection scenario
                    (WDPA, or one of the scenarios available in calcConservationPriorities, e.g.,
                    30by20, BH, BH_IFL, PBL_HalfEarth, or NA for no protection). For case of no
                    land protection select "NA" in second part of argument or do not specify second
                    part of the argument

cropmix   Selected cropmix (options: "hist_irrig" for historical cropmix on currently irri-
                    gated area, "hist_total" for historical cropmix on total cropland, or selection of
                    proxycrops)

multicropping   Multicropping activated (TRUE) or not (FALSE) and Multiple Cropping Suit-
                    ability mask selected (mask can be: "none": no mask applied (only for develop-
                    ment purposes) "actual:total": currently multicropped areas calculated from to-
                    tal harvested areas and total physical areas per cell from LandInG "actual:crop"
                    (crop-specific), "actual:irrigation" (irrigation-specific), "actual:irrig_crop" (crop-
                    and irrigation-specific) "total" "potential:endogenous": potentially multicropped
                    areas given temperature and productivity limits "potential:exogenous": poten-
                    tially multicropped areas given GAEZ suitability classification) (e.g. TRUE:actual:total;
                    TRUE:none; FALSE)

unlimited   TRUE: no water limitation to potentially irrigated area FALSE: irrigatable area
                    limited by water availability

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("YieldgainPotential", aggregate = FALSE)

## End(Not run)
```

---

calcYieldgainWatUse   *calcYieldgainWatUse*

Description

This function calculates water use on selected land areas without considering water constraints

Usage

```
calcYieldgainWatUse(
  lpjml,
  climatetype,
  selectyears,
  iniyear,
  landScen,
  cropmix,
  yieldcalib,
  multicropping,
  unit,
  irrigationsystem,
  rangeGT
)
```

Arguments

lpjml	LPJmL version required for respective inputs: natveg or crop
climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"
selectyears	Years to be returned
iniyear	Year of initialization for cropland area
landScen	Land availability scenario consisting of two parts separated by ":": 1. available land scenario (currCropland, currIrrig, potCropland) 2. protection scenario (WDPA, or one of the scenarios available in calcConservationPriorities, e.g., 30by20, BH, BH_IFL, PBL_HalfEarth, or NA for no protection). For case of no land protection select "NA" in second part of argument or do not specify second part of the argument
cropmix	Selected cropmix (options: "hist_irrig" for historical cropmix on currently irrigated area, "hist_total" for historical cropmix on total cropland, or selection of proxycrops)
yieldcalib	If TRUE: LPJmL yields calibrated to FAO country yield in iniyear Also needs specification of refYields, separated by ":". Options: FALSE (for single cropping analyses) or "TRUE:actual:irrig_crop" (for multiple cropping analyses) If FALSE: uncalibrated LPJmL yields are used
multicropping	Multicropping activated (TRUE) or not (FALSE) and Multiple Cropping Suitability mask selected (mask can be: "none": no mask applied (only for development purposes) "actual:total": currently multicropped areas calculated from total harvested areas and total physical areas per cell from LandInG "actual:crop" (crop-specific), "actual:irrigation" (irrigation-specific), "actual:irrig_crop" (crop- and irrigation-specific) "total" "potential:endogenous": potentially multicropped areas given temperature and productivity limits "potential:exogenous": potentially multicropped areas given GAEZ suitability classification) (e.g. TRUE:actual:total; TRUE:none; FALSE)
unit	Unit of yield improvement potential to be returned and level of price aggregation used, separated by ":". Unit: USD_ha (USD per hectare) for relative area return, or USD_m3 (USD per cubic meter) for relative volumetric return; USD

for absolute return (total profit); Price aggregation: "GLO" for global average prices, or "ISO" for country-level prices

irrigationsystem

Irrigation system used: system share as in initialization year, or drip, surface, sprinkler for full irrigation by selected system

rangeGT   Range of gainthreshold for calculation of potentially irrigated areas (in USD per hectare)

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("YieldgainWatUse", aggregate = FALSE)

## End(Not run)
```

---

calcYieldImprovementPotential
                    calcYieldImprovementPotential

Description

This function calculates the yield improvement potential through irrigation or multiple cropping per grid cell for a given cropmix

Usage

```
calcYieldImprovementPotential(
  lpjml,
  climatetype,
  yieldgaintype,
  priceAgg,
  iniyear,
  selectyears,
  cropmix,
  yieldcalib,
  multicropping
)
```

Arguments

`lpjml`	LPJmL version used for yields
`climatetype`	Climate scenarios or historical baseline "GSWP3-W5E5:historical"
`yieldgaintype`	Crop yield gain through multiple cropping under rainfed conditions "multicropping_rf", multiple cropping under irrigated conditions "multicropping_ir", irrigation under single cropping conditions "irrigation_singlecropping" irrigation and multiple cropping "irrigation_multicropping"
`priceAgg`	Price aggregation: "GLO" for global average prices, or "ISO" for country-level prices, or "CONST" for same price for all crops
`iniyear`	initialization year for food price and cropmix area
`selectyears`	Years to be returned by the function
`cropmix`	Selected cropmix for which yield improvement potential is calculated (options: "hist_irrig" for historical cropmix on currently irrigated area, "hist_total" for historical cropmix on total cropland, or selection of proxycrops) NULL returns all crops individually
`yieldcalib`	If TRUE: LPJmL yields calibrated to FAO country yield in iniyear Also needs specification of refYields, separated by ":". Options: FALSE (for single cropping analyses) or "TRUE:actual:irrig_crop" (for multiple cropping analyses) If FALSE: uncalibrated LPJmL yields are used
`multicropping`	Multicropping activated (TRUE) or not (FALSE) and Multiple Cropping Suitability mask selected (mask can be: "none": no mask applied (only for development purposes) "actual:total": currently multicropped areas calculated from total harvested areas and total physical areas per cell from LandInG "actual:crop" (crop-specific), "actual:irrigation" (irrigation-specific), "actual:irrig_crop" (crop- and irrigation-specific) "total" "potential:endogenous": potentially multicropped areas given temperature and productivity limits "potential:exogenous": potentially multicropped areas given GAEZ suitability classification) (e.g. TRUE:actual:total; TRUE:none; FALSE)

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("YieldImprovementPotential", aggregate = FALSE)

## End(Not run)
```

calcYieldsAdjusted   *calcYieldsAdjusted*

Description

This function returns irrigated and rainfed yields for MAgPIE crops.

Usage

```
calcYieldsAdjusted(
  lpjml,
  climatetype,
  iniyear,
  selectyears,
  yieldcalib,
  multicropping
)
```

Arguments

lpjml	LPJmL version used
climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical" for yields
iniyear	Year to be used for cropland of yield calibration
selectyears	Years to be returned by the function
yieldcalib	If TRUE: LPJmL yields calibrated to FAO country yield in iniyear Also needs specification of refYields, separated by ":". Options: FALSE (for single cropping analyses) or "TRUE:actual:irrig_crop" (for multiple cropping analyses) If FALSE: uncalibrated LPJmL yields are used
multicropping	Multicropping activated (TRUE) or not (FALSE) and Multiple Cropping Suitability mask selected (mask can be: "none": no mask applied (only for development purposes) "actual:total": currently multicropped areas calculated from total harvested areas and total physical areas per cell from LandInG "actual:crop" (crop-specific), "actual:irrigation" (irrigation-specific), "actual:irrig_crop" (crop- and irrigation-specific) "total" "potential:endogenous": potentially multicropped areas given temperature and productivity limits "potential:exogenous": potentially multicropped areas given GAEZ suitability classification) (e.g. TRUE:actual:total; TRUE:none; FALSE)

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("YieldsAdjusted", aggregate = FALSE)

## End(Not run)
```

---

calcYieldsValued   *calcYieldsValued*

Description

This function calculates yields per crop valued at FAO prices (in USD per hectare)

Usage

```
calcYieldsValued(
  lpjml,
  climatetype,
  priceAgg,
  iniyear,
  selectyears,
  yieldcalib,
  multicropping
)
```

Arguments

lpjml	LPJmL version used for yields
climatetype	Climate scenarios or historical baseline "GSWP3-W5E5:historical"
priceAgg	Price aggregation: "GLO" for global average prices, or "ISO" for country-level prices, or "CONST" for same price for all crops
iniyear	initialization year for food price and cropmix area
selectyears	Years to be returned by the function
yieldcalib	If TRUE: LPJmL yields calibrated to FAO country yield in iniyear Also needs specification of refYields, separated by ":". Options: FALSE (for single cropping analyses) or "TRUE:actual:irrig_crop" (for multiple cropping analyses) If FALSE: uncalibrated LPJmL yields are used
multicropping	Multicropping activated (TRUE) or not (FALSE) and Multiple Cropping Suitability mask selected (mask can be: "none": no mask applied (only for development purposes) "actual:total": currently multicropped areas calculated from total harvested areas and total physical areas per cell from LandInG "actual:crop" (crop-specific), "actual:irrigation" (irrigation-specific), "actual:irrig_crop" (crop- and irrigation-specific) "total" "potential:endogenous": potentially multicropped areas given temperature and productivity limits "potential:exogenous": potentially multicropped areas given GAEZ suitability classification) (e.g. TRUE:actual:total; TRUE:none; FALSE)

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier

Examples

```
## Not run:
calcOutput("YieldsValued", aggregate = FALSE)

## End(Not run)
```

---

correctDams *correctDams*

Description

Read dam file (no source information available)

Usage

```
correctDams(x)
```

Arguments

x   magpie object provided by the read function

Value

List of magpie objects with results on cellular level, weight, unit and description.

Author(s)

Kristine Karstens

See Also

[readDams](#)

Examples

```
## Not run:
readSource("Dams", convert = "onlycorrect")

## End(Not run)
```

correctISIMIPinputs *correctISIMIPinputs*

Description

Correct ISIMIP data

Usage

```
correctISIMIPinputs(x)
```

Arguments

x   MAgPIE object provided by the read function

Value

List of magpie objects with results on cellular level, weight, unit and description.

Author(s)

Felicitas Beier

See Also

readISIMIPinputs

Examples

```
## Not run:
  readSource("ISIMIPinputs", convert="onlycorrect")

## End(Not run)
```

correctWATERGAP *correctWATERGAP*

Description

Correct WATERGAP data

Usage

```
correctWATERGAP(x)
```

Arguments

x   MAgPIE object provided by the read function

Value

List of magpie objects with results on cellular level, weight, unit and description.

Author(s)

Felicitas Beier

See Also

[readWATERGAP](#)

Examples

```
## Not run:
  readSource("WATERGAP", convert="onlycorrect")

## End(Not run)
```

fullCURRENTIRRIGATION   *fullCURRENTIRRIGATION*

Description

Function that produces output for irrigation potentials under multiple cropping on cellular resolution.

Usage

```
fullCURRENTIRRIGATION(yieldcalib = "TRUE:TRUE:actual:irrig_crop")
```

Arguments

yieldcalib   If TRUE: LPJmL yields calibrated to FAO country yield in iniyear Also needs
                specification of refYields, separated by ":". Options: FALSE (for single crop-
                ping analyses) or "TRUE:actual:irrig_crop" (for multiple cropping analyses) If
                FALSE: uncalibrated LPJmL yields are used

Author(s)

Felicitas Beier

---

fullGROUNDWATER *fullGROUNDWATER*

Description

Function that produces output for analysis of non-renewable groundwater resources

Usage

```
fullGROUNDWATER(multicropping = FALSE, rankmethod = "USD_ha:GLO:TRUE")
```

Arguments

multicropping   Multicropping activated (TRUE) or not (FALSE) and Multiple Cropping Suitability mask selected ("endogenous": suitability for multiple cropping determined by rules based on grass and crop productivity "exogenous": suitability for multiple cropping given by GAEZ data set), separated by ":" (e.g. TRUE:endogenous; TRUE:exogenous; FALSE)

rankmethod   Rank and optimization method consisting of Unit according to which rank is calculated: USD_ha (USD per hectare) for relative area return, or USD_m3 (USD per cubic meter) for relative volumetric return; USD for absolute return (total profit); Price aggregation: "GLO" for global average prices, or "ISO" for country-level prices and boolean indicating fullpotential (TRUE, i.e. cell receives full irrigation requirements in total area) or reduced potential (FALSE, reduced potential of cell receives at later stage in allocation algorithm); separated by ":"

Author(s)

Felicitas Beier

---

fullIRRIGATIONPOTENTIAL

fullIRRIGATIONPOTENTIAL

Description

Function that produces the objects for Technical and Economic Irrigation Potentials within land and water boundaries

Usage

```
fullIRRIGATIONPOTENTIAL(
  efrMethod = "VMF:fair",
  accessibilityrule = "CV:2",
  transDist = 0,
  fossilGW = FALSE,
  allocationrule = "optimization",
  rankmethod = "USD_ha:GLO:TRUE",
  gainthreshold = 500,
  protectLand = "HalfEarth",
  yieldcalib = "TRUE:FALSE",
  multicropping = FALSE,
  cropmix = "hist_total",
  climatetype = "MRI-ESM2-0:ssp370",
  lpjml = c(natveg = "LPJmL4_for_MAgPIE_44ac93de", crop =
    "ggcmi_phase3_nchecks_9ca735cb")
)
```

Arguments

efrMethod   EFR method used including selected strictness of EFRs (Smakhtin:good, VMF:fair)

accessibilityrule

                   Method used: Quantile method (Q) or Coefficient of Variation (CV) combined with scalar value defining the strictness of accessibility restriction: discharge that is exceeded x percent of the time on average throughout a year (Qx, e.g. Q75: 0.25, Q50: 0.5) or base value for exponential curve separated by : (CV:2)

transDist   Water transport distance allowed to fulfill locally unfulfilled water demand by surrounding cell water availability

fossilGW   If TRUE: non-renewable groundwater can be used. If FALSE: non-renewable groundwater cannot be used.

allocationrule   Rule to be applied for river basin discharge allocation across cells of river basin ("optimization", "upstreamfirst")

rankmethod   Rank and optimization method consisting of Unit according to which rank is calculated: USD_ha (USD per hectare) for relative area return, or USD_m3 (USD per cubic meter) for relative volumetric return; USD for absolute return (total profit); Price aggregation: "GLO" for global average prices, or "ISO" for country-level prices and boolean indicating fullpotential (TRUE, i.e. cell receives full irrigation requirements in total area) or reduced potential (FALSE, reduced potential of cell receives at later stage in allocation algorithm); separated by ":"

gainthreshold   Threshold of yield improvement potential required for water allocation in up-streamfirst algorithm (in same unit as in rankmethod)

protectLand   Land protection scenario (WDPA, or one of the scenarios available in calc-ConservationPriorities, e.g., 30by20, BH, BH_IFL, PBL_HalfEarth, or NA for no protection).

yieldcalib
: If TRUE: LPJmL yields calibrated to FAO country yield in iniyear Also needs specification of refYields, separated by ":". Options: FALSE (for single cropping analyses) or "TRUE:actual:irrig_crop" (for multiple cropping analyses) If FALSE: uncalibrated LPJmL yields are used

multicropping
: Multicropping activated (TRUE) or not (FALSE) and Multiple Cropping Suitability mask selected (mask can be: "none": no mask applied (only for development purposes) "actual:total": currently multicropped areas calculated from total harvested areas and total physical areas per cell from LandInG "actual:crop" (crop-specific), "actual:irrigation" (irrigation-specific), "actual:irrig_crop" (crop- and irrigation-specific) "total" "potential:endogenous": potentially multicropped areas given temperature and productivity limits "potential:exogenous": potentially multicropped areas given GAEZ suitability classification) (e.g. TRUE:actual:total; TRUE:none; FALSE)

cropmix
: Selected cropmix (options: "hist_irrig" for historical cropmix on currently irrigated area, "hist_total" for historical cropmix on total cropland, or selection of proxycrops)

climatetype
: Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"

lpjml
: LPJmL version required for respective inputs: natveg or crop

Author(s)

Felicitas Beier

---

fullMULTICROPPING   *fullMULTICROPPING*

Description

Function that produces output for multiple cropping and irrigation potentials on current cropland at cellular resolution.

Usage

```
fullMULTICROPPING(
  allocationrule = "optimization",
  comAg = TRUE,
  fossilGW = TRUE,
  transDist = 100
)
```

Arguments

allocationrule
: Rule to be applied for river basin discharge allocation across cells of river basin ("optimization", "upstreamfirst")

comAg
: if TRUE: the currently already irrigated areas in initialization year are reserved for irrigation, if FALSE: no irrigation areas reserved (irrigation potential)

| fossilGW | If TRUE: non-renewable groundwater can be used. If FALSE: non-renewable groundwater cannot be used. |
| transDist | Water transport distance allowed to fulfill locally unfulfilled water demand by surrounding cell water availability |

Author(s)

Felicitas Beier

| fullPREPROCESSING | *fullPREPROCESSING* |

Description

Function that produces the objects for Technical and Economic Irrigation Potentials within land and water boundaries

Usage

```
fullPREPROCESSING(
  protectLand = "HalfEarth",
  yieldcalib = "TRUE:TRUE:actual:irrig_crop",
  multicropping = "TRUE:potential:endogenous",
  cropmix = "hist_total",
  climatetype = "MRI-ESM2-0:ssp370",
  lpjml = c(natveg = "LPJmL4_for_MAgPIE_44ac93de", crop =
    "ggcmi_phase3_nchecks_9ca735cb")
)
```

Arguments

protectLand	Land protection scenario (WDPA, or one of the scenarios available in calc-ConservationPriorities, e.g., 30by20, BH, BH_IFL, PBL_HalfEarth, or NA for no protection
yieldcalib	If TRUE: LPJmL yields calibrated to FAO country yield in iniyear Also needs specification of refYields, separated by ":". Options: FALSE (for single cropping analyses) or "TRUE:actual:irrig_crop" (for multiple cropping analyses) If FALSE: uncalibrated LPJmL yields are used
multicropping	Multicropping activated (TRUE) or not (FALSE) and Multiple Cropping Suitability mask selected (mask can be: "none": no mask applied (only for development purposes) "actual:total": currently multicropped areas calculated from total harvested areas and total physical areas per cell from LandInG "actual:crop" (crop-specific), "actual:irrigation" (irrigation-specific), "actual:irrig_crop" (crop- and irrigation-specific) "total" "potential:endogenous": potentially multicropped areas given temperature and productivity limits "potential:exogenous": potentially multicropped areas given GAEZ suitability classification) (e.g. TRUE:actual:total; TRUE:none; FALSE)

cropmix	Selected cropmix (options: "hist_irrig" for historical cropmix on currently irrigated area, "hist_total" for historical cropmix on total cropland, or selection of proxycrops)
climatetype	Switch between different climate scenarios or historical baseline "GSWP3-W5E5:historical"
lpjml	LPJmL version required for respective inputs: natveg or crop

Author(s)

Felicitas Beier

---

fullSIMPLE	*fullSIMPLE*

Description

Function that produces gridded outputs for usage in the SIMPLE model (Baldos & Hertel 2012) and the SIMPLE-G model (Baldos et al. 2020)

Usage

```
fullSIMPLE(
  transDist = 100,
  fossilGW = TRUE,
  allocationrule = "optimization",
  rankmethod = "USD_m3:GLO:TRUE"
)
```

Arguments

transDist	Water transport distance allowed to fulfill locally unfulfilled water demand by surrounding cell water availability
fossilGW	If TRUE: non-renewable groundwater can be used. If FALSE: non-renewable groundwater cannot be used.
allocationrule	Rule to be applied for river basin discharge allocation across cells of river basin ("optimization", "upstreamfirst")
rankmethod	Rank and optimization method consisting of Unit according to which rank is calculated: USD_ha (USD per hectare) for relative area return, or USD_m3 (USD per cubic meter) for relative volumetric return; USD for absolute return (total profit); Price aggregation: "GLO" for global average prices, or "ISO" for country-level prices and boolean indicating fullpotential (TRUE, i.e. cell receives full irrigation requirements in total area) or reduced potential (FALSE, reduced potential of cell receives at later stage in allocation algorithm); separated by ":"

Author(s)

Felicitas Beier

---

fullTRANSPORT   *fullTRANSPORT*

Description

Function that produces output for analysis of water transport for provision to cells in surrounding

Usage

```
fullTRANSPORT(multicropping, rankmethod = "USD_ha:GLO:TRUE")
```

Arguments

multicropping   Multicropping activated (TRUE) or not (FALSE) and Multiple Cropping Suitability mask selected ("endogenous": suitability for multiple cropping determined by rules based on grass and crop productivity "exogenous": suitability for multiple cropping given by GAEZ data set), separated by ":" (e.g. TRUE:endogenous; TRUE:exogenous; FALSE)

rankmethod   Rank and optimization method consisting of Unit according to which rank is calculated: USD_ha (USD per hectare) for relative area return, or USD_m3 (USD per cubic meter) for relative volumetric return; USD for absolute return (total profit); Price aggregation: "GLO" for global average prices, or "ISO" for country-level prices and boolean indicating fullpotential (TRUE, i.e. cell receives full irrigation requirements in total area) or reduced potential (FALSE, reduced potential of cell receives at later stage in allocation algorithm); separated by ":"

Author(s)

Felicitas Beier

---

readDams   *readDams*

Description

Read dam file (no source information available)

Usage

```
readDams()
```

Value

List of magpie objects with results on cellular level, weight, unit and description.

Author(s)

Kristine Karstens

Examples

```
## Not run:
readSource("Dams", convert = "onlycorrect")

## End(Not run)
```

---

readIrrigationSystem *readIrrigationSystem*

Description

Read in irrigation system type for initialization

Usage

```
readIrrigationSystem(subtype = "Jaegermeyr")
```

Arguments

subtype   Data source to be used: Jaegermeyr (irrigation system share based on FAO 2014,
                 ICID 2012 and Rohwer et al. 2007) or LPJmL (dominant irrigation system per
                 country)

Value

MAgPIE object of at country-level

Author(s)

Felicitas Beier

Examples

```
## Not run:
readSource("IrrigationSystem", convert = FALSE)

## End(Not run)
```

---

readISIMIPinputs   *readISIMIPinputs*

Description

Read in non-agricultural water demand data from ISIMIP inputs

Usage

```
readISIMIPinputs(subtype = "ISIMIP3b:water:histsoc.waterabstraction")
```

Arguments

subtype   Data source to be read from including path separated by ":", subtype separated
                 by "."

Value

MAgPIE object of non-agricultural water demand at 0.5 cellular level in mio. m^3

Author(s)

Felicitas Beier

Examples

```
## Not run:
readSource("ISIMIPinputs",
subtype = "ISIMIP3b:water:histsoc.waterabstraction",
convert = "onlycorrect")

## End(Not run)
```

---

readJaegermeyr2015   *readJaegermeyr2015*

Description

Read in irrigation system suitability per crop type and country-level irrigation system shares from
Jaegermeyr (2015)

Usage

```
readJaegermeyr2015(subtype)
```

Arguments

subtype   Data to be read in: "systemShare": irrigation system share as provided in SI of Jägermeyr et al. (2015), based on FAO 2014, ICID 2012 and Rohwer et al. 2007); "systemSuitability": biophysical and technical irrigation system suitability by crop type (CFT) as provided in Table 2 of Jägermeyr et al. (2015) based on Sauer et al. (2010) and Fischer et al. (2012).

Value

MAgPIE object

Author(s)

Felicitas Beier

Examples

```
## Not run:
readSource("Jaegerymeyr2015", convert = FALSE)

## End(Not run)
```

---

readNeighborCells *readNeighborCells*

Description

read file with neighbor cell and distance information derived from LPJmL grid

Usage

```
readNeighborCells()
```

Value

empty magpie object with list data stored in attributes

Author(s)

Felicitas Beier

Examples

```
## Not run:
readSource("NeighborCells", convert = FALSE)

## End(Not run)
```

---

readWATERGAP   *readWATERGAP*

Description

Read in non-agricultural water demand data from WATERGAP model

Usage

```
readWATERGAP(subtype = "WATCH_ISIMIP_WATERGAP")
```

Arguments

subtype   Data source to be read from

Value

MAgPIE object of non-agricultural water demand at 0.5 cellular level in mio. m^3

Author(s)

Felicitas Beier, Abhijeet Mishra

Examples

```
## Not run:
readSource("WATERGAP", convert = "onlycorrect")

## End(Not run)
```

---

toolLPJarrayToMAgPIEmap
                          toolLPJarrayToMAgPIEmap

Description

transforms object (array) with 67420 cells to be able to be used in plotmap function

This tool function selects the required cells from object with 67420 cells to be able to plot using
plotmap or plotmap2 that are applied to magpie object of size 59199 cells

Usage

```
toolLPJarrayToMAgPIEmap(x)
```

Arguments

x   magpie object to be transformed

Value

magpie object with correct dimension for use in plotmap

Author(s)

Felicitas Beier

---

toolLPJcell2MAgPIEcell

toolLPJcell2MAgPIEcell

Description

transforms magpie object with 67420 cells to object with 59199 cells

This tool function selects the required cells from object with 67420 cells to be able to plot using plotmap or plotmap2 that are applied to magpie object of size 59199 cells

Usage

```
toolLPJcell2MAgPIEcell(x)
```

Arguments

x   magpie object to be transformed

Value

magpie object with correct dimension for use in plotmap

Author(s)

Felicitas Beier

```
toolLPJcellCoordinates
```
                          toolLPJcellCoordinates

Description

maps LPJ cells and coordinates

Usage

```
toolLPJcellCoordinates(x, type)
```

Arguments

x	magpie object for which coordinatese should be remapped
type	direction of transformation (coord2lpj or lpj2coord)

Value

magpie object with coordinates in LPJ cell ordering

Author(s)

Felicitas Beier

```
toolNeighborUpDownProvision
```
                          toolNeighborUpDownProvision

Description

This function calculates water provision by surrounding grid cells for upstream-downstream allocation set-up

Usage

```
toolNeighborUpDownProvision(rs, transDist, years, scenarios, listNeighborIN)
```

Arguments

rs	River structure including information on neighboring cells
transDist	Water transport distance allowed to fulfill locally unfulfilled water demand by surrounding cell water availability
years	Vector of years for which neighbor allocation shall be applied
scenarios	Vector of scenarios for which neighbor allocation shall be applied
listNeighborIN	List of arrays required for the algorithm: yearlyRunoff, lakeEvap reserved flows from previous water allocation round (prevReservedWC, prevReservedWW) missing water at this stage of water allocation (missingWW, missingWC) discharge

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier, Jens Heinke

Examples

```
## Not run:
calcOutput("RiverHumanUseAccounting", aggregate = FALSE)

## End(Not run)
```

---

toolRegionSums	*toolRegionSums*

Description

sum over regional aggregation chosen in region argument

Usage

```
toolRegionSums(x, region)
```

Arguments

x	magpie object to be summed up over first dimension
region	regional resolution (can be country iso-code, "GLO" for global, or region name and respective mapping "EUR:H12")

Value

magpie object with regional sum

Author(s)

Felicitas Beier

---

toolRiverDischargeAllocation

toolRiverDischargeAllocation

Description

This tool function allocates discharge for grid cells respecting upstream-downstream relationships and various water constraints

Usage

```
toolRiverDischargeAllocation(
  rs,
  c,
  downCells,
  iteration,
  transDist,
  inLIST,
  inoutLIST
)
```

Arguments

rs	River structure with information on upstreamcells, downstreamcells and neighboring cells and distances
c	Current cell for which water shall be allocated
downCells	Downstream cells of c
iteration	Currently active iteration of river discharge allocation. Arguments: "main" for case of main river cells "neighbor" for case of neighboring cells of main river cells
transDist	Water transport distance allowed to fulfill locally unfulfilled water demand by surrounding cell water availability
inLIST	List of objects that are inputs to the function irrigGain, gainthreshold,
inoutLIST	List of objects that are inputs to the function and are updated by the function

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier, Jens Heinke, Jan Philipp Dietrich

```
toolRiverDischargeUpdate
```
toolRiverDischargeUpdate

Description

This function calculates cellular discharge after reserving water uses for consumption

Usage

```
toolRiverDischargeUpdate(rs, runoffWOEvap, watCons)
```

Arguments

rs	River structure
runoffWOEvap	Array that contains (runoff - lake evap)
watCons	Array that contains water reserved for consumptive use

Value

array in cellular resolution and all year and scenario dimensions

Author(s)

Felicitas Beier, Jens Heinke

Examples

```
## Not run:
calcOutput("RiverHumanUseAccounting", aggregate = FALSE)

## End(Not run)
```

```
toolRiverUpDownBalance
```
toolRiverUpDownBalance

Description

This function calculates the cell water balance under consideration of different reserved human uses (non-agricultural, neighbor water requirements, committed-agricultural uses)

Usage

```
toolRiverUpDownBalance(inLIST, inoutLIST)
```

Arguments

`inLIST`	List of objects that are inputs to the function: previously reserved withdrawals and consumption in current cell; currently requested withdrawal in current cell
`inoutLIST`	List of objects that are inputs to the function and are updated by the function: discharge (including up- and downstream cells) currently requested consumption (including upstream cells)

Value

list of arrays objects in cellular resolution

Author(s)

Felicitas Beier, Jens Heinke

---

toolSelectNeighborCell

toolSelectNeighborCell

Description

Selects cells in certain radius of current cell

Usage

```
toolSelectNeighborCell(transDist, rs = rs, neighborCells = neighborCells)
```

Arguments

`transDist`	Water transport distance allowed to fulfill locally unfulfilled water demand
`rs`	River structure list
`neighborCells`	List of neighboring cells for all river cells

Value

magpie object in cellular resolution

Author(s)

Felicitas Beier, Jens Heinke

toolSelectRiverBasin *toolSelectRiverBasin*

Description

returns coordinates of cells that belong to chosen basin

Usage

```
toolSelectRiverBasin(basinname)
```

Arguments

basinname   river basin name as listed in mapping file RiverBasinMapping.csv

Value

list of cell names

Author(s)

Felicitas Beier

Index