Package 'optimLanduse'

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Title Robust Land-Use Optimization

Version 1.1.0

Description Robust multi-criteria land-allocation optimization that explicitly accounts for the uncertainty of the indicators in the objective function. Solves the problem of allocating scarce land to various land-use options with regard to multiple, coequal indicators. The method aims to find the land allocation that represents the indicator composition with the best possible trade-off under uncertainty. optimLanduse includes the actual optimization procedure as described by Knoke et al. (2016) <doi:10.1038/ncomms11877> and the post-hoc calculation of the portfolio performance as presented by Gosling et al. (2020) <doi:10.1016/j.jenvman.2020.110248>.

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Encoding UTF-8

RoxygenNote 7.2.1

Imports lpSolveAPI (>= 5.5.2.0-17.7), tidyr (>= 1.1.2), dplyr (>= 1.0.0)

Suggests readxl, ggplot2

URL https://github.com/Forest-Economics-Goettingen/optimLanduse/

NeedsCompilation no

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R topics documented:

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calcPerformance   *Attach portfolio performance and distance to target*

Description

The Portfolio performances are calculated and attached to the solved optimLanduse object. Each
performance measure describes the relative proportion to the maximum achievable (the "target")
of the indicator, given the current solution. The lowest performance of all indicators is the degree
of fulfillment of the worst performing indicator. It can thus be interpreted as the guaranteed per-
formance under the worst-possible scenario. At least this proportion will be achieved across all
indicators.

Usage

```
calcPerformance(x)
```

Arguments

x   An optimized optimLanduse object.

Details

For further information and calculation, see the supplement of Gosling et al. (2020), Formula S5
(in the supplement of the paper) and also the paragraph optimLanduse functions and workflow -
Post-processing in Husmann et al. (n. d.).

Value

An optimized optimLanduse object with attached portfolio performance.

References

Gosling, E., Reith, E., Knoke T., Gerique, A., Paul, C. (2020): Exploring farmer perceptions of
agroforestry via multi-objective optimisation: a test application in Eastern Panama. *Agroforestry
Systems* **94**. doi:10.1007/s10457020005190

Husmann, K., von Groß, V., Bödeker, K., Fuchs, J. M., Paul, C., Knoke, T. (no date): optimLanduse:
A Package for Multiobjective Land-cover1Composition Optimization under Uncertainty. *Methods
in Ecology and Management*. Under review.

Examples

```
require(ggplot2)
require(readxl)

dat <- read_xlsx(exampleData("exampleGosling.xlsx"))
init <- initScenario(dat, uValue = 2,
                        optimisticRule = "expectation",
                        fixDistance = 3)
result <- solveScenario(x = init)
performance <- calcPerformance(result)

# Visualize the distance

ggplot(performance$scenarioTable,
        aes(x = indicator,
            y = performance,
            color = indicator)) +
geom_point() +
geom_hline(yintercept =
            min(performance$scenarioTable$performance),
          linetype = "dashed", color = "red") +
ylim(0, 1)
```

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dataPreparation	*Transform data into the expected format*

Description

The input data must suit the specific expected optimLanduse format prior to initialization and optimization. This function provides the possibility to easily transform data from the commonly used form of the exemplary data exampleData into the expected format. Please consider that the application of this function is not mandatory and in most cases not required. Best practice is to transform your data yourself into the expected format. Detailed information about the expected format and possible data processing can be found on the GitHub project page. Note that incomplete rows, which include NA-values will be deleted and an error message will be thrown.

Usage

```
dataPreparation(dat, uncertainty = "SE", expVAL = "mean")
```

Arguments

dat	Data frame or tibble in the format of the exampleData. Please refer to the GitHub project page for more details.
uncertainty	Indicates the column name of the uncertainty measure. Typical is "SE" for standard error or "SD" for standard deviation.
expVAL	Indicates the column name of the expected value.

Value

A formatted coefficients table with land-use options and indicator values ready for initialization via [initScenario](#).

References

Gosling, E., Reith, E., Knoke, T. et al. Exploring farmer perceptions of agroforestry via multi-objective optimisation: a test application in Eastern Panama. Agroforest Syst 94, 2003–2020 (2020). https://doi.org/10.1007/s10457-020-00519-0

Examples

```
require(readxl)
dat <- read_xlsx(exampleData("exampleGosling_dataPrep.xlsx"), col_names = TRUE)
dat <- dataPreparation(dat, uncertainty = "sd", expVAL = "mean")
```

---

exampleData   *Exemplary data in the required format*

Description

optimLanduse comes bundled with exemplary data for land-use optimization. The files can also be found on your computer in the package folder './extdata'. These examples provide some quick applications of the package for demonstration and an example of the expected data structure of the data. Consider also the [GitHub project page](#) for exemplary applications of the package.

Usage

```
exampleData(fileName = "exampleGosling.xlsx")
```

Arguments

fileName   Name of the example file. See 'details' section for further explanation of all provided examples.

Details

exampleGosling.xlsx contains the freely available data from Gosling et al. (2020). *exampleEmpty.xlsx* contains a template for your data.

Value

The path to the example file on your computer.

References

Gosling, E., Reith, E., Knoke, T. et al. Exploring farmer perceptions of agroforestry via multi-objective optimisation: a test application in Eastern Panama. Agroforest Syst 94, 2003–2020 (2020). https://doi.org/10.1007/s10457-020-00519-0

Examples

```
require(readxl)
path <- exampleData()
read_xlsx(path, col_names = FALSE)
path <- exampleData("exampleGosling.xlsx")
read_xlsx(path, col_names = FALSE)
```

---

initScenario   *Initialize the robust optimization*

Description

The function initializes an *optimLanduse* S3 object on the basis of a coefficients table. Please note that the coefficients table must follow the expected *optimLanduse* format. The expected format is explained in the example on the [GitHub project page](#).

Usage

```
initScenario(
  coefTable,
  uValue = 1,
  optimisticRule = "expectation",
  fixDistance = 3
)
```

Arguments

coefTable	Coefficient table in the expected *optimLanduse* format.
uValue	*u* Value. The uncertainty value delivered in the coefTable is multiplied with this u value. The value, therefore, enables scenario analyses with differing uncertainties in relation to indicator values. Higher u values can be interpreted as a higher risk aversion of the decision maker.
optimisticRule	Either *expectation* or *uncertaintyAdjustedExpectation*. The rule indicates whether the optimistic outcomes of an indicator are directly reflected by their expectations or if the indicator is calculated as expectation + uncertainty when "more is better" or expectation - uncertainty respectively when "less is better". An optimization based on *expectation* considers only downside risks.
fixDistance	This optional numeric value allows to define distinct uncertainty levels for the calculation of the uncertainty space and the averaged distances of a certain land-cover composition (see Equation 9 in Husmann et al. (n. d.)). Passing NA disables fixDistance. In this case, the uncertainty space is defined by uValue.

Details

Separating the initialization from the optimization is to save computation time in batch analysis. The separated function calls allow the user to perform multiple optimizations from one initialized object. This could save time in the scenario or sensitivity analysis.

A detailed description of the input parameters can be found in Husmann et al. (n.d.).

Value

An initialized optimLanduse S3 object ready for optimization.

References

Husmann, K., von Groß, V., Bödeker, K., Fuchs, J. M., Paul, C., Knoke, T. (no date): optimLanduse: A Package for Multiobjective Land-cover1Composition Optimization under Uncertainty. *Methods in Ecology and Management*. Under review.

Examples

```
require(readxl)
dat <- read_xlsx(exampleData("exampleGosling.xlsx"))

init <- initScenario(dat,
                     uValue = 2,
                     optimisticRule = "expectation",
                     fixDistance = 3)
```

---

solveScenario   *Perform the optimization*

Description

The function solves the optimization framework specified by the initialized *optimLanduse* object.

Usage

```
solveScenario(x, digitsPrecision = 4, lowerBound = 0, upperBound = 1)
```

Arguments

x	The initialized *optimLanduse* object. See [initScenario](#) for the initialization.
digitsPrecision	
	Precision of the loss value. digitsPrecision is the possibility to influence the calculation time.
lowerBound	Optional lower bounds for the land-use options. Must be 0 or a vector in the dimension of the land-use options.
upperBound	Optional upper bounds for the land-use options. Must be 1 or a vector in the dimension of the land-use options.

Details

The methodological background and the formulation of the optimization framework are described in Knoke et al. (2016) and in Husmann et al. (n d.)

Value

A solved landUse portfolio ready for export or further data processing.

References

Knoke, T., Paul, C., Hildebrandt, P. et al. (2016): Compositional diversity of rehabilitated tropical lands supports multiple ecosystem services and buffers uncertainties. *Nat Commun* **7**, 11877. doi:10.1038/ncomms11877

Husmann, K., von Groß, V., Bödeker, K., Fuchs, J. M., Paul, C., Knoke, T. (no date): optimLanduse: A Package for Multiobjective Land-cover1Composition Optimization under Uncertainty. *Methods in Ecology and Management*. Under review.

Examples

```
require(readxl)
dat <- read_xlsx(exampleData("exampleGosling.xlsx"))
init <- initScenario(dat, uValue = 2,
                     optimisticRule = "expectation",
                     fixDistance = 3)
result <- solveScenario(x = init)
```

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