Package ‘swcEcon’

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Title Economic Analysis of Soil and Water Conservation Measures in Watersheds

Version 0.1.0

Description Provides functions and benchmark datasets for the economic appraisal of soil and water conservation (SWC) measures in watershed development projects. Implements benefit-cost ratio (BCR), net present value (NPV), internal rate of return (IRR) via the bisection method of Brent (1973, ISBN:9780130223715), modified BCR, marginal rate of return using the CIMMYT (1988, ISBN:9686127127) method, payback period, soil loss economic valuation via the Universal Soil Loss Equation of Wischmeier and Smith (1978, ISBN:0160016258), groundwater recharge valuation, employment generation ratio, sensitivity analysis, switching value analysis, and Monte Carlo simulation. Six datasets are included: state-wise BCR benchmarks from NABARD (2019) watershed evaluations, USLE erodibility parameters for Indian soil orders from NBSS and LUP, rainfall erosivity for twenty Indian districts from IMD data, SWC unit cost norms from PMKSY-WDC (GoI 2015), and two hypothetical datasets for illustration. Methods follow Gittinger (1982, ISBN:9780801825439) and Squire and van der Tak (1975, ISBN:9780801816697).

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`swcEcon-package` *swcEcon: Economic Analysis of Soil and Water Conservation Measures*

Description

Provides functions and benchmark datasets for the economic appraisal of soil and water conservation (SWC) measures in watershed development projects. Functions cover financial appraisal (BCR, NPV, IRR, PBP, MRR), soil loss valuation (USLE), water resource valuation, employment generation, sensitivity analysis, switching value, Monte Carlo simulation, a full pipeline runner, and automated HTML report generation.

Author(s)

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References

Brent, R.P. (1973). *Algorithms for Minimization Without Derivatives*. Prentice-Hall. ISBN: 9780130223715.

CIMMYT (1988). *From Agronomic Data to Farmer Recommendations*. CIMMYT, Mexico DF. ISBN: 9686127127.

Gittinger, J.P. (1982). *Economic Analysis of Agricultural Projects*, 2nd ed. Johns Hopkins University Press. ISBN: 9780801825439.

GoI (2015). *Common Guidelines for Watershed Development Projects under PMKSY-WDC*. Ministry of Rural Development, New Delhi.

Joshi, P.K., Jha, A.K., Wani, S.P., Joshi, L. and Shiyani, R.L. (2005). *Meta-Analysis to Assess Impact of Watershed Program and People's Participation*. IWMI Research Report 8. ISBN: 9290906677.

NABARD (2019). *Operational Guidelines: Watershed Development Fund*. National Bank for Agriculture and Rural Development, Mumbai.

Squire, L. and van der Tak, H.G. (1975). *Economic Analysis of Projects*. Johns Hopkins University Press. ISBN: 9780801816697.

Wischmeier, W.H. and Smith, D.D. (1978). *Predicting Rainfall Erosion Losses*. USDA Agriculture Handbook No. 537. ISBN: 0160016258.

---

calc_bcr *Benefit-cost ratio for SWC watershed projects*

Description

Computes the discounted Benefit-Cost Ratio (BCR) for a SWC project. BCR is the ratio of present value of benefits to present value of costs.

Usage

```
calc_bcr(
  investment,
  annual_benefit,
  annual_omc = 0,
  life = 20L,
  discount_rate = 0.12,
  residual_value = 0,
  benefit_lag = 0L
)
```

Arguments

`investment`	Numeric. Capital investment (INR lakh or consistent unit).
`annual_benefit`	Numeric. Annual gross benefit. Scalar or vector of length `life`.
`annual_omc`	Numeric. Annual O&M cost. Default `0`.
`life`	Integer. Project design life (years). Default `20`.
`discount_rate`	Numeric. Annual discount rate as proportion (e.g. `0.12` for 12 per cent). Default `0.12`.
`residual_value`	Numeric. Salvage value at project end. Default `0`.
`benefit_lag`	Integer. Gestation years before benefits begin. Default `0`.

Details

$$BCR = \frac{\sum_{t=1}^{n} B_t/(1+r)^t + S/(1+r)^n}{I_0 + \sum_{t=1}^{n} C_t/(1+r)^t}$$

Decision rules (Gittinger 1982; GoI 2008): BCR > 1.0 is viable; BCR >= 1.5 meets NABARD threshold for watershed funding (NABARD 2019); BCR < 1.0 is not viable at the chosen discount rate.

Value

A named list of class `"swcEcon_bcr"` with elements: `bcr`, `pv_benefits`, `pv_costs`, `verdict`, and `inputs`.

References

Gittinger, J.P. (1982). *Economic Analysis of Agricultural Projects*, 2nd ed. Johns Hopkins University Press. ISBN: 9780801825439.

GoI (2008). *Guidelines for Economic Analysis of Projects*. Planning Commission of India, New Delhi.

NABARD (2019). *Operational Guidelines: Watershed Development Fund*. National Bank for Agriculture and Rural Development, Mumbai.

Examples

```
calc_bcr(investment = 20, annual_benefit = 6,
         annual_omc = 0.8, life = 20, discount_rate = 0.12)

# With 2-year gestation period
calc_bcr(investment = 35, annual_benefit = 9, annual_omc = 1.2,
         life = 20, discount_rate = 0.12, benefit_lag = 2)
```

`calc_employment` *Employment generation ratio for SWC projects*

Description

Computes the Employment Generation Ratio (EGR) and checks compliance with the MGNREGS 60 per cent labour norm.

Usage

```
calc_employment(employment_days, investment_lakh, wages_per_day = 250)
```

Arguments

`employment_days`
: Numeric. Total person-days generated.

`investment_lakh`
: Numeric. Total investment (INR lakh).

`wages_per_day`
: Numeric. Daily wage rate (INR). Default `250`.

Details

$$EGR = \frac{\text{Person-days}}{\text{Investment (INR lakh)}}$$

Value

A named list with `egr_days_per_lakh`, `total_wage_bill_inr`, `labour_share_pct`, and `mgnregs_60pct_norm`.

References

GoI (2023). *Mahatma Gandhi National Rural Employment Guarantee Scheme: Operational Guidelines*, 4th ed. Ministry of Rural Development, New Delhi.

NABARD (2019). *Operational Guidelines: Watershed Development Fund*. National Bank for Agriculture and Rural Development, Mumbai.

Examples

```
calc_employment(employment_days = 45000, investment_lakh = 50,
                wages_per_day = 250)
```

calc_irr *Internal rate of return for SWC watershed projects*

Description

Computes the IRR – the discount rate at which NPV equals zero – using the bisection algorithm of Brent (1973).

Usage

```
calc_irr(
  investment,
  annual_benefit,
  annual_omc = 0,
  life = 20L,
  lower = 0,
  upper = 2
)
```

Arguments

`investment`	Numeric. Capital investment.
`annual_benefit`	Numeric. Annual gross benefit.
`annual_omc`	Numeric. Annual O&M cost. Default `0`.
`life`	Integer. Project life (years). Default `20`.
`lower`	Numeric. Lower search bound. Default `0`.
`upper`	Numeric. Upper search bound. Default `2`.

Details

Benchmarks: 12 per cent (Planning Commission, GoI 2008); 12–15 per cent (NABARD 2019); 10–15 per cent (World Bank 1998).

Value

A list of class `"swcEcon_irr"` with `irr`, `irr_pct`, `converged`, and benchmark comparisons.

References

Brent, R.P. (1973). *Algorithms for Minimization Without Derivatives*. Prentice-Hall. ISBN: 9780130223715.

GoI (2008). *Guidelines for Economic Analysis of Projects*. Planning Commission of India, New Delhi.

NABARD (2019). *Operational Guidelines: Watershed Development Fund*. National Bank for Agriculture and Rural Development, Mumbai.

Examples

```
calc_irr(investment = 20, annual_benefit = 6,
         annual_omc = 0.8, life = 20)
```

---

calc_irrigation_benefit

Additional crop income from SWC-enabled irrigation

Description

Additional crop income from SWC-enabled irrigation

Usage

```
calc_irrigation_benefit(
  irrig_area_ha,
  yield_increase_t_ha,
  crop_price_inr_t,
  input_cost_inr_ha = 8000
)
```

Arguments

`irrig_area_ha` Numeric. Additional irrigated area (ha).

`yield_increase_t_ha` Numeric. Yield increase (t/ha).

`crop_price_inr_t` Numeric. Farm-gate crop price (INR/t).

`input_cost_inr_ha` Numeric. Additional input cost (INR/ha). Default `8000`.

Value

A named list with gross, additional cost, and net benefit.

References

Joshi, P.K., Jha, A.K., Wani, S.P., Joshi, L. and Shiyani, R.L. (2005). *Meta-Analysis to Assess Impact of Watershed Program and People's Participation*. IWMI Research Report 8. ISBN: 9290906677.

Examples

```
calc_irrigation_benefit(irrig_area_ha = 80, yield_increase_t_ha = 1.6,
                        crop_price_inr_t = 18000, input_cost_inr_ha = 8000)
```

calc_mbcr *Modified benefit-cost ratio*

Description

Computes the Modified BCR: $MBCR = (TB - OC)/CC$ (Gittinger 1982).

Usage

```
calc_mbcr(total_benefit, operating_cost, capital_cost)
```

Arguments

total_benefit	Numeric. Total benefit over project life.
operating_cost	Numeric. Total operating costs over life.
capital_cost	Numeric. Initial capital investment.

Value

A list of class "swcEcon_mbcr" with mbcr and interpretation.

References

Gittinger, J.P. (1982). *Economic Analysis of Agricultural Projects*, 2nd ed. Johns Hopkins University Press. ISBN: 9780801825439.

Examples

```
calc_mbcr(total_benefit = 80, operating_cost = 12, capital_cost = 20)
```

calc_mrr *Marginal rate of return (CIMMYT method)*

Description

Computes MRR following CIMMYT (1988): the return per unit of additional investment when switching from current practice to a SWC technology.

Usage

```
calc_mrr(nb_with, nb_without, cost_with, cost_without, min_mrr = 100)
```

Arguments

`nb_with`	Numeric. Net benefit per ha with SWC technology.
`nb_without`	Numeric. Net benefit per ha without SWC.
`cost_with`	Numeric. Variable cost per ha with SWC.
`cost_without`	Numeric. Variable cost per ha without SWC.
`min_mrr`	Numeric. Minimum acceptable MRR (per cent). Default `100`.

Details

$$MRR = \frac{NB_{with} - NB_{without}}{C_{with} - C_{without}} \times 100$$

A minimum acceptable MRR of 100 per cent is recommended by CIMMYT (1988).

Value

A list of class `"swcEcon_mrr"` with `mrr`, `marginal_benefit`, `marginal_cost`, and `recommendation`.

References

CIMMYT (1988). *From Agronomic Data to Farmer Recommendations*. CIMMYT, Mexico DF. ISBN: 9686127127.

Byerlee, D. and Collinson, M. (1980). *Planning Technologies Appropriate to Farmers*. CIMMYT, Mexico DF.

Examples

```
calc_mrr(nb_with = 18000, nb_without = 11000,
         cost_with = 16000, cost_without = 11500)
```

`calc_npv` *Net present value for SWC watershed projects*

Description

Computes the Net Present Value (NPV) by discounting annual net benefits.

Usage

```
calc_npv(
  investment,
  annual_benefit,
  annual_omc = 0,
  life = 20L,
  discount_rate = 0.12,
  residual_value = 0
)
```

Arguments

`investment`	Numeric. Capital investment.
`annual_benefit`	Numeric. Annual gross benefit.
`annual_omc`	Numeric. Annual O&M cost. Default `0`.
`life`	Integer. Project life (years). Default `20`.
`discount_rate`	Numeric. Discount rate. Default `0.12`.
`residual_value`	Numeric. Salvage value. Default `0`.

Details

$$NPV = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+r)^t} + \frac{S}{(1+r)^n} - I_0$$

Value

A list of class `"swcEcon_npv"` with `npv`, `cashflows` (data frame), and `decision`.

References

Gittinger, J.P. (1982). *Economic Analysis of Agricultural Projects*, 2nd ed. Johns Hopkins University Press. ISBN: 9780801825439.

Squire, L. and van der Tak, H.G. (1975). *Economic Analysis of Projects*. Johns Hopkins University Press. ISBN: 9780801816697.

Examples

```
r <- calc_npv(investment = 20, annual_benefit = 6,
              annual_omc = 0.8, life = 20, discount_rate = 0.12)
print(r)
head(r$cashflows)
```

`calc_nutrient_cost` *Nutrient replacement cost from soil erosion*

Description

Estimates the annual economic cost of NPK nutrients lost through soil erosion based on soil nutrient content and fertiliser prices.

Usage

```
calc_nutrient_cost(
  soil_loss_t_ha,
  area_ha,
  n_kg_per_t = 0.5,
  p_kg_per_t = 0.08,
  k_kg_per_t = 1.2,
  n_price = 20,
  p_price = 50,
  k_price = 25
)
```

Arguments

`soil_loss_t_ha`	Numeric. Annual soil loss (t/ha/yr).
`area_ha`	Numeric. Catchment area (ha).
`n_kg_per_t`	Numeric. N per tonne of soil (kg/t). Default `0.5`.
`p_kg_per_t`	Numeric. P per tonne (kg/t). Default `0.08`.
`k_kg_per_t`	Numeric. K per tonne (kg/t). Default `1.2`.
`n_price`	Numeric. N fertiliser price (INR/kg). Default `20`.
`p_price`	Numeric. P fertiliser price (INR/kg). Default `50`.
`k_price`	Numeric. K fertiliser price (INR/kg). Default `25`.

Value

A named list with nutrient quantities lost and replacement costs.

References

Katyal, J.C. and Sharma, B.D. (1991). Nutrients in soil fertility. *Fertiliser News*, **36**(4), 13–24.

Examples

```
data(usle_india_soils)
s <- usle_india_soils[usle_india_soils$soil_series == "Alfisols", ]
calc_nutrient_cost(soil_loss_t_ha = 12, area_ha = 200,
                   n_kg_per_t = s$n_kg_per_t,
                   p_kg_per_t = s$p_kg_per_t,
                   k_kg_per_t = s$k_kg_per_t)
```

`calc_pbp` *Payback period for SWC projects*

Description

Computes simple and discounted payback periods and assesses adoption likelihood. PBP is the strongest predictor of voluntary SWC uptake among smallholders in rainfed India (Joshi et al. 2005).

Usage

```
calc_pbp(
  investment,
  annual_benefit,
  annual_omc = 0,
  life = 20L,
  discount_rate = 0.12
)
```

Arguments

`investment`	Numeric. Capital investment.
`annual_benefit`	Numeric. Annual gross benefit.
`annual_omc`	Numeric. Annual O&M cost. Default `0`.
`life`	Integer. Project life (years). Default `20`.
`discount_rate`	Numeric. Discount rate. Default `0.12`.

Value

A list of class `"swcEcon_pbp"` with `simple_pbp`, `discounted_pbp`, and `adoption`.

References

Joshi, P.K., Jha, A.K., Wani, S.P., Joshi, L. and Shiyani, R.L. (2005). *Meta-Analysis to Assess Impact of Watershed Program and People's Participation*. IWMI Research Report 8. ISBN: 9290906677.

Singh, A.J., Lal, P. and Sharma, S.K. (2006). Economics of adoption of improved technologies in rainfed farming systems. *Indian Journal of Agricultural Economics*, **61**(3), 420–435.

Examples

```
calc_pbp(investment = 20, annual_benefit = 6, annual_omc = 0.8)
```

calc_soil_loss_cost — *Economic cost of soil loss using the USLE*

Description

Estimates annual economic cost of soil loss using the Universal Soil Loss Equation (Wischmeier and Smith 1978) and converts the reduction achieved by a SWC measure to monetary value.

Usage

```
calc_soil_loss_cost(
  R,
  K,
  LS,
  C_pre,
  C_post,
  P_pre = 1,
  P_post = 0.5,
  area_ha = 1,
  nutrient_cost_per_t = 1000,
  years = 1
)
```

Arguments

`R`	Numeric. Rainfall erosivity factor (MJ mm / ha hr yr). Use `rainfall_erosivity_india` for Indian district values.
`K`	Numeric. Soil erodibility factor. Use `usle_india_soils` for Indian soil orders.
`LS`	Numeric. Slope length-gradient factor (dimensionless).
`C_pre`	Numeric. Cover-management factor before SWC.
`C_post`	Numeric. Cover-management factor after SWC.
`P_pre`	Numeric. Support practice factor before SWC. Default `1.0`.
`P_post`	Numeric. Support practice factor after SWC. Default `0.5`.
`area_ha`	Numeric. Treatment area (ha). Default `1`.
`nutrient_cost_per_t`	Numeric. Nutrient replacement cost per tonne of soil (INR/t). Default `1000`.
`years`	Numeric. Annualisation multiplier. Default `1`.

Details

$$A = R \cdot K \cdot LS \cdot C \cdot P \quad (t/ha/yr)$$

The annual economic benefit = (A_pre - A_post) x area x nutrient cost.

Value

A list of class "swcEcon_soil" with soil_loss_pre, soil_loss_post, soil_saved_ha, soil_saved_total, annual_benefit_inr, and pct_reduction.

References

Wischmeier, W.H. and Smith, D.D. (1978). *Predicting Rainfall Erosion Losses*. USDA Agriculture Handbook No. 537. ISBN: 0160016258.

Singh, G., Babu, R., Narain, P., Bhushan, L.S. and Abrol, I.P. (1992). Soil erosion rates in India. *Journal of Soil and Water Conservation*, **47**(1), 97–99.

Katyal, J.C. and Sharma, B.D. (1991). Nutrients in soil fertility. *Fertiliser News*, **36**(4), 13–24.

Examples

```
data(usle_india_soils)
K <- usle_india_soils[usle_india_soils$soil_series == "Vertisols", "k_mean"]
calc_soil_loss_cost(R = 720, K = K, LS = 4.2,
                    C_pre = 0.35, C_post = 0.18,
                    P_pre = 1.0, P_post = 0.5, area_ha = 500)
```

---

calc_switching_value *Switching value analysis for SWC projects*

Description

Computes how much costs can rise (or benefits fall) before BCR = 1.0. A higher switching value indicates greater robustness to estimation error (Gittinger 1982; World Bank 1998).

Usage

```
calc_switching_value(
  investment,
  annual_benefit,
  annual_omc = 0,
  life = 20L,
  discount_rate = 0.12
)
```

Arguments

investment	Numeric. Capital investment.
annual_benefit	Numeric. Annual gross benefit.
annual_omc	Numeric. Annual O&M cost. Default 0.
life	Integer. Project life (years). Default 20.
discount_rate	Numeric. Discount rate. Default 0.12.

Value

A list of class "swcEcon_sv" with switching values and interpretations.

References

Gittinger, J.P. (1982). *Economic Analysis of Agricultural Projects*, 2nd ed. Johns Hopkins University Press. ISBN: 9780801825439.

World Bank (1998). *Handbook on Economic Analysis of Investment Operations*. World Bank, Washington DC.

Examples

```
calc_switching_value(investment = 20, annual_benefit = 6,
                     annual_omc = 0.8, life = 20,
                     discount_rate = 0.12)
```

---

calc_water_value *Groundwater recharge and runoff harvesting value*

Description

Estimates annual economic value of water benefits from a SWC watershed intervention.

Usage

```
calc_water_value(
  area_ha,
  rainfall_mm,
  rc_pre = 0.35,
  rc_post = 0.2,
  harvest_pct = 45,
  gw_recharge_pct = 20,
  water_value_m3 = 3.5
)
```

Arguments

area_ha	Numeric. Watershed area (ha).
rainfall_mm	Numeric. Mean annual rainfall (mm).
rc_pre	Numeric. Runoff coefficient before SWC (0–1). Default 0.35.
rc_post	Numeric. Runoff coefficient after SWC (0–1). Default 0.20.
harvest_pct	Numeric. Percentage of reduced runoff harvested. Default 45.
gw_recharge_pct	Numeric. Percentage percolating to groundwater. Default 20.
water_value_m3	Numeric. Value of water (INR/m3). Default 3.5.

Details

Runoff volume (m3/yr) = RC x P x A x 10. Annual water benefit = (Q_harvest + Q_recharge) x water_value.

Value

A list of class "swcEcon_water" with runoff volumes and annual_benefit_inr.

References

Joshi, P.K., Jha, A.K., Wani, S.P., Joshi, L. and Shiyani, R.L. (2005). *Meta-Analysis to Assess Impact of Watershed Program and People's Participation*. IWMI Research Report 8. ISBN: 9290906677.

Examples

```
data(rainfall_erosivity_india)
rf <- rainfall_erosivity_india[
  rainfall_erosivity_india$district == "Pune", "annual_rf_mm"]
calc_water_value(area_ha = 500, rainfall_mm = rf,
                 rc_pre = 0.35, rc_post = 0.20)
```

---

farmer_adoption *Simulated farm-level SWC adoption survey dataset*

Description

A hypothetically generated survey of 120 farm households from four Indian states. SWC adoption modelled via logistic regression. Not real survey data.

Usage

```
data(farmer_adoption)
```

Format

A data frame with 120 rows and 10 variables:

farmer_id Character. Farmer identifier.

state Character. State (Maharashtra, Rajasthan, Karnataka, MP).

farm_size_ha Numeric. Farm area (ha).

education_yrs Integer. Years of formal education.

annual_income_lakh Numeric. Annual household income (INR lakh).

credit_access Character. Institutional credit access (Yes/No).

extension_visits Integer. Extension agent visits per year.

yield_pre_kharif Numeric. Kharif yield before SWC (t/ha).

adopted_swc Integer. Adoption: 1 = adopted, 0 = not adopted.

yield_post_kharif Numeric. Kharif yield after SWC (t/ha); `NA` for non-adopters.

Details

Data status: HYPOTHETICALLY GENERATED. Not real survey data.

Adoption logit model:

$$logit(p) = -1.2 + 0.15 \cdot size + 0.08 \cdot edu + 0.20 \cdot income + 0.60 \cdot credit + 0.18 \cdot extension$$

Simulated adoption rate approx. 63 per cent. `set.seed(2025)`.

Source

Hypothetical. See `data-raw/generate_all_datasets.R`.

References

Joshi, P.K., Jha, A.K., Wani, S.P., Joshi, L. and Shiyani, R.L. (2005). *Meta-Analysis to Assess Impact of Watershed Program and People's Participation*. IWMI Research Report 8. ISBN: 9290906677.

Singh, A.J., Lal, P. and Sharma, S.K. (2006). Economics of adoption of improved technologies in rainfed farming systems. *Indian Journal of Agricultural Economics*, **61**(3), 420–435.

Examples

```
data(farmer_adoption)
mean(farmer_adoption$adopted_swc)
aggregate(adopted_swc ~ state, data = farmer_adoption, FUN = mean)
```

`generate_swc_report` *Generate an automated HTML economic appraisal report*

Description

Produces a self-contained HTML report from a `run_swc_pipeline` result, formatted for NABARD and PMKSY-WDC project proposals.

Usage

```
generate_swc_report(
  pipeline,
  output_file = "swcEcon_report.html",
  title = "SWC Economic Appraisal Report",
  author = "swcEcon",
  organisation = ""
)
```

Arguments

`pipeline`	An object of class "swcEcon_pipeline".
`output_file`	Character. Output HTML path. Default "swcEcon_report.html".
`title`	Character. Report title.
`author`	Character. Author name.
`organisation`	Character. Organisation name. Default "".

Value

Invisibly returns the path to the HTML file.

References

GoI (2015). *Common Guidelines for Watershed Development Projects under PMKSY-WDC*. Ministry of Rural Development, New Delhi.

NABARD (2019). *Operational Guidelines: Watershed Development Fund*. National Bank for Agriculture and Rural Development, Mumbai.

Examples

```
pl  <- run_swc_pipeline(investment = 20, annual_benefit = 6,
                        annual_omc = 0.8, include_sensitivity = FALSE)
tmp <- tempfile(fileext = ".html")
generate_swc_report(pl, output_file = tmp, author = "Researcher")
```

---

monte_carlo_swc   *Monte Carlo simulation for SWC project risk analysis*

Description

Stochastic simulation of BCR and NPV distributions. Investment, benefit, and O&M costs are sampled from truncated Normal distributions; project life from a discrete Uniform; discount rate from a continuous Uniform. Follows Pouliquen (1970) as recommended by World Bank (1998).

Usage

```
monte_carlo_swc(
  inv_mean = 20,
  inv_cv = 0.1,
  ben_mean = 6,
  ben_cv = 0.15,
  omc_mean = 0,
  omc_cv = 0.2,
  life_min = 15L,
```

```
  life_max = 25L,
  r_min = 0.1,
  r_max = 0.14,
  n_sim = 5000L,
  seed = 42L
)
```

Arguments

inv_mean	Numeric. Mean capital investment. Default 20.
inv_cv	Numeric. CV for investment. Default 0.10.
ben_mean	Numeric. Mean annual benefit. Default 6.
ben_cv	Numeric. CV for benefit. Default 0.15.
omc_mean	Numeric. Mean annual O&M. Default 0.
omc_cv	Numeric. CV for O&M. Default 0.20.
life_min	Integer. Minimum project life. Default 15.
life_max	Integer. Maximum project life. Default 25.
r_min	Numeric. Minimum discount rate. Default 0.10.
r_max	Numeric. Maximum discount rate. Default 0.14.
n_sim	Integer. Number of simulations. Default 5000.
seed	Integer or NULL. Random seed. Default 42.

Value

A list of class "swcEcon_mc" with simulated BCR and NPV vectors, probability estimates, and summary statistics.

References

ADB (2017). *Guidelines for the Economic Analysis of Projects*. Asian Development Bank, Manila. https://www.adb.org/documents/guidelines-economic-analysis-projects

Pouliquen, L.Y. (1970). *Risk Analysis in Project Appraisal*. World Bank Occasional Papers No. 11. Johns Hopkins University Press.

World Bank (1998). *Handbook on Economic Analysis of Investment Operations*. World Bank, Washington DC.

Examples

```
mc <- monte_carlo_swc(inv_mean = 20, ben_mean = 6, omc_mean = 0.8,
                       n_sim = 1000, seed = 42)
print(mc)
```

print.swcEcon_result *Print a swcEcon_result object*

Description

Print a swcEcon_result object

Usage

```
## S3 method for class 'swcEcon_result'
print(x, ...)
```

Arguments

`x`	An object of class `"swcEcon_result"`.
`...`	Ignored.

Value

Invisibly returns `x`.

rainfall_erosivity_india *Rainfall erosivity (R-factor) for 20 Indian watershed districts*

Description

USLE R-factor and climatological parameters for 20 representative watershed districts across major Indian agro-ecological zones.

Usage

```
data(rainfall_erosivity_india)
```

Format

A data frame with 20 rows and 8 variables:

district Character. District headquarters name.

state Character. State name.

lat Numeric. Latitude, decimal degrees (WGS84).

lon Numeric. Longitude, decimal degrees (WGS84).

annual_rf_mm Numeric. Mean annual rainfall (mm), 1981–2010.

r_factor Numeric. USLE R-factor (MJ mm / ha hr yr).

kharif_pct Numeric. June–September rainfall (per cent).

mean_temp_c Numeric. Mean annual temperature (degrees C).

Details

Data status: Real – derived from public domain data using published peer-reviewed formulae.

R-factor computed using Modified Fournier Index (MFI) and the regression: R = 38.46 + 3.48 x MFI (Bhattacharyya et al. 2010). Rainfall normals from IMD 0.25-degree gridded dataset, 1981–2010.

Source

IMD 0.25-degree gridded rainfall, 1981–2010. India Meteorological Department, Pune (public domain). https://imdpune.gov.in

References

Bhattacharyya, T., Pal, D.K., Mandal, C. and others (2010). Soils of India: Historical perspective, classification and recent advances. *Current Science*, **98**(9), 1248–1257.

Pai, D.S. and others (2014). Development of a new high spatial resolution long period daily gridded rainfall data set over India. *Mausam*, **65**(1), 1–18.

Examples

```
data(rainfall_erosivity_india)
rainfall_erosivity_india[rainfall_erosivity_india$r_factor > 900,
  c("district", "state", "r_factor")]
```

`run_swc_pipeline` *Run the complete swcEcon economic appraisal pipeline*

Description

Runs BCR, NPV, IRR, payback period, switching value, and optionally sensitivity analysis and Monte Carlo simulation in a single call.

Usage

```
run_swc_pipeline(
  investment,
  annual_benefit,
  annual_omc = 0,
  life = 20L,
  discount_rate = 0.12,
  project_name = "SWC Project",
  include_sensitivity = TRUE,
  include_monte_carlo = FALSE,
  n_sim = 2000L,
  ...
)
```

Arguments

`investment`	Numeric. Capital investment.
`annual_benefit`	Numeric. Annual gross benefit.
`annual_omc`	Numeric. Annual O&M cost. Default `0`.
`life`	Integer. Project life (years). Default `20`.
`discount_rate`	Numeric. Discount rate. Default `0.12`.
`project_name`	Character. Project label. Default `"SWC Project"`.
`include_sensitivity`	Logical. Run sensitivity analysis. Default `TRUE`.
`include_monte_carlo`	Logical. Run Monte Carlo. Default `FALSE`.
`n_sim`	Integer. Monte Carlo iterations. Default `2000`.
`...`	Reserved for future use.

Value

A list of class `"swcEcon_pipeline"` with `steps` (sub-module results), `summary` (data frame), and metadata.

Examples

```
pl <- run_swc_pipeline(
  investment     = 20,
  annual_benefit = 6,
  annual_omc     = 0.8,
  project_name   = "Hypothetical Check Dam Project",
  include_sensitivity  = FALSE,
  include_monte_carlo  = FALSE
)
print(pl)
```

`sensitivity_analysis` *Sensitivity analysis for SWC project appraisal*

Description

Performs one-at-a-time (OAT) sensitivity analysis varying costs, benefits, and discount rate by specified ranges. Returns an 8-scenario table suitable for a tornado diagram.

Usage

```
sensitivity_analysis(
  investment,
  annual_benefit,
  annual_omc = 0,
  life = 20L,
  discount_rate = 0.12,
  cost_range_pct = 20,
  benefit_range_pct = 20,
  rate_range_pct = 3
)
```

Arguments

`investment`	Numeric. Base capital investment.
`annual_benefit`	Numeric. Base annual benefit.
`annual_omc`	Numeric. Base annual O&M cost. Default `0`.
`life`	Integer. Project life (years). Default `20`.
`discount_rate`	Numeric. Base discount rate. Default `0.12`.
`cost_range_pct`	Numeric. Variation applied to costs (per cent). Default `20`.
`benefit_range_pct`	Numeric. Variation applied to benefit (per cent). Default `20`.
`rate_range_pct`	Numeric. Percentage points added/subtracted from discount rate. Default `3`.

Details

Required by NABARD (2019) for watershed project appraisal and recommended by World Bank (1998) for agricultural investment projects.

Value

A list of class `"swcEcon_sens"` with `scenarios` (data frame), `base_bcr`, `base_npv`, and `summary`.

References

NABARD (2019). *Operational Guidelines: Watershed Development Fund*. National Bank for Agriculture and Rural Development, Mumbai.

World Bank (1998). *Handbook on Economic Analysis of Investment Operations*. World Bank, Washington DC.

Examples

```
sensitivity_analysis(investment = 20, annual_benefit = 6,
                     annual_omc = 0.8, life = 20,
                     discount_rate = 0.12)
```

`swc_benchmarks` *State-wise SWC watershed economic benchmarks for India*

Description

Typical ranges of BCR, IRR, unit cost, employment generation ratio, and payback period for watershed SWC projects across ten major Indian states. Compiled from published government evaluation reports.

Usage

```
data(swc_benchmarks)
```

Format

A data frame with 10 rows and 10 variables:

state Character. State name.

agro_zone Character. Agro-ecological zone.

annual_rainfall_mm Numeric. Mean annual rainfall (mm).

bcr_min Numeric. Minimum BCR from evaluated projects.

bcr_max Numeric. Maximum BCR.

bcr_typical Numeric. Median BCR across evaluations.

irr_pct Numeric. Typical IRR (per cent).

cost_per_ha Numeric. Investment cost per ha (INR).

egr_person_days_per_lakh Numeric. Person-days per INR lakh.

pbp_years Numeric. Typical payback period (years).

Details

Data status: Real – public domain government documents.

Compiled from NABARD WDF Annual Reports 2010–2022 (National Bank for Agriculture and Rural Development), PMKSY-WDC Progress Reports (https://dolr.gov.in), and CRIDA Technical Bulletins (ICAR). All BCR values computed at 12 per cent discount rate.

Source

NABARD WDF Annual Reports 2010–2022 (public domain). PMKSY-WDC Progress Reports, GoI (public domain).

References

NABARD (2019). *Operational Guidelines: Watershed Development Fund*. National Bank for Agriculture and Rural Development, Mumbai.

GoI (2015). *Common Guidelines for Watershed Development Projects under PMKSY-WDC*. Ministry of Rural Development, New Delhi.

Examples

```
data(swc_benchmarks)
swc_benchmarks[swc_benchmarks$bcr_typical >= 2.0,
               c("state", "bcr_typical", "irr_pct")]
```

`swc_cost_norms` *SWC measure unit cost norms (PMKSY-WDC 2015, updated to 2024)*

Description

Standard unit costs for 18 common SWC structures from PMKSY-WDC Common Guidelines (GoI 2015), updated to 2024 using RBI CPI.

Usage

```
data(swc_cost_norms)
```

Format

A data frame with 18 rows and 7 variables:

measure Character. SWC measure name.

unit Character. Cost basis: per unit or per ha.

norm_2015_inr Numeric. PMKSY-WDC 2015 unit cost (INR).

norm_2024_inr Numeric. Estimated 2024 unit cost (INR).

design_life_yr Numeric. Expected design life (years).

omc_pct_capital Numeric. Annual O&M as per cent of capital.

labour_pct Numeric. Labour as per cent of total cost.

Details

Data status: Real – public domain Government of India guidelines.

Unit costs from PMKSY-WDC Common Guidelines (GoI 2015), available at https://dolr.gov.in. The 2024 estimates apply a CPI inflation factor of 1.65 (RBI CPI April 2015 to April 2024).

Source

GoI (2015). *Common Guidelines for Watershed Development Projects under PMKSY-WDC*. Ministry of Rural Development, New Delhi. Available at https://dolr.gov.in.

References

GoI (2015). *Common Guidelines for Watershed Development Projects under PMKSY-WDC*. Ministry of Rural Development, New Delhi.

CSWCRTI (2019). *Technical Manual on Soil and Water Conservation Structures*. ICAR, Dehradun (public domain).

Examples

```
data(swc_cost_norms)
swc_cost_norms[swc_cost_norms$design_life_yr >= 20,
               c("measure", "norm_2024_inr", "design_life_yr")]
```

`usle_india_soils` *USLE erodibility and nutrient parameters for Indian soil orders*

Description

Soil erodibility K-factor ranges and NPK nutrient content for eight major soil orders in Indian watersheds.

Usage

```
data(usle_india_soils)
```

Format

A data frame with 8 rows and 11 variables:

soil_series Character. Soil order (USDA classification).

soil_order Character. Common Indian name.

states_typical Character. States where order predominates.

k_min Numeric. Minimum K-factor (t ha hr / ha MJ mm).

k_max Numeric. Maximum K-factor.

k_mean Numeric. Mean K-factor for use when site data unavailable.

oc_pct Numeric. Typical organic carbon (per cent).

t_value Numeric. Permissible soil loss (t/ha/yr).

n_kg_per_t Numeric. N per tonne of soil (kg/t).

p_kg_per_t Numeric. P per tonne (kg/t).

k_kg_per_t Numeric. K per tonne (kg/t).

Details

Data status: Real – public domain scientific literature.

K-factor values from NBSS and LUP Technical Bulletin No. 132 (ICAR) and Singh et al. (1992). Nutrient content from Katyal and Sharma (1991).

Source

NBSS and LUP (2002). *Soil Erodibility (K Factor) of Different Soils of India*. Technical Bulletin 132. ICAR, Nagpur.

References

Wischmeier, W.H. and Smith, D.D. (1978). *Predicting Rainfall Erosion Losses*. USDA Agriculture Handbook No. 537. ISBN: 0160016258.

Singh, G., Babu, R., Narain, P., Bhushan, L.S. and Abrol, I.P. (1992). Soil erosion rates in India. *Journal of Soil and Water Conservation*, **47**(1), 97–99.

Katyal, J.C. and Sharma, B.D. (1991). Nutrients in soil fertility. *Fertiliser News*, **36**(4), 13–24.

Examples

```
data(usle_india_soils)
usle_india_soils[usle_india_soils$soil_series == "Vertisols", ]
```

---

watershed_projects *Simulated watershed SWC project evaluation dataset*

Description

A hypothetically generated dataset of 50 simulated SWC project evaluations for package illustration. Not real project data.

Usage

```
data(watershed_projects)
```

Format

A data frame with 50 rows and 18 variables:

project_id Character. Identifier (WS001–WS050).
state Character. Simulated state name.
swc_measure Character. Primary SWC measure.
area_ha Numeric. Watershed area (ha).
investment_lakh Numeric. Capital investment (INR lakh).
annual_benefit_lakh Numeric. Annual gross benefit (INR lakh).
annual_omc_lakh Numeric. Annual O&M cost (INR lakh).
discount_rate_pct Numeric. Discount rate (per cent).
project_life Numeric. Design life (years).
soil_loss_pre Numeric. Pre-SWC soil loss (t/ha/yr).
soil_loss_post Numeric. Post-SWC soil loss (t/ha/yr).
gw_level_change_m Numeric. Groundwater level change (m).
irrig_area_added_ha Numeric. Additional irrigated area (ha).
employment_days Numeric. Employment generated (person-days).
hh_benefited Numeric. Beneficiary households.
bcr Numeric. Computed benefit-cost ratio.
npv_lakh Numeric. Net present value (INR lakh).
pbp_years Numeric. Simple payback period (years).

Details

Data status: HYPOTHETICALLY GENERATED. Not real project data.

Generated with `set.seed(2025)`. Parameter distributions calibrated to NABARD WDF project characteristics (Joshi et al. 2005). See `data-raw/generate_all_datasets.R`.

Source

Hypothetical. See `data-raw/generate_all_datasets.R`.

References

Joshi, P.K., Jha, A.K., Wani, S.P., Joshi, L. and Shiyani, R.L. (2005). *Meta-Analysis to Assess Impact of Watershed Program and People's Participation*. IWMI Research Report 8. ISBN: 9290906677.

Examples

```
data(watershed_projects)
summary(watershed_projects$bcr)
aggregate(bcr ~ swc_measure, data = watershed_projects, FUN = mean)
```

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