

# Package ‘swcEcon’

April 16, 2026

**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	<i>swcEcon: Economic Analysis of Soil and Water Conservation Measures</i>
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## 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.

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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	<i>Employment generation ratio for SWC projects</i>
-----------------	---

---

### 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_mbc	<i>Modified benefit-cost ratio</i>
----------	------------------------------------

---

**Description**

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

**Usage**

```
calc_mbc(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\_mbc" with mbc and interpretation.

**References**

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

**Examples**

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

---

calc_mrr	<i>Marginal rate of return (CIMMYT method)</i>
----------	--

---

**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	<i>Net present value for SWC watershed projects</i>
----------	---

---

**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 <a href="#">rainfall_erosivity_india</a> for Indian district values.
K	Numeric. Soil erodibility factor. Use <a href="#">usle_india_soils</a> 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	<i>Groundwater recharge and runoff harvesting value</i>
------------------	---

---

**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 (m<sup>3</sup>/yr) = RC x P x A x 10. Annual water benefit = (Q<sub>harvest</sub> + Q<sub>recharge</sub>) 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:

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

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,
```



---

```
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:  $R = 38.46 + 3.48 \times \text{MFI}$  (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	<i>SWC measure unit cost norms (PMKSY-WDC 2015, updated to 2024)</i>
----------------	--

---

**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	<i>USLE erodibility and nutrient parameters for Indian soil orders</i>
------------------	--

---

**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.
- ber** 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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