2015 International conference Soil and Water Assessment Tool

SWAT 2015
PULA / SARDINIA / ITALY

Impact of best management practices to improve water quality from mountainous catchment: Haean catchment in South Korea

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UNIVERSITÄT BAYREUTH

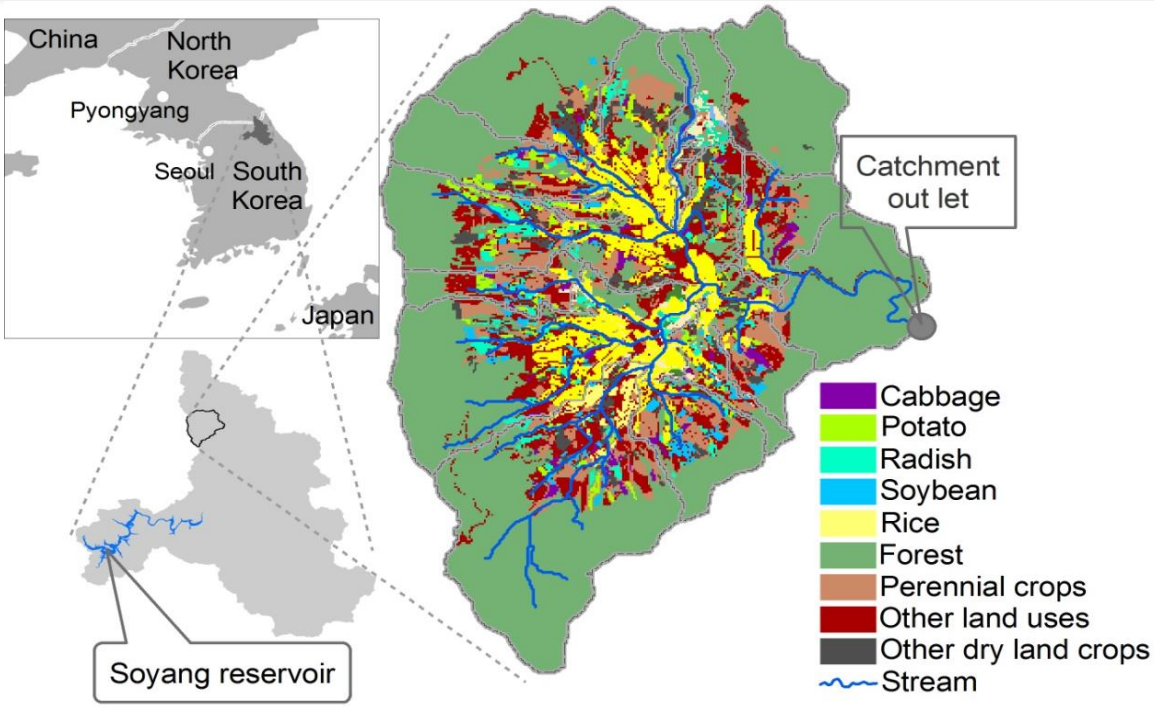
BoPhy

TERRECO

Complex TERRain and ECOlogical Heterogeneity
International Research Training Group
DFG / KOSEF

Contents

- Intensive dry and wet land agriculture in **mountainous landscape**
- Excess use of **fertilization**
- **Steep slopes**
- **Monsoon rain**
- Export large amount of **sediment and nutrients**
- **Water quality problem**



Location of Study Area (Haean Catchment)

Gangwon Provience near Demilitarized Zone (DMZ) between North and South Korea.

Area: 62 Km^2

Land Use:
Forest and Orchard: 62 %
Annual Dry land: 26 %
Wet land/Rice: 8 %

Annual Precipitation (pcp):
1650mm 70% of pcp
June-August

- To evaluate current land use system and management practices
- To improve the water quality by using Best Management Practices (BMPs)
  - Reduce sediment and nitrate export
- To evaluate the effectiveness BMPs
- To provide recommendation of BMPs

BMPs scenarios to mojor dry land crops

Baseline scenario :- **BL** Split fertilizer scenario:- **SF** Cover crop scenarios:- **CC**

Combined scenario:- **SFCC**

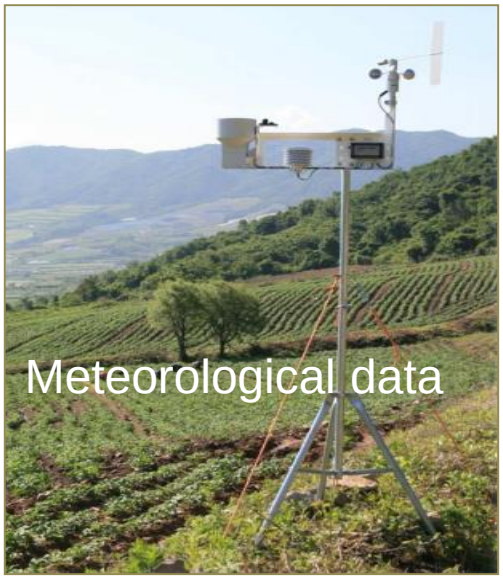
1. BL scenario:
- Single fertilizer application
- Land are barren after harvest

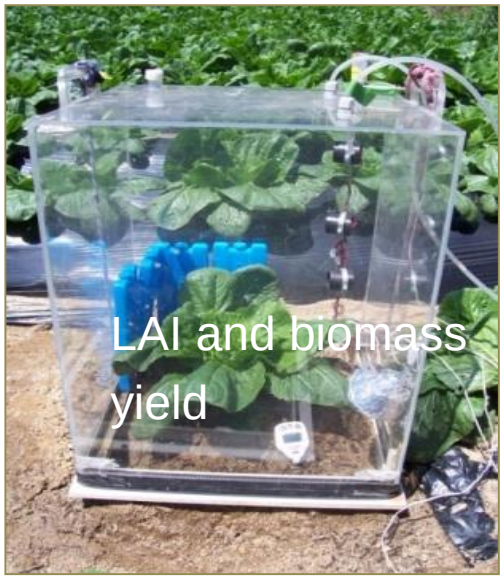
2. SF scenario:
- Multiple fertilizer application
- Land are barren after harvest

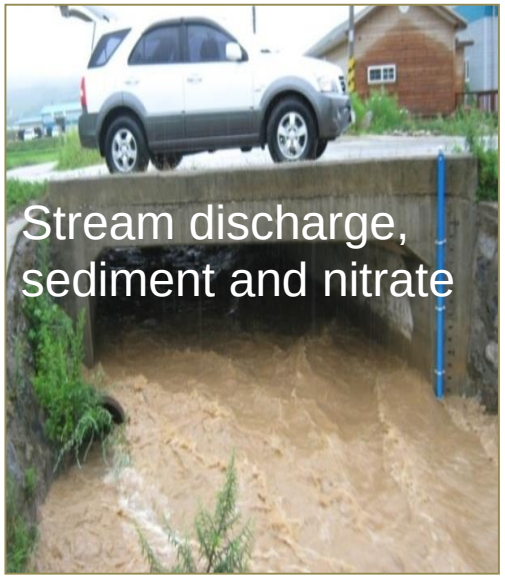
3. CC scenario:
- Single fertilizer application
- Cover crop after harvest

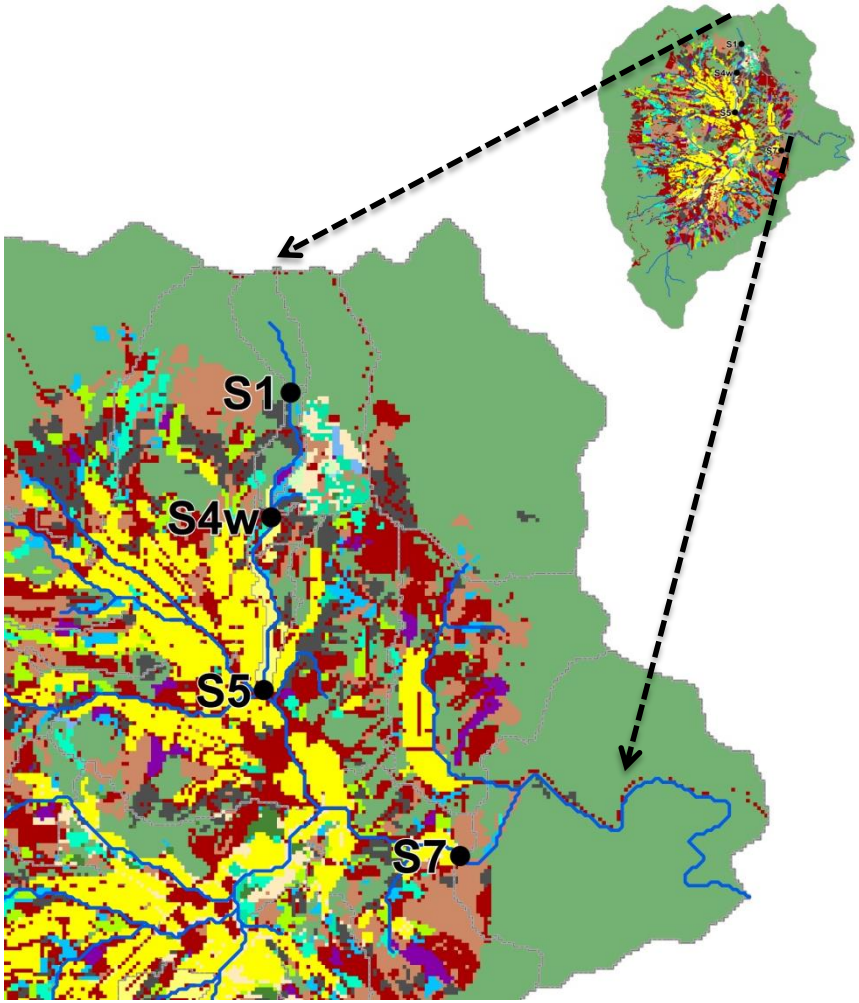
4. SFCC scenario:
- Multiple fertilizer application
- Cover crop after harvest

Experimental setup: Data generation









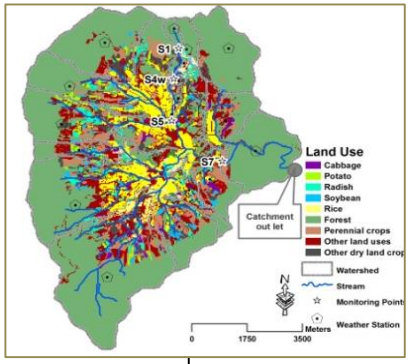
Methodological frame work

Climatological data
rainfall, temperature, solar radiation, relative humidity , wind velocity

GIS data
DEM, land use map, soil map

Observational data
discharge, sediment and nitrate

Agro-ecological model **(SWAT-Model)**
(calibration 2009-2010 and validation 2011)



Baseline scenario
BL=Baseline
(Current Agri. activity)

BMPs Scenarios
SF=Split fertilizer
CC=Cover crop
SFCC=both

Analysis of Considerable difference

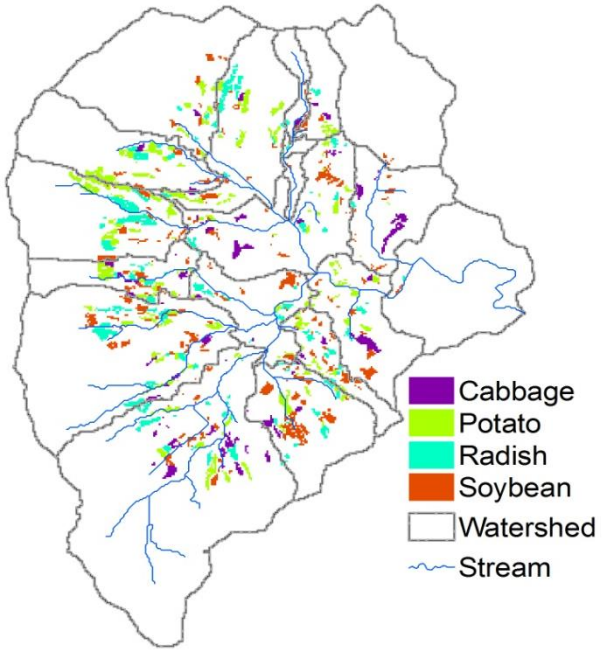
Recommendation of BMP to improve water quality

Model calibration and validation

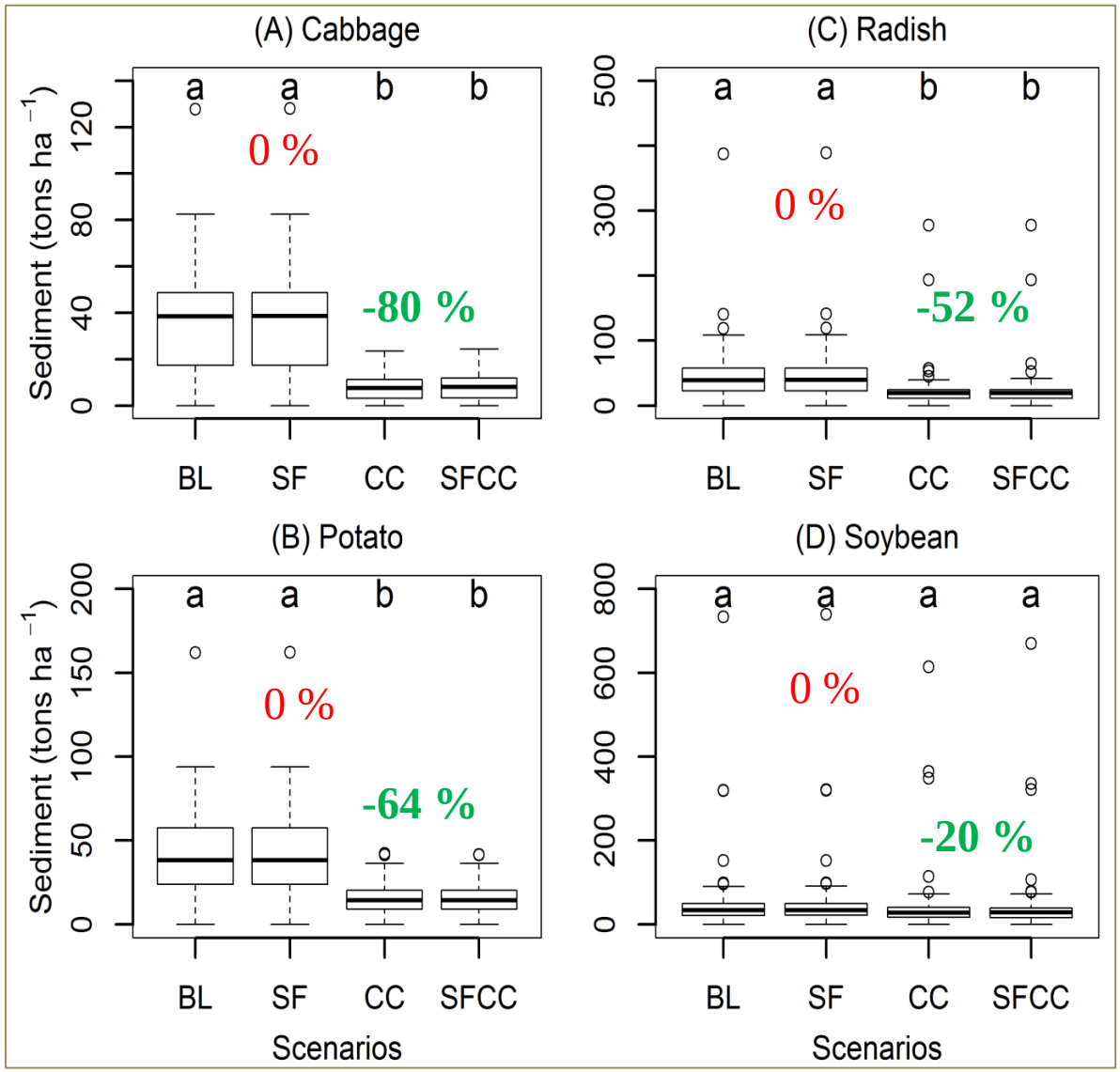
		Calibration (2009-2010)			Validation (2011)		
Variable	Stream site	R^2	NSE	PBIAS(%)	R^2	NSE	PBIAS(%)
Discharge	S1	0.76	0.72	2.7	0.75	0.56	43.8
	S4W*	0.8	0.6	-1.9	0.68	0.02	43.4
	S5	0.89	0.88	-5.7	0.74	0.50	66.7
	S7	0.82	0.75	-38.9	0.85	0.73	-33.2
Average		**0.82**	**0.74**	-10.95	**0.76**	**0.45**	30.18
Sediment	S1	0.98	0.82	13.0	0.64	0.56	-38.9
	S4W*	0.87	0.86	6.8	0.78	0.35	125.7
	S5	0.92	0.87	15.6	0.84	0.60	72.2
	S7	0.82	0.58	-47	0.92	0.90	11.6
Average		**0.90**	**0.78**	-2.9	**0.80**	**0.60**	42.65
Nitrate**	S7	**0.62**	**0.48**	-40.10	**0.61**	**0.52**	34.1

*Calibration period for stream site S4W was only 2010, **Nitrate calibrated and validated only for downstream site at S7

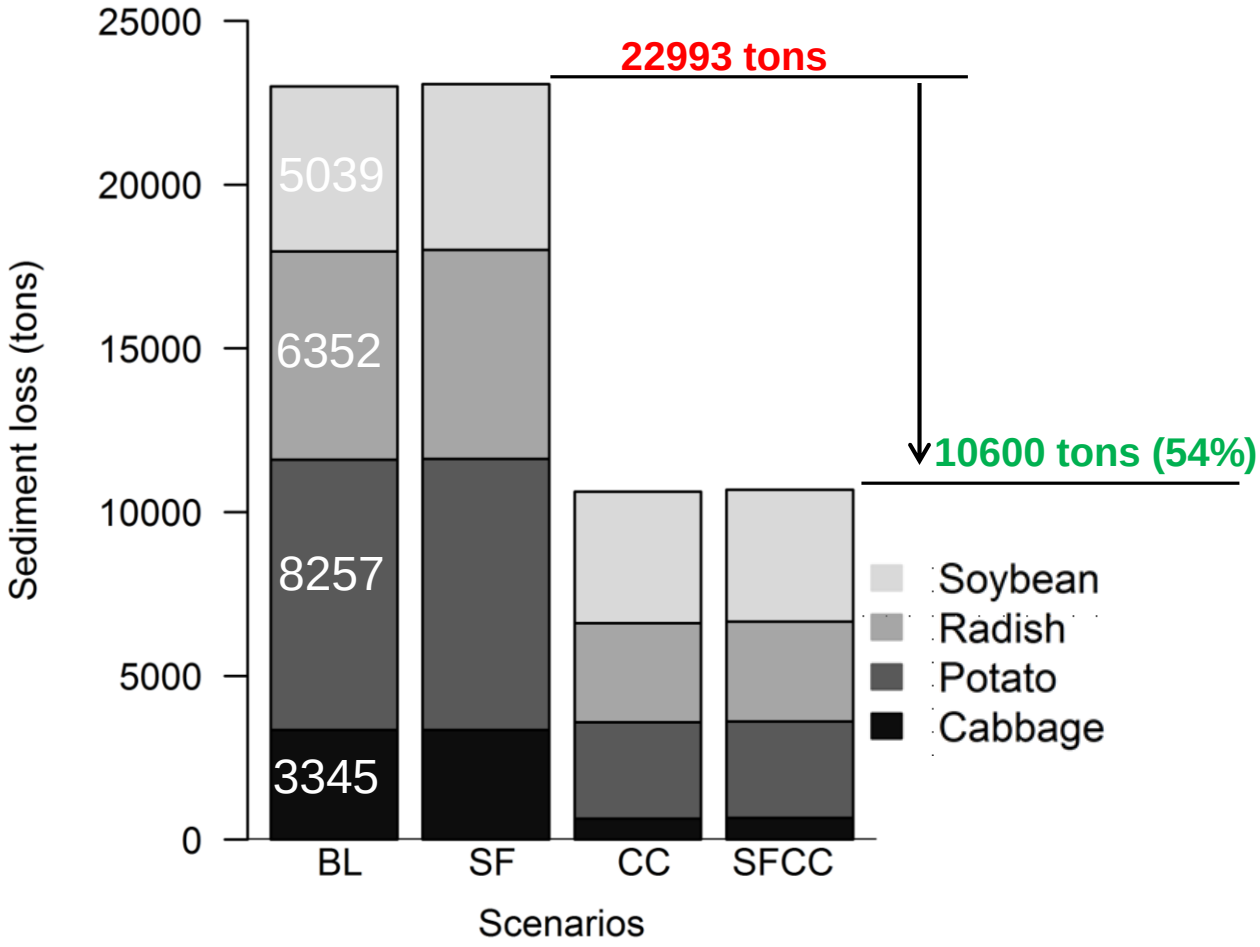
Effectiveness of BMPs scenarios to control **Sediment loss**



Crop types	Area (ha)	BL (ton/ha)
Cabbage	70	48
Potato	156	53
Radish	121	52
Soybean	142	36

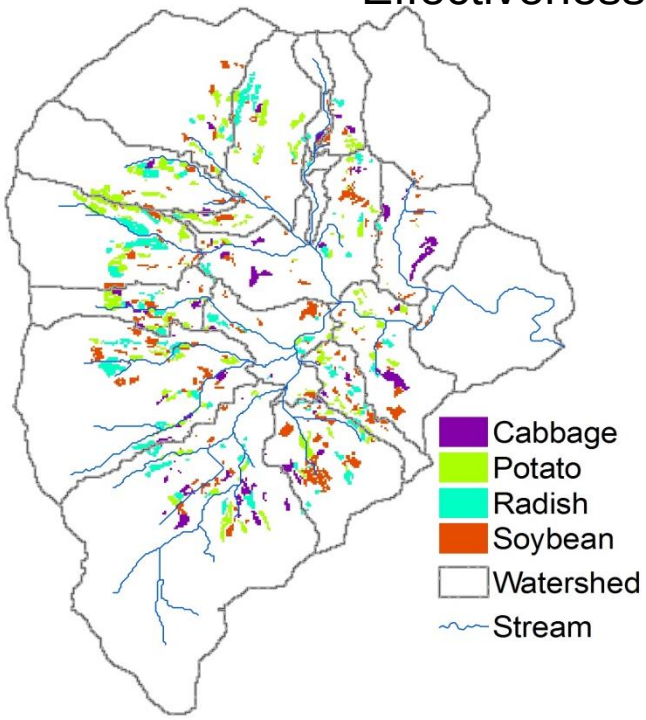


Total sediment loss from different crops

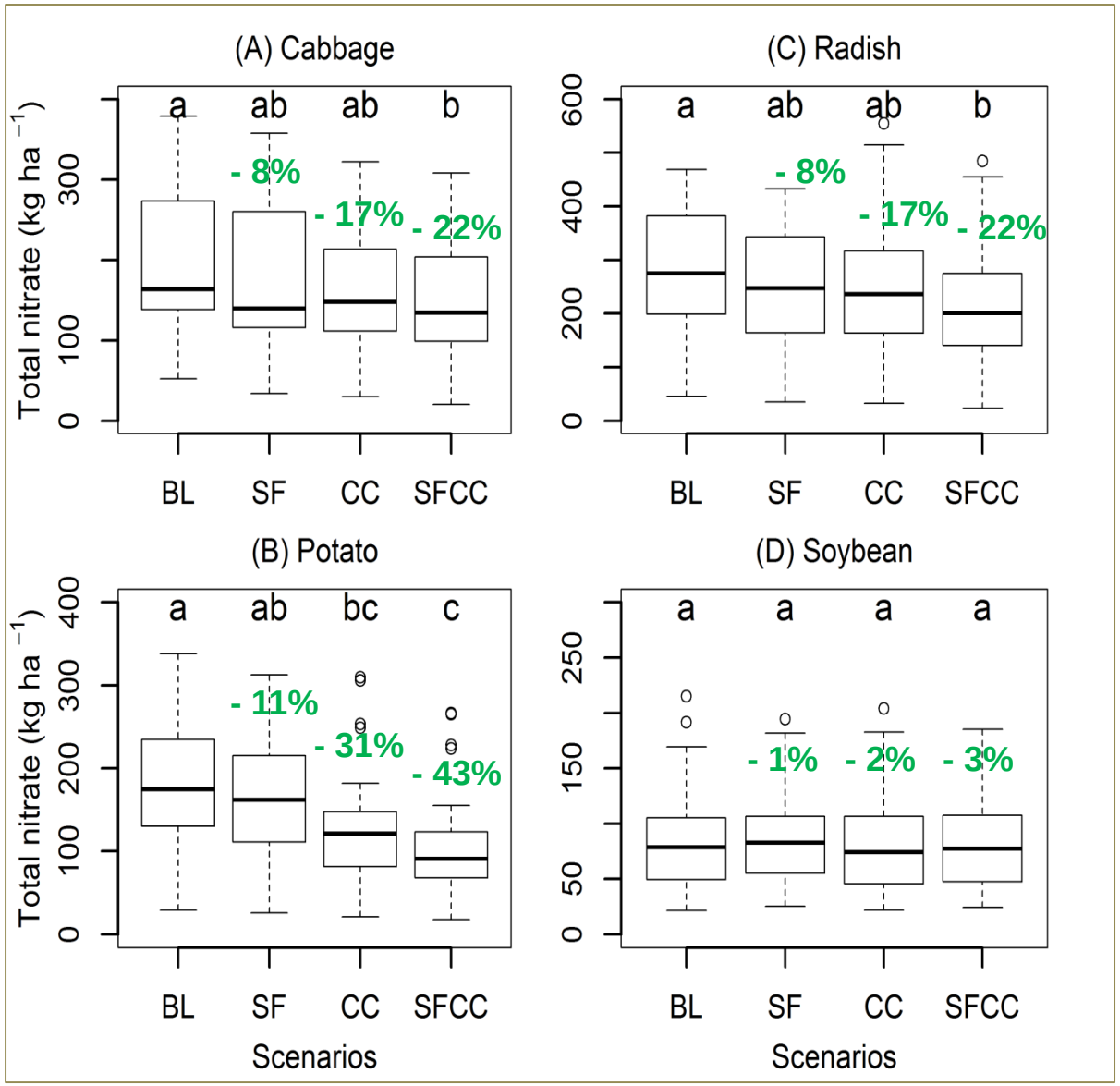


Level	Area (ha)	BL (ton/ha)	Total sediment	% contirbution
Average (4 crops)	489	47	22993	37
Catchment average	6274	10	62740	---

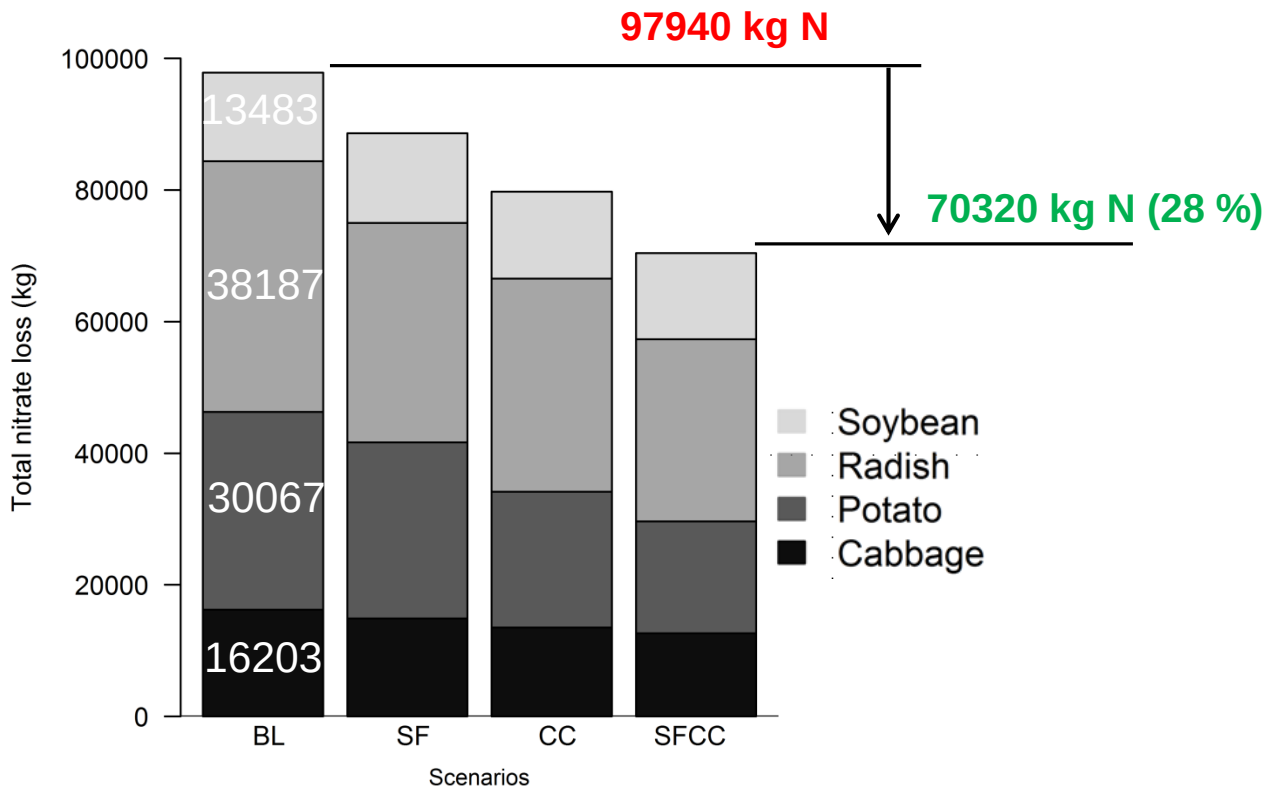
Effectiveness of BMPs scenarios to control **Total nitrate loss**



Crop types	Area (ha)	BL (kg/ha)
Cabbage	70	232
Potato	156	193
Radish	121	315
Soybean	142	95



Total nitrate loss from different crops

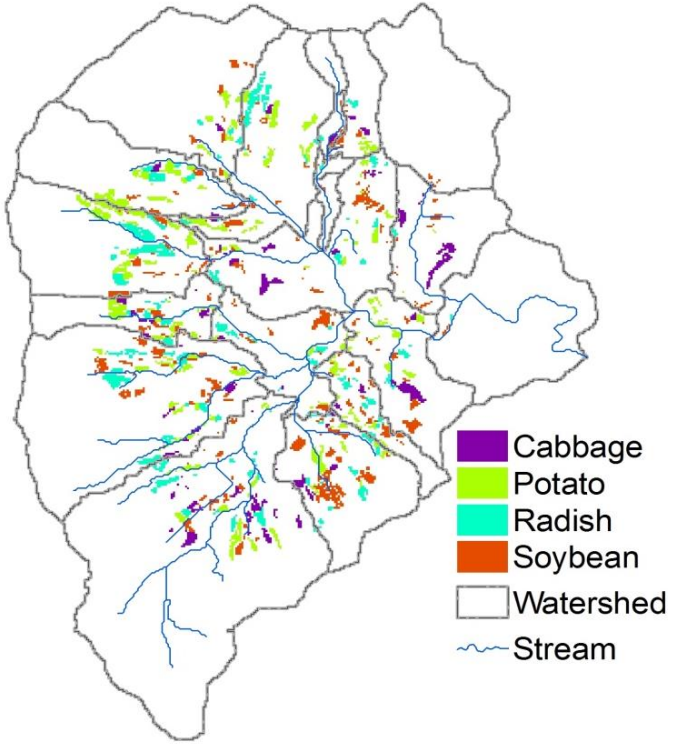


Level	Area (ha)	BL (kg/ha)	Total	% contirbution
Average (4 crops)	489	200	97940	40
Catchment average	6274	39	244686	---

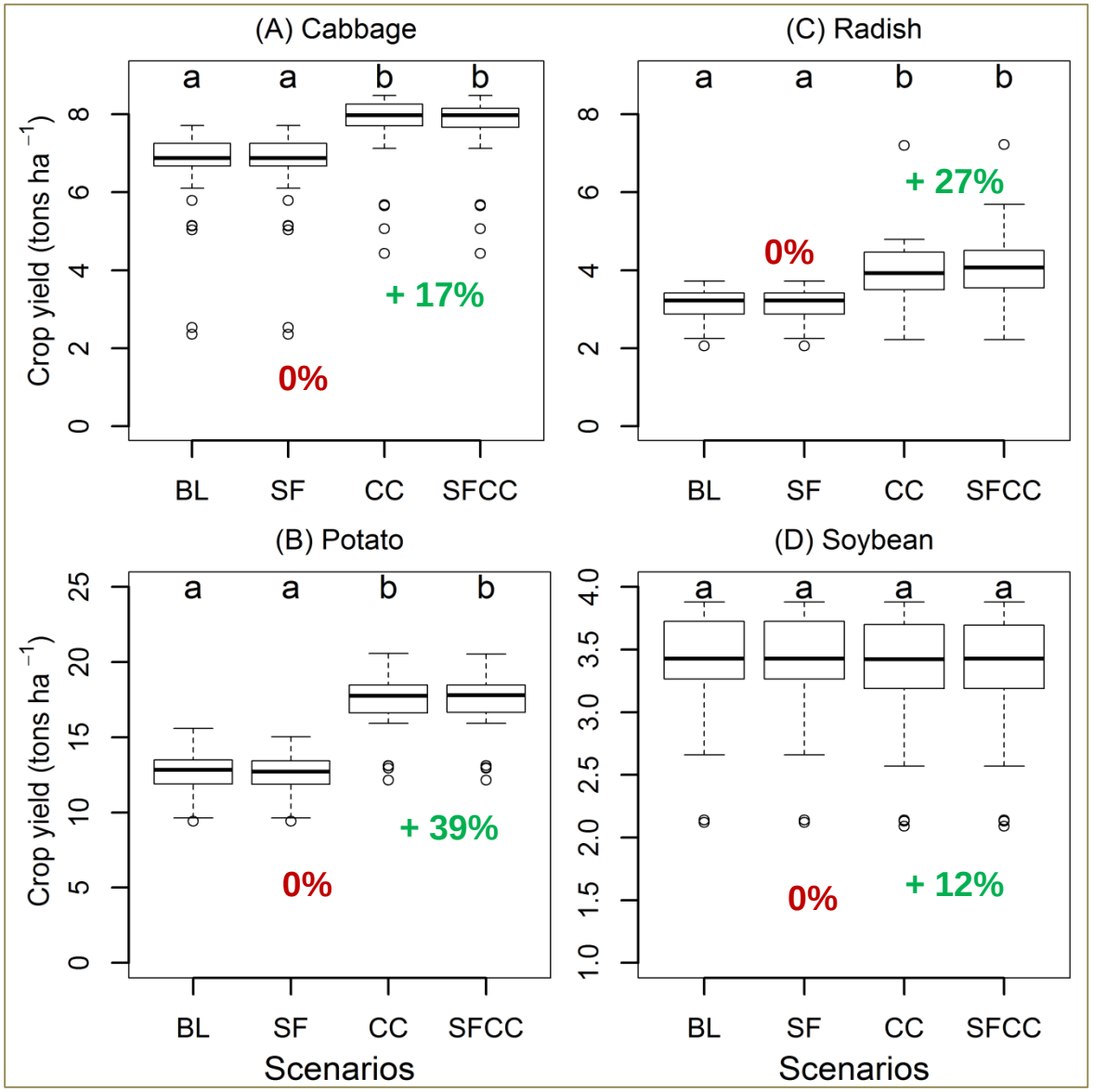
Scenarios

BL= Baseline, **SF**=Split Fertilizer, **CC**=Cover Crop, **SFCC**=Split Fertilizer & Cover Crop

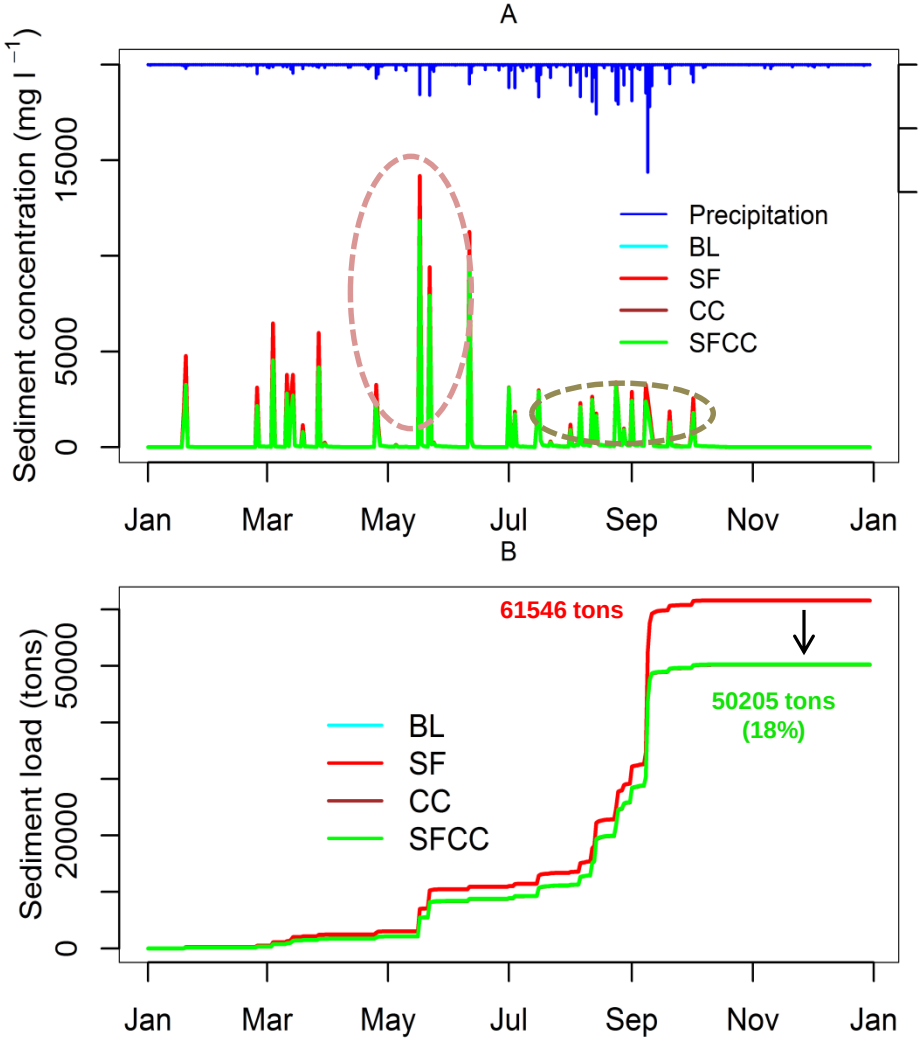
Effectiveness of BMPs scenarios to increase the **Crop yield**



Crop types	Area (ha)	BL (ton/ha)
Cabbage	70	6.4
Potato	156	12.6
Radish	121	3.0
Soybean	142	3.4

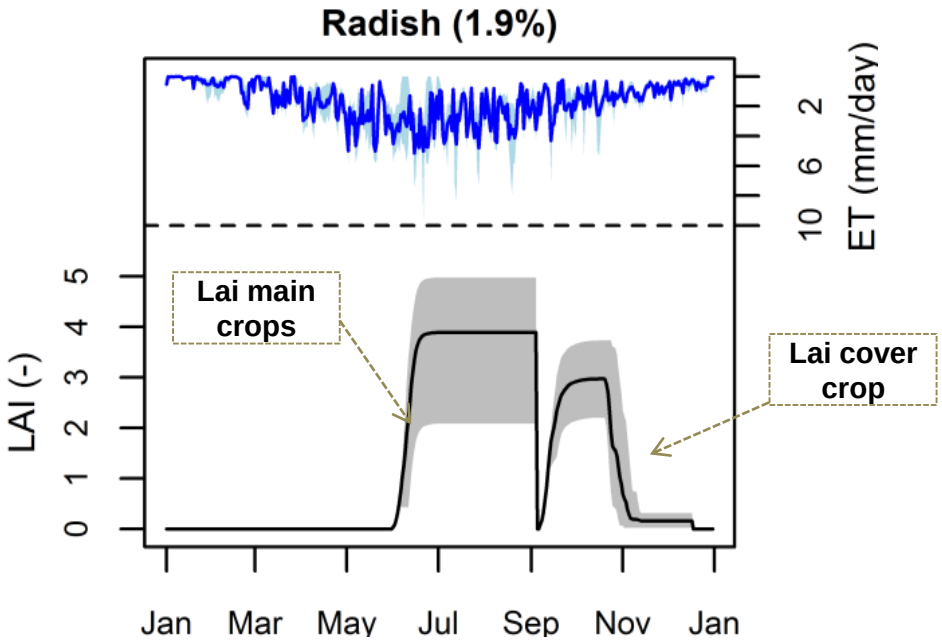


BMP impact on A) daily sed concentration and B) cumulative sed load



High concentration
Low concentration

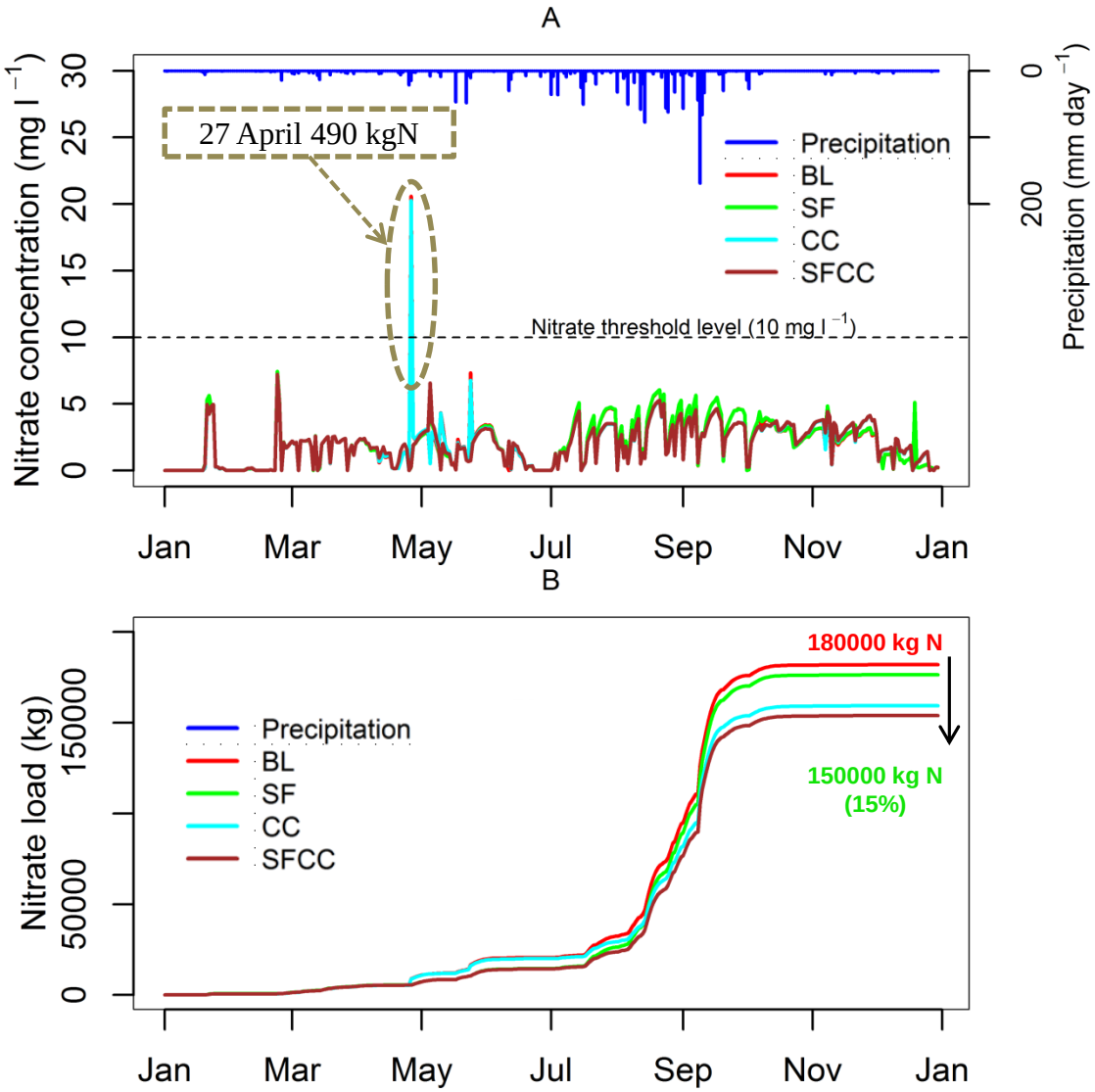
Lai simulation for main crop and cover crop



Scenarios

BL= Baseline, **SF**=Split Fertilizer, **CC**=Cover Crop, **SFCC**=Split Fertilizer & Cover Crop

BMP impact on A) daily nitrate concentration and B) cumulative nitrate load



❖BMPs related to cover crop reduces sediment and nitrate loss

❖BMP related to split fertilizer reduce nitrate loss.
Where as no impact on reduction of sediment loss and crop yield

❖The combination of BMPs showed a synergic effect on reduction sediment and nitrate loss while increasing crop yields.

❖The soybean showed only small responses to the applied BMP scenarios

❖The effectiveness of the BMPs in reducing total catchment loads is limited

❖BMP to minor crops and other land use types should be considered to reduce water quality deterioration for catchment wide management plans.

Further study

Reallocation of land use and management operation

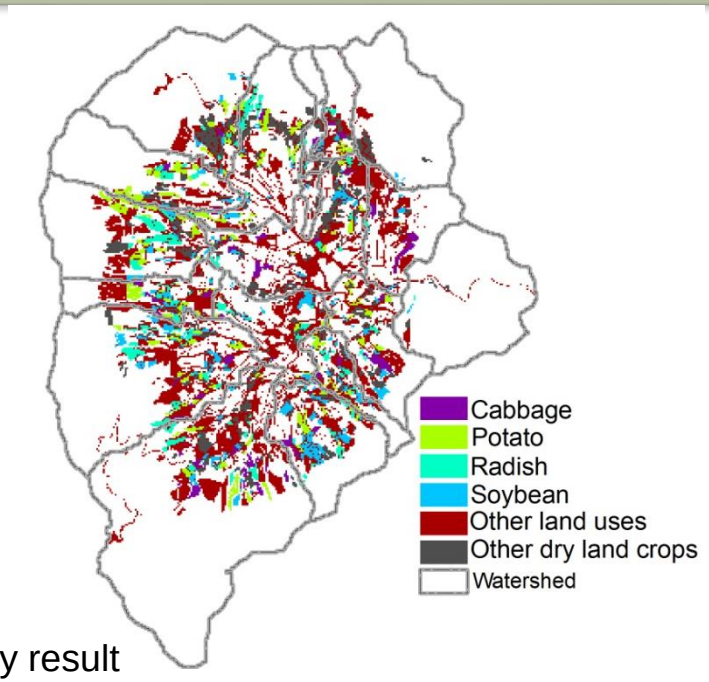
To determine pareto-optimal solution for minimizing environmental impact while maximizing farm income

Coupling

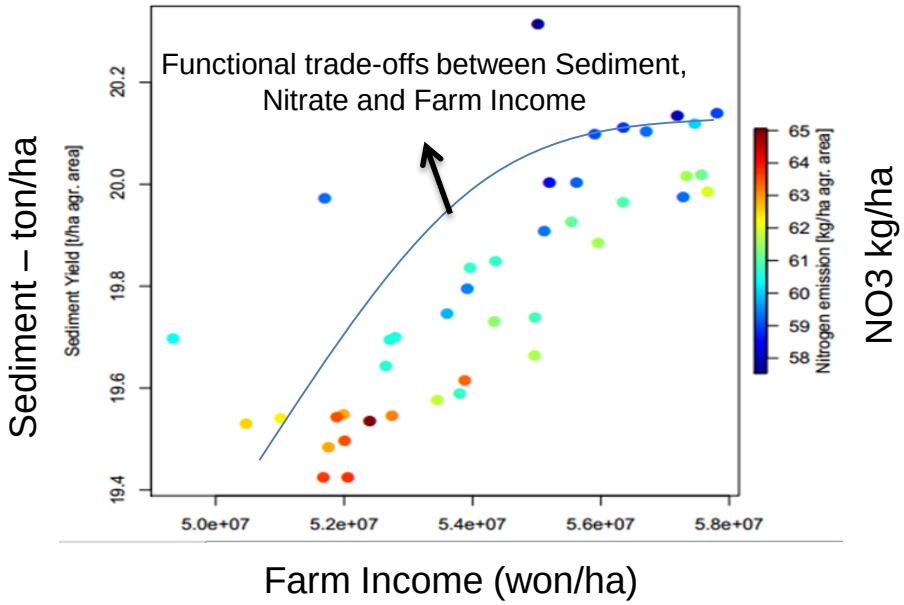
SWAT and optimization algorithm (NSGA-ii) UFZ, Leipzig

BMPs
- Split fertilization
- Cover crop
- Reduced fertilizer application
- Filter strips

Total BMPs combination=144
Reallocated to 381 dryland agri HRU



Preliminary result



“Thank You„

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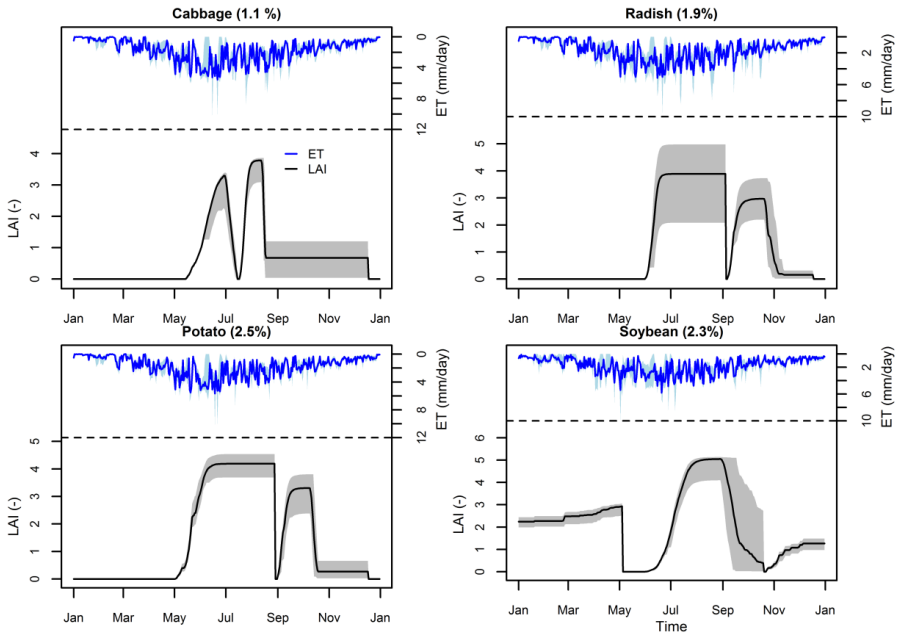
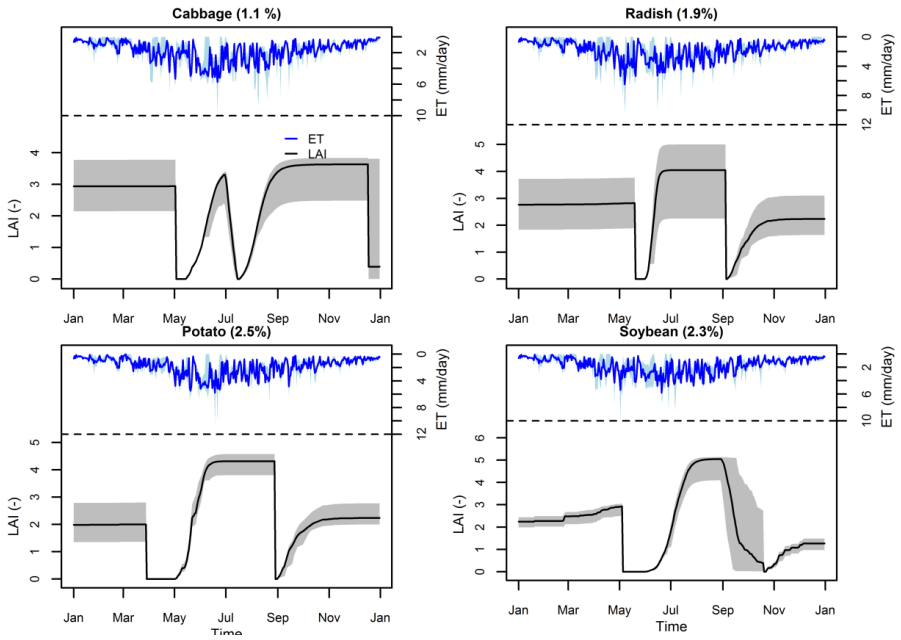




Baseline management operation

Crop	Tillage date	Tillage type	Fertilizer date	Fertilizer* amount	Planting date	Harvest date
Cabbage	6-May 10-May	Rotary hoe Furrow out cultivator	11-May	360	15-May	15-Jul
Potato	1-Apr 12-Apr	Rotary hoe Furrow out cultivator	17-Apr	330	29-Apr	29-Aug
Radish	25-May 30-May	Rotary hoe Furrow out cultivator	27-Apr	490	1-Jun	5-Sep
Soybean	10-May 15-May	Rotary hoe Furrow out cultivator	25-May	345	29-May	20-Oct

*Mineral fertilizer in kg ha^{-1}

Crop types	Area (ha)	BL (ton/ha)	SF	CC	SFCC
Cabbage	69.84	47.9	47.9(0%)	9.2(-81%)	9.5(-80%)
Potato	155.79	53.0	53.1(0%)	18.9(-64%)	18.9(-64%)
Radish	121.23	52.4	52.7(0%)	24.9(-52%)	25.1(-52%)
Soybean	141.93	35.5	35.6(0%)	28.3(-20%)	28.4(-20%)
*Average	488.79	47.1	47.2(0%)	21.7(-54%)	21.9(-54%)
**Catchment average	6273.9	10.2	10.2(0%)	8.2(-19%)	8.2(-19%)

*Sediment calculated at field level is due to weighted mean for major dry land crops: cabbage, potato, radish and soybean, **Sediment simulated at catchment level is weighted mean for all land use type within the entire catchment

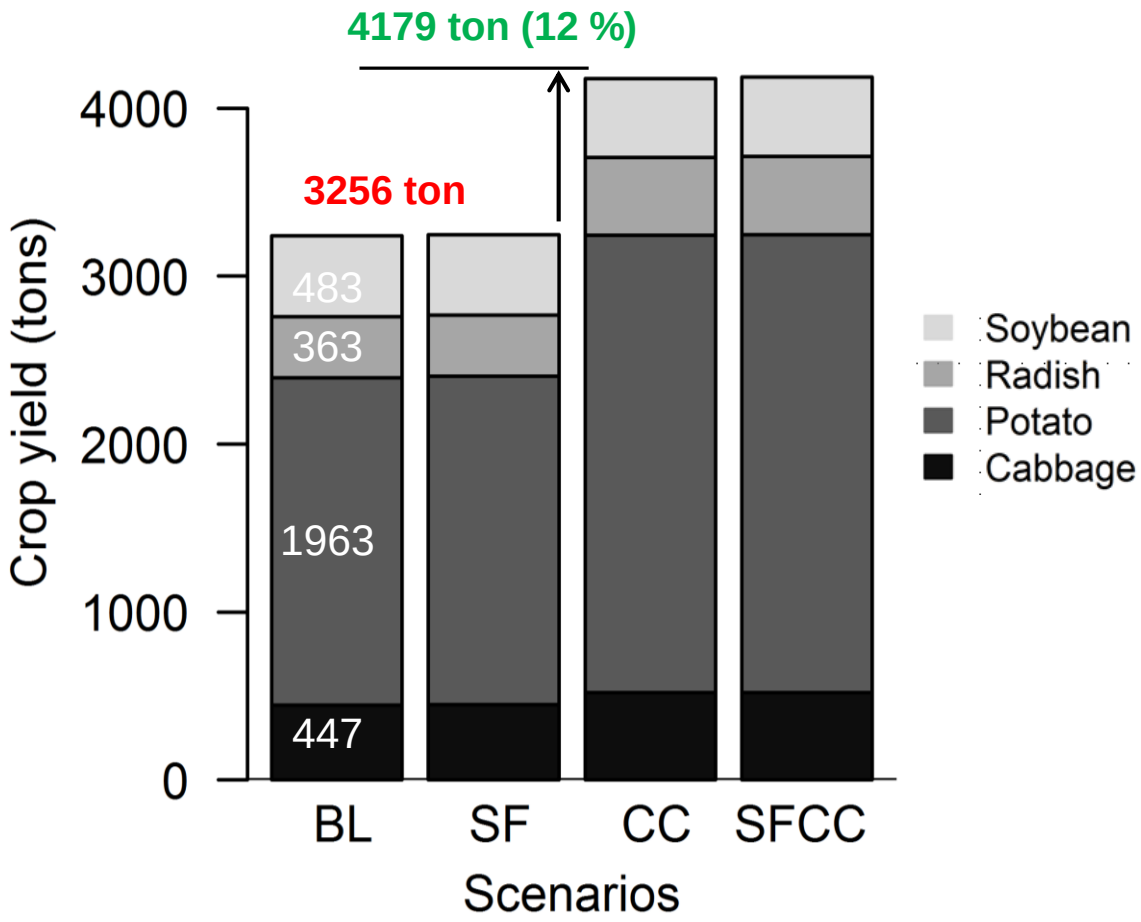
Crop types	Area (ha)	BL(Kg/ha)	SF(Kg/ha)	CC(Kg/ha)	SFCC(Kg/ha)
Cabbage	69.84	232	213(-8%)	193(-17%)	181(-22%)
Potato	155.79	193	172(-11%)	132(-31%)	109(-43%)
Radish	121.23	315	275(-13%)	267(-15%)	228(-27%)
Soybean	141.93	95	96(1%)	93(-2%)	92(-3%)
*Average	488.79	200	181(-9%)	163(-18%)	144(-28%)
**Catchment average	6273.9	39	38(-4%)	36(-7%)	35(-11%)

*Total nitrate calculated as average is due to weighted mean for major dry land crops: cabbage, potato, radish and soybean, **Total nitrate simulated at catchment level is weighted mean for all land use type within the whole study catchment

Crop type	Area (ha)	BL	SF	CC	SFCC
Cabbage	69.84	6.4	6.4(0%)	7.5(+17%)	7.5(+17%)
Potato	155.79	12.6	12.5(0%)	17.5(+39%)	17.5(+39%)
Radish	121.23	3.0	3.0(0%)	3.8(+27%)	3.8(+27%)
Soybean	141.93	3.4	3.4(0%)	3.3(-1%)	3.3(-1%)
*Average	488.79	6.6	6.6(0%)	8.6(+29%)	8.6(+29%)
**Catchment average	6273.9	1.7	1.7(0%)	1.9(+12%)	1.9(+12%)

*Crop yield calculate at field level is due to weighted mean for major dry land crops: cabbage, potato, radish and soybean, **Crop yield simulated at catchment level is weighted mean for all land use type within the whole study catchment

Total crop yield from different crops

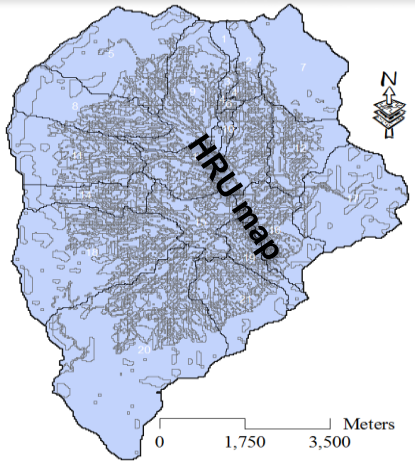


Scenarios

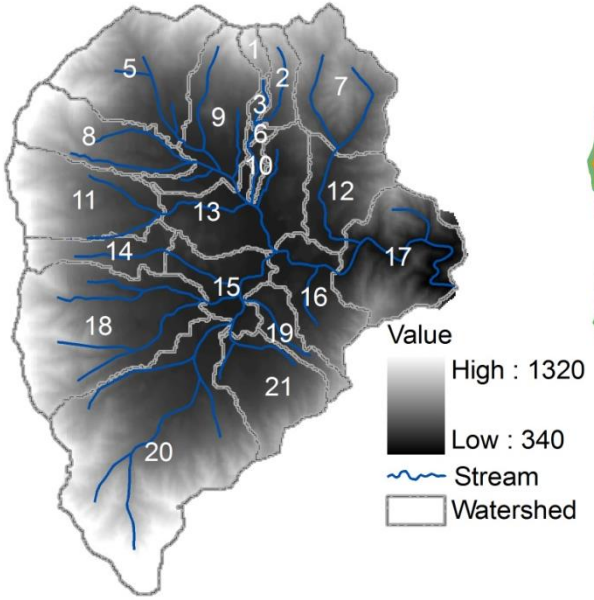
BL= Baseline, **SF**=Split Fertilizer, **CC**=Cover Crop, **SFCC**=Split Fertilizer & Cover Crop

Model setup (In put maps)

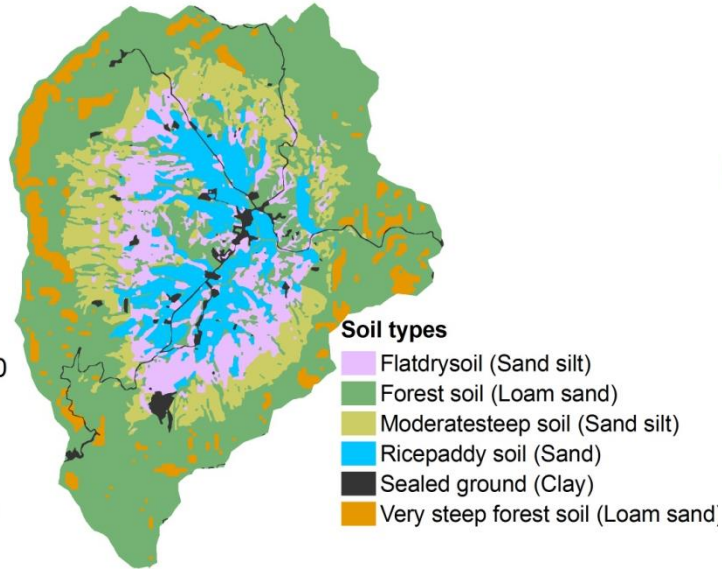
- Study area: Haean catchment, South Korea
- Total number of subbasin: 21
- Number of HRU formation: 792
- Simulation period : 2007-2011 (3 year warmup)



DEM



Soil map



Land use map