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The U.S. Government's Global Hunger & Food Security Initiative

Effects of PW on watershed rehabilitation and irrigation interventions in BHA-supported PSNP areas of Ethiopia

Household food security, Nutrition, and Resilience
&
Institutional capacity and sustainability

Contributors in alphabetical order:

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BACKGROUND

- **PSNP's Aim:** (1) Improve food & nutrition security (short-term); and (2) Protect/build/develop assets for sustaining stable access to food (long-term).
- **Program Target (PSNP4):** Chronically food-insecure households in areas of high food insecurity.
- **Study Focus & Geography:** Understand the effects of the BHA investments (2017 to 2021) in watershed rehabilitation and SSI interventions in the Tigray, Oromia, and Amhara regions.
- **Scope of Assessment:** Changes in Biophyiscal indicators (vegetation, water, sustainability) and in socio-economic indicators (food security, nutrition, resilience, institutional Capacity)

OBJECTIVES

- **Programmatic approach:** Assess the ***programmatic approach*** of implementation of BHA-supported watershed and SSI interventions.
- **Targeting of beneficiaries:** Understand ***who benefits*** from the watershed rehabilitation and SSI investments of PSNP in the BHA focal areas
- **Impacts:** Assess the ***impacts/effects*** of these interventions/investments on food security, nutrition, resilience and institutional development
- **Sustainability:** Assess early indicators of ***sustainability*** *of assets and future benefits*
- **Good practices**: Identify ***good practices*** to guide impactful water-agriculture-nutrition interventions supported, generate evidence that help strengthen capabilities of BHA, implementing partners and key national Ethiopian agencies in planning and design of such interventions.

RESEARCH QUESTIONS

1. a) Has the PSNP/BHA-supported watershed approach been followed in PSNP DFSA program areas, and if not, what are barriers to its implementation? (SE)

   b) In areas where the approach has been followed, how has watershed rehabilitation supported downstream irrigation development and sustainability of water supply for irrigation? (BP)

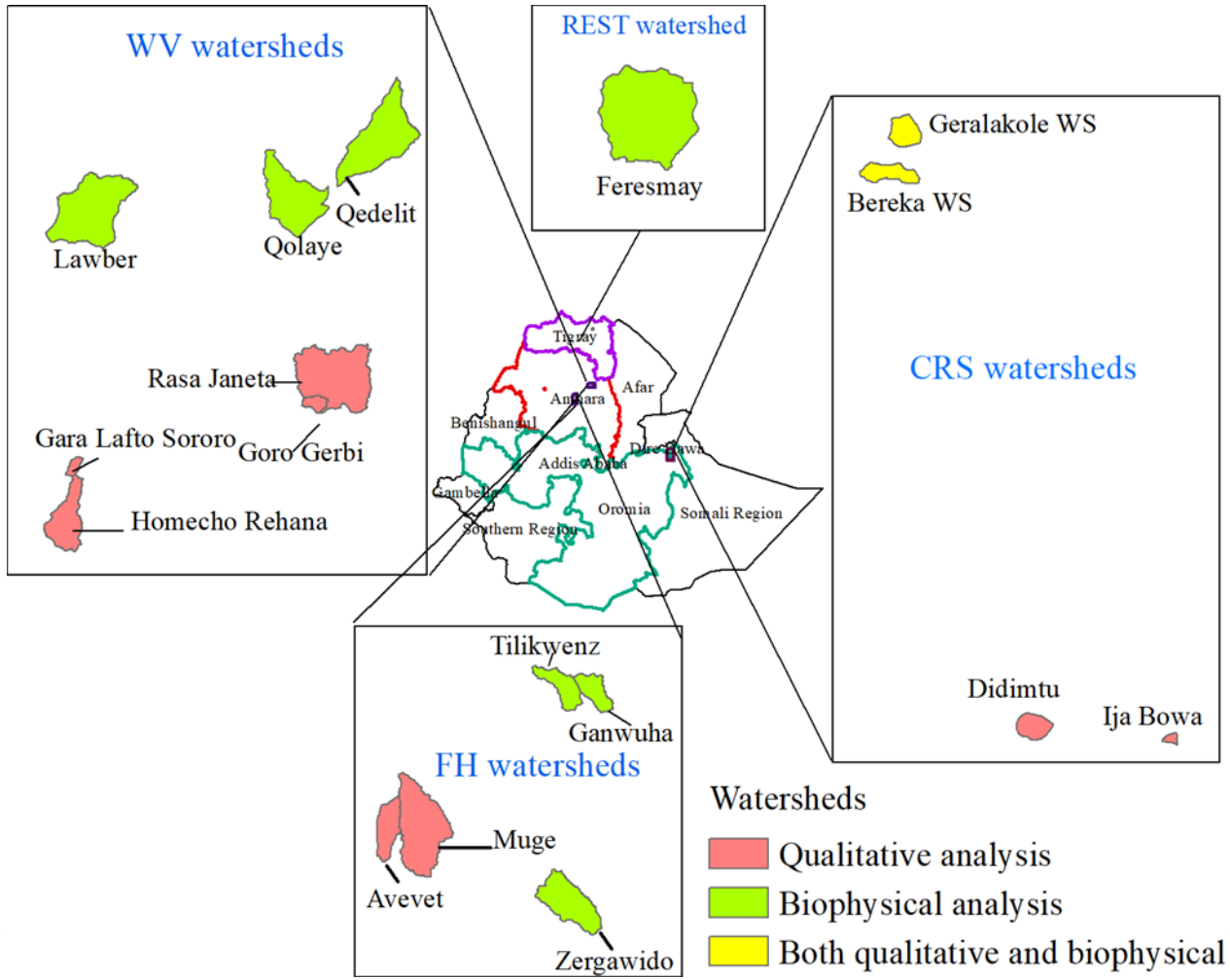
2. a) Who has benefitted, and to what extent, from BHA-supported watershed rehabilitation and small-scale irrigation investments? (SE)

   b) Have these investments demonstrated positive impacts for key indicators of food security, nutrition, and resilience of households? (Key SE)

RESEARCH QUESTIONS *…(contd.)*

3. (a) What are the differences of observed outcomes across different implementing partners? (b) What factors appear to influence achievement of positive outcomes and (early) sustainability of PSNP irrigation investments? (BP(a); SE(b))
4. What is the cost-effectiveness of irrigation investments, directly through assets and income and indirectly through more diverse foods available in local markets vs. recurrent operation and maintenance costs?
5. In terms of sustaining improvements to nutrition/resilience, what programmatic approaches can be added, or in what way can existing approaches be strengthened to maximize the effectiveness of watershed and of SSI investments?

STUDY WATERSHEDS



Sno	Watersheds	Area (ha)	Type of Interventions
I	**Relief Society of Tigray (REST)**		
1	Feresmay	7662	14
II	**Catholic Relief Services (CRS)**		
1	Bereka	484	6
2	Garalakole	440	4
3	Didimtu	406	6
4	Ija Bowa	65	5
II	**World Vision (WV)**		
1	Laweber	1051	10
2	Qolaye	770	9
3	Qedelit	940	11
4	Rasa Janeta	67764	
5	Goro Gerbi	4853	
6	Garalafto Sororo	3168	
7	Homecho Rehana	27735	
IV	**Food for the Hungry (FH)**		
1	Zergawido	4843	14
2	Ganwuha	1900	12
3	Tilikwenz	2265	8
4	Muge	8497	
5	Avevet	2664	

Methodology – Data (1)

- **Qualitative Data**
  - Key informant Interviews (KIIs)
    - 16 with national stakeholders
    - 10 group interview with local implementors and gov't staffs
  - Focus Group Discussions (FGDs)
    - 19 with PSNP beneficiaries
    - 1 with non- beneficiaries

Men and women participants of FGDs

Woreda	Women	Men	Total
Simada	25	22	47
Dire Dawa	19	20	39
Babile	17	18	35
Kurfa Chele	19	18	37
Gemechis	14	15	29
Total	94	93	187

Methodology – Data (2)

- **Quantitative Data**
  - PSNP4 data collected in 2016, 2018 and 2021
  - A total of 66 woredas covered by PSNP4 survey (21 BHA and 45 non-BHA). Three kebeles per woreda & 28 HHs per kebele were randomly selected. We thus have information on 1,764 HHs from 63 BHA kebeles and 3,780 HHs from 135 non-BHA kebeles/areas.
  - From both BHA and non-BHA woredas, PSNP4 collected data from 5,443 rural HHs, which was used in this analysis.

PSNP woredas and their match with BHA intervention

Region	BHA woredas	BHA woredas in PSNP data	non-BHA woredas in PSNP data	Total woredas
Tigray	17	10	12	22
Amhara	20	4	18	22
Oromia	17	7	15	22
Total	54	21	45	66

Methodology – Indicators & Models (1)

- **Targeting beneficiaries:** ***Participation*** in PSNP, PW SWC practice, and SSI practice on **own** plot are outcome variables.

$$Y_{it}^{*} = \alpha + \beta_1 BHA_i + \beta_{it} X_{it} + u_{it} + \varepsilon_{it} \qquad i = 1, \ldots, N \text{ and } t = 1, \ldots, T$$

$$Y_{it} = \begin{cases} 1 \; if \; Y_{it}^{*} \geq 0 \\ 0 \; if \; Y_{it}^{*} < 0 \end{cases}$$

MODEL: We employ **Random Effect Probit** Model

Where Y_{it}^{*} is the unabsorbed latent variable, Y_{it} represents participation in PSNP, PW SWC practice, and SSI for household i and round t. Participation in the PSNP, PW SWC, and irrigation practice are binary outcome variables that take 1 if household participates in watershed rehabilitation and irrigation practice and 0 otherwise.

Methodology – Indicators & Models (2)

- **Food (in)security indicator(s):** *food gaps* **-** the number of months (in the last 12 months) that households had trouble meeting their food needs. The food gap values range from 0 to 12, with zero indicating that households are fully food secure and 12 suggesting the worst food insecurity scenario.

  MODEL: We employ a panel **Poisson regression model** (count data model).

- **Nutrition indicator (s):** *daily per capita calorie intake* of the household and the impact of the intervention is estimated using a random effect panel regression model.

  MODEL: We use a **random effect panel** to understand the nutritional outcome of PSNP interventions.

Resilience

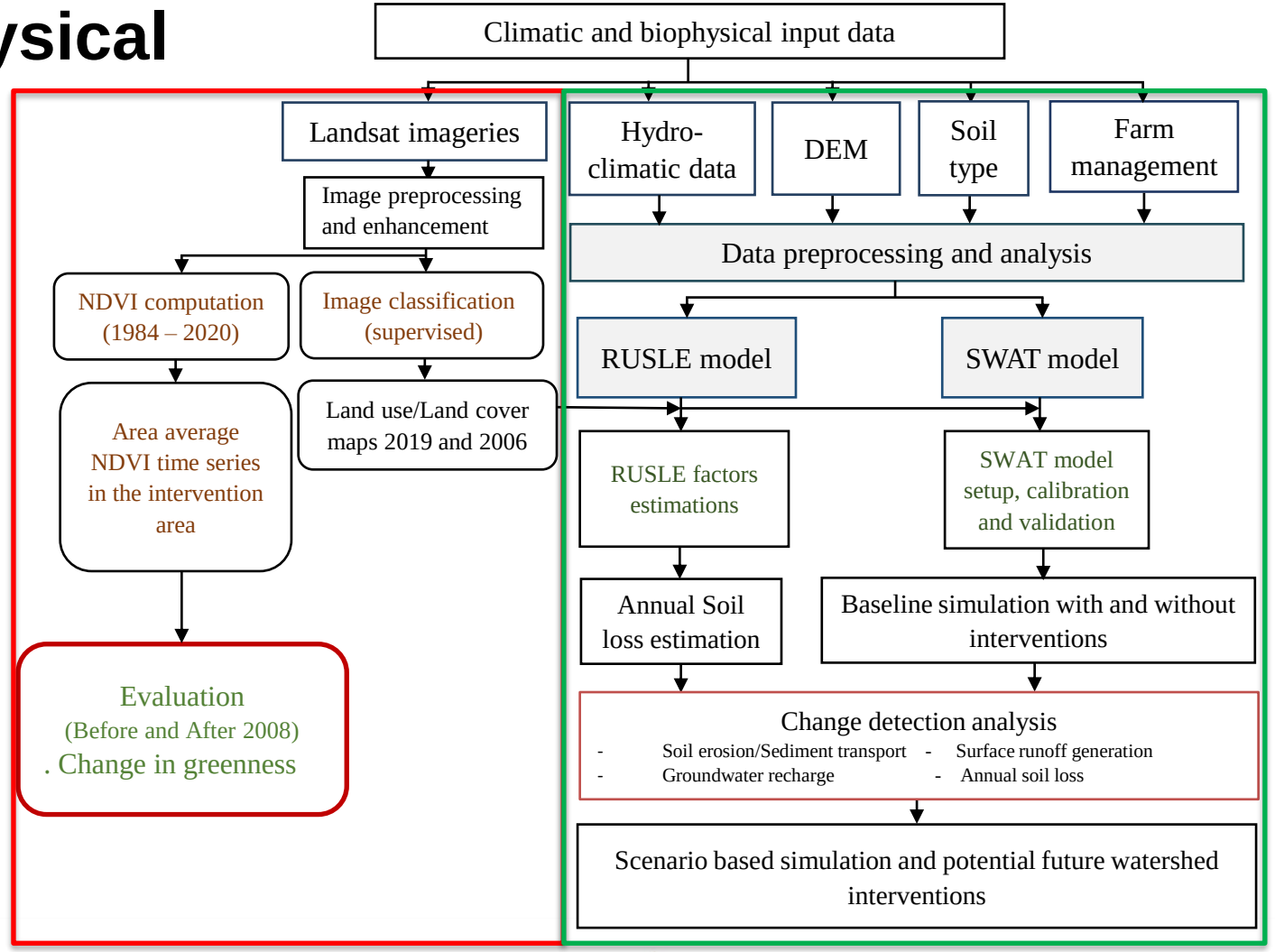
- Several household and individual level observable variables were used to construct the five key resilience indicators.
- Multiple Indicators and Multiple Outcomes model **(MIMIC) in a framework of structural equations** is used to estimate resilience capacity of the household.
- Each pillar is individually estimated using factor analysis of the variables that make up the dimension and constructed the resilience index.

Resilience Pillars	Indicator variables
Food security (FS)	-Monthly per capita food expenditure
	-No of months a household suffered from food shortages (food gap)
Access to Basic services (ABS)	=1 if there is access to electricity
	=1 if there is access to pied public water
	=1 if there is access to daily market
	=1 if there is access to primary school
	=1 if there is cellphone coverage
	=1 if there is access to roads in rainy times
Asset (A)	-Land size (ha) (per capita)
	-TLU (Per capita)
	-radio/tv ownership
	-table/chair ownership
Social Safety Nets (SSN)	-Total amount in birr for all in kind payments (log)
	-Total cash payment in birr (log)
	-Remittance from relatives (log)
	-Loan transfer (log)
Adaptive Capacity (AC)	=1 if household head has formal education (literate)
	Dependency ratio (inverse)
	No of crop produced
	=1 if household member is engaged in off-farm wage work or casual/irregular wage

Methodology--Biophysical

Overall approaches

- Biophysical simulation
  - Remote sensing
  - Biophysical modeling (SWAT)



RQ.1: Program Implementation Approach --- FGD/KII ---(1)

- ❑ Design and implementation of the watershed development interventions were guided by the PSNP **Program Implementation Manual (PIM)**
- ❑ Investment priorities, planning and implementation followed **participatory approach**:
  - Involving woreda food security task force, IPs
  - Kebele watershed committee and extension personnel-identify sites and activities to be implemented and share the plans with the public general assembly
  - The public provides feedback, series of assessments were undertaken to prioritize needs of the community
  - The planning stage ensures public participation, alsoyearly community needs assessments

RQ1: Targeting beneficiaries --- FGD/KII ---(2)

- FGDs confirmed that the targeting had been fair and had followed a transparent process.
- PSNP **beneficiaries were identified through a participatory process** based on criteria:

  (1) asset ownership (i.e., land and livestock),

  (2) crop productivity and income in the last three consecutive years, and

  (3) size of household.
- **Gender considerations: kebele** watershed committees representing the voices of the community
- **Re-targeting** processes is applied to correct possible inclusion and exclusion errors
- However, graduation from PSNP lacked clarity in the Amhara sites.
- Econometric results also confirm qualitative findings on targeting (asset poor HHs., more female-headed HHs., vulnerable HHs to shocks, Hhs with more number of dependents…)

RQ1: Downstream water use (sustainability) ---FGD/KII ---(3)

- In 6 out of the 10 study sites, increased water availability has led to investment in irrigation infrastructure
- Interventions in rehabilitating the watersheds increased water discharge
- Community benefited from improved access to water for drinking, domestic use, and agricultural purposes
- New springs developed in Garalakole and Avevet watersheds
- In 9 of the 10 study sites, communities had access to tap water, and only in the Lega Lafto Sororo watershed did they still rely on spring water for drinking and domestic purposes.

RQ1. BHA interventions and Irrigators

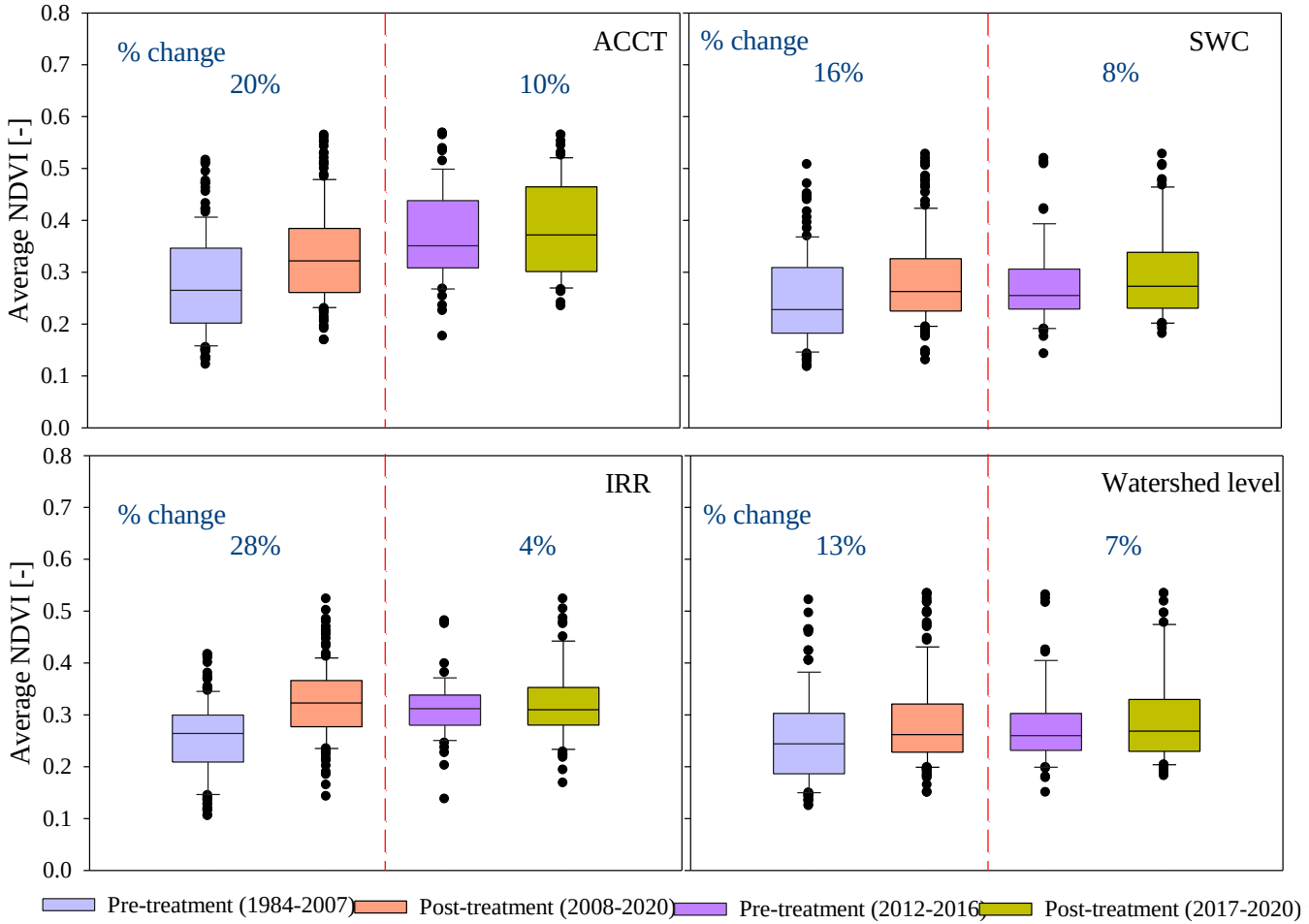
- The share of PSNP households in BHA that practice irrigation activities increased.
- After the BHA investment, the share of irrigator PSNP households increased to 11 percent in 2021 in BHA woreda while the average share of irrigators for other groups remains constant and even decreases.
- Households in BHA woredas were more likely to participate in irrigation activities, compared to non-BHA woredas.

RQ1: Downstream water use (sustainability) ---Biophysical analyses

PART I: Remote sensing-based vegetation greenness assessment

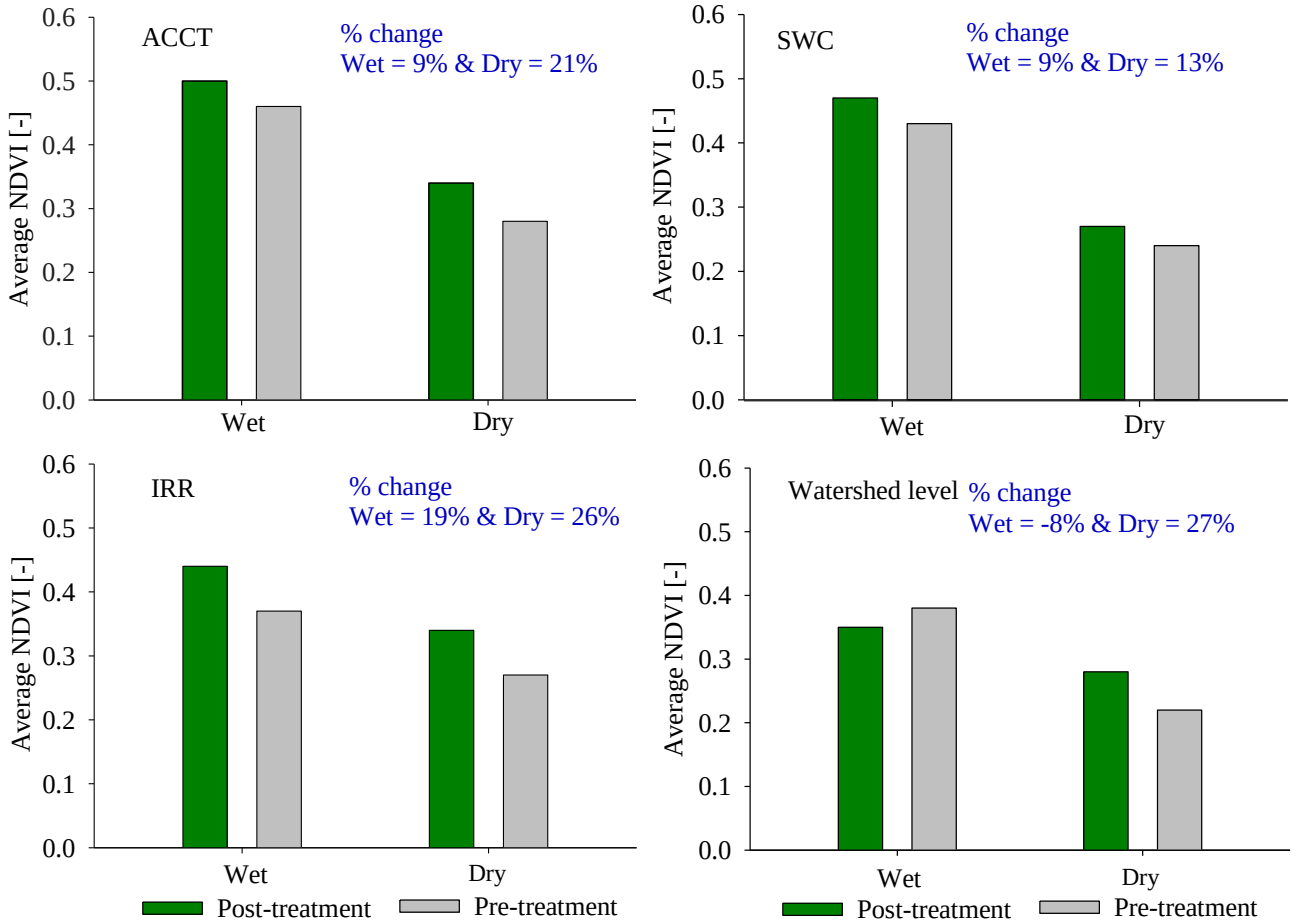
- Before and after intervention analysis
  - Before interventions → 1984-2007 & 2012-2016
  - After interventions → 2008-2020 & 2017-2020
- Vegetation enhancement during shock years due to interventions
  - Drought years (based on rainfall and literature) → Before (1984, 1989, 1990), and after (2009, 2013 and 2015) intervention
- Impacts of interventions on vegetation greenness during wet and dry seasons
  - Dry season → Nov – Feb
  - Wet season → Jun - Sep

PRE- AND POST-INTERVENTION ANALYSIS (FERESMAY WATERSHED)



- There is improvement in vegetation greenness in the treated area:
  - Post-interventions (2008-2020) compared to pre-intervention(1984-2007)
  - ACCT and IRR improved the vegetation greenness 20 and 28%
  - Watershed-level analysis revealed an overall improvement in vegetation greenness across the watershed

VEGETATION GREENNESS ENHANCEMENT: WET AND DRY SEASONS



- Vegetation greenness enhancement during wet and dry seasons
- There is up to 27% change in greenness at watershed scale during dry season

SUMMARY RESULT FOR SELECTED WATERSHEDS

Watershed area/implementer/type of treatment	Column A	Column B	Column C	Column D	Column E
a. Interventions implemented at the Bereka watershed by Catholic Relief Services					
Area closure and catchment treatment	0	3	3	-8	43
Irrigation interventions	14	8	19	6	52
Soil and water conservation practices	1	3	6	-5	40
Overall watershed-level assessment	1	3	6	-5	41
b. Interventions implemented at the Ganwuhu watershed by Food for the Hungry					
Area closure and catchment treatment	8	3	9	-5	31
Irrigation interventions	0	17	15	1	18
Soil and water conservation practices	3	12	8	-12	24
Overall watershed-level assessment	5	8	9	-14	30
c. Interventions implemented at the Lawber watershed by World Vision					
Area closure and catchment treatment	15	8	16	-4	52
Irrigation interventions	-	-	-	-	-
Soil and water conservation practices	16	6	13	-9	64
Overall watershed-level assessment	10	6	15	6	49
d. Interventions implemented at the Feresmay Watershed by the Relief Society of Tigray					
Area closure and catchment treatment	20	10	21	9	26
Irrigation interventions	28	4	26	19	41
Soil and water conservation practices	16	8	13	9	20
Overall watershed-level assessment	13	7	27	-8	14

Column A: Change in greenness from before interventions, 1984–2007, until after interventions, 2008–2020 (%)
Column B: Change in greenness from before interventions, 2012–2016, until after interventions, 2017–2020 (%)
Column C: Change in greenness during the dry season before interventions, 1984–2007, until after interventions, 2008–2020 (%)
Column D: Change in greenness during the wet season before interventions, 1984–2007, until after interventions, 2008–2020 (%)
Column E: Change in greenness for selected drought years before (1984, and 1991) and after (2009 and 2015) interventions (%)

PART II: Biophysical modeling

- Model setup, calibration and validation
- Baseline SWAT model simulation for BHA watersheds
- Model simulation with and with out interventions

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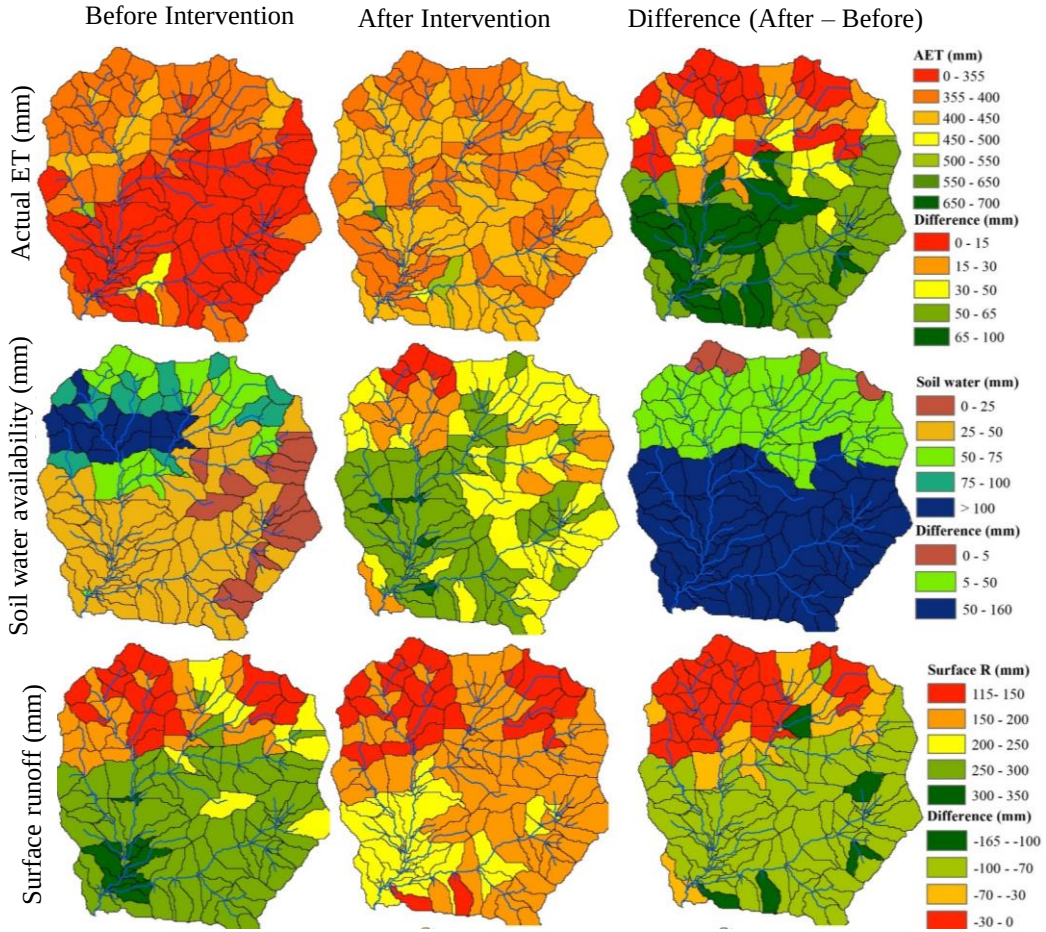
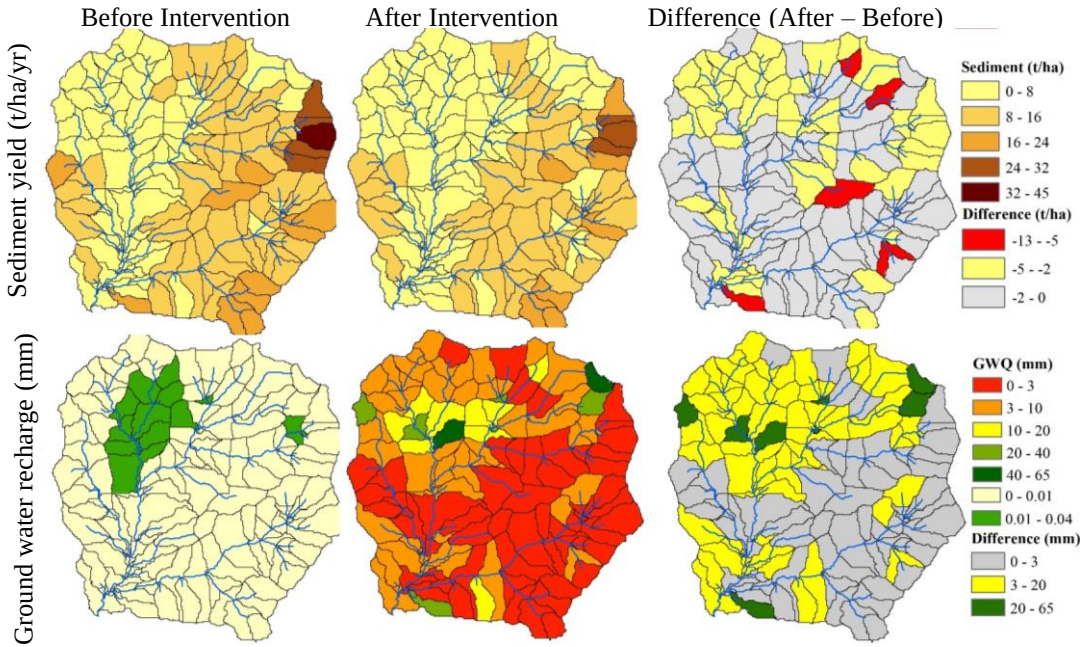
WATER BALANCE COMPONENTS BEFORE AND AFTER INTERVENTIONS, FERESMAY WATERSHED





- Relatively high actual ET mainly in irrigation intervention area
- Soil water content is also enhanced while surface runoff reduced
- Sediment yield is reduced in some of the subbasins
- Ground water recharge enhanced in Northern and northwest parts of the watershed

Before intervention period -> 1982-2007 After intervention period -> 2008-2020

RQ1: Downstream water use (sustainability) ---biophysical modeling

- Overall improvement in vegetation greenness and water budget components in the watersheds due to the interventions although the change varies by type of intervention, and across watersheds
- Water availability improved with increased actual ET, soil water content and groundwater recharge in most of the watersheds
- Soil erosion and surface runoff declined, with varying magnitudes across watersheds
- Pronounced improvement in greenness has been observed during the dry season in most watersheds
- The interventions further helped to improve drought resilience due to increases in water availability during drought years

RQ2. Food (in)security

Overall, households in BHA woredas are found to have a smaller food gap that signifies better food security status.

VARIABLES	Coef.	Se.
BHA woreda (1=yes)	-0.17***	0.02
Public work SWC (1=participate)	0.11***	0.02
Water harvesting PW (1=practice)	-0.08**	0.03
Year (2018)	-0.33***	0.02
Year (2021)	0.06***	0.02
Plot irrigation (1=irrigator)	-0.05*	0.03
No of crops produced	-0.08***	0.01
Age of the head of the household	-0.00***	0.00
Sex (1=female)	0.06***	0.02
Family size	0.06***	0.00
Literacy (1=read& write)	-0.05***	0.02
TLU	-0.05***	0.00
Credit for productive purpose	-0.03	0.03
Cultivates land size (ha)	-0.13***	0.01
Constant	1.05***	0.03
Observations	12,201	

*** p<0.01, ** p<0.05, * p<0.1

RQ2. Nutrition

- Nutritional outcome of households in BHA woredas is not statistically different from non-BHA households.

- FGD and KIIs participants reported positive nutrition outcomes when irrigation development was combined with watershed development at Simada, Kurfa Chele, and Gemechis sites

VARIABLES	Nutrition calorie intake	se
BHA Woreda (1=yes)	60.26	151.04
Public work SWC (1=participate)	-95.60	66.58
Water harvesting PW (1=practice)	105.88	77.47
Year (2018)	-345.80***	103.48
Year (2021)	-84.95	141.82
Plot irrigation (1=irrigator)	108.69	95.20
No of crops produced	46.28**	20.48
Age of the head of the household	6.05***	2.08
Sex (1=female)	401.11***	69.67
Family size	-255.35***	15.13
Literacy (1=read& write)	129.95**	61.21
Remittance	0.07**	0.04
TLU	47.62***	10.17
Credit for productive purpose	159.72	102.94
Cultivates land size (ha)	224.38***	80.98
Constant	2,991.58***	103.00
Observations	11,203	

*** p<0.01, ** p<0.05, * p<0.1

RQ2. Resilience – Descriptive Results

- BHA households have better access to basic services such as electricity and water than non-BHA residents
- Household financial inclusion rate in the surveyed area is quite low for both informal and formal financial institutions
- Households in BHA woredas have better access to informal financial services such as VSLA.
- The rate of formal financial inclusion (such as holding bank accounts) seems to be higher for non-BHA households than BHA households for all periods
- BHA kebeles have better access to roads and markets than non-BHA households in all surveyed years except for 2016

RQ2. Resilience

- Generally, the results suggest that BHA woredas are more resilient than non-BHA woredas.

- The watershed rehabilitation practices show no significant impact on the resilience capacity of households.

- Households that practice irrigation on their plot are much more resilient to shocks than their counterparts.

Variables	Coeff	Se
BHA woreda (1=yes)	0.01***	0.00
Water harvesting PW (1=practice)	0.00	0.00
Public work SWC (1=participate)	0.00	0.00
Plot irrigation (1=irrigator)	0.01***	0.00
Improved seed (1= user)	0.01**	0.00
Chemical fertilizer (1=user)	0.03***	0.00
Pesticide (1=user)	0.01***	0.00
Extension (1=received any advice)	0.02***	0.00
Village saving and lending association (1=member)	-0.00	0.00
Micro finance (1=member)	0.01***	0.00
Bank (1=have account)	0.02***	0.00
Year (2018)	0.03***	0.00
Year (2021)	0.01***	0.00
Sex (1=female)	0.04***	0.00
Dependency ratio	-0.02***	0.00
Literacy (1=read& write)	0.01**	0.00
Faced drought shock (1=yes)	0.00	0.00
Faced flooding shock (1=yes)	-0.01**	0.00
Constant	-0.23***	0.00
Observations	11,581	

*** p<0.01, ** p<0.05, * p<0.1

RQ3. (i) Differences in observed outcomes across different implementing partners?
(ii) What factor influence achievement of positive outcomes & sustainability?

(I) Differences in outcomes across IPs

There are differences in outcomes across IP sites. But, due to the heterogeneity in biophysical parameters, agroclimatic conditions, & area coverage of the activities, any comparative in outcomes across the IPs cannot be considered as an apple-to-apple comparison.

(II) Factors influencing outcomes and sustainability

- Participatory site selection
- Local institutions (bylaws)
- Physical design for the interventions, such as SSI
- Construction quality and maintenance
- Benefit sharing and effective conflict resolution mechanisms among common pool resource users

RQ4. Cost-effectiveness (CE)

- No measured quantitative data on various indicators that can be attributed to each intervention implemented in different watersheds, also no accurate cost data.
- KIIs acknowledged that the community's labor contribution contributed significantly to the projects' cost-effectiveness; however, quality and extent of construction and effectiveness could have been higher without restrictions on infrastructure size and capital use
- Participants indicated that factors such as increased crop productivity, ground water recharge, livelihood benefits, and reduced gender inequality may be considered cost-effective PW activities
- FGD participants agreed that the combination of watershed development with SSI, gender considerations, and livelihood interventions could have enhanced the cost-effectiveness of these interventions.

RQ5. Institutional infrastructure – Collaboration/partnership

- PSNP4 strengthened collaboration among government institutions at the woreda and kebele levels, implementing partners, and with communities.
- PSNP enabled collaboration among government departments such as agriculture, natural resource management, and health and nutrition.
- PSNP4 contributed to strengthening existing institutions as well as creating new ones.
- Institutional arrangements revealed similarities across sites involve all stakeholders
- The watershed development committees at the kebele level played a central role in planning, identifying watershed development activities, targeting of PSNP beneficiaries, and protecting infrastructures.
- PSNP promoted the establishment VSLAs. IPs mobilized groups and provided training and guidance on organizing and running VSLAs.

RQ5. Institutional infrastructure – M&E

- The program uses various M&E mechanisms that require detailed information on the major subprojects.
- However, M&E indicators are limited to recording implementation; not on tracking impacts.
- Quality of the constructed infrastructure and the functionality of the PW infrastructure (including tailored maintenance plans/systems) are not targeted during M&E.
- Rehabilitated watersheds and irrigation dams are also not georeferenced and tracked
- The knowledge management system is inadequate and paper-based to facilitate M&E of the PWs components of the project.
- The M&E system has also limitations in the design and use of tailored tools for measuring attitudes and for gauging behavioral changes within beneficiary households.
- Nutrition and resilience indicators are not explicitly tracked

Conclusions

- Results from biophysical, qualitative and quantitative analysis are complementary to a certain extent
- PW activities had substantial biophysical impacts, particularly enhanced vegetation greenness
- Households in intervention areas reported reduced food gaps, and thus improved food security compared to areas without BHA support.
- Farmers who benefited from the irrigation interventions were able to increase their crop productivity by expanding the number of growing seasons.
- PW watershed rehabilitation under PSNP primarily targets the creation of community assets, strengthened local institutional capacity
- We do not find evidence on households' nutritional impacts of the interventions studied.

Recommendations---(1)

- Direct support to individuals for groundwater irrigation could improve the livelihood of PSNP beneficiaries with land holdings; intensification approaches are particularly needed in land-scarce areas
- Programs should be designed to strike the right balance between time on public works and other gainful activities households engage in to improve their livelihoods, particularly in Amhara sites
- Increased emphasis is needed regarding the functionality and maintenance of constructed irrigation and watershed infrastructure, as the current focus is primarily on construction
- Monitoring and evaluation approaches should be strengthened to help realize positive outcomes from the interventions; priority needs to be given to revising indicators and georeferencing rehabilitated watersheds and irrigation works

Recommendations …(2)

- Long-term rehabilitation practices should be combined with immediate income-generating activities as a potential solution to ensure sustainability
- Introduce periodic and targeted capacity-building for user associations, community leaders, community facilitators, and other entities that can strengthen the sustainability of investments
- Experience-sharing programs among kebeles, woredas, or IPs can promote peer learning and build capacity for PSNP beneficiaries.

Thank you!