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INNOVATION LAB FOR Small Scale Irrigation

Effects of Irrigation Levels and Fertilizer Rates on Water Use Efficiency of Grass Forage at Robit Bata, Upper Blue Nile, Ethiopia

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Introduction

Livestock is an essential asset for economic diversification and rural livelihoods in the smallholder system. In Ethiopia, livestock productivity is highly constrained, among others, by feed shortage and poor quality of available feeds. Natural pasture and crop residue are the major feed resources, but seasonal fluctuations in supply and low nutritional quality pose challenges for livestock production. Production of improved forages with irrigation is considered as one of the options to increase availability and quality feeds and hence livestock productivity.

Objectives

- To determine the water use efficiency of forage grasses at different irrigation levels and types of fertilizer rates.
- To evaluate the effects of different irrigation levels and types of fertilizer rates on growth parameters, biomass, and dry matter yield of forage grasses

Methods

Study area

- The study area was located at Robit Bata site, Upper Blue Nile, Ethiopia.
- Rainfall and irrigation data was collected in the field.

Experimental design

Factor A: irrigation level	Factor B: Fertilizer rate	Factor C: Forage varieties
• Irr-60% →I1 • Irr-80% →I2 • Irr-100% →I3 ***Main plot***	• Manure in ton/ha→F1 • Urea1 in kg/ha→F2 • Urea2 in kg/ha→F3 ***Subplot***	V1. Desho grass V2. Bracharia mutica V3. Bracharia decumbens ***Sub-sub plot***
Design	Split-split plot	
Replication	3	
Total plot	3 x 3 x 3 x3 = 81	

Agronomy Data collection

- Fresh biomass harvested at physiological maturity and yield measured
- Dry matter content was determined in the lab, and used to calculate dry matter yield. R programming was used for the statistical analysis

Water use efficiency (WUE)

$$\left[WUE = \frac{Y}{I + Pe}\right]$$

Where WUE is the water productivity (kg/m^3), Y is total dry matter yield (kg), I is the amount of irrigation water applied (mm), Pe is effective rainfall (mm).

Acknowledgement:
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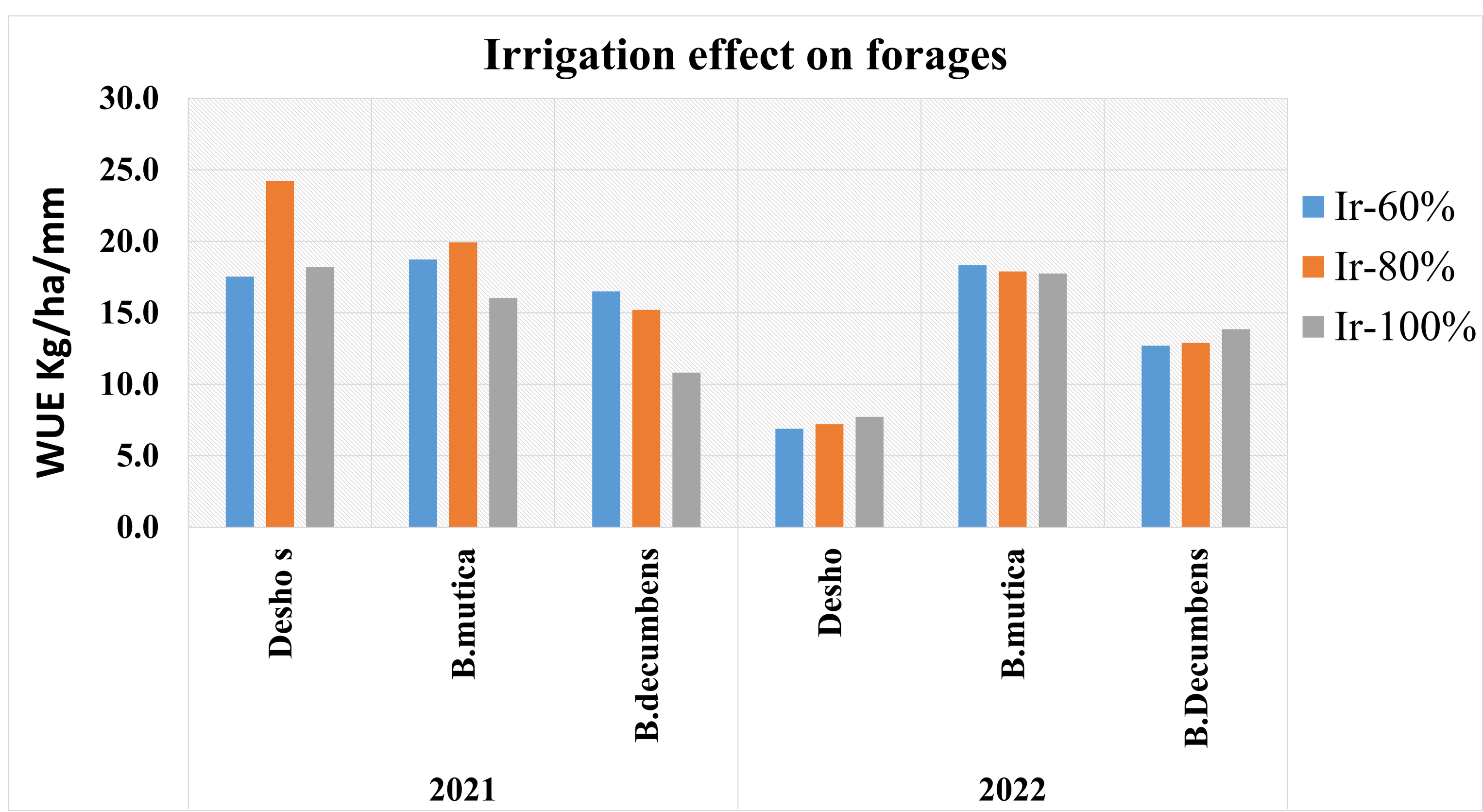
Results

Analysis Result for Water Use Efficiency of Grass Forage					
Source	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig**
Year	822.269	1	822.269	8.098	0.005
Forage	757.646	2	378.823	3.731	0.027
Fertilizer	266.709	2	133.354	1.313	0.273
Irrigation	101.330	2	50.665	0.499	0.609
Year * Forage	1362.305	2	681.153	6.708	0.002
Year * Fertilizer	339.678	2	169.839	1.673	0.193
Year * Irrigation	156.423	2	78.212	0.770	0.465
Forage * Fertilizer	475.527	4	118.882	1.171	0.328
Forage * Irrigation	109.074	4	27.269	0.269	0.898
Fertilizer * Irrigation	196.649	4	49.162	0.484	0.747
Year * Forage * Fertilizer	320.477	4	80.119	0.789	0.535
Year * Forage * Irrigation	106.251	4	26.563	0.262	0.902
Year * Fertilizer * Irrigation	182.773	4	45.693	0.450	0.772
Forage * Fertilizer * Irrigation	240.884	8	30.111	0.297	0.966
Year * Forage * Fertilizer * Irrigation	495.701	8	61.963	0.610	0.768



- In year 1, Desho grass had the highest WUE (23.8 Kg/ha/mm) and minimum is 9.9 Kg/ha/mm for B.Decumbens in 2021 year of production.
- In year 2, B. Mutica had the highest WUE (21.8Kg/ha/mm).

Conclusions

- Forage variability affects the WUE of grass forage production
- Irrigation level and fertilizer type and rate have insignificant effect on the production forage grasses
- Among grasses *B. Mutica* had the highest, mean WUE and Desho had the lowest mean WUE.

Key Messages

- The choice of suitable forage types is important to efficiently use limited agricultural water for fodder production.
- Significant variety by year interactions suggest the need to evaluate perennial forages over several seasons to account for forage establishment and peak production periods.

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Spatial Prediction of Daily Groundwater Level Using Machine Learning Approach in Gilgle Abay Watershed

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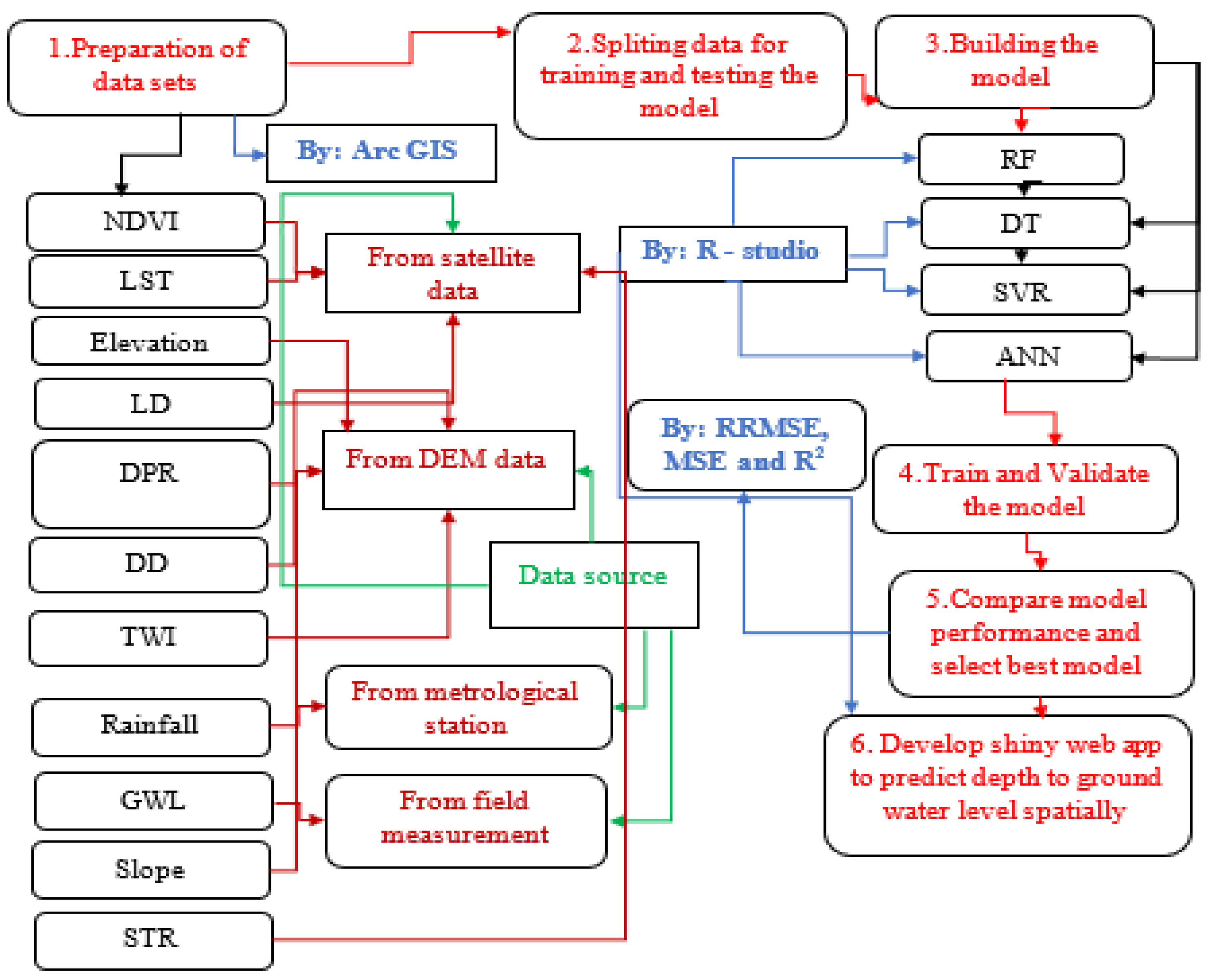
Introduction

Groundwater resources development has generated enormous socio-economic benefits by providing better quality, low-cost, drought-resilient water supplies for urban and rural welfare. However, to locate what depth the groundwater exists, the field assessment needs the application of geophysical exploration methods, which are costly and difficult to conduct at every location in the landscape. This study focuses on the data-driven methodology of estimating the depth of groundwater level in the landscape of Dangishta area of Gilgel Abbay watershed of Laka Tana Bain in Ethiopia.

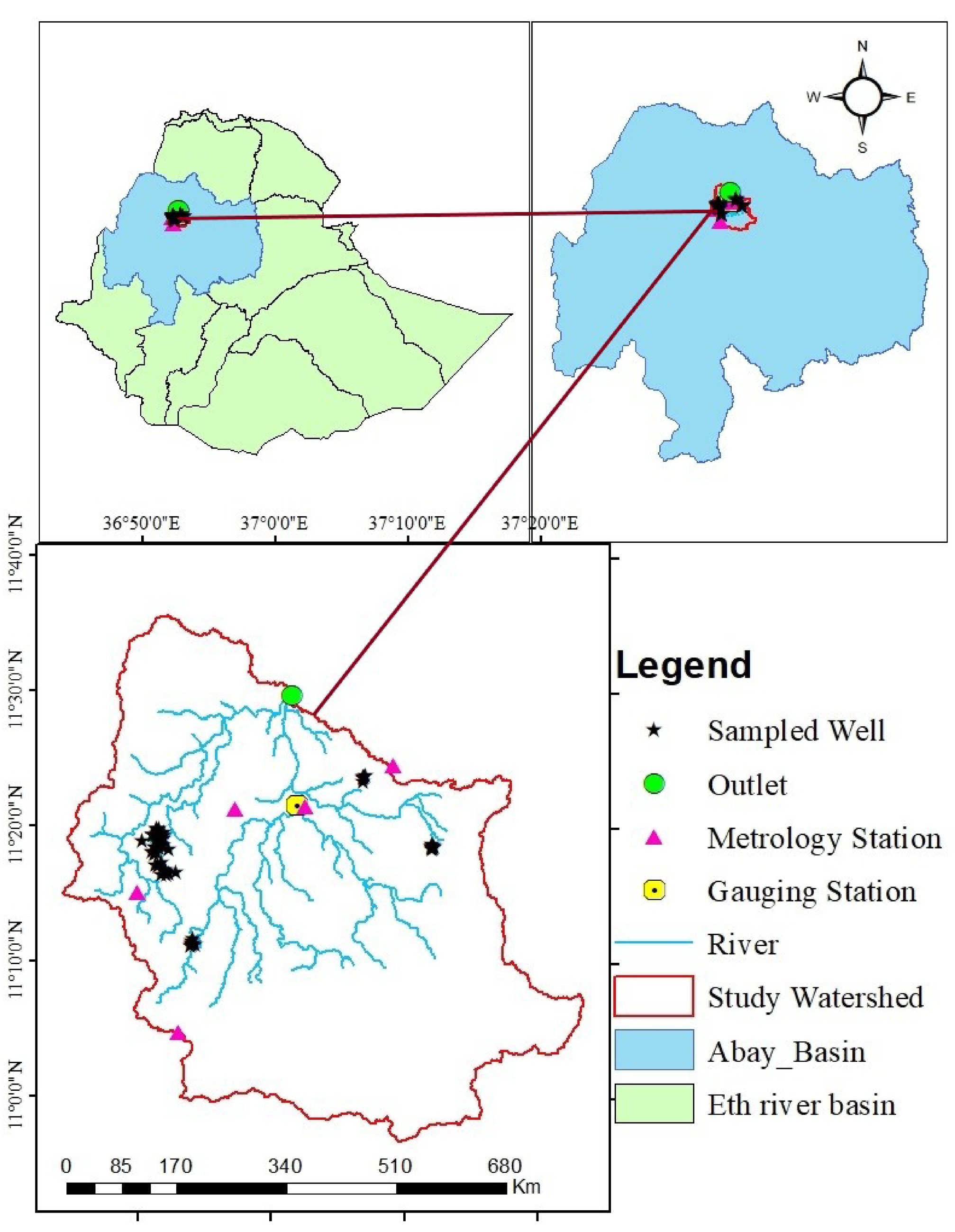
Objectives

- To develop ML of ANN, RF, DT, and SVR for the prediction of groundwater level.
- To develop an app to predict the depth of groundwater level spatially at a given location using selected features.

Methods



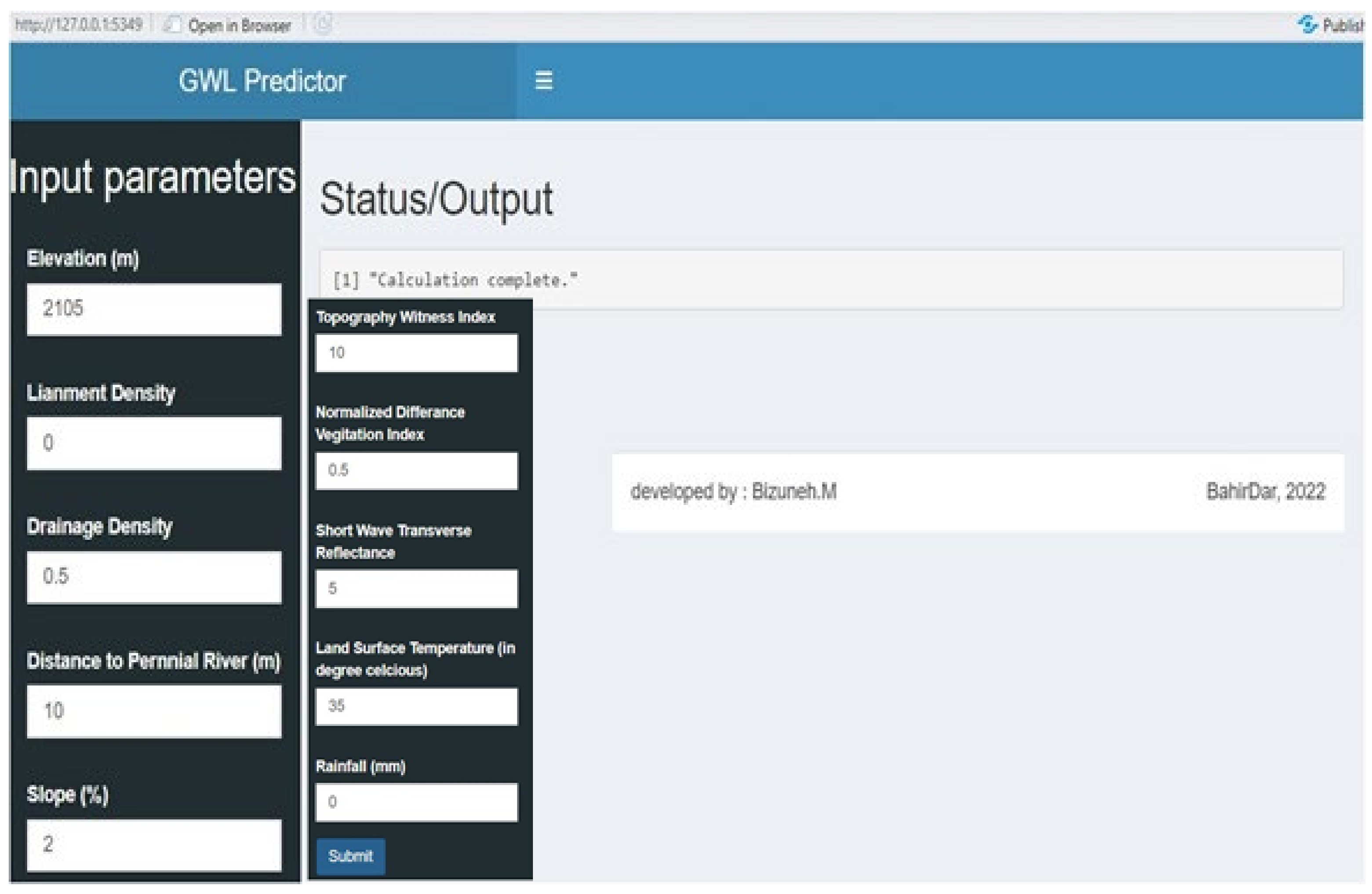
Study area



- Area of the watershed is 2,882.17 km^2
- In order to predict the depth to groundwater level, **122 in-situ groundwater well** observations and **10 proxy input data** were used
- Input data were obtained from field observation, weather data, remote sensing, and GIS analysis

Results

- Based on variable importance analysis: Lineament density (LD), Slope, cumulative rainfall, Topographic Wetness Index (TWI), and Elevation were the most important variables to predict groundwater water level depth using ML.
- the Random Forest was the best machine learning model to predict the depth to groundwater level with RMSE of 0.83, MSE of 0.68, and R2 of 0.96 .
- Finally, the shiny web app was built by using the RF model to predict the groundwater level spatially using the identified variables as input.



Conclusions

- Based on the overall result, the Random Forest was the best machine learning model to predict the depth to groundwater level in the study area.
- Applications of this kind of machine learning tools will reduce a lot of effort and money in locating where the well should be dug.

Key Messages

- **The result of the study suggests that ML approaches with climate, geographics and remote sensing data have a promising potential for groundwater level prediction.**
- **The long-term spatio-temporal groundwater data management should be planned and implemented so that the data could be used to develop more accurate retrieval data driven ML algorithms in the topic.**
- **An improved app like Shiny could be used as water management information system at various level in the sector of groundwater resources management.**

Acknowledgement:
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Evaluating the Effect of Fertilizer Type and Rate, Different Levels of Water and Forage Types on Residual Soil Nitrate in the Upper Blue Nile Basin of Ethiopia

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Introduction

Irrigated fodder production has shown the potential to alleviate critical feed shortages during the dry season and improve the nutrition of animals, which is mainly based on poor quality crop residues in the highlands of Ethiopia. In the conventional farming system, farmers usually tend to apply water and fertilizer, with limited information on optimum levels. Such practices could lead to loss of residual nitrate in runoff and leachate. To improve forage production sustainably, it is important to identify the right combinations of water and nutrient inputs that result in optimal soil nutrient availability.

Objectives

- To evaluate the vertical variations of nitrate accumulation in the soil
- To examine the effects of different irrigation levels and types of fertilizer rates on nitrate uptake.

Methods

Study area

- The study area was located at Robit Bata site, Upper Blue Nile, Ethiopia.
- Rainfall and irrigation data was collected in the field.

Experimental design

Irrigation treatment(I)	Fertilizer treatments(F)	Forage variety (V)
60% of ASW (I1)	30t/ha manure (F1)	Napier grass 16791 (V1)
80% of ASW (I2)	100kg/ha urea (F2)	Napier grass 16803 (V2)
100% of ASW (I3)	300kg/ha urea (F3)	Desho grass ArekaDZF590 (V3)
NB: ASW means Total Available Soil Water		Brachiaria decumbens 10871 (V4)
		Desmodium uncinatum 6765 (V5)
		Stylosanthes hamata 75 (V6)
		Stylosanthes scabra 140 (V7)

Data collection

- Forages were harvested at physiological maturity and fresh yield was recorded. Forage samples were taken for chemical analysis, including dry matter and nitrogen.
- Soil samples were collected at different root lengths (0-30; 30-60; and 60-90cm) and analyzed in the laboratory for bulk density, nitrate concentration of disturbed soil samples.
- Data was analyzed using the SPSS statistical software.

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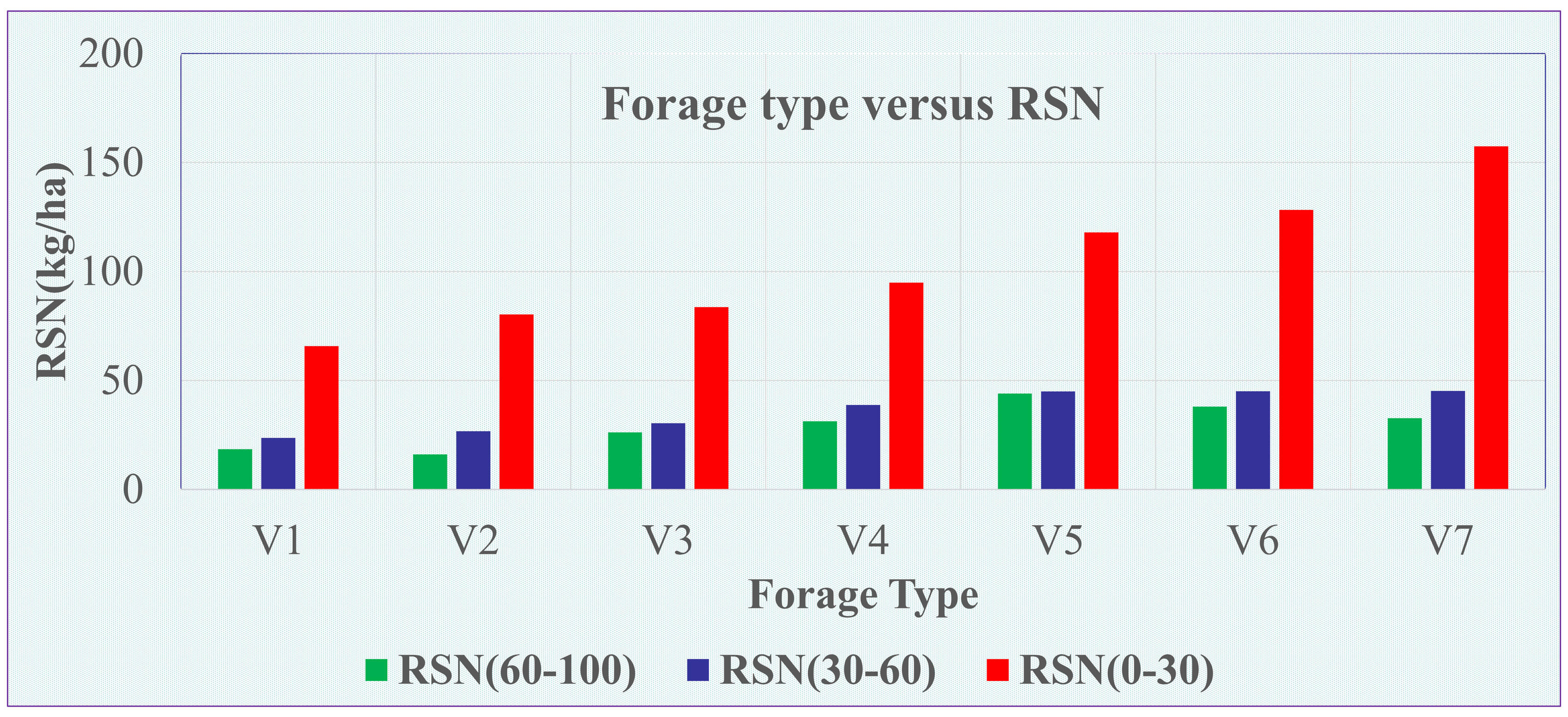
Results

Effects of fertilizer type, irrigation regime and varieties

Independent Variable	N Uptake	RSN(0-30)	RSN(30-60)	RSN(60-100)
Forage	0.0000	0.0000	0.0000	0.0000
Fertilizer	0.7380	0.0030	0.0020	0.9440
Irrigation	0.1240	0.0890	0.1850	0.6880
Forage * Fertilizer	0.0200	0.8010	0.9110	0.8940
Forage * Irrigation	0.9970	0.9020	0.7820	0.9700
Fertilizer * Irrigation	0.6980	0.0000	0.9020	0.7260
Forage * Fertilizer * Irrigation	0.9990	0.9740	0.9420	0.9840
Total	189			

- Napier grass has the highest N uptake as compared to other N-fixing forage types. And, Stylosanthes scabra has the highest residual N.
- Fertilizer has a significant effect on residual N (0 to 60 cm), but not for N uptake.
- Irrigation has no effect on the N uptake and Residual Soil Nitrogen (RSN).
- However, only forage type had a significant effect on RSN in the 60-100 cm depth.

	N Uptake (kg/ha)		RSN (0-30) (kg/ha)		RSN (30-60) (kg/ha)		RSN (60-100) (kg/ha)	
	highest	lowest	highest	lowest	highest	lowest	highest	lowest
V	V1(298.7)	V7(46.3)	V7(157.5)	V1(65.8)	V7 (45.2)	V1 (23.7)	V5 (44.0)	V2(16.2)
F	no sig.	no sig.	F3(205.5)	F1(53.4)	F3(55.8)	F2(19.5)	no sig.	no sig.
V*F	V1*F1 (308.2)	V7F3 (27.3)	no sig.	no sig.	no sig.	no sig.	no sig.	no sig.
F*I	no sig.	no sig.	F3*I1 (333.1)	F2*I1(44.4)	no sig.	no sig.	no sig.	no sig.



Conclusions

- Large forage type/varietal differences in N uptake was observed.
- Application of manure at a rate of 30 t/ha for V1 had highest N uptake. However, application of urea at a rate of 300 kg/ha for V7 had lowest N uptake.
- Application of urea at a rate of 300 kg/ha with I60 had highest RSN. However, 100kg/ha of urea with I60 had lowest RSN up to 30cm.

Key Messages

- **Maximum amount of nitrate was accumulated at the top 0 to 30cm soil depth.**
- **Grass have maximum N uptake rate than that of legumes.**
- **Deficient irrigation can be a good management option to tackle water scarcity challenges for irrigation.**

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Co-development of Milk Churning Machine for Dairy Cooperatives

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Introduction

Dairy cooperatives and smallholder livestock farmers operating in remote areas of the country are failing to generate a reasonable income from their milk products. One major reason for their loss and is a lack of suitable and affordable dairy processing and preservation equipment. Even though smallholder farmers couldn't afford them, at the cooperative level, some have purchased imported equipment and machinery. However, these equipment and machines bring a challenge to the cooperatives and smallholder farmers:

- They are not compatible with the environmental conditions at the location of the cooperatives and smallholder farmers
- The imported machines do not have spare parts in local markets, and
- The availability of skilled workers to provide maintenance services upon damage is very scarce.

This project focuses on the design, development, and performance evaluation of a suitable and affordable milk churning machine via a human-centered design approach.

Objectives

- To design and develop a milk churning machine.
- To evaluate the performance of the milk churning machine.
- Pilot testing of the machine on the project site.

Methods

Human Center Design approach		
Data gathering on the project site	**Technology adaptation**	**Design and manufacturing**
Main grid power availability of project area.	User preferred qualities of existing solutions.	Iterative.
Type of cow breeds in the area.	Drawbacks of existing solutions according to users.	Better suited for the particular project area.
Climate condition.	Scientific incompatibilities of existing solution to the project site.	Real time testing in the audience of users.
Preferable layout of machine by the users.		Locally available spare parts.
Average milk collection capacity of the area per day.		Easy to use and reliable.

Visit on the Project Site

- **Location**: Robit Bata near Bahir Dar city.
- **Name of beneficiary**: Genet le Robit Dairy cooperative
- **Project**: Milk churning machine.
- Powered manually or by solar energy.

Acknowledgement:
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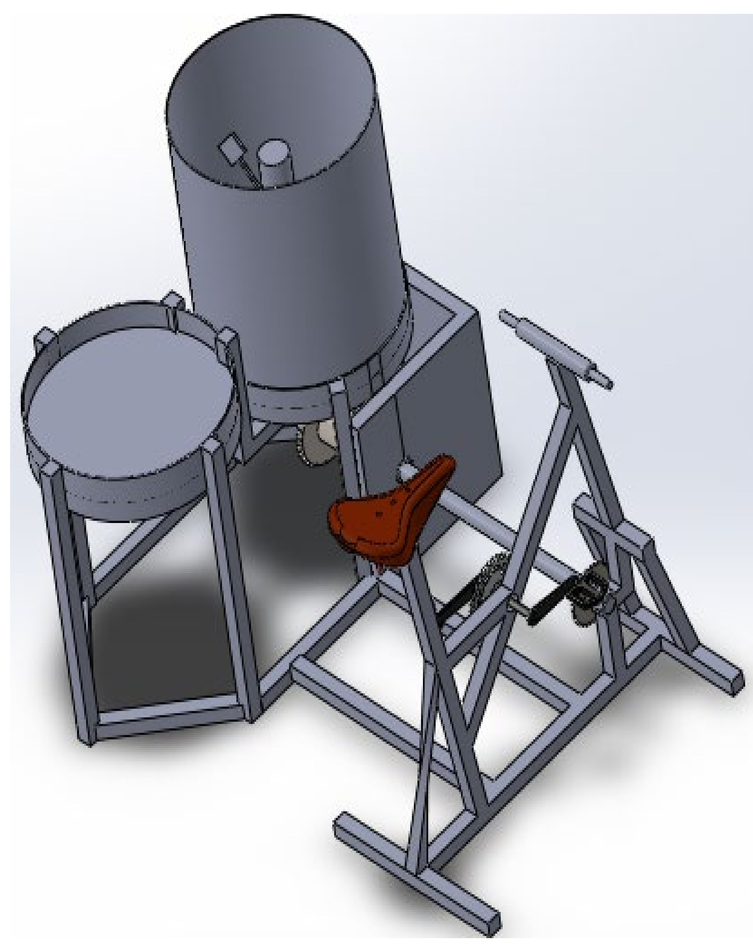
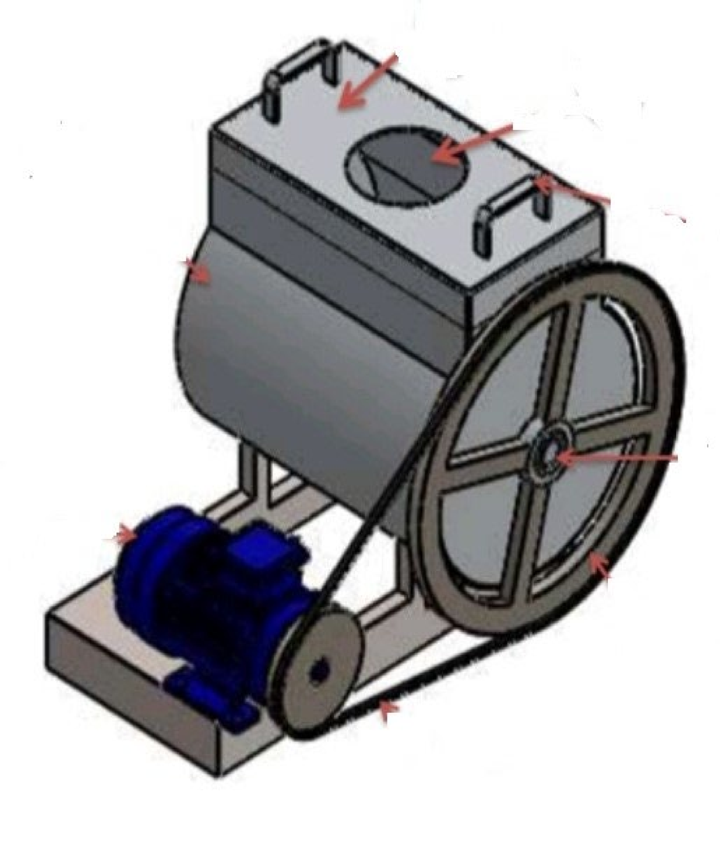
Results

- Based on the primary data gathered, a first prototype model was designed and presented to the users.
- However, the machine design, controlled by a foot pedal, and the activities it could perform, such as cream separation, were not preferred by the cooperatives and smallholder farmers, which led us to the design modification.
- The modified design is now in the development stage.



Previous Design



Current Design

Conclusions

- Dairy cooperatives and smallholder livestock farmers in remote areas are struggling to generate a reasonable income from their milk products due to a lack of suitable and affordable dairy processing and preservation equipment.
- This project will develop a prototype that enables them to elongate the shelf life of their milk products by producing diversified milk products and adding value.

Key Messages

- **The hackathon process and training of HCD approach help to design and manufacture machines in the dairy processing sector that enable better yields.**
- **This pilot project could be scaled up and expanded to cover more community in the country.**
- **Higher education could be a solution for developmental challenges through joint mentoring from all parties.**

Mobile and Web-based Maintenance Management System Development for Solar Products

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Introduction

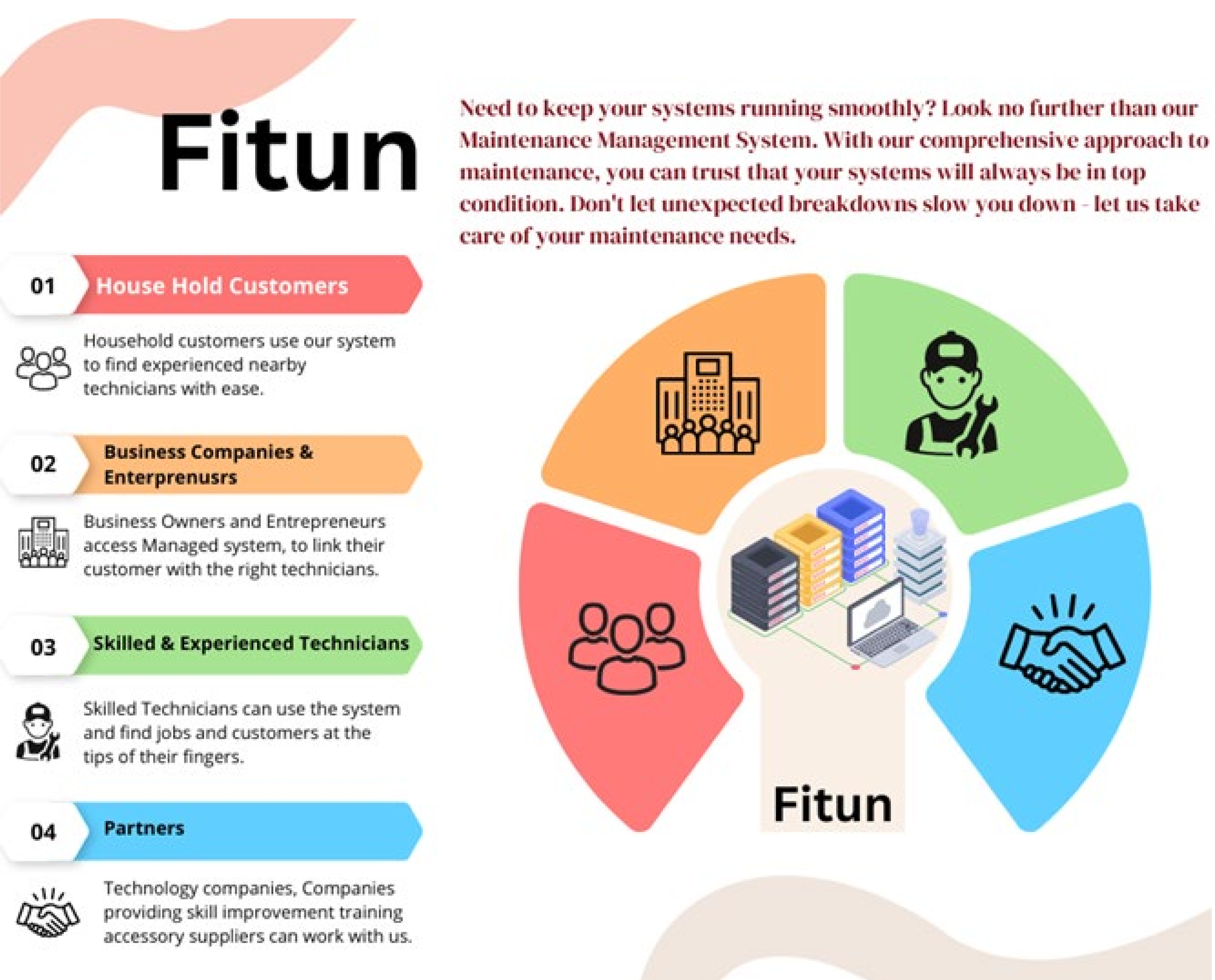
Solar irrigation technology users, such as smallholder farmers today face a significant issue in finding qualified technicians for maintenance. This issue could be resolved by innovative digital solutions which offer a platform for customers to quickly and effectively connect with qualified technicians. The benefits of such digital solutions are improving client satisfaction, decreasing downtime, and ultimately raising customer revenue. It would also play a great role for private companies working in technology distribution.

- Most farmers who rely on solar pumps have maintenance issues which force them to stop irrigation due to a lack of skilled technicians

Objectives

- To develop a digital system that matches businesses with skilled technicians in the market.
- To provide businesses with a centralized platform for managing technician needs, including scheduling, communication, and payment.

Methods



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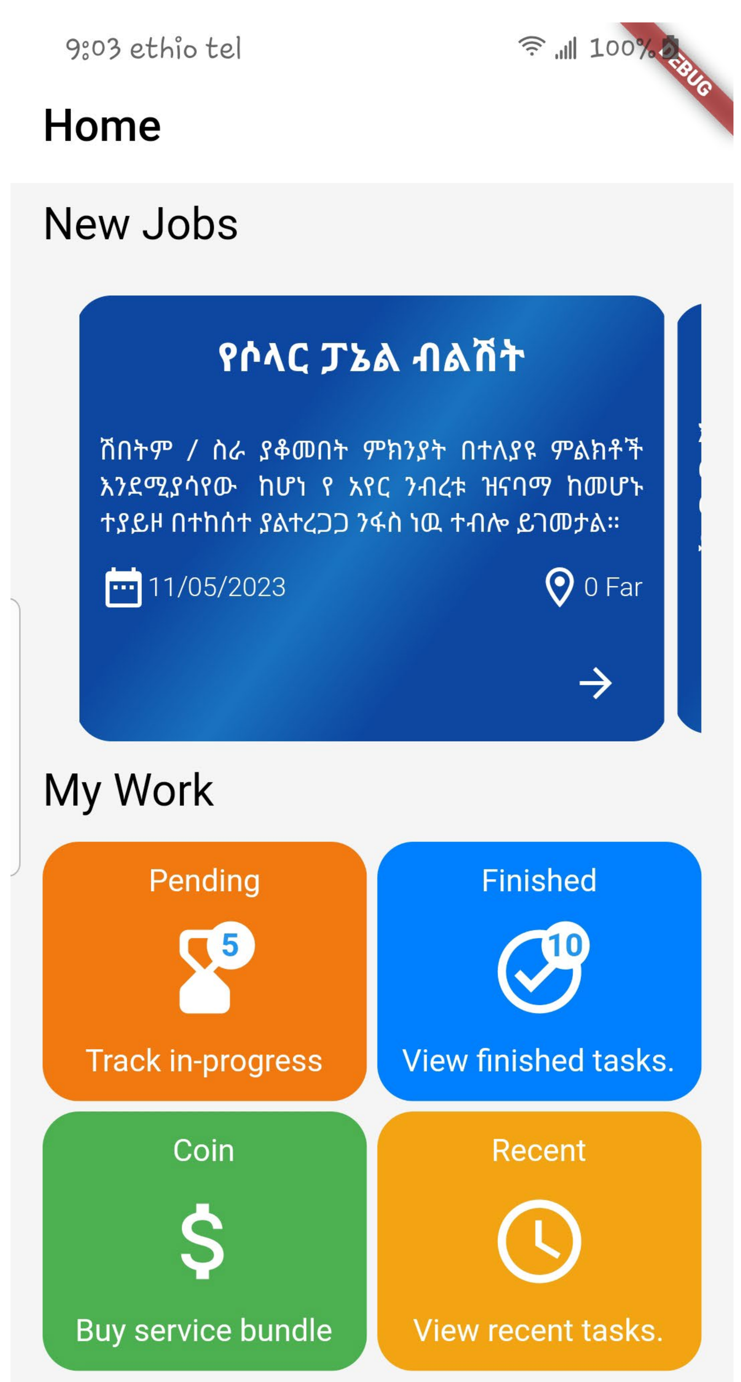
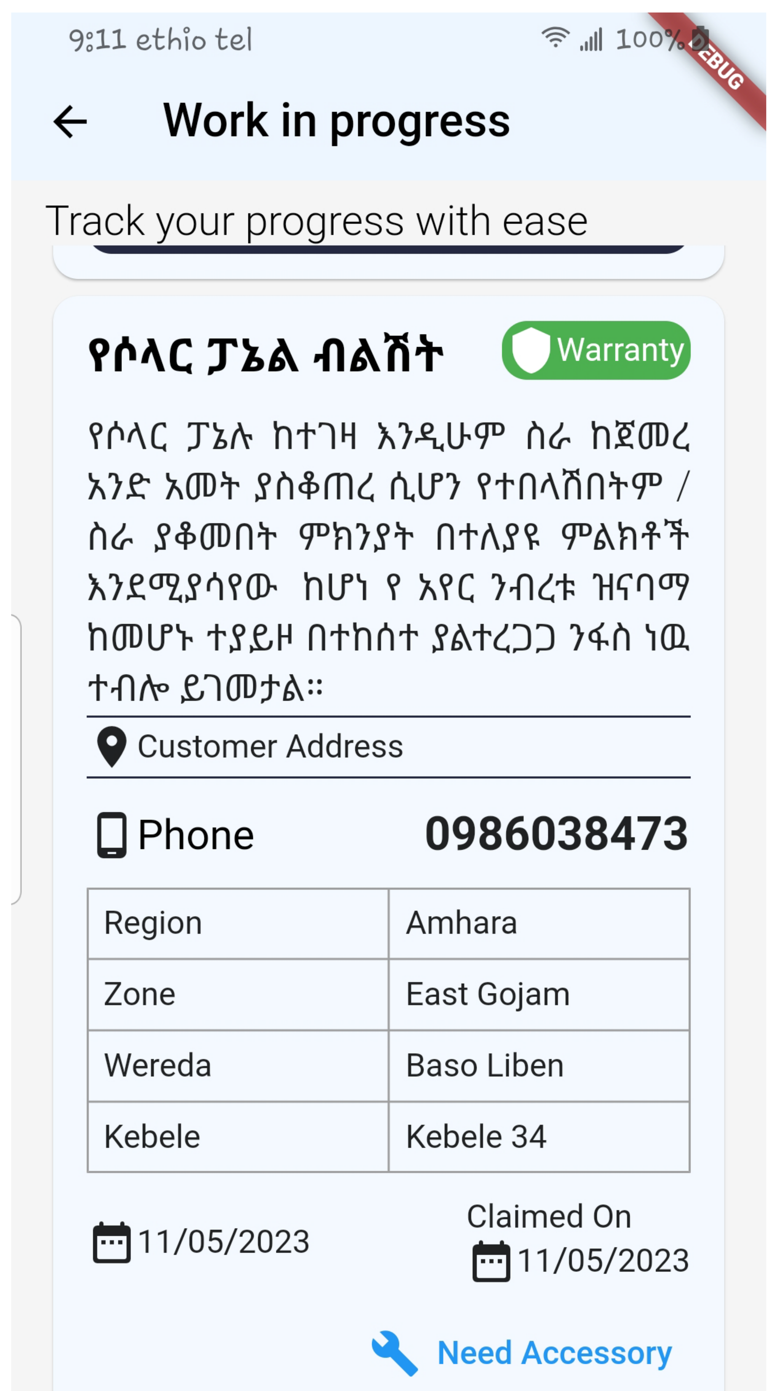
Results

- Mobile and web-based maintenance management system has been developed and completed.
- The system is in the process of being tested and deployed at Rensys Engineering to prepare for implementation.





Conclusion

- Irrigation production could be sustained by providing a user-friendly platform for customers to search for and connect with skilled technicians for irrigation technology maintenance.
- With a comprehensive database of skilled technicians, verified credentials, and centralized management tools, the system helps businesses to effectively track maintenance of their products.

Key Messages

- **Such digital technologies increase the efficiency and effectiveness of maintenance and repair services, leading to reduced downtime and increased revenue for businesses.**
- **It also improves customer service resulting in higher satisfaction rates and positive referrals.**
- **It increases access to a wider pool of skilled technicians by providing businesses with more options for their maintenance and repair needs.**

Small-scale Irrigation Technology Adoption and its Impact on Women's Empowerment in Western Amhara Region, Ethiopia.

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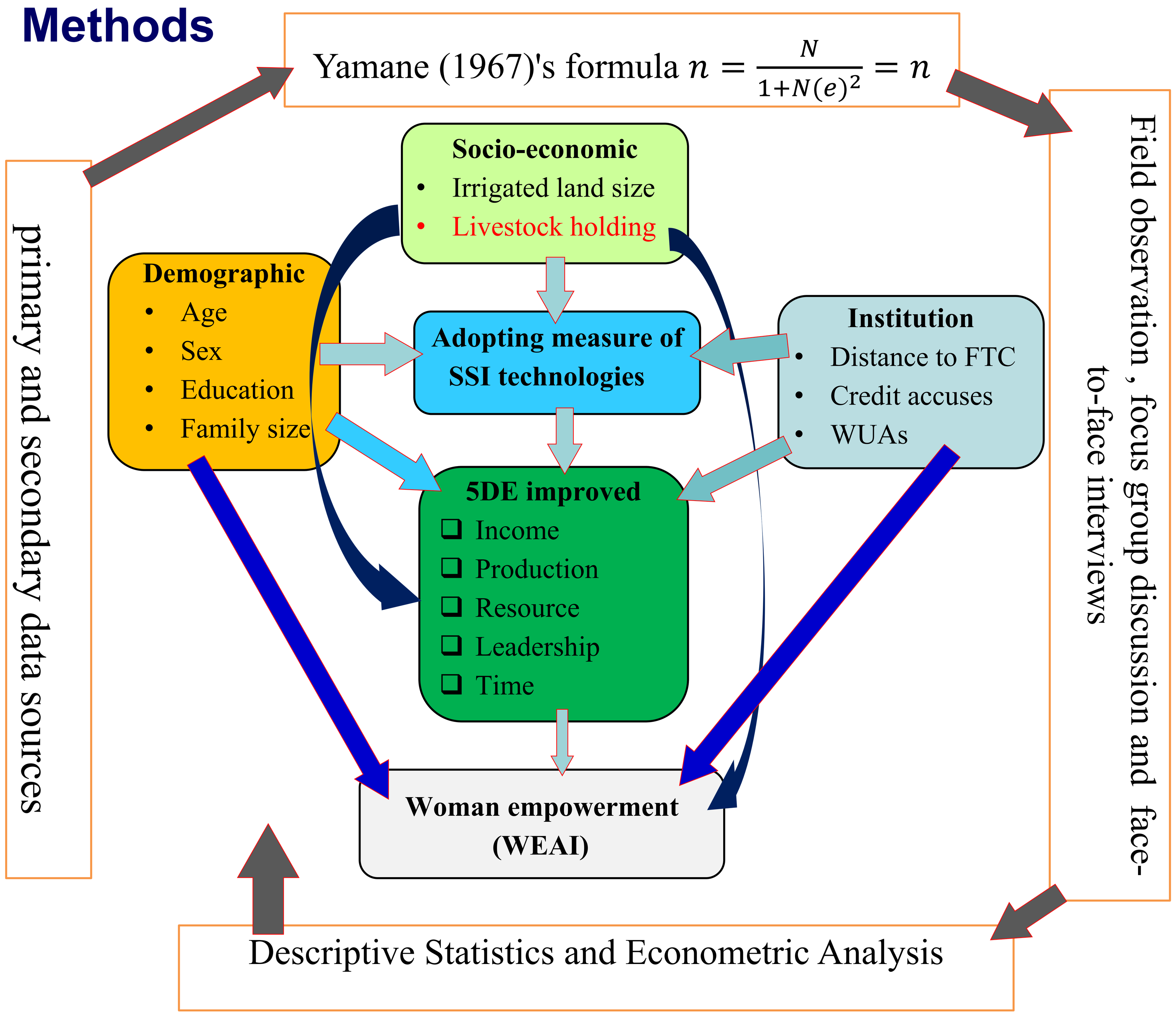
Introduction

Women empowerment is an integral part of development strategies in developing countries. However, most women in Ethiopia face serious constraints to participating in developmental interventions such as small-scale irrigation (SSI) technologies. This situation has undermined the potential of women in contributing to societal development issues. The untapped potential of women in irrigation farming is manifested in low-income earnings, low food security, and little access to production resources which put them in weak decision-making statuses. Therefore, this study intended to assess SSIT adoption and its impact on women's empowerment in the western Amara region of Ethiopia.

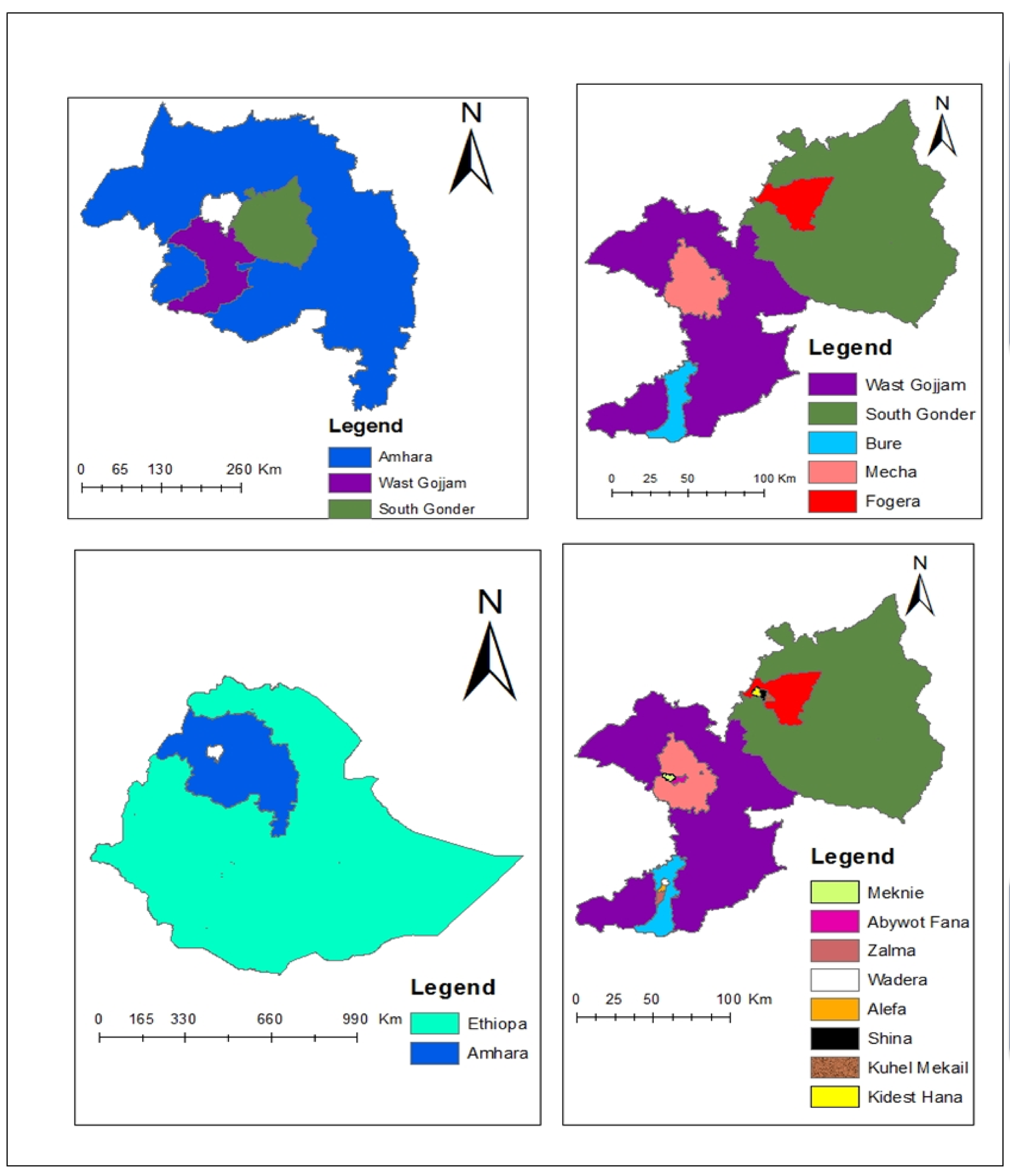
Objectives

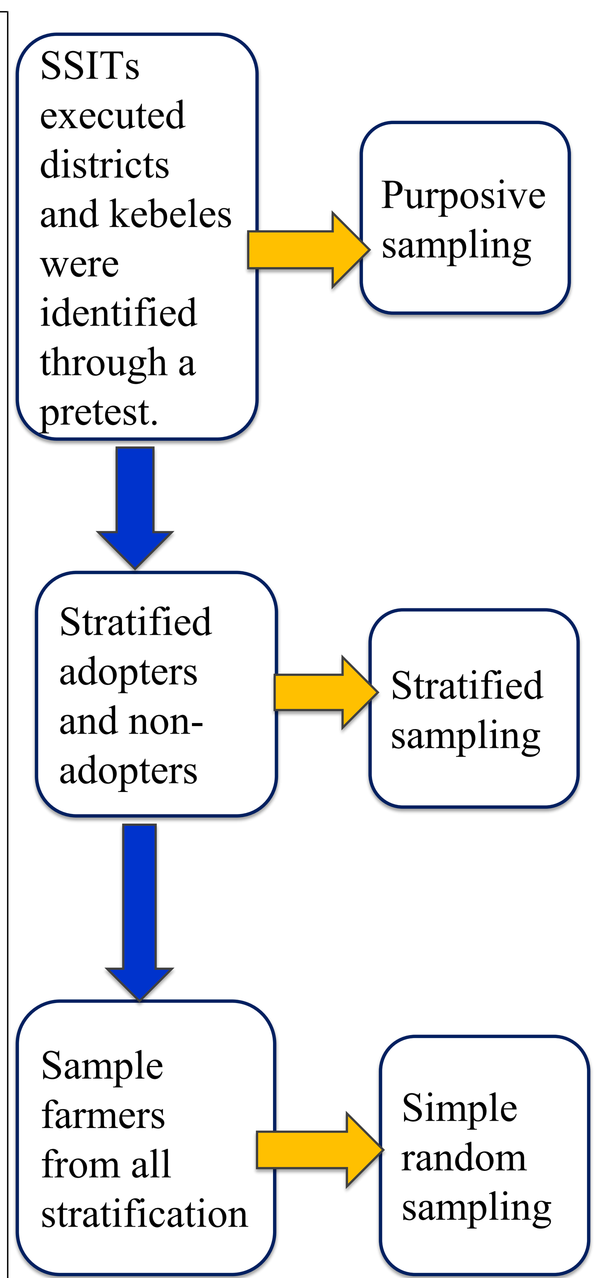
- Determine the factors that affect adoption of small-scale irrigation technology in western Amara region.
- Evaluate the impact of small-scale irrigation technology adoption on women's production capability, and income-earning capacity using the women empowerment agricultural index.

Methods



Study Area





Results

- Based on variable importance analysis: sex, irrigated land size, access to credit, and ownership of livestock were affected positively while distance to farmers' training centers, FTCs, was affected negatively.
- The results showed that adopters of SSI technologies were significantly empowered on average of 0.845 WEAI.
- ESR revealed that the average treatment effect on WEAI for treated (adopters) is 0.0012. This implies that if adopters did not adopt, the WEAI obtained from the technology would have decreased by 0.0012.
- For non-adopters, the average treatment effect on WEAI was 0.0015 implying that if non-adopters had been adopted, WEAI could have increased by 0.0015.

Index	Women	Men
Disempowered Headcount (Hp)	47.92%	47.12%
Empowered Headcount (He) (1-Hp)	52.08%	52.88%
Average Inadequacy Score (Ap)	34.42%	33.33%
Average Adequacy Score (Ae) (1- A)	65.58%	66.67%
Disempowerment Index (M0 = Hp x Ap)	0.165	0.157
5DE Index (1-M0)	0.835	0.843
% of women without gender parity (HGPI)	19.06%	
% of women with gender parity (1-HGPI)	80.94%	
Average Empowerment Gap (IGPI)	35.10%	
GPI (1 - HGPI x IGPI)	0.933	
A-WEAI score (0.9 x 5DE + 0.1 x GPI)	0.845	

Conclusions

- Irrigation technology allows women to spend less time in collecting water, allowing them to engage in more productive activities.
- Minimizing the limitations of women's contributions through empowerment is a sensible way to build, equitable, and productive rural societies.

Key Messages

- **Adoption of SSI technologies is determined by different socio-economics, demographic, and institutional characteristics.**
- **An intervention in small-scale irrigation technology empowers women in a variety of ways.**
- **Factors that impede the empowerment of women, particularly in the areas of time allocation and credit access in the area, is scarce.**

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Developing rhizobia inoculants for forage legumes alfalfa, vetch, lupine and tree lucerne growing in Ethiopia

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Introduction

Livestock production in Ethiopia is constrained by low feed quality, shortage and seasonal fluctuations. The use of high-yielding & drought-tolerant forage legumes that can fix N_2 have been suggested to produce high quality and quantity forages. But this has been poorly practiced in Ethiopia. Thus, this work was initiated to develop N_2-fixing rhizobia inoculants for forage legumes alfalfa, vetch, lupine & tree lucerne.

Objectives:

- Isolate compatible rhizobia
- Screen for elite strains
- Evaluate the screened strains

Methods

- Nodules & soil collection from Amhara, Oromia & SNNPR.
- Authenticating and evaluating the strains in modified Leonard Jars and in potted soils.

Results

Fig 1: Evaluation of strains in modified Leonard jars.

A total of 40 vetch, 50 alfalfa, 50 lupine & 65 tree lucerne rhizobia strains were isolated, authenticated and evaluated for symbiotic effectiveness (Fig 2,4). Six lupine, three vetch and 10 alfalfa strains had symbiotic effectiveness greater than or equal to 80% (Fig. 2, 4).

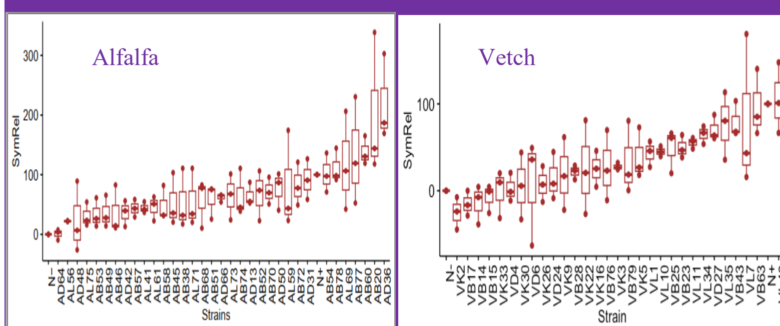

Fig 2: Symbiotic effectiveness of alfalfa and vetch strains

Results

Fig 3. Nodulation status of vetch & alfalfa

Tree lucerne seeds had germination problems & delayed strain evaluations.

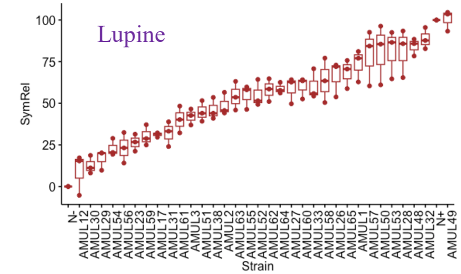

Fig 4 Symbiotic effectiveness of lupine strains

Conclusions

19 symbiotically highly effective strains were identified & forwarded for pot experiment.

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