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Design, Construction and Evaluation of Run-off Water Harvesting for Supplementary Irrigation at Smallholder Farm

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ABSTRACT

Rainwater harvesting (RWH) and management, especially on-farm storage ponds for supplemental irrigation offers an opportunity to mitigate the recurrent dry spells. For this reason, this study was conducted to design, construct, and evaluate run off water harvester for supplementary irrigation at Dodota Alem, Burkitu and Bokoji Nageso kebele of Dodota, D/Tijo and L/Bilbil Woreda, respectively. Run-off water harvester with capacity of 196.29, 359.04 and 284.38m³ volumes were designed and constructed depending on crop water requirement and commend area of selected farmer's gardens at Dodota Alem, Burkitu and Bokoji Nageso Kebele respectively. Also, experiment were conducted using three water level of supplementary (100, 75 and 50% ETc) irrigation and arranged as RCBD with three replications. Test crop used were onion at Dodota-Alam and potato for Burkitu and Bokoji Nageso Kebele. The maximum total yield of onion at 100% water level was (38.77 ton/ha) were significant different (P≤0.05) from 75% and 50% water levels but water productivity of 100% and 75% were not statically significant different (P≤0.05) from each. At Burkitu, total yield and water productivity of 100 and 75% SI were not statically significant at (P≤0.05). At Bokoji Nageso, total yield 100, 75 and 50% SI were statically significant at (P≤0.05). But, water productivity of 100 and 75% SI at both site were statically not significant different (P≤0.05) from each other. The average water saved from 75% ETc and 50% ETc were 887.03 and 1773.97 m^3/ha that can irrigate 0.25 and 0.5 ha additional area respectively. Therefore, it was recommended to use 75% SI for both crops to save water harvested and obtain low yield reduction. It is similarly recommended to demonstrate technology to farmers.

Keywords: Crop; Crop water requirement; Rainfall; Run-off; Water harvester; Pick run-off; Water level; Water productivity; Yield.

1. Introduction

Effective utilization of water is one of the most important reflections for agricultural sustainability in dry lands (Wale et al., 2019; Ahmed et al., 2021). This concern is due to water scarcity that has been a common issue in many areas worldwide due to rapid population growth and leaping economic development. Increasing population has led to an ever-increasing demand for food and farmland expansion, which are hard to be supported by physically limited natural resources. Among the water-consuming sectors, agriculture accounts for 70% of the total water use worldwide (Aregay et al., 2016). Water scarcity and increasing demand, coupled with climate change, require maximizing the use of available resources (Mume et al., 2023). Water harvesting systems are currently being used in many areas to sustain crops and increase water productivity (Ahmed & Gemeda, 2021). Rainwater harvesting is the technology used to conserve rainwater by collecting, storing, conveying and purifying of rainwater that runs off from rooftops, parks, roads, open grounds, etc. for later use.

Rainwater harvesting and management, especially on-farm storage ponds for supplemental irrigation offers an opportunity to mitigate the recurrent dry spells. The limited stored runoff by smallholder on-farm ponds may not permit full irrigation of most crops. Instead, water is used for supplemental irrigation of rain fed crops to mitigate dry spells and/or full off-season irrigation of small-scale vegetable gardens. Supplemental irrigation is also applied to mitigate intra-seasonal dry spells, which may occur during critical crop growth stages.

There is a distinct seasonality in the availability of feeds in the highlands of Ethiopia, reaching a peak and low levels towards the end of the rainy and dry season respectively. Thus, among the tested grasses species, Napier

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grass showed outstanding potential as a forage plant followed by Phalaris and Desho grass under supplementary irrigation in the central highland of Ethiopia (Faji et al., 2022). Supplementing rain-fed for sorghum production starting from the development stage was obtained better head weight, grain yield, water productivity, and stem diameter (Wale et al., 2019).

For the reason of rainfall shortage and variability constrain, crop production in Ethiopia is the main problem. For this supplementary irrigation by run off harvesting is strategic pathway to enhancing agricultural productivity and increasing smallholder farmers' income (Ahmed & Gemeda, 2021).

One of the main pillars of the Ethiopian government on food security strategy is the development and implementation of water harvesting schemes. For this, the government has constructed the Finna micro dam irrigation project at different sites in the country. In line with this, it was encouraging any organization that has idea of research to mitigate erratic rainfall at household level.

1.1. Specific Objectives

(1) To design and construct house hold level runoff water harvesting structure, and (2) On farm evaluation of runoff water harvester at different supplementary irrigation water levels on potato and onion crops at study site.

2. Materials and Methods

2.1. Materials

The materials used were - GP, meter, line level, fence wire, wood, nail, peg, treadle pump and geo-membrane.

2.2. Description of the study area

The study was conducted in Arsi zone of Digalu-Tijo, Lemu-Bilbilo and Dodota district. From each district one Kebele were selected. The selected Kebele were Dodota-Alam, Burkitu and Bokoji Nageso from Dodota, D/Tijo and L/Bilbilo respectively.

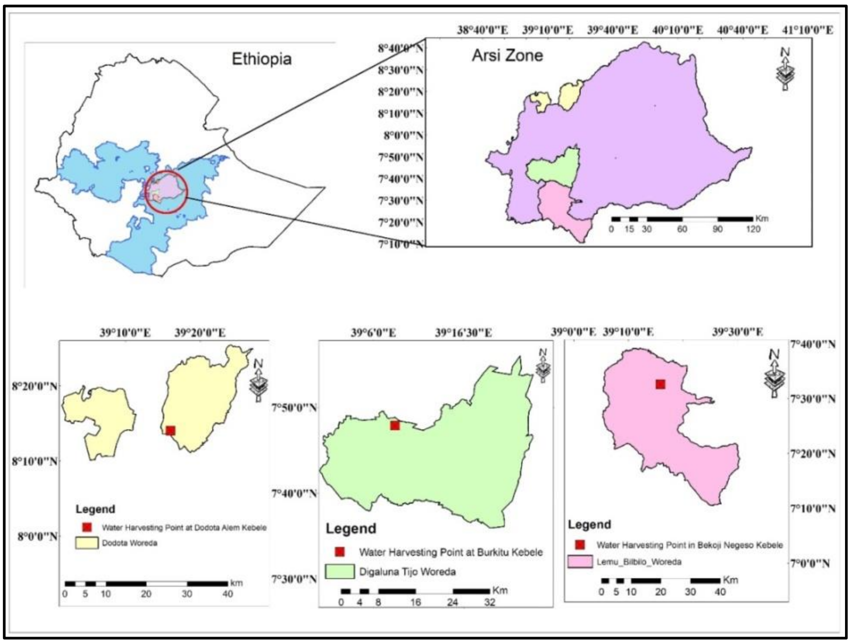

Figure 1. Study area map

2.3. Mean Annual Rainfall

To assess harvestable quantity of rainwater, average rainfall intensity over 2003-2023 mean annual rainfall were used. The mean annual were calculated on the basis of measured rainfall over 20 years' time period.

2.4. Soil data

To determine the soil texture disturbed soil samples by auger and bulk density, moisture content at field capacity (FC) and permanent wilting point (PWP)undisturbed soil samples were collected by core samples from two depths 0-30cm and 30-60cm at three points diagonally of the experimental site and were taken to laboratory for analysis.

2.5. Run-off discharge determination

Rational method equation was used to determine peak discharge from catchment basin runoff. The method was used quantify runoff from drainage areas less than 20 acres as stated by (Cleveland et al., 2011):

$$Q = CIA \qquad \ldots(1)$$

Where; Q = harvesting discharge (m^3/sec); C = Rational method runoff coefficient; I = Rainfall intensity in (mm/ hour); and A = Drainage area in (ha).

2.6. Rainfall intensity

$$I = \frac{RF\,(mm)}{T_C\,(hr)} \qquad \ldots(2)$$

2.7. Concentration time

Used to compute the peak discharge for a watershed. It was calculated by Kirpich equation (Kirpich, 1940):

$$T_c = Gk\left(\frac{L}{\sqrt{S}}\right)^{0.77} \qquad \ldots(3)$$

Where; G = 0.0078; L = the longest watercourse length in the watershed; S = Average slope of that watercourse; and K = Kirpich adjustment factor.

2.8. Determination of runoff Rainwater volume

The volume of runoff water harvester was determined by considering area irrigated and supplementary irrigation. The storage volume of RWH pond is given by Equation:

$$V = \frac{1}{3}(a^2 + ab + b^2) \qquad \ldots(4)$$

$$F = 2(a+b)\sqrt{h^2 + \frac{(a-b)^2}{2}} \qquad \ldots(5)$$

$$S = F + a^2 + b^2 \qquad \ldots(6)$$

Where; V = Volume in (m^3); a = Lower base length in (m); b = Top base length in (m); h = Height in (m); F = Lateral area in (m^2); and S = Surface area (m^2).

2.9. Soil sampling and analysis

To determine the soil texture, organic matter (OM), pH and electrical conductivity (EC), disturbed soil samples by auger and for bulk density, FC and PWP undisturbed soil samples were collected by core sampler. Sampling was from two depths 0-30cm and 30-60cm at three points diagonally of the experimental site and was taken to laboratory for analysis. The soil bulk density was analyzed after oven drying the samples for 24 hours at 105°C and weighed for calculating dry density as given by (Michael, 2009):

$$p_b = \frac{M_s}{V_t} \qquad \ldots(7)$$

Where; pb = soil bulk density (gm/cm^3); M_s = mass of dry soil (gm); and V_t = total volume of soil in the core sampler (cm^3).

TAW and RAW were determined as stated (Allen et al., 1998):

$$TAW = \frac{FC - PWP}{100} * P_b * d \qquad \ldots(8)$$

$$RAW = TAW * MAD \qquad \ldots(9)$$

Where; *TAW* = total available water (mm); *FC* = field capacity (% by weight); *PWP* = permanent wilting point (% by weight); *d* = depth of root zone (mm); P_b = specific density of soil; RAW= readily available water; and MAD = Management allowable depletion.

2.10. Irrigation water requirement

CROPWAT version-8 was used and soil data and twenty years climatic data were fed to calculate the reference evapotranspiration (ETo) of the study area.

$$ET_c = ET_o * K_c \qquad \ldots(10)$$

Where; ETc = crop evapotranspiration (mm/day); ETo = reference crop evapotranspiration (mm/day); and Kc = crop coefficient.

Total irrigation water requirement for the crop was calculated using net-irrigation requirement of the crop, irrigated areas and irrigation efficiency. Irrigation interval was calculated as:

$$I = \frac{d_{net}}{ET_c} \qquad \ldots(11)$$

Where; I = irrigation interval (days); D_{net} = net-depth of irrigation (mm); and ET_c = daily crop evapotranspiration (mm/day).

2.11. Soil moisture measurement

For soil moisture determines gravimetric method was used. For this soil before and after irrigation were collected from two soil depths (0-30 cm and 30-60 cm) of the field. The samples were taken at 30 cm depth interval within the effective root zone, which was considered to be 60 cm for potato and 40cm for onion. The moisture status of the soil profile for each field was measured before and after each irrigation event. The samples were collected using manually driven soil auger. The soil sampler was placed in the air tight container and weighed prior to placing in an oven dry at 105 °C. The oven dried soil samples with container and cover was weighed again. After the soil moisture sampler collected and oven dried, the moisture was calculated as a percentage of dry weight of the soil sample (W) as:

$$W = \frac{M_t - M_s}{M_s} * 100 = \frac{M_w}{M_s} \% * 100 \qquad \dots(12)$$

Where; W = weight of soil sample (gm); M_t = weight of fresh sample (gm); M_s = weight of over dried sample (gm); and M_w = weight of moisture (gm).

To convert these soil moisture measurements into volumes of water, the volumetric moisture content (θ) was calculated as:

$$\theta = \frac{\rho_b * W}{\rho_w} \qquad \dots(13)$$

Where; θ = volumetric moisture content (%); ρ_b = Soil bulk density (gm/cm^3); W = moisture content on dry weight basis (%); and ρ_w = unit weight of water (1gm/cm^3).

2.12. Discharge measurements at field

The flow of water into the experimental flow was measured using 3" (3 inch) size parshall flume to be installed at its entrance. Discharge measurement was taken at 2/3A (two-third of length of converging section). Then the flow depth observed on the flume was converted to the corresponding discharge using equation (14) for 3" size parshall flume. Then the total volume of water applied (V_a) was calculated using equation (15) as stated (James, 1988) and the total depth of applied water was calculated based on the representative plot.

$$Q = 0.1771H^{1.550} \qquad \dots(14)$$

$$V_a = Q * \Delta t \qquad \dots(15)$$

Where; Q = discharge through the flume (l/s); V_a = total volume of water applied (m^3); Δt = flow time to the field.

2.13. Determination of runoff Rainwater volume

The volume of runoff water harvester was determined considering area irrigated and supplementary water applied.

2.14. Experimental design and treatments

The crops used for the experiment were potato at Burkitu and Bokoji-Negeso onion for Dodota-Alam. The experiment was arranged in Randomized Complete Block Design (RCBD) with three replications. The treatments considered for the experiments were three supplementary irrigation (SI) water levels that are Full SI (100% ETc), ¾SI (75% ETc) and ½SI (50% ETc). The experiment was conducted on plot size of 5 m x 5 m (25 m^2) with 9 number of such plot for each crops. The spacing between the blocks and plots were kept as 1.5m and 1 m respectively.

Table 1. Arrangement of Treatments

Treatment	Description
T1	Full Supplementary irrigation (100% ETc)
T2	¾ Supplementary irrigation (75% ETc)
T3	½ Supplementary irrigation (50% ETc)

2.15. Agronomic data collection

Agronomic data collected for onion were plant height, leaf height, bulb diameter, and bulb length and leaf number. For potato marketable tuber yield, unmarketable tuber yield and total yield.

2.16. Water productivity

The irrigation water productivity (WP) are determined by dividing the yield to total seasonal irrigation water (IW) applied (Cook, 2006):

$$WP = \frac{Y_a}{IW} \qquad \ldots(16)$$

2.17. Statically data analysis

The collected data were statistically analyzed using Statistic version 8.0 and statistical package of using ANOVA. Mean comparisons were performed using least significant difference (LSD) at 5% probability level.

3. Results and Discussions

3.1. Soil Physico-Chemical Properties

From the laboratory results, textures of the soil in the three study fields of Bokoji Negeso, Burkitu and Dodota Alam were loamy, clay loam and sandy loam with bulky density of 1.44, 1.35 and 1.46 respectively. The three site of EC were less than 0.2 mmhos/cm that show EC of soil in the range of neutral and non-saline (less than 2 mmhos/ cm) and also pH closed to 7(neutral). This shows that the pH and EC of the area were suitable for selected crop productions (Allen et al., 1998).

Table 2. Laboratory result of soil Physico-Chemical Properties

Soil properties	Soil sampling location kebele		
Soil depth (cm)	Bokoji Negeso	Burkitu	Doddota-Alam
Texture	Loam	Clay Loam	Sandy loam
pH	6.8	7.71	7.15
EC mmhos/cm at 25^0c	0.18	0.14	0.19
% C	2.12	1.81	1.71
OM (%)	3.65	3.13	2.95

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Crop root depth	0.6	0.6	0.4
Bulk density (g/cm^3)	1.44	1.35	1.46
FC (% Vol)	30.90	36.1	23.80
PWP (%Vol)	18.15	21.8	12.60
TAW (mm/m)	127.50	143.00	112.00

EC = Electrical conductivity, C = organic carbon, OM = organic matter, FC = field capacity, PWP = Permanent wilting point

3.2. Monthly rainfall and Evapotranspiration of study area

The study was conducted end of July to end of November for Dodota Alam and end of August to mediu of January for Burkitu and Bokoji-Nageso site. The maximum and minimum rainfalls of Dodota Alam were 138.23 and 7.27mm. For Burkitu and Bokoji-Nageso maximum run fall were recorded August and minimum of December (Figure 2).

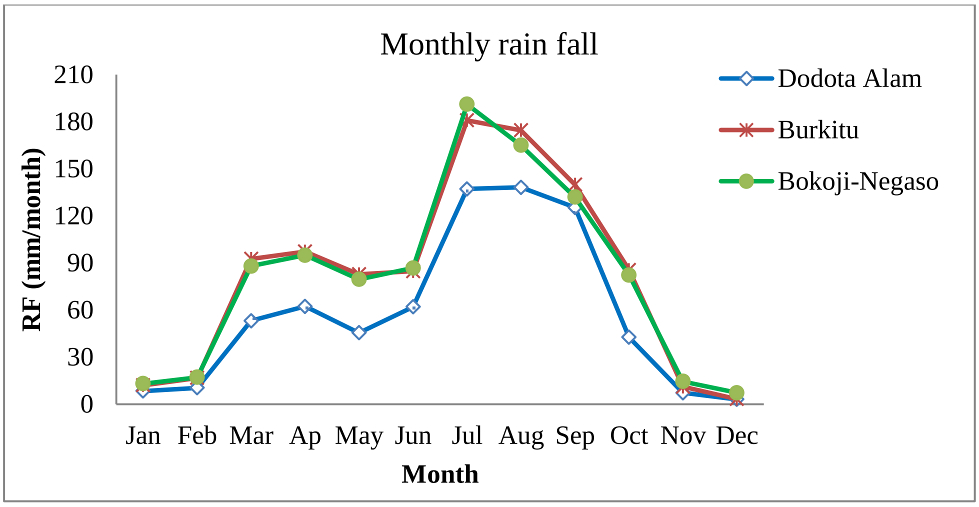

Figure 2. Monthly rain fall of study area

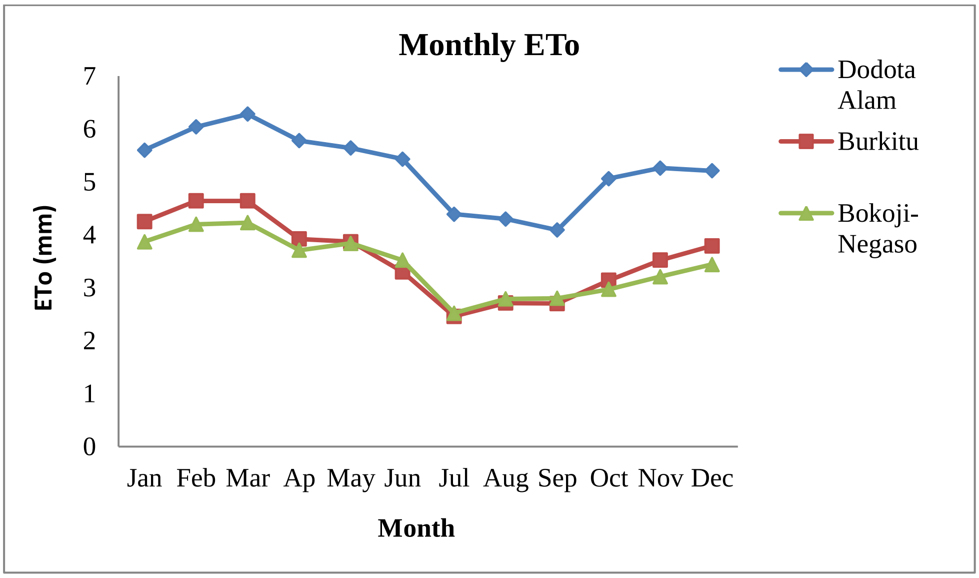

Figure 3. Monthly reference evapotranspiration of study area

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3.3. Irrigation water requirement

There is no need of irrigation water from July to end of August due to effective rainfall satisfy crop water requirement (Table 3). The total water required to from irrigation to supplement of onion were 325.88mm starting from August to end November.

Table 3. Irrigation water requirement of onion at Dodota Alam site

Month	Decade	Stage	Kc coeff	Eto mm/day	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Jul	3	Init	0.50	4.39	2.20	24.15	28.57	0.00
Aug	1	Init	0.50	4.30	2.15	21.50	28.86	0.00
Aug	2	Deve	0.56	4.30	2.41	24.08	28.86	0.00
Aug	3	Deve	0.76	4.30	3.27	35.95	28.86	7.09
Sep	1	Mid	0.96	4.09	3.93	39.26	25.43	13.83
Sep	2	Mid	1.00	4.09	4.09	40.90	25.43	15.47
Sep	3	Mid	1.00	4.09	4.09	40.90	25.43	15.47
Oct	1	Mid	1.00	5.06	5.06	50.60	5.12	45.48
Oct	2	Mid	1.00	5.06	5.06	50.60	5.12	45.48
Oct	3	Late	0.99	5.06	5.01	55.10	5.12	49.98
Nov	1	Late	0.92	5.26	4.84	48.39	0.00	48.39
Nov	2	Late	0.84	5.26	4.42	44.18	0.00	44.18
Nov	3	Late	0.77	5.26	4.05	40.50	0.00	40.50
						516.12	206.80	325.88

The crop water requirement of Burkitu site was 491.78mm, from this water need, 386.5mm of water obtained from irrigation and the rest was from rainfall (Table 4). There is no need of irrigation water from august to end of September due to effective rainfall satisfy crop water requirement.

Table 4. Crop water requirement of potato at Burkitu kebele

Month	Decade	Stage	Kc coeff	ETo mm/day	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Aug	3	Init	0.50	2.71	1.36	14.91	38.56	0.00
Sep	1	Init	0.50	2.70	1.35	13.50	29.31	0.00
Sep	2	Deve	0.54	2.70	1.46	14.58	29.31	0.00
Sep	3	Deve	0.66	2.70	1.78	17.82	29.31	0.00
Oct	1	Deve	0.79	3.14	2.48	24.81	14.83	9.98
Oct	2	Deve	0.92	3.14	2.89	28.89	14.83	14.06

Oct	3	Deve	1.06	3.14	3.33	36.61	14.83	21.79
Nov	1	Mid	1.15	3.52	4.05	40.48	0.00	40.48
Nov	2	Mid	1.15	3.52	4.05	40.48	0.00	40.48
Nov	3	Mid	1.15	3.52	4.05	40.48	0.00	40.48
Dec	1	Mid	1.15	3.79	4.36	43.59	0.00	43.59
Dec	2	Mid	1.15	3.79	4.36	43.59	0.00	43.59
Dec	3	Late	1.14	3.79	4.32	47.53	0.00	47.53
Jan	1	Late	1.01	4.25	4.29	42.93	0.00	42.93
Jan	2	Late	0.89	4.25	3.78	41.61	0.00	41.61
						491.78	170.96	386.50

From Table 5 below, there is no need of irrigation water from August to end of September due to effective rainfall satisfy crop water requirement. The total water required to from irrigation to supplement of onion were 325.88mm starting from October to January.

Table 5. Crop water requirement of potato at Bokoji Nageso kebele

Month	Decade	Stage	Kc coeff	ETo mm/day	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Aug	3	Init	0.50	2.79	1.40	13.95	36.00	0.00
Sep	1	Init	0.50	2.80	1.40	14.00	27.20	0.00
Sep	2	Deve	0.54	2.80	1.51	15.12	27.20	0.00
Sep	3	Deve	0.66	2.80	1.85	18.48	27.20	0.00
Oct	1	Deve	0.79	2.97	2.35	23.46	13.95	9.51
Oct	2	Deve	0.92	2.97	2.73	27.32	13.95	27.32
Oct	3	Deve	1.06	2.97	3.15	31.48	13.95	31.48
Nov	1	Mid	1.15	3.21	3.69	36.92	0.00	36.92
Nov	2	Mid	1.15	3.21	3.69	36.92	0.00	36.92
Nov	3	Mid	1.15	3.21	3.69	36.92	0.00	36.92
Dec	1	Mid	1.15	3.44	3.96	39.56	0.00	39.56
Dec	2	Mid	1.15	3.44	3.96	39.56	0.00	39.56
Dec	3	Late	1.14	3.44	3.92	39.22	0.00	39.22
Jan	1	Late	1.01	3.87	3.91	39.09	0.00	39.09
Jan	2	Late	0.89	3.87	3.44	34.44	0.00	34.44
						446.43	97.70	352.00

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3.4. Determination of peak runoff discharge

From Table 6, the peak runoff discharge collected from 5.4, 8.9 and 7.6 ha of catchments were 37.58, 404.16 and 387.52 m^3/hr for Dodota Alam, Burkitu and Bokoji-Nageso, respectively.

Table 6. Calculated Peak Run off Discharge

Kebele	G	K	Length (m)	S (%)	T_c (min)	Rain (mm)	I (mm/hr)	C	A	Q (m^3/hr)
Dodota_Alam	0.0078	2	355	0.043	4.82	137.15	0.191788	0.3	5.4	37.582
Burqitu	0.0078	2	895	0.32	4.53	180.9	0.626	0.60	8.900	404.162
Boqoji Nageso	0.0078	2	765	0.019	11.92	191.15	0.703	0.60	7.600	387.516

G = constant, L=the longest watercourse length in the watershed (m), S= Average slope of that watercourse, K= Kirpich adjustment factor, Q = harvesting discharge, (m^3/sec), C = Rational method runoff coefficient, I= Rainfall intensity in (mm/hour), A = Drainage area in (ha).

3.5. Design volume of runoff water harvester

Considering irrigation water requirement depth and farmers command area, the volume of runoff water harvesting capacity and design dimension was calculated. The designed and constructed runoff water harvester at Dodota-Alam has volume capacity of 196.29m^3 with top, base and height dimension of 10.5, 4 and 3.5 m, respectively. Those of Burkitu and Bokoji-Nageso were 359.04m^3 and 284.38m^3 volume capacity (Table 7). Each of runoff water harvester were laminated by 0.8mm thickens geo-membrane to minimize water loss in the form of de-percolation.

Table 7. Volume capacity of RWH and its dimension

Site	Crop	Irr. water requirement (mm)	irrigated area in m^2	Volume WH	Dimension of WH in (m)		
					Top	Base	Height
Dodota_Alam	Onion	325	603.97	196.29	10.5	4	3.5
Burqitu	Potato	386.5	928.95	359.04	14.5	5	3.5
Boqoji Nageso	Potato	352	807.90	284.38	12.5	5	3.5

3.6. Effect of supplementary water level on yield and water productivity of onion

Total yield of onion on the supplemental water level were significantly deferent from each other (Table 8). The maximum yield was obtained at full supplement (100%ETc) and minimum was at supplement (50%ETc) with value of 38.77 and 22.77 t/ha. The result of water productivity at full supplement (100%ETc) and 2/3 supplement irrigation water applied were not statically significant difference. The result agrees with the finding of Aleman et al., (2016) the supplementary irrigation water level combined with organic manure fertilization provided the highest yield. Reshmidevi et al., (2010) also recommend supplementary irrigation is appropriate measures to reduce the risk of crop failure.

Table 8. Onion yield and water productivity at Dodota Alam

Water level	MY ($t\ ha^{-1}$)	UMY($t\ ha^{-1}$)	TY ($t\ ha^{-1}$)	WP ($kg\ m^{-3}$)
100% ETc	31.01^{a}	7.763^{a}	38.77^{a}	18.90^{b}
75% ETc	24.12^{b}	6.82^{ab}	30.94^{b}	20.11^{b}
50% ETc	16.86^{c}	5.91^{b}	22.77^{c}	22.20^{a}
S.Em±	0.52	0.33	0.38	0.25
CV	3.80	8.43	2.16	3.39
LSD (5 %)	2.07	1.31	1.51	1.5713

Means with the same letter (s) in columns are not significantly different at $P \leq 0.05$, PH – Plant height, LH – Leaf height, LN – Leaf Number, BD – Bulb diameter, BH- Bulb height, BW – Bulb weigh,tMy – Marketable yield, UMY – Un-marketable yield, TY – Total yield, WP – Water productivity

3.7. Yield and water productivity of Potato at Burkitu and Bokoji Negeso

From Table 9 and 10, total yield and water productivity of full supplement (100% ETc) and 2/3 supplementary (75%ETc) irrigation water applied was not statically significant difference but significant different with ½ supplement (50% ETc).

Table 9. Potato yield and water productivity at Burkitu site

Water level	MY ($t\ ha^{-1}$)	UMY($t\ ha^{-1}$)	TY ($t\ ha^{-1}$)	WP ($kg\ m^{-3}$)
100% ETc	28.40^{a}	1.55^{a}	29.95a	7.75^{b}
75% ETc	24.63^{a}	1.43^{a}	26.07ab	8.99^{b}
50% ETc	19.93^{b}	2.07^{a}	22.00b	11.38^{a}
S.Em±	1.19	0.18	1.20	0.37
CV	8.48	18.53	8.03	6.95
LSD (5 %)	4.67	0.71	4.73	1.62

Table 10. Potato yield and water productivity at Bokoji-Nageso site

water level	MY ($t\ ha^{-1}$)	UMY($t\ ha^{-1}$)	TY ($t\ ha^{-1}$)	WP ($kg\ m^{-3}$)
100% ETc	30.20^{a}	8.73^{a}	38.93^{a}	11.06^{b}
75% ETc	25.86^{ab}	9.03^{a}	34.90^{b}	13.22^{b}
50% ETc	23.36^{b}	7.93^{a}	31.30^{c}	17.78^{a}
S.Em±	1.13	1.02	0.82	0.55

CV	7.42	20.66	4.07	6.96
LSD (5 %)	4.45	4.01	1.20	0.37

3.8. Water saved and additional area irrigated

The average water saved from 75% ETc and 50% ETc were 887.03 and 1773.97 m^3/ha that can irrigate 0.25 and 0.5 ha additional area respectively.

Table 11. Irrigation water saved and additional area irrigated

Kebele	Water level	Seasonal irrigation water depth (mm)	Seasonal irrigation water saved (mm)	Water saved in m^3/ha	Additional area irrigated by saved water (ha)	Total yield (t ha^{-1})	Additional yield (t ha^{-1})
	100%	325.88	-	-	-	38.77	-
Doddota Alam	75%	244.41	81.47	814.7	0.25	30.94	7.74
	50%	162.94	162.94	1629.4	0.5	22.77	11.39
Burkitu	100%	386.5	-	-	-	29.95	-
	75%	289.86	96.64	966.4	0.25	26.07	6.52
	50%	193.25	193.25	1932.5	0.5	22.00	11.00
Bokoji Nageso	100%	352	-	-	-	38.93	
	75%	264	88	880	0.25	34.90	8.73
	50%	176	176	1760	0.5	31.30	15.65

4. Conclusion

This study evaluated supplementary irrigation at Dodota Alem,Burkitu and Bokoji Nageso kebele of Dodota, D/Tijo and L/Bilbil woreda, respectively. Runoff water harvester with capacity of 196.29, 359.04 and 284.38m^3 volumes were designed and constructed depending on crop water requirement and commend area. Also an experiment was conducted using three water level of supplementary (100, 75 and 50 %ET_C) irrigation as treatments. Test crop used were onion at Dodota-Alam and potato for Burkitu and Bokoji Nageso Kebele. The total yield of onion at three water levels were significant different ($P \leq 0.05$) from each other but water productivity of 100% and 75% were not statically significant different ($P \leq 0.05$). At Burkitu , total yield and water productivity of 100 and 75% SI were not statically significant at ($p \leq 0.05$). At Bokoji Nageso, total yield 100, 75 and 50% SI were statically significant at ($p \leq 0.05$). But water productivity of 100 and 75% SI at both site were statically not significant different ($P \leq 0.05$). The average water saved from 75%ETc and 50%ETc were 887.03 and 1773.97 m^3/ha that can irrigate 0.25 and 0.5 ha additional area respectively.

Therefore, it was recommended to use 75% SI for both crops to save water harvested and obtain low yield reduction. It also recommended demonstrating and scaling up this technology to farmers.

Declarations

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Competing Interests Statement

The authors declare no competing financial, professional, or personal interests.

Consent for publication

The authors declare that they consented to the publication of this study.

Authors' contributions

All the authors took part in literature review, analysis, and manuscript writing equally.

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