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Development of low-cost rainwater harvesting to support on-site water supply in rural Tajikistan

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ABSTRACT

Farmers in remote, arid areas, far from available water sources, need affordable water solutions for household and livestock use. In this study, the water needs and potential for rainwater harvesting (RWH) in the Kysylsu River Basin are estimated at different altitudes. The mean annual net rainfall depth varied from 545 to 900 mm. With an average roof area of 550 m^2, 211 m^3 to 344 m^3 rainwater can be harvested for dry and wet years respectively. Based on the estimated water demand and rainfall deficit, the average household need was estimated to be 100 m^3. For a low-cost water storage solution, we tested different types of waterproof materials to replace smaller 12-18 m^3 concrete tanks commonly used in the region. Soil pits lined with 0.3 mm double layer polyethene (0.6 mm in total) was the best solution for 5 m^3 volume tanks in terms of the costs and durability and 0.8 mm double layer polyethene (1.6 mm in total) was ideal for sealing 10 m^3 volume tanks. This study demonstrates the efficiency of the system for improved livelihood of the families through rain harvesting.

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1. Introduction

Tajikistan is a mountainous country with vast water resources, but access to water is a key problem for rural water supply and for the development of agriculture (OSCE, 2014; Zohrab Samani, 2022). Due to the high cost of rehabilitating old pumping stations or building and operating a cascade of pumping stations to secure water supply in mountainous regions (Bucknall et al., 2003; Wegerich et al., 2016; Soliev et al., 2018), rainwater harvesting (RWH) is seen as a potential cost-efficient solution (Sivanappan, 2006). In the past, these solutions have been based on expensive reinforced concrete tanks or metal cisterns and transport of water from a regional source (Ali et al., 2011). In order to make RWH systems more widespread and available to local farmers, it important to design affordable systems to harvest rain during the wet season for crops water requirement during the growing season (Maheswari, 2022). Besides providing a reliable water source, the promotion of RWH can increase the income of rural households and contributes to the achievement of SDG 13 (Lenntech. (n.d.), 2002; IFFAD, 2013).

Water harvesting systems have been discovered dating back 9000 years in Jordan (Prinz, 1996), around 4500 BC in southern Mesopotamia (Bruins et al., 1986) and 4000 years back in the Negev desert of Israel (Evanari et al. 1971). RWH is still considered an important water supply option and the principles of RWH and examples of runoff calculations are discussed in various recent publications (FAO, 2014; Salman, 2016). Lancaster identifies the eight main principles of RWH and recommends that action be taken from top to bottom after very careful observation and planning small and simple activities according to continually reevaluating of the system (Lancaster, 2008). Recent studies on RWH have been carried out in different countries and are shortly reviewed here (Chowdhury et al., 2016; Wolfgramm, 2011; Critchley, 1991; ICIMOD, 2004, 2008; FAO, 2014; Oweis & Hachum, 2009). Wolfgramm (2011) presented conservation techniques documented in the World Overview of Conservation Approaches and Techniques (WOCAT) network by various organisations working in Tajikistan. This included a rooftop RWH system using a concrete tank to improve household access to water for irrigation of kitchen garden plots during the hot and dry summer months. The contour ditches (0.3m*0.3m) were on a slope at 5 m intervals to harvest runoff to conserve soil moisture for rainfed crop production. ICIMOD (2004; 2008) documented a widespread water harvesting system in the mid-hills of Nepal, where rain falling on a roof is channelled through connecting pipes into a ferro-cement water tank (capacity 500 to 2,000 litres), mainly for drinking water; the People And Resources Dynamics Project (PARDYP) tested and demonstrated a plastic-lined dugout pond (capacity 8,000 - 10,000 litres) to store run-off and household wastewater for irrigation during dry periods; run-off is harvested in conservation ponds (capacity over 100-300 m^3) placed along the gullies. Critchley (1991) and

Chowdhury et al. (2016) reported on low-cost mechanical/engineering measures to conserve rainwater in the soil profile. These techniques are mainly dedicated to harvest runoff through contour ploughing, bunding, trenching, establishment of moisture conservation pits, crescent terracing, zing terracing and stone walls for further conservation in soil for crop irrigation.

Oweis and Hachum (2009) studied different designs and sizes of water harvesting structures for agriculture. They studied for example small runoff harvesting basins (negarim) (with plots of 50-100 m^2) for fruit trees in Jordan, established to grow almonds and pistachios; small farm reservoirs in Jordan of 10,000-20,000 m^3, used to irrigate crops and trees and to support livestock; underground cisterns of 10 to 500 m^3, established in arid areas of north-western Egypt, to direct runoff during the rainy season to refill cisterns 2-3 times per rainy season. The water in the cisterns is clean and typically used for human drinking, animal needs and growing cash crops in home gardens. The authors reported about significant role of agriculture water harvesting for crop production in arid and semi aria areas. Moreover, FAO (2014) describes principles and experiences of agricultural RWH by smallholder farmers in the Caribbean subregion, based on analysis and estimation of water availability to meet demand. The principle is to deprive part of the land of its share of rainfall and redirect it to another part of the farmland to have enough water to meet crop water needs and ensure stable and high crop yields. Availability of local materials should be taken into account when designing RWH solutions. Farmers in different countries have used a wide variety of construction materials, designs and techniques for RWH (Lininger, 2013). Lancaster, (2008) recommended that RWH should begin with the construction of earthworks to divert runoff and the storage of water in various types of reservoirs (berm basins, terraces, French drains, infiltration basins, cisterns, etc.) for irrigation of crops (Lancaster 2008).

The aim of the study was to develop a low-cost RWH system using locally available materials to address the water availability problems of resource-poor, remote rural households in the arid foothills. In line with the first principles of RWH presented by Lancaster, the activities were initiated after very long and careful observations. To determine the water needs of rural households in three main agro-climatic zones of the river basin, field data were collected on the number of water users per family, the number of livestock and the area of homestead plots. The main crops grown in each zone were identified and crop water requirements were estimated for average, dry and wet years. To understand water availability, we estimated water supply potential in all zones, at different altitudes, identified the average roof catchment area, the average annual rainfall. We chose the household level and conducted field tests on the impermeability of various materials, especially implementable with low-cost materials for use in water reservoirs. The efficiency of low-cost RWH systems was tested, taking into account the overflow water as a resource and maximizing the beneficial cost-durability ratio. Based on continuous re-evaluation of the RWH system, planning is underway in the country to use surplus harvested rainwater for agriculture to increase living and organic ground cover area and, more importantly, improve food security for resource-poor farmers. The following section describes the local conditions, data collection and estimation methods, as well as the process used to construct and test RWH systems. Then we provide our key findings on viability of RWH systems before discussing these findings in light of local conditions.

2. Materials and methods

2.1 Study area

The study was conducted in the Kyzylsu or Kyzylsu Southern river basin located in South-Western part of Tajikistan. It covers the territories of Baljuvan, Vose, Dangara, Muminobad, Farkhar, Temurmalik, M.S.A. Hamadony, Khovaling administrative districts and Kulyab city of Khatlon region, Tajikistan.

For Tajik conditions, Kyzylsu river basin is in a relatively low altitude of the catchment area (up to 3000 m), so snow and rain are the main supply of the river flow, and the specific run off is less than 20 litres per second from km^2. The Kyzylsu basin includes tributaries – the Toirsu, Kyzylsu and Yakhsu river basins, and the total catchment area is 8353 km^2. This is 4.5% of the total area of the country's river basins.

The sum of annual active temperatures in the valley part of the basin above 100C reaches 54000C-55000C, which indicates that the area is very heat rich (Brudnoy, 1962). The duration of spring and autumn is 70-90 days. In the hottest months, the absolute maximum air temperature in the valleys rises to +45-470C, and above 2000 m up to +300C.

The average annual air temperature in the upper reaches, 1300 - 1400 m a.s.l. is around 12.20C, at the elevations of 920 - 1200 m a.s.l. it is in the range of 14.2-15.60C, and in the lower regions at 660 - 800 m a.s.l. it is around 16.70C (average for the basin is 14.80C). The maximum average daily temperature fall is in July (24.7-29.50C), and the minimum is in January (-0.8-3.40C).

According to the analysis and processing of meteorological data, the variation of annual precipitation in the region varies between 323 and 920 mm, of which 135-311 mm falls in the winter month (December-February) and 98-389 mm in spring (March-May). There is practically no precipitation during the summer months.

The tests in this study were carried out in three main zones: hilly (601-800 m a.s.l.), piedmont (801-1200 m a.s.l.) and low mountain range (1201-1600 m a.s.l.).

These three zones represent 64.3% of the total area of the basin. The climatic data of four meteorological stations located in different altitude of Kyzylsu river basin were used in our study (Fig 1.).

In the arid foothills of the country, the location of rural communities at a distance of 18-25 km from the main water sources in the higher elevations of hilly and mountainous areas, and the outdated water pumping infrastructure built during the Soviet era, meant that local low-income families paid for the transport of water for 10 months in a year.

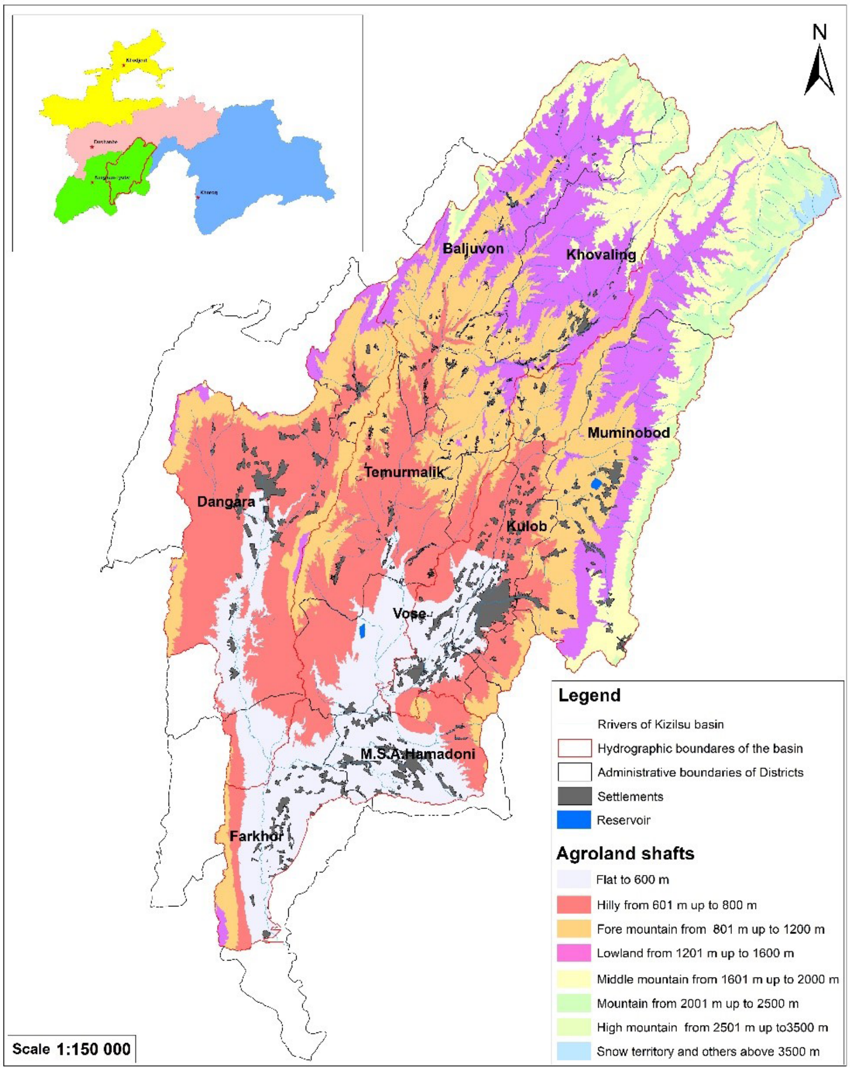

Fig. 1. The main three zones (hilly, fore mountains and low mountains) of Kysylsu river basin. Source: Domullodzanov (2021)

2.2. Methods

The study defines the water needs of an average household through the identified number of water consumers, estimated water use norms, potential area for irrigation of kitchen gardens, identified main crops and estimated crop water needs for three agro-climatic zones (Table I).

Table I. Water users of 3 agro-climatic zones

#	Agrolandscape zones of the river basin	Main water consumers					
		Average size of household (person)	Livestock (average number of heads)			Kitchen garden (ha)	
			Cattle	Ruminant	Poultry	Average size	Including orchards
1	Hilly areas	8	7	12	11	0.33	0.064
2	Fore mountains	9	4	12	5	0.35	0.092
3	Low mountains	11	5	7	6	0.36	0.110

Statistical data on the district population and the number of households in the target districts, the area of kitchen gardens and the total area under crops were taken from official statistical reports (Tajstat, 2018). Information on the average number of livestock and poultry and the types of crops produced in rainfed and irrigated areas was obtained from the district authorities.

As farm animals spend a significant part of their time in settled pastures and use different water sources for drinking, a coefficient (0.5) has been introduced to estimate the water demand for livestock needs. The same coefficient (0.5) was introduced for domestic water needs. The study showed that the use of water resources in households is multipurpose. Water used for domestic purposes is reused for irrigation or for livestock. In addition, run-off from heavy rainfall is used for irrigation, which significantly increases the efficiency of rainwater use.

Using existing hygiene and water consumption standards and introducing correction factors, the total amount of water needed for livestock and household needs of an average family in three agro-landscapes of the river basin was calculated (Ovodov, 1984).

After identifying the number of water users in each agro-landscape zone, the water demand per household was estimated. The CROPWAT 8.0 software developed by FAO was used to estimate the water requirements for the cultivation of major crops on the homestead (FAO, 1992). Water requirements for main crops and orchards were estimated for dry, average and wet years. All the information collected was analyzed in an excel spreadsheet.

2.3. The construction process of polyethylene lined water tank

We followed multiple literature sources in developing our approach to construction of polyethylene lined water tanks (see introduction section). After careful observations over many years of project work (from 2008 to 2010) and identifying the local conditions in terms of water availability, household conditions, and availability of materials in the local markets, the first step in installing a polyethylene lined water tank was to select a suitable location for digging a cylindrical pit. The location of the tank should have been far from trees to avoid infiltration by roots. If after digging the pit there were many stones with sharp edges, the walls in the pit must have been plastered with a mixture of clay and water. Based on the availability of materials, there were two options for the size of the cylindrical pits: for tanks with a volume of 5 m^3, the diameter of the pits was up to 1.25 m, and for tanks with a volume of 10 m^3, the diameter of the pits was up to 1.9 m. In order to have easy access to the water, the tanks were placed close to the gutter at four corners of the buildings and connected with polyethylene pipes (Fig. 2).

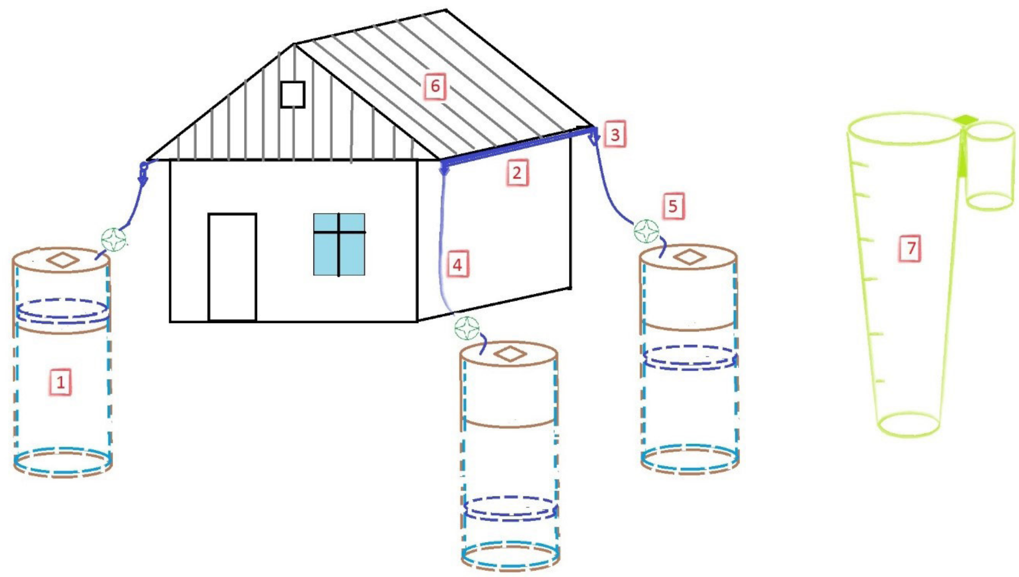

Fig. 2. The location of polyethylene lined water tanks linked to house gutters: 1 - low-cost polyethylene lined water tanks, 2 – gutters, 3 – funnel, 4 – polyethylene pipes diameter 20-32mm, 5 – water meter, 6 – roof catchment area. Source: Domullodzanov (2021).

3. Results

3.1. RWH viability and cost comparison

RWH is a feasible low-cost solution for smallholder farms in an arid climate with limited access to water sources (Table II). The pay-off time for the tested system is about 2 months given an investment cost of 204 USD and an annual maintenance cost and depreciation of 16 USD for an RWH tank with a volume of 10 m^3 and 24 USD for an RWH tank with a volume of 5 m^3. The service life of the water reservoir is 24 years and for the waterproof layer is at least 6 years. After installing the first RWH tank and refilling it during the year an average family can save 1100 USD.

Table II. The cost of water supply before and after constricting RWH.

No.	Cost of materials and works	Quantity (m^3)	Unit cost (USD)	Total cost (USD)
1.	Before constricting low-cost RWH tanks			
1.1	Water transportation cost by trucks, \$85-\$170 per month for transporting 4-8 m^3 water during 10-month annually	40	21.25	850
		80	21.25	1700
1.2	Average cost			1275
2.	Cost of investment and operation of 5 m^3 RWH tanks			
2.1	Investment cost		105.58	105.58
2.2	Operation cost		7.8	7.8
2.3	Depreciation		15.8	15.8
2.4	Subtotal			129.18
3.	Cost of investment and operation of 10 m^3 RWH tanks			
3.1	Investment cost establishing low cost RWH tank, volume 10 m^3, 8 times refilling of tank during the year		203.93	203.93
3.2	Operation cost		7.8	7.8
3.3	Depreciation		8	8
3.4	Subtotal			219.73
3.5	Average cost			174.45
	Difference (Line 1.2-Line 3.5)			1100.55

Only 38 per cent of people in Tajikistan have access to safely managed drinking water services (World Bank, 2020). This study provides a low-cost solution for rural water supply. Our estimation showed that the RWH system saves USD 1,100 per year compared to the current practice of transporting water with water supplying trucks. Using locally available materials for constructing RWH tanks is cheaper than hiring a water supply truck. In addition, during the collecting of field data, it was reported that the transportation cost of water was 10-20% higher for the households' location on the upper part of the hill. Also, the size of the family and farm affect water supply cost as more water is needed for bigger families, as shown in Table 1.

The RWH system needs a certain roof area to harvest enough water to supply households. This study provides information about the average roof surface area (550 m^2) measured in 120 representative households from the three zones for river basins with different altitudes (Fig. 3). The analysis of the historical climatic data from the four local meteorological stations located in the different altitudes of the river basin showed 545 mm mean annual precipitation in the driest regions. Our estimations showed that establishing at least one RWH reservoir can harvest more than 60 m^3 rainwater per year from the average surface area.

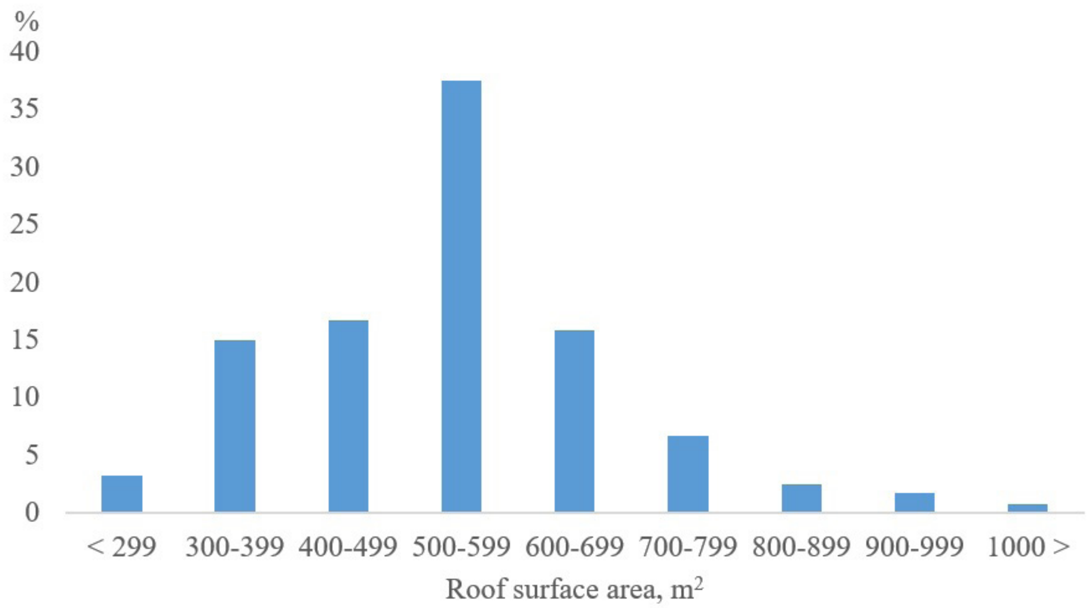

Fig. 3. The roof surface area of households in three zones of Kysylsu river basin. Source: Authors' own work.

3.2. Evaluation of the waterproof materials

Comparison of different tank materials show that 0.3 mm double layer (0.6 mm in total) polyethylene is optimal for 5 m^3 volume tanks and 0.8 mm double layer (1.6 mm in total) polyethylene for constricting 10 m^3 volume reservoirs. The tests showed the best waterproof materials for water tanks were polyethylene coating. Polyethylene (PE) has the advantage over concrete due to its low cost and availability in the local markets. The durability of the PE waterproof coating is a minimum of 6 years. When leaking was observed a new coating was needed. It can last for long up to 20 years; however, the limitation is the sensitivity of the materials to sharp-edged objectives. Another limitation of coating for stony and sandy soils. The inner part of the water tank collapses, and it is impossible to maintain the designed diameter of the tank.

Within this study, 4 types of waterproof materials and 17 different thickness PE coating with widths 2 m and 3 m were tested against waterproofness, unit cost and durability (Table III). The tanks with armoured concrete wall was more solid and waterproof material, but most expensive and according to our observations, only 10% of local farmers could afford to construct it due to extremely high cost. The PE with thickness less than 0.3 mm, reinforced polyethylene sheets with strips and rubberized tarpaulin were not waterproof, two last materials were durable despite their high unit cost.

Table III. Result of testing different waterproof materials for RWH.

#	List of materials for RWH	Evaluation criteria			Evaluation of materials
		Water-proofness (yes/no)	Unit cost of material (USD)	Durability (yes/no)	
1	Reinforced polyethylene film with strips	no	30	yes	Water leaked, high cost
2	Rubberized tarpaulin	no	45	yes	Water leaked, high cost
3	Concrete, armoured	yes	480	yes	Most expensive and water proof, easy to crack and difficulties to repair
4	Polyethylene film, thickness more than 0,3 mm for 2 m width and more than 0.8 mm for 3 m width coating material	yes	3 and 9	yes	Low cost, affordable and water proof option

Table III.*Cont*.

5	Polyethylene film, thickness less than 0,3 mm	no	<3	no	Water leaked, low cost, not durable

The study showed that the most popular design of RWH structure among the local households was a cylindrical shape with underground part up to 4-5 m depth and on-ground part with 1-1.2 m height. Initially, two designs including cylinder shape and rectangular shape tanks established in the manually dug hole with polished walls and with an underground part. To ensure safety the design of the cylinder shape reservoir was adjusted and added on-ground part. In addition, the cylinder shape tank occupies less space in the house yard and it is easy to wash PE coating after emptying of the water tank.

3.3. Potentials of RWH to meet water supply and demand

The study showed RWH capacity to provide sufficient water to cover domestic needs and livestock needs of households, and irrigation of the kitchen garden plots in three agrolandscapes of the river basin. The household water balance developed for years with mean precipitation distributed within the year (545 mm) from the roof surface (550 m^2). The RWH constructed in the average household located in the hilly zone (altitude 600-800 m) shows that on average 270 m^3 water can be harvested annually (Table IV). This system can harvest on average 211 m^3 rainwater during dry years and 344 m^3 in wet years.

Table IV. Water supply and demand of average households in the lowlands.

Months	Water demand of the family (m^3)			Monthly mean precipitation in hilly zone (mm)	Volume of harvested rainwater (m^3)	Balance (m^3)
	Livestock needs	Household needs	Crops irrigation			
1	6.32	5.89		67	33.17	20.96
2	5.71	5.32		72	35.64	24.61
3	6.32	5.89		78	38.61	26.40
4	6.12	5.70	10.00	116	57.42	35.60
5	6.32	5.89	14.00	75	37.13	10.92
6	6.12	5.70	20.00	0	0	-31.82
7	6.32	5.89	22.00	0	0	-34.21

Table IV. *Cont*.

8	6.32	5.89	21.00	0	0	-33.21
9	6.12	5.70	14.50	0	0	-26.32
10	6.32	5.89		20	9.9	-2.31
11	6.12	5.70		68	33.66	21.84
12	6.32	5.89		49	24.26	12.05
Annual amount	74.40	69.35	101.50	545.00	270.00	24.53

The study identifies household water demand to be on average 69 m^3 for a family of 8 persons, livestock needs 79 m^3 for a typical herd (19 animals) and the remaining 101 m^3 can be used for irrigation of crops on kitchen garden plots (0.3 ha) to produce more food. In most years rainwater is available for garden plant during the rainy season before the vegetation period starts. Our estimations showed that with the increase of water use demand the storage capacity of 100 m^3 is needed to harvest and store enough rainwater to cover water deficit in dry months (May-October).

With RWH, water becomes available for different uses providing multiple benefits. Our experiments conducted in four pilot sites showed that RWH system efficiency is 90.5-93.3% (Table V) (Domullodzhanov and Rakhmatilloev, 2020). The finding suggests that the RWH system established on the testing households cannot collect all potentially available rainwater due to evaporations from the roof surface, washing dust and during the intensification of the rainfalls if the water tanks are filled already.

Table V. Waterproof coating efficiency measured in the testing households.

#	Location of test house	Precipitation (mm)	Water harvesting surface (m^2)	Total water collected (m^3)	Theoretically available water (m^3)	RWH coefficient (%)
1	Bulakdasht	599	84	46.9	50.3	93.3
2	Sartez	511	156	72.1	79.7	90.5
3	Chilcha	598	120	65.3	71.8	91.0
4	Sadbargho	634	210	122.8	133.1	92.3

The study reports that after beginning the promotion of the RWH the local farmers started to change their water use behaviour and use more water for domestic and other purposes. For instance, washing clothes and taking shower become 2-3 times more frequent. The number of domestic animals increased by 30-100%. To use water heaters for bathroom/kitchen and tap water, farmers started to lift rainwater by using small electrical pumps to the higher elevated plastic water tank. The surplus of the collected rainwater is used for irrigation of crops to produce more yield and diversify cropping patterns in the kitchen gardens.

The main limitation of the current study is the estimation of changes in water resource use caused by behavioural changes. It is necessary to develop a methodology to determine the direction of rainwater use for livestock or crop irrigation. It is also necessary to develop a methodology for calculating the threshold of effectiveness of the use of rainwater depending on the amount of annual rainfall and the catchment area; to determine the effectiveness of the use of rainwater between competing uses, i.e. to clarify the feasibility of the use of rainwater for the development of livestock or irrigation, as well as their optimal combination. The use of rainwater for other income-generating activities of households, processing of livestock products, vegetables and fruits to increase the value addition of household products needs to be explored. Finally, research is needed on the use of new waterproof materials and technologies for the construction of RWH systems.According to studies by Ali et al. (2011), ICIMOD (2004 and 2008) and Wolfgramm (2011), RWH systems are important for resource-poor farmers and materials are durable. However, the proposed design and materials used are costly and not affordable for about 90% of vulnerable farmers in the region to harvest the required amount of water (Domullodzhanov and Rakhmatilloev, 2020). The current study identified the needs of the local farmers and offered a low-cost solution to accommodate sufficient amount of water for the dry season. The materials used are locally available and the proposed design was acceptable to the beneficiaries of the study.

4. Discussion

The study show how rainwater harvesting can be used in Tajikistan for improved livelihood. The present study shows that proposed low-cost RWH system using polyethylene-lined tanks are affordable for resource-poor farmers in drylands. The tanks proposed allow the farmer to construct a sufficient number and volume of tanks to meet farmers' needs for household, livestock during wet and dry years. As only 158-327 mm or 28-36% of the average rainfall occurs during the growing season (April to September), the average evaporation deficit for the period April-September varies between 611 and 1130 mm (Domullodzhanov, 1988), so irrigation is needed. According to the analysis, the system is efficient and the payback period is about 2 months. Rainwater harvesting has the potential to increase agricultural production. Previously Oweis & Hachum (2009) reported that almond and olive trees planted in the negarim (small basin) water harvesting system survived in an area with Mediterranean climate in Jordan, with average annual rainfall of 100-200 mm, grew satisfactorily over the seasons and are still producing after 23 years. In addition, water harvested in cisterns along the north-west coast of Egypt, with an average annual rainfall of about 150 mm, was used to grow cash crops in home gardens.

Rainwater harvesting can lead to several other benefits in developing regions. Teshome et al (2010) reported a high socio-economic impact of the application of rainwater harvesting systems introduced among 308 households in 2004. The harvested water was used to produce onion seedlings on 100 m^2 in the kitchen garden plot and, after using the produced seedlings, to plant bulb onion on 1 ha of rainfed plots. The study showed that 50% of the harvested water was used for livestock, 5% for household purposes and the remaining 45% for seed and fruit production. As a result, the production of onion seedlings and the cultivation of bulb onions generated USD 2,003 per year (USD 155 + USD 1,848). This net income was higher than other crops in the region. By 2008, the technology had spread to 7,618 households.

Nouri et al. (2010) highlighted the importance of water harvesting in an area with mean annual rainfall less than 250 mm to sustain agricultural production. To enhance water use efficiency using mulching and applying water saving technologies is crucial. Shan et al. (2000), Shan (2002) stated that "water saving agriculture practices three techniques consist of water saving irrigation that is based on actual crop need, limited irrigation which means deficit irrigation in non-critical stages of crop growth".

Our study shows that the efficiency of using RWH systems is more than 90.5%, and the proposed design of a cylinder-shaped reservoir lined with polyethylene is a low-cost option for local smallholder farmers to meet household water needs. To ensure harvesting clean water and to increase the service life of using waterproof coating, harvesting rainwater started 10-15 minutes after starting rainfall and it was recommended to take out and wash PE coating after deplenishing of the water tank. In addition, to identify the maximum waterproofness durability of the PE coating need additional research.

Conclusions

In this study rainwater harvesting was studied in the Kysylsu River Basin of Tajikistan at different altitudes with mean annual net rainfall depth variation from 545 to 900 mm. The main finding is that there are RWH systems with locally-sourced materials that are very efficient and durable. It is estimated that the volume of tanks for household rainwater harvesting systems in different agricultural landscapes is around 100 m^3 to harvest and store enough rainwater to cover the water deficit in the dry months of May to October.

For the collection and storage of precipitation in drylands of agro-landscapes of Kyzylsu river basin, the most popular design of RWH structure tank among the local households was a cylindrical shape with underground part up to 4-5 m depth and on-ground part with 1-1.2 m height. The field tests showed that the RWH installed in an average household with a roof area of 550 m^2, located in the hilly zone of the river basin at an altitude of 600-800 m a.s.l., can help to harvest an average of 211 m^3 of rainwater in a normal year with an average rainfall of 545 mm, 211 m^3 in dry years and 344 m^3 in wet years.

The findings suggest that research and policies need to focus on solutions that take local contextual factors into account and ones that are tested in the field with actual water users. Such an inclusive and place-based approach might be key to many resource-related issues on the ground in developing countries such as Tajikistan.

Disclaimer

The views expressed in this publication are those of the author(s) and do not necessarily reflect the views or policies of the Food and Agriculture Organization of the United Nations.

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