Chapter 11
Benefits of Reviving Indigenous Water Conservation Practices for Drought Resilience in Red and Lateritic Zones of West Bengal, India

Sabita Roy, Rahi Soren, and Sugata Hazra

Abstract Water conservation practices have a fundamental role in facilitating irrigation and groundwater recharge in drought-prone regions. The present research aimed to determine benefits of indigenous water conservation (IWC) practices—tanks, dug wells, and ditches—in Kashipur and Chhatna blocks of Purulia and Bankura districts belonging to the red and lateritic zones (RLZ) of West Bengal, India. The household survey and focus group discussions were conducted on a total of 460 households (Kashipur, 150, and Chhatna, 310), which were selected by utilizing a stratified sampling method that covered 36 villages of the blocks. The analysis revealed that IWC structures along with the promotion of scientific cropping practices have provided supplementary water supply for micro-irrigation, increased cropping intensity, crop variability and rotation, and benefitted crop production—especially in drought and drought-like situations. As a result, income from agriculture has enhanced. Livestock ownership and income from livestock also improved due to increased water and feed availability supported by IWC structures. In all the study villages, additional water supply led to the adoption of nutrition gardening and revival of indigenous crops. This, in turn, ensured food and nutrition security and improvement in vegetable and fruit consumption and also led to a reduction in hunger days. The fundamental impacts of the IWC structures with scientific cropping techniques including the promotion of double cropping, nutrition gardening, indigenous crops, animal husbandry, and backyard fishery in ditches emerged as potential livelihood options. The present study suggests increasing community participation in the implementation of these structures, adoption of mixed cropping and multi-cropping practices, and up-scaling these multi-stakeholder approaches can continue to secure livelihoods and drought resilience in the RLZ, paving pathways for the adaptation of the marginalized communities to climate change.

S. Roy · R. Soren (✉) · S. Hazra
School of Oceanographic Studies, Jadavpur University, Kolkata, West Bengal, India
e-mail: sugata.hazra@jadavpuruniversity.in

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11.1 Introduction

The adverse effects of climate change and global warming on agriculture have been recognized globally. In India, high dependence on rainfed agriculture and excessive pressure on natural resources make it highly vulnerable to climatic extreme (Kumar et al., 2020; Venkateswarlu & Singh, 2015; Khan et al., 2009). Climate change is leading to an increase in the frequency and intensity of droughts, heat stress, and more evaporation (IPCC, 2021; Chauhan et al., 2014) which negatively affects the crop production and food security in India (Singh et al., 2012; Rao et al., 2015). Thus, sustaining crop production in the rainfed farming system is essential to maintain India's food security (Kumar et al., 2020). Warming-induced frequent droughts in monsoon season are common in red and lateritic zone (RLZ) often resulting in severe crop loss and food shortages (Mishra et al., 2022), and the most severe impacts are felt among the small and marginal farmers. The occurrence of crop failure is on the increase as the frequency and intensity of droughts have been raised in the RLZ (Bhunia et al., 2020; Palchaudhuri & Biswas, 2020). Farmers understand the uncertainties of rainfall and associated production risk and try to manage it by implementing indigenous water conservation structures.

Water conservation structures have been executed widely for infield water storage all over the world. Water conservation practices among the indigenous population of the United States have been recorded for at least 1500 years (Pretty & Shah, 1997). Traditional water conservation practices in the sub-humid undulating terrain area were to excavate land to store excess rainfall (Mitiku et al., 2006; Mihret et al., 2020). Water conservation structures constructed thousands of years ago are known from the Babylonia, Israel, Tunisia, China, and also the United States (Frasier, 1980; Boers & Ben-Asher, 1982; Li, 2000; Ouessar et al., 2004). Such structures have received renewed consideration to increase crop yield since the prolonged drought conditions in sub-Saharan Africa, Ethiopia (Critchley et al., 1991; Pretty & Shah, 1997; Prinz & Singh, 2000; Kunze, 2000; Ouessar et al., 2004). Though traditional water conservation practices have been prevalent dating back to 4500 BC, the agricultural revolution of the late 1990s in India has brought it in again into focus (Sivanappan, 1997; Rockstrom, 2002; SIWI, 2001).

The indigenous water conservation (IWC) structures have increased the amount of water stored by retaining rain and reduced surface losses, so that water can be used where and when it is needed (UNEP, 1997). The IWC structures implicate the storage and usage of rainwater for domestic, agricultural, and other livelihood activities (Ngigi et al., 2006; Jebamalar & Ravikumar, 2011). Therefore, IWC structures have been considered as an effective adaptation strategy against drought and climate variability (Wolka et al., 2018).

Previous studies concluded that farmers have received benefit from IWC structures through run-off retention, thereby improving water availability to crops in different countries of the world such as semi-arid region of Zimbabwe (Nyagumbo et al., 2019) and humid uplands of Ethiopia (Mekonnen, 2021; Mihret et al., 2020; Mekuriaw et al., 2018; Adimassu et al., 2017), China (Jia et al., 2019; Jiang et al., 2019), Africa (Wolka et al., 2018), and Kenya (Ngetich et al., 2014).

Climate change and associated recurring monsoon drought have resulted in frequent crop failure in most small and marginal farming in Purulia and Bankura of West Bengal, India (Bhunia et al., 2020; Roy & Hazra, 2020). Agriculture in this region is predominantly dependent on rainfall, and primarily a single crop is cultivated which makes it vulnerable to drought and drought-like situations. Recently, higher rise in temperatures led to higher evaporation which affected the agriculture production and water resource sectors of the region (Roy et al., 2020). Since 1990, the RLZ has been experiencing frequent severe droughts for a short period (Mishra & Desai, 2005) with reduction of around 24% Kharif (monsoon) crop production (Pandey, 2012). Incidents of drought frequency and intensity have also been increased (Bhunia et al., 2020). The tribal communities dominate the population in the villages of Kashipur (Purulia) and Chhatna (Bankura) with high rate of poverty (Mishra et al., 2022) and irrigation deficiency restricting agricultural and socioeconomic improvement (Palchaudhuri & Biswas, 2020; Pant & Verma, 2010). It is essential to popularize and adopt water conservation practices that can reduce the vulnerability of marginal farmers who cultivate in upland areas in the drought-prone RLZ. The water conservation practices are considered one of the key strategies to sustain crop production in prospect of growing water shortages and deteriorating soil health to fight the increasing incidence of drought and desertification and also to moderate the negative impacts of climate change and variability.

In India, IWC structures have been considered as supplementary irrigation sources which can possibly sustain crop production during drought conditions (Pani et al., 2021; Kumar et al., 2020; Pender & Kerr, 1998; Kerr & Sanghi, 1992). The IWC structures provided additional water supply and enhanced crop yield in Sikkim (Mishra & Rai, 2014; Mishra et al., 2019), Sone river catchment (Goel & Kumar, 2005), Andhra Pradesh (Kumar, 2016), Karnataka (Naveena et al., 2019), Gujarat (Pande et al., 2011), Madhya Pradesh (Malik et al., 2014), and Odisha (Sahoo et al., 2017).

To stabilize the production and reduce the probabilities of crop failures during dry spells, IWC structures have been provided with significant positive changes in the RLZ of West Bengal (Croke et al., 2012). The production of fish and carp in IWC structures has created alternative livelihood options and enhanced economic conditions in drought-prone RLZ region (Mishra et al., 2021, 2022). The indigenous people of the region have adopted various IWC practices such as happa, pond, well, pitcher watering system, drip watering system, etc. to cope with drought in RLZ. These structures supported micro-irrigation during drought conditions (Bauri et al., 2020). Small in-field IWC structure has facilitated groundwater recharge and increased soil moisture leading to higher crop production and intensity in drought-prone Bankura district of West Bengal, India (Pani & Mishra, 2021).

However, while the benefit using large-scale water bodies on fishing yields has been evaluated, overall benefits of IWC structures on the improvement of agriculture and drought risk reduction have not been evaluated so far. Therefore, the current research chapter focuses on the benefits of indigenous water conservation practices on the profile of agriculture, income, nutrition, food security, and livelihood diversification in smallholder farming villages of Kashipur and Chhatna blocks of Purulia and Bankura. The study evaluated the role of indigenous water conservation practices in improving food and nutrition security and drought-resilient farming through increasing water availability.

11.2 Study Area

The present study was conducted at 36 villages of Kashipur (17 villages) and Chhatna (19 villages) blocks (Table 11.1) of Purulia and Bankura, which are part of the RLZ, West Bengal (Roy et al., 2020). Kashipur and Chhatna blocks are situated between 23°26′,54″N to 23°21′26″N latitude, 86°34′20″E to 86°49′50″E longitude, and 23°27′8″N to 23°18′2″N latitude, 86°49′27″E to 87° 0′34″E, respectively (Fig. 11.1). Kashipur covers an area of about 434 km^2 with elevation varying from 88 to 228 m above mean sea level. Chhatna covers 449 km^2 area, and its elevation varies between 63 and 199 m above mean sea level. Thus, compared to Chhatna, Kashipur is at a higher elevation, and its topography is steeper, which results in a relatively higher risk of drought. The major landscape of these blocks is characterized by undulating terrain topography. Around 30% of the area have slopes in the range of above 6° and are prone to drought. The annual average rainfall is 1300 mm. The annual mean minimum temperature is 10 °C, whereas the annual mean maximum temperature is 45 °C (Roy et al., 2020). The non-perennial Dwarakeswar is the principal river in the area and follows the master slope toward the southeast. The soil is mainly red sandy to red and yellow loam (NBSS and LUP, 2006) with fewer nutrients and less water-holding capacity. Livelihoods of the community predominantly depend on agriculture. About 60% of the cultivators are marginal, and 30% are small farmers. Recurring drought is common in the study area which suffered a severe drought in the year 2015 (Roy & Hazra, 2020). In response to the water scant condition, indigenous water conservation and scientific agricultural practices were popularized and employed by a non-governmental organization (DRCSC) in the study area to reduce drought impact. In the area, traditional water conservation practices such as pond, dug well, and ditch or farm pond have commonly been observed.

Table 11.1 Distribution of sample household over the study villages

Block	Village	No. of sample household
Kashipur	Jagannathdi	4
	Lari	5
	Jamkiri	5
	Jibanpur	12
	Bodma	22
	Jorthol	5
	Kashidi	6
	Sunra	10
	Seja	5
	Lajhna	3
	Ranjandi	25
	Tilabani	4
	Bhatin	4
	Chaka	3
	Pabra Pahari	13
	Ichamara	4
	Lara	20
Chhatna	Saluni	7
	Besara	8
	Enari	14
	Kalipur	27
	Jhunka	22
	Hausibad	23
	Majhidi	3
	Kendua	12
	Penchasimul	17
	Shirpura	9
	Jirra Kelai	29
	Jai Nagar	14
	Dumur Kundi	11
	Benagoria	21
	Ghoshergan	32
	Kharbana	24
	Hans Pahari	15
	Dumdumi	14
	Shuara Bakra	8

11.3 Materials and Methods

11.3.1 Sampling Method and Data Collection

The present research applies a semi-structured questionnaire and focus group discussions for data collection. The household survey was conducted to collect primary

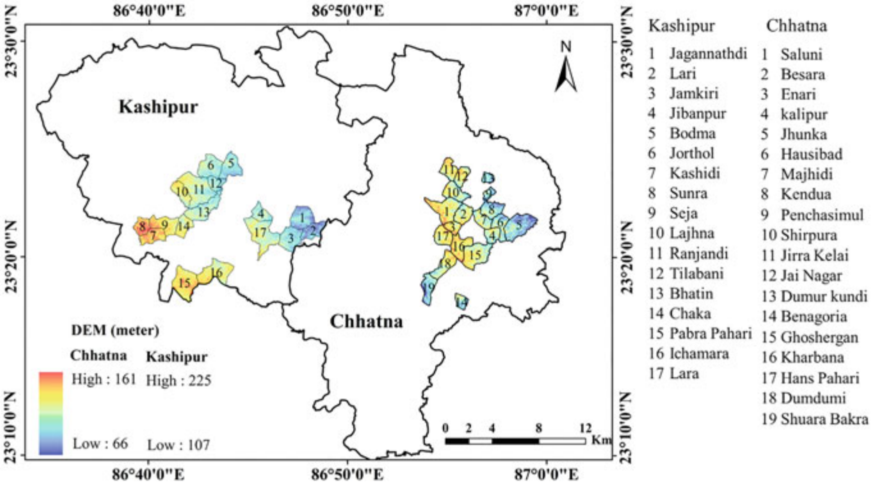

Fig. 11.1 Location of the study area

data on the socioeconomic profile of the 460 sample households (Table 11.1). The detailed information on their age, educational status, agricultural land holding, source of drinking water, major source of income, and access to banking facility, electricity, and sanitation were collected. The stratified random sampling technique was employed for selecting sample households in the villages. In each community development block, villages were recognized and selected based on the percentage of tribal population who are mostly small and marginal farmers. Furthermore, in each village, households who have water conservation structures such as pond, dug well, and ditch on their agricultural land (adopters) were chosen.

Sample size was computed by the equation (Cochran, 1977; Adjimoti & Kwadzo, 2018):

$$n = z^2 \times p(1 - p)/m^2$$

where n is the required sample size, z refers to the confidence level, p is the estimated extent of farmers in the area, and m denotes the margin of error.

In the present study, the confidence level of 95% with the standard value of 1.96 was used, and the margin of error (m) is 5% (Adjimoti & Kwadzo, 2018). The tribal small and marginal farmer households in the villages represent 54% ($p = 0.54$) of the total household in the villages. Therefore, $n = 3.8416*87.04 = 381$.

The sample size was increased by 20% to account for contingencies such as recording error or non-response. $382*1.20 = 459$.

11.3.2 Household Survey

A pre-tested questionnaire consisting of open-ended questions and multiple choices was used to collect data from the sample households with their prior consent. The issues addressed in the questionnaire contained basic socioeconomic characteristics, intensity of drought impact, types of indigenous water conservation structures, reasons for selecting and implementing the indigenous water conservation structures, and identified advantages of these indigenous water conservation structures on agricultural, income, livestock, and food security. The questionnaire has been used to collect data for both before (2015) and after (2021) the adaptation of the indigenous water conservation practices. The questioner has been attached as a supplementary material in the annexure.

11.3.3 Focus Group Discussions

The checklist-guided discussions with focus group members, both men and women, concentrated on the effects of drought on the past and present indigenous water conservation activities. Specifically, the effects of indigenous water conservation structures on reducing crop failure and improving crop yield, income, food, and water supply during dry spell were discussed. Additionally, discussions were held with the members of the implementing organization (DRCSC) and experts to triangulate the data collected using questionnaire and focus group discussions. Consequences of conversations with agricultural and natural resource specialists and focus group members helped to substantiate the individual interviews.

11.3.4 Data Analyses

The present study assesses the comparison of incremental changes on past and present adaptation and is extensively utilized for impact evaluation. The collected data were compared using percentages and average and by employing the one-way ANOVA using SPSS version 20. The present research studies the impacts of indigenous water conservation structures on agriculture, livestock ownership, and food supply by comparing changes on past and present adaptation for a period of 6 years, from 2015 to 2021. To determine the impacts on agriculture, it assesses changes in cropping intensification and crop yield (Malik et al., 2014). The study thus examines the impacts of indigenous water conservation structures on livestock by analyzing changes in the livestock ownership for 6 years (Kumar et al., 2016). Lastly, the impacts of indigenous water conservation structures on food security were analyzed by tracking the hunger days for 6 years (Tesfamariam et al., 2018).

11.4 Results and Discussion

11.4.1 Socioeconomic Attributes

Rainfed agriculture is the main livelihood of the villages, as above 77% of the total working people employed as cultivators or as agricultural laborers. Most of the respondents belonged from indigenous (scheduled tribe) as well as scheduled caste backgrounds. A higher percentage of adopter of IWCs were heads of households within the age range between 20 and 50 years (Table 11.2). This indicates that mainly younger persons are engaged in construction and repairing of labor-intensive indigenous water conservation structures. The education level of the majority of respondents is low (upper primary to secondary). The respondents had a small farmland area which consisted of lands having higher slope (known as Baid and Kanali) (Table 11.2). This, on the one hand, can motivate respondents to build the indigenous water conservation structures on sloping land for improving or maintaining the productivity in a small area. On the other hand, since the IWC structures occupy cultivable areas, these are not easily adapted by farmers. Source of drinking water for the majority of respondents is tube well. A large proportion of respondents have electricity and banking facilities. In both administrative blocks, more than 85% of respondents perceived frequent moderate to severe drought and associate crop failure which was also confirmed by the focus group discussants. Therefore, indigenous water conservation practices are highly persuasive in the present drought-prone villages. Village-wise intervention of IWC structures from 2015 to 2021 has been shown in Table 11.3, Figs. 11.2, and 11.3.

Most of the respondents used their own labor for the construction of indigenous water conservation structures. In addition, availability of government and non-government support and advisory service might have contributed to the indigenous water conservation structures which helped to promote scientific agricultural practices like mixed cropping and multi-cropping, nutrition gardening, and animal husbandry and backyard fisheries with the help of the IWCs.

11.4.2 Perceived Benefits of Indigenous Water Conservation Structures

In both administrative blocks, the majority of respondents perceived lifesaving irrigation positively affected agriculture during the recent drought-like conditions (2019). The focus group discussants also agreed on the role of indigenous water conservation structures in reducing drought impact and improving crop yields.

Table 11.2 Principal socioeconomic profiles of the respondents in villages of Kashipur and Chhatna blocks

Household socioeconomic characteristics			Chhatna (%) $n = 310$	Kashipur (%) $n = 150$
Cast structure	Scheduled tribes (ST)		58	85
	Scheduled castes (SC)		14	7
	Other backward castes (OBC)		7	7
	General category (GEN)		21	1
Age composition	<18 years	M	16	15
		F	13	14
	19–35 years	M	16	18
		F	17	17
	35–59 years	M	15	14
		F	13	13
	>60 years	M	4	4
		F	6	5
Educational status (%)	Primary	M	9	7
		F	10	7
	Upper primary	M	18	20
		F	16	15
	Secondary	M	14	14
		F	9	13
	Higher secondary	M	9	10
		F	6	6
	Undergraduate	M	6	5
		F	2	4
Average land holding size (hectare)	Pediment (Tnar)		0.27	0.15
	Upper mid terrace (Baid)		0.35	0.29
	Lower mid terrace (Kanali)		0.28	0.20
	Lower terrace (Bohal)		0.22	0.11
Source of drinking water (%)	Tube well		68	86
	Dug well		5	14
	Tap water		27	1
Main source of lighting (%)	Electricity		92	94
	Kerosene		8	6
Number of households having latrine facility (%)			40	57
Total number of households availing banking services (%)			90	85

Table 11.3 Village-specific interventions of indigenous water conservation structures from 2015 to 2021

	Village	Ditch	Pond	Well
Kashipur	Jagannathdi	13	10	1
	Lari	6	3	
	Jamkiri	5	3	
	Jibanpur	14	5	
	Bodma	3	13	
	Jorthol	2	32	
	Kashidi	9	8	1
	Sunra	6	5	
	Seja	28	1	3
	Lajhna		4	
	Ranjandi	10	26	12
	Tilabani	1	8	
	Bhatin	9	18	
	Chaka	7	8	2
	Pabra Pahari	28	13	1
	Ichamara	1	12	
	Lara	6	8	
Chhatna	Saluni	12	6	2
	Besara	1	8	2
	Enari	2	2	
	Kalipur	6	2	2
	Jhunka	6	8	5
	Hausibad	5	2	4
	Majhidi	2	3	3
	Kendua	3	5	1
	Penchasimul	2	3	1
	Shirpura	8	8	
	Jirra Kelai	7	4	7
	Jai Nagar	8	6	2
	Dumur Kundi		1	
	Benagoria	1	14	
	Ghoshergan	20	4	9
	Kharbana	3	4	6
	Hans Pahari	14	7	6
	Dumdumi		3	
	Shuara Bakra	1		1

11.4.3 *Impact on Agriculture*

11.4.3.1 Crop Intensification

General agriculture practice in the study villages is of cultivating one crop in a year, during the monsoon (Kharif crop). After implementation of indigenous water

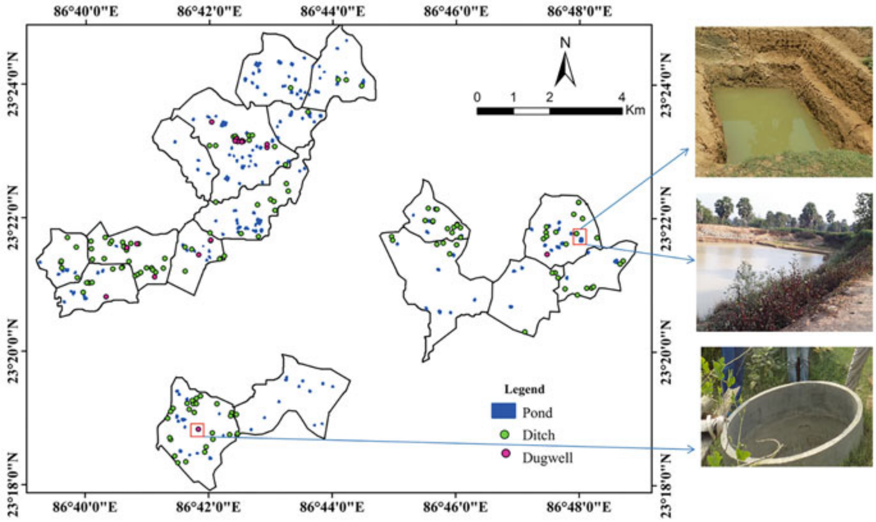

Fig. 11.2 Village-wise location of IWC structures in Kashipur

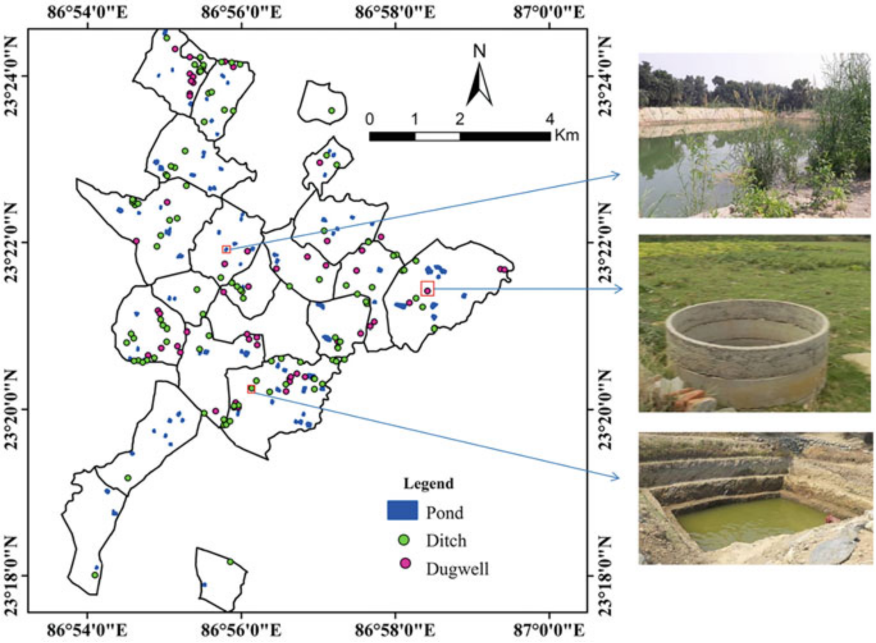

Fig. 11.3 Village-wise location of IWC structures in Chhatna

Table 11.4 Changes in double cropping practicing after IWC structure implementation

Kashipur	Percentage of people practicing double cropping		Chhatna	Percentage of people practicing double cropping	
	2015	2021		2015	2021
Jagannathdi	27	55	Saluni	0	63
Lari	25	55	Besara	3	63
Jamkiri	0	54	Enari	0	67
Jibanpur	13	55	Kalipur	3	63
Bodma	36	62	Jhunka	18	84
Jorthol	30	60	Hausibad	0	65
Kashidi	0	56	Majhidi	0	67
Sunra	0	50	Kendua	17	83
Seja	22	60	Penchasimul	13	82
Lajhna	16	60	Shirpura	1	66
Ranjandi	14	88	Jirra Kelai	1	80
Tilabani	26	50	Jai Nagar	0	80
Bhatin	0	60	Dumur Kundi	0	44
Chaka	0	60	Benagoria	10	65
Pabra Pahari	0	70	Ghoshergan	3	75
Ichamara	0	55	Kharbana	6	85
Lara	12	50	Hans Pahari	8	75
			Dumdumi	0	71
			Shuara Bakra	18	80

conservation structures, farmers cultivated two crops in a year, one during the monsoon (Kharif crop) and other during the winter (Rabi crop). Before adaptation, only 10–20% of the respondents in 10 villages (Table 11.4) practiced double cropping. But after adaptation, above 50% and 70% of the respondents in all villages of Kashipur and Chhatna, respectively, have been cultivating twice a year. About 67 % of surveyed households have access to at least one-time irrigation supply from indigenous water conservation structures during drought conditions. After indigenous water conservation structures were excavated, average cropping intensity has increased from 15% in 2015 to above 60% in 2021. The difference in the average cropping intensities, obtained between the before (2015) and after adaptation (2021), is statistically significant at 5% significance level (p-values are 0.00063 and 0.00025 for Kashipur and Chhatna, respectively). Indigenous water conservation structures have facilitated additional water availability for irrigation which has supported crop intensification.

Utilization of the supplementary water available through indigenous water conservation structures has increased the crop diversity. Responses to the survey reveal that a majority of the respondents cultivate multiple crops during the two crop cycles over a year. The average varieties of crops cultivated over agricultural land in two cropping seasons have also increased from two in 2015 to five in 2021. The findings were statistically significant at 5% significance level (p-values are 0.0163 and

0.00034 for Kashipur and Chhatna, respectively) (Table 11.7). After digging the water conservation structures, the sample households are cultivating around five varieties of crops on more than 5 ha of agricultural land. Currently, the majority of sample households cultivated two cropping seasons annually; the varieties like paddy and vegetables (okra, ridge gourd, etc.) are farmed in the Kharif (monsoon) season, while mustard, peanut, and lentils are grown in the Rabi (winter) season.

The considerable improvement in the cropping intensity and crop diversity cultivated were also found in several other studies on the various water conservation structures such as in India (Pani & Mishra, 2021; Deora & Nanore, 2019; Malik et al., 2014; Sur et al., 2001) and abroad, e.g., Ethiopia (Wolka et al., 2018) and Africa (Adjimoti & Kwadzo, 2018).

11.4.3.2 Increase in Crop Yield

An increased crop production is one of the indicators of the impact of water conservation structures (Bouma et al., 2016; Wolka et al., 2018). Therefore, the present study evaluates crop production across the before (2015) and after (2021) adaptation. Rice is the primary crop in this area. The average rice production has been increased from 1200 kg/ha to 1600 kg/ha within this time interval. The statistical analysis using one-way ANOVA, comparing crop yields after and before adaptation, indicates that the difference in average crop yields is statistically significant at 5% significance level with *p*-values 0.00023 and 0.0202 for Kashipur and Chhatna, respectively (Table 11.7).

Studies on various water conservation structures such as the farm ponds, 30 ft. X 40 ft. ditches along slope, nala bund, and check dam could also found increase in the crop yields (Wolka et al., 2018; Deora & Nanore, 2019). It was revealed from focus group discussions that the additional water availability in the wells and ditches has also facilitated micro-irrigation during drought conditions and reduction of crop failure (Kumar et al., 2016; Malik et al., 2014).

11.4.4 Increase in Livestock Ownership

After IWC implementation, the number of sample households having livestock has increased from 52 to 75% (Table 11.5). The respondents have also reported that the variety of livestock like cow, pig, sheep, goat, chicken, and duck has increased. Animal husbandry not only improved the income for the households but also secured their nutrition intake at no additional expense and contributed to drought risk reduction during monthly or seasonal droughts. The difference between the percentage of livestock ownership households before and after adaptation is statistically significant at 5% significance level ($p = 0.003$ and 0.00014) (Table 11.7). Sample households stated that the rice has been primarily used as a livestock feed by a considerable portion, and the analysis on crop production revealed that after

Table 11.5 Changes in crop variation, income, production, and livestock ownership after IWC structure implementation

Village	Change (%)				
Kashipur	No. of crop varieties	Livestock ownership	Poultry	Agricultural production	Income
Jagannathdi	8	33	4	6	30
Lari	3	40	4	16	23
Jamkiri	40	25	13	17	8
Jibanpur	5	98	15	8	40
Bodma	25	21	8	22	25
Jorthol	7	31	60	25	18
Kashidi	40	4	4	35	28
Sunra	20	6	58	23	70
Seja	15	78	60	19	95
Lajhna	5	3	19	57	46
Ranjandi	5	85	19	70	92
Tilabani	5	70	37	15	23
Bhatin	40	51	57	18	11
Chaka	20	10	8	24	57
Pabra Pahari	50	95	52	57	85
Ichamara	40	96	72	27	44
Lara	10	95	80	11	55
Chhatna	No. of crop varieties	Livestock ownership	Poultry	Agricultural production	Income
Saluni	40	96	71	41	46
Besara	3	91	85	17	17
Enari	50	75	63	87	84
Kalipur	10	89	72	24	26
Jhunka	25	14	2	11	16
Hausibad	50	39	40	26	14
Majhidi	30	49	33	19	19
Kendua	12	4	25	25	35
Penchasimul	25	6	17	35	29
Shirpura	10	80	79	31	25
Jirra Kelai	10	69	79	12	26
Jai Nagar	50	63	75	28	25
Dumur Kundi	20	90	89	36	18
Benagoria	13	25	78	2	28
Ghoshergan	7	43	27	31	40
Kharbana	2	83	46	12	18
Hans Pahari	10	49	33	46	35
Dumdumi	50	50	81	39	21
Shuara Bakra	24	57	17	25	12

adaptation, rice production has increased significantly. Therefore, the availability of livestock feed has been raised. The IWC subtly associates with the drinking water availability for the livestock. IWCs have been advantageous to ensure feed and water availability for livestock. Similar findings were reported in the earlier studies (Deora & Nanore, 2019; Renganayaki & Elango, 2013; Sur et al., 2001).

11.4.5 Introduce Nutrition Gardening and Increase in Indigenous Crop Cultivation

Water conservation structures have been found to be helpful in introducing nutrition gardening and enhancing indigenous crop cultivation. The introduction of nutrition gardens, where a variety of vegetables, leafy vegetables, and fruits are being grown for household consumption, has helped to ensure food and nutrition security for 83% of beneficiaries in 2021 (Table 11.6). The revival of indigenous crops like okra, wild potato, and pigeon pea has helped to secure household subsistence during adverse climatic conditions and achieve nutritional security.

11.4.6 Increase in Food Security

After adaptation, crop yield has been increased, and the nutrition garden provided vegetable supply throughout the year. Consequently, the number of hunger days has decreased. The average number of hunger days has decreased around 68% and 71% respondents in Kashipur and Chhatna, respectively (Table 11.6). They attributed their enhanced food security to a range of initiatives which yielded interlinked benefits for them. The introduction of improved water supply at the appropriate levels using dug wells and ditches and promotion of double or triple cropping with improved water supply for micro-irrigation, indigenous crop revival, nutrition gardening, and fishing significantly have improved food and nutrition security of the beneficiaries and reduced the need to purchase food for daily consumption. The previous studies on the farm ponds also find a similar increase in food security (Adjimoti & Kwadzo, 2018). These studies have shown that crop intensification, crop diversification, indigenous crop cultivation, and nutrition gardening have a positive effect on households' food security status.

11.4.7 Increased Income and Livelihood Diversification

Water conservation structures have been supportive to increased income and livelihood diversification in the study area. The increase in income is one of the most

Table 11.6 Percentage of respondents involved in nutrition gardening and fishing and who experienced food security after adaptation

		% of people who experienced reduction of hunger days (by 2–3 months)	% of people having backyard fishery	% of people having nutrition garden
Kashipur	Jagannathdi	85	60	85
	Lari	84	60	80
	Jamkiri	89	75	80
	Jibanpur	81	66	83
	Bodma	86	52	60
	Jorthol	75	20	80
	Kashidi	76	25	83
	Sunra	79	80	98
	Seja	82	75	85
	Lajhna	72	80	95
	Ranjandi	74	72	92
	Tilabani	76	75	75
	Bhatin	69	75	75
	Chaka	83	65	98
	Pabra Pahari	82	76	98
	Ichamara	83	77	85
	Lara	86	80	70
Chhatna	Saluni	72	65	87
	Besara	65	65	87
	Enari	68	0	78
	Kalipur	75	35	71
	Jhunka	78	75	81
	Hausibad	69	65	86
	Majhidi	67	35	67
	Kendua	71	83	75
	Penchasimul	73	58	94
	Shirpura	73	55	77
	Jirra Kelai	71	50	95
	Jai Nagar	72	50	95
	Dumur Kundi	75	0	80
	Benagoria	69	0	80
	Ghoshergan	70	55	95
	Kharbana	69	65	79
	Hans Pahari	71	60	93
	Dumdumi	73	42	85
	Shuara Bakra	68	60	85

frequently recorded indicators of the impact of water conservation structures (Bouma et al., 2016). Therefore, this analysis compared the income before and after adaptation. Diversification of livelihoods, utilizing the additional water available through water conservation structures, has been found to result in a definite increase in the net agricultural, livestock, and nutrition garden returns. The average annual income from agriculture has increased from 15,000 INR to 20,000 INR in Kashipur and from 17,000 INR to 24,000 INR in Chhatna. The difference in the average annual income from agriculture, obtained after adaptation, is statistically significant at 5% significance level ($p = 0.02$) (Table 11.7). Responses to the questionnaire indicate that the majority of respondent households cultivate multiple crops during the two crop cycles over a year and the crop yield has increased. Consequently, income from agriculture has enhanced. The construction of community ponds and ditches enabled the beneficiaries to practice group-based aquaculture, while increasing the depth of existing ponds caused improved returns from fishing. After adaptation, around 50% and 65% sample households have started practicing fishing in Kashipur and Chhatna, respectively (Table 11.6). Rearing livestock like hen, duck, fowl, sheep, goat, pig, and cow supplied milk, eggs, and meat for household consumption and sale, supplementing income and nutrition during periods of drought and water stress. A variety of vegetables like green and red spinach, grown in the nutrition garden, and the revival of old crops like lady's finger and wild potato have promoted the consumption of a wider variety of nutrients and reduced expenditure during dry spell. Accordingly, after adaptation, fishing, nutrition gardens, and animal husbandry have produced interlinked advantages for the respondents and emerged as potential livelihood options. Similar results have been found in other studies in different regions like Purulia (Roy et al., 2022), Maharashtra (Deora & Nanore, 2019), Karnataka (Kumar et al., 2021), Zimbabwe (Nyagumbo et al., 2019), and Africa (Lasage & Verburg, 2015). These studies have concluded that IWC structures have resulted in significant increase in income, crop intensity, livestock, and livelihood which have been able to cope with drought (Malik et al., 2014; Sur et al., 2001).

11.5 Conclusions

Various indigenous water conservation structures such as ponds, dug wells, and ditches were adopted for drought along with scientific farming practices. Benefits of reviving indigenous water conservation practices for drought resilience were analyzed based on primary data acquired by the household survey. Farmers were selecting and implementing IWC structures depending on the local land characteristics. Ditches and dug wells were widely implemented in the blocks because they required a small area and were cost-effective. In both administrative blocks, the respondents perceived fundamental benefits of these IWC structures including lifesaving irrigation during drought conditions and reduced crop failure. In this regard, the IWC structures were recognized to positively contribute to agricultural

Table 11.7 Results of the ANOVA

Kashipur $n = 150$	Average		Variance		*F*	*p*-value	F crit
	Before	After	Before	After			
Crop intensification	20.06	58.82	388.43	82.28	62.78	0.00063	4.49
No. of crops	2.29	5.18	1.72	1.53	87.71	0.01637	4.49
Livestock ownership	52.82	75.82	306.53	56.28	31.71	0.00375	4.49
Poultry	62.29	80.76	121.85	46.57	32.79	0.00312	4.49
Production	1559.6	1910.55	373,355.69	397,016.65	72.45	0.00023	4.49
Income	17,508.72	24,202	65,793,700.79	66,051,135.75	73.29	0.00024	4.49
Chhatna $n = 310$							
Crop intensification	5.32	71.47	44.34	108.37	44.55	0.00025	4.11
No. of crops	2.53	5.58	2.49	1.15	48.75	0.00034	4.11
Livestock ownership	40.37	80.89	76.36	97.10	79.90	0.00014	4.11
Poultry	36.74	74.58	56.43	235.92	93.07	0.00016	4.11
Production	1247.05	1558.74	157,026.50	155,625.03	5.90	0.020223	4.11
Income	15,740.37	19,771.07	15,111,948.15	17,454,204.16	9.48	0.003964	4.11

Significantly different at $p < 0.05$, degree of freedom is 16 for Kashipur and 36 for Chhatna production, income, food security, and livelihood. IWC structures have ensured micro-irrigation and supported farmers in increasing their agricultural cropping intensity, crop diversity, and crop production for the majority of crops. Livestock rearing has also obtained a raise after IWS structure excavation, through increase in ownership and additional feed and water availability for livestock. The benefits of these interventions were reflected in income enhancement, food security, more nutrition intake, livelihood diversification, reduction in hunger days, and improved purchasing power. For the implementation of IWC structures, less requirement of land acquisition makes it more useful for small and marginal farmers. It has been concluded that IWC structures have the potential to intensify agriculture and provide food security and livelihood options in the drought-prone villages of the RLZ. Hence, these can be an effective strategy for drought adaptation. The present study provides insights for decision-makers by highlighting the impacts of a low-cost small water conservation structure in drought-prone undulating terrains. These practices can further be replicated in the drought-prone areas of India and the world to facilitate potential solutions of water shortages in the smallholder farming.

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Sabita Roy is a Ph.D. scholar at School of Oceanographic Studies, Jadavpur University. Her research interest is the application of remote sensing and GIS, spatial statistics, and geospatial analysis in land use, drought assessment, sustainable agriculture and water resource management.

Rahi Soren is an Assistant Professor at School of Oceanographic Studies, Jadavpur University, Kolkata. She is interested in understanding the effective use of scientific information for conserving culture, habitat and biodiversity in the face of the growing threats of extinction.

Sugata Hazra is a geologist and professor at Jadavpur University, India. He has extensively researched the impacts of climate change in India's major ecological hotspots, and is the scientific advisor in the Adaptation Fund Board project in Purulia-Bankura.