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# Final Evaluation of the Project on Decentralized Supply and Water Use Management in the Sana'a Basin to Sustain Water Resources and Rural Livelihoods

December 2018



**PROJECT EVALUATION SERIES**

**Final Evaluation of the Project on  
Decentralized Supply and Water Use  
Management in the Sana'a Basin to  
Sustain Water Resources and Rural  
Livelihoods**

**GCP/YEM/036/NET**

**FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS  
OFFICE OF EVALUATION  
December 2018**

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The evaluation was led by Steven Watkins and supported by Abdullah Saleh Ahmad Saif, National Evaluation Consultant. The evaluation was managed by Serdar Bayryyev from the FAO Office of Evaluation.

## Acronyms and abbreviations

CTA	Chief Technical Advisor
FAO	Food and Agriculture Organization of the United Nations
FAORNE	FAO Regional Office for North-East and North Africa
FAOYE	FAO Country Office, Yemen
FFS	Farmer Field School
GDP	Gross Domestic Product
GIS	Geographic Information System
HIV/AIDS	Human immuno deficiency virus /acquired immune deficiency syndrome
IWRM	Integrated Water Resources Management
JICA	Japan International Cooperation Agency
LOA	Letter of Agreement
M&E	Monitoring and Evaluation
MAI	Ministry of Agriculture and Irrigation
MSAL	Ministry of Social Affairs and Labour
MWE	Ministry of Water and Environment
NIP	National Irrigation Programme
NHRRS	Northern Highlands Regional Research Station
NWRA	National Water Resources Authority
NGO	Non-Government Organisation
OED	FAO Office of Evaluation
PCC	Project Coordination Committee
PMS	Participatory Monitoring System
SBP	Sana'a Basin Project
SO2	FAO's Strategic Objective 2
UNHCR	United Nations High Commissioner for Refugees
US\$	United States Dollar = 250 Yemeni Rial
VCA	Value Chain Analysis
WEC	Water and Environment Centre
WUA	Water User Association
WUG	Water User Group



## Executive summary

### Introduction

- 1 This is the Final Evaluation of the Project on Decentralized Supply and Water Use Management in the Sana'a Basin to Sustain Water Resources and Rural Livelihoods (GCP/YEM/036/NET also known as the Sana'a Basin Project: SBP). The project was originally scheduled as a three-year project, with funding of USD 4.83 million and received a one and half year no-cost extension (July 2014–December 2018). The project was funded by the Government of the Netherlands and implemented by the Food and Agriculture Organization of the United Nations (FAO - Yemen) in collaboration with the Ministry of Water and the Environment and the Ministry of Agriculture and Irrigation. It was designed to establish sustainable management of local water resources and improve rural livelihoods through integrated water resources management (IWRM), improving cropping systems, raising the productivity per unit area and improving the income of farmers in the basin area.
- 2 The main purpose of the evaluation was to provide accountability to the donor and partners by assessing FAO's contribution to the objective of the project, i.e. sustainable crop production systems based on reduced groundwater extraction in the Sana'a basin to help increase food security. The evaluation proposed lessons from implementation processes that could inform future decisions by the Governments of Yemen and the Netherlands, and FAO regarding formulation of projects or follow-up interventions.
- 3 The evaluation was limited by a lack of project monitoring data collected regularly during the project. This was particularly noticeable concerning data and information on the extent of adoption of climate-smart crop varieties, the extent that farmers reverted back to rainfed farming (and thus, these interventions' contribution to reduced groundwater abstraction), and the overall project impact on livelihoods. Security in Yemen was an impediment and the mission was unable to visit Yemen, and so, was dependent on the national consultant for collection of primary data from beneficiaries. In addition to primary data collection conducted by the national consultant, representatives from the three project implementing partners and the Chief Technical Adviser discussed project results with the evaluation team at the FAO Regional Office in Cairo.

### Main findings

#### **EQ.1. Is this project relevant in meeting the needs of the beneficiaries and does it contribute to implementation of the national development strategy, and fulfilment of the objectives of the FAO country programme?**

- 4 By promoting modern irrigation systems and improved, climate-smart cropping practices SBP remained relevant to the many farmers seeking alternatives to their current cropping systems based on accessing increasingly expensive groundwater. SBP established water user associations (WUA) and progressed the Government's policy for creation of an IWRM governance structure as a means to decentralize water regulation and support local development. The project was relevant to FAO's country programme and the objectives of the Government of the Netherlands in Yemen aimed at sustainable groundwater usage and resilient livelihoods. SBP

contributed to FAO's Strategic Objective 2 through productivity enhancement, sustainable food systems, investment in rural infrastructure; empowerment of women; improved water efficiency and sustainable use of natural resources. The project also supported the FAO-managed Regional Initiative on Water Scarcity in Near East and North Africa.

**EQ.2. What were the intended and unintended results achieved by the concluded project? To what extent did the project achieve its intended results?**

- 5 SBP achieved most of its intended results and provided an effective model for developing community-level regulation of groundwater abstraction and livelihood development. The project met its objectives by focusing on the cultivation of crops that were more appropriate to the evolving environmental and climatic conditions in the Sana'a basin and promoted the adoption of modern irrigation systems.

**EQ.3. What factors contributed to achieving or not achieving intended outcomes?**

- 6 The competence and determination of the project team to operate in a difficult, often unstable and insecure working environment was the main factor that contributed to SBP's achievements. Collaboration between implementing partners was effective in producing complementarities, and integrated workplans across ministries also assisted achievement of results. The outbreak of war created implementation gaps and uncertainty about project funding. During this period, the team built the capacities of 38 water user associations (WUA) which laid a basis for building the sub-basin governance structure based on integrated water resource management (IWRM) principles.

**EQ.4. Are the project's results sustainable beyond project conclusion?**

- 7 Sustainability was integrated throughout the project's design and implementation, based on building the capacity of farmers to new irrigation and farming practices, and creation of active WUAs to be important players in the IWRM governance structure for the project sub-basins. SBP also supported WUAs to provide services to their members such as input supply, marketing and processing farmer produce. Sustainability of WUAs will depend on the services they can deliver to their members and the willingness of farmers to pay for these services. This will also be a factor in the sustainability of results.

**Conclusions**

- 8 **Conclusion 1. (EQ.1)** Through participative processes, the project supported beneficiaries to establish active WUAs that were integral to the government's policy to decentralise groundwater regulation and progress towards creation of the IWRM governance structure in each sub-basin. SBP expended substantial time and resources in raising awareness among communities in project sub-basins of impending problems on groundwater management, and proposed activities to assist farmers ameliorate these issues. The IWRM governance structure devolves authority to local organisations to regulate water usage and formulate their longer term development plans.
- 9 **Conclusion 2. (EQ.2)** Adaptation of modern irrigation systems, protected agriculture production, introduction of crop varieties more tolerant of low water regimes, and support to farmers to switch to alternative cash crops helped SBP deliver its objective of improving farmer productivity, incomes and resilience whilst reducing groundwater abstraction. The development of the IWRM governance structure and 10 year IWRM action plans for each

WUA helped increase institutional and individual capacities. Women were integrated into governance structures and decision-making processes.

- 10 **Conclusion 3. (EQ.3)** A competent project team that worked collaboratively and flexibly in a difficult operational environment was the main factor contributing to effective project outcomes. The collaborative effort between two ministries helped deliver project results as they needed to work adeptly to keep SBP on schedule as much as possible following the outbreak of war, which caused disruptions to funding and workplans. The project team was flexible in adapting to these disruptions and alterations to the project design (e.g. the decision to drop the pilot waste water treatment unit and support farmers to access water in shallow wells with solar pumps).
- 11 **Conclusion 4. (EQ.4)** The IWRM action plan provides a 10-year development strategy with WUAs integral to implementation of the plan. These WUAs need to be sustainable by providing valued services to their members in order to collect subscriptions and generate income from other sources such as their project-supplied greenhouses. Sustainability was integrated throughout the project's design and implementation, based on building the capacity of farmers to adopt new irrigation and farming practices. Reducing groundwater abstraction can only be achieved through adoption of a longer term holistic strategy involving all stakeholders in the Sana'a basin in all sectors (social, environment, economic).

## **Recommendations**

### **Recommendation 1. (To FAO, donors and project designers).**

**To ensure continued progress and positive outcomes in applying integrated approaches to water resources management in Yemen, government and external support agencies should implement an integrated approach in the entire Sana'a basin.**

- 12 Given the increasing challenges and risks in the Sana'a basin, it is important that the international community supports Yemen to implement integrated and participatory basin management that focuses on solutions to address water supply priorities and needs throughout the basin. Institutional reforms started by SBP aimed at increasing joint decision-making, facilitating management at the sub-basin level and to legitimise stakeholder structures at community level through stakeholder participation. IWRM governance remains an on-going process. Raising revenues for water resources management from users remains challenging to creating sustainable community-level structures. Future basin-level projects should prioritise infrastructure development, legislation and financing for water resources management.

### **Recommendation 2. (To FAO, government partners and project designers).**

**Project funds to support research, development and promotion of new climate smart crop varieties to farmers should be informed by analysis and focused on several varieties likely to provide the greatest impact toward desired results.**

- 13 Project funds have to be focused and allocated to those interventions likely to provide the greatest impact to beneficiaries. Investment decisions on the development and promotion of new crop varieties need to be informed by prior analysis of a narrow range of new cash crops or improved varieties of existing crops that also target market opportunities for farmers to grow these new crops to increase their profitability.

**Recommendation 3. (To FAO, donors and designers of water efficiency projects). Groundwater abstraction projects need to be designed with longer duration and include effective monitoring and evaluation frameworks from project commencement to enable regular monitoring of performance and to inform timely project adjustments.**

- 14 Groundwater depletion projects need to be more than three years duration. The project duration was too short to demonstrate potential benefits and accurately reflect the impact of the project on production and productivity of beneficiaries. Attention at project commencement needs to ensure all project units are in-place so that projects can be implemented as planned. In view of the inherent complexities of groundwater projects in Yemen, rigorous monitoring and evaluation practices are essential in order to obtain data of potential problems, and implement remedial activities in order to maximise achievement of intended results.

**Recommendation 4. (To FAO as the implementing partner and designers of irrigation rehabilitation projects).**

**GIS should be necessary to support evidence-based decision-making, more accurate monitoring and assessment of project progress and results.**

- 15 There are methodological problems in developing cost-effective and reliable approaches that can effectively monitor progress with the resources and expertise available. GIS would assist in overcoming these problems and help establish baselines, monitor project progress, identify limitations, assist with work planning, and increase the irrigation potential of rehabilitated systems.

**Recommendation 5. (To project designers, implementing partners and FAO). While there is inherent tension between the urgency of delivering results to satisfy community needs and allowing sufficient time for members to gather and cooperate effectively, the latter should be prioritised early in project implementation as a basis to identify priorities and address local problems.**

- 16 SBP demonstrated the effective results when sufficient resources and long periods were expended on beneficiary consultation and participatory planning that improved information flows and increased local participation in WUAs. This shift from top-down to a more bottom-up approach, provided a basis for formulating action plans. This participatory approach to groundwater resources appraisal, planning and management was endorsed by all stakeholders through the creation of organisations, such as WUAs and sub-basin water management committees, and meant that further groundwater development can be more inclusive and marginal groups included in decision making.

**Recommendation 6. (To donors, FAO and project designers). Changing weather patterns are increasing vulnerability in rural livelihoods and therefore, mitigation and adaptation interventions need to be prioritised in groundwater and livelihood projects**

- 17 Climate change is an additional influence on sustainable groundwater management that adds to other pressures, such as land use changes, population growth, over-abstraction, and groundwater pollution. Greater use of artificial recharge methods to increase water flow into aquifers is necessary. Therefore,

international support for climate change adaptation programs should focus on capacity strengthening in groundwater management, planning, and conceptualisation of adaptation programs. Building effective institutions, with the legal and regulatory framework, organisation and stakeholder engagement mechanisms are at the core of groundwater governance.

## **1 Introduction**

1. This is the Final Evaluation of the Project on Decentralized Supply and Water Use Management in the Sana'a Basin to Sustain Water Resources and Rural Livelihoods (GCP/YEM/036/NET). This evaluation was included in the project design document, according to agreed arrangements between the donor (the Government of the Netherlands), the Government of Yemen and the Food and Agriculture Organization of the United Nations (FAO). GCP/YEM/036/NET was originally scheduled as a three-year project, with funding of USD 4.83 million and received a one and half year no-cost extension (July 2014–December 2018). The project was implemented by FAO in collaboration with the Ministry of Water and the Environment and the Ministry of Agriculture and Irrigation. It was designed to establish sustainable management of local water resources and improve rural livelihoods through integrated water resources management (IWRM), improving cropping systems, raising the productivity per unit area and improving the income of farmers in the basin area.

### **1.1 Purpose the Evaluation**

2. The main purpose of the evaluation was to provide accountability to the donor and partners by assessing FAO's contribution to the overall objective of the project, i.e. sustainable crop production systems based on reduced groundwater extraction in the Sana'a basin that helps increase food security. The evaluation also proposed lessons from the implementation processes that could inform future decisions by the Governments of Yemen and the Netherlands, and FAO regarding formulation of projects or follow-up interventions.

#### **1.1.1 Intended users**

3. The primary users of this evaluation are the Governments of Yemen and the Netherlands, and FAO. These intended users may be interested to know whether the project was still relevant, how effective the institutional mechanisms were in delivering intended or unintended results, what impact the projects delivered to beneficiaries (farming households and government partners) and whether the results were sustainable beyond the conclusion of the project. Lessons learned and recommendations proposed in this evaluation may be used by other project teams as a basis for strategic planning and implementation for similar projects in Yemen and other countries in the region.

### **1.2 Scope and Objective of the Evaluation**

4. The Final Evaluation reviewed an irrigation and cropping project implemented by FAO in Yemen: GCP/YEM/036/NET – The Project on Decentralized Supply and Water Use Management in the Sana'a Basin to Sustain Water Resources and Rural (or Sana'a Basin Project - SBP). This evaluation assessed achievements of the project at district- and farm-levels. Assessments against other irrigation and livelihood projects in Yemen funded by other donors were also included within the scope of the evaluation.

5. The main objective of this independent evaluation was to learn about results achieved through FAO's ongoing support to livelihoods in Yemen including results achieved in capacity development, management of water resources and agricultural productivity addressing government partner agencies, water user associations (WUA) and beneficiary farming households. The evaluation also considered SBP's contributions towards FAO's Strategic Objective 2 (Increase and improve provision of goods and services from agriculture, forestry and fisheries in a sustainable manner).
6. The evaluation deduced conclusions, and provided recommendations and lessons learned on performance and good practices based on evidence and the findings of the evaluation, which would be suitable for replication or up-scaling in future projects.
7. In order to achieve these objectives, the evaluation addressed the following key questions (full list of evaluation questions and sub-questions is included in the TOR annexed to this report):
  - i. **Relevance:** Is this project relevant in meeting the needs of the beneficiaries and to what extent does it contribute to implementation of the Government's national development strategy, and fulfilment of the objectives of the FAO country programme?
  - ii. **Impact:** What were the intended and unintended results achieved by the project? To what extent did the project achieve its intended results?
  - iii. **Effectiveness:** What factors contributed to achieving or not achieving intended outcomes?
  - iv. **Sustainability:** Are the project's results sustainable beyond project conclusion?

### 1.3 Methodology

8. The Final Evaluation was conducted from May to July 2018. The evaluation implemented a transparent and consultative approach with stakeholders during the evaluation. The final evaluation process followed the principles outlined in the United Nations Evaluation Group's *Norms for Evaluations in the UN System*, and aligned with the Office of Evaluation's (OED's) Manual on evaluation guidelines and practices.
9. A preliminary review was conducted of relevant background documentation that included but was not limited to project documents, progress reports, evaluations of other livelihood projects in Yemen, photographs (before and after project interventions), baseline survey and beneficiary impact assessments. The team also researched secondary data for Yemen such as agricultural statistics, national development policies, FAO sectoral evaluations, industry reports and studies.
10. Findings on alignment, including consistency with FAO's Plan of Action (2018-2020) and FAO Strategic Objectives were mostly based on review of background

documentation as well as interviews with FAO staff from the Country Office (FNYE) and the Regional Office for the Near East (FAORNE).

11. To assess the contribution of the project towards its expected outcomes and impact, the national consultant collected primary data during field visits through discussions, open and semi-structured interviews with in-country stakeholders and beneficiaries in the four project subregions of the Sana'a basin. The information collected during these interviews was used to validate and triangulate results detailed in annual progress reports, case studies and other surveys provided by the SBP team. The consultant further verified this data, where possible, with walk-through observations during field visits to project areas that were inaccessible to the evaluation team.

#### **1.4 Limitations**

12. The evaluation was limited by a lack of project monitoring data collected regularly during the project and evidence to support many of the project results. This was particularly noticeable concerning data and information on the extent of adoption of climate-smart crop varieties, the extent that farmers reverted back to rainfed farming (and thus, these interventions' contribution to reduced groundwater abstraction), and the overall project impact on livelihoods. The team also did not monitor the effectiveness of changes made to the original project design, such as the decision to drop the pilot waste water treatment unit and use these funds to support farmers to utilize water from shallow wells with solar pumps instead.
13. Security in Yemen remains a serious impediment to the delivery of development assistance and implementation of livelihood support projects. The evaluation team was unable to visit Yemen and therefore was dependent on the fieldwork conducted by the national consultant for the collection of primary data from project beneficiaries. Representatives from the three project implementing partners and the Chief Technical Adviser travelled to the Regional FAO Office in Cairo to conduct discussions and interviews with the evaluation team.

#### **1.5 Structure of the report**

14. Following this introduction, Chapter 2 presents the background and context of the project; Chapter 3 presents the evaluation questions and key findings; lessons learned are presented in Chapter 4 while conclusions and recommendations in Chapter 5.



## 2 Background and context of the Project

### 2.1 Context of the Project

15. The Sana'a Basin, located in the Central Highlands of Yemen, includes Sana'a City, the capital city of Yemen. The basin ranges in elevation from 2 000 to 2 200 metres above sea level and experiences localized rainfall with intense precipitation events of relatively short duration that supplies runoff into wadis (valleys) and recharge of underground aquifers. The Decentralized Supply and Water Use Management in the Sana'a Basin to Sustain Water Resources and Rural Livelihoods project (GCP/YEM/036/NET) aimed to enhance food security among farming households and reduce groundwater depletion in four sub-basins of the 22 sub-basins of the Sana'a basin (Sana'a City is located in Bani Huwat sub-basin).

**Table 1:** Details of project sub-basins

<b>Sub-basin (number)</b>	<b>Bani Huwat 9</b>	<b>Zahr Al Ghayl 14</b>	<b>Hamdan 15</b>	<b>Ghayman 19</b>	<b>Sana'a basin</b>
Population	1 161 546	76 512	57 953	18 779	2 247 483
Rural	15 389	41 288	7 727	18 779	309 653
Area (ha)	32 703	36 083	6 350	14 334	323 976
- Non-Arable	25 164	29 372	5 378	12 954	
- Rainfed	2 423	5 247	657	801	
- Irrigated	5 247	1 453	906	578	18 953
Qat (ha)	1 747	1 110	717	288	11 466
Grapes (ha)	2 133	0	0	244	5 818

16. Rain-fed crops such as maize, wheat, barley and some leguminous crops are cultivated on arable lands in all sub-basins. Irrigated crops vary across each sub-basin. For example, cactus dominates sub-basin 19, grapes and Qat sub-basins 9 and 15, and almonds dominate sub-basin 14. Non-arable land is used for livestock production and water harvesting. In average wet years, farmers grow grains, legumes and fodder as priority crops, and after the rain ceases but the soil is still moist, farmers grow maize as a fodder crop. Vegetables are irrigated due to the high returns and short growing season. In dry years, farmers grow smaller areas of cereals.
17. In sub-basins 9 and 14, an estimated 40 percent of the arable area has potential for improved irrigation systems. Sub-basin 15 is dominated by Qat and farmers would need convincing to switch to alternative cash crops that use less water - modern irrigation systems will not be effective as these old Qat trees are well-established with extensive root systems. However, there are possibilities of introducing different irrigation techniques such as alternative tree watering. Sub-basin 19 is dominated by rain-fed agriculture, with some irrigation of grapes and Qat cultivated in terraces. The potential for improved irrigation systems is restricted due to cost and the limited number of farms that could adopt such improvements due to lengthy conveyance distances. However, greenhouses could be effective in reducing water requirements for irrigation and increased productivity.
18. SBP was implemented by FAO in Yemen with MWE and MAI as the government counterpart agencies, and funded by the Government of the Netherlands. It built

on the results and lessons learned from earlier rural development projects in Yemen.<sup>1</sup> The components of SBP and expected results were:

**Component 1.** Raised awareness among farmers of water scarcity and their preparedness to adopt sustainable groundwater development. Farmers in the four project sub-basins were mobilized into WUA and informed on actions to reduce groundwater depletion to zero levels; WUAs, in cooperation with water management committees in each project sub-basin, helped guide farmers through the SBP-supported processes of change in their farming systems.

**Component 2.** Water efficient and climate-smart crop production systems based on IWRM principles.<sup>2</sup> Existing cropping systems were reviewed and higher value crops suitable for project areas were analysed; demonstration plots for improved crop and horticultural production were established and utilized for training following a Farmer Field School (FFS) approach; each WUA developed a ten-year water resources management plan that was integrated into four sub-basin water management plans; water infrastructure was improved and government agencies regulated water extraction more rigorously; and wastewater from the Sana'a city treatment plant was re-treated to higher standards in order to be safely used for crop irrigation.

**Component 3.** Create an enabling environment for sustainable development. Government agencies and the private sector were supported to provide better services (e.g. extension, marketing, irrigation, credit) to farmers; four sub-basin water management committees were created; and the Sana'a basin Committee negotiated financial support for farmers from urban water users.

19. The primary target group were farmers in the four project sub-basins who were supported by the project to adopt improved irrigation and farming systems, and farmers using groundwater recharged by rehabilitation of the dams, construction of spate breaks and check dams. Farmers outside the project areas who used these water savings from the aquifers were indirect beneficiaries of the project. Another major beneficiary of the water savings in the basin was the citizens of Sana'a City who received some respite from future scarcity of drinking water.
20. The Government of Yemen requested external support from FAO and the Government of the Netherlands because of weak regulation of groundwater extraction and the Government's desire to decentralize this task. However, the empowerment of WUA to regulate groundwater usage among farmers has proven difficult in previous development assistance projects, as noted in the implementation completion report (2010) of the World Bank-funded Sana'a Basin Water Management Project:

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<sup>1</sup> Projects included: the World Bank-funded: Sana'a Basin Water Management Project (2004-2009, US\$24 million); the Groundwater and Soil Conservation Project (2005-2011, US\$55 million); and the Water Sector Support Project (2009-2016, US\$90 million); and the IFAD-funded Dhamar Participatory Rural Development Project (2004-2012, US\$24 million).

<sup>2</sup> IWRM targets an entire river valley or sub-basin for interventions aimed at maximising water use efficiency for all basin water consumers. It tackles complex water-management problems through a fully integrated approach (social, economic, institutional, political and technical) with a focus on engaging the different and sometimes contradictory interests of all stakeholders.

*Design relied on an essentially top-down approach to community water management, with WUAs promoting compliance with regulations prohibiting counter-productive practices such as illegal well drilling. This did not succeed. More community-based governance, backed by technical assistance and an adequate legal framework, may have been more successful, but was not considered [by the project management unit].*

21. Lack of knowledge of project communities on some issues can lead to unrealistic suggestions that may create conflicts and other problems in the future. Therefore, it was important for the SBP team to involve stakeholders from project commencement in problem assessment and identify possible solutions. This approach provided insight into the community's perspectives on the issues under discussion that were initially, considering their past experiences with project-led group formation, negative towards the establishment (or re-activation) of WUAs. In this respect, however, the SBP team had to assess whether the suggestions from prospective beneficiaries were realistic from a specialist point of view, including various social, technical and economic aspects. Therefore, the SBP team needed to balance between a totally top-down and a bottom-up approach, and only then could appropriate decisions be made about practical solutions.
22. The implementing partners from government counterparts responsible for the different project interventions included:
  - The National Irrigation Program (NIP) of MAI - upgraded existing irrigation infrastructure, advised WUA on improved irrigation techniques, contributed to WUA water planning, assisted in demonstrations and trained farmers in improved irrigation mechanisms, implemented FFS training and greenhouse farming practices, and trained women on food processing and marketing.
  - The Northern Highlands Regional Research Station (NHRRS) from MAI – conducted value chain analyses of suitable high value crops, developed new and improved cropping varieties suitable for local agroecological conditions, advised, demonstrated and trained farmers on improved production systems, assisted with drafting each WUA action plan, and establishment of a farmer information system.
  - The National Water Resources Authority – Sana'a Branch (NWRA) of MWE – modelled and assessed water balances in project areas, advised each WUA on most effective groundwater usage actions and assisted development of each sub-basin water management plan, and local water system monitoring.
  - The Water and Environment Centre (WEC) of Sana'a University – conducted initial awareness raising sessions with communities on water depletion problems.
23. Each implementing partner was employed through Letters of Agreement (LOA) with FAO in Yemen (FAOYE). Due to the troublesome operational environment within the Sana'a basin that caused inevitable delays for implementing partners to deliver their specific project activities and utilize their budget allocations, these LOAs needed to be extended several times to allow implementing partners to complete their tasks.

## 2.2 Context description

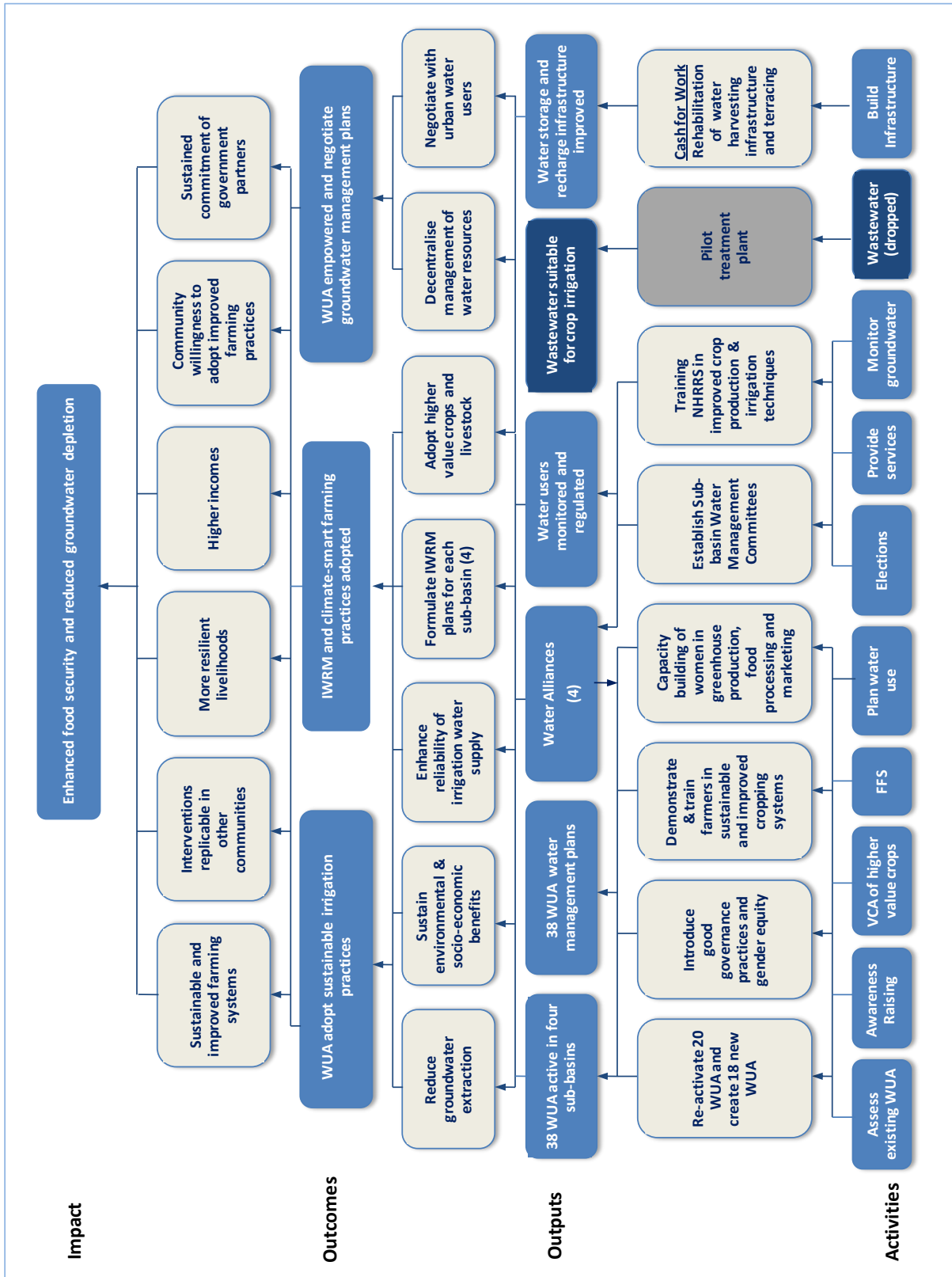
24. Yemen remains a predominantly rural country, with over 70 percent of the population living in rural areas where irrigated agriculture remains the main economic activity and source of income and employment, although only 3 percent of the country is considered to be arable land. Agriculture contributes about 10 percent to Yemen's gross domestic product (GDP).
25. Yemen has limited freshwater supplies, with no perennial rivers; the country is dependent on rainfall, springs, seasonal flash floods (spate) and groundwater. Water availability in Yemen at 115m<sup>3</sup>/capita/year is among the lowest in the world, compared to the already-low regional average of 1 250 m<sup>3</sup>/capita/year. This water scarcity is exacerbated by water allocation problems and rapid population growth. Yemen has tradition systems for managing its scarce water resources for domestic and agricultural purposes, including operation and maintenance of infrastructure, dispute resolution, leadership and coordination, and water rights but these systems have been disrupted by recent conflicts.
26. Due to an expansion of irrigated agriculture, supported by better drilling equipment and mechanized water pumps, and the competing demands of an expanding urban population, groundwater is not replenishing (being pumped at an average rate of one and a half times the natural recharge, and in some areas up to four times), and hence reserves are declining. The Sana'a basin presents the additional challenge of balancing the water requirements of urban/industrial users with agricultural use. Sana'a City, with a population of about four million and growing at a rate of more than 3.5 percent (2014-2017) per year, mostly due to internal displacement caused by war, increased the proportion of water use for domestic and industrial purposes accordingly. Therefore, to reverse the decline in groundwater supplies in the Sana'a basin, efforts need to be directed at reducing agricultural water use without adversely affecting farmers' livelihoods.
27. Almost 90 percent of water use in Yemen is for agriculture, and a large proportion of this is due to inefficient irrigation techniques and the expansion of Qat cultivation, which alone accounts for 30 percent of water use. Qat, a mild stimulant regularly chewed by about 70 percent of Yemeni men, is six times more profitable than most food crops, and relatively easy to grow. Qat cultivation has expanded at the expense of food crops (sorghum, maize, millet and pulses). Qat can account for up to 30 percent of household expenditure, ranking second only to food for many poor people. Due to its profitability, year-round cultivation and high domestic demand, Qat production has almost doubled from 80 000 ha ten years ago to roughly 145 000 ha today. In the Sana'a Basin, Qat production occupies half of the irrigated land. Without any groundwater regulation, Qat farmers are able to pump water freely to irrigate their plants. Qat has driven prosperity in rural areas, assisted by previous diesel subsidies and restrictions on imports resulting in high prices, meaning farmers have not needed to diversify their cropping systems. But this prosperity reduces the economic returns from irrigation, and although once self-sufficient in cereal crops, Yemen now imports over 90 percent of the country's food.

28. Yemen's internal divisions and hostilities have spawned an escalating political, military and humanitarian crisis. The ongoing conflict has damaged public infrastructure, interrupted essential services, displaced populations and reduced the level of commercial imports to a fraction of the levels required to sustain the Yemeni population. The escalated conflict, coupled with protracted political instability, the resulting economic crisis, rising fuel and food prices and high unemployment, has left millions of people destitute. SBP needed to operate in an environment of lawlessness, corruption and bureaucratic impediments; procurement of essential inputs for interventions imported from abroad was a continuous challenge for the team throughout the project.

### **2.3 Project Theory of Change**

29. The project concept and design seeks to strengthen resilience among farming communities by reducing groundwater used for irrigation, improving efficiencies and decentralizing authority to WUAs to regulate local water usage. The internal logic of SBP and the causal linkage between project outcomes and the final desired impact is based on results and lessons learned from field activities in four sub-basins of the main agricultural/urban water basin in Yemen, the Sana'a basin:
- i. mobilization of farmers into WUAs, introduction of better governance and gender equity into the groups which guide their members through the process of change encouraged by the project (Outcome 1);
  - ii. training in improved irrigation techniques and alternative crops and support farmers to adopt these technologies into their production systems; each WUA develops their long-term water management plans (Outcome 2);
  - iii. improved enabling environment - government and private sector provide improved services to farmers, and WUA water management plans are integrated into the Sana'a basin water management plan (Outcome 3).
30. The Theory of Change describes and illustrates how and why a desired change was expected to happen in a particular context. Project activities included initial awareness raising among prospective beneficiary farmers on groundwater depletion problems within their local areas and likely consequences for their future livelihoods. Following participatory project intervention approaches, farmers were organized into active WUAs, trained and supported to adopt better irrigation and water management practices, enhanced livelihoods, and restoration of local water management infrastructure.
31. These interventions led to desired results regarding groundwater conservation, enhanced capacities within farming communities and improved livelihoods for beneficiary households. SBP also helped improve service provision for farmers, and together with their enhanced skills and infrastructure. These outcomes contributed to the higher level results which were enhanced food security and reduced groundwater depletion through increased agriculture production and productivity with the main indicators being more resilient livelihoods and increased incomes.

**Figure 1:** The project's Theory of Change



### 3 Evaluation questions: key findings

32. The evaluation findings are presented in response to the main evaluation questions and sub-questions. Evidence obtained from relevant sources, triangulated, and supported by analysis and assessments substantiate the main findings. Questions reflect the context of SBP as presented in the theory of change. Cross-cutting issues such as gender and other equity issues, human rights, environment, climate change and partnerships are addressed under each of the evaluation questions.

#### 3.1 Evaluation Question 1. Is this project relevant in meeting the needs of the beneficiaries and to what extent does it contribute to implementation of the national development strategy, and fulfilment of the objectives of the FAO country programme?

##### Main findings:

**By promoting modern irrigation systems and improved, climate-smart cropping practices Sana'a Basin Project (SBP) remained relevant to the many farmers seeking alternatives to their current cropping systems based on accessing increasingly expensive groundwater irrigation. SBP established active Water User Associations and progressed towards the government's policy for creation of an Integrated Water Resources Management governance structure in the four project sub-basins as a means to decentralise water regulation and support local development. SBP remained relevant to FAO's country program and objectives of the Government of Netherlands in Yemen that aimed at sustainable groundwater usage and resilient livelihoods.**

33. SBP remains highly relevant to meeting beneficiary and national development objectives. Prior to the conflict, agriculture and fisheries contributed between 18 and 27 percent of Yemen's GDP, 25 to 30 percent of annual food requirements and employed more than 50 percent of the country's workforce. These percentages are now shrinking as the agriculture sector has been adversely affected by the current crisis with resultant reductions in local food production. By demonstrating more efficient and effective use of resources, SBP helped overcome the limited availability and high costs of agricultural inputs, particularly fuel costs for deep-well pumping; problems associated with: (i) diminishing natural resources, in particular groundwater mining (following uncontrolled extraction and inefficient water management practices) and the degradation of land (following deforestation, lack of terrace maintenance, soil erosion); and (ii) the effects of climate change and increasing weather variability.

34. Irrigation in the Sana'a basin is dependent on groundwater, which in-turn, relies on sufficient rainfall and water flow into wadis to recharge aquifers. Improved irrigation infrastructure to capture these surface water flows and increase recharge of groundwater resources together with improved irrigation and cropping practices helped increase the efficiency of irrigation, so that more farmers can properly plan their cropping cycles and maximise their use of improved production inputs. These outcomes will become more critical as changing weather patterns

could reduce annual rainfall in Yemen and thus, groundwater available for irrigation. Therefore, rehabilitated infrastructure and improved irrigation systems will be important to improving on-farm productivity with diminishing water supplies.

35. **National Development Strategies.** Due to the fracturing of the country among opposing forces, Yemen does not possess current national development plans or strategies for its key economic sectors. SBP contributed to the following national development programmes:

- National Agriculture Sector Strategy (2012–2016): SBP supported the sub-sectors for - horticulture, cereals and fodder, water resources, extension, research and inputs, capacity building, women's participation in agriculture, marketing, and quality control; and
- National Water Sector Strategy and Investment Programme (2005–2009) – SBP supported the IWRM plan, urban water and sanitation plan, and the irrigation and watershed management strategy.

36. **FAO Country Programme.** In response to the four-year conflict, severe economic decline and collapsing essential services, FAO in Yemen concentrated its efforts on the humanitarian emergency with the Plan of Action – Strengthening Resilient Agricultural Livelihoods (2018-2020). SBP aligns with two of the three pillars of the Action Plan<sup>3</sup>: (i) Support to the sustainable restoration and diversification of agricultural livelihoods and agri-food systems; and (ii) Improved coordination of planning, programming and support for food security, nutrition and agricultural livelihoods

37. Even before the conflict escalated in 2015, Yemen already suffered high levels of poverty, food insecurity, under-nutrition and malnutrition, water shortages and land degradation. SBP aligned with the earlier FAO Country Programming Framework (2013-2017) that was current during project design and implementation. SBP supported four of the five priority areas in that framework: (i) improved efficiency of the agri-food sector and enhanced agricultural and fishery production and productivity, food safety and food security and nutrition; (ii) development and conservation of natural resources and their sustainable management and efficient utilisation; (iii) value addition, agro-processing and marketing, and promoting the private sector's role; and (iv) sustainable livelihoods and enhanced food security and nutrition for the most vulnerable farming, fishing and rural communities.

- *Have project interventions responded to the needs and priorities identified by the government?*

38. SBP's interventions supported the central government's principle to decentralise authority and provide support to local communities to control the management of their common natural resources. The government's water law of 2002 is well

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<sup>3</sup> SBP did not support the first pillar of the action plan that aimed to scale up FAO's current emergency response across all 107 famine-risk districts of Yemen in order to prevent the already severe levels of food insecurity and malnutrition from worsening.



established, however, the decentralisation of authority to regulate water usage to WUAs was a relatively new concept that had not been adequately implemented. SBP supported the government's decentralisation policies through capacity building, awareness raising, groundwater monitoring, and construction and rehabilitation of water harvesting and recharge structures.

39. SBP continued the government's water management strategies by piloting an IWRM approach to managing water resources in four sub-basins to combat depletion of underground aquifers. IWRM as a means to alleviate water degradation, proved flexible, adaptable, and responsive to local conditions and needs. However, government authority was fractured and the medium to longer control of the Sana'a basin will continue to be contested. Despite many difficulties, SBP successfully demonstrated the governance and technological issues involved in utilising an IWRM approach to managing water resources in an area. The project focused on developing a decentralised participatory methodology to water management that could be adopted for application to the entire Sana'a basin and at a national level. Results would be improved with stronger water legislation supporting the regulatory role of WUAs.

- *Have interventions responded to the intended objectives established by the donor?*

40. The Government of the Netherlands considers Yemen, along with six other countries, to be a special development cooperation relationship (partnership country). These 'fragile states' affected by war, weak governance, and major ethnic and political tensions lack the capacity to reduce poverty effectively without outside aid. The Government of Netherland's multi-annual strategic plan for Yemen (2014-2017) focused on the following areas of assistance:

- Improvements in water management, drinking water and sanitation;
- Sexual and reproductive health and rights for all; stopping the spread of HIV/AIDS;
- Equal rights and opportunities for women; and
- Developing the rule of law, reconstruction, peace-building, strengthening the legitimacy of democratic structures and combating corruption.

41. SBP contributed to improved water management, gender equality, reconstruction, and the strengthening of legitimacy of democratic structures and the rule of law.

42. The Government of Netherlands also seeks a more active role for the Dutch private sector in its aid programme. While this programme did not actively promote Dutch companies, NGOs or agencies to work in Yemen, they did support Dutch consulting companies to formulate the original design of the project and conduct the GIS training course for SBP team members and government partners in Jordan in 2017. The Dutch company that provided this training also provided back-up support with online data relevant to Yemen for use by government agencies.

- *How have the interventions contributed to strengthening national and local capacity development to design and implement relevant activities, steps and processes?*
43. The four government partner agencies had implemented similar interventions in previous donor-funded projects, and thus, they were aware of the pitfalls and problems in various approaches to tackle groundwater depletion problems in Yemen. They were able to build on these experiences and focus on areas of greater potential to impact on SBP objectives, and build towards the IWRM governance structure in the sub-basins.
  44. The design of the project included MAI and MWE staff as integral members of the project team: they were involved at every implementation stage – from community mobilisation, awareness raising, and design of interventions, to oversight of WUA rehabilitation of water harvesting infrastructure, training in improved irrigation operations, and adoption of dry-tolerant, higher value crops by farmers. Through a small grants scheme, SBP supported on-the-job training for members of WUAs to rehabilitate one local water harvesting structure in their area. This activity helped support local communities to plan, build, own and thus, be responsible for the operations and maintenance of their water harvesting structure.
  45. To assist the strengthening of research capacity at NHRRS, SBP organised a seven-day training mission for five NHRRS research specialists to the Lebanese Agricultural Research Centre. They received training in modern irrigated cropping systems, tissue culture production, plant breeding, genetics, improved production techniques, disease reduction etc. Additionally, 12 representatives from implementing partners and local NGOs attended a 10-day remote sensing training course in Jordan provided by a specialist Dutch trainer. This was followed-up with a refresher course in Yemen. Back-up support would be provided by the Dutch company and FAO in Rome, however, slow Internet connection speeds in Sana'a City has prevented further local capacity building in this area of agricultural development.
  46. SBP had budgetary allocations for foreign technical specialists that would also assist the strengthening of local capacities in various areas of expertise relevant to the objectives of the project. This technical support was not forthcoming due to the ongoing conflict in Yemen.
  47. SBP was the only source of financing for implementing partners' field operations. Implementing partners documented in a step-by-step operations manual their successful methodology for developing a sustainable governance model and implementing an IWRM approach at basin level for management of natural resources. Prior to SBP, the NHRRS facility was decrepit and not providing any services to farmers. The project financed the rehabilitation at this research station and the provision of improved cropping varieties and advisory services to local farmers by NHRRS specialists.
    - *To what extent is the project aligned with FAO Strategic Framework (in particularly SO2)? How coherent is it with the work of the Water Scarcity Initiative in Yemen?*

48. SBP contributed to several targets related to the sustainable production objectives of SO2: productivity enhancement, sustainable food systems, investment in rural infrastructure; empowerment of women; water quality; water use, transboundary cooperation; sustainable use of natural resources, and enhanced scientific and technological capacities.
49. The FAO-managed *Regional Initiative on Water Scarcity in Near East and North Africa*<sup>4</sup> aims to support countries adopt and implement evidence-based policy-decisions, sound governance and institutions, cost-effective water investments, best management practices, and inject innovation into the process of finding sustainable solutions to water scarcity and food security problems. SBP interventions supported the Initiative by:
- Improving water use efficiency and crop water productivity, the adoption of higher value crops, and improving irrigation, crop, livestock and water management.
  - Modernising irrigation and related investments - infrastructure, water measurement and control devices, empowering WUAs and building capacity in order to improve flexibility, equity and reliability of water delivery services.
  - Support the decentralisation policy of the Government of Yemen's Water Law (2002) to empower WUA to be local regulatory authority for groundwater extraction and usage
  - Applying best practice principles of IWRM with more focus on water demand management - decentralisation and basin planning helped achieve better efficiency and productivity in agriculture water use, and greater social equity and environmental sustainability.

### **3.2 Evaluation question 2. What were the intended and unintended results achieved by the concluded project? To what extent did the project achieve its intended results?**

#### **Main findings:**

**Sana'a Basin Project achieved most of its intended results and provided an effective model for developing community-level regulation of groundwater abstraction and livelihood development. The project met its objective by focusing on the cultivation of crops that were more appropriate to the evolving environmental and climatic conditions in the Sana'a basin and promoted the adoption of modern irrigation systems. The development of the Integrated Water Resources Management governance structure and 10 year action plans helped increase institutional and individual capacities. Women were fully integrated into these governance structures and decision-making processes for their communities' future development plans.**

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<sup>4</sup> Launched in 2013, the Initiative advises governments and the private sector on the adoption of modern technologies and institutional solutions to increase the efficiency and productivity of water use in agriculture. Governments are encouraged to promote incentive frameworks to reposition farmers as the focus for sustainable management of land and water resources.

50. Interventions by the project were effective at reducing groundwater extraction in the four sub-basins while enhancing beneficiary farmer livelihoods. The project achieved its intended objectives and delivered the following results:

### Impact

51. The Tawilah sandstone aquifer is deepest in the southern end of the Sana'a basin, with some farmers drilling to 500 metres in some locations of the project area to obtain groundwater. The project successfully reduced the water use on irrigated land in the four project sub-basins by 19 percent (target: 15 percent) from 72.6 m<sup>3</sup>/ha/year to 58.56 m<sup>3</sup>/ha/year (agricultural usage only). This was achieved through adoption of modern irrigation equipment, piped conveyance systems, protected agriculture (greenhouses), planting perennial tree crops (almonds, peaches), and rehabilitated water harvesting infrastructure. Total groundwater abstraction rates were not measured because the project only covered four of the 22 sub-basins of the Sana'a basin and taking such measurements per sub-basin was meaningless.

**Table 2: Water savings by intervention**

Description	Unit	Sub-basins				Total
		9	14	15	19	
Irrigated area	ha	4,825	1,297	788	533	7,443
Area - improved irrigation systems	ha	1,851	122	38	10	1,593
Water saving - improved irrigation <sup>#</sup>	Mm <sup>3</sup> /yr	7.91	0.52	0.16	0.04	6.81
Area - piped conveyance	ha	2,000	1,118	80	187	2,997
Water saving - piped conveyance <sup>@</sup>	Mm <sup>3</sup> /yr	3.02	1.69	0.12	0.28	4.52
Greenhouses	No.	767	382	15	13	1,177
Area - greenhouses <sup>&amp;</sup>	ha	28	14	1	0	44
Water saving - protected agriculture	Mm <sup>3</sup> /yr	0.12	0.06	0.00	0.00	0.18
Water saving - infrastructure	Mm <sup>3</sup> /yr	0.05	0.05	0.00	0.02	0.12
Total water saving	Mm <sup>3</sup> /yr	11.10	2.32	0.29	0.34	14.04
Abstraction (baseline: 2015, NWRA)*	Mm <sup>3</sup> /yr	49.5	17.2	1.9	4.0	72.6
Estimated abstraction (2018)	Mm <sup>3</sup> /yr	38.40	14.88	1.61	3.66	58.56

<sup>#</sup>Average water saving (NIP): 4,275 m<sup>3</sup>/ha

<sup>@</sup>Average water saving (NIP): 1,508 m<sup>3</sup>/ha

<sup>&</sup>Average size of greenhouse: 9 m x 41 m and 27 greenhouses = 1 ha.

Average water saving (NIP): 4,146 m<sup>3</sup>/ha

\*Measurement excludes Sana'a City (estimated 18 Mm<sup>3</sup>/yr)

52. The project achieved additional water usage efficiencies through farmer adoption of crop varieties that were more tolerant to less water and utilising climate smart agricultural practices on their farms. NHRRS also promoted a return to rainfed agricultural practices for growing crops, and the conversion of irrigated cropping areas to rainfed areas would also deliver additional water savings and reduced depletion of the Tawilah aquifer. Unfortunately, no statistical data on land usage was available at project commencement, and the changes in land usage were not monitored during the project implementation period.

### Raised Awareness

53. While farmers were amenable to saving fuel costs and through pumping less groundwater from increasingly deeper aquifers for irrigation, they were initially sceptical about another project promising to deliver benefits for their farming livelihoods. Implementing partners needed to expend significant efforts to convince farmers to participate in SBP and join WUAs. These awareness-raising sessions were successful as evidenced by increased farmer demand, both as individuals and as members of WUAs, for the project to provide capacity building and support for activities such as: modern irrigation systems, soil fertiliser particularly organic fertilizer (compost); protected cultivation techniques; crop diversification and provision of seeds for new crop varieties; improved seeds/seedlings; and rainfed agriculture.
54. The substantial gap in funding from mid-2015 to end of 2016 due to the outbreak of conflict in Yemen and a re-focus by the donor on humanitarian assistance was a mixed blessing for SBP. Even though a lack of funding interrupted the project work plan for the period and impeded the momentum developed by the SBP team and implementing partners following the establishment of 38 WUAs, they continued implement "passive" activities. As a consequence, implementing partners had to spend more time than planned developing and strengthening the internal capacities of WUAs rather than commencing the process of formulating the IWRM action plans for each WUA and funding the accompanying investments. The lack of funding also impeded the development of the IWRM governance structure for the sub-basins.
55. While the interruption to the project's workplan was unavoidable, it provided more time to provide bottom-up support to the IWRM governance structure and establish more durable WUAs whose membership was more active and keen to adopt improved farming practices. This extended period of focus on community-driven development undoubtedly laid a solid basis for women and men to effectively organise, identify their priorities and address their local water problems by working in partnership with local governments and other institutions to formulate their action plans, build small-scale infrastructure and deliver basic services. WUAs were integral in guiding their members in adopting new and improved irrigation and cropping practices in their farming systems, and reduce their groundwater needs.
56. Water User Groups (WUG) were established based around each well (8-20 users) or for farmers practising rainfed agriculture. A total of 987 WUGs were formed (556 male and 331 female). Initial interactions with farmers in project areas were important in laying the foundations for implementing a participatory approach to electing board members in each WUA with 30 percent women participation. Other issues that were considered during WUA establishment were: (i) a traditional lack of motivation among farmers to reduce their groundwater abstraction as they considered their incomes would be reduced; (ii) avoid domination of WUAs by large, influential farmers; (iii) sustainable financing for WUAs; and (iv) lack of governmental support and cooperation. Subsequently, 38 WUAs were officially registered as NGOs with the Ministry of Social Affairs and Labour by early 2016.

**Table 3:** Water savings against sub-basin targets

	Unit	Sub-basin				Total
		9	14	15	19	
WUA	No.	20	11	3	4	38
Abstraction (baseline: 2010)	Mm <sup>3</sup> /yr	60.9	16.5	7.5	4.2	89.1
Target Abstraction	Mm <sup>3</sup> /yr	40.00	11.00	5.00	2.00	58.00
Water saving	Mm <sup>3</sup> /yr	11.10	2.32	0.29	0.34	14.04
	:%: baseline	18.2	14.0	3.8	8.1	15.8
	:%: target	53.1	42.1	11.4	15.5	45.2

57. WUA membership was estimated to cover more than half of the rural households in the project area. Close to 100 percent of WUA members were aware (and experiencing) water scarcity problems within their traditional cropping systems. Additionally, they were searching for cost-effective solutions to their increasingly expensive annual production costs, especially fuel for water pumps.

**Table 4:** Estimated WUA coverage of rural households (WEC, 2016)

	Unit	Sub-basin				Total
		9	14	15	19	
Rural Population	HH	15,056	5,898	1,104	2,683	24,741
WUA members	HH	6,641	3,735	485	2,415	13,276
Membership coverage	%	44	63	44	90	54

58. The target abstraction savings for each sub-basin were considered impractical and unachievable from project commencement, and as the operating environment in the Sana'a basin deteriorated, there was less interaction with WUAs to encourage uptake of improved irrigation and production systems aimed at increasing water use efficiency and reduced groundwater depletion. Additionally, SBP did not provide any subsidised improved irrigation inputs so that farmers wanting to adopt improved systems seen on demonstration plots needed to self-purchase these inputs<sup>5</sup>. Therefore, while the majority of WUA members were willing to adopt improved irrigation systems, some were financially constrained while others waited to observe results from those farmers who had already installed modern irrigation systems into their cropping systems and adopted greenhouse production.
59. Owners of drilling companies interviewed by the SBP team stated they had noticed a drop in their business of deepening on-farm wells in project areas as few farmers could afford the expense of deepening their wells, and therefore, they were more accommodative of recommendations and demonstrations provided by SBP for reducing groundwater usage.

### Climate Smart Agriculture

60. Based on lessons learned from previous groundwater support projects, SBP developed suitable cropping patterns that aligned with sustainable irrigation extraction capacities of existing groundwater resources. SBP studies were designed

<sup>5</sup> The World Bank-funded Water Sector Support Project provided irrigation equipment to farmers at a 75 percent subsidy. NIP implemented these activities, however, the project ceased operations following the outbreak of war in March 2015. NIP continued to disburse the remaining irrigation equipment from this project throughout 2015 and some SBP farmers benefited through purchasing this subsidised equipment from NIP.

to introduce interventions that were based on better seasonal cropping patterns that would not affect farmers' livelihoods rather than trying to increase their incomes. However, the target to expand the area under improved production systems by 30 percent and subsequently reduce irrigation water usage could not be measured due to a lack of capacity among implementing partners to utilise GIS remote sensing to measure land-use changes in the four sub-basins before, during and after project interventions.

61. NHRRS developed and demonstrated different fruit, vegetable and cereal varieties capable of growing and producing marketable crops in water-constrained environments for distribution to farmers. Introduction of crop diversification activities included: distribution of almond trees; improved cereal varieties and dual purpose crops (quinoa, triticale, beet, safflower); promotion of legumes for dual purpose crops and soil improvement; protected agriculture (greenhouses); and development of Good Agricultural Practices (e.g. integrated pest management in grapes and vegetables, mulching of vegetables in open fields and greenhouses to reduce chemical usage).
62. SBP conducted 45 field days at NHRRS to demonstrate crop diversification and different farming practices to assist farmers cope with lower use of irrigation and help them adapt to the vagaries of changing weather patterns. The field days were well-supported and reflected the growing enthusiasm among local farmers to learn about improved farming systems focused on prevailing agroecological conditions in the Sana'a basin –4,428 farmers attended the field days.
63. However, the project and its government partner agency, NHRRS, developed and promoted 25 fruit, vegetable, cereal, legume and fodder crops during the project period as alternative crops that were highly productive and tolerant to low water conditions. The objective of introducing new varieties was to reduce water usage and encourage farmers to revert back to rainfed cropping practices was laudable. But this development of 25 alternative crops or improved varieties of existing crops was excessive, and it was not clear what was the basis for selection of all these crop varieties. Also, neither the SBP team nor NHRRS monitored the uptake of all these new crop varieties and therefore, the effectiveness nor success of these crops in delivering desired results could not be evaluated.
64. To help demonstrate protected horticultural production and promote the uptake of greenhouses and improve the financial viability of WUAs, SBP provided four greenhouses to each WUA. Members could hire these greenhouses or share their proceeds with their WUA, which provides some income and improves WUA sustainability. WUAs could also provide micro-credit services to their members to promote the adoption of protected farming systems in the Sana'a basin. An unintended outcome of the promotion of sheltered agriculture and other improved farming techniques initiated by the project was the uptake of these techniques and resultant high demand for greenhouses among non-project farmers in the Sana'a basin who had seen these techniques implemented by project beneficiaries.

### **Capacity Building**

65. In order to strengthen the institutional capacity of newly established and existing WUAs, SBP conducted training sessions for 2,809 WUA members that included: 52.5 percent female trainees; and 326 participants (110 female) were elected as WUA board members. Trainees were from 35 of the 38 WUAs supported by SBP. WUA members also requested training on financial and organisational management, computer skills, training and facilitation, reporting, first aid and English language training. Some respondents suggested building capacity of local women on income-generating activities, such as sewing, and beauty care.
66. All 35 WUAs confirmed that they had functional organisational structures and about three-quarters of the WUAs considered their financial status had improved due to SBP training support. The remaining eight WUAs (three WUAs supported by SBP and five existing WUA pre-SBP) did not have such organisational structures, with the Chairperson appointed by local authorities. Additionally, 13 percent of members in these WUAs were smallholder farmers, whereas in SBP-supported WUAs this figure was 63 percent. This data helped demonstrate the inclusiveness of SBP and the project's success in democratising local organisational development processes to more accurately reflect the socio-economic status of local communities in project sub-basins.
67. The Board of Directors was elected in 70 percent of WUAs and in the remaining WUAs, they were appointed by community leaders. The boards of the SBP-supported WUAs usually met once per month, and for other WUAs, meetings were quarterly. SBP instilled activeness and accountability among WUA board members. Over 90 percent of members considered the organisational capacity of their WUA was sufficient to deliver results. However, the majority of members considered the financial status of their WUA was poor. Only about one-third of WUAs collected monthly subscription fees (US\$3) from members.

### **Farmer Incomes**

68. SBP and the Government of Yemen did not conduct household surveys during the project in order to monitor progress of beneficiary households against project indicators (10 percent increase in household incomes, adoption of new cropping techniques, modern irrigation systems, women food processing results etc.). Indicative productivity gains and savings from less groundwater abstraction by farmers adopting improved irrigation systems (drip irrigation, sprinklers, piped conveyance) and production practices (more productive crops, higher value crops, greenhouses) was used as an indication of subsequent increased incomes possible for farmers.



**Table 5.** Indicative productivity gains with modern production systems

Crop	Water usage m <sup>3</sup> /ha				Savings (m <sup>3</sup> /ha)		Yield (ton/ha)			Productivity (kg/m <sup>3</sup> )		
	Base	BAU	Modern	Green house	Modern	Green house	BAU	Modern	Green house	BAU	Modern	Green house
Tomato	6 048	12 046	6 720	7 398	5 326	4 648	20	25	176	1.66	3.72	23.72
Cucumber	4 500	8 100	5 650	4 455	2 450	3 645	20	22	194	2.47	3.89	43.64
Pepper	5 250	8 750	6 150	5 300	2 600	3 450	12	16	45	1.37	2.60	8.49

BAU: business as usual

69. For adoption of climate smart and improved cropping systems supported by SBP, such as higher production varieties in low water environments, correct plant spacing, pest control etc. productivity gains were demonstrated for rainfed cereal and legume production and open-field production of fruit and vegetables. These productivity improvements should generate income increases for farmers adopting all improved production practices as demonstrated by NHRRS in their plots and field days for local farmers.

**Table 6.** Indicative revenue increases

	area (ha)	Av. Yield (ton/ha)		Return (Av.\$/ton)	Revenue (\$/ha)	
		Traditional	Improved		Traditional	Improved
Wheat	4,280	1.4	1.8	720	1,008	1,296
Maize	2,891	1.7	2.4	600	1,020	1,440
Sorghum	18,283	0.8	1.2	480	384	576
Barley	4,300	1	1.4	600	600	840
Legumes	814	1.8	2.2	1,800	3,240	3,960
Almond	9,307	3.9	4.5	4,000	15,600	18,000
Grape	8,101	9.7	12	1,600	15,520	19,200
Cactus	1,375	16.5	20	-	-	-
Apple/pear	534	13.2	15	1,600	21,120	24,000
Tomato	1,219	14	30	800	11,200	24,000
Potato	945	13	25	-	-	-
Onion	506	14.4	20	600	8,640	12,000
Carrot	1,019	15	20	400	6,000	8,000
Cucurbits	830	13	18	800	10,400	14,400

### Enabling Environment

70. Sub-basin 14 was selected as a representative area sample of the four project sub-basins to analyse the almond, pea, tomato, strawberry, prickly pear, grape and barley value chains. The project design stated that value chain analysis (VCA) would be utilised to help improve the marketing of key crops in the Sana'a basin and improve returns to growers by WUA adopting some marketing responsibilities for members, remove middlemen from the supply chain and thus, return more profits to members. VCA in the project was also designed to identify service providers for provision of credit, processing, marketing etc. to WUA members.
71. SBP facilitated linkages between farmers and local banks; representatives from the Cooperative Agricultural Credit and Amal banks were present during some training and awareness-raising sessions with WUAs and they provided presentations on loan application procedures for farmers. SBP provided training to representatives

from each WUA in marketing. WUAs had assisted 212 farmers obtain loans from microfinance institutions.

72. While no data or information was available, anecdotal evidence from the SBP team suggests that about 20 WUAs were facilitating linkages between individual farmers and traders, and three WUAs were assisting farmers to contact local greenhouse manufacturer in Sana'a city. All WUA were seeking opportunities to link their members with private sector partners to help improve financial returns to them.
73. The planned distribution of four greenhouses to each WUA before the end of the project will generate some income for WUAs through rent or a share of the returns from produce sales from members utilising these greenhouses. This income will contribute to the financial viability of WUAs following the end of the project. SBP need to support formulation of regulations governing the usage requirements of these greenhouses with local councils and WUAs. Additionally, the SBP team will include regulations for WUAs to provide micro-credit loans to members, with preference to the poorest members of WUAs. The SBP team were confident that each WUA board were sufficiently competent to manage such a micro-credit scheme among their members.
74. SBP provided training to 786 women members of WUAs in processing of local produce (sauces, juices, jams etc.) and marketing of their finished products aimed at providing them with an income. The training was provided in November 2017 prior to the onset of winter. SBP expected these micro-enterprises to become active during summer when fruit and vegetables will be more abundant in local markets with lower prices so that these women will be able to process this cheaper produce and sell their products locally.

### **Water Use Planning**

75. WUAs composed a list of their existing water harvesting structures and terracing required for rehabilitation – they identified 80 irrigation structures and 1,000 metres of terraces in their 10-year IWRM action plans. NIP nominated a single structure for each WUA and thus, 38 water harvesting and groundwater recharge projects were rehabilitated benefiting 4,122 households and 172.5 ha. SBP supported each WUA with a \$5,000 grant in a "cash for work" scheme to construct or rehabilitate a surface water harvesting structure. Some WUAs rehabilitated multiple structures with these funds and their own contributions for a total of 46 structures rehabilitated. This approach helped create a sense of ownership among WUA members for their water harvesting structures and encouraged community participation in management and maintenance of local water resources.
76. Project specialists prepared 28 hydrological studies with cost estimates for recommended improvements, which helped inform WUAs prepare their two-year action plans with the objective of adopting improved irrigation practices and a reduction in groundwater depletion.
77. SBP utilised IWRM and planning at the sub-basin level, with the objective of demonstrating the success of this common resource management approach, which could be expanded to the entire Sana'a basin with the intention of improving

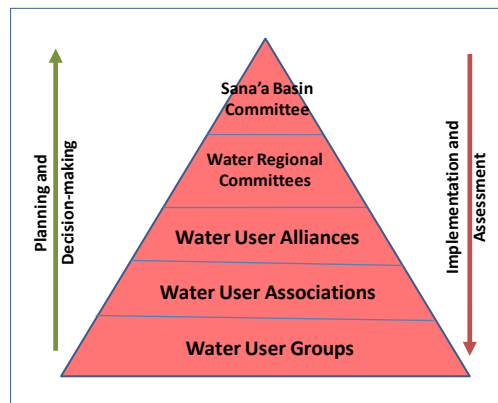
efficiency, integrating investment programming and strengthening environmental outcomes. The basin approach would have the advantage of settling sectoral allocations, providing certainty and transparency, which was demonstrated in SBP as a driver of greater efficiency in irrigation. In the future, as demand from other sectors grows, basin-level institutional mechanisms for orderly transfer of water between users will become increasingly necessary.

**Governance**

78. The governance model implemented by SBP in accordance with the national water law, decentralises authority and empowers communities to be responsible for sustainable management of their water resources and develop agricultural practices to improve water efficiency and productivity. It also provides communities the task of supervising and evaluating the performance of their WUA in comparison to neighbouring WUAs.

79. A Water Alliance would be formed in each sub-basin. SBP in coordination with the Ministry of Social Affairs and Labour (MSAL), supervised the election of the executive committee, the monitoring and supervisory committees. All four alliances were expected to be established and registered by the end of 2018. The next step was to establish six Water Regional Committees that consist of Local Councils, Water Alliances, civil society, and private sector stakeholders in the basin. SBP estimated that 25 percent was completed of the process to establish this management structure in the Sana'a basin.

**Figure 2:** IWRM governance structure as mandated by the Water Law (2002)



Farmer Compensation

80. The final indicator regarding urban water users providing compensation to farmers for costs they incurred for adopting water-saving practices and equipment as per government decree<sup>6</sup> did not eventuate due to the breakdown of central government authority in Yemen in March 2015. WUAs were supposed to receive eight percent of the water use charges levied against urban consumers, which was aimed to assist WUAs provide worthwhile services to their members, improve their monitoring skills and regulatory capacities, and their overall sustainability.

**Table 7:** Intended disbursement of urban consumer fees

Disbursement	Institution
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<sup>6</sup> Clause 3 of Prime Minister Decree No. 135 of 2014 regarding water rights registration and water use fees for protecting water resources from depletion and pollution.

	MWE	NWRA HQ	NWRA branches	Basin plans	Basin/regional committees	WUA
Research – resource protection	2%	3%	12%	-	-	-
Prevention - illegal drilling		1%	5%	-	3%	3%
Performance improvements	2%	2%	4%	-	1%	1%
Capacity building	2%	1%	5%	-	1%	2%
Fee collection	-	-	5%	-	2%	2%
Development and protection	-	-	11%	30%	-	-
<b>Total</b>	6%	7%	42%	30%	7%	8%

### Unintended Results

81. Several unintended results contributed both negative and positive outcomes for the project. The outbreak of conflict between government and rebel forces in Yemen and the Sana'a basin in March 2015 directly impacted the project and delayed implementation by an estimated six months. The SBP team worked diligently to overcome this delay and achieved the target of establishing 38 WUAs by March 2016.
82. The growing volumes (and treatment) of wastewater coming from Sana'a city is a valuable resource for farmers in the Bani Huwat sub-basin. However, they were utilising untreated effluent from the wastewater treatment plant for irrigation purposes with accompanying risks of serious health problems. SBP in consultation with local farmers using this resource, decided not to implement the planned activity to pilot a small-scale wastewater treatment unit for the delivery of improved treated effluent for irrigation. They agreed a more worthwhile activity was to provide solar-powered water pumps to allow farmers to access shallow water sources in the Bani Huwat sub-basin for irrigation (this water was tested by SBP and deemed safe for irrigation, however, at the time of the evaluation, the solar pumps had still not been delivered to the farmers in this sub-basin). The funds from this activity were re-allocated to technical assistance and staff salaries for the project extensions due to delays at the start of the project following the outbreak of conflict in the Sana'a basin in March 2015.
83. Another necessary change to the original project design was the decision by the SBP team to directly purchase greenhouses (160) and distribute to farmer groups (four each) and women (8) rather than try to facilitate linkages with finance agencies to enable farmers to purchase their own greenhouses. This decision was based on the prevailing instability in the finance sector in Yemen due to the ongoing conflict, which hampered the ability of financial institutions to effectively operate in rural areas.
84. The project CTA managed to apply successful concepts from SBP to obtain funding to help address two aspects within the SBP operational environment:
  - The Japan International Cooperation Agency (JICA) provided \$1 million to install a waste water treatment unit in Bani Huwat sub-basin to process effluent from the Sana'a City waste water treatment plant to standards suitable for irrigation of food crops. The funding will also be used to install modern irrigation systems for farmers to improve their productivity and efficiency. There may be sufficient funds to install more units and the CTA was also

seeking funds from UNICEF for five more units to assist farmers utilising the effluent from the treatment plant.

- Following SBP brokering of a peaceful resolution to a 15-year stand-off between two feuding villages over access to 170,000 m<sup>3</sup> water stored in a government-built dam, the CTA successfully applied for a \$2 million grant from the Secretary General's Peace Building Fund. The conflict was resolved principally by SBP working with women members of WUAs and the construction of shallow holding wells that are supplied water from the dam. The extra funds will be used to try and redress 10 water-based conflicts in Sana'a basin and another 10 conflicts in Lahaj.

- *What are the tangible changes in the livelihoods of the communities in targeted provinces?*

85. SBP aimed to meet its objective to reduce groundwater depletion by five percent in the four project sub-basins without adversely affecting farmers' incomes (or increasing the irrigated area in project sub-basins), by focusing on the cultivation of crops that were more appropriate to the environmental and climatic conditions in the Sana'a basin and adding more value locally for farmer household benefit. This required SBP to promote substitution of high water consumption crops, such as Qat, with other high value cash crops, and improved irrigation and cropping techniques, such as protected horticulture, improved rainfed cropping, adoption of more dry-tolerant crops, and safe use of treated wastewater for irrigation.

86. SBP had the dual purpose to increase cereal production and to encourage farmers to grow higher value commodities that assisted their livelihood diversification. The project included training activities that aimed to encourage beneficiaries to pursue cropping systems that returned higher incomes with less groundwater usage, and thus, improve farmer livelihood resilience in the project areas. Overall, beneficiary farming households have more knowledge of production systems they can adopt to cope with less groundwater usage and changing weather patterns, they are more confident in seeking loans (and the associated risk) and approaching government agencies for assistance, work collaboratively in WUAs, and some households have expanded their livelihood activities into value-added enterprises to local fresh produce and off-farm ventures, such as beauty parlours and handicrafts.

- *How has the projects' implementation supported institutional and individual capacity development at the local and national levels?*

87. The project hired different expertise covering irrigation and agronomy, post-harvest processing, and plant protection to train local extension officers and farmers through FFS methodology. This training aimed to improve adoption of improved agriculture practices, modern conveyance and local irrigation systems, technical and practical knowledge operations and maintenance of greenhouse vegetable production, food processing and problems solving. SBP also raised the skill levels among WUA members for managing their water resources at the sub-basin level. The training methods included FFS, demonstration farms, training sessions and field visits to exchange experiences among farmers in new farming techniques.

88. Implementing partners trained WUAs and community representatives in various topics concerning regulation of groundwater usage including: well inventory surveying; measuring available groundwater resources; and downscaling water resource information from the basin level to the WUA level. These training sessions helped raising awareness among communities about the risks related to over-exploitation of groundwater use and increased their readiness to accept changes and adopt necessary obligations to manage the limited available water resources in each project area.
89. Foreign technical assistance comprised almost 10 percent of the project budget, which was targeted at providing project implementation support and building institutional and individual capacities. Unfortunately, due to the conflict, foreign technical expertise could not be mobilised and SBP compensated with local technical support. For organisations such as WUAs, this was a missed opportunity to build their capacities to provide worthwhile services to their members in areas such as marketing. Projects such as SBP provide an opportunity to build local capacities that aim to introduce industry best practices through international expertise.
90. The development of a 10-year IWRM plan for each project sub-basin was significant in building local capacity to sustainably manage the groundwater resources into the future. SBP assisted government partners, local councils and communities to formulate their plans that was informed by modelling of the basin taking into account the inventory of existing wells, groundwater flows in the aquifers, rainfall, location of weather stations, soil types, land usage, and topography. The modelling exercise indicated that the best scenario was to aim for a 30 percent reduction in groundwater irrigation. The 10-year IWRM plan provides a blueprint for all sub-basin stakeholders to collaborate and sustainably utilise available groundwater resources.
91. The objective of each WUA Action Plan was to improve the efficiency of groundwater in irrigation and reduce abstraction rates. SBP trained three representatives from each WUA in groundwater monitoring in order to establish afield monitoring network in participation with WUAs. NWRA provided technical support to communities in the four sub-basins in order to establish this Participatory Monitoring System (PMS) to collect and analyse field data. The disruption in donor funding caused a delay in procuring the necessary monitoring equipment and developing WUAs' capacity to participate in PMS, which had not progressed before the end of the project.
92. SBP's progress in establishing the basin IWRM structure was successful with NWRA gaining experience during the establishment process and planning to replicate the exercise in other basins. A committee from MSAL and NWRA was formulated guidelines for establishing WUAs and alliances, and explain the regulatory procedures, clarify the responsibilities of NWRA and MSAL, and describe the relationship between WUAs and the alliances with the relevant authorities and local communities in their area.
93. SBP increased the awareness of farmers about groundwater depletion in project areas and established an active role for them in the management and conservation

of water resources in their local areas that was described in each IWRM action plan. The use of small grants by SBP supported WUAs to adopt water conservation techniques, such as water harvesting and groundwater recharge with small-scale structures to capture rainwater runoff in the wadis. SBP provided on-the-job training for WUAs to draft proposals and supervise construction and rehabilitation of these water harvesting structures. These activities helped to strengthen WUAs in developing similar plans for other structures, maintenance, finances, and successfully managing the operations of these structures.

- *What positive or negative impacts have project activities had on individuals within households and communities?*
94. The increased depth of the groundwater is impairing the economic situation of local communities in the Sana'a basin. In the past, agriculture did not need extensive irrigation technology because the groundwater was shallow (less than one metre below the soil surface). Aquifers are now much deeper and today's cost of drilling a borehole to depths of 40–50 m is high and with pumping equipment can reach above US\$8,500. Most people in project areas cannot afford such costs and only those few who obtain financial support from emigrated relatives or other sources can afford borehole wells. The cost of diesel to operate pumps for longer periods to extract deeper groundwater for irrigation became excessively expensive for most farmers who were seeking alternative cropping systems.
95. Representatives from WUA in each sub-basin reported the following impacts from project interventions:
- Rainfed agriculture: in sub-basin 9, NHRRS supplied improved barley, wheat, and triticale seed and thornless cactus that produced more grain/fruit and fodder, for less water usage. NHRRS provided 100 - 200 seedlings of improved almond, plum and peach trees to all WUAs in all sub-basins. In sub-basin 9, these trees were used to replace Qat trees damaged by frost during the past winter. Some WUAs in sub-basin 14 purchased additional improved almond trees due to their potential to produce higher quantities of fruit with low water requirements.
  - Improved irrigation: SBP assisted WUAs in sub-basins 9 and 14 to install drip irrigation systems for open-field tomato and potato production on over 10 hectares financed by bank loans. These sub-basins were the most prospective to produce good results from improved irrigation systems. The experience gained through SBP also encouraged seven farmers in sub-basin 19 to introduce drip irrigation financed by loans for tomato crops.
  - Greenhouses: Following project demonstrations and training, greenhouse production became more popular<sup>7</sup> in all four sub-basins, for cultivation of

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<sup>7</sup> Other agricultural development projects had tried to introduce protected agricultural production into the Sana'a basin with limited success. Beneficiaries considered that the training and follow-up support for greenhouse production provided by the project implementing partners had helped convince most farmers in the sub-basins that this was likely the best option for their future production systems and income generation.

tomato, cucumber, and pepper, mostly purchased with bank loans. A total of 266 farmers (114 males, 152 females) were trained in greenhouse production techniques. Consequently, in sub-basin 9, 80 greenhouses were established, in sub-basin 14, 43 greenhouses were built, two greenhouses were purchased by farmers in sub-basin 15, and one greenhouse in sub-basin 19. SBP had also started to distribute the 160 greenhouses purchased for distribution to each WUA, which was expected to be completed before the project closes at the end of 2018.

- Water harvesting infrastructure: the main benefits flowing to communities from SBP was the rehabilitation and construction of water harvesting infrastructure: recharge pits and wells, check dams, terrace rehabilitation, protection walls etc. were constructed with local labour (approximately 2,300 locals received payment for their work). Many WUAs obtained additional funding and labour contributions from members and thus, were able to complete additional water harvesting infrastructures in their local areas. An estimated 500 farmers were able to irrigate their crops from these shallow wells and check dams rather than pumping groundwater.
- *Have gender considerations been integrated in the design and implementation of the projects?*

96. By following an IWRM approach, SBP coordinated all sub-basin actors in a way that balances economic, social and environmental interests and placed an emphasis on sustainable and equitable access to water for all. Thus, a key result from the project was the empowerment of women in the management of common water resources. Gender was mainstreamed in SBP and the project actively accounted for the perspectives, roles and responsibilities of both women and men in project initiatives and designed activities that targeted women exclusively (e.g. food processing, women FFS). This prioritisation of women's needs helped improve the sustainability of project interventions and the more efficient use of groundwater resources. The project implemented measures to involve women in all activities, and ensured women participated in WUAs and supported them to constitute 30 percent of WUA Board positions and other leadership roles.

97. Examples of women involvement in SBP interventions included:

- 4,611 women registered as WUA members (32 percent of all members).
- 6,698 women participated in the introductory awareness raising sessions;
- 950 women trained in water management and farming skills;
- 331 women water user groups formed;
- 114 women trained in food processing and marketing skills (each was expected to train 7-8 other women in their WUAs); and
- 152 women participated in women-only FFS for greenhouse production

98. An example of leadership by women in the project was Ahlam who was one of the first farmers in sub-basin 15 to convert her Qat farm to greenhouse production, which defied local perceptions of profitable farming practices in her area. She



purchased a greenhouse with savings and a small loan. SBP took advantage of Ahlam's leadership and utilised her greenhouse and farming skills for women FFS training in protected agricultural production. It is possible that Ahlam's leadership and initiative could inspire other farmers to follow her example and convert to other cash crops.

- *What are potential contributions from the project towards environmental sustainability and socio-economic conditions?*

99. Groundwater depletion in the Sana'a basin remains a continuous environmental problem exacerbated by unsustainable agricultural practices and expanding urban populations. The ongoing conflict had disrupted traditional water management practices, and most surface water harvesting and recharge infrastructure became dilapidated. The water harvesting infrastructure, agriculture land protection, and wadi reclamation interventions contributed to the environmental sustainability of project activities. These interventions helped protect valuable agricultural soil, and improve groundwater recharge from wadi floors.
100. The project measured irrigation efficiency of the traditional open channel system in three sub-basins, which is labour intensive and causes loss of farm land for water conveyance channels, with sub-channels for irrigating fruit trees or flood irrigation for fruit, vegetables and cereal crops. The average water use efficiency for smallholders using this system was estimated at 61 percent. NIP collected irrigation data on smallholder adoption of modern irrigation systems (tables 2 and 3) that indicated with piped conveyance also, irrigation efficiency improved 22 and 42 percent over traditional open channel and flood irrigation respectively.
101. Existing water management infrastructure was in need of rehabilitation and modernising in order to improve groundwater delivery and more efficient use of the resource. As demonstrated by SBP, modern irrigation techniques improved water usage during the cropping season, particularly for those farmers choosing more resilient and sustainable cropping systems, including substituting higher value crops for Qat cultivation with greenhouse vegetable production. This reduced groundwater usage in the sub-basins, increased incomes and enhanced food security for local communities.
102. Project-supported improved irrigation systems, such as drip irrigation and sprinklers, helped increase efficiency of irrigation water usage ("more crop per drop") and thus the environmental sustainability of the project-supported improved cropping systems. Farmers, working cohesively in WUAs, formulated longer term water management plans, which provide some stability to their farming systems so they can properly plan their cropping cycles, maximise their use of other improved inputs and work towards more sustainable cropping systems in the context of a water-constrained environment.
103. These outcomes will become more critical as the effects of changing weather patterns potentially reduce annual rainfall in Yemen and thus, volumes of surface water to recharge underground aquifers. Therefore, rehabilitated common water management infrastructure and improved on-farm irrigation systems will be

important to increasing farmer productivity with diminishing water supplies that will further enhance socio-economic outcomes within project areas.

### **3.3 Evaluation question 3. What factors contributed to achieving or not achieving intended outcomes?**

#### **Main findings:**

**The competence and determination of the project team to operate in a difficult, often unstable and insecure working environment was the main factor contribution to Sana'a basin project's achievements. Collaboration between implementing partners was effective in producing complementarities and integrated work plans across ministries that also assisted achievement of results. The outbreak of war and decisions by the donor created gaps in implementation and uncertainty about future directions.**

104. The main factor that contributed to the achievement of the intended results was the competence and determination of the SBP team to implement activities and manage the project in a difficult and unstable operational environment. The outbreak of armed conflict in Yemen soon after project commencement led to setbacks and delays. The project team and partners worked resolutely to recover lost time in the work program in order to minimise delays and avoid extended hold-ups to work schedules. However, disruption in project management was inevitable for tasks such as procurement, financial transfers etc. Improved production inputs and green-houses needed to be imported, which created further challenges for FAO procurement and inexorable time delays that further impacted timely delivery of inputs to farmers for seasonal cropping purposes. Due to these delays the project was extended until December 2018, in order for all greenhouses to be delivered and distributed to WUAs and selected farmers.
105. The SBP team and implementing partners demonstrated flexibility and determination to deliver effective results under onerous conditions. For example, the SBP team and farmers realised the implementation of a pilot waste water treatment unit at the effluent treatment plant for Sana'a city was unlikely to deliver substantive results towards improving water quality for irrigation. Farmers along this 20 km channel utilise partially treated sewerage to irrigate their crops that has potential to cause disease outbreaks. Alternatively, SBP team used the budget allocation for this activity to buy solar water pumps for farmers to access water from shallow wells (of higher quality than the waste water), and the purchase of greenhouses.
106. Overall the project design was satisfactory and devoted sufficient effort to the twin focus of promoting adoption of improved irrigation systems and climate smart productivity improvements towards the objective of reducing groundwater usage in the four project sub-basins. However, the design did not adequately equate the measurement of groundwater depth and abstraction rates from an aquifer that spans 22 sub-basins with the reality of implementing a pilot project in four sub-basins only. Therefore, three indicators related to these measurements and efforts to obtain zero groundwater depletion were impractical and not monitored by implementing partners.

107. The instability in Yemen at the start of the second year of the project and the resultant gaps in project funding disrupted the early momentum created by the implementing partners following the establishment of 38 WUAs, and the commencement of training in areas such as groundwater monitoring. As a result, no mid-term review was completed for the project and therefore, there was no opportunity for monitoring and assessing project progress from a longer time perspective towards its expected outcome and impact. This was important because some assumptions made at project preparation had changed; and therefore several project issues needed to be clarified; gaps and weaknesses identified, and remedies proposed and implemented; and activities adjusted as necessary within the project's stated outcome.
- *To what extent has the institutional and implementation set-up been conducive to achieve the intended results?*
108. Implementing partners' staff were responsible for liaising with communities through the introductory awareness raising sessions and the work of each implementing partner complemented the work of the other implementing partners. Farmers met during the mission were satisfied with their involvement in the project from initial discussions and creation of active WUAs through drafting their action plans, construction of water harvesting infrastructure and training for modern irrigation systems and on-farm productivity improvements. WUAs selected individuals to attend training sessions or demonstrations and to pass on new knowledge and information to their members. Training materials were adequately presented at levels easily understood by farmers attending training courses. Beneficiary farmers considered they were adequately involved in all decision-making processes concerning establishing WUAs, management, training and ownership of their infrastructure.
109. All stakeholders in the project areas were aware of the decentralisation of authority to communities through the IWRM governance structure for local groundwater regulation. SBP made substantial progress to establishing this structure within the four sub-basins of the project. The SBP team and implementing partners had the target to establish four sub-basin water management committees that would link into the Sana'a basin committee. Farmers and other stakeholders were eager to implement their IWRM action plans and achieve a sustainable governance structure to regulate local groundwater usage and assist further development of farming systems based on project results.
- *Was there good coordination and decision-making arrangements established among key partners?*
110. The Project Coordination Committee (PCC) was part of the Sana'a basin committee so that high-level officials within the Sana'a basin were aware of the project and its approach to management of groundwater resources. The committee met every six months and approved proposed work plans and provided advice on issues or problems concerning implementation. PCC meetings were organised as public forums and all stakeholders could attend, including farmers from project areas, and provide inputs into discussions.

111. FAO in Yemen reported that the project provided an opportunity for two ministries to collaborate and complement each other's work towards common project goals. Coordination and decision-making were designed to create partnerships between implementing partners that provided a collaborative, integrated approach for developing and implementing SBP that proved a necessity considering the unstable operational environment and the many impediments to continuous project implementation.
- *Were there any implementation gaps and delays; if any, what are their causes and consequences on planned and implemented outputs?*
112. Project designs generally over-estimate what could be achieved in the time available and under-estimate the security and capacity constraints relevant to Yemen. The causes for unintended delays in the project included:
- The escalation of hostilities from March 2015 onwards lead to deterioration in field security and fuel shortages.
  - Security concerns among local communities in project areas meant that community meetings were only possible in Sana'a city.
  - Opposition by directors of existing WUAs to the prospect of re-launching their associations as new WUAs with wider community involvement and participation.
  - Challenges for women to attend monthly WUA board meetings, especially when meetings occurred during local Qat chewing times.
113. Due to the outbreak of war in Yemen in March 2015, the Government of Netherlands suspended funding to SBP in April 2016 as the Dutch Parliament considered whether funds for projects should be re-directed to humanitarian assistance priorities. By the end of 2016, the parliament resolved that SBP had sufficient humanitarian focus to resume funding. However, further delays prevented funds flowing to implementing partners until July 2017. During this gap in funding, implementing partners were restricted to providing passive support to WUAs. This interruption to the project work-plans led to two no-cost extensions to the project that ended in December 2018.

### **3.4 Evaluation question 4. Are the project's results sustainable beyond project conclusion?**

#### **Main findings:**

**Sustainability was integrated throughout the project's design and implementation, based on building the capacity of farmers to new irrigation and farming practices, and creation of active WUAs to be important players in the IWRM governance structure for the project sub-basins. Sustainability of Water User Associations will depend on the services they can deliver to their members, and the willingness of farmers to pay for these services. This will also be a large factor in the overall sustainability of project results.**

114. State-led water governance is weak in Yemen and decision-making over water is generally decentralized to the level of the micro-catchment, the local community and the household. In practice, many communities have become well aware of the need for collective action, and there are examples of communities organising themselves to reassert control over their local water resources and to manage them for sustainability. In some cases, these initiatives have benefitted from public support for information, monitoring and investment. The challenge is to catalyse the replication of this bottom-up partnership approach across all areas of the country.
115. Water user associations formed at the behest of projects have proliferated throughout Yemen, with variable results – from empty shells set up to garner subsidies to associations that look capable of taking collective action on water resources management. Building on lessons learned from previous groundwater supply projects in Yemen, the SBP team made a conscious effort to include local communities in awareness-raising campaigns and planning processes from project commencement. While most farmers in the sub-basins were initially sceptical of another groundwater project, eventually 38 WUAs were re-activated or established for the purposes of decentralising authority to the community for regulating water usage. WUAs were also integral players in guiding and encouraging their members to adopt new farming techniques.
116. SBP tried to improve the effectiveness and sustainability of WUAs by building their capacity to provide services to members such as input supply, processing produce and marketing services. These efforts to flatten supply chains, remove middle-men and thus, improve returns to members would enhance WUA sustainability provided they can offer valued services. Members would then be prepared to pay for such services and also pay their WUA membership subscriptions.
- *To what extent were sustainability considerations taken into account in the design and implementation of interventions?*
117. Sustainability was a constant theme in the project design and implementation, building on lessons learned from several previous groundwater management projects in the Sana'a basin that had followed a similar theory of change to SBP. Overall, coverage of improved irrigation technologies remains limited in Yemen, and the project designers were aware that there was little spontaneous adoption by farmers. Support needed to be directed at development pathways that promoted higher levels of productivity coupled with sustainability of groundwater quantity and quality and, as much as possible, equitable access.
118. Decentralisation and community collaboration on natural resources and environmental management through WUAs, assisted these groups to develop services for their members. The sustainability of WUAs in the four project sub-basins will be strongly linked to the quality of water-related and farming services delivered by each association and therefore, the willingness of members to pay their subscription fees. WUAs have adopted a regulatory role by reporting illegal drilling practices, establishing an inventory of water sources, monitoring of water stations, presenting the interests of their members to local authorities and NGOs, and raising awareness of different concepts in the water law.

119. WUAs were also partners in the development of improved cropping techniques and new varieties, and they were integral players in assisting their members to adopt these practices. However, without legislation that sufficiently empowers WUAs, the quality of the services they deliver, and thus their sustainability could be compromised. Also, without an institutional framework to regulate abstractions, it is not clear that 'saved' groundwater really is saved and not just used elsewhere.
- *Were exit strategies appropriately defined and implemented, and what steps have been taken to ensure sustainability of results?*
120. Exit strategies were not defined, however, the SBP team worked towards the objective of building sustainable WUAs that could continue to manage their local groundwater resources, provide services to their members and be active members in the IWRM governance structure for the Sana'a basin. SBP provided four greenhouses to each WUA and these assets could provide a regular income for each WUA to assist with service provision to their members. The SBP team also discussed with the evaluation mission about using the income from the greenhouses to develop a micro-credit fund for the poorest members of WUAs to assist with their livelihood development, but nothing concrete had eventuated before the end of the project.
121. SBP provided training in marketing for WUA members to assist them provide services to their members. The project also trained women in processing fresh produce so they could sell these products in local markets and generate their own income. These training courses occurred during late 2017 and cheaper seasonal produce was not yet available to gauge the level of success of these income-support activities before the end of the project, although some women were beginning to produce these products for their family consumption replacing the need to purchase these goods.
122. Longer term approaches to water supply are needed with an emphasis on building the capacity of government partners and other local organisations such as WUAs to manage rural water supply programmes. If these local community-based organisations are fully involved from the outset, and projects are able to support sufficient systems, skills, human and financial resources, there are higher probabilities of sustainable outcomes. A long-term approach is needed which avoids arbitrary time-limits and deadlines that create perverse incentives for poorly targeted spending. SBP moved thinking away from projects that simply install a product (e.g. WUA training, greenhouses) towards service delivery that placed more emphasis on WUAs having a viable role to regulate local water usage and provide services to members.
- *Did the development of partnerships at the national level contribute to sustainability of results?*
123. The partnerships between IPs provided a collaborative work-plan, complement each other's work and contributed to the sustainability of results. Another important partnership was the location of the PCC within the Sana'a Basin committee, which consisted of senior representatives of government and non-government sectors based in Sana'a City. PCC meetings were usually high profile

events with large audiences. This relationship with the Sana'a basin committee helped raise SBP's profile at the regional level, build support and contribute to sustainability of results.

124. During the preparation of WUAs' action plans it became clear to members that they needed to make contacts with funding agencies in order to obtain the necessary support for activities in their plans. Farmers need to switch from traditional irrigation based on groundwater to modern irrigation technologies but to facilitate this transition farmers need to find reliable and affordable loan sources to buy modern irrigation technologies, and improved inputs. Some WUAs took the initiative to apply for funds and loans from donors and financing organisations. Funding partners included: the Social Fund Development Project, UNICEF, CAC Bank, Al Kurime Bank, National Foundation for Microfinance, Food Security Enhancement Project in Dhamar, International Red Cross, Yemen Red Crescent, and ZOA NGO.
125. There is also coordination and cooperation between WUAs in the sub- basins for exchange of knowledge and experience on new technologies such as drip irrigation, solar energy for ground water pumps and greenhouse production. In addition, WUAs in each sub-basin need to collaborate and form the WUA alliance. Several WUAs also organised cross-visits between each other to exchange information and knowledge among peers.

## **4 Lessons Learned**

126. SBP demonstrated the results possible when sufficient time is dedicated to key activities, such as forming WUAs, developing management capacities, and establishing services to help improve WUA sustainability. The project team devoted sufficient time to train and demonstrate alternative farming strategies to existing practices of farmer dependence on groundwater irrigation. While farmers were keen to seek alternative systems to the expensive extraction of groundwater, they were initially sceptical that another development project could deliver results. SBP patiently worked through alternative production systems, such as improved irrigation systems, greenhouses, and introduction of crops with lower water needs. This created a significant change to farmer mindsets and most now seek loans or other funding to pay for these improved production systems.



## 5 Conclusions and Recommendations

### 5.1 Conclusions

**Conclusion 1. (EQ.1) Participatory decision-making processes promoted by the project supported beneficiaries to establish active WUAs and were highly relevant in the context of the government's policy of decentralisation of groundwater regulation to the community level and progress towards creation of the IWRM governance structure in each sub-basin.**

127. Learning from experiences in past water resource projects in Yemen, SBP expended substantial time and resources in raising awareness among communities in the project sub-basins of the impending problems regarding groundwater management, and proposed activities to help support farmers ameliorate these issues. This initial work overcame much of the scepticism within these communities. Implementing partners established 38 functional WUAs, which became integral to promoting improved irrigation and farming systems among members, and building towards an IWRM governance structure that decentralises water regulation to communities and supports them in their longer term development plans.

**Conclusion 2. (EQ.2) Adaptation of modern irrigation systems, protected agriculture production, introduction of crop varieties more tolerant of low water regimes, and support to farmers to switch to alternative cash crops helped SBP deliver its objective of improving farmer productivity, incomes and resilience whilst reducing groundwater abstraction.**

128. SBP piloted an effective approach to livelihood development by encouraging farmers to cultivate crops more appropriate to the evolving environmental and climatic conditions in the Sana'a basin and promoting the adoption of modern irrigation systems. The development of the IWRM governance structure and 10 year IWRM action plans for each WUA helped increase institutional and individual capacities. Women were fully integrated into these governance structures and decision-making processes for their communities' future development plans.

**Conclusion 3. (EQ.3) A competent project team that worked collaboratively and flexibly in a difficult operational environment was the main factor contributing to effective project outcomes.**

129. The collaborative effort between the four implementing partners from two ministries helped deliver project results. They needed to work adeptly to keep SBP on schedule as much as possible following the outbreak of war during the second year of the project, which caused disruptions to funding and workplans. The project team was flexible in adapting to these disruptions and alterations to the project design (e.g. the decision to drop the pilot waste water treatment unit and support farmers to access water in shallow wells with solar pumps).

**Conclusion 4. (EQ.4) The IWRM action plan provides a 10-year development strategy with WUAs integral to the implementation of the plan, and therefore they need to be sustainable by providing valued services to their members in order to**

**collect subscriptions and generate income from other sources such as their project-supplied greenhouses.**

130. Sustainability was integrated throughout the project's design and implementation, based on building the capacity of farmers to adopt new irrigation and farming practices. WUAs were important facilitators and their sustainability will be crucial to the basin governance structures and local development. The exit strategy was focused on these developments but only a longer term holistic strategy involving all stakeholders in the Sana'a basin under all sectors (social, environment, economic) can deliver sustainable results for reducing groundwater abstraction.

## **5.2 Recommendations**

### **Recommendation 1. (To FAO, donors and designers of groundwater projects).**

**To ensure continued progress and positive outcomes in water resources management in Yemen, government and external support agencies should implement an integrated approach in the entire Sana'a basin, taking into consideration social, economic and institutional factors, and context-specific challenges.**

131. Given the increasing challenges and risks in the Sana'a basin, it is important that the international community supports Yemen to implement integrated and participatory basin management that focuses on solutions to address water supply priorities and needs throughout the basin. Targeted support is necessary to further improve the institutional framework for water resources management. IWRM must be a key component in the context of sustainable development, improved livelihoods and an important element in building climate resilience.
132. A project such as SBP can help address technical measures that include water-saving technologies to reduce non-consumptive water use, such as protected agriculture, changes to higher-value or more water-efficient crops, and improvements in water management, farming and post-harvest practices. However, only a holistic approach at a national level can sustainably tackle the groundwater depletion problems in the Sana'a basin:
- Economic measures need to address the incentive framework which influences the revenue side (e.g. trade policy – import taxes and tariffs) and the cost side – the cost of groundwater pumping (e.g. fuel subsidies) and the cost of technological upgrading (e.g. monitoring extraction).
  - Institutional measures to set a rigorous regulatory framework, to decentralise resource management to a local-level partnership basis.
  - Social measures to help remove barriers to entry or improvements for marginal groups who struggle to gain access to natural resources, decision-making processes etc. (e.g. the poor, women).
133. Institutional reforms started by SBP aimed at increasing joint decision-making, facilitating management at the sub-basin level and to legitimise stakeholder structures at community level through stakeholder participation. The project also

aimed to improve water security and resilience of farmers to potential vagaries of climate change in the project sub-basins. It built on farmers' desire for alternatives to accessing increasingly expensive groundwater for irrigation and the Government's efforts to decentralise water regulation to local levels.

134. These experiences need to be shared in order to avoid delays and high transaction costs in future basin-level projects. Capacity building remains critical to successful implementation at all levels of the IWRM governance structure. Progress to improve governance of water resources was significant in SBP but this remains an on-going process beyond SBP and into future investment projects. Challenges also remain in the development of appropriate institutional arrangements related to mandates; cross-sector coordination; capacity; participation and awareness. The development of an integrated basin development master plan and action plan agreed by all stakeholders would be a successful outcome.
135. Whilst SBP demonstrated some progress on raising revenues for water resources management from users, there remains many challenges to creating sustainable community-level structures, especially regarding payment for WUA services. Future basin-level projects need to give priority to infrastructure development and financing, legislation and the financing for water resources management. Climate change has become increasingly significant adding to the other water development and management challenges in any groundwater abstraction projects in Yemen, which would be amplified at a basin level.

**Recommendation 2. (To FAO, government partners and project designers).**

**Project funds to support research, development and promotion of new climate smart crop varieties to farmers should be informed by prior analysis and focused on several varieties likely to provide the greatest impact toward desired results.**

136. For pilot projects with limited funds, such as SBP, that try to cover groundwater abstraction remedial activities, adoption of modern irrigation systems and the development of climate smart cropping practices, project funds need to be highly focused and prioritise allocations to those interventions that are likely to provide the greatest impact to beneficiaries and contribute to project results. The project design indicated decisions on the development and promotion of new crop varieties should be informed by value chain analyses of several popularly grown local crop species.
137. Project partners, such as NHRRS, cannot utilise their budget allocation from a project, such as SBP, to fund their entire research and development program. Projects need to focus on a narrow range of new cash crops or improved varieties of existing crops with decisions informed by prior analysis, such as value chain analyses, that also target market opportunities for farmers growing these new crops to increase their profitability.

**Recommendation 3. (To FAO, donors and designers of water efficiency projects).**

**Groundwater abstraction projects need to be designed with longer duration and include effective monitoring and evaluation frameworks from project**

**commencement to enable regular monitoring of performance and to inform timely project adjustments.**

138. Groundwater depletion projects implemented in complex operational environments, such as Yemen, need to be more than three years duration. The promotion of alternative high value crops to Qat including perennial fruit trees, such as almonds and other stone fruit, require many years before on-farm productivity increases can be monitored and farmers are able to sell marketable quantities of fruit. The expectation that funds would be disbursed evenly over the three years of the project proved infeasible as conflict disrupted project implementation and implementing partners needed to adapt to changing operational circumstances..
139. With the benefit of hindsight, the project design generally over-estimated what could be achieved in the time available and under-estimated the security and capacity constraints of all stakeholders. These time periods were too short to accurately reflect the impact of the project on production and productivity of beneficiaries.
140. In view of the inherent complexities of groundwater projects in Yemen, rigorous monitoring and evaluation (M&E) practices are essential in order to obtain data of issues and potential problems, and implement timely remedial activities in order to maximise achievement of intended results.
141. Special attention at project commencement needs to ensure all project units are in-place so that projects can be implemented as planned. Systematic monitoring of project indicators throughout the project cycle and a robust mid-term review should address any weaknesses, identify possible risks and constraints, and propose necessary remedial actions. Also periodic stakeholder discussions need to be organised to provide opportunities for all project stakeholders to propose alterations to the design including indicators and targets. Several indicators of the 30 indicators in the results framework were altered or ignored during the project.

**Recommendation 4. (To FAO as the implementing partner and designers of groundwater conservation projects).**

**GIS should be a necessary tool to support evidence-based decision-making, and more accurate monitoring and assessment of project progress and results.**

142. Geospatial monitoring and evaluation of project progress needs to be included from commencement of irrigation enhancement projects, such as SBP. Groundwater irrigation projects suffer from a lack of regular monitoring and evaluation. As the primary purpose of monitoring was to achieve efficient and effective project performance, GIS should be an integral part of the Management Information System and a regular internal activity in any irrigation project. Regular and reliable evaluation of irrigation agricultural projects is not an easy task within the operational context of Yemen.
143. There are methodological problems in developing cost-effective and reliable approaches with the resources and expertise available in Yemen. GIS would assist

in overcoming some problems and help establish baselines, monitor project progress, identify limitations, assist work planning, and increase irrigation potential of rehabilitated systems. There are open source GIS software programmes and geospatial data is freely available. These solutions may guarantee a more cost-effective and sustainable approach with the cost to projects reduced to capacity building and human resources.

144. GIS would be effective in mapping existing and possible decreases in irrigated areas in the basin following project interventions. One of the main objectives of SBP was to encourage farmers to reduce or cease using groundwater for irrigation and revert back to rainfed agriculture. Farmers were willing to reduce their groundwater pumping as costs had become prohibitive, and they were seeking viable alternative solutions, through adoption of improved irrigation systems and climate smart cropping practices. While the flow of water from underground aquifers to farmer fields/greenhouses and thus improvements in efficiency of water usage could be measured through flow meters and aquifer depth measuring equipment, changes in land usage were much more difficult to measure. Thus, GIS would be a valuable tool to measure such indicators of progress.
145. GIS can also be utilised more broadly for multiple tasks and monitoring indicators to provide an array of performance evaluation information – realisation of irrigation potential, production and productivity improvements (maximisation of crop yields), changes in land use (uptake of higher value crops), efficient management of irrigation water, improvements or deterioration (salinity, water-logging) in irrigated lands. Such monitoring and evaluation data will become more critical as government agencies, farmers and other stakeholders seek to implement their IWRM action plans and perhaps adopt a whole basin management approach to implement future groundwater conservation projects.
146. SBP provided some GIS capacity building for implementing partners but much more support would be required before they could possess a functional monitoring unit. Skilled GIS technicians were in high demand and often difficult to recruit for development assistance projects. Therefore, designers of irrigation projects should allocate sufficient funds to employ external GIS monitoring services that can complement information provided by in-house GIS technicians, and provide a wide selection of M&E information relevant to irrigation rehabilitation projects to assist accurate decision-making processes.

**Recommendation 5. (To designers of community-driven development projects, implementing partners and FAO).**

**While there is inherent tension between the urgency of delivering results to satisfy community needs and allowing sufficient time for community members to gather and cooperate effectively, the latter should be prioritised early in project implementation as a basis to identify community priorities and addressing local problems.**

147. Building upon lessons learned and effective results that SBP should continue allocating sufficient resources and ample time for beneficiary consultation and participatory planning. This level of consultations, that improved information flows

and created new delivery mechanisms for interventions, will increase local participation in WUAs and empower beneficiaries in resource control and decision making, giving them authority to hold their WUA leadership accountable, enhanced their ownership of assets, future development directions, and motivated them to care for their project-supplied facilities (e.g. water harvesting infrastructure, greenhouses).

148. This approach, built on lessons learned from previous development assistance projects, initiated a shift from top-down to a more bottom-up approach, and provided a blueprint for an interactive learning process. Through consensus-building techniques in creating WUAs and formulating action plans in the early stages of developing the groundwater regulation process helped reduce the number of conflicts, led to mutual learning and built trust between parties (government and local communities).
149. As demonstrated by SBP, creating cost-effective methods for groundwater resources appraisal, planning and management that are endorsed by all stakeholders through the creation of sustainable organisations, such as WUAs and sub-basin water management committees, can be difficult due to insufficient resources and support. There is a need for a lean approach to water resource planning that identifies and prioritises the biggest risks and challenges associated with a river basin or aquifer so that all water (and land) users affected will have a direct stake in the outcome and be more willing to engage with the process. All groups in society should be aware of their access rights and local actions provide them protection and benefits from the aquifers on which their livelihoods depend. A process of local planning and water user engagement means that opportunities for further groundwater development can be identified and rural communities can be served without fear of being ignored.

**Recommendation 6. (To donors, FAO and project designers).**

**Climate change adaptation challenges, and increasing vulnerability in all rural livelihoods should be adequately addressed in future project activities. Better analysis of climate-related data and proposed approaches for mitigation and adaptation activities need to be prioritised in groundwater and livelihood projects.**

150. Climate change is an additional influence on sustainable groundwater management that adds to other pressures, such as land use changes, over-abstraction, and groundwater pollution. While global temperatures look likely to rise over the next century, the impact on rainfall is less certain. For Yemen, groundwater recharge is sensitive to rainfall intensity and rainfall distribution. While in some settings, heavier rainfall can benefit recharge, if it becomes too intense then the soil cannot accept the excess infiltration, resulting in flooding, which subsequently can enable contaminated surface water to enter the aquifer through boreholes and open wells.
151. Greater use of artificial recharge methods, such as sand dams that harvest surface water and increase water flow into the aquifer may help, at least at local level, and reduce flood risk. It would be prudent for future projects to increase efforts to enhance recharge, particularly in areas such as the Sana'a basin where abstraction

rates are high compared to existing re-charge. Climate change also needs to be considered in the context of other changes, such as land use and population growth.

152. Effective adaption to changing weather patterns will depend largely on data and effective monitoring of rainfall, groundwater and river flows, and a robust conceptual understanding of hydrological systems so that cause-and-effective relationships can be established. Data is of critical importance and in many areas there is a lack of hydrogeological information and records. Implementing a high quality hydrometric monitoring network is also important but difficult to fund. In SBP, the purchase of sophisticated monitoring equipment was deferred due to the likelihood of theft at some stage during the supply or installation process. This may be alleviated to a degree with cheaper, automated water-level measuring equipment.
153. International support for climate change adaptation programs should be prioritised, together with providing incentives for capacity strengthening in groundwater management, planning, and conceptualisation of adaptation programs. Political commitment and leadership are essential to create an adequate basis for governance. Building effective institutions, comprising the legal and regulatory framework, organisation (both governmental and non-governmental) and stakeholder engagement mechanisms are at the core of groundwater governance. Likewise, implementation and adoption of laws and regulations by stakeholders are essential to effective management.

## 6 Appendices

### Appendix 1. List of documents consulted

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## **7 List of Annexes**

Annexes available at <http://www.fao.org/evaluation/en/>

Annex 1. Terms of Reference

Annex 2. Achievements against Results

