National Conference for the Management and Development of Water Resources in Yemen

Paper 2-B Agriculture's contribution to solving the water crisis

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Abstract

This paper discusses experience and prospects for irrigation improvement in Yemen, and experience and prospects for a revival of rainfed agriculture, terrace agriculture and water harvesting.

The paper looks first at the water saving and economic benefits of improved irrigation as practiced so far in Yemen, and assesses how strong is the empirical evidence for these benefits and what are the economics of water saving through irrigation conservation. The paper reviews the justification for subsidy on irrigation equipment, and asks how it might be phased out. What measures, for example, might be pursued to promote unsubsidized adoption of efficient irrigation, and could local manufacture and repair industries for irrigation equipment be promoted?

The paper then looks at how irrigation improvement might be better linked to sub-basin planning, and in this context asks when is improved irrigation likely to be a good investment – and when is it **not** worthwhile to invest in irrigation improvement?

The paper also looks at further measures that mighty be taken to strengthen research and extension on irrigated agronomy and water management and to link it to the National Irrigation Program (NIP). In this context, the paper asks how can subsidized support to irrigation improvement be better integrated with the decentralized water management framework - for example, should NIP require that there be in place a water user association working with the local council and NWRA on a water conservation plan for the local area.

The paper also reviews what has been achieved in reviving rainfed agriculture, terrace agriculture and water harvesting, and discusses what are the economic and environmental options and ways of support for the crucial ecological balance and function played by the country's terraced agriculture - for example, is 'payment for ecosystems services' a practical option and how would it be implemented?

Finally, the paper looks at the role of qat in the rural economy and examines what measures in the incentive system might be used to discourage qat growing, and what would be the impact on rural incomes and employment.

Agriculture's contribution to solving the water crisis

Introduction

The country's present population of about 26 million is likely to be doubled after 20-25 years which will reduce the per capita availability of water, which is already the lowest in the world, to 55 m^3 per capita per year in 2031 as against the world average of 7,500 m^3 per capita per year and 667 m^3 per capita per year in the MENA region. As per the international norms, a minimum of 100 m^3 per capita per year is necessary to meet domestic requirements alone and 1000 m^3 per capita per year for food self sufficiency.

About 74 % of the population lives in rural areas and in close proximity of wadis where water may be available for irrigated agriculture, which provides most of rural income. It covers an area of 789,000 ha (including an area of 154,000 ha under Qat) irrigated by spate, springs and groundwater out of a total area of 1,306,776 ha cultivated in the year 2009 (remaining 614,185 ha under rain-

fed). Agriculture as a whole accounts for about 17 % of GDP. Agriculture sector employment is estimated at 54 % of the total labor force.

Yemen depends on two main sources of water: rainfall and groundwater. This country is regarded as one of the countries of scarce water due to its geographical location within the arid and semi arid countries where the average annual rainfall is between 200 – 800 mm, while 1200 mm in the three highly land Governorates (Ibb, Al-Mahweet and part of Hajja). The quantity of annual rain volumes all over the country is between 67.11 billion cubic meters (BCM) and 93 BCM annually.

The quantity of the pumping from groundwater reaches to 1.5 BCM annually through more than 99,000 groundwater wells drawn from several Basins. The total annual used water quantity is about 3.9 BCM of which 90% mostly exploited for agricultural activities, 8% for municipal water supply sector and 2% for industrial sector. The quantity of water exploited exceeds the average of groundwater recharge. That deficit is around 1.4 BCM (2010), resulting a decline in the level of groundwater. In some basins the decrease in the level reaches between 2 – 6 meters annually. This situation had got worse toward the end of seventies and early eighties of the twentieth century when farmers discovered that it had rapid response by using these waters in agriculture, as consequence, the process of digging deep wells had been carried out increasingly, resulted in exploiting great quantities of groundwater. The rates of rapid depletion of groundwater up to 6-7 m/year are leading to a situation beyond recovery. Yemen is abstracting over 50 % more than the annual renewable water supply of 2.5 BCM to meet the present demand of 3.9 BCM of which over 3.2 BCM is the irrigation demand.

Irrigated area and qat cultivation

The total cultivated lands in Yemen in 1970 were 1.29 mha (37,000 ha irrigated by groundwater, 120,000 by spate, 73,000 ha by springs, and 1.06m ha were rain-fed). In the year 2008, the total cultivated lands increased marginally to 1.37 mha, the groundwater irrigation increased to 418,879 ha (almost 11 times), spate irrigation increased marginally to 136,335 ha, and rain-fed irrigation decreased to 695,388 ha. While the areas under cereals dropped by one-third during 1970- **2008**, those under irrigated fruits and vegetables increased five times, fodder crops increased 4 times and area under Qat increased almost seventeen times. *(source: Agriculture Statistic Book)*

Table 1: Agricultural irrigated areas and Qat Cultivation

No.	Particulars	Unit	Year 1970	Year 1996	Year 2001	Year 2008
1	-Total Cropped Area	Million ha	1.29	1.155	1.2	1.4
2	-Well Irrigated Area	Million ha	0.037	0.368	0.41	0.42
3	-Rain-fed Area	Million ha	1.056	0.579	0.61	0.695
4	- Area under Cereals crops	Million ha	1.082	0.704	0.66	0.76
5	Area under irrigated Fruits & Vegetables	Million ha	0.039	NA	0.163	0.176
6	-Qat Areas	Million ha	0.008	0.091	0.109	0.147

(source: Agriculture Statistic Book)

Challenges facing irrigated agriculture in Yemen

The challenges that face irrigated agriculture in Yemen are basically four: (i) sustainability of groundwater irrigation (ii) low productivity of all irrigated agriculture; (iii) the enhancement of irrigation efficiency move slowly and (iv) need to institutional strengthen and enhancing the capacity building of the institutions connected with water use in the agriculture sector.

Rate of depletion of aquifers

Against the renewable water supply of 2,500 mm3 , the water demand for the country during 1990-2010 is estimated to increase from 2,897 mm^3 in 1990 to 3,923 in 2010 (Table 2). Sectoral shares are given in Table-2 below. The annual deficit, which was 400 mm^3 in 1990 is now 1,400 mm^3. This huge deficit is met from the deep aquifer storage, which is the root cause of rapid depletion of groundwater.

Table 2: Sector- wise water demand (mm^3)

Sectors	1990	1998	2000	2005	2010
Irrigation	2,675	2,896	2,958	3,119	3,224
Live- stock	25	29	30	33	37
Municipal	166	274	300	408	553
Industrial	31	64	72	118	109
Total	2,897	3,263	3,360	3,678	3,923

Low productivity of agriculture

A comparison of the productivity (in tons/ha) of some crops (Potato, Tomato, Citrus and Banana) with the productivity in neighboring countries is given in Table (3) below. The figures of Cereals are not readily available.

Table 3: Crop productivity

Crop	Yemen 1] (Tons /ha)	Lebanon 2] (Tons /ha)	Jordon 3] (Tons /ha)	Typical 4] (Tons/ha)
Potato	13	25.5	31.3	20-25
Tomato	16	33.5	41.2	25-50
Banana	7.4	18.9	37.5	15-25
Citrus (Orange)	1.8	13.5	36.3	10-25

1] Source:- Statistical year Book
2] Source :- Rapid Rural Appraisal and Farmers Surveys conducted during the preparation of Lebanon Irrigation Improvement Project
3] Source:- Towards an Agriculture Sector Strategy June 12,1990)
4] Source :- Technique Rurales en Afrique 1980

As regards the productivity of cereals, the average productivity of all cereal crops is 0.71 t/ha (Sorghum 0.85 t/ha, Maize 1.51 t/ha, Millet 0.65 t/ha, Wheat 1.40 t/ha, Barley 0.72 t/ha). The Sorghum crop yield (which represents 58 % of all cereal crops in Yemen) in China is 3.97 t/ha, Thailand 2.27 t/ha and Saudi Arabia 1.11 t/ha.

Low irrigation efficiency;

The overall efficiency of on-farm controlled irrigation system has been estimated at between 35 and 40% of which conveyance efficiency is about 75 %. It is estimated that the conveyance efficiency could be increased to over 95% with a piped conveyance system. A well designed pipe distribution system would increase the overall efficiency to over 60%. Use of Localized On-farm Irrigation System may increase the overall efficiency to over 75-80 %. As regards spate irrigation, the overall efficiency of the existing spate irrigation system is below 35%, of which the conveyance/ distribution efficiency is 65% and field application efficiency of 35%. With improvement in spate works, the overall efficiency could be improved to 40-45%. This is depicted in a tabular form in Table 4 below.

Table 4: Irrigation efficiency

Existing Situation		After Improvement	
Irrigation Type	**Irrigation Efficiencies**	**Irrigation Type**	**Irrigation Efficiencies**
On-farm Irrigation with Open Channels	35-40 %	Piped conveyance of groundwater for irrigation	60 %
		Localized on-farm irrigation system	80-90 %
Spate Irrigation	<35 %	Improved Spate Irrigation after Rehabilitation	40-45 %

Institutional strengthening of water institutions

In cooperation with donors MAI has a good progressing in term of Institutional Strengthening (including capacity building and training) as follows:

- Insert in all investment program/projects a special component for the capacity building and training;
- Start to strengthen the relation ship with other related Water Institutions particularly MWE including NWRA and GARWPS as well as Water supply and Sanitation Corporations.
- Issue the restructuring of the ministry and create Irrigation and Land Reclamation Sector to carry out the responsibility of the water management in the agricultural use.

To address the above challenges MAI adopted a number of policy measures, the most important of which include, the preparation of the national water strategy, the preparation of the agriculture; strategy (Aden Agenda.

National Water Sector Strategy

For the longer term, the Government has developed a "Strategic Vision 2025" which identifies several challenges such as high population growth, poor human development indicators, depleting water resources, large expansion of qat cultivation and the crop's social and economic impacts, which undermine our ambitions for achieving the desired development for a decent livelihood.

The GOY is aware of the challenges that the country's water problems pose for achieving food security, and has taken some significant institutional steps over the past years. Strategic planning began in the early 1990s. In 1996, the National Water Resources Authority (NWRA) was created to implement an integrated approach. A water law was enacted in 2002, and in 2003 the Ministry of Water and Environment (MWE) was established. MWE prepared a consolidated strategy, action plan, and an investment program for the water sector as a whole namely the National Water Sector Strategy and Investment Program (NWSSIP).

Agricultural Strategy (Aden Agenda)

The agricultural strategy for Yemen was compiled by the Ministry of Agriculture and Irrigation in 2000. The overall objective of the agricultural sector is to contribute to national development through:

1. Food security: The achievement of high levels of food security
2. Combating poverty: Support the anti-poverty efforts exerted in rural communities, and
3. Sustainable growth: The realization of sustainable growth at rates that should at least match the population growth rate.

Major constraints that prevent agriculture from fulfilling this role, include (i) natural disasters such as droughts and floods and climate changes, (ii) low productivity, use of inefficient technologies, unsustainable water use and lack of access of small producers to credit; (iii) lack of education, poor health and nutrition, use of qat and (iv) inadequate legal framework and poor law enforcement. To address these challenges strategic actions were proposed such as:

- Increase production of cereals, especially wheat, and the production of livestock and find alternatives to qat;
- Support rain fed agriculture and create income generating opportunities;
- Increase productivity of irrigated agriculture systems through improving groundwater use and irrigation efficiency.
- Encouraging institutional building such as WUAs etc
- Promote private sector investment in market-oriented agriculture

The update of Agricultural Strategy is under preparation.

MAI interventions to address the groundwater crisis

Introduction of new water saving technologies

Of the total irrigated area by spate, springs and groundwater, the area irrigated by groundwater is almost 70 %. However, in most areas groundwater is being over-exploited far beyond the safe levels of annual recharge. In western highlands part of the country, where groundwater is the main source of water, aquifers are depleting some 1-4 m per year (and even up to 7 m per year in some basins). There is a need to conserve groundwater, to improve efficiencies of water use, and to reduce over-exploitation.

GOY has taken a number of projects aiming at reducing groundwater use for agriculture, soil conservation and improving water productivity: namely (a) GSCP (US$ 55 million) closing on October 31, 2011; (b) SBWMP (US$ 24 million) closed on June 30, 2010; (c) WSSP (US$ 90 million) which became effective on December 15, 2009 and (d) Rainfed Agriculture and Livestock Project (financed by IDA US$ 20 million and IFAD US$ 16 million) to be closed in June 2012, Hassan Dam Project (finance by Abu-Dhabi Fund).

This is the main focus of the MAI through many projects, which aim to install improved irrigation technologies with a view to conserve groundwater, improve efficiencies of water use, and to reduce over-exploitation. This issue has been addressed by mainly through the implementation of the following projects:

No	Project Name	Area Covered by Conveyance Pipe System (ha)	Area Covered by Localized Irrigation System (ha)	Amount of water savings (MCM)
1	Land and Water Conservation Project (LWCP)	10,000	65	16
2	Groundwater and Soil Conservation Project (GSCP)	48,200	2,200	56
3	Sana'a Basin Water Management Project (SBWMP)	2,900	1,600	10
4	Agriculture and Fisheries Production Promotion Fund (AFPPF)	8,000	2,500	31
	Total	**69,100**	**6,365**	**113**

The achievements in the introduction of improved / modern irrigation networks are very low about, 75,000 ha (17%) of the total irrigated area by groundwater (420,000 ha). The low achievement is mainly related to the limited of fund and increasing in the prices of irrigation technologies. The

highly needs to more water savings lead the government to give the farmers more subsidy to encouraging farmers to install irrigation technologies in the remaining area. However, if the achievements in the covering area by improved / modern irrigation technologies reach above 60% of irrigated areas the government can change the subsidy policy.

There are direct and indirect benefits which will accrue to farmers as a result of the installation of improved / localized on farm irrigation systems. The direct benefits will accrue to farmers from the extractive use of groundwater for irrigation in the production process. On other hand, the indirect benefits are not easy to quantify by farmers. These indirect benefits which will accrue as result of installation of improved / localized on farm irrigation systems include, prolonging the operational life of the well, prolonging the operational life of the engine and prolonging the operational life of the pump.

The improved irrigation systems, namely piped conveyance and localized irrigation systems are tested technologies and estimation of assured water savings and increase in crop productivity as a result of these systems, as observed under GSCP, is given in Table 5 below

Table 5: Benefits of improved irrigation

S. No.	Items	Unit	Groundwater Irrigation through open channels	Irrigation after installation of piped conveyance	Irrigation after installation of pressurized (Drip, Bubbler, Sprinkler) systems
1	Water consumption	M^3/ha	9500	7980	5235
2	Net water saving	M^3/ha	0	1520	4275
3	% Water Savings	%	0	16	45
4	Diesel Consumption	Litres / ha	1360	1160	750
5	Saving of Diesel	Litres / ha	0	200	610
6	Cost of Diesel	YR/ha	47,700	40,600	26250
7	Saving in cost of Diesel	YR/ha	0	7100	21450
8	Pumping time required to irrigate one ha	Hrs/ha	300	255	165
9	Saving in Pumping time	Hrs/ha	-	45	135
10	Increase in water productivity	Kg/m^3	-	-	About 70 %
11	Increase in crop production	%	-	-	15

Table 6 below shows a summary of the average percentage savings in irrigation water, fuel consumption and irrigation labor as well as increase in yield realized after the installation of the installation of the piped conveyance systems and localized on-farm irrigation systems.

Table 6: Savings from improved irrigation

Irrigation System	Saving (%)			Average Increase in Yield (%)
	Irrigation water	Fuel	Irrigation labor	
Piped conveyance system	15 - 20	15 – 17	14 - 16	12 - 13
Localized Irrigation systems	35 - 40	29 – 33	30 - 34	14 - 16

Farmers subsidy

The above achievements in the installation of improved a/ localized irrigation system are direct results of the subsidy program to farmers to encourage them to install the water saving technologies. It is quite clear from the figures in the table below that the subsidy rate to farmers adopted under the SBWMP and the NIP is higher than the LWCP, the GSCP and the AFPPF. This is justifiable on the basis of the precise targeting approach adopted under the SBWMP and the NIP. The targeted basins under the SBWMP and the NIP (Amran, Sana'a and Dhamar) are subjected to enormous groundwater depletion and thus considered critical.

Projects	Subsidy on Conveyance Pipe Irrigation system		Subsidy on Modernized system	
	Subsidy on Material	Subsidy on installation	Subsidy on Material	Subsidy on installation
LWCP	50-60 %	50%	50 %	50%
SBWMP	60%	90%	75%	90%
GSCP	50 – 70 %	No	50%	No
NIP	50- 90 %	-	50 -90%	-
AFPPF	50%	No	50%	No

From the results obtained from the analysis of investment in improved piped conveyance system and the analysis of investment in the installation of localized on farm irrigation systems that the investment in the improved conveyance of groundwater for irrigation seems to be more attractive to farmers than the investment in localized on farm irrigation systems for many reasons, the most important of which include, the initial investment cost for the improved conveyance for irrigation represents only between 10% (drip system) to 20% (bubbler system) of the investment costs in localized on farm irrigation and the subsidy level for small farms to be equipped with improved conveyance of groundwater for irrigation (70%) is lower than the subsidy level for small farms to be equipped with the localized on farm irrigation systems (50%).

Consistency between the country's national objective and farmer's objective in relation to groundwater conservation

The adoption of water saving technologies serves the national objective of conserving groundwater through reduction of pumping groundwater for irrigation. (i.e. rest in the aquifer)
• The adoption of water saving technologies serve the farmer objective through realizing financial saving in fuel use, lubricants use and irrigation labor as well as increase in crop productivity.
• The financial subsidy to farmers on water saving technologies will encourage farmers to adopt these water saving technologies and this will serve both the national objective as well the farmers objectives (i.e. this bring consistency between the achievement of national objectives as well as farmers objective).

Irrigation Advisory Services (IAS)

This activity basically aims at providing irrigation extension services to participating farmers who installed piped conveyance systems and/or localized irrigation systems in their fields. The irrigation advisory service advise participating farmers on efficient irrigation practices to optimize, use of groundwater for irrigation, adopt crop water requirement for irrigation and proper irrigation scheduling. The irrigation advisory service (IAS) also responsible for general evaluation of the performance of the irrigation systems implemented and for assessment of savings of water, as well as creating the Water User Groups WUGs and Water User Association WUAs.

The integration of the IAS activities with extension specialist in the Agricultural Offices during farmers field days held in the demonstration farms was very instrumental in providing a comprehensive package. Accordingly it is recommended that utmost cooperation and coordination between the IAS and the extension specialist be institutionalized.

MAI intervention to improve surface water conservation and efficient utilization;

Yemen has practiced water harvesting techniques for centuries, and they represent the most efficient methods to improve the available moisture in the soil profile (both for agriculture and rangeland). In addition, water harvesting is a good way of involving and organizing communities and good experience is now available in Yemen.

MAI has increasing interest in the water harvesting schemes (i.e. construction of dams, weirs and low cost Water harvesting structures). Water harvesting is a traditional and often skillfully applied method of water resources exploitation in many areas of Yemen. It is based on collecting and retaining overland flow in zones where soils permit agriculture.

The numerous management-made mountain terraces that cover considerable parts of the western and southern slopes collect and retain rains and overland flow. They are supported by walls of stones, not only to retain water but also to prevent the soils being washed away. As a result, there is large extent of agricultural lands on the mountain slopes during wet periods, the 'Hanging gardens of Yemen'. Thus, under water harvesting, instead of the runoff being left to cause erosion in the uplands, it is harvested and utilized to become productive form of soil and water conservation. Both yields and production significantly improved with these methods.

MAI has given special attention to improving the efficiency and utilization of surface water through the construction of about 2967 hydraulic structures constructed and other 413 are under construction, including dams, spate diversion structures, canal control structures, new water tanks & traditional cisterns, bank protection works , erosion control structures and terrace rehabilitation .

Irrigation structures have been constructed by MAI/IS through different financing sources.

Improvement of Spate Irrigation and Water Harvesting Systems	Unit	Total
Dams (399 financed by AFPPF , 98 by Local budget and the remaining financed by other donors)	No.	532
Diversion Weirs (almost constructed by IIP)	No.	42
New Spate diversion and Canal Control Structures (mainly constructed by GSCP)	No.	288
New Water tanks, Cisterns and Traditional Pits (615 financed by AFPPF , 65 by Local budget, 958 by GSCP and the remaining financed by other donors)	No.	1623
Bank Protection Works and Soil Conservation & Erosion Control Works (almost constructed by GSCP)	Sites	506
Terrace Rehabilitation Works (almost constructed by GSCP)	Meter length	300400

Source: Joint Annual Review (JAR Reports)

Problems that face the sustainability of spate improvement structures

The main problem is O&M of these structures since these are expensive structures and farmers can't afford to pay for the O&M of these structures and the government has no budget for the O&M, a number of such structures become non functioning or partially damaged.

Spate irrigation improvement by IIP

Improvement of spate irrigation management needs not only hardware interventions (rehabilitation and modernization of infrastructure) but also institutional development and information management measures. Also, due to the absence of inter-seasonal surface water storage, spate diversion and conveyance improvement works cannot (at unit costs as high as $3,000 to $4,000/hectare) be economic unless they are complemented by (i) on-farm agronomic and irrigation enhancement techniques and advisory services to help raise water productivity, (ii) flood protections works, and (iii) conjunctive use works (low-cost sub-surface dams or recharge dams at appropriately defined upstream and downstream wadi locations), to help increase the availability of groundwater for rural non-irrigation uses and to counteract sea water intrusion.

In general the outcomes are very positive. For example, the average productivity of cotton has increased by about 50%, Sorghum by 49% for grain and 34% for fodder, Sesame by 53%, tomatoes by 62%, and onion by 73%. The outcomes of the study also revealed that the number of farm

animals increased by 40% (largely due to the increased productivity of Sorghum fodder). These outcomes have directly or indirectly improved farmers income and the wellbeing of their families.

Yield and Farm Revenue Increases Due to Improved Farming Practices in spate irrigation areas in Wadi Zabid and Wadi Tuban

Crop	**Planned yield increase** (%)	**Measured yield increase (end 2005)** (%)
Cotton	13 Zabid 15 Tuban	45–100
Sorghum grain	5	Up to 98
Sorghum fodder	4 Zabid – 8 Tuban	Up to 44
Sesame	10	Up to 55
Maize	18 Zabid	62–97 Zabid
Cucurbits	3 Tuban	Up to 200
Tomatoes	20	87
Onions	20	12 to 25
Eggplant	20 Tuban	44
Okra	15	25

Source: ICR of IIP project financed by IDA

Rain-fed areas

Rain-fed agriculture has been very popular in Yemen, However, as a result of large-scale introduction of pumps to abstract groundwater and the decreased rainfall in the past 10 years, the rain-fed agriculture has suffered a serious set back and the rain-fed areas of over one million hectares in 1970 now stand at 600,000 ha. As compared to this the groundwater irrigated areas which were 37,000 ha in 1970 are now 450,000 ha leading to severe depletion of groundwater resources. The rain-fed agriculture need to be revived.

Further, there are numerous man-made mountain terraces that cover considerable parts of the western and southern slopes collect and retain rains and overland flow. They are supported by walls of stones, not only to retain water but also to prevent the soils being washed away. As a result, there is large extent of agricultural lands on the mountain slopes during wet periods, called the 'Hanging gardens of Yemen'. The rehabilitation of terraces also, besides water conservation, helps in preventing soil erosion in the uplands, and thus helps in both soil and water conservation. Both yields and production are significantly improved with this method.

Yemen's food insecurity is one of highest in the world, and the per capita availability of water is, perhaps the lowest. These two indicators are eye openers for the authorities and the planners to save this country from going to an unsustainable situation. This is the time to wake up and take urgent steps to save this great nation. This is the time for every one to take a pledge that we shall hand over the land, water and air resources to our next generation in a better and more sustainable condition than we enjoyed it.

Qat issues

The qat issue becomes one of the most important issues affecting all segments of the Yemeni society, especially those working in irrigation. MAI and the Government are engaged in the formulation of clear policies dealing with Qat as a crop with negative impacts on farmers and the public health and the environment at large and water resources in particular. The approach to this crop should be treated in equal levels in. Therefore we find that it was approved to provide localized irrigation techniques in the context of Sana'a Basin Project.

Qat areas under groundwater irrigation represent around 25% of the total farm area under groundwater irrigation and consume more than 25% of groundwater used for irrigation. Until the

qat issue is seriously addresses, it is recommended that the installation of the improved irrigation systems in qat farms become mandatory and as soon as possible.

Potential water saving in qat irrigated areas

Average water requirement for qat per hectare per year is 7300 – 10000 cubic meters (see papers of 1st Qat conference) while average water savings for conveyance pipe system can reach between 25-30 percent.

In Sana'a governorate, for example, 22,000 hectares of Qat are irrigated. Given crop water requirements of 7300 – 10000 cubic meters per hectare, the total water demand per annum would come to 160 million cubic meters. Assuming that only one third of farmers have installed conveyance pipes, the estimated water savings per year for the remaining two-thirds could equal the domestic water needs for the entire city of Sana'a.

The total area of qat in Yemen is given as 153,000 hectares, of which 81 percent is irrigated by groundwater (124,000 hectare) amounting to 904 million cubic meters per year. With two thirds of farmers applying basic conveyance pipes, savings of 25 percent would amount to 226 million cubic meters per annum. This is my be equal of what the Sana'a basin currently abstracts from its aquifers (250 million cubic meters) for agricultural, industrial and domestic demand

It is widely known that the present critical problem can be postponed and addressed to a great extent by (i) improvement of efficiencies of water use per drop of water thereby conserving water, water harvesting and improving agricultural production; and (ii) reduction of qat areas in a systematic manner by reducing the demand. It is widely known that without reducing qat demand, qat production can not be controlled.

LESSONS LEARNED

The following lessons have been learned from the projects completed or on-going:

- We have so far covered only 10 % of the groundwater irrigated area under modernized irrigation systems and that too in patches and not contiguous areas. It is likely that the water saved by the 10 % area is utilized by the remaining 90 % area not covered under modernized irrigation system and for which there is no obligation (like under the Tripartite Agreements for the 10 % of the area) not to use the saved water.
- The project(s) so far have been focusing on small and poor farmers and large farmers which consume bulk of the groundwater are not covered by project intervention. In order that savings effected by small farmers are not consumed by large farmers, we should cover large farmers also under project intervention;
- The projects undertaken so far envisage about 50 % subsidies for the modernized irrigation systems on a sliding scale with more subsidies for small/poor farmers and smaller subsidies for large farmers. In order to make the use of modern irrigation systems sustainable and to ensure that these can be replicated in other areas after successful demonstrations under the projects taken up so far, it is necessary that the subsidies to farmers should be lifted gradually say in the next 10 years (@ 25 % in each 5-year period). The Water User Groups (WUGs) / Water User Associations (WUAs) can play an important role in achieving this goal; and

- The WUGs / WUAs established under the various projects are not sustainable in the absence of resources after the projects close. The WUGs / WUAs can assist a lot in conservation / control of the use of groundwater, which is very critical for Yemen by communicating with the farmers. The whole issue requires to be reviewed and for some period say 5 years after the closure of the project these organizations need to be provided support and methods devised to see that these become self supporting after the closure of projects and become sustainable.

RECOMMENDATIONS

Recommendations for groundwater in normal irrigated areas

⇒ Prepare a plan to systematically cover the entire groundwater irrigated area of over 450,000 ha with improved irrigation systems with in the next 10-15 years, requiring an investment of about US$ 30 million per year. This investment can be met through foreign assistance and through AFPPF;

⇒ The project intervention should not be confined to small farmers only but the large farmers should also be covered;

⇒ The subsidies being provided to farmers should be lifted gradually in the next 10 years;

⇒ The whole issue of sustainability of WUGs / WUAs should be reconsidered and support provided to these for at least 5 years after the closure of projects and methods devised to ensure their sustainability after this period without government support.

Recommendations to improve irrigation efficiency and make groundwater irrigation farming sustainable

⇒ Increase subsidy level on localized on-farm irrigation systems to be comparable or higher than the subsidy level granted to farmers for the installation of piped conveyance system, to encourage more farmers to adopt these modern technologies and subsequently saving of more groundwater;

⇒ Increase the ceiling of farm size to be covered by piped conveyance (to be up to 20 ha) and increase the ceiling of farm size to be covered by localized on farm irrigation system (to be up to 5 ha) for interested farmers;

⇒ All large farmers should be obliged to install piped conveyance system /localized on-farm irrigation systems in their farms within 5 years. The mechanism to implement this initiative may be considered later. (i.e. the installation of improved irrigation systems / localized on farm irrigation system become mandatory for large farmers).

⇒ IAS is an innovative endeavour adopted by the GSCP, however it is observed that the integration of the IAS activities with extension specialist in the Agric. Offices during farmer's field days held in the demonstration farms was very instrumental in providing a comprehensive package. Accordingly it is recommended that utmost cooperation and coordination between the IAS and the extension specialist be institutionalized.

⇒ Reasonable funds should be granted to the Agricultural Research Authority to conduct intensive research on crop varieties that require low quantity of water for irrigation and that produce good quality and reasonable yield, including research on deficit irrigation, especially for high water demanding crops.

⇒ Qat areas under groundwater irrigation represent around 25% of the total farm areas under groundwater irrigation and consume more than 25% of groundwater used for irrigation.

Until the Qat issue is seriously addresses, it is recommended that the installation of the improved irrigation systems in Qat farms become mandatory and as soon as possible.

Recommendations to improve the efficient utilization of surface water

⇒ For more benefit from the rainfall MAI should expand the construction of dams, water harvesting spate irrigation structures as well as terraces rehabilitation.

⇒ The ownership of the relatively large spate structures should be shared between the farming communities and the local administration including the contribution towards the construction cost. i.e. beneficiaries contribution be 5% and the district should be 10% and the rest would be from the projects (the donor).

⇒ The maintenance of the relatively large spate structures is high and should be shouldered by the local administration with regular nominal fees to be collected by the local administration (the districts) from the beneficiaries/ farmers but by in large the maintenance cost should be covered from the districts budget.

⇒ MAI efforts to rehabilitae abondoned terraces, provide tested seeds, enhance the adaptive resarch for local varieties and agricultural practices to achieve high productivity. i.e. terrace farming deserve more subsidy to maintain this heritage and keep it sustainable.

Recommendations to address the qat Issue

- All possible methods of creating mass awareness among the people relating to following should be resorted to:
  - critical water situation in the country;
  - conservation of water;
  - reducing Qat demand through awareness campaign
  - Incentives for replacing Qat by other less water consuming cash crops like Almonds, coffee etc.
  - ill effects of Qat consumption on health and nutrition status of people and on water depletion
  - non-transfer of water through tankers for irrigation of Qat
  - non-transfer of water to other basins/sub-basins except for drinking
  - creating awareness among farmers for areas which have the annual groundwater depletion rate of over 3 m/year;
    - Installation of the Localized Irrigation Systems should be enforced in all Qat areas. It is recommended that this should be done within next 4-5 years;
    - Incentives / Subsidies should be provided to farmers, NGOs and privet companies who replace Qat by other crops like Almonds and Coffee etc.

It is widely known that without reducing Qat demand, Qat production can not be controlled.

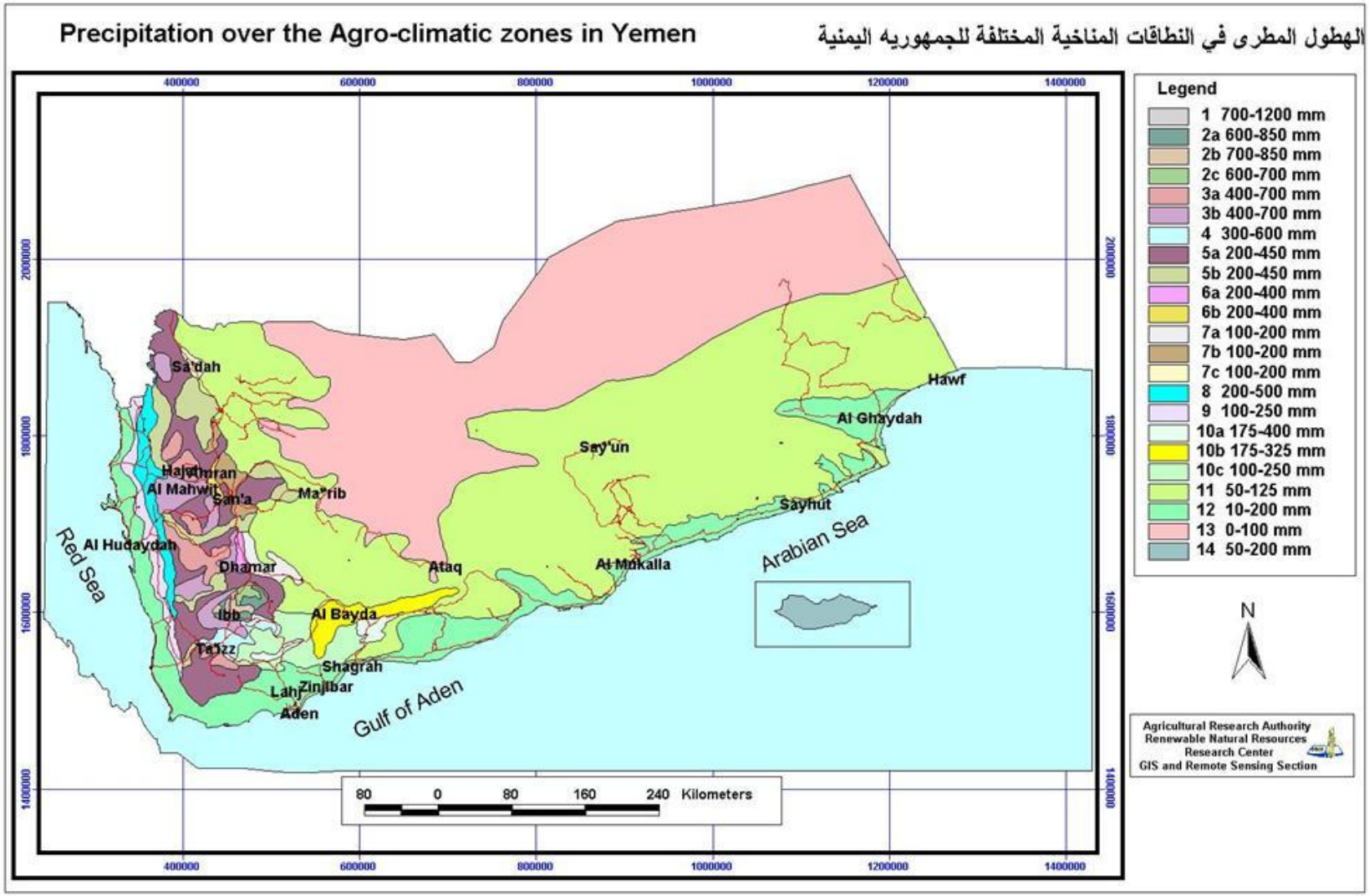
TAKE HOME MESSAGES

- More income for less water is possible
- There is a public interest in subsidizing irrigation improvement but it has to be done as efficiently as possible

- Farmers, MAI and MWE/NWRA have to work together to save water cooperatively – for example, through WUAs at the sub-basin level

- We need to work out ways of supporting rainfed agriculture sustainably

- For qat, we have to work on the demand side but also on alternative markets and crops.


Precipitation over the Agro-climatic zones in Yemen
الهطول المطرى في النطاقات المناخية المختلفة للجمهوريه اليمنية
Legend
1 700-1200 mm
2a 600-850 mm
2b 700-850 mm
2c 600-700 mm
3a 400-700 mm
3b 400-700 mm
4 300-600 mm
5a 200-450 mm
5b 200-450 mm
6a 200-400 mm
6b 200-400 mm
7a 100-200 mm
7b 100-200 mm
7c 100-200 mm
8 200-500 mm
9 100-250 mm
10a 175-400 mm
10b 175-325 mm
10c 100-250 mm
11 50-125 mm
12 10-200 mm
13 0-100 mm
14 50-200 mm
Sa'dah
Hajjah
Al Mahwit
San'a
Ma'rib
Say'un
Hawf
Al Ghaydah
Sayhut
Al Hudaydah
Dhamar
Ataq
Al Mukalla
Ibb
Al Bayda
Taizz
Shagrah
Lahj
Zinjibar
Aden
Red Sea
Arabian Sea
Gulf of Aden
N
80 0 80 160 240 Kilometers
Agricultural Research Authority
Renewable Natural Resources
Research Center
GIS and Remote Sensing Section

الأحواض والمساقط المائية في الجمهورية اليمنية

Drainage Basins & Watersheds of Yemen