APPENDIX: DIAGNOSTIC REPORT

Study on Strategic Orientation and Reorganization of the Irrigation Sector

62/CS/IRR/WSSP/11
October 2013
Foreword

This diagnostic report is part of the Study on the Orientation/Restructuring of the Irrigation Sector. It is based on interviews, discussion and review of documents and data analysis. It discusses current (1) Irrigation Water Use (2) Institutions, (3) Economics and Financing and (4) Legal Provisions.

The Diagnostic Report is meant as the main basis for the (draft) Final Report, which will outline how current strategies and policies in water management in Yemen can be implemented with the help of a restructured and realigned irrigation sector.
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CHAPTER 1

Irrigation Water Use
Irrigation

- Employment for future generation?
- Largest water consumer: 92%
- Heavily subsidized (though reducing)
- Long term food security?
- Link with private sector?
1 Irrigation Water Use

Although Yemen has a long and outstanding history of water resource management and irrigation, the rapid population growth during the last decades has made water and food security a major challenge. The current annual population growth rate of 3.7% is one of the highest in the world. It is expected that the present population of about 25 million will increase to about 37.9 million in 2021 and 53.4 million in 2031.

As a result of the rapid population growth, the current per capita availability of water of 116 m$^3$ per year, which is already the lowest in the world, will drop to 55 m$^3$ per year in 2031. In the MENA region, the average per capita water availability is 667 m$^3$ per year and the world average is 7,500 m$^3$. According to international norms, a minimum of 100 m$^3$ per capita per year is necessary to meet domestic requirements and 1,000 m$^3$ for food self-sufficiency (MAI, 2013).

Urban centres in Yemen have seen a large influx of people from rural areas and they can barely cope with supplying sufficient water to all inhabitants. Access to safe water is still low in Yemen with 56% of the urban population and 45% of the rural population having access to safe water supply in 2007 (Al-Eryani et al, 2011).

Irrigated agriculture in Yemen has developed enormously during the last four decades: the irrigated area using groundwater increased from 37,000 ha in 1970 to about 405,000 ha in 2012, whereas the spate-irrigated area expanded from 120,000 ha in 1970 to about 255,000 ha in 2012. (MAI, 2013). However, the rapid expansion of irrigated agriculture resulted in a serious over-exploitation of the renewable fresh water resources in the country. As a consequence, the groundwater level is decreasing between 2 to 6 metres annually in some basins and for instance in Dhamar Basin much of the groundwater up to 700 metres could be exhausted within the next 30 years. Other impacts of the over-exploitation of surface water are the drying up of wadi systems with spates reduced in quantity and frequency, as well as degradation of farmlands.

In this chapter, the existing and envisaged/planned management of available water resources in Yemen are described. This chapter first discuss the larger picture on agricultural development and food security in Yemen (section 1.1). It next discusses water resources availability including the likely effect of climate change (section 1.2). The last two sections discuss respectively the performance of the irrigation sector and the most important policies (sections 1.3 and 1.4).
1.1 Agriculture and Development in Yemen

1.1.1 Introduction

Yemen is classified by the United Nations as one of the Least Developed Countries (LDCs). In 2011, life expectancy for women was 64 years against 61 years for the male population. During the last 20 years, the scores on a number of social indicators have improved considerably in Yemen, except for access to safe potable water in rural areas:

Table 1.1: Social indicators

<table>
<thead>
<tr>
<th>Social indicator</th>
<th>1990</th>
<th>2000</th>
<th>2010-12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death rate (per 1000 people)</td>
<td>12</td>
<td>9</td>
<td>7 (2011)</td>
</tr>
<tr>
<td>Birth rate (per 1000 people)</td>
<td>52</td>
<td>39</td>
<td>32 (2011)</td>
</tr>
<tr>
<td>Fertility rate (births per women)</td>
<td>8.7</td>
<td>6.4</td>
<td>4.3 (2011)</td>
</tr>
<tr>
<td>Immunisation DPT (12-23 months old)</td>
<td>-</td>
<td>76</td>
<td>87 (2010)</td>
</tr>
<tr>
<td>Immunisation measles (12-23 months old)</td>
<td>-</td>
<td>71</td>
<td>71 (2011)</td>
</tr>
<tr>
<td>Child mortality &lt; 5 years (per 1000 live birth)</td>
<td>125</td>
<td>97</td>
<td>60 (2012)</td>
</tr>
<tr>
<td>Maternal mortality (per 100,000 live births)</td>
<td>610</td>
<td>380</td>
<td>200 (2010)</td>
</tr>
<tr>
<td>Literacy rate adult population</td>
<td>37% (1994)</td>
<td>55% (2005)</td>
<td>64% (2010)</td>
</tr>
<tr>
<td>Access to safe potable water (rural population)</td>
<td>59%</td>
<td>52%</td>
<td>47%</td>
</tr>
</tbody>
</table>

Despite the improvements that were made over the last two decades in which Human Development Index (HDI) has shifted on HDI from 0.402 in 1990 to 0.575 in 2009, the ranking of Yemen is still low: 140 out of 182 countries.

During the last two decades, the GDP per capita (current US$) increased significantly from US$ 479 in 1990 to US$ 1,494 in 2012. The annual GDP growth between 2008 and 2012 was erratic and has also suffered from the political turmoil in 2011-2012: 3.6% in 2008, 3.9% in 2009, 7.7% in 2010, -10.5% in 2011 and 0.1% in 2012.

There are other indicators that highlight the high and growing vulnerability of a large part of the population: the large proportion of families that resort to borrowing to pay for daily food necessities and widespread undernourishment – linked to food habits and diets as well as poverty (see 1.1.8.)

1.1.2 Role of agriculture in Yemeni economy

According UNDP’s MDG Report (2010), the agriculture sector in Yemen mainly depends on basic methods and rainfed farming, which make it vulnerable to extreme climate changes, such as drought and floods. The sector also faces various challenges and the most important of all is the scarcity of water resources. Although the agriculture sector absorbs almost 30% of the work force and accounts for 11.4% of GDP (current prices) during the period 2001-08, its exports did not exceed 1.2% of the gross non-oil exports in 2008. Arable land is estimated at 1.6 million hectares, of which the cultivated area is estimated at 1.3 million hectares. The agriculture land represents 2% of the total area of Yemen. The following statistical data related to agriculture in Yemen show that though crop production is increasing, agriculture’s share as part of national GDP is declining.
According to the World Development Indicators, the value added by the agriculture sector decreased from 24% of GDP in 1990 to 8% in 2010. During the same period, the crop production index increased considerably from 61.3 in 1990 to 143.4 in 2011. Similarly, the food production index rose from 56.6 in 1990 to 146.4 in 2011, although the cereal yield only improved slightly from 908 kg/ha in 1990 to 1,057 kg/ha in 2012. The proportion of the total population living in rural areas declined sharply from 79% in 1990 to 60% in 2012.

Taking in account the amount of people working in the agriculture sector, the contribution of agriculture to the GDP is disproportionally low, mainly due to subsistence farming and low productivity (WRAY 1992, NASS 2012, Al Abs, 2005). Also according to Egel (2011) income from wages and remittances and income from services are the most important sources of income in rural areas in Yemen, but in irrigated villages crop income exceeds that from remittances.

About 75% of the agricultural GDP is produced in the densely populated Upper and Lower Highlands (agro-ecological zones 1 and 2) where 30% and 40% of the total population are living. The production of qat accounts for about 6% of the total GDP, a third of the agricultural GDP, 14% of employment, GDP, 40% of the groundwater irrigated lands and over 50% of the extracted groundwater used for irrigation. Vegetables and fruits make up another one-third of agricultural GDP, whereas livestock and cereals contribute about 20% and 10% to agricultural GDP respectively (see also Annex 1).

Qat is almost exclusively concentrated in the highland agro-ecological zones 1 and 2, while other water-intensive crops, such as fruits and vegetables, are also grown in zone 3 (Red Sea and Tihama Plain). Agro-ecological zones 1 and 2 are the two main contributors to the agricultural GDP followed by zones 3, 5, 4 and 6. The latter three zones together account for only 8% of agricultural GDP.

### 1.1.3 Cropped area

The development of cropped area in Yemen between 1970 and 2012 is presented in table 1.3.
### Table 1.3: Cropped area (ha)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater irrigated area</td>
<td>37,000</td>
<td>410,000</td>
<td>453,616</td>
<td>405,264</td>
<td>995%</td>
</tr>
<tr>
<td>Spring irrigated area</td>
<td>73,000</td>
<td>n/a</td>
<td>29,492</td>
<td>40,527</td>
<td>-44%</td>
</tr>
<tr>
<td>Spate irrigated area</td>
<td>120,000</td>
<td>n/a</td>
<td>147,602</td>
<td>255,175</td>
<td>113%</td>
</tr>
<tr>
<td>Subtotal irrigated area</td>
<td>230,000</td>
<td>n/a</td>
<td>630,710</td>
<td>700,966</td>
<td>205%</td>
</tr>
<tr>
<td>Rainfed area</td>
<td>1,056,000</td>
<td>610,000</td>
<td>614,185</td>
<td>735,480</td>
<td>-30%</td>
</tr>
<tr>
<td><strong>Total cropped area</strong></td>
<td>1,290,000</td>
<td>1,200,000</td>
<td>1,484,852</td>
<td>1,500,973</td>
<td>16%</td>
</tr>
</tbody>
</table>

Source: MIA (2013)

Between 1970 and 2012, the total cropped area increased by 16% from 1.29 million ha to 1.50 million ha, despite a 30% decline in rainfed area from 1.06 million ha in 1970 to 0.74 million ha in 2012. During the same period, the total irrigated cropped area increased by 205% from 230,000 ha in 1970 to about 700,000 ha in 2012, mainly due to a sharp expansion of groundwater irrigated area (995%) and spate-irrigated area (113%). In 1970, about 18% of the total cropped area was under irrigation against 47% in 2012. An interesting trend is that the area under groundwater irrigation appears to have declined since 2007 (-12%). According to some sources it is mainly the area under *qat* that is expanding. On the other hand a more detailed assessment of four important sub-basins undertaken under GSCP with the use of advanced remote sensing suggest that the area under perennial irrigation increased with 6% from 2006-2010.

#### 1.1.4 Cultivated crops

The area used for the cultivation of cereals, horticultural crops, fodder crops and *qat* is shown in table 1.4.

### Table 1.4: Cultivated crops 1970-2012 (ha)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals crops</td>
<td>1,082,000</td>
<td>660,000</td>
<td>890,633</td>
<td>854,689</td>
<td>-21%</td>
</tr>
<tr>
<td>Irrigated fruits and vegetables</td>
<td>39,000</td>
<td>163,000</td>
<td>169,884</td>
<td>183,896</td>
<td>372%</td>
</tr>
<tr>
<td>Fodder crops</td>
<td>40,000</td>
<td>n/a</td>
<td>147,007</td>
<td>158,546</td>
<td>296%</td>
</tr>
<tr>
<td><em>Qat</em></td>
<td>8,000</td>
<td>109,000</td>
<td>141,000</td>
<td>147,682</td>
<td>1,746%</td>
</tr>
</tbody>
</table>

Source: MAI (2013)

Between 1970 and 2012, the area used for the cultivation of *qat* increased by 1,746% from only 8,000 ha to 147,682 ha. During the same period, the area under horticultural and fodder crops also expanded considerable with 372% and 296% respectively. The area used for cultivating cereals decreased by 21% from 1.08 million ha in 1970 to 0.85 million ha in 2012. As explained later this has caused Yemen to become increasingly dependent on the import of staple crops.

#### 1.1.5 Crop yields

Crop yields in the highlands vary greatly depending upon the agro-ecological zone, rainfed or irrigated, and management practices. In rainfed areas, crop failures occur often due to erratic rainfall. It is difficult to find reliable data on crop yields under spate irrigation area in the highlands. As a proxy, crop yields under rainfed cultivation and groundwater irrigation may be taken with the crop yields under spate irrigation may be between these two yields (see table 1.5) (Al-Shaybani 2003).
Table 1.5: Main crops and crop yields under Rainfed-irrigated area in the Highlands

<table>
<thead>
<tr>
<th>Crop</th>
<th>Rainfed Median yield (tons/ha.)</th>
<th>Rainfed Ranges (tons/ha.)</th>
<th>Irrigated Median yield (tons/ha.)</th>
<th>Irrigated Ranges (tons/ha.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorghum*</td>
<td>0.7</td>
<td>F-1.2</td>
<td>1.8</td>
<td>1.5-3.0</td>
</tr>
<tr>
<td>Barley*</td>
<td>0.7</td>
<td>F-1.0</td>
<td>2.0</td>
<td>1.5-2.5</td>
</tr>
<tr>
<td>Wheat*</td>
<td>1.0</td>
<td>F-1.2</td>
<td>2.0</td>
<td>1.0-3.0</td>
</tr>
<tr>
<td>Alas*</td>
<td>0.7</td>
<td>F-1.0</td>
<td>1.8</td>
<td>1.3-2.5</td>
</tr>
<tr>
<td>Lentils*</td>
<td>0.6</td>
<td>F-1.0</td>
<td>1.0</td>
<td>0.7-1.4</td>
</tr>
<tr>
<td>Peas*</td>
<td>0.6</td>
<td>F-0.9</td>
<td>1.0</td>
<td>0.7-1.4</td>
</tr>
<tr>
<td>Maize*</td>
<td>1.3</td>
<td>F-2.2</td>
<td>2.0</td>
<td>1.0-3.0</td>
</tr>
<tr>
<td>Millet**</td>
<td>0.8</td>
<td>F-1.2</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Assume the following Stover/grain ratios: sorghum 4.0 wheat and barley 1.0; maize 1.5; pulses 2.0.

**Green weight of six to seven cuts at 25% dry matter.


The crop yields in the coastal region fluctuate due to the different types of local cultivars grown with different yield potentials as well as a wide range of planting dates during the two flood periods. Variation in crop yields may also be caused to the fact whether the crop is the main or secondary crop and whether fertilisers, herbicides and pesticides are used (see table 1.6 and 1.7) (Al-Shaybani, 2003).

Table 1.6: Main crops and crop yields under spate irrigation in the coastal area of Tihama (Red Sea coast)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Average yield (tons/ha.)</th>
<th>Ranges (tons/ha.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>1.3</td>
<td>1.1-1.5</td>
</tr>
<tr>
<td>Sorghum</td>
<td>2.75</td>
<td>2.0-3.5</td>
</tr>
<tr>
<td>Cotton</td>
<td>1.0</td>
<td>0.65-1.35</td>
</tr>
<tr>
<td>Sesame</td>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>Tomato</td>
<td>9.5</td>
<td>9.0-10.0</td>
</tr>
<tr>
<td>Vegetable</td>
<td>16.0</td>
<td>16.0</td>
</tr>
<tr>
<td>Fruits</td>
<td>17.5</td>
<td>15.0-20.0</td>
</tr>
</tbody>
</table>

Source: Abraham Adoni, Spate irrigation workshop 22-24 November 1998

Table 1.7: Main crops and crops yields under spate irrigation in the coastal area of Aden Gulf

<table>
<thead>
<tr>
<th>Crop</th>
<th>Average yield 8 seasons (Tons/ha.)</th>
<th>Ranges (tons/ha.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorghum and Millet</td>
<td>0.96</td>
<td>0.73-1.2</td>
</tr>
<tr>
<td>Cotton Extra Long Staple</td>
<td>0.91</td>
<td>0.865-0.95</td>
</tr>
<tr>
<td>Cotton Medium Staple</td>
<td>1.30</td>
<td>0.98-1.63</td>
</tr>
<tr>
<td>Sesame</td>
<td>0.50</td>
<td>0.36-0.64</td>
</tr>
<tr>
<td>Melons</td>
<td>10.90</td>
<td>7.78-14.1</td>
</tr>
<tr>
<td>Groundnuts</td>
<td>1.24</td>
<td>1.24</td>
</tr>
</tbody>
</table>

During the Participatory Spate Irrigation Management Study, the yields for main crops grown in the command areas of different spate irrigation systems in the lowlands were collected and they are presented in table 1.8.
Table 1.8: The yields of main crops grown in the command areas of different spate irrigation systems

<table>
<thead>
<tr>
<th>Crop</th>
<th>Wadi Tuban</th>
<th>Wadi Bana</th>
<th>Wadi Hassan</th>
<th>Wadi Siham</th>
<th>Wadi Rima</th>
<th>Wadi Zabid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>1.32-2.02</td>
<td>1.28</td>
<td>1.28</td>
<td>0.525</td>
<td>0.63</td>
<td>1.2-1.9</td>
</tr>
<tr>
<td>Sorg-hum grains –</td>
<td>0.77-1.85</td>
<td>0.98</td>
<td>0.98</td>
<td>0.83</td>
<td>0.97</td>
<td>0.8-1.3</td>
</tr>
<tr>
<td>Sorg-hum fodder</td>
<td>0.81-1.1</td>
<td>11.5</td>
<td>1.02</td>
<td>Sorg-hum fodder</td>
<td>6.8-8.8</td>
<td></td>
</tr>
<tr>
<td>Sesame</td>
<td>0.65-0.88</td>
<td>1.2</td>
<td>0.71</td>
<td>Sesame</td>
<td>0.49-0.71</td>
<td></td>
</tr>
<tr>
<td>Groud-nut</td>
<td>0.53-0.78</td>
<td>0.71</td>
<td>8.73</td>
<td>Maize</td>
<td>2.78-3.7</td>
<td></td>
</tr>
<tr>
<td>Watermelon</td>
<td>8.73</td>
<td>Watermelon</td>
<td>5.86</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweet melon</td>
<td>5.86</td>
<td>Sweet melon</td>
<td>0.98</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Participatory Spate Irrigation Management Study

These yields in spate-irrigated systems are low compared to similar spate irrigated areas in North and East Africa for instance. Sorghum grain yields in Ethiopia average 2.0 tons/ha, whereas in Eritrea they may reach 2.8 tons/ha. On the other hand sorghum grain yields in Pakistan are of the same – equally low – order of magnitude (0.6-1.0 ton/ha. There is a number of explanations: the more intense water management and more concentrated command areas in Ethiopia and Eritrea, allowing second or third irrigation turns and also the lower incidence of mesquite (prosopisjuliflora) investment – an invasive species that in Yemen has seriously impacted the spate command areas.

Similarly, the productivity of irrigated crops in Yemen is low compared with other countries in the region. The yields for potato, tomato, banana and orange in Yemen, Lebanon and Jordan are shown in table 1.9. They are significantly higher – a factor 2 – in the latter two countries.

Table 1.9: Comparison of Irrigated Crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yemen (Tons/ha)</th>
<th>Lebanon (Tons/ha)</th>
<th>Jordan (Tons/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potato</td>
<td>13</td>
<td>25.5</td>
<td>31.3</td>
</tr>
<tr>
<td>Tomato</td>
<td>16</td>
<td>33.5</td>
<td>41.2</td>
</tr>
<tr>
<td>Banana</td>
<td>7.4</td>
<td>18.9</td>
<td>37.5</td>
</tr>
<tr>
<td>Orange</td>
<td>1.8</td>
<td>13.5</td>
<td>36.3</td>
</tr>
</tbody>
</table>

Source: MAI (2013)
1.1.6 Agricultural production

Based on FAOstat data, the quantity and value of the production of main agriculture commodities in Yemen for 2005 are presented in table 1.10. In terms of production value qat and mangoes top the list and are almost of a ‘different category’ (see also chapter 3).

<table>
<thead>
<tr>
<th>Rank</th>
<th>Commodity</th>
<th>Production ('000 US$)</th>
<th>Production (MT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Qat</td>
<td>1,004,762¹</td>
<td>121,399²</td>
</tr>
<tr>
<td>2</td>
<td>Mangoes, guavas</td>
<td>206,653</td>
<td>344,901</td>
</tr>
<tr>
<td>3</td>
<td>Indigenous chicken meat</td>
<td>159,925</td>
<td>112,275</td>
</tr>
<tr>
<td>4</td>
<td>Indigenous cattle meat</td>
<td>153,767</td>
<td>56,922</td>
</tr>
<tr>
<td>5</td>
<td>Tomatoes</td>
<td>75,556</td>
<td>204,446</td>
</tr>
<tr>
<td>6</td>
<td>Cow milk, whole, fresh</td>
<td>67,595</td>
<td>216,608</td>
</tr>
<tr>
<td>7</td>
<td>Indigenous sheep meat</td>
<td>64,888</td>
<td>23,832</td>
</tr>
<tr>
<td>8</td>
<td>Grapes</td>
<td>61,593</td>
<td>107,753</td>
</tr>
<tr>
<td>9</td>
<td>Sorghum</td>
<td>48,630</td>
<td>330,330</td>
</tr>
<tr>
<td>10</td>
<td>Hen eggs, in shell</td>
<td>40,109</td>
<td>48,360</td>
</tr>
<tr>
<td>11</td>
<td>Onions, dry</td>
<td>36,359</td>
<td>173,112</td>
</tr>
<tr>
<td>12</td>
<td>Potatoes</td>
<td>33,744</td>
<td>217,759</td>
</tr>
<tr>
<td>13</td>
<td>Tobacco, unmanufactured</td>
<td>28,182</td>
<td>17,694</td>
</tr>
<tr>
<td>14</td>
<td>Indigenous goat meat</td>
<td>26,440</td>
<td>11,035</td>
</tr>
<tr>
<td>15</td>
<td>Bananas</td>
<td>25,320</td>
<td>89,905</td>
</tr>
<tr>
<td>16</td>
<td>Chick peas</td>
<td>18,142</td>
<td>37,479</td>
</tr>
<tr>
<td>17</td>
<td>Watermelons</td>
<td>16,428</td>
<td>144,212</td>
</tr>
<tr>
<td>18</td>
<td>Wheat</td>
<td>16,426</td>
<td>112,963</td>
</tr>
<tr>
<td>19</td>
<td>Oranges</td>
<td>16,230</td>
<td>83,979</td>
</tr>
<tr>
<td>20</td>
<td>Dates</td>
<td>15,316</td>
<td>29,990</td>
</tr>
</tbody>
</table>

Qat in particular is a crop that compares to no other agricultural commodity in Yemen – in terms of economic and environmental impact. Various reports (i.e. (World Bank 2007; Gatter & Al Asbahi, 2009; Ward & Gatter, 2000; JAR on Qat issues) have been written about qat, including the effect of qat consumption on people’s health (also due to pesticide use), sharp increase in demand and production of qat, the water consumed for the cultivation of qat, regulation and control of qat consumption and production, and alternatives to qat production.

The government has issued decrees aimed at awareness raising, promotion of alternative means of leisure, and regulation of qat consumption and use of chemicals during qat production. So far, however, limited measures have been carried out due to the absence of a clear vision among various

¹Based on data suggesting that qat contributed 6% to GDP in 2005 (Gatter & Al Asbahi, 2009) and GDP data from the World Bank (http://data.worldbank.org)
²Source: NASS 2012
government organisations, no policy had been formulated, and lack of financial resources to implement the decrees (Gatter & Al Asbahi, 2009).

The following numbers related to the production and consumption of qat demonstrate its social and economic importance:

- Average qat consumption requires 10% of people’s income; expenditures on qat are of the same order of magnitude as expenditures on health (Egel 2011). For better off people qat expenditures are even higher.
- Qat production represents 6% to the country’s GDP in 2005 (Gatter & Al Asbahi, 2009);
- Nearly one-third of the agricultural labour force is engaged in qat production (World Bank, 2007) making it the second largest source of employment in the country and exceeding employment in the public sector (Gatter & Al Asbahi, 2009);
- Net profits range from YER 400,000 to YER 1,800,000 per ha (US$2,500 to US$11,000 per ha) (World Bank, 2000);
- Formal consumption tax of 20% on qat sales but the collection rate of this tax is very low (World Bank, 2000): suggestion has been made to improve enforcement or to reduce the consumption tax to 10% to increase the total tax revenue;
- One-third of the total annual groundwater abstraction of 1.5 BCM is used for irrigating qat (Gatter & Al Asbahi, 2009); and
- Qat is 10 to 20 times more profitable than most competing crops (Ward, C. & P. Gatter, 2000).

These figures clearly show that the production and consumption of qat contributes significantly to the Yemeni economy, in particular the transfer of money from urban to rural areas as well as the highly effective marketing system in place. It is essential to consider these numbers and facts in the discussions on qat. The rapid expansion of qat production has contributed to the depletion of groundwater resources and it has replaced the production of food crops and the cultivation of important export crops, such as coffee. As a result, poor rural households have less access to essential food crops due to reduced availability in local rural markets and/or higher market prices. Furthermore, Yemen as a country has to import more food crops, especially wheat. The balance is that the production of qat has meant has been the most dynamic element in the rural economy and has for instance often caused terraces and watershed to be maintained and in some cases even

---

*Figure 1 Rural Livelihoods in Yemen before the crisis*

newly developed. (In fact according to Egel (2011) – contrary to conventional wisdom 0–80% of the terraces in Yemen are maintained).

Numerous recommendations on the production, marketing and consumption of qat have been formulated. With regard to the production of qat, it is recommended to introduce (or even enforce the introduction) of efficient irrigation techniques in order to reduce the amount of groundwater abstraction. With regard to marketing, it is suggested to import qat from other countries, such as Ethiopia, where it could be grown as a rainfed crop. To reduce the demand for qat, it is recommended to tax the consumption of qat similar as for cigarettes (World Bank, 2007).

1.1.7 Agricultural research and opportunities for improved water productivity

At present, the Agricultural Research and Extension Authority (AREA) is the main organisation responsible for the generation and transfer of agricultural technology. AREA has established regional agriculture research centres in different parts of the country to cover various crops and agro-ecological zones. AREA maintains close collaboration with national and international research centres, such as CIMMYT, ICARDA and ICRISAT. In addition, some universities are also involved in agricultural research. The weak link is the connection between research and extension: over the years AREA’s involvement in extension has declined.

<table>
<thead>
<tr>
<th>Table 1.11: Agricultural research in Yemen</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Solution area</strong></td>
</tr>
<tr>
<td>1. Bridging the yield gap</td>
</tr>
<tr>
<td>Using best known realistic management practices lbybettee extension and input availability</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>2. Smart Varieties</td>
</tr>
<tr>
<td>Higher yielding varieties</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Pest smart varieties</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Recourse smart</td>
</tr>
<tr>
<td>3. Clever crop agronomy</td>
</tr>
<tr>
<td>Efficient fertilizer use</td>
</tr>
<tr>
<td>Boron application</td>
</tr>
<tr>
<td>Zinc folar spray</td>
</tr>
<tr>
<td>4. Better groundwater irrigation management</td>
</tr>
<tr>
<td>Precision Irrigation</td>
</tr>
<tr>
<td>Better conveyance systems</td>
</tr>
<tr>
<td>Land levelling and basins</td>
</tr>
<tr>
<td>5. Better spate water management</td>
</tr>
<tr>
<td>Improved spate management</td>
</tr>
</tbody>
</table>
This however constitutes a major missed opportunity. According to Ward and Naif (2011) quoting figures from NWRA, there is a considerable yield gap. The actual crop yields for main crops irrigated crops are only 20 to 40% of the optimum. The largest gap is for alfalfa (19% of optimum) followed by qat (27%). For grapes, banana, oranges and mango, the yield gap is respectively 40%, 42%, 46% and 51% of the optimum. To address the observed yield gap, agricultural research is focused on improved high yielding crop varieties for cotton (i.e. Kod-94, Al-Muallem-2000), onion (i.e. yellow Baftaim), wheat (i.e. MA-2-1, MA-2-8, MA-2-9, Qa'a Elhaql-7), barley (i.e. Al-erra 2003-5a-11 and Al-erra2003-8a-21), faba bean (i.e. Giza-3), maize (i.e. Taiz 2) and sorghum (i.e. IS-3461). In addition, agricultural research is also focused on: i) efficient fertiliser use; ii) improved disease control; iii) bio-stimulants (i.e. boric acid, zinc); iv) mixed/intercropping; v) mechanisation; and vi) improved on-farm irrigation.

In the table 1.11 some main studies from Yemen – many from AREA - are summarized that indicate the scope for improved production by better varieties, new agronomic practices and in general farmers making use of knowledge that exists. They suggest a large scope for improved water productivity in Yemen – by increasing yields, but also better use of water and fertilizer. The findings from these multiple studies corroborate the observed low agricultural yields in Yemen compared to other countries (see section 1.1.5) and suggest that there is much to gain by more research and better linkage and services to farmers.

Moreover a number of (innovative) practices that have proven their added value in increasing yields globally are as yet not tried out in Yemen, such as:

- Use of plastic mulch and greenhouse farming
- Application of bio-fertilizer
- Use of zeolite and other rock/clay dusts (box 1.1)

**Box 1.1 Use of zeolite rocks**

Due to its unique structure, zeolite rocks functions as a slow water and nutrient release system and it could be considered as a banking system, whereby the ‘deposit’ of water and nutrients provided by the farmers to the soil is returned by the zeolite rocks with ‘interest’ over the season. First trials with zeolite use in Yemen were performed last three years by GSMB (Geologic Survey and Mineral Resources Board). Preliminary results of zeolite use in zucchini vegetable production shows that the zeolite reduced the irrigation water consumption by 30%. Also the yield of the crop increased, while costs on fertilizers were reduced by 40%. The benefits are multiple, but can be summarized as below:

**Water storage benefits**

- Decreases water runoff and ponding
  - Increases amount of water available to plants
  - Increases length of time between irrigations
- Decreases occurrence of localized dry spots

**Soil structure benefits**

- Breaks down clay clumping
- Improved root development and aeration
- Provides buffering capacity by balancing soil pH

**Fertiliser benefits**

- Increases fertiliser use efficiency, particular by binding K and NH4+
- Reduces nitrogen use and ammonia volatilisation
- Reduces alkalinity effects
Yemen has very extensive and high quality deposits of zeolite – located close to major agricultural production areas (Taiz, Ibb, Tihama).

1.1.8 Import of agricultural commodities

In the past decades Yemen has turned from near self-sufficiency for its major staples to becoming highly dependent on the import. Yemen imports up to 90% of its wheat and 100% of its rice. The import of essential food commodities between 2004 and 2010 is presented in figure 2.

Figure 2 Import of major agricultural food products

![Graph showing import of major agricultural food products]

Source: FAOstat (2013)

Between 2004 and 2010, the import increased from almost 2 million tons to 2.8 million tons. During the same period, the import of maize augmented from about 182,000 tons to about 380,000 with a peak of 500,000 tons in 2009. The import of sugar rose from 390,000 tons to almost 670,000 tons. As food prices have become more volatile, risks have greatly increased – with further increases in grain prices having a severe impact on the economy of the country.

In addition to the import of mainly cereals and sugar, Yemen also exports agricultural produce, in particular bananas and onions (see figure 3).
Between 2004 and 2010, the export of onions increased by 140% from about 35,000 tons to almost 85,000 tons. The export of bananas grew from almost 40,000 tons in 2004 to about 85,000 tons in 2009 but dropped to about 57,000 tons in 2010. Similarly, the export of fodder crops increased from about 46,500 tons in 2004 to almost 124,000 tons in 2007 but declined to around 14,500 tons in 2010.

### 1.1.8 Employment and poverty

Unemployment has increased from 13.7% in 1999 to 15% in 2008, of which 11.5% male and 40.9% female. This is attributed to the fact that total workforce in the agriculture and fishery sector has dropped from 43.9% in 1999 (male 43.1% and female 53.1%) to 31% in 2004 (male 30.1% and female 41.5%), which is mainly due to drought, urbanization and increased poverty among rural population. Moreover, unemployment and underemployment among youth is estimated at 53-60% (UNDP, 2010, Egel 2011). According to UNDP’s MDG Report (2010), 46.6% of the total population lived on less than US$ 2 per day in 2005. In same year, 34.8% of the total population lived under the national poverty line against 40.1% in the rural areas. About 45% of the total poor in Yemen lives in rural areas of five governorates: Taiz, Hodeidah, Hajjah, Ibb, and Amran.

In 2012, 60% of the population of Yemen arriving in rural areas 2012. It is estimated that 75% of rural people is dependent on the agricultural sector. According to World Development Indicators, 45.3% of the income in Yemen was earned by the richest 20% of the population in 2005, while the poorest 20% earn 7.2%. The distribution of average rural household incomes in Yemen is shown in figure 4.
WFP and UNICEF (2006) found that most households relied on salaries and wages as main income source (30%), followed by skilled and unskilled labour (26%) and remittances (9%). Agriculture, livestock and fishing account as main income source for 8% of households, while qat features as the major income for 2% of households (WFP & UNICEF 2006). The picture is different for irrigated areas: here crop income is the second largest income source, after salaries and wages (Egel 2011). According to the WFP high food price study, the main source of income was non-agricultural wage labour, though a quarter of the population reports having more than one source of income (see figure 5). Households, who are able to sell agricultural produce or generate income through petty trade, are less vulnerable than those relying on fixed incomes (i.e. pensions, remittances). Over 50% of households relying on remittances and/or pensions as their primary source of income are food insecure (WFP 2008).
1.1.9 Food security

Since ancient history Yemen has always been on the crossroads of food/spices and produce trails. Food products have entered and left the country, with imports and exports and local produce allowing for a balance with local demand. In the last decades, however, Yemen has seen a sharp increase in population and increase in demand per capita that has far outrun the production capabilities of the country’s land and water resources.

In Yemen, economic access to food is a main food security issue. Food and agriculture-related processing makes up about 50% of household consumption expenditures. (Breisinger et al. 2011) Large number of rural households produces a small proportion of their food needs and they rely heavily on other sources of income to buy food items. Low purchasing power due to limited sources of cash income and high food prices are determinants of food insecurity and malnutrition.

Annual growth in the production of cereals, including sorghum, wheat, coffee and honey has been achieved even though outmoded technologies are still used by farmers. Despite this growth, the World Food Programme identified that 24% of households to be food insecure in 2012. However, there are substantial differences in the geographic distribution of food insecure households (see figure 6). More than 50% of the half a million food insecure households in Yemen are located in Ibb, Hodeida, Taiz, and Hajja.
In 2004, the prevalence of food insecurity ranged from 8% in Sana'a City to 44% in Shabwa. Other governorates with a relatively high proportion of food insecure households include Sa’ada (40%), Hajja (36%), Ibb (29%) and Al-Mahra (29%). On the other end of the spectrum, several governorates have below average prevalence rates of food insecurity, including Sana’a City with 8% followed by Sana’a (10%), Addaleh (13.5%), and Aden (14.6%). Variation of food insecurity is higher within than across governorates, mainly due to differences in agricultural productivity and natural resources, remittances received, and proximity to markets.

According to the Global Hunger Index (GHI) developed by IFPRI to measure and track hunger using three equally weighed indicators (i.e. undernourishment, child underweight and child mortality); the situation in Yemen is alarming. Between 1990 and 2013, the GHI score for Yemen improved slightly from 29.8 in 1990 to 26.5 in 2013 (see figure 7).

According to UNDP’s MDG Report (2010), the rate of population suffering from food poverty was 12.5% in 2005, ranging from only 2.1% in Aden and 2.2% in Al-Maharah to as high as 23.3% in Shabwah, 28.0% in Mareb and 28.3% in Al-Baida. The child mortality rate (< 5 years) has improved considerable during the last two decades from 125 per 1000 live births in 1990 to 97 in 2000 and 60
in 2012. The underweight among children under 5 years is a major challenge that human resources development faces in Yemen and the data show that against a sharp increase in this indicator from 30% in 1992 to 46% in 1998 there was a slight reduction to 42.9% in 2005. The proportion of underweight children under 5 years ranges from 71% in Al-Dhaleah, 64.4% in Amran and 63.4% in Al-Hodeidah (63.4%) to 11.8% in Al-Maharah, 20.8% in Hajja (20.8%) and 23.4% in Aden. The distribution of food insecure households in Yemen for 2009 is shown in figure 8.

Figure 8 Distribution of food insecure people in Yemen in 2009

Source: UNDP, 2010

It is clear that the rural areas of Yemen are centres of poverty and that food insecurity is widespread. The area under cultivation and irrigation has increased tremendously – jeopardizing water availability (see next section) – yet without lifting a large part of the population out of poverty. There are two explanations; one is the skewed nature with income inequality being high and the cultivation of some crops generating adequate return but other crops having low returns. This leads to a second explanation – the generally low returns to farming, and hence in rural areas hence quite widespread un/underemployment and dependency on non-agricultural sources of income. At the same time as Yemen’s relatively low yields show, as well as the outcomes of AREA research, there are large opportunities to do better, in terms of yields and in terms of water use.
1.2 Availability and use of water resources

Yemen has a predominantly semi-arid to arid climate with the mean annual rainfall varying from less than 50 mm in the coastal areas to over 700 mm in the highlands. The challenges semi-arid climate has given rise to often innovative and intense water use. The average temperatures vary from 12° C to 31° C with the absolute maximum temperature in the Tihama Plain exceeding 45° C in the summer months and the minimum temperature is less -5° C in the highlands during the winter. This section discusses respectively water resources availability (1.2.1); use of surface and groundwater (1.2.2); salinity (1.2.3) and the effect of climate change.

1.2.1 Water resource availability in Yemen

Water resources availability in Yemen has in the past two decades been a most discussed topic and Yemen ranks among the five most water scarce countries. In the National Water Strategy (2004), the challenge has been summarized as the ‘population versus water resources equation’. The National Water Strategy clearly states the urgency of sustainable water management by phrasing that ‘water security is ranked second to national security’ (NWRA, 2004). Hellegers et al (2009) picture the urgency by presenting two scenarios for ‘bringing about a balance between water demand and sustainable supply: collective actions at local level must enforce reductions in use or the balance is achieved by default as wells dry up’.

As effective systems to monitor the availability and use of surface and groundwater in Yemen are insufficient, reliable and real-time data on water availability, consumption and groundwater levels are unsatisfactory and there is much ‘groping in the dark’. However, the available water resources data clearly show that an unsustainable amount of water is being used in Yemen. By 2010, the total annual water usage in Yemen is estimated at 3.92 BCM, of which 3.23 BCM (82%) is used for agricultural activities, 0.55 BCM (14%) for municipal water supply and 0.11 BCM (2.7%) for industrial purposes. As the total annual renewable water supply is estimated to be 2.5BCM, of which 1.5BCM is surface water and 1.0 BCM is groundwater, the deficit is around 1.4 BCM (MAI, 2013). The development of water use per sector and the water use deficit during the last two decades are presented in table 1.12. The consequences are declining water tables in all areas where groundwater is used for agriculture, the inability to provide public water services to still fast growing cities, increasing bore failure rate (40%) for rural water supply systems and the abandonment of land in of the most fragile (coastal) areas (Wahib et al, 2013). In some areas an exit from agriculture appears to be the most feasible solution (Hellegers et al, 2011).

Table 1.12: Water use per sector and deficit (million m$^3$)

<table>
<thead>
<tr>
<th>Water use</th>
<th>1990</th>
<th>2000</th>
<th>2010</th>
<th>% Increase (1990-2010)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>2,700</td>
<td>2,988</td>
<td>3,261</td>
<td>20.8%</td>
</tr>
<tr>
<td>- Irrigation</td>
<td>2,675</td>
<td>2,958</td>
<td>3,224</td>
<td>20.5%</td>
</tr>
<tr>
<td>Municipal</td>
<td>166</td>
<td>300</td>
<td>553</td>
<td>233%</td>
</tr>
<tr>
<td>Industrial</td>
<td>31</td>
<td>72</td>
<td>109</td>
<td>251%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2,897</strong></td>
<td><strong>3,360</strong></td>
<td><strong>3,923</strong></td>
<td><strong>35.4%</strong></td>
</tr>
<tr>
<td>Deficit</td>
<td>400</td>
<td>860</td>
<td>1,420</td>
<td>255%</td>
</tr>
</tbody>
</table>

Source: MAI, 2013

Overall, the water use increased by about 35% between 1990 and 2010. In the agricultural sector, the increase in water use was about 21% whereas it was 233% and 251% in the municipal water
supply sector and industrial sector respectively. The deficit increased by 255% from 0.4 BCM in 1990 to 1.4 BCM in 2010.

A detailed study was done under GSCP by WaterWatch (2012) to document the trends in water use over the period 2006-2010 in four (sub) basins: Siham, Dhamar, Rada and Abyan. In all these areas GSCP worked intensively to introduce efficient irrigation methods and invest in watershed improvement and spate irrigation, although obviously investment covered only a fraction of these (sub) basins.

During the study period (2006 - 2010), the area under irrigation in the four subbasins expanded by 5,702 ha or 6% (horizontal expansion), whilst a total of 29% of irrigated land moved to more intensive irrigated agriculture (vertical expansion). The total consumptive use in the four basins increased from an estimated amount 864 MCM to 917 MCM per year. The study also estimated that in the four areas 4-15% water saving would be possible realistically (in total 55 MCM), with improved irrigation methods that would not cause a negative effect on crop production. More specific information per basin is summarised in the table below. This assessment is quite sobering. It suggests a much more dramatic intervention is required to reverse the increase in water consumption, which was as much as 8% over the five year period. The margins to do better and save water on a net basis with efficient irrigation are limited and would not even bring back consumption levels to where they were in 2006.

This analysis has a number of implications:

- Gains in water productivity have to be sought from increased yields that also come with the efficient irrigation methods;
- Several other methods should be introduced – still new to Yemen, see also section 1.1.8.
- The implementation of evidence-based water plans and the broad engagement and awareness is overdue.

### Table 1.13: Trends in water use over the period 2006-2010 in four sub basins: Siham, Dhamar, Rada and Abyan

<table>
<thead>
<tr>
<th></th>
<th>Wadi Siham*</th>
<th>Dhamar**</th>
<th>Rada’a***</th>
<th>Wadi Abyan****</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total study area (ha)</td>
<td>343,508</td>
<td>143,810</td>
<td>165,228</td>
<td>147,093</td>
</tr>
<tr>
<td>Total irrigated area (ha)</td>
<td>65,525</td>
<td>20,135</td>
<td>7,724</td>
<td>14,840</td>
</tr>
<tr>
<td>Gross irrigation supply (mm/yr)</td>
<td>849</td>
<td>1,157</td>
<td>285</td>
<td>1071</td>
</tr>
<tr>
<td>Gross groundwater abstraction (mm/yr)</td>
<td>160</td>
<td>1013</td>
<td>272</td>
<td>909</td>
</tr>
<tr>
<td>Irrigation intensity (%)</td>
<td>19</td>
<td>14</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Horizontal expansion (%)</td>
<td>13</td>
<td>-16</td>
<td>0</td>
<td>1.5</td>
</tr>
<tr>
<td>Vertical expansion (%)</td>
<td>20</td>
<td>+</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Scope for reduced use (MCM/yr)</td>
<td>7</td>
<td>22</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

*More intensive cropping systems have been introduced (20%) resulting into a greener vegetation cover; deficit irrigation is practised at a large scale, which is an important reason that total groundwater abstraction increased only marginally from 103 to 105 MCM/yr despite the observed horizontal expansion

**Shrinkage in horizontal area occurred mainly for single season irrigated crops; evapotranspiration (ET) of single season crops increased from 817 mm to 922 mm; deficit irrigation is practised due to a lower rainfall in 2010; amount of 204 MCM/yr was abstracted from aquifers and it is feasible to reduce it by another 22 MCM/yr.
***Rainfall in 2010 was 17% less than in 2006; no significant horizontal expansion; vegetation cover has become greener in February; deficit irrigation is practised at a large scale; amount of 21 MCM/yr without changes in irrigated area and crop production

****Rainfall was less by 20.9% in 2010 than in 2006; irrigation with groundwater was 5.6 times more common than irrigation with surface water resources; irrigated area has expanded by 1,867 ha; area used for cultivation of bananas and double season crops decreased; amount of 135 MCM/yr was abstracted from aquifers and it’s possible to reduce another 5 MCM/yr.

1.2.2 Water Use in Yemen

As mentioned above, data on water availability and use are not always consistent, particularly at governorate level. For instance, a review of the agricultural statistical data for 2011 on cultivated area by source of irrigation showed that the same percentages were used in all governorates: 47% of cultivated area is rainfed, 29% is well-irrigated area, 17% is spate irrigated, 3% is irrigated by respectively dams and springs, whereas with the remaining 1% is serviced by water tankers or other sources. This underlines a high degree of non-seriousness in water accounting in the country.

More specific and reliable data may be obtained from completed and on-going projects, such as the Irrigation Improvement Project, the Groundwater and Soil Conservation Project (GSCP) and National Irrigation Programme (NIP). Below data are presented on the availability of surface water and groundwater, as well as the extent and use of saline water.

Use of Surface Water

The salient features of the wadi systems in Yemen are presented in table 1.14.

Table 1.14: Salient features of wadi systems

<table>
<thead>
<tr>
<th>Escarpment</th>
<th>Name of wadi</th>
<th>Catchment area (km²)</th>
<th>Mean annual rainfall (mm)</th>
<th>Irrigated area (ha)</th>
<th>Mean annual flow (m³/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western</td>
<td>Mwar</td>
<td>8,000</td>
<td>480</td>
<td>17,000</td>
<td>210</td>
</tr>
<tr>
<td></td>
<td>Surdud</td>
<td>2,700</td>
<td>650</td>
<td>10,929</td>
<td>121</td>
</tr>
<tr>
<td></td>
<td>Siham</td>
<td>4,900</td>
<td>50</td>
<td>7,100</td>
<td>103</td>
</tr>
<tr>
<td></td>
<td>Rima</td>
<td>2,700</td>
<td>570</td>
<td>15,215</td>
<td>164</td>
</tr>
<tr>
<td></td>
<td>Zabid</td>
<td>4,700</td>
<td>560</td>
<td>121</td>
<td>54</td>
</tr>
<tr>
<td>Southern</td>
<td>Bana</td>
<td>7,200</td>
<td>349</td>
<td>25,722</td>
<td>160</td>
</tr>
<tr>
<td></td>
<td>Tuban</td>
<td>5,090</td>
<td>224</td>
<td>11,000</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td>Hassan</td>
<td>3,300</td>
<td>300</td>
<td>6,300</td>
<td>30</td>
</tr>
<tr>
<td>Middle</td>
<td>Al-Jawf</td>
<td>14,000</td>
<td>140</td>
<td>7,000</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Adhanah</td>
<td>12,600</td>
<td>Not available</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td></td>
<td>Ahwar</td>
<td>7,250</td>
<td>100</td>
<td>7,000</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Maifaa</td>
<td>6,000</td>
<td>200</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Baihan</td>
<td>3,600</td>
<td>150</td>
<td>54</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hajr</td>
<td>9,324</td>
<td>80</td>
<td>228</td>
<td></td>
</tr>
<tr>
<td>Eastern</td>
<td>Hadramaut</td>
<td>113,900</td>
<td>63</td>
<td>8,000</td>
<td>230</td>
</tr>
<tr>
<td></td>
<td>Masila</td>
<td>Not available</td>
<td>200</td>
<td>27</td>
<td></td>
</tr>
</tbody>
</table>
Table 1.15: Spate irrigated areas per wadi

<table>
<thead>
<tr>
<th>Escarpment</th>
<th>Name of Wadi</th>
<th>Irrigated Area (ha)</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western Wadis</td>
<td>Mwar</td>
<td>17,000</td>
<td>Traditional systems of 9,000ha</td>
</tr>
<tr>
<td></td>
<td>Siham</td>
<td>10,929</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rima</td>
<td>7,100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zabid</td>
<td>15,215</td>
<td>Sometimes extended to 21,000ha</td>
</tr>
<tr>
<td></td>
<td>Rasyan</td>
<td>Not available</td>
<td></td>
</tr>
<tr>
<td>South and Eastern Wadis</td>
<td>Bana</td>
<td>25,722</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tuban</td>
<td>11,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hassan</td>
<td>6,300</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ahwar</td>
<td>7,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hadramaut</td>
<td>8,000</td>
<td>Floods occur every 1.5 to 2 years</td>
</tr>
</tbody>
</table>

Excluding Rasyan wadi, the total irrigated area for the nine listed wadis is 108,266 ha, including 50,244 in the western regions of Yemen and 58,022 ha in the southern and eastern parts. The wadis system also contain substantial subsurface flows.

Groundwater use and recharge management

Until the late 1970s, irrigated agriculture was largely based on the use of spate water, springs and groundwater pumped from shallow wells. Between 1970 and 2012, the groundwater irrigated area increased by around 950% from 37,000 to about 405,000 ha. In 1970, only 3% of the total cropped area of 1.29 million ha was well irrigated. By 2012, about 27% of the total cropped area of 1.50 million ha was under groundwater irrigation. One of the driving forces behind the "groundwater revolution" was the installation of drilled tube wells with diesel and electric pumps allowing farmers to tap deeper aquifers. According to Abdurrahman al-Eryani et al (2011), the following factors also contribute to the rapid development of groundwater irrigation in Yemen:

- Yemenis with capital, in particular migrant workers, began to invest in groundwater irrigated farms;
- Government provided easy and cheap credit to farmers to stimulate the development of groundwater irrigated agriculture during the 1970s and 1980s;
- Energy was cheaply priced by the government;
- Increased demand for higher value agricultural products due to a growing urban population and higher incomes; and
- Rapid expansion of the irrigated area used for the cultivation of qat to meet the increasing demand among the Yemeni population.

Due to the "groundwater revolution", the rural economy in Yemen developed strongly during the last three decades of the 20th century. However, these developments are threatened by three factors: i) rapid decline in the level of groundwater; ii) deteriorating quality of groundwater; and iii) higher pumping costs.

Al-Eryani et al (2011) identified the following factors contributing to the over-exploitation of groundwater:
Existing water management rules and practices based on spate irrigation were not applied to the exploitation of groundwater;

No new rules and organisational structures were developed by the government or local communities to address the overdraft of groundwater;

Both the government and private individuals were not concerned about the efficient and sustainable use of groundwater for a long period; and

Local leaders and large farmers having political and financial clout appropriated and monopolised the access to groundwater.

In a study carried out using data from NWRA monitoring wells between February 2005 and December 2010, Rybakov (2012) clearly points out that in the Amran, Rada’a and Sana’a basins three different groundwater level patterns can be identified: i) decline in water level; ii) nearly stable positions; and iii) elevation of water levels. In the Marib, Surdud and Tuban basins (and wadis), however, a significant predominance of continuous decline in water levels is observed. The latter observations could both relate to the increased activities in the catchments of the wadis as well as increased use of groundwater in the lowland spate irrigation areas for the cultivation of water-intensive crops, such as bananas.

The most significant observation made by Rybakov is the continued long-term decline of groundwater levels in the surroundings of tube wells supplying drinking water. To address this ‘localised’ decline, the study argues that site-specific interventions have to be carried immediately to ‘avoid socio-economic failures’, including recharge and water-saving measures in the upstream direction of operating wells. In some cases the large drawdown may be caused by wells that have too large a capacity for the aquifer system in which they are located. The study also concludes that national groundwater resource management at basin scale has its limitations and recommends that a shift from traditional basin-scale managerial options to more localized site-related interventions should be envisioned.

This conclusion is also supported by another study (WRAY 1995) stating: “it is much more difficult to estimate number of groundwater recharge than groundwater abstraction. Methods used for studies in Yemen include water balance methods, through flow estimation, tracer techniques, modelling techniques and empirical relations with rainfall. The resulting estimates are of variable reliability and generally not very accurate”.

The World Bank-funded GSCP completed a study related to the assessment of water resources in the Dhamar Plain and it described the alarming situation as follows:

- With a growth rate of 2% in water abstraction, which is normally expected in a developing economy, the shallow groundwater up to a depth of 200 metres would be exhausted within the next 10 years; and
- Within the next 30 years, all groundwater up to 700 metres would be exhausted with a growth rate of 2%.

By supporting ‘small works by the communities’, GSCP demonstrated that ‘institutional and technical methods can help to slow aquifer depletion’ (World Bank, 2012) and supporting the rationale of decentralisation and community-managed groundwater systems.

Following a short study of the village of Hijrat al-Muntasir in the Amran basin, where the local community successfully deterred further deep drilling in 2007 allowing water to still trickle from a spring in 2009, Lichtentaler (2010) made the conclusion that the development of coping mechanisms at community level is a step in the right direction. Social scientist would refer to the efforts of this...
community as an ‘adaptive capacity, defined as the sum of social resources available to counter an increasing natural resource scarcity’.

The National Water Strategy also states that local water user partnerships at community level should be encouraged, including the sharing and distribution of groundwater resources, operation and maintenance (O&M) of irrigation systems and most importantly securing of rural water supply. However, the National Water Sector Strategy and Investment Programme (NWSSIP) stated that ‘some evidence of localised reduction in groundwater use, where farmers have organised together and have modernised their irrigation, there is little evidence of a beneficial impact on the water balance’. Successful cases of local (ground) water management will be described in paragraph 1.3. That local community-based (ground) water management is not always the solution is illustrated by cases of violence and the destruction of dams in the Sana’a basin, where communities living too close to each other have built dams that affect the runoff for downstream users. This case and other show the limitation of existing rules and rights in Yemen with regard to the management of surface as well as groundwater, which are based on a complex system of urf (traditional law and practice) and shari’a. The existing laws, traditional rules and regulations will further be discussed in chapter 4.
1.2.3 Salinity and use of brackish water

In many places in Yemen, brackish water appears naturally either in surface water or in groundwater. Due to the extensive withdrawal of groundwater and lower recharge, however, the salinity of groundwater has increased in many basins, particularly in the coastal areas. The most well known example is the Al Ger, where a completely non-sustainable rush in groundwater irrigated agriculture led to well densities of more than 10/kms. The result was a major imbalance developing after 2000 with groundwater abstraction of 67 MCM in 2008 while the renewable groundwater resources dose not exceed 10 MCM (SCSAS 2010). This severe overuse and the lower recharge from spate flows have

### Groundwater balances - geo-hydraulic complexity and contradictory recharge assessment

One of the main aspects in Yemen’s debate on groundwater is the tipped balance, whereby more water is abstracted from aquifers than that is contributed to them. From both these aspects of groundwater resources balance, abstraction is the most easily estimated. Recharge and lateral and upward inflows on the other hand are a lot more complex to estimate, particularly in Yemen where highly disturbed hydraulic conditions prevail. With regard to recharge, the estimates differ considerably among quite a number of (inter)national consultancy and research organisations. Rybakov (2012) has listed (see the table underneath) these studies and states the following: ‘such uncertainty of recharge estimates cannot serve a basis for the adequate water resources management. In the case of the Abyan Delta, for instance, the following conflicting conclusions have been drawn: (a) groundwater recharge and abstraction are in balance (Komex, 2002); (b) deficit in groundwater balance at 35 Mm³/year (Margane, 2004); and (c) huge groundwater recharge surplus over abstraction at 200-250 Mm³/year (PTP II, 2004).’

<table>
<thead>
<tr>
<th>Basin</th>
<th>Recharge, Mm³/year</th>
<th>Information source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abyan Delta</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>105</td>
<td>FAO, 1992</td>
</tr>
<tr>
<td></td>
<td>109</td>
<td>WRAY-34, 1995</td>
</tr>
<tr>
<td></td>
<td>96</td>
<td>Komex, 2002</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>PTP-II, 2004</td>
</tr>
<tr>
<td>Sana’a Basin</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>59</td>
<td>Italconsult, 1973</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>Humphreys &amp; Sons, 1977</td>
</tr>
<tr>
<td></td>
<td>56</td>
<td>Mosgiprovodkhoz, 1986</td>
</tr>
<tr>
<td></td>
<td>42</td>
<td>TS-HWC, 1992</td>
</tr>
<tr>
<td></td>
<td>102</td>
<td>Alderwish and Dottridge, 1996</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>SAWAS, 1996</td>
</tr>
<tr>
<td></td>
<td>53.4</td>
<td>Hydrosult, 2010</td>
</tr>
<tr>
<td>Sa’adah Basin</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>TS-HWC, 1992</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>WRAY-3, 1985</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>Techniplan, 2004</td>
</tr>
<tr>
<td>Amran Basin</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>BGR/GTZ, 1977</td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>DHV, 1993</td>
</tr>
</tbody>
</table>

Furthermore, evidence of changing groundwater tables in Yemen is also based on scarce and poorly constructed monitoring wells that are irregularly monitored as well as farmer and utility complaints of wells drying up. In the latter case, wells might merely run dry when water is pumped at unsustainable discharge rates (water for irrigation) but be able to sustain smaller pumps and demands.
caused serious saline ingression. Saline ingression is also reported from other areas along the coast. A typical example for instance is the coastal zone of Wadi Mawr (see picture).

In some areas brackish water is put into economic use. Brackish water is mainly used for rock cutting industry in the highlands as well as for irrigating salinity-tolerant crops mainly in coastal plains. Brackish water with high salinity is also used for water supply in the city of Taiz by mixing it with freshwater without any desalination. It is further estimated that about 300 MCM of brackish water is used annually for growing crops in Yemen, mostly in the coastal areas particularly in Tihama region. The total area irrigated with brackish water is about 38,500 ha (Stenhouse and Kijne (2006)).

Possible negative impacts of the (increased) use of brackish water for irrigated agriculture may be as follows:

- Reduction in crop yields due to the accumulation of salts accumulate in the root zone to such an extent that the crop is no longer able to extract sufficient water from the salty soil solution, resulting in water stress for a significant period of time;
- Change in cropping patterns in the coastal areas with a shift from the cultivation of high value crops such as fruits (i.e. mango, banana) to the cultivation of low value field crops (i.e. sorghum, millet, cotton) and limited types of vegetables; and
- Significant decline in the prices of agricultural lands where salinity is already high or a possibility of salinity increase in the future.

The main crops irrigated with brackish water under various ranges of salinity in Yemen include sorghum, millet, cotton, tobacco, sesame, elephant grass, date and tomato (SCAS, 2008).
Impact of crop yields: There are no data available about the impact of the use of brackish irrigation water on crop yields, except one field trial conducted by the team of experts working in the Field Unit of the Land and Water Conservation Project (LWCP), piloted by Dr. Makki Omar from the Tihama Environment Protection Project (TEPP). This trial was conducted in 1999 at the El-Zuafran extension centre in the central Tihama Plain and the farmer used water from tubewell with salinity EC of 6000 micromhos/cm. The results of the trial are shown in table 1.16.

Table 1.16: Difference in yields for crops irrigated with brackish water compared with the use of fresh groundwater in Tihama region

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield for the crops irrigated by Brackish water (ton/ha)</th>
<th>Yield for the crops irrigated by fresh groundwater in Tihama (ton/ha)</th>
<th>A balance of the yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorghum (grain)</td>
<td>1.22</td>
<td>0.8</td>
<td>+60%</td>
</tr>
<tr>
<td>Sorghum dry matter</td>
<td>8.52</td>
<td>12.8</td>
<td>-60%</td>
</tr>
<tr>
<td>Cotton</td>
<td>1.8</td>
<td>1.3</td>
<td>+70%</td>
</tr>
<tr>
<td>Okra</td>
<td>0.75</td>
<td>6.1</td>
<td>The yield is only 13% of the normal</td>
</tr>
</tbody>
</table>

Source: Al-Sabri (2012)

The yield of sorghum (grain) irrigated with brackish groundwater was 60% higher than for the same crops irrigated with fresh groundwater, but it was 60% lower for overall sorghum dry matter. Similarly, the yield of cotton irrigated with brackish water was 70% higher compared with irrigation using fresh groundwater. Okra is very vulnerable for water salinity as the yield was very low (0.75 ton/ha) when irrigated with brackish water compared the use of fresh groundwater (6.1 tons/ha). These results are counter-intuitive, but also in other parts of the world it has been established that some crop/varieties do relatively well under saline water supplies.

During the trial, the impact of leaching and reducing the irrigation interval on the yield of sorghum, cotton and okra was assessed as well. The results of these measures on the yields are summarised in table 1.17.
Table 1.17: Impact of leaching and reduced irrigation interval on crop yields using brackish irrigation water

<table>
<thead>
<tr>
<th>Crop</th>
<th>Salinity Tolerance Rate</th>
<th>Treatment (A)</th>
<th>Treatment (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Applied water including leaching water requirement (m³/ha)</td>
<td>Yield (ton/ha)</td>
</tr>
<tr>
<td>Sorghum (grain)</td>
<td>Moderate salinity tolerance</td>
<td>7500</td>
<td>1.22</td>
</tr>
<tr>
<td>Sorghum dry matter</td>
<td></td>
<td>8.52</td>
<td></td>
</tr>
<tr>
<td>Cotton</td>
<td>High salinity tolerance</td>
<td>12950</td>
<td>1.8</td>
</tr>
<tr>
<td>Okra</td>
<td>Low salinity tolerance</td>
<td>10237</td>
<td>0.75</td>
</tr>
</tbody>
</table>

Source: Al-Sabri (2012)

If water leaching is practiced and the irrigation interval time is reduced with 50%, the yields of sorghum (grain), sorghum (dry matter) and cotton increased by 134%, 64% and 62% respectively, whereas the impact on the yield of okra was very small (3%). However, the amount of groundwater used was 19%, 33% and 26% higher for sorghum, cotton and okra respectively.

It is stated in the NWSSIP Update (2008) that poor farmers in the coastal areas currently use brackish water for the irrigation of different crops without any guidance from the official institutions and that no specific policies, strategies or regulations concerning the use of brackish water for irrigation purposes were have been formulated in Yemen. Therefore, it is highly recommended that technical assistance be provided to the Government to develop an appropriate policy, strategy and regulations for use of brackish irrigation water.

**Opportunities:** To address the (ground)water scarcity problem, the use of brackish water for the irrigation of specific crops with a high resistance to salinity, in particular cereals and fodder crops, should be encouraged together with the implementation of the following recommended actions and measures:

- Sound water management system to ensure that the quality of water available is put to the best use;
- Promotion of conjunctive use of brackish water with fresh (spate) water;
- Maintaining a low salinity in the root zone through frequent irrigation and leaching requirement applications;
- Water-saving technologies must be applied in order to save water and increase irrigation efficiency;
- Law cost reverse osmosis desalination units could be used to desalinate brackish water for the agriculture purposes;
- Preparation of specific policy for brackish water use in agricultural purposes;
- Execution of brackish water assessment studies for all basins;
- Implementation of brackish water research programmes with the aim of increasing crop yield and identifying the leaching water requirements;
- Production of brackish water use guidelines, including recommended cropping patterns and crop rotations; and
• Implementation of water quality monitoring programme, including a regular basis monitoring activity for groundwater pollution in the main recharge zones. (Al-Sabri, 2013)

1.2.4 Climate scenarios

Changes in temperature and precipitation resulting from climate change are expected to impact the available water resources in the MENA region, including Yemen, and they are directly relevant to irrigation and provide insight into the risk of climate change for agricultural water availability and demand. One of the expected results of climate change will be a decreased mean annual runoff (MAR), especially in Yemen, Jordan and Tunisia. Under the high impact scenario, the crop water deficit is expected to increase in all MENA countries, with the greatest increases occurring in Morocco, Tunisia, Jordan and Yemen. Under the low and medium impact scenarios, more moderate increases in crop water deficits are expected for all countries, except for Yemen where some areas of the country may see decreased deficits. Climate change together with population growth and socio-economic development will contribute to changes in future agricultural water demands with significant agricultural water shortages projected for all MENA countries, including Yemen (MAI 2013).

The variation in temperature and precipitation in the Republic of Yemen over their baseline equivalents differs under the two GCM scenarios; CSIRO and MIROC. Under the CSIRO scenario, monthly maximum temperatures do not rise above 1.7°C over the baseline maximum temperatures and rise 2.3°C above baseline for the average monthly temperatures. Under the MIROC scenario, the variations are far greater for both the minimum and maximum temperatures (see figure X). For nine months out of the year, the MIROC scenario projects a more than 2°C rise in temperatures by 2050 in minimum temperatures over the baseline, and in May, the MIROC scenario projects that minimum temperatures will rise over their baseline values by more than 3°C. Maximum temperatures are also expected to increase over their baseline values under the MIROC scenario. For four months out of the year, MIROC temperature highs are expected to rise more than 2°C over their baseline equivalents and by more than 3°C over their baseline equivalents. Variation in average monthly rainfall across the Republic of Yemen, as projected by the CSIRO and MIROC GCM scenarios, is significant only for the latter scenario.
Average monthly rainfall of the CSIRO scenario roughly follows the baseline. However, the MIROC scenario projects an increase in rainfall from June to October across the Republic of Yemen. From October to December, rainfall under the MIROC scenario is below that projected under the baseline. This pattern of variation (or lack thereof for the CSIRO scenario) is consistent across all the Republic of Yemen’s regions with the exception of the Upper Highlands, where the rainfall projections under the CSIRO scenario are significantly lower than their baseline equivalents (see figure below).

During the Netherlands Climate Change Studies Assistance Program (NCCSAP: 1996–2000), two different climate change scenarios were prepared using changes in precipitation and temperature through 2025 as predicted by the Oregon State University model (OSU Core) and UK Meteorological Office High Resolution General Circulation model (UKHI) respectively. The OSU Core model represented an “expected” climate trajectory, whereas the UKHI model represented a “worse case”, drier trajectory. The assumptions for OSU Core and UKHI climate trajectories are based on previous climate modelling work that was undertaken during the Netherlands Climate Change Studies Assistance Programme (NCCSAP) and the trajectories are summarised in table 1.18.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Annual change by 2025</th>
<th>Precipitation</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sana’a</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OSU Core</td>
<td>+2%</td>
<td>+1.0°C</td>
<td></td>
</tr>
<tr>
<td>UKHI Dry</td>
<td>-10%</td>
<td>+1.3°C</td>
<td></td>
</tr>
<tr>
<td><strong>Sadah</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OSU Core</td>
<td>+10%</td>
<td>+1.8°C</td>
<td></td>
</tr>
<tr>
<td>UKHI Dry</td>
<td>-32%</td>
<td>+2.2°C</td>
<td></td>
</tr>
<tr>
<td><strong>Aden City</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OSU Core</td>
<td>+10%</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>UKHI Dry</td>
<td>-16%</td>
<td>NA</td>
<td></td>
</tr>
</tbody>
</table>

As noted by the World Bank (2010), limited meteorological data collection and uncertainty make difficult the detailed downscaling of climate trajectories for Yemen from the number of existing global climate model sources. Like that study, the intent here is to explore the impact of selected adaptation strategies in the context of several possible simplified future climate trajectories, and is certainly not meant to be a comprehensive analysis that considers the broad range of possible future climate patterns.

Results of the DCGE model for Yemen show that climate change related global food price increases might benefit the agricultural sector in Yemen through higher returns to production factors. Despite the fixed supply of land (to reflect water scarcity), agricultural activities benefit from price increases, attract additional capital and labour and thereby increase production. Compared to perfect mitigation, the annual average agricultural growth rate is between 0.1% to 0.5% higher in the MIR scenario and between 0.1% and 0.2% higher in the CSI scenario and exhibits an increasing trend over time (see figure 9).

Figure 9 Impacts of global changes on agricultural GDP (2010-2050)

Farmers are likely to have to adjust to warmer temperatures and to manage risks from more unpredictable rainfall patterns and from heavier rains. Increasing temperatures could increase output if water is available. The recent HR Wallingford study modelled the impact of possible climate change on agriculture. Overall, a number of key points can be drawn from the analysis:

- Agricultural production is sensitive to climate change, although the direction of change is unpredictable. Under the ‘warm & wet’ (optimistic) scenario, crop production could increase by more than 10%, whilst under the ‘hot & dry’ (pessimistic) scenario, production could go down by at least 10% (and even by a quarter towards the end of the century);
- There are significant differences in the response of different crops to changes in temperature and water availability, and these allow scope for farmer coping strategies;
- Some areas of Yemen are more adversely affected than others, pointing to areas of comparative advantage, and areas where adaptation measures are more likely to be needed;
- Increasing temperature could assist crop production in some areas, particularly the cooler highland areas where increased precipitation, runoff and recharge make water more available, and where the growing season may be extended;
- By contrast, where temperatures are significantly higher and precipitation significantly lower, ET would increase but runoff and recharge would reduce and the net effect of higher temperatures on production would be negative; and
Unpredictability is likely to increase, suggesting that more tactical use of dwindling groundwater for supplementary irrigation could be a useful strategy to cope with dry spells and drought.
1.3 Current practices in irrigation water management

1.3.1 Irrigation efficiency

The overall irrigation efficiencies for groundwater irrigation systems are low (35 to 40%), but it could be improved to over 60% if conveyance pipe distribution systems are installed. The overall irrigation efficiency may be as high as 75 to 80% of farmers would use water-saving on-farm systems, such as sprinkler and drip.

The overall efficiency of spate irrigation systems is below 35%, but the improvement of spate irrigation infrastructure may enhance the overall irrigation efficiency to 45%. (MAI 2013). This can be done by better command area development and controlled field overflow structures for instance.

It is however important to make a distinction between gross and net losses in irrigation. The difference is that much water that is apparently lost by leakage is recouped as it is added to the recharge of shallow groundwater and hence can be recycled for productive use. This is most apparent in spate irrigation systems where the spate flows also massively recharge the underlying shallow aquifers – ensuring that little water is lost to the system and net water productivities are high.

1.3.2 Water use efficiency

In 2000, El-Ghouri M. et al published the results of a research on irrigated agriculture in Yemen, including water productivity in terms of crop yield (kg) per unit of water (m$^3$). The water use efficiency for different crops being irrigated with spate water and groundwater are presented in table 1.19 and 1.20 respectively.

**Table 1.19: Water use efficiency for spate irrigated crops**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Station</th>
<th>Water requirements (mm)</th>
<th>Irrigation Water m$^3$/ha</th>
<th>Total growing period (days)</th>
<th>Years of Research</th>
<th>Water utilization efficiency kg/m$^3$</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorghum</td>
<td>A1-Kod</td>
<td>350-400</td>
<td>5000-5714</td>
<td>95</td>
<td>2</td>
<td>0.51</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tihama</td>
<td>561</td>
<td>669</td>
<td>98</td>
<td>1</td>
<td>0.447</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Taiz</td>
<td>540</td>
<td>5400</td>
<td>148</td>
<td>2</td>
<td>0.80</td>
<td></td>
</tr>
<tr>
<td>Millet</td>
<td>A1-Kod</td>
<td>300-390</td>
<td>4286-5571</td>
<td>95</td>
<td>NA</td>
<td>0.31</td>
<td></td>
</tr>
<tr>
<td>Sesame</td>
<td>A1-Kod</td>
<td>350-450</td>
<td>5000-5952</td>
<td>95</td>
<td>2</td>
<td>0.34</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tihama</td>
<td>810</td>
<td>NA</td>
<td>110</td>
<td>2</td>
<td>0.13</td>
<td>Autumn</td>
</tr>
<tr>
<td></td>
<td>Tihama</td>
<td>915</td>
<td>NA</td>
<td>108</td>
<td>2</td>
<td>0.13</td>
<td>Summer</td>
</tr>
<tr>
<td></td>
<td>Marib</td>
<td>474-500</td>
<td>5930-6250</td>
<td>112</td>
<td>2</td>
<td>0.222</td>
<td></td>
</tr>
<tr>
<td>Groundnut</td>
<td>A1-Kod</td>
<td>450-600</td>
<td>5952-8571</td>
<td>135</td>
<td>3</td>
<td>0.432</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Marib</td>
<td>495-600</td>
<td>6188-7500</td>
<td>123</td>
<td>2</td>
<td>0.441</td>
<td></td>
</tr>
<tr>
<td>Cotton/g. hirsutum</td>
<td>A1-Kod</td>
<td>600-700</td>
<td>8571-10000</td>
<td>240</td>
<td>3</td>
<td>0.28</td>
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</tr>
<tr>
<td>Cotton/g. barbadense</td>
<td>A1-Kod</td>
<td>450-600</td>
<td>6429-8571</td>
<td>195</td>
<td>2</td>
<td>0.56</td>
<td>Supplemental</td>
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<tr>
<td>Watermelon</td>
<td>A1-Kod</td>
<td>718</td>
<td>680</td>
<td>130</td>
<td>1</td>
<td>0.59</td>
<td></td>
</tr>
</tbody>
</table>

The water productivity for spate-irrigated sorghum varies from 0.45 kg/m$^3$ in Tihama to 0.80 kg/m$^3$ in Taiz, whereas the water use efficiency for spate irrigated sesame ranges from 0.13 kg/m$^3$ in Tihama to 0.34 kg/m$^3$ in Al-Kod.

### Table 1.20: Water use efficiency for groundwater irrigated crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Station</th>
<th>Water requirements (mm)</th>
<th>Irrigation water m3/ha</th>
<th>Irrigation frequency</th>
<th>Total growing period (day)</th>
<th>Years of research</th>
<th>Water productivity kg/m$^3$</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorghum</td>
<td>Highland</td>
<td>NA</td>
<td>100</td>
<td>2</td>
<td>150</td>
<td>2</td>
<td>1.75</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Seiyun</td>
<td>466</td>
<td>350</td>
<td>6</td>
<td>160</td>
<td>2</td>
<td>1.11</td>
<td>Supplementary</td>
</tr>
<tr>
<td></td>
<td>Marib</td>
<td>398-438</td>
<td>4660</td>
<td>10</td>
<td>85</td>
<td>3</td>
<td>0.64</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5820-6960</td>
<td>6-8</td>
<td>120</td>
<td>3</td>
<td>0.86-0.92</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Seiyun</td>
<td>460</td>
<td>4600</td>
<td>10</td>
<td>120</td>
<td>3</td>
<td>0.64</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Highland</td>
<td></td>
<td>NA</td>
<td>NA</td>
<td>165</td>
<td>3</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A1-Kod</td>
<td>350-550</td>
<td>5000-7857</td>
<td>12</td>
<td>120</td>
<td>3</td>
<td>6.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Marib</td>
<td>468-504</td>
<td>6800-7890</td>
<td>14-18</td>
<td>139</td>
<td>1</td>
<td>4.7-5.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Seiyun</td>
<td>363</td>
<td>3630</td>
<td>11</td>
<td>150</td>
<td>3</td>
<td>12.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A1-Kod</td>
<td>1970-2200</td>
<td>24625-27500</td>
<td>55</td>
<td>360</td>
<td>2</td>
<td>2.03-2.73</td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>N.</td>
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<td>NA</td>
<td>NA</td>
<td>170</td>
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<td>NA</td>
<td></td>
</tr>
<tr>
<td>Onion</td>
<td>Highland A1-Kod</td>
<td>350-550</td>
<td>5000-7857</td>
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<td>120</td>
<td>3</td>
<td>6.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Marib</td>
<td>468-504</td>
<td>6800-7890</td>
<td>14-18</td>
<td>139</td>
<td>1</td>
<td>4.7-5.1</td>
<td></td>
</tr>
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<td>Banana</td>
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<td>1970-2200</td>
<td>24625-27500</td>
<td>55</td>
<td>360</td>
<td>2</td>
<td>2.03-2.73</td>
<td></td>
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<tr>
<td>Been</td>
<td>N.</td>
<td>460</td>
<td>NA</td>
<td>NA</td>
<td>170</td>
<td>1</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Tobacco</td>
<td>A1-Kod</td>
<td>400-600</td>
<td>5000-7500</td>
<td>10</td>
<td>120</td>
<td>2</td>
<td>0.595</td>
<td></td>
</tr>
<tr>
<td>Potato</td>
<td>Highland</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Taiz</td>
<td>310</td>
<td>3100</td>
<td>6</td>
<td>126</td>
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<td>5.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Marib</td>
<td>423-485</td>
<td>5490-6380</td>
<td>6-8</td>
<td>125</td>
<td>3</td>
<td>5.13</td>
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</tr>
<tr>
<td>Tomato</td>
<td>A1-Kod</td>
<td>340</td>
<td>3400</td>
<td>9</td>
<td>125</td>
<td>2</td>
<td>9.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Marib</td>
<td>459-585</td>
<td>9429</td>
<td>14</td>
<td>120</td>
<td>2</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6400-8150</td>
<td>12-14</td>
<td>134</td>
<td>1</td>
<td>3.5</td>
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</tr>
<tr>
<td>Garlic</td>
<td>Seiyun</td>
<td>435</td>
<td>4350</td>
<td>15</td>
<td>170</td>
<td>1</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>Maize</td>
<td>Taiz</td>
<td>430</td>
<td>4300</td>
<td>8</td>
<td>135</td>
<td>2</td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A1-Kod</td>
<td>400-450</td>
<td>5714-5952</td>
<td>5</td>
<td>110</td>
<td>2</td>
<td>0.8</td>
<td>border</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>293-359</td>
<td>5</td>
<td>110</td>
<td>3</td>
<td>1.72-2.01</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tihama</td>
<td>460</td>
<td>4830</td>
<td>NA</td>
<td>102</td>
<td>2</td>
<td>1.3</td>
<td>Var.setilagius</td>
</tr>
<tr>
<td></td>
<td></td>
<td>730</td>
<td>NA</td>
<td>NA</td>
<td>120</td>
<td>NA</td>
<td>0.9</td>
<td>Var.Tihama</td>
</tr>
</tbody>
</table>

In groundwater-irrigated areas, the water use efficiency for sorghum varies from 0.64 kg/m$^3$ in Seiyun to 1.75 kg/m$^3$ in the highlands, 4.7 kg/m$^3$ to 12.4 kg/m$^3$ for onion, 5.1 kg/m$^3$ to 9.4 kg/m$^3$ for potato, and 0.8 kg/m$^3$ to 2.0 kg/m$^3$ for maize.

**1.3.3 Saving water in irrigated agriculture**

In recent years, a variety of water-saving technologies and practices have been introduced and promoted in Yemen with the aim to reduce the consumption of scarce (ground) water in the irrigated agricultural sector. Reportedly, the introduction of improved irrigation technologies (i.e. piped conveyance and pressurised systems) by different project has resulted in the following annual water savings:

- 16 MCM from 10,500 ha under the completed Land and Water Conservation Project (LWCP);
- 10 MCM from 4,000 ha under the completed Sana’a Basin Water Management Project (SBWMP);
- 83 MCM from 51,000 ha under the completed GSCP; and
- 13 MCM (against target of 21 MCM by 2016) under the on-going NIP (MAI 2013).

Under the GSCP, the use of drip systems to irrigate banana in the Tihama Plain have been very successful resulting in a significant reduction in the use of groundwater and an increase in crop productivity. (MAI, 2013). The water savings that are mentioned above – it should be noted – are gross saving. Corrected for the lost recharge, the net savings maybe a lot less. The most significant impact of the efficient irrigation methods may not be so much the saving of water, but the increased yield because of more precise water delivery, less local water logging and less humidity related pests and diseases. According to the beneficiary impact assessment that was carried among farmers for the GSCP, the main reported benefits of improved conveyance system and modern on-farm irrigation systems (i.e. sprinkler and drip) were in order of importance:

1. Increase in income due increased crop productivity and reduced expenditures;
2. Savings in labour related to irrigation;
3. Water savings.

The proportion of interviewed farmers responding positively on the benefits of improved conveyance system and modern on-farm irrigation systems is presented in table 1.21.

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Improved conveyance system</th>
<th>Modern on-farm irrigation system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in income</td>
<td>94%</td>
<td>80%</td>
</tr>
<tr>
<td>Labour saving</td>
<td>75%</td>
<td>96%</td>
</tr>
<tr>
<td>Crop productivity increase by 15 %</td>
<td>25%</td>
<td>76%</td>
</tr>
<tr>
<td>Water savings more than 25%</td>
<td>34%</td>
<td>68%</td>
</tr>
<tr>
<td>Positive/significant impact on groundwater levels</td>
<td>4%</td>
<td>9%</td>
</tr>
</tbody>
</table>

Source: MetaMeta, 2012

According to the contacted farmers, the main benefits of the installation of improved conveyance system an increase in income (94% of interviewed farmers) and labour saving (75%), whereas respectively a quarter and one-third of the respondents reported increased crop productivity and water savings as a main benefit. With regard to the introduction of modern on-farm irrigation systems seems, the saving of labour is reported as a main benefit by 96% of the respondents.
followed by increased income (80%), increased crop productivity (76%) and water savings (68%). Field measurements revealed that the use of modern on-farm irrigation systems resulting in water saving of 33%, whereas the installation of improved conveyance systems resulted in a reduction of water use of 13%.

A significant impact of installing improved conveyance systems and the use of modern on-farm irrigation systems on groundwater levels was not immediately significant as only 4% and 9% of the respondents mentioned it as a main benefit (MetaMeta and WEC, 2012). This is in line with the NWSSIP Update (2008) stating that: ‘there is some evidence of localised reduction in groundwater use where farmers have organised together and have modernised their irrigation, there is however little evidence of a beneficial impact on the water balance’. Again the reason may be the difference between gross and net gains from improved irrigation systems. As there is less leakage, there is at the same time also less recharge. As a result the effect on groundwater tables is less.

**Use of wastewater:** At present, an estimated amount of 88 MCM per year of untreated wastewater is produced in Yemen causing serious pollution of the groundwater due to percolation. If properly treated, this amount of effluent could be used to irrigate 24,000 ha annually. By 2031, it is envisaged that about 185 MCM of wastewater is produced annually and the reuse of this amount of treated effluent would allow the irrigation of over 50,000 ha per year (MAI, 2013).
Annex 1: Agricultural value added by zone and crop, 2009 (Billions of YR and percent)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3</th>
<th>Zone 4</th>
<th>Zone 5</th>
<th>Zone 6</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Billions YR</td>
<td>percent</td>
<td>Billions YR</td>
<td>percent</td>
<td>Billions YR</td>
<td>percent</td>
<td>Billions YR</td>
</tr>
<tr>
<td>Sorghum</td>
<td>7.36</td>
<td>5.25</td>
<td>5.10</td>
<td>3.09</td>
<td>3.65</td>
<td>4.71</td>
<td>0.07</td>
</tr>
<tr>
<td>Maize</td>
<td>2.50</td>
<td>1.78</td>
<td>4.09</td>
<td>2.48</td>
<td>0.35</td>
<td>0.46</td>
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</tr>
<tr>
<td>Millet</td>
<td>1.83</td>
<td>1.31</td>
<td>0.55</td>
<td>0.33</td>
<td>2.59</td>
<td>3.35</td>
<td>0.03</td>
</tr>
<tr>
<td>Wheat</td>
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<td>0.73</td>
<td>6.05</td>
<td>3.66</td>
<td>0.17</td>
<td>0.22</td>
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<td>Other grains</td>
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<td>0.14</td>
<td>3.53</td>
<td>2.14</td>
<td>0.04</td>
<td>0.05</td>
<td>0.01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Activity</th>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3</th>
<th>Zone 4</th>
<th>Zone 5</th>
<th>Zone 6</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Billions YR</td>
<td>percent</td>
<td>Billions YR</td>
<td>percent</td>
<td>Billions YR</td>
<td>percent</td>
<td>Billions YR</td>
</tr>
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<td>Potatoes</td>
<td>15.78</td>
<td>11.26</td>
<td>0.79</td>
<td>0.48</td>
<td>0.86</td>
<td>1.10</td>
<td>0.01</td>
</tr>
<tr>
<td>Vegetables</td>
<td>8.88</td>
<td>6.34</td>
<td>11.67</td>
<td>7.07</td>
<td>7.36</td>
<td>9.49</td>
<td>2.29</td>
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<tr>
<td>Tomatoes</td>
<td>10.78</td>
<td>7.69</td>
<td>3.62</td>
<td>2.19</td>
<td>5.22</td>
<td>6.74</td>
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<td>Pulses</td>
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<td>4.12</td>
<td>0.70</td>
<td>0.43</td>
<td>1.51</td>
<td>1.95</td>
<td>0.19</td>
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<td>Coffee</td>
<td>0.29</td>
<td>0.21</td>
<td>7.41</td>
<td>4.49</td>
<td>0.02</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Sesame</td>
<td>0.03</td>
<td>0.02</td>
<td>0.04</td>
<td>0.02</td>
<td>0.34</td>
<td>0.44</td>
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<tr>
<td>Cotton</td>
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<td>0.15</td>
<td>5.02</td>
<td>6.48</td>
<td>0.05</td>
<td>0.41</td>
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</tr>
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<td>39.93</td>
<td>84.18</td>
<td>50.99</td>
<td>0.06</td>
<td>0.08</td>
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<tr>
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<td>0.06</td>
<td>8.54</td>
<td>11.01</td>
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<td>Total</td>
</tr>
<tr>
<td>--------------</td>
<td>--------</td>
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<td>--------</td>
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</tr>
<tr>
<td></td>
<td>Billions YR</td>
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<td>percent</td>
<td>Billions YR</td>
<td>percent</td>
<td>Billions YR</td>
</tr>
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<td>6.21</td>
<td>3.66</td>
<td>4.72</td>
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<td>0.41</td>
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<td>7.73</td>
<td>4.68</td>
<td>2.45</td>
<td>3.17</td>
<td>2.58</td>
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<tr>
<td>Fish</td>
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<td>13.02</td>
<td>4.08</td>
<td>36.71</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Breisinger et al. 2011
CHAPTER 2

Institutions
Irrigation sector now

- Fragmented
- Insufficient capacity
- Project based implementation
- MAI-MWE better approach
- Research limited outreach
- Different unrelated organisations
- WUA sustainability dubious
- Not enough proposals for funding
- No private service sector
- 'Good legislation, missing implementation'
- Slow project implementation
2. **Institutions in the Irrigation Sector**

This section reviews the institutional arrangements and setup of the water sector with special focus on irrigation management. It is prepared on the basis of literature review of documents prepared by the government institutions, donors, consultants and researchers as well as special questionnaires to retrieve detailed information from the main organizations. Added to this are group discussions and personal interviews to get insights and feedback from specialized staff and persons including members of the private sector. It discusses the main public institutions at national and governorate level (section 2.1), the functioning of WUAs and Irrigation Councils (section 2.2) and the role of the private sector in irrigation services (2.3).

Different policies have emphasized that institutions need to be strengthened. The first major document was the Aden Agenda (1998) that aimed to increase the productivity of irrigated agriculture. The Aden Agenda emphasized the need to strengthen farmers’ organizations as well as a restructuring of the public organizations involved in irrigation management. Part of the restructuring was a proposed better incentive structure for professional staff.

In subsequent policy documents these points have been reinforced. The NWSSIP I for instance argued that institutional strengthening is a cornerstone to sustainable water management and emphasizes better coordination mechanisms between MAI and MWE/NWRA with water resources investments screened based on basin water plans, building a decentralized program for efficient water use and increased roles of community organizations and civil society. This point was reinforced in the NWSSIP Update that calls for a restructuring of the irrigation sector to match the need for introducing water saving at scale. Within the framework of NWSSIP MAI in particularly committed itself to:

- Service orientation to be improved by decentralization
- Programs in water use efficiency and community groundwater management to be strengthened.
- Farmers’ water rights to be recognized
- Research and extension to refocus on water use efficiency and on rain-fed agriculture.
- Dams program to be reviewed and integrated into watershed management programs
- AFPPF resources to be increasingly allocated to modern irrigation technology
- Cost recovery to be progressively introduced in public schemes
- MAI to work with NGOs as service delivery partners.

The National Agricultural Sector Strategy (NASS - 2012) issued by the Minister for Agriculture and Irrigation, titled ‘A promising sector for a diversified Yemen’ also list among the main strategies for the water sector to:

- Build the institutions and capacities within the agriculture sector to promote water conservation
- Promote capacity building and expansion of gender-based farmers’ organizations and water user associations
- Promote community participation in water management and involvement of farmers, water users associations, cooperative and private sector.

There is hence convergence on the need for engaging in water plans, decentralization, bottom up process and local management and in general a move to a water saving society. The challenge is to put the policy intentions into practice and come to effective local management as well as an irrigation sector that is aligned within the overall integrated management of water resources. This chapter is an assessment of the main government organizations working in the irrigation sector: MAI, but also the organizations at governorate level and NWRA (section 2.1); farmer organizations, in particular WUAs and the Irrigation Councils (section 2.2) and finally the private sector active in irrigation (2.3).
2.1 Government institutions

A large effort has gone in to building up a modern system of government in Yemen. Reforms have been undertaken in most sectors in the last decades. In the water sector there has been concerted effort to introduce the regulation of water use. At the same there has been a reorientation towards promoting water saving rather than water capture in the main investment programs.

After unification in May 1990, the newly formed Ministry of Agriculture and Water Resources (MAWR) was made the prime institution responsible for the planning, development, management and control of water resources. Agriculture and water resources were combined in one Ministry because the irrigated agriculture sector is the largest water user in the country. Soon after, in April 1991 a draft Water and Irrigation Law prepared by the MAWR was submitted. In December 1991, a decree was issued giving the MAWR the responsibility to regulate the drilling of wells until the enactment of the law. This constituted the first attempt to control agricultural water use.

There have been substantial efforts in setting up the institutions and creating a regulatory system for groundwater management in Yemen in the last two decades (WEC 2012). The most important feat was the establishment of the National Water Resources Authority (NWRA) in October 1995 by Presidential Decree. NWRA took over the water resource management activities from the Ministry of Agriculture and Water Resources at the time. The Ministry was subsequently renamed the Ministry of Water and Electricity in 1996.

The establishment of NWRA was a step ahead and recognition of the importance to address water use. NWRA was entrusted as the main body to carry out policy formulation and planning of the water resources all over the country. In the years to follow branch offices of NWRA were established in seven out of 24 governorates.

In 2003 the Government created the Ministry of Water and Environment in order to raise major issues on water and environment to ministerial level and to bring fragmented institutions working in water under one umbrella (NAWASA, GWRSP, NWRA). The MWE with engagement of development partners prepared the Water Resources Strategy and prepared the plan of implementation for the water sector (NWSSIP) in 2004. In 2003, soon after the announcement of the Water Law the Ministry of Water and Environment was established, taking over from the Ministry of Water and Energy and incorporating the Environmental Protection Agency that used to be under the Ministry of Tourism. NWRA also reported to the MWE, in addition to the authorities for urban and rural water supply.

The Water Law was promulgated in the 2002, after protracted preparation and insistence of bilateral donors active in the water management in Yemen. The Water Law was amended in 2006 with only minor revision. Bylaws were issued in 2011. This is discussed in chapter 4.

In 2008 the Ministry of Agriculture and Irrigation was restructured and a sector for irrigation was created headed by Deputy Minister. The earlier General Directorate for Irrigation was abolished and its different departments were incorporated within the Ministry. Also MAI did develop and produced the National Agriculture Sector Strategy (NASS) in 2012, which outlined the ministry’s development plans and activities in guiding the sector for the future in food security and the sustainable utilization of agricultural resources.

The Ministry of Local Affairs was created in 1993 in response to the decentralization policy. It was followed by preparation of the Local Authority Law (2000). This Law entrusted the authority of implementing development plans to the local governorates and local offices of the ministries. This decentralization had a major impact on the work of the Ministry of Agriculture and Water Resources. The law fundamentally changed the relationship between the existing organs of the Agriculture Ministry at governorate level and at the national level. Under this law, the Agricultural Offices in each governorate were moved under the financial and administrative jurisdiction of the Governor’s office,
while the central Ministry retained a role in technical supervision and policy making. By removing administrative and financial control of the local agriculture offices, the Local Authority Law changed the power of the Agriculture Ministry.

There is little connect between organizations at central level and governorate level in irrigation and water management. The Ministry of Agriculture and Irrigation for instance has irrigation units in only four out of twenty governorates. the Ministry of Water and Environment itself has none but the different Authorities under MWE (including NWRA) have units in several but not all of the governorates. The administration is not unified and there is – unlike in other countries - no staff exchange between organizations at central government and governorates.

In addition, there is still a tendency for fiduciary reasons and effectiveness to have project implemented through special organizations with separate field units and a separate project management structure. A prime example in the water sector is the Social Development Fund with special staffing arrangements and salary structures and project administration. In the water saving the largest investment have come been funded by World Bank, such as in recent times the Groundwater and Soil Conservation Project and more recent the National Irrigation Program – hosted within the MAI. These projects created their own temporary outreach arrangements, such as the Irrigation Advisory Services that are staffed by contract employees.

Below a more detailed description of the current position of the main institutions in irrigation and water management is given:

- the MAI at Sana’a (2.1.1) and its different organs, in particular the Irrigation and Land Reclamation Sector (2.1.1.1); the NIP including the IAS (2.1.1.2) and special units such as AREA and TDA (respectively 2.1.1.3 and 2.1.1.4)
- the irrigation units in the Agricultural Offices in the Governorates (2.1.2)
- the main body responsible for water management in Yemen, i.e. NWRA (2.1.3)

### 2.1.1 Ministry of Agriculture and Irrigation (MAI)

The Ministry of Agriculture and Irrigation (MAI) is responsible for policies and programs on crops, livestock, and forestry and irrigation. The Ministry’s Mission is ‘to work to develop and sustainably exploit agricultural resources and potentials of the country in a way that fulfills the needs of citizens and the national economy, in particular contribute to achieving food security and comprehensive sustainable development’. The vision of the Ministry is ‘to improve the annual growth rate of the agricultural sector and raise its nominal contribution to the Gross Domestic Product (GDP), in particular by working on improving the efficiency and productivity of the various agricultural activities’. The organizational structure was defined in the organizational bylaw of 2008 on MAI restructuring. At present the MAI consists of three main sectors, each headed by a Deputy Minister:

- Agricultural Production Development Sector;
- Agricultural Services Sector;
- Irrigation and Land Reclamation Sector (ILRS).

The number of the general departments within these sectors is 21. Eight general departments were added in comparison with the original structure (described in the Organizational Bylaw issued by the Republican Decree No. (5) of 1996). The increase in departments is particularly attributed to the attention being paid to irrigation and the merger of the General Directorate Irrigation (GDI) into the IRLS.
In addition there are two specially tasked authorities, the Tihama Development Authority – responsible for maintenance of main irrigation infrastructure, agricultural extension and area development - and the Agriculture Research and Extension Authority (AREA). Other special development authorities under the MAI have been closed down.

A special program investing in efficient irrigation and spate irrigation, i.e. the National Irrigation Programme (NIP), is hosted within MAI. NIP was one of the centerpieces of the Water Sector Strengthening Program (WSSP) that was set up as a ‘sector wide approach program (SWAP) in line with the Paris Agenda on donor harmonization and alignment. The idea was that different donors would contribute to WSSP, yet at this stage only the World Bank is left supporting WSSP.

2.1.1.1 Irrigation and Land Reclamation Sector

Within the MAI the main sector responsible for irrigation is the Irrigation and Land Reclamation Sector (ILRS). This has been placed under one of three Deputy Ministers. The Deputy Minister is assisted by four different DGs, i.e.:

- DG for Irrigation and Hydraulic Structures
- DG for On-farm Irrigation
- DG for Forestry, Rangeland Management and Desertification Control,
- DG for Agricultural Land Inventory and Reclamation

The tasks and functions of the four different sections of the IRLS are defined in the MAI bylaw of 2008 is described below.

First, the General Department for On Farm Irrigation is particularly responsible for promoting and supporting more efficient use of water for irrigation at field level. Its mandated tasks concern a range of activities, several of which are implemented with other concerned organizations.

- Proposing policies and legislation, which regulates the use of irrigation water in line with national water policies and plans, the main aim being to achieve optimal benefit from agricultural sector water share.
- Contributing to water use standards for field crops and determining feasibility of irrigation methods through analyzing soil and water requirements for each crop according to the climate of the region.
- Proposing appropriate and modern irrigation methods and planning and designing irrigation network and encouraging farmers to use modern technology in irrigation.
- Participating in general water studies and studies linked to water use and making use of this in setting plans and programs related to exploiting, managing and protecting irrigation water sources.
- Contributing to awareness and extension programs and the preparation and implementation of training programs for farmers in the efficient irrigation in coordination with the related agencies.
- Proposing criteria on the distributing water from storage reservoirs, taking into consideration customs in the areas concerned and encouraging the formation of associations and societies of irrigation water users.
- Proposing legislations regulating the use of non-conventional water sources for purposes of irrigation in coordination with the related agencies.
- Establishing and operating agricultural observation network and collecting data and information from the meteorological centers and recording them and analyzing the results in coordination with the related agencies;
- Taking actions so as to protect irrigation water from pollution in coordination with the related agencies.
- Collecting information on the development and improvement of the productivity of water in agriculture and conducting experiments in support of it;
• Any other tasks related to its job or prescribed by the existing laws and decisions or assigned by
the Ministry leadership.

Secondly, the General Department for Irrigation and Hydraulic Structures is tasked with
responsibilities on the development of new irrigation systems as well as the supervision of main
system management of existing irrigation systems, linked to flood control and watershed protection.
In detail the mandate activities are:
• Proposing policies and legislations that regulate the setting up and managing irrigation
establishments in coordination with the related agencies.
• Conducting field surveys and topographic studies to determine suitable locations to establish
new irrigation structures and participating in social and economic feasibility studies.
• Proposing general technical criteria to establish irrigation establishments and the conditions of
classifying and qualifying contractors working in this area.
• Contributing to preparing and reviewing the technical designs and tables of quantities and the
documents of bids for irrigation structures and participate in tender evaluation.
• Supervising implementation progress of irrigation structures and providing necessary reports on
implementation level in coordination with the related agencies.
• Registering the existing irrigation establishments and making maps for their locations and
collecting and documenting data and information about their storage capacities and concerned
water balances in coordination with the related agencies.
• Participating in setting conditions for the operation and maintenance of irrigation establishment
and controlling the proper operation and maintenance according to the technical rules and the
applicable operation systems in coordination with the related agencies.
• Supervising the operation of main irrigation establishment and regulating the exploitation and
disposal of water into main and branch channels and following up the implementation of
maintenance programs and doing periodic inspection.
• Setting the systems of storing water behind dams to ensure protecting villages, houses and lands
located in its area from environmental threats and floods in coordination with the related
agencies.
• Studying the topography of watershed and protecting the agricultural lands and terraces from
land-sliding in coordination with the related agencies.
• Taking precautionary procedures against threats of floods to preserve irrigation water from
waste and pollution in coordination with the related agencies.

Thirdly, the General Department for Forests, Pastures and Desertification Control is tasked to
support forest protection and control of desertification and sand dunes. Its relevance to the irrigated
areas concerns the protection of land near the irrigated areas and control of sand dune movement
and control of mesquite infestation, which is an issue in the spate irrigated areas of the lowlands in
particular. The mandates activities of the Department are:
• Proposing policies and setting plans and programs on combatting desertification and developing
forests and natural pastures in coordination with the related agencies to implement them.
• Surveying and identifying the areas of desertification and preparing maps and a database.
• Surveying and classifying the forests and natural pastures and doing technical, economic and
social studies with aim of developing and preserving them in coordination with the related
agencies.
• Supervising the implementation of plans and projects related to the forests and pastures in
coordination with the related agencies.
• Contributing to raising awareness on forest protection, desertification control and tree planting
to increase the green areas.
• Collecting and classifying forest plant types and locate where they grow and preserving them in
gene banks.
• Proliferating forest and pasture types and classes appropriate for different environmental conditions and participating in defining the quality of seeds and nurseries in this scope in light of the scientific researches.
• Studying and identifying the annual needs in terms of the requirements and inputs of nurseries and producing forest nurseries based on the annual tree-planting plans and programs.
• Issuing licenses and permits to invest in forests products and monitoring the production and transport of charcoal.

Finally, within ILRS, the General Department for Surveys and Land Reclamation is in charge of land reclamation, including the use of saline lands. The tasks of the Department are:
• Proposing policies, plans, programs for land reclamation to increase the area under agricultural production.
• Surveying and classifying the agricultural lands.
• Conducting technical studies and topographic surveys for the agricultural lands and setting maps for optimal use and protecting them from erosion and desertification in coordination with the related agencies.
• Identifying promising investments for land reclamation and preparing feasibility studies and proposing necessary incentives to attract investors.
• Conducting soil analysis to determine the levels of exploited agricultural lands fertility and proposing appropriate fertilizers for soil and crops to raise its productive efficiency in coordination with the related agencies.
• Conducting studies related the saline lands to determine the best crops and water shares to raise its efficiency in coordination with the related agencies.
• Preparing technical studies and economic and social feasibility studies and proposing plans and programs for the projects that aim to the desert lands reclamation.
• Working to develop the used machineries in the agricultural operations and encouraging the introduction of modern technologies in this domain.
• Proposing laws and legislations related to preserving the agricultural lands and raising the efficient exploitation in coordination with the related agencies.

Of the four General Departments within the IRLS the General Department of Irrigation and Hydraulic Structures is well endowed with staff and is involved in new irrigation investments. Similarly the On Farm Irrigation General Department has been implementing a program of irrigation investment, with funding primarily from the AFPPF. It achieved high targets but this was also related to the fact that it did not have to use the stringent criteria on beneficiary selection that were applied for NIP. Whereas in NIP for instance subsidies of 80% applied for localized systems (drip and sprinklers), subsidies amounts under ILRS were lower: 50%. Yet targets achieved in ILRS were four times higher than in NIP – as there as no ceiling on the land holding of the applicant farmer – and farms of even 80 ha were equipped.

In both Departments however, there have been no activities on the policy, study and regulatory aspects of their mandate. Even though these activities are useful, there is no plan or resource to work on these aspects.

In addition, there are relatively few activities in the other two General Departments, i.e. Forest and Desertification Control and Survey and Land Reclamation. The main reason is the non-availability of funds either for investments, activities or staff incentives.

Below the staff strength of the four section within IRLS is given with the educational qualifications. The IRLS has a considerable number of highly educated staff – with almost half of its technical staff having a university degree, including 10 PhDs. It has supported by an administrative department.
numbering 24 persons. The complete number of staff and their distribution and qualifications are presented in the above table with total of 264 persons.

Table 2.1 Staff Strength of ILRS

<table>
<thead>
<tr>
<th>General Departments</th>
<th>PhD</th>
<th>MSc</th>
<th>BSc</th>
<th>Diploma</th>
<th>High</th>
<th>Less</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>irrigation and Hydraulic Structures</td>
<td>1</td>
<td>1</td>
<td>67</td>
<td>17</td>
<td>22</td>
<td>2</td>
<td>110</td>
</tr>
<tr>
<td>On farm Irrigation</td>
<td>1</td>
<td>2</td>
<td>20</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>Forests and Desertification Control</td>
<td>7</td>
<td>12</td>
<td>16</td>
<td>14</td>
<td>10</td>
<td>16</td>
<td>75</td>
</tr>
<tr>
<td>Surveys and Land Reclamation</td>
<td>1</td>
<td>0</td>
<td>9</td>
<td>10</td>
<td>2</td>
<td>3</td>
<td>25</td>
</tr>
<tr>
<td><strong>Sub total</strong></td>
<td>10</td>
<td>15</td>
<td>112</td>
<td>45</td>
<td>37</td>
<td>21</td>
<td>240</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Administrative support units</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Finance</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Services</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>D.G. office</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Deputy office</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total staff ILRS</strong></td>
<td>10</td>
<td>15</td>
<td>116</td>
<td>46</td>
<td>52</td>
<td>25</td>
<td>264</td>
</tr>
</tbody>
</table>

Source: MAI data

2.1.1.2 National Irrigation Program (NIP)

Within MAI the National Irrigation Program is a special program set up efficient irrigation in three basins. Under the Sector Wide Approach (SWAp), the Government and the major donors had agreed to move to finance irrigation investments under the Water Sector Support Program (WSSP) in line with the NWSSIP. Although there are several successful projects being implemented by the specific project management units (PMUs) in irrigation subsector, the WSSP requires a unified country system to implement its investments.

Accordingly, the Minister MAI in his letter of June 2, 2008 addressed to the World Bank and copied to MWE, MoPIC and the Donor Groups and requested Donor assistance for the consolidation of existing PMUs (GSCP, IIP, SBWMP) Irrigation Component into one single Irrigation National Program (NIP) that would carry out procurement and implementation of irrigation improvement infrastructure, spate irrigation, water recharge structures as well as continue with the Irrigation Advisory Services (IAS) that were started under previous projects. Policy issues, long-term strategies as well as M&E of the sector would remain with the MAI.

The World Bank, welcomed the initiative, which would become an effective instrument of WSSP in consolidating the lessons of the current IDA funded projects including IIP, GSCP and SBWMP (Irrigation Component), and suggested that the proposed NIP could focus:

- in the short-term to strengthen the capacity of MAI’s irrigation sector in implementing the current IDA funded projects as well as the irrigation component of the ongoing WSSP; and
• in the medium to long term, pave way for more sustainable sector reorganization in line with the expected forthcoming recommendations of the NWSSIP Update. This would require coordination and integration with NWRA and decentralization of responsibilities to the WUAs and the Irrigation Councils.

The NIP was established in November 5\textsuperscript{th} 2008 by Ministerial Decree No.69 as a transitional arrangement before moving into the country system. One option was in the future for NIP to transform into an entity, one possibility being a National Irrigation Authority (NIA). As per NIP establishment documents. NIP will be in charge of planning, budgeting designing, procurement, disbursement/ financial management and implementation of groundwater and spate irrigation schemes, funded under WSSP. Planning, constructional design and monitoring of well drilling, groundwater abstraction, flood control, water harvesting and watershed management tasks would be coordinated with NWRA or the Basin Committees as stated in the Water Law. NIP shall have full authority for awarding contracts in accordance with the government law and bylaws and shall have full responsibility of implementing respective works all over the country. In parallel to this, the NIP will also provide Irrigation Advisory Services and give assistance for establishing and empowering water user associations/organizations.

NIP operates under a steering committee. The minister of MAI chairs this steering committee with the following members:

- Deputy Minister of Irrigation and Land Reclamation Sector (vice-chairman) / direct supervisor of the program.
- Chairman of National Water Resources Authority (NWRA).
- Director of Agriculture and Fisheries Dept.
- Ministry of Planning and International Cooperation.
- Representative of Ministry of Finance for the budgetary sector.
- DG’s of Irrigation and Hydraulic Structures and On-farm Depts. under ILRS.
- DG’s of Planning and Monitoring and Projects Depts. In MAI.
- Project Manager of GSCP.
- DG of NIP as secretary.

The tasks of the Steering Committee are (a) review and approve plans and annual work programs and related budgets; (b) review the functioning of the program through periodic review and program management reports and annual and quarterly reports as well as guidance to correct wrong actions, if any, and to overcome difficulties encountered in the functioning of the program; (c) approve the employment of the basic elements of the program; (d) Review and approve reports of the auditor (e) benefit from infrastructure of upcoming or completed projects to ensure its smooth transfer to the NIP for sustainability of ongoing activities.

The NIP implement the irrigation works/activities through the existing Field Units (FUs) and additional FUs are to be created under NIP which will implement activities relating to both (i) groundwater irrigation and (ii) surface water irrigation. Presently with the available funds NIP activities are confined to three basins (Sana’a, Amran and Dhamar) for Groundwater Irrigation Improvement and Wadi Ahwar (Abyan), Wadi Khwrah (Shabwa) and Wadi Zabid (Tihama) for Spate Improvement. Activities in the 10 Field Units transferred from GSCP to NIP are not in operation now – as fewer funds have been committed to NIP than anticipated. These units would be under operation after additional funds become available to NIP by donors. Some of the Field Unit staff is engaged in activities implemented through ILRS. This somehow speaks for the failure of project based funding and the dependence on external support. It also is a disappointment on the ambitions in NWSSIP – where USD 750 M was estimated to be required to achieve the targets over a seven-year period. In
practice the commitments, and solely from the World Bank, are less than 10% of this amount. The irony hence is that though the demand is high, even some of the limited capacity in promoting better agricultural water management is not utilized.

The total staff of NIP numbers according to salary payment sheet 146 staff member – including 117 civil servants and 29 consultants. Out of this number 100 staff are assigned to the different field units. The educational breakdown is given in the table below.

<table>
<thead>
<tr>
<th>NIP</th>
<th>PhD</th>
<th>MSc</th>
<th>BSc</th>
<th>Diploma</th>
<th>High</th>
<th>Less</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professional staff</td>
<td>14</td>
<td>70</td>
<td>8</td>
<td>54</td>
<td>146</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NIP was meant to become the umbrella for all irrigation investments. At the same time it is a parallel body not unlike the PMUs of the previous projects in the irrigation structures. The project-oriented approach is also present in the functioning of NIP and there is a risk of creating an isolated structure not capable of sustaining itself outside the currently implemented projects. There is a gap between NIP and the IRLS. This gap is prominent because of differences in salary scales applied in NIP and the one adopted by MAI in the Irrigation Sector. The mandates of ILRS and NIP are quite similar and overlapping.

The Irrigation Advisory Services (IAS) has been set up to raise the capacities and awareness of local farmers through extension and material and equipment supply in water saving technology, and creation of WUGs and WUAs. They came into being under the GSCP and continued under NIP. Farmers’ perception of the IAS has been positive, as revealed from the Beneficiary Impact Assessment (MetaMeta/ WEC 2012). There is a large interest in training – and in some cases farmers mentioned they are even willing to pay for it. The demand in fact appears far more than the GSCP project could offer within constraints of time and transport. 28% of the farmers attended training directly (including visit to demonstration farms or workshop). A regular ‘complaint’ of farmers was that they would have like to have more support in this regard and did not see the IAS as frequently as they would have like to: this reflects on the large needs for the services as provided by IAS. The majority of the beneficiary farmers did not take part in a training event.

The IAS unit of NIP is working in 3 three ground water areas, i.e. Sana’a, Dahmar, and Amran. The unit activities as per their plan for 2012-2016 (are 1) fields days and workshops, (2) establishment demonstration farms with water saving technology (conveyance pipes, drip and bubbler systems); (3) establishment of water user groups/unions. (4) training to farmers and staff (5) conducting public awareness campaigns in form of extension massages in printed material, media flashes and film production in radio and TV programs.

Also NIP as part of IAS activities has contracted AREA to carry out research in spate area of Wadi Ahwar through the AL-Kod research station. This research looks at improving the productivities and
increasing the income of farmers through demonstration fields over an area of 104 ha with crops of cotton, sorghum, millet, sesame and several vegetables such as watermelon, tomato, and onion. The research station will conduct studies on soil properties water soil and plant requirements and convey the results through training and public awareness and field days to the farmers.

The importance of extension is clear from the scope in ‘closing the yield gap’ – described in section 1.1.7. Reigniting extension and research capacity can contribute greatly to increase productivity in the agriculture sector. Current service provision in this regard is lacking to non-existent in most parts of Yemen. In addition, research and extension do not work together as they should, whereby advances in research are passed on to the farmer through the extension system. Also, extension services are spread across several directorates in MAI, and do not work in a coordinated manner. Private sector extension and technical advice exists in Yemen, and is often performed by existing MAI employees of the extension service for a fee. However, this level of extension is not available to small farmers due to lack of funds.

The By-Law 112 of 2011 proposes that IAS is extended to cover the entire country. A complete re-building of the public extension service is indeed needed including restructuring, capacity building, introducing effective extension techniques, strengthening linkages to research, and employing a new male and female extension agents with adequate means of transport and other facilities. Capacity building is needed for these new recruits to add new skills such as financial management, efficient water usage, water saving agronomic techniques, introduction of new crops and varieties, and association or cooperative development. This will be the best way to increase productivity for Yemen’s small farmers, and to provide services and inputs to the underserved rural communities. There is also interest of farmers to pay and contribute to quality training and extension services and this should be developed as well.

2.1.1.3 Agriculture and Research and Extension Authority (AREA)

Agriculture research is primarily the responsibility of the Ministry’s Agricultural Research and Extension Authority (AREA), with its headquarters in Dhamar and regional research stations located in various agricultural zones of the country. The organization was established in 1983 by decree/law No. 32. There were no amendments of the decree but there was a new decree after the Yemen Unification in 1990. This defined the title of AREA and the new branches established after 1990 as a result of the unity of Yemen in 1990. The amendment decree was issued in 1998. The bylaw of AREA is still under process at the Ministry of Civil Service according to the resolution of the council of the ministries No.107 for 2008. An internal structural set up is being implemented to date. According to chairman statement It is envisaged that the by law will be issued in the foreseeable future.

Generally, AREA is mandated to conduct applied research in soil and water conservation with emphasis on water resource management. An estimated 20-30 % of the annual plans cover water related research such as crop water requirements, assessments of on farm water losses and prepare recommendations on the most appropriate water applications required by each crop. In chapter 1 some of these researches have been highlighted.

Initially AREA also was responsible for extension, but at present it focuses on research mainly. The AREA extension roles and services have been moved to the General Department of Extension in the ministry (MAI) since 2004. The most significant coordination mechanism is reflected in the research and extension linkage mechanisms at the regional and local levels. The linkage with extension organizations at the governorate level is based on joint activities in testing technologies on farm.
The second coordination mechanism is the contractual arrangements with projects and the private sector to test new technologies and disseminate the technologies, which prove successful under the local conditions of Yemen. This type of coordination is called "research on request". The linkages with NIP is reflected for instance in the contract for AREA to conduct on farm demonstrations in Ahwar Wadi (Abyan).

AREA has an Irrigation Production System Department at the Research Sector responsible for the coordination of irrigation activities and on farm water management. Related work by the AREA branches and regional offices mainly concerns in plant water requirements and soil investigation. The scope of activities is limited due to limited research funding, including the provision of staff incentives. Some of the research results however are summarized in section 1.1.7.

AREA also has a specialized centre for natural resource management and conservation. This "Renewable Natural Resource Centre" undertakes research and trials to:

- Increase production of agricultural crops in quality and quantity with emphasis on market demands in every production system
- Improve crop management with the aim of sustainable use of inputs
- rational and efficient use of land and water
- use of biodiversity for environment protection
- improve animal production in the context of integrated system of animal, plant and range management.
- reduce post harvest losses and improve techniques of food marketing, handling and storage.
- review marketing systems and suggest alternatives for improvement of marketing procedures.

According to report of finance and administrative department of December 2012 AREA has 1,395 staff, including 69 PhD. holders, 99 MSc, 230 BSc, and 204 technicians as researchers and scientists working in eight (8) research stations and five (4) specialized research centers plus the head quarter in Dhamar as well as the Sana’a and Aden offices. The professional staff is supported by 787 administrative staff and skilled labor. AREA employees operate under the technical supervision of the Ministry’s Agricultural Offices and District Extension Centers located all over the country. Following the passage of the decentralization law, local authorities now manage this entire service.

The lack of funds and particular the limitation of operational fund and running costs is a major bottleneck. In addition there are a number of other constraints:

- Most of the qualified staff in AREA is close to retirement and no replacements or recruitment of new staff is foreseen. This also applies for the staff working on water related issues
- There is overstaffing of relatively junior staff, with poor qualifications.
- An important constraint in covering the major agro-ecological zones concerns the limited facilities in the regional stations and the long travelling distance to targeted areas. It is difficult to locate staff in targeted areas because of accommodation facilities and proper environment for settlement. Moreover, the incentive system is not encouraging staff to be located in remote areas for long periods.

### 2.1.1.4 Tihama Development Authority

TDA was established according to Law No (2) for the year 1973. According to its law of Establishment, TDA works to improve utilization of water resources, lands and improve agriculture production. TDA is working in several governorates: Hajjah, Raimah, Dhamar, Ta’iz (Bab al Mandib), Hodeidah. The working area of TDA is huge: 600 km of coastline from Bab Almandab, Ta’iz south to border of Saudi Arabia in the north with about 50-60 km from sea coast line inward, where the mountain ranges starts. The authority divided into three areas of operations: Northern, Central and Southern.
The mandate of TDA is the “management and proper utilization of the available agricultural resources and improving agricultural production (both livestock and crops) in the Tihama Plain in accordance with government’s policies and strategies for developing permanent agriculture using the approaches of participation and involvement of local community”.

A mission of TDA was formulated with senior management in 2007: to contribute to better rural livelihoods in the Tihama plains, in particular by effectively contributing to increased agricultural and livestock production and managing the natural resources – including the irrigation systems - in a sustainable way. A special consideration is to improve and protect the income position of the poorest people in the region.”

Its main activities are in the maintenance of the spate systems in the area, providing agricultural extension and monitoring of groundwater. Over time it has also been involved in special projects, such as the stabilization of sand dunes in coastal zones. Its list of activities concerns:

- Increased agricultural and livestock production through extension services
  - Increase production of cereals, vegetables, fruit, fodder and sesame.
  - Increase livestock production.
  - Double honey production in 5 years
- Sustainable natural resource management
  - Ensure adequate operation and maintenance of improved spate irrigation infrastructure.
  - Protect lands from floods and sand dune movement.
  - Increase water productivity and promote use of water efficient crops.
  - Improving economic use of rain-fed lands.

The Authority is also monitoring the ground water through 300 wells across Tihama plain as well as surface water, covering 11 main wadis with 103 stations all over. It also monitors climate having 13 meteorological stations from Abs (North) to Albarh (south). Sand dunes movement is monitored in Wadi Sihan and Zabid.

For its irrigation and water resources activities 8 transportation vehicles, 1 truck, 8 water monitoring stations, 85 rain monitoring stations and 13 automatic monitoring stations, 5 wadis water monitoring equipment, 5 equipment to monitor salt ratios of water and 10 measuring tapes in addition to 20 automatic rain monitoring stations and 50 water level recorders are available.

Like other organizations TDA has an extensive staff pool. The number of TDA employees is 1228, of which 3 are PhDs, 13 Masters, 7 Diploma Holders, 141 BScs, 47 Technical Diploma, 329 Secondary School Certificate, and 688 lower than Secondary Certificate. The Authority has in its departments in the three regional areas 57 water monitoring technicians, 5 monitoring specialists, 2 guards, 25 engineers and technicians, 3 departments heads one for each area and the director of the Department.

The main problems, as assessed in 2008, were:

- Very little happens. The staff’s capacity in TDA to undertake activities is much larger than what it actually does. An example is the sand dune stabilization program. During the Tihama Environmental Protection Program TDA was working on 32 sites, now this is limited to 5 sites. Another example is the Rural Women Development Programme. This section has approximately 50 female rural extension workers, yet due to lack of vehicles and very limited budget the section only does a fraction of what it could do, if it had the resources. TDA also has more than 50 extension centre but several of these are not in operation as there is no budget for electricity and water bills.
• The effective budget for important activities is very limited and the allocation of the total resources available is not transparent. According to Euroconsult/ Pan Yemen (2008) the total budget allocated to TDA for instance 2007 was YR 1,786 Million (including an investment budget of YR 1.046). What is important is to compare this with the YR 40 Million available for O&M; YR 10 Million allocated for extension and YR 4 Million for Rural Women Development – respectively 4% and 1% and 0.5% of the overall budget.

• Fieldwork transportation vehicles are not enough to carry out the expected activities of the TDA and the available vehicles most of them old and need maintenance.

• The professional staffs in general in TDA is getting old and new specialized staff are not recruited to replace the old generation and to transfer knowledge, which are an assets of TDA.

These problems relates to a large extent to organization structure of the TDA and its most important working procedures, including budget allocation. These procedures stand in the way of an effective implementation of programmes. Similar issues also characterize other organizations in the irrigation sectors. The organizational structure of TDA makes it difficult to see who is responsible for what and how coordination has to take place.

• There is no organizational integration between closely related technical functions:
  o There is an overlap between the work of some sections;
  o Some work is organizationally scattered;
  o Some sections exist but are ‘empty’;

• There is little or no delegation – both in the implementation of programmes and in the general administration;

• The relationship between the technical department in Head Office and the corresponding sections in the regional office is not clear.

• There is ambiguity on the roles in the Management Board.

The TDA still works according to its old organogram. A new structure was prepared and agreed in 2008, but there has been no follow up. Also important changes to the procedures were proposed that could serve as examples for others, in particular:

• Working in program based manner
• Budget based on results
• Program team based on results
• Regular management meetings
• Clarifying the relations between head office units and corresponding units in the regions
2.1.2 Irrigation services/organizations in the Governorates

Whereas the MAI through IRLS is responsible for policy and strategy issues, following the decentralization, implementation of the agricultural as well as irrigation program were meant to be undertaken by the Agricultural Office based in the governorates. Most of MAI branches in the governorates are only involved in providing limited maintenance and extension services on irrigation activities and have little or no access to operational budgets in general. The exception is governorates where projects are being implemented through Field Units or the Tihama food belts where the TDA is the sole representative of MAI. The staffing capacity in irrigation varies considerably between the units in the governorates. In some unit there is a still operational staff employed, causing high staff numbers.

The Law of Local Authority enacted in 2000 aimed to bring decentralization. It had a major impact on the work of the Agriculture Ministry. The law fundamentally changed the relationship between the existing bodies of the MAI at the governorate level and at the national level. Under this law, the Agricultural Office in each governorate was placed under the financial and administrative jurisdiction of the Governor’s office, while the Ministry retained the technical supervision. By removing administrative and financial control of the local agriculture offices, the Local Authority Law changed the internal coordination mechanisms within the Agriculture Ministry.

Under the Law of Local Authority, the annual budgets of the Agriculture Offices in the governorates would be part of the governorate budget. However, this has yet to be implemented in all governorates and generally the budget allocated to the Agriculture Offices is insufficient. This has caused services by local Agriculture Offices to become unpredictable, which has contributed to the weak performance of agriculture sector.
Table 2.3 Irrigation staff in the governorates (2013)

<table>
<thead>
<tr>
<th>Directorate</th>
<th>PhD</th>
<th>MSc</th>
<th>Diploma (High)</th>
<th>BSc</th>
<th>Diploma (Med)</th>
<th>High School</th>
<th>Other</th>
<th>Total</th>
</tr>
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<tr>
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<td>10</td>
<td>16</td>
<td>10</td>
<td>120</td>
<td>18</td>
<td>69</td>
<td>52</td>
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<td>2</td>
<td>10</td>
<td>14</td>
<td>4</td>
<td>6</td>
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<td>1</td>
<td>5</td>
<td>1</td>
<td>15</td>
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<td>1</td>
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<td>3</td>
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<td></td>
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<td>3</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
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<td>4</td>
<td>1</td>
<td>12</td>
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<td></td>
<td></td>
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<tr>
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<td>7</td>
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</tr>
<tr>
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<td></td>
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<tr>
<td>Mareb Agricultural Office</td>
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<td>4</td>
<td></td>
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<tr>
<td>GDI&amp;LR/Hadramout</td>
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<td>2</td>
<td>5</td>
<td>17</td>
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<td>161</td>
<td></td>
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</tr>
<tr>
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<td>14</td>
<td>31</td>
<td>7</td>
<td>48</td>
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<td></td>
</tr>
<tr>
<td>Hajah Agricultural Office</td>
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<td></td>
<td>23</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
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<td></td>
<td>5</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
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<td>18</td>
<td>325</td>
<td>79</td>
<td>207</td>
<td>509</td>
<td>1211</td>
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</tbody>
</table>

The poor performance also concerns the extension programs at the local level. These extension services were begun under donor-funded projects — and often had major impacts as for instance in the IIP. They are now inoperable following the closeout of donor support. The Ministry’s budgetary insufficiency and managerial weaknesses have simply not been able to anticipate and address these issues of sustainability.

As a result implementation activities in the governorates take place under a number of arrangements. Apart from the field offices of the MAI, they may concern (a) field unit of project such as GSCP and currently NIP (b) field activities of the IRLS themselves and (c) investment from special funds such as the Social Fund for Development (d) TDA in its area of operation.

The existing arrangements have caused overlap and lack of coordination between these entities, which resulted in loss of resources and responsibilities. One example of such occurrence can be seen in intervention of a GSCP project and the continuation of work by NIP in wadi Zabid in Tihama. The intervention in raising the crest of the weir in the wadi by the system without full engagement of TDA. This created disturbance to the water allocations to beneficiaries either downstream and upstream and affected the canal and it’s embankments.

2.1.3 National Water Resources Authority (NWRA)

NWRA is the dedicated agency responsible for water resources planning and management in the country. It is meant to play a regulating and mediating role between the often-conflicting interests of users in irrigation/agriculture, drinking water supply, industry and commerce. As such NWRA is the custodian for Integrated Water Resources Management (IWRM) in the country.
NWRA’s mandate is defined in the Water Law and fine-tuned in the By-law of the NWRA. It is amended and adjusted by the committee in MWE in June 2003. As to these law and by-law NWRA has the following functions and responsibilities: -

(1) Policy, Strategy and Planning: -
- Prepare the General Policy of the State regarding water resources and policy here means define the overall policy and priorities to achieve sustainable and equitably integrated Water Resources Management (IWRM).
- Implement the approved water policy.
- Propose a water strategy, i.e. the framework within which Integrated Water Resources Management (IWRM) will be carried out, identify the actions to be taken and clearly define the entities in their responsibilities and powers.
- Formulate the foundations for water planning [art (13)].
- Develop a water plan for each basin and integrate it into a national water plan [art (16), (17)]; priority should be given to the critical water basins and water zones.
- Prepare NWRA’s investment plan.
- Estimate water budgets at the Water Basin Level [Art (12)].

(2) Implementation and Regulation
- Enhance water resources management at water Basin Level.
- Prepare corresponding (proposed) laws by-laws, to Water Law [Art (78)].
- Set –up Water Basin and Water Zones Committees.
- Organize the use of water resources and the disposal of wastewater through the issue of licenses and permits.
- Control and evaluate the use of water.
- Follow up and penalize those violating water regulations.
- Register the water rights.
- Develop, administer and maintain a water observation network.

(3) Water Quality: -
- Establish a national program to protect water resources and to control water quality.
- Protect water resources against pollution and maintain water quality [Art (54)].
- Prepare-in coordination with relevant concerned entities-the procedures for regulating the disposal of industrial wastes, the use of agricultural fertilizers and pesticides and all hazardous substances [Art (54)].
- Carry out studies and research related to the protection of ground water aquifers.
- Monitor the quality of water at the level of water resources.
- Harmonize policy with Environmental Departments in MWE, EPA and other stakeholders.

(4) Reporting and Monitoring: -
- Collect data and information on water resources.
- Monitor performance of projects, local branches etc.
- Receive periodical reports from them about their performance, achievements, plans, problems etc., analyze and evaluate them.
- Prepare periodical sub-sector reports and transfer them to MWE.
- Prepare annual Financial report to MWE.

(5) Studies and researches: -
- Prepare studies on all relevant subjects according to priorities.
• Initiate applied research on efficient water use.
• Support the ministry in preparing a program for educating the public in preservation and better use of water.

(6) Training:
• Prepare, execute and follow-up long and short run training programs for management and administration, for planning, evaluation and implementation of project.
• Coordinate this with bilateral and international technical assistance and MWE.

2.1.4 Social Fund for Development (SFD)
The SFD is an independent Yemeni Government multi-sectoral development funding and implementation agency. It was established to assist and provide development support in economically productive activities with poor communities. Funding sources include the World Bank, the European Commission, Government of Yemen and bilateral donors.

In the water and environment unit, priority is given to rural water supply projects operated by gravity (springs, small streams) or based on shallow wells, which can be operated by hand pumps. In earlier years, the SFD was also involved in mechanized systems, but has stopped due to the non-sustainability (fiscal and resource wise) of these projects. Funding for the rural water sector is up to USD 5 M per year (approximately 10% of the total SFD budget). The work conducted by SFD is largely through contractors. The SFD’s projects emphasized community participation and the use of traditional knowledge and experience.

The water sector focuses on implementing low-cost projects to provide water services to the poor. The water sector has 4 sub-sectors: rainwater harvesting (public tanks), rooftop rainwater harvesting tanks (private tanks), piped water systems, training and awareness. In addition, the SFD focuses on soil protection, water collection management, flood protection works, improvement of traditional irrigation systems and recharge of groundwater, and cultivation of high value crops.

To have an idea of the order of operations during 2012, the SFD approved 44 projects worth about USD 8 M, targeting 63,043 beneficiaries. In Irrigation Systems, the SFD approved 2 projects worth USD 12,159, to train 61 project officers and consultants in water for agriculture development policies and implementation mechanisms. In Soil and Water Conservation, 11 projects worth $1.7 million, serving 14,283 beneficiaries, were approved. One of these projects aims at updating the intervention policy of this sub-sector, while the remaining projects aim to rehabilitate watersheds through different types of interventions. In addition, 26 Small Dams projects worth USD 6 M were approved, targeting 32,982 beneficiaries. These include 23 projects for the construction of dams, 2 for training and 1 for the preparation of studies. Dam projects were situated in Mareb, Al-Jawf, Shabwah, Sana’a, Ibb and Al-Baidha governorates. Also, the SFD approved 5 small projects for Qat substitution, aiming to produce and print materials to help raise the awareness of more than 15,700 schoolchildren and parents.

In 2011, the SFD began the implementation of a project to install supplementary irrigation tanks in Lahej and Hajjah as well as the implementation of a water and soil conservation project in Al-Hudaidah, which is expected to benefit approximately 2,000 people. The implementation of watershed and agricultural terraces projects is also underway in Wadi Shareem (Al-Hudaidah) and in various sites of the watershed in Wadi Majbar (Al-Mahweet), with sites’ treeing and cultivation of more than 9,000 olives and coffee seedlings.
The projects implemented by SFD are generally high quality and innovative. Part of the explanation is the more detailed management systems and the better staff incentives. Being an independent Fund the SFD also devotes considerable attention to quality control and reporting on results.

2.3 Status of Water Users Associations, Irrigation Councils and the Cooperative Union

The importance of community management and the role particularly of WUA has been acknowledged in all main policy documents relating to the Water Sector. The role of WUAs considered as (a) regulation of water use in groundwater dependent areas including the promotion of water saving measures and (b) operation and maintenance of spate irrigation system, an area that is considered quite problematic.

In addition WUAs are considered a party in water management at larger scale, in Basin Plans and Water Plans but also through Irrigation Councils in the management of large spate irrigation systems. Whereas the first is based on provision in the Law on Local Authorities (2000) but not in the Water Law (2002) or the By-Law, the role of WUAs in Basin Management is acknowledged in the By-Law 112 of 2011.

This By-Law 112 of 2011 in fact gives a large importance to WUAs and o prescribes that water users associations and groups and committees and unions should be formed all over the country. This should be implemented by both NWRA and MAI in a coordinated way. Articles (8, 12-14) of the by-law give the legal basis for WUAs and unions to be involved in such activities. Another important breakthrough is the majority rule – where a majority decision of a WUA general assembly is binding to all users of water – provided the WUA represents two-thirds of the water users in the area.

Hence the role of WUAs based on these legal documents in irrigation and the water sector at large is set to increase. This section discusses first the current functioning of WUAs (2.3.1), the functioning of the Irrigation Councils (2.3.2) and the role of WUAs in Basin Councils and the preparation and implementation of Basin Plans (2.3.3).

2.3.1 Water Users Associations

The development of WUAs started in response to irrigation investment paying little attention to local management. Starting fifteen years ago the establishment of Water Users Groups and Water Users Associations has been promoted under several irrigation and water resource management projects, such as Irrigation Improvement Project, Groundwater and Soil Conservation Project, Sana’a Basin Water Management Project, EU Food Security Project, GtZ Amran program, Community Water Management Project and the National Irrigation Program.

There has been no uniform methodology – though many programs have started with smaller informal and temporary units (Water User Groups (WUG) and Design Committees) and then combined these into Water Users Associations. The size of the WUAs differs between projects. The NWSSIP update estimated in 2008 that there were 165 WUAs in the country, in addition to 640 informal project based WUGs.
In addition to the WUAs established under projects in a number of cases farmers have taken the initiative themselves to set up a WUA – for self supply of drinking water or to regulate groundwater use. An example is the self organized WUA at Khrabat Muyyab (see box).

**Box 2.1 Self organized farmers, Khrabat Muyyab, Bani Matar, Sana’a**

The main water source of the Khrabat Muyyab area is the run-off from nearby mountains, which feeds aquifers and springs. Over the years farmers have moved to groundwater irrigation, typically pumping water from wells 150 to 180 m deep. The wells – if only because of their cost – are shared by many families. A typical well may have 17 shares and ownership between 25-30 families.

Following a violent conflict in a nearby area over the sharing of water from a dam that was to be built by the government, farmers decided to regulate the use of water in their area. The establishment of the WUA, called ‘Belad Albustan’, was triggered by seeing the conflict and hardship arising from overuse of groundwater in nearby areas; it was not set up by any project but created at the initiative of concerned farmers. The WUA initially regulated the seven wells in Khrabat Muyyab village. Minimum rules were set on the distance between wells. Wells were to be at least 500 m apart, but depending on the location the distance can be even larger. The minimum distance to a spring, for instance, is 2000 m.

Whereas the WUA initially covered seven wells in two villages, its usefulness has been recognized and it now covers the area of 58 wells in eight villages. The membership went up from 80 to several hundred. The development of new wells in the area is not allowed unless a clear need for a new well (rather than getting water from an existing well) is proven and the minimum distance is observed. Improved irrigation techniques are relatively exceptional in the area and there appears to be a good scope for improving water management on this front too.

The current number of WUAs in Yemen is unknown, because there is no unified, consolidated register. The total number is probably close to 300 – though the status is of the WUAs is not known. The Union of WUAs – that brings together and represents WUAs all over the country – estimates that at least 100 WUAs are still active. It needs to be noted that there is no support mechanism for the WUAs – in terms of extension, credit, marketing or elsewhere beyond the duration of the projects. This has been a problem all over the world and one of the major shortcomings of the Participatory Irrigation Management approach that has been actively promoted since 1995. WUAs were introduced as part of irrigation investment programs – involved in design and cost contribution - but after that they are left at their own devices and often whither away. Given this trend it is encouraging that in Yemen that at least a considerable number of WUAs seemingly continues to do well: support of federating organizations such as the Union of WUAs is indispensable as they link the WUAs to other programs and they facilitate learning between WUAs.

There have been only few evaluations of WUA performance. In the GSCP the functioning of the WUAs was assessed. In this project eleven WUAs became active. The members of the WUAs interviewed consisted of a board (ranging from 10-16 members) that was meeting regularly (3 to 12 times year) and in between was maintaining contact by telephone. In some cases the WUAs also had their own office. Board members were nominated or elected for duration of three years. In three of the five cases the chairperson was a small farmer. Also in three of five cases a (small) subscription fees was collected from all members.

Group discussions were held specifically with the members of five WUAs as part of the Beneficiary Impact Assessment undertaken in 2012. All these organizations were registered with the Social Affairs Administrator. Membership ranged from 79 persons to 425 members. In four of the WUAs tenants are members too – in the fifth WUA there are no tenants in the area. Also in two WUA female farmers are among the members.
Of the five WUAs four had received very regular training by IAS (Irrigation Advisory Services) on organizational management. These trainings sessions were assessed as very useful. Besides, the WUAs had cooperated with the IAS on facilitating farmer training. Contact with the field unit management of the GSCP was very intense during the implementation of the works but became more sporadic afterwards. Of the five WUAs four had regular contact with other WUAs and three received training from other organizations besides GSCP.

The scope of some of the WUAs has gone beyond facilitating project implementation (such as raising awareness, approaching beneficiary farmers, arranging distribution of pipes, identifying farmers for training, facilitating cost contributions, supervising and liaising with contractors) - but also concerned conflict resolution and the regulation of water resources – in liaison with the National Water Resources Authority. The political turmoil of 2011 made this regulatory role more difficult as the local NWRA offices were hardly functioning, giving rise to a surge in unauthorized drilling. What is clear from these episodes and from interviews with WUA leaders is that WUAs can play a role in regulating local water use, but they need to be part of larger governance systems and not be a temporary arrangement for the duration of a project. WUAs in GSCP for instance endeavoured to provide direct services such as the regulating access to diesel supplies during the shortage of 2011. Box 2.2 gives an example of the role of WUA in supporting the enforcement of the Water Law.

Box 2.2 WUAs under GSCP: Yerim WUA (Ibb)
The Yerim WUA was set up with the help of GSCP. It served to create awareness on the groundwater issues. It introduced the water saving program and helped farmers get access to the localized systems and conveyance systems promoted under the project. It also made the link with possible beneficiaries for the water harvesting program and the GSCP. The Yerim WUA was also active in controlling unlicensed drilling – working in close cooperation with the branch office of the NWRA. However, with the political crisis starting from 2011 and the disappearance of an active role of public organizations such as NWRA uncontrolled drilling re-emerged.

In the spate irrigation systems the focus of WUA differs from that in groundwater areas. Whereas in groundwater dependent area the main focus is efficient water use and regulating access, in spate irrigation the WUAs concentrates on operation and maintenance of the irrigation infrastructure. WUAs play a role in particular in (1) future maintenance of the structures (2) introduction of improved land and water management and (3) improved farming practices. There is in many cases a large unutilized potential for the improved of land and water management within the command area of spate irrigation systems, for instance in (1) mesquite (prosopis juliflora) eradication (2) commercial acacia plantations (3) introduction of field overflow structures to avoid field rutting (4) better moisture management in general. At system level there is also a need for a more considerate water sharing of spate flow – looking at the recharge of drinking water wells from the floods and not only distribute the flood water according to agricultural needs (see also chapter 4). Also the consensus is that low cost flexible structure serve spate irrigation better than heavily engineered diversion and water control works.

An evaluation was done in 2013 of sixteen WUAs established in the spate irrigated areas of Wadi Zabid under the IIP Projec. These WUAs were set up with support of the Irrigation Improvement Project. This support stopped in 2007 – so the evaluation is insightful in that it looks at WUAs a long time after they were of the external support system. The WUAs were assessed on 20 criteria, related to their internal democratic functioning, to their administrative and financial capacities, their ability to deal with conflicts and relations internally and externally. The table above is the outcome. Out of a maximum score of 40, 6 WUAs scored 20 or more, whereas 6 scores 10 or less – meaning they had virtually ceased to function. On some parameters all WUA scored poor:
Most WUAs did well in keeping financial records and in having council meetings. Meetings with the general members, however, were infrequent or did not happen at all. Most WUAs were poor in keeping relations with external parties and in land and water distribution record keeping. The capacity to solve problems varied between the WUAs: in some conflicts on water rights persisted, in others they were addressed by the WUA. In some areas not the entire system was transferred. There was a good understanding especially of the traditional designs but little flexibility in adjusting the system of water allocation. Only 2 out of 16 WUAs made financial plans and non payment of fees was a uniform problem: as a result most WUAs were poor in finances. On the positive side substantial donations were made for emergency repairs and a fee charging system was in place.

Another main experiment was the creation of WUAs in Wadi Moor, from 2007 onwards. Unlike the WUAs in Wadi Zabid, which were created by the team recruited under the IIP project, the 32 WUAs in Wadi Mawr were established by the TDA itself and 33 TDA extension staff were trained to provide support to the WUAs. The process followed was not as detailed as in Wadi Zabid and also there was less direct investment – the main support was for prioritizing deferred maintenance. The steps are described in figure 2.1.

All in all, 164 lead farmers from 36 secondary canals were trained in different aspects of WUAs; and 2,064 farmers or about 40% of total 6,000 farmers in the 34 secondary canals in Wadi Mawr and 2 secondary canals in Wadi Rima were directly trained in different aspects of WUA management. Twelve secondary canal WUAs prepared their own By-laws. Preliminary priority lists of repair and maintenance works for 30 of the 38 secondary canals were prepared along with action plans for their implementation.
The impression is that the sustainability of the WUAs in Wadi Mawr were better than in Wadi Zabid. Two reasons may explain this (1) the engagement of a local organization, in this case the TDA, rather than a temporary facilitation unit, allowed permanent relations to build up between the WUAs and TDA and (2) the investment process in Wadi Moor was not as intensive as in Wadi Zabid and more discussion concerned local water management, hence a more genuine interest by the WUA members.

In addition to the registered WUAs there are also a considerable number of traditional arrangements under which water is managed in Yemen. Yemen in fact has a large history in developing its water resources and many water management practices, including spate irrigation, the development of qanats (including mechanism to store water in the aquifer) and water harvesting practices have a very long history in Yemen. Yemen’s communities possess rich traditions of experience managing land and water resources, demonstrated not only by physical works such as terraces, diversion dams and canals but also by an array of customary institutions for organizing collective action, regulating access to land for cultivation and water harvesting, and resolving conflicts by discussion, mediation and arbitration through networks of social relationships.1 Traditional spate irrigation institutions established leadership roles, norms for shared contributions, allocated rights to water (primarily through upstream-first served rules suited to uncertain and highly variable flows) and processes for dealing with conflicts.

The local governance not only concerned surface water but related to the use of groundwater. In the past in Shabwa and Hadramawt for instance local laws ensured that any new qanat (canal) that was to be developed could not interfere with existing ones. If a newly constructed qanat was found to interfere with an existing one, work on it would have to be stopped immediately. Another age-old groundwater management rule is the ‘harim’ (border) that has its origins in the Sunnah (statements approved by the Prophet PBUH considered as legally binding precedents). The harim defines a protected area1 around a spring, qanat, or well – where no other source could be developed and contaminating activities were forbidden.

In the wake of the groundwater crisis new local arrangement have come up. A paper by Tahir et al (2011) describes more than 25 areas where farmers have agreed on informal restriction on the use of groundwater so as avoid its overuse. In the table below a number of cases are summarized on local groundwater management in Yemen. Though such cases are not systematically recorded, the impression of the table is that community regulation of groundwater is not exceptional and occurs in several places throughout the country. The rules adopted are usually easy to implement and monitor – restriction of well drilling, maintaining a minimum distance, protected zones or bans on water demanding crops. From the diagnostic work undertaken as part of the report it appears that in some area local regulation are more common than elsewhere, possibly under the influence of a catalyst initiative (or project) that then spreads to other areas.

At present such informal arrangements largely come up spontaneously and ‘against the odds’. A process for supporting community groundwater governance could be organized in a series of steps. This would concentrate at the level of villages and districts, appropriately integrated with activities at the sub-basin, governorate, basin and national scale. This could be done at relatively low cost, and, while key activities need to be carefully carried out, would be feasible to scale up for widespread implementation and meaningful results with a time frame of a few years.

Tahir et al (2011) suggest a number of steps to promote local groundwater management. A community-driven process should start by working in districts where there is substantial interest from local leaders and citizens in finding better ways of dealing with water scarcity. Initial workshops and training can prepare district councilors and others to go out to communities and help them assess and improve local water management.

The process at local level could then consist of a number of stages:
- Initial meetings can encourage discussion of local water problems, past efforts, and examples of what has been done elsewhere.
- Sketch maps can be used to identify water resources and problems (along with topographic maps, air photos, and remote sensing images if available).
- Trends in water use, well numbers and depth, irrigated area and other factors can be plotted on graphs and maps.
- Joint walks help people to observe actual conditions and discuss problems.
- Reviewing relevant values helps identify priorities and principles that should guide the search for solutions. In the context of Yemen, important values are likely to include customary and Islamic values of assuring access to drinking water, avoiding waste and harm, orderly access, productive use of resources, and balancing of public and private interests.
- Envisioning a desirable future that could result from better management of shared resources is a crucial stage, synthesizing ideas from earlier steps, reacting to current problems and the scenarios most likely to occur if changes are not made, and coming up with feasible, desirable visions for a better future.
- Participants can then consider more thoroughly practical steps that they could take to respond to local problems and priorities, moving towards a future they want. This could include assuring access to adequate supplies of water for drinking and domestic use, preventing harmful changes, reducing waste, replenishing groundwater, adapting agriculture to increasing water scarcity and improving livelihoods. Discussion should emphasize what communities, at the level of households, villages, and districts could do using their own capabilities and resources, but might also identify what more they might be able to accomplish with aid from outside.
- Agreement should be established on some practical steps that communities can do on their own, deciding who will do what, and when to meet again to review progress and discuss problems, solutions and further steps that could build on initial accomplishments. Periodic meetings can be help to follow up on what has occurred, work out ways to deal with problems and take further actions to improve water management.

There is also scope to promote water efficiency measures through WUAs beyond the promotion of conveyance systems and localized irrigation. There is a range of water efficiency measures as yet uncommon in the different groundwater irrigation systems and would deserved to be better promoted: irrigation scheduling (this is promoted under the GSCP), land leveling, root zone irrigation and moisture conservation measures (mulching). It is also worth investigating whether the investments in conveyance systems can be extended so as to connect different wells with another. This will have a number of advantages. It will connect the wells so as to turn them into collective systems – making it possible to (1) have a fall back from other wells in case a well fails (2) make it easier to come to collective agreement on local groundwater management (3) encourage efficiency as flow from several wells can be combined leading to less proportional losses.

**2.3.2 Irrigation Councils**

Irrigation councils have been established in three large spate irrigation systems in Yemen: in Wadi Zabid, in Wadi Abyan and in Lahj. They were set up to manage the spate system, also to form a front against encroachers.

Of these three the Wadi Zabid Irrigation Council was established most recently, i.e. in September 2005, by a Governor Decree No.124. The purpose of establishing this council was to serve and facilitate the work of the Water Users Associations in Wadi Zabid covering an estimated area of 18,690 hectares. The larger idea was to have a decision making platform that could bring together all major stakeholders and influential organizations to ensure the proper management of the Wadi
Zabid system, including addressing conflicts, as there used to for instance with powerful land owners endeavouring to make new diversions.

The Wadi Zabid Irrigation Council has 27 members and is headed by the Governor of Hodeida. The members are:

- 16 members representing the water user associations (already working in the wadi and responsible for 16 flood outlet called Shereg).
- 2 members representatives, respectively of TDA (director of the southern region office) and director of NWRA branch office in Hodeida,
- 3 District Directors of Zabid, Aljarahi and Atuheta ,
- In addition three district local councils trustees.
- Finally, a representative of the local attorney general office.

The council has an executive committee of 7 members, and financial committee of 2 members, and 2 members as a committee of conflict resolution and partitioning. The Council Committees were selected through secret ballot by the members of the council. The council prepared in 2007 an internal executive roles and instruction manuals, which contains description of the formation of the council (legal background and responsibilities), the rights and obligations of members, the administrative and financial working system with description of the committees tasks. Also the manual has provisions on violations expected and the fines and punishments that will applied on those violators.

The council has an office building in Zabid Town, built by GSCP project. In addition, the council has 1 bulldozer, 1 truck loader transferred from the previous IIP project in addition to some equipments owned by TDA and left under the council’s operation as government support.

In principle the council should finance itself from fines, contributions, and from a surcharge on the equipment operations (20%). This equipment left by GSCP for the council and operated by TDA in the wadi. In addition, 5% for the maintenance and operation of the IC office building was to be collected from TDA from the income of equipment operations. The council has an account at the local bank. According to the executive manual the irrigation council is supposed to have 6 annual meetings every year to do the following:

- In January to review and approve the financial and work plan.
- In March to review the maintenance review report on the conditions of the irrigation system.
- In May to review and approve the irrigation operation plan before the flood season.
- In July to review the execution of the operation plan during the flood season.
- In September to review and evaluate the execution of the operation plan and the data and information collected during the flood season.
- In November review and evaluation of the council performance during the year.

Unfortunately, the Irrigation Council is not in a good shape. The office building cannot be used due to a lack of furniture and equipment and a need to rehabilitate the electrical and water system. The council has no financial resources and used to depend on the GSCP support before closure of the project. The equipment rental returns have to be resolved with TDA. The council is not functioning and planned meetings are not carried out. The last council meeting was 2 years ago.

The Irrigation Council moreover at the best of times concentrated its activities on the operation and maintenance of the system. The Council did not engage in water distribution issues at wadi level, even though there would be a case to at least discuss the loss of flood water and the blockage of subsurface flows for the lower middle and downstream area, where drinking water wells are running dry and sand dune formation is increasing. There has been a continuous decline of the water table in the lower part of the wadi due to high abstraction of ground water and little recharge from surface
flow. Some farmers and families have abandoned their areas and moved up in the wadi for work and life.

Box 2.3 Lahj Irrigation Council

1 - How the Irrigation Council Functions:- the Irrigation Department, in coordination with the chairman of the council, prepares for the council meetings. Extraordinary meetings are held under certain conditions described in the regulations. Voting system and rules for decision-making are also defined.

2 - Organizing the irrigation Activities:-

- Supervision: - the ID supervises the use of water on behalf of the Irrigation Council
- Forbidding repeated irrigation: - the regulations prohibit irrigation of the same piece of land more than once during the season/year except if flood waters are abundant (as decided by the ID or the irrigation council).
- Water cut-off: - the ID may cut the water off (from an agricultural land under the following conditions: (a) - the land/areas has already received irrigation water during the season. (b) - to enable undertaking of irrigation works (c) - to avoid damages to lives, property, or irrigation structures. (d) - when the beneficiary misuse the water. (e) - if the channels are not fit to receive the water (flow rate greater than channel capacity).
- Exceptional cases: - the ID may remove earth dikes /structures for fear of damages caused by such dikes/structures.
- Private intakes: - the regulations also allow the use of a private channels/intakes to serve another land. The regulations also give the ID the right to supervise and use that private channel/drain.
- Irrigation fees: a fee per feddan is collected per irrigation per season (and a higher fee for lands irrigated from base flow). The fees are used to operate and maintain the irrigation structures in the governorate. The regulations charge the MAI or the local authorities with the responsibility of building and maintaining the structures, the irrigation network, the main and branch canals, and the protection of land from erosion. However, the implementation of these activities is the responsibility of the ID and the MAI office in Lahej.
- Private irrigation works: - each farmer is given the right to build private irrigation works to irrigate his land, in coordination with the ID and the MAI office in Lahej.
- Irrigation dikes: - a user must remove the earth dikes (which they build in main and branch canals) as soon as he finishes irrigation of his land and as instructed by the Irrigation Extensionist.
- Other organizing provision: these deal with: damages and compensation, prohibited activities, and irrigation of land with special irrigation rights.

3- General Provisions:- these deals with implementation and modification of these regulations, establishing regulations for irrigation at the district-level, allocation of the income from fines (75% for O&M and 25% for management expenditures). The regulations also included provisions dealing with incrimination of violators, tasks of the A’abar (intake) Sheikhs, procedures to modify the irrigation council, cancellation of the provisions, and the effective date of the new regulations.

4- Penalties:- The regulations outlined a number of violations and their respective penalties, as follows:-

- Repeated irrigation: a fine of 10,000 YR for repeated irrigation of the same piece of land more than once per season or per year (article 9-1-a). If the violator repeats the violation then he is fined 20,000 YR and legal actions are taken against him
- Offense against the irrigation water works: a fine of 10,000 YR and legal actions are taken against every person who un-rightfully opens a diversion structure or establishes an earth dike.
- Offence by opening the gates: similar fine of 10,000 YR but this time per feddan, and legal actions are taken against every person who un-rightfully opens a gate.
- Other types of violations and penalties are described such as offenses against diversion structures, the wadi course, etc. In general, the offender pays a fine of 10,000 YR.

Other issues related to the Zabid IC were the inadequate response to the needs of users for the clearing of canals and the continued influence of local powerbrokers. The disappointing experience of the Irrigation Council in Wadi Zabid may be compared to the Irrigation Councils of Lahj and Abyan, that have a longer history and are also strongly supported by the local and central government. The Lahej Irrigation Council was already in existence before the 1967 independence of the South of Yemen and at the time of the Sultanate of Lahj. All functions of the Irrigation Council were for spate
management, water distribution and settlement of disputes among farmers. These Irrigation Councils have been always composed of government officials and farmer representativeness. Now, MAI’s branch officer is member of the Irrigation Council of Lahj, and similarly in Abyan Governorate.

The IC prepares schedules of irrigation for each diversion structure (weir or traditional uqma) and its command areas of each canal. IC is also supposed to monitor the application of traditional rules in order to foster equity among farmers also for downstream fields. These rules are based on the concept that, at flood times, spate water will not be diverted to the fields that have received water either from base flow or from earlier floods. Kharif season’s spate water will be allocated to fields that have received no water during that year and only when these requirements have been met, the previously irrigated land will get additional amount of water.\(^{11}\)

The council is established in accordance with the law of "Local Administration", by a resolution issued by the governor upon a proposal by the DG of the MAI office in the governorate. The council is consultative in nature. It is led and supervised by the DG of the MAI office in Lahej. It advises the Irrigation Department (ID) and helps implement these directions. The council has 3 main functions: to discuss and approve the irrigation plan and forward it to the governor, to decide how to best use floods in the delta, and to assist in the irrigation management and maintenance of structures. In comparison to Wadi Zabid the Irrigation Council does not replace the Irrigation Department but creates as strong partnership – with the Irrigation Department managing the complex spate irrigation system on behalf of the Irrigation Council (see box 2.xx).

### 2.3.3 WUA engagement in Basin Councils

In two basins (Sana’a, Amran) Basin Committees are in place. The Basin Committees are supposed to issue among others Basin Plans and discuss larger water allocation issues. A Basin Plan for Amran has been prepared yet it is very cursory and not a basis for water allocation decisions. In general the format for the Basin Plans is not clear and it would be useful if a start would be made with the development of Basin Plans and the establishment of Basin Councils so that a momentum develops.

The recent By-Law (article 18) has defined a substantial role for (see also chapter 4) WUAs in Basin Management. It has identified a number of specific roles – see box 2.4.

The move towards a more broad based basin management, based on local water management throughout the basin, follows examples such as in Kenya, where Water Resources Users Associations are established throughout the basins setting a strong local basis for water management. This avoids that basin management remain aloof and isolated, and particularly in Yemen there is a strong need to strengthen water management at local level too.

The By-Law also created the possibility of creating Unions of WUAs with each Basins. This would resolve the issue of representation of WUAs in Basin Councils which would otherwise exist, because:

- (a) There are a limited number of WUAs within each Basin – so representation would have an arbitrary element;
- (b) Even if WUAs would be established throughout the country and the basins, there would need to be a mechanism to select WUA representation in Basin Councils, as not every can take part in the Basin meeting.

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**Box 2.4 Roles of WUAs in Basin Management (By-Law 112, 2011, article 18)**
- To participate in preparation of legislations and strategies pertinent to such Basin and play roles in supervision on implementation.
• To encourage the special and private activities in relation to rationalize uses of water in particular to develop new methods and systems of modern irrigation and to benefit from seasonal rain and spate water and treated water to reduce pressure on demand of ground water.
• To participate in coordination of efforts on the local level to confront water crisis, floods, pollution incidents that occur suddenly and to urge the concerned authorities to monitor means of transportation of water and its distribution canals and to maintain irrigation systems and protection of dams.
• To propose priorities of water services projects and irrigation structures

At present there is no systematic linkage to the WUAs in the Basin Management and in general relatively little is happening in terms of active basin management. It is proposed that as a priority efforts are made to put broad-based basin management in place, engaging WUAs and local councils.

2.3.4 Agriculture Cooperative Union (ACU)

Outside the mainstream development of Water User Association and having no reference in the Water Law for instance, are the Agricultural Cooperatives – assembled under the Agricultural Cooperative Union. The ACU has been active in irrigation through the General Cooperation of Irrigation and Water, which was established in June 1999 with head quarter in Sana’a. The Cooperation is managed by board of trustees consist of 11 member plus a monitoring committee with 5 members.

At the time of the establishment there were 37 local cooperatives from different parts of the country that joined as members in the general Cooperation and considered as founders. The initial capital estimated at that time was YR 100 M, with the paid capital by the member cooperative was YR 34 M. By December 2006 the capital of the cooperative reached 186 million and the members reached 73 distributed over the country. The cooperatives are organizations, that works as contractors, yet without often having to competitively tender for the activities they undertake.

The work undertaken concerns largely;
(1) Dams and water diversion construction, 48 such structures were executed by the Cooperation until the end of 2007. The spate irrigation work were given to the Cooperation through direct order from the government. Only, later on the cooperative was competing against other contractors for bidding for contracts.
(2) Supply of water saving equipment to members cooperation in the governorates with total covered area of 11,586 ha up to mid of 2007 and total cost of USD 7,4 M. The process of supply was carried through requests comes from the members cooperation in the governorates after technical evaluation by the Agriculture Office specialist who confirm the need at the field level. The cooperative would make the purchase order and receive the goods and would take care of storing and delivery of materials to the cooperative members in the governorates. The supply of modern saving technology inputs was done through direct purchases with three quotes from suppliers. AFPPF has been the main financer of the ACU activities, especially for the water savings systems. Subsidies stand at 50% and repayment is by the member cooperative through installments.

The ACU and the general cooperation for water establishment was a major player in the in the water sector up to 2007. In later years the ACU became more a bidding contractor as the Government reduced the support in the form of direct contracts. The ACU only made one procurement for supplying water saving equipment afterwards (in 2009). This was subject to auditing by the central auditing agency and a number of violations were observed. Recently the Ministry of Finance have put some restrictions against further work.
2.3 Private sector agriculture and irrigation sector support mechanisms

The private sector has played an important role in the development of the irrigation sector, but primarily through well drilling services. The customer base for drilling rig operators is a mix of public organizations (in water supply) and private farmers or group of farmers. The latter is quite common – a deep tubewell may cost up to USD 50,000 and it is not uncommon for groups of 20 farmers to share in the cost of investment.

The business of well drilling has changed however with the number of well drilling that fail having increased to 40-50%. Part of this risk is on the drilling rig operators, as farmer-client as a rule pay less (only 30%) for failed drillings. The siting of well locations is usually done by farmers who better skilled than hydrogeologists in this respect. The market for well drillings is stagnant, it is only qat farmers who can afford the deeper wells. This confirms the observation that the agricultural area in Yemen is not expanding at present with the exception of the area under qat cultivation. The practice of political leadership distribution favours in the shape of well drillings (sometimes guised as a drinking water scheme) has also stopped.

Drilling contractors wanting to qualify for government contracts needs to have their wells equipped with a GPS that makes it possible to track the movement of the drilling rigs. It is not uncommon for drilling contractors to have more than one rig, with at least one properly equipped and the other roaming freely. The most cumbersome part of operating the drilling rigs are the permits for taking rigs from one governorate to other – which is a license to bribe.

There has been for less engagement of the private sector in water saving measures. This is partly because the procurement of conveyance pipes, drip and bubbler systems has been largely done through subsidized public procurement channels, giving no scope for a private service sector to come about. In other countries ‘smart subsidies’ systems have been used, whereby procurement is through the local private suppliers who may even play a role in the preparation of the subsidy requests, the installation and after service.

As part of the diagnostic survey several private sector enterprises working in agriculture, irrigation and groundwater development were interviewed. What is striking is the high awareness of these entrepreneurs that things needs to be done differently in the irrigation sector as well as an interest in the business opportunities that can support this. From interviews with well drillers it is also understood that they are not against even engaging in awareness activities and promoting water saving devices, given the chance, as part of their services. Many well drillers professed that less pumping will be beneficial for the sector as it (1) reduces pumping costs; (2) causes less wear and tear and (3) increase crop yields.

The private sector can also play a large role in the sales and promotion of water efficient measures, that are as yet unknown in Yemen, but are commercially ‘off the shelf’ available in other countries. Examples are:
- Green houses
- Plastic mulch (thin plastic sheets that reduce soil evaporation and regulate soil temperature)
- Biofertilizer that convert waste streams and help improve soil structure
- Zeolite which is a mineral clay, amply available in Yemen, that can improves moisture retention and fertilizer absorption
- Red soils, with a bituminous clay basis – that are available in Sana’a Basin and also help retain soil moisture
- Dew plates, that concentrate rainfall and generate dew by cooling below the dew point
- Drought resistant seeds and varieties.
The private sector can also play a role in marketing of lower water demand crops – be it almonds, coffee or cactus. The existence of efficient supply chains is a precondition for the alternative crops to find a commercial market and there is need to work on this by supporting new market operators and for instance reforming YECO. An example is the marketing of cactus products, that has taken a large flight in Yemen (see box 2.6).

**Box 2.6  Market for the fig cactus**

Cactus is a miracle plant. It grows in arid places where no other fruit ‘fears to thread’ and during the most severe droughts the dried pads are the lifeline of cattle that have no other means of support. For a long time the Indian fig cactus (*opuntia ficus-indica*) cactus was considered a wild crop, at best grown as a live fence. In Yemen cactus for instance was popular mainly as an extra defense around fortified houses. Yet in a few decades this has all changed: *opuntia* cactus fruits are recognized for the delicacy of their taste and in the last ten years the juice has founds its way to supermarkets.

In Yemen commercial cultivation started 40 years ago and was very much the making of a single man: Ahmed Motahar. Having worked for nearly twenty years abroad in commercial agriculture, he looked for farming opportunities upon his return to Yemen in 1967. He settled on cactus – it being most suitable in a natural environment defined by water scarcity. In Ghayman in Sanhal District in Sana’a Governorate he started a first farm of 4 ha of cultivated fig cactus, unheard off as previously the fruits were at best collected wildly. The next step was to set up a market chain: peeling the finely thorned fruits and selling them in one kilogram hygienic plastic bags at his own streetside outlets. As profits were high new land in Ghayman was developed for the fig cactus. The cultivation of cactus also spread beyond Ghayman, with other farmers imitating Ahmed Motahar’s cultivation techniques.

One problem was the large quantity of cactus pads after thinning. From 2005 a successful experiment was started to convert these pads into compost and waste was turned into an asset. Moreover, new products were developed: juice, jam and the packaging of the fresh fruits in appealing boxes. In addition a market developed for the cactus seeds, for fodder from the pads and for the compost from the waste material. In the last ten years the ‘dry’ fig cactus has made a steady march. It has replaced *qat* in Ghayman: more than 80% of the 800 ha is now under fig cactus.
2.4 Conclusions

There are a number of conclusions from this assessment of the institutions that make up the irrigation sector. Overall the picture is bewildering and institutional arrangement are disjointed and appear to be regressing.

First is in general the fragmented and scattered nature of the irrigation sector. This is apparent from:

- The disconnect between central level organizations, i.e. MAI and MWE, based in the capital and corresponding organizations in the governorates. NWRA has opened branch offices in seven governorates, with variable performance related to the funding and staffing. The MAI continues to operate in some of the governorates through TDA and elsewhere through
- The all-pervasive parallelism with special projects set up – to avoid the inadequate incentive system within current government arrangements, but at the same time undermining and marginalizing the functioning of regular government. This is a point raised for many years but it remains unaddressed. It is fair to say that the coordinated sector wide approach under WSSP did not materialize and that temporary project arrangements are still the order of the day in irrigation services
- The differences between MAI and MWE, although bridges have been built. There is a tendency of these differences being highlighted too much at the costs of paying attention to other structural weaknesses in the irrigation and water sector. It was observed for instance that there is a lack of familiarity of NWRA Branches with the (possible) programmes of AFPPF – which presents an opportunity missed.

A second major issue is the lack of capacity. This is apparent from a number of issues:

- The non-implementation of task, allocated to different General Departments within ILRS, in particular tasks related to regulation, norm setting and study;
- Similary the non-implementation of important provision in the Water Law, such as the development of water plans for basins and zones;
- The non-availability of professional capacity in irrigation or in water management within regular government institutions in different parts of the country
- The delays in implementation of investment projects in the irrigation sector, even though the entire investment portfolio is far below the ambition levels in the NWSSIP and its Update for instance. This is partly related to the scattered nature of the irrigation sector and the non-engagement of the regular departments in ongoing main projects
- The inability to generate enough meaningful proposals from within the system for instance for funding under AFPPF

A third point is that the role of non-state actors in water management still leaves much to be desired:

- The performance of WUAs is mixed and there is an artificiality around them that is related to the intense roles they play during investment projects, but they are not being made part of water governance yet – this needs to change
- There is a need to do better at higher level – with Union of WUAs or effective Irrigaiton Council being involved in basin planning or water management in large spate systems
- The role of the private sector in irrigation services is also weak. It should have been possible with the investment in localized irrigation and in conveyance systems that a more vibrant irrigation services sector would have come about – mirroring the services in groundwater drilling. As most investment has been routed through public procurement without systematically engaging private installers or distributors an opportunity has been missed to set up a self standing private sector.
In the consultation for the restructuring study representatives from different main organization assessed the major institutional problems as follows:

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<th>Constraint</th>
<th>NIP</th>
<th>ILRS</th>
<th>TDA</th>
<th>NWRA</th>
<th>AREA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limited Investment budget</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Low operation and maintenance budget</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Weak law enforcement</td>
<td>√</td>
<td>√</td>
<td>√</td>
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<td></td>
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<tr>
<td>Long government financial procedures (procurement and disbursements)</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Low local staff salary and incentives</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Staff aging</td>
<td></td>
<td></td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
</tbody>
</table>

It is clear that a major restructuring of the irrigation sector is overdue, as also highlighted in the NWSSIP Update. There are different options to consider to strengthen the Irrigation Sector. One of these has been suggested as an option in the establishment documents of the NIP is the development of a more permanent arrangement, in particular a National Irrigation Authority.

In moving to a new arrangement in the medium and long terms there are a number of considerations, in particular:

- Any new arrangement should be able to attract and retain motivated and capable staff by a conducive work arrangement and adequate incentives;
- Any new arrangement should be able to effectively deliver – providing the broad range services the Irrigation Sector in the country needs, in terms of quality implementation and innovation;
- Any new arrangement should be able to reach scale and cover the Irrigation Sector in the entire country – and avoid parallelism;
- It should be possible to cover and integrate activities within the country;
- Any new arrangement should be able to attract adequate funding from within the country and from outside the country – this means that programs have to have appeal and confidence and that the fiduciary systems are in order.

There is also the issue of time. As the water crisis is Yemen is ‘way past midnight’, there is a need to come to a significant improvement that match the challenge in the medium term already and not loose too much precious time with a reform process that in the end is not ‘delivering the goods’.

There are a number of options in this respect and these may be compared against the criteria above:

- The establishment of an National Irrigation Authority – with branches in different governorates, comparable to GARWSP or NWRA;
- The development of an Irrigation Corporations – providing services to the irrigation sector in the country, not unlike some of the Municipal Water Corporations, serving as independent profit and loss centre;
- The development of a dedicated Irrigation/Sustainable Water Fund meeting fiduciary requirements and quality of implementation standards, that could fund activities of different parties promoting regulation and higher efficiency of agricultural water use. This could be a restructured AFPPF;
- Continuation of time-bound programs, such as the National Irrigation Program;
- Reliance of the current government organizations, yet developing their capacity further.

The tabel 2.6 underneath compares these options. The most attractive option is the establishment of a Sustainable Water Fund, which could effectively be a reformed AFPPF – in line with the
recommendations of recent policy documents. A prerequisite would be a better governance structure and fiduciary procedures that are of international standards – so that many funding agencies could support it.

Such a Sustainable Water Fund would fund activities within the country implemented by (partnerships of) different national organizations: ILRS, Agricultural Offices, TDA, AREA, NWRA but also WUAs, WUA Unions, NGOs and private sector. This would leave the existing set up of organizations intact and avoid parallel structures – as prevail at the moment and are also a risk for a NIA or of Irrigation Corporations. The establishment of a NIA or of Irrigation Corporation may moreover take time as it would require transition and reform. This precious time is at variance with the urgency to turn around the irrigation sector on a massive scale, as is the conclusion of Chapter 1.

Table 2.6: Institutional options in the irrigation sector

<table>
<thead>
<tr>
<th></th>
<th>Staff motivation</th>
<th>Effective delivery</th>
<th>No parallelism</th>
<th>National scale and integration</th>
<th>Ability to attract funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Irrigation Authority</td>
<td>√ √</td>
<td>√ √</td>
<td>√ √</td>
<td>√ √ √</td>
<td>√ √</td>
</tr>
<tr>
<td>Irrigation Corporations</td>
<td>√</td>
<td>√</td>
<td>√ √</td>
<td>√</td>
<td>√ √ √</td>
</tr>
<tr>
<td>Sustainable Water Fund</td>
<td>√ √ √</td>
<td>√ √</td>
<td>√ √ √</td>
<td>√ √ √</td>
<td>√ √ √</td>
</tr>
<tr>
<td>Continued NIP Program Approach</td>
<td>√ √ √</td>
<td>√ √</td>
<td>√ √</td>
<td>√ √</td>
<td>√ √</td>
</tr>
<tr>
<td>Strengthen Government Organizations</td>
<td></td>
<td></td>
<td>√ √ √</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A Sustainable Water Fund could also systematically program in innovative activities (as in Chapter 1) and support to the development private sector delivery of relevant services. It could support capacity building and documentation and awareness – much as are the strong points of the SDF. Such flexibility is missing in the other options.

In addition there is a need to come with a totally different engagement with non-state actors, especially the Water Users Associations. So far these have been treated as project constructs, but they should be part of regular and permanent water governance. This is possible with the far-reaching powers given in the By-Law (112), which in several respects is a visionary document. Similarly the private sector so far only has a role in drilling and little in agricultural improvement, water savings and awareness. This should be enlarged – as water saving agriculture offers many business opportunities and many services can be provided on a commercial or semi-commercial (i.e. through smart subsidies) basis.
CHAPTER 3

Economics and finance
highest land productivity:
1. qat  
2. mangoes  
3. bananas

much variation depending on agro-ecological zone

Irrigation economics

highest water productivity:
1. qat  
2. tomatoes  
3. mangoes

Apart from some 'winners', margin in irrigated agriculture very slim
Financing

- Changing economics
  - Higher diesel prices
  - Extremely high amount/ha
- No single subsidy strategy
- Limited credit facilities now
- Donor funding at lower levels
  - Internal funding (AFPPF) reduced for time being
  - Expected increase in prices for agricultural commodities
3. Economics and financing

This section of the diagnostic report looks at the financing and economics in the irrigation sector. It is based on information collected from primary and secondary sources. It was found that in general economic and financial information on irrigation investments is relatively difficult to find.

The use of economic instruments to regulate irrigation water consumption has been studied under NWRA\(^1\) in 2008. The findings of that study are updated with this chapter. As the cost of water make up between 42 and 87\% of the cost of crop production (see also table 3.3) in Yemen the price of water in principle has a large influence on water use. There is no fee system in place in Yemen, and in fact the irrigation sector is a major recipient of public subsidies. The recent legislation however has opened up the possibility for such water charges.

The chapter discusses first (section 3.1) the economics of irrigated farming, looking at crop margins and income per unit of water consumed, so-called water productivity for different crops and areas. It makes the link with the feasibility of investment programs in efficient irrigation.

The chapter then discusses (section 3.2) the financing arrangements in the water sector, especially the external support provided. It makes a number of suggestions on how to deal with this strategically as an input to the orientation and restructuring plan for the irrigation sector.

3.1 Economics of irrigated farming in Yemen

The expansion of irrigated farming in Yemen, as described in chapter 1, is much related to the profitability of irrigated farming vis-à-vis other forms of agriculture. Particularly the highly profitable cultivation of qat, mango and recently oranges has been growing and continues to do so. There has also been a considerable inflow of money to rural areas – in the shape of cash grants to local leaders and remittances. These have been partly converted into productive assets, in particular investments in wells and distribution networks and some of the storage dams. It is also common that water systems are developed as a shared asset – with ownership of deep tube wells wells for instance running up to 15 to 20 farmers in some cases. According to well developers, this is becoming increasingly common because the cost for well development are increasing, as wells have to be developed at larger depths. In spate irrigated areas there have been private (but unauthorized) efforts to develop new intakes from the main wadis, using earthmoving equipment, in this case usually undertaken by well-to-do land owners.

This section among others uses unpublished data on returns per hectare from the Agricultural Marketing Management Study (2006), by the Ministry of Agricultural and Irrigation – updated for 2012 prices. The study is the most recent complete recent record on crop returns. Table 3.1 and 3.2 give the returns per hectare for irrigated and non-irrigated crops. For irrigated crops possible returns have also been calculated in terms of water productivity: the return per cubic meter of water used (table 3.3). Data from the 2008 NWRA study, collected from different sources and for different areas, are presented in table 3.4.

From the overview a number of factors stand out that confirm the findings of the NWRA (2008) study on economic incentives

First, there are large differences between regions in terms of revenues and profits from similar crops. This suggests that there is a scope for improvements in optimizing returns. Earlier in chapter 1 Yemen’s low performance compared to other countries in the region was observed. The key to
Higher water productivity lies very much in better farming practices, not so much in water saving as such. There has been virtually no support to farmers in the shape of extension (see chapter 1 and 2) and hence demand for services of IAS is high. Water and land productivity in Yemen is low compared with other countries in the Middle East.

Secondly, in general across the boards agriculture is not profitable. Margins are low for the main staple crops, even by international standards. This will limit investment of farmers in (efficient) irrigation. It also explains the high vulnerability to changing input prices, in particular energy/diesel costs. The returns for irrigated vegetables (tomatoes, potatoes) are generally not impressive – though there are some remarkable local exceptions - and moreover fraught with uncertainty due to price fluctuation and the risk from gluts or disease outbreaks. The low returns to different types of farming can be seen in the effect that lower diesel subsidies had on vegetable cultivation in coastal areas for instance. Support to these type of farms may include a certain degree of subsidy for a long time.

Similarly supplementary irrigation to coarse grains (sorghum) is more profitable than rain fed agriculture, but the difference is not dramatic and the risk with supplementary irrigation is that the costs of pumping can turn the margins into the negative. The increase in diesel prices as a result of the phasing out of subsidies hence appears to have affected these crops more than qat, bananas and mangoes – that are non-essential for food security or in case of bananas and mangoes constitute export commodities. Sorghum and wheat continue to be irrigated as they are used in self-sufficiency or local cattle keeping and here irrigation is of a life saving nature. Increasing the cost of water, by lowering diesel subsidies, will affect the local food production more where margins are very slim. Yemen is an un-enviable position where it imports a large part of its grain crops (75%) from a volatile world market (see chapter 1), yet its own staple crop production is hardly attractive for farmers.

Thirdly, there are some crops of a ‘special category’ – in particular qat and mangoes, and bananas and vegetables (in some areas) and in recent years oranges. The cost of production of mangoes and qat are very high – but so are the returns and profit margins. In comparison to other crops the economics of these cash crops are ‘off the scale’, justifying almost any investment. Economic instruments such as increasing input prices or reducing subsidies will not work here, because the margins are too attractive and the difference between pumping costs and crop values is too high. The unit cost of pumping varies with the depth of the costs. Average pumping depths in three main basins in Yemen are 180 m (Sana’a); 94 m (Taiz) and 63 m (Wadi Hadramwt). The corresponding cost of pumping was respectively (in 2008) USD 0.20; USD 0.15 and USD 0.12 per m³. Diesel prices make up 60% of the cost of pumping and since these have been increased, the current costs of pumping (that have increase 270% since 2008) in the three basins has gone up to relatively USD 0.39, USD 0.28 and USD 0.24 per m³. Yet even for international terms the margin on agriculture for these high value crops in Yemen are extra-ordinary high (Helligers et al, 2010) – see also table 3.4. So far – especially in case of qat – there has been little effort in improving water efficiency, even though water consumption is extraordinary. This would need to change – and given the high return there is a strong business base. Working on effective restrictions and capping water use and expansion may encourage investment in better and more sustainable agricultural water management.

Fourthly, in general water productivities are low in Yemen, compared to other water scarce countries. Merrett (1997) presents one of the first examples in the literature of water productivity values in economic terms. Economic water productivity for agriculture in Jordan expressed in USUSD /m³ ranged from USD 0.03 for wheat to USD 0.30 for potato. Molden et al. (1998 and 2001) analyzed economic water productivity data from two irrigation systems in South Asia and gave values for wheat production ranging from USD 0.07 to USD 0.17 per m³. Figures for Yemen are of the same order of magnitude but a little lower. Table 3.3 shows that the economic water productivity of wheat in Yemen ranges between USD 0,01 - 0,03 per m³. This is low compared to results from Jordan and
South Asia. The economic water productivity of irrigated potato in the governorates of Yemen is also low and ranges between USD 0.03 - 0.27 per m$^3$.

The relative low economic water productivities relate to the relative low yields per cubic meter:

- The water productivity of irrigated tomato in Yemen ranges between 0.87-1.03 kg/m$^3$. Globally, tomato water productivity for biomass (WBP/et) ranges from 1.3 to 3.5 kg/m$^3$, with 3 kg/m$^3$ being considered as common for favourable conditions and practices (Battilani, 2006).

- The water productivity of wheat in Saada is 0.82 kg/m$^3$. In Dhamar irrigated wheat water productivity ranges does not exceed 0.44 kg /m$^3$. In Seyoun it stands at 0.64kg/m$^3$ and in Marib at 0.86-0.92 lg/m$^3$ (see also table 1.20). An international analysis has indicated the maximum achievable efficiency (for grain) in current wheat systems is likely to be around 2.2 kg/m$^3$ (Sadras and Angus, 2006).

- In Abyan the water productivity of irrigated bananas is 1.69 kg/m$^3$, which is better than international figures. At Al Kod research station even higher yield were achieved. Teixeira et al. (2008) estimated a water productivity of irrigated bananas in Northeast Brazil to be 1.10 kg/m$^3$. On the other hand, the water productivity of irrigated mango in Abyan is 0.95 kg/m$^3$. Again, Teixeira et al. (2008) estimated in Northeast Brazil a water productivity of irrigated mango of 1.5 kg/m$^3$.

### Table 3.1: Agricultural Irrigated Crops Costs & Returns Per Hectare In Yemen (US Dollar) 2012

<table>
<thead>
<tr>
<th>Governorate</th>
<th>Crops</th>
<th>Revenue</th>
<th>Costs</th>
<th>Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abyan</td>
<td>Irrigated Sorghum</td>
<td>1,063.57</td>
<td>771.44</td>
<td>292.13</td>
</tr>
<tr>
<td>Abyan</td>
<td>Irrigated Millet</td>
<td>346.15</td>
<td>1,838.59</td>
<td>1,492.44</td>
</tr>
<tr>
<td>Abyan</td>
<td>Irrigated Mango</td>
<td>2,659.92</td>
<td>2,480.54</td>
<td>178.38</td>
</tr>
<tr>
<td>Abyan</td>
<td>Irrigated Bananas</td>
<td>4,599.10</td>
<td>2,225.93</td>
<td>2,373.17</td>
</tr>
<tr>
<td>Aden</td>
<td>Irrigated Tomatoes</td>
<td>2,492.74</td>
<td>1,628.35</td>
<td>864.39</td>
</tr>
<tr>
<td>Aden</td>
<td>Irrigated Potatoes</td>
<td>2,659.92</td>
<td>2,480.54</td>
<td>178.38</td>
</tr>
<tr>
<td>Saada</td>
<td>Irrigated Wheat</td>
<td>1,297.73</td>
<td>1,275.66</td>
<td>22.07</td>
</tr>
<tr>
<td>Lahj</td>
<td>Irrigated Sorghum</td>
<td>994.77</td>
<td>195.66</td>
<td>799.11</td>
</tr>
<tr>
<td>Lahj</td>
<td>Irrigated Potatoes</td>
<td>50.86</td>
<td>40.66</td>
<td>10.20</td>
</tr>
<tr>
<td>Lahj</td>
<td>Irrigated Tomatoes</td>
<td>2,180.31</td>
<td>1,458.98</td>
<td>721.33</td>
</tr>
<tr>
<td>Sana’a</td>
<td>Irrigated Sorghum</td>
<td>638.70</td>
<td>713.39</td>
<td>74.69</td>
</tr>
<tr>
<td>Sana’a</td>
<td>Irrigated Millet</td>
<td>353.64</td>
<td>58.83</td>
<td>294.81</td>
</tr>
<tr>
<td>Sana’a</td>
<td>Irrigated Tomatoes</td>
<td>1,110.40</td>
<td>1,087.08</td>
<td>23.32</td>
</tr>
<tr>
<td>Hodeida</td>
<td>Irrigated Sorghum</td>
<td>278.70</td>
<td>276.24</td>
<td>2.46</td>
</tr>
<tr>
<td>Hodeida</td>
<td>Irrigated Millet</td>
<td>254.32</td>
<td>214.51</td>
<td>39.81</td>
</tr>
<tr>
<td>Hodeida</td>
<td>Irrigated Tomatoes</td>
<td>1,430.83</td>
<td>724.45</td>
<td>706.38</td>
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<tr>
<td>Dalea</td>
<td>Irrigated Mango</td>
<td>20,440.86</td>
<td>6,478.11</td>
<td>13,962.75</td>
</tr>
<tr>
<td>Dalea</td>
<td>Irrigated Oat</td>
<td>21,259.00</td>
<td>6,658.00</td>
<td>14,601.00</td>
</tr>
<tr>
<td>Dhamar</td>
<td>Irrigated Wheat</td>
<td>763.11</td>
<td>601.06</td>
<td>162.05</td>
</tr>
<tr>
<td>Dhamar</td>
<td>Irrigated Tomatoes</td>
<td>1,752.04</td>
<td>1,540.92</td>
<td>211.12</td>
</tr>
<tr>
<td>Dhamar</td>
<td>Irrigated Potatoes</td>
<td>1,460.03</td>
<td>1,261.61</td>
<td>198.42</td>
</tr>
</tbody>
</table>

### Table 3.2 Agricultural Rained Crops Costs & Returns Per Hectare In USD Dollar) 2012

<table>
<thead>
<tr>
<th>Governorate</th>
<th>Crops</th>
<th>Revenue</th>
<th>Costs</th>
<th>Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abyan</td>
<td>Rain-fed Sorghum</td>
<td>239.77</td>
<td>209.99</td>
<td>29.78</td>
</tr>
<tr>
<td>Abyan</td>
<td>Rain-fed Millet</td>
<td>193.88</td>
<td>135.35</td>
<td>58.53</td>
</tr>
<tr>
<td>Saada</td>
<td>Rain-fed Sorghum</td>
<td>474.15</td>
<td>230.28</td>
<td>243.87</td>
</tr>
<tr>
<td>Lahj</td>
<td>Rain-fed Millet</td>
<td>592.77</td>
<td>422.15</td>
<td>170.62</td>
</tr>
<tr>
<td>Hodeida</td>
<td>Rain-fed Sorghum</td>
<td>113.17</td>
<td>121.33</td>
<td>8.16</td>
</tr>
<tr>
<td>Hodeida</td>
<td>Rain-fed Millet</td>
<td>84.56</td>
<td>104.26</td>
<td>19.70</td>
</tr>
</tbody>
</table>


### Table 3.3 Agricultural irrigated crops water productivity (kg/m3) and water costs of total costs 2012

<table>
<thead>
<tr>
<th>Governorate</th>
<th>Crops</th>
<th>Water productivity kg/m3</th>
<th>Water productivity $/m3</th>
<th>Water costs / total costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abian</td>
<td>Irrigated Sorghum</td>
<td>0.73-1.81</td>
<td>0.07</td>
<td>0.34</td>
</tr>
<tr>
<td>Abian</td>
<td>Irrigated Millet</td>
<td>0.0003-1.12</td>
<td>-0.02</td>
<td>0.43</td>
</tr>
<tr>
<td>Abian</td>
<td>Irrigated Mango</td>
<td>0.95</td>
<td>0.56</td>
<td>0.21</td>
</tr>
<tr>
<td>Abian</td>
<td>Irrigated Bananas</td>
<td>1.69</td>
<td>0.13</td>
<td>0.49</td>
</tr>
<tr>
<td>Aden</td>
<td>Irrigated Tomatoes</td>
<td>0.87</td>
<td>0.09</td>
<td>0.35</td>
</tr>
<tr>
<td>Aden</td>
<td>Irrigated Potatoes</td>
<td>0.83</td>
<td>0.03</td>
<td>0.16</td>
</tr>
<tr>
<td>Saada</td>
<td>Irrigated Wheat</td>
<td>0.82</td>
<td>0.02</td>
<td>0.23</td>
</tr>
<tr>
<td>Lahj</td>
<td>Irrigated Potatoes</td>
<td>0.95</td>
<td>0.27</td>
<td>0.21</td>
</tr>
<tr>
<td>Lahj</td>
<td>Irrigated Tomatoes</td>
<td>1.005</td>
<td>0.08</td>
<td>0.37</td>
</tr>
<tr>
<td>Sana’a</td>
<td>Irrigated Tomatoes</td>
<td>1,005</td>
<td>0.003</td>
<td>0.41</td>
</tr>
<tr>
<td>Hodeida</td>
<td>Irrigated Sorghum</td>
<td>0.00025-0.14</td>
<td>0.001</td>
<td>0.42</td>
</tr>
<tr>
<td>Hodeida</td>
<td>Irrigated Millet</td>
<td>0.0003-0.23</td>
<td>0.014</td>
<td>0.40</td>
</tr>
<tr>
<td>Hodeida</td>
<td>Irrigated Tomatoes</td>
<td>5.56</td>
<td>0.71</td>
<td>0.04</td>
</tr>
<tr>
<td>Dalea</td>
<td>Irrigated Mango</td>
<td>0.015</td>
<td>1.15</td>
<td>0.11</td>
</tr>
<tr>
<td>Dalea</td>
<td>Irrigated Qat</td>
<td>0.026</td>
<td>0.77</td>
<td>0.16</td>
</tr>
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<td>Dhamar</td>
<td>Irrigated Wheat</td>
<td>0.0088-0.44</td>
<td>0.03</td>
<td>0.48</td>
</tr>
<tr>
<td>Dhamar</td>
<td>Irrigated Tomatoes</td>
<td>1.03</td>
<td>0.02</td>
<td>0.35</td>
</tr>
<tr>
<td>Dhamar</td>
<td>Irrigated Potatoes</td>
<td>1.46</td>
<td>0.03</td>
<td>0.32</td>
</tr>
</tbody>
</table>

Source: Unpublished study, 2006 Agricultural Marketing Management, MAI
Table 3.4 Crop budgets, pumping cost and water productivity (in USD) in Sana’a, Taiz and Wadi Hadramwat

<table>
<thead>
<tr>
<th>Sana’a basin</th>
<th>Qat</th>
<th>Grapes</th>
<th>Alfalfa</th>
<th>Tomatoes</th>
<th>Potatoes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross production value (USD /ha)</td>
<td>14,823</td>
<td>6,612</td>
<td>3,000</td>
<td>6,060</td>
<td>4,480</td>
</tr>
<tr>
<td>-crop yield (kg/ha)</td>
<td>900</td>
<td>8,700</td>
<td>18,750</td>
<td>20,200</td>
<td>11,200</td>
</tr>
<tr>
<td>-crop price (USD /kg)</td>
<td>16.47</td>
<td>0.76</td>
<td>0.16</td>
<td>0.3</td>
<td>0.4</td>
</tr>
<tr>
<td>Costs of production (USD /ha excl costs of water)</td>
<td>680</td>
<td>708</td>
<td>375</td>
<td>793</td>
<td>531</td>
</tr>
<tr>
<td>- costs of fertilizer, pesticides, clay (USD /ha)</td>
<td>354</td>
<td>381</td>
<td>202</td>
<td>427</td>
<td>286</td>
</tr>
<tr>
<td>- costs of labor (USD /ha)</td>
<td>326</td>
<td>327</td>
<td>173</td>
<td>366</td>
<td>245</td>
</tr>
<tr>
<td>Net production value (USD /ha) or net returns to land</td>
<td>14,143</td>
<td>5,904</td>
<td>2,625</td>
<td>5,267</td>
<td>3,949</td>
</tr>
<tr>
<td>Actual irrigation water applied (m³/ha)</td>
<td>12,500</td>
<td>8,500</td>
<td>14,200</td>
<td>5,750</td>
<td>5,420</td>
</tr>
<tr>
<td>Net returns to water (USD /m³) or value of water</td>
<td>1.13</td>
<td>0.69</td>
<td>0.18</td>
<td>0.92</td>
<td>0.73</td>
</tr>
<tr>
<td>Costs of pumping water at a depth of 180 m (USD /m³)</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Value/Cost Ratio | 5.6:1 | 3.5:1 | 0.9:1 | 4.6:1 | 3.7:1 |

<table>
<thead>
<tr>
<th>Taiz basin</th>
<th>Qat</th>
<th>Onion</th>
<th>Sorghum</th>
<th>Mango</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross production value (USD /ha)</td>
<td>11,970</td>
<td>4,500</td>
<td>238</td>
<td>10,990</td>
</tr>
<tr>
<td>-crop yield (kg/ha)</td>
<td>700</td>
<td>15,000</td>
<td>720</td>
<td>15,700</td>
</tr>
<tr>
<td>-crop price (USD /kg)</td>
<td>17.1</td>
<td>0.3</td>
<td>0.33</td>
<td>0.7</td>
</tr>
<tr>
<td>Costs of production (USD /ha excl costs of water)</td>
<td>680</td>
<td>720</td>
<td>30</td>
<td>680</td>
</tr>
<tr>
<td>- costs of fertilizer, pesticides, clay (USD /ha)</td>
<td>354</td>
<td>387</td>
<td>13</td>
<td>354</td>
</tr>
<tr>
<td>- costs of labor (USD /ha)</td>
<td>326</td>
<td>333</td>
<td>17</td>
<td>326</td>
</tr>
<tr>
<td>Net production value (USD /ha) or net returns to land</td>
<td>11,290</td>
<td>3,780</td>
<td>208</td>
<td>10,310</td>
</tr>
<tr>
<td>Actual irrigation water applied (m³/ha)</td>
<td>9,980</td>
<td>6,100</td>
<td>6,700</td>
<td>18,800</td>
</tr>
<tr>
<td>Net returns to water (USD /m³) or value of water</td>
<td>1.13</td>
<td>0.62</td>
<td>0.03</td>
<td>0.55</td>
</tr>
<tr>
<td>Costs of pumping water at a depth of 94 m (USD /m³)</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Value/Cost Ratio | 7.5:1 | 4.1:1 | 0.2:1 | 3.6:1 |

<table>
<thead>
<tr>
<th>Wadi Hadramaut.</th>
<th>Alfalfa</th>
<th>Wheat</th>
<th>Onions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross production value (USD /ha)</td>
<td>3,188</td>
<td>1,800</td>
<td>4,500</td>
</tr>
<tr>
<td>-crop yield (kg/ha)</td>
<td>18,750</td>
<td>3,000</td>
<td>15,000</td>
</tr>
<tr>
<td>-crop price (USD /kg)</td>
<td>0.17</td>
<td>0.6</td>
<td>0.3</td>
</tr>
<tr>
<td>Costs of production (USD /ha excl costs of water)</td>
<td>413</td>
<td>400</td>
<td>345</td>
</tr>
<tr>
<td>- costs of fertilizer, pesticides, clay (USD /ha)</td>
<td>222</td>
<td>300</td>
<td>186</td>
</tr>
<tr>
<td>- costs of labor (USD /ha)</td>
<td>191</td>
<td>100</td>
<td>159</td>
</tr>
<tr>
<td>Net production value (USD /ha) or net returns to land</td>
<td>2,775</td>
<td>1,400</td>
<td>4,155</td>
</tr>
<tr>
<td>Actual irrigation water applied (m³/ha)</td>
<td>22,590</td>
<td>7,000</td>
<td>13,096</td>
</tr>
<tr>
<td>Net returns to water (USD /m³) or value of water</td>
<td>0.12</td>
<td>0.2</td>
<td>0.32</td>
</tr>
<tr>
<td>Costs of pumping water at a depth of 63 m (USD /m³)</td>
<td>0.12</td>
<td>0.12</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Value/Cost Ratio | 1:1 | 1.7:1 | 2.7:1 |

3.2 Financing the irrigation sector

3.2.1 Subsidizing operational costs

It is important that limited public funds in the water sector are spent on public priorities. This principle has so far not been systematically implemented in Yemen, in spite of the clear statement to this effect in the main policy documents. The National Water Strategy for instance recommended the following with regards to subsidies and tax exemptions in the sector: (1) remove distortive incentives; (2) increase diesel prices; (3) higher tariffs and taxes on pumping equipment; and (4) eliminating credit subsidies on pumping equipment. The NWSSIP also made a strong recommendation to invest in water saving technologies rather than water capture.

There has however been a long track record of ‘distortive subsidies’. Under the AFPPPF over the years large investment were made in storage reservoirs, that often had no irrigation outlets and serves as source of prestige, whilst contributing to evaporation. Only in recent years the portfolio of AFPPF is reorienting towards investment in water efficiency.

Similar, extraordinary amounts were devoted to diesel subsidies, far outpacing investment in water infrastructure. The subsidy on fuel accounted for 22% of all government expenditures in 2009 (World Bank 2011). One source (Philips 2011) estimated that in 2008 at least 50% of the public resources were allocated to diesel subsidy (close to USD 3.8 Billion – equivalent to 12% of GDP). Approximately 30% of the diesel subsidies are allocated to agricultural use – or equivalent to USD 1.14 Billion in 2008. Diesel import increased spectacularly tripling between 2000-2007. This increase cannot be explained by increased demand within the country and equally relates to the practice of smuggling diesel out of the country (Philips 2011). For an overview see Annex (3) 1.

Since 2008 diesel subsidies have been reduced. In 2012 they amounted to USD 1.46 Billion for the country as a whole out of which USD 438 M for agricultural usage. This amount still dwarves all other expenditures on agriculture and water management. As most of the subsidies are for groundwater pumping and the area under groundwater irrigation is estimated to be 405,000 ha, the amount of subsidy per hectare averages USD 1080. This is an extraordinary amount, which should be compared with the cost of water saving measures, such as localized systems, or conveyance pipe as have been promoted in a succession of projects in the last ten years (see table 3.5).

There is a very strong case to promote improved irrigation systems rather than subsidizing pumping. An investment in conveyance systems would generate an annual saving in fuel subsidies of USD 236 (22% of USD 1080) at a costs of USD 450-900 and in localized systems the fuel subsidy saving would be USD 400 per ha at a cost of USD 2450-5450 (table 3.5). The promotion of PVC conveyance systems at 50% subsidy (as is common in program promoted by the AFPPF) would earn the public investment back in a single year. In addition the introduction of efficient irrigation of course results in gross water savings and yield increases.

For more sophisticated systems the pay back period – only measured in diesel subsidies saved – would be longer (3-6 years), but still attractive. There is from public expenditure point of view a strong argument to aggressively promote efficient irrigation systems, leave outside the impact on yield and gross water saving. At present public funding is entirely misaligned with subsidies going to water use rather than water saving. As discussed in chapter 2 it would be more worthwhile to use public resources to source a Sustainable Water Fund, or restructured AFPPF. Besides the localized systems and conveyance systems there are more methods moreover to reduce water use and control ET, from leveling to applying zeolite.
Table 3.5: Cost and benefits of efficient field irrigation systems

<table>
<thead>
<tr>
<th>Improved irrigation systems</th>
<th>Cost Per Ha (USD)</th>
<th>Fuel saving (%)</th>
<th>Labor saving (%)</th>
<th>Gross water saving (%)</th>
<th>Yield increase (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conveyance system (Galvanized Iron)</td>
<td>900</td>
<td>-23</td>
<td>-22</td>
<td>-18</td>
<td>17</td>
</tr>
<tr>
<td>Conveyance system (PVC)</td>
<td>450</td>
<td>-23</td>
<td>-22</td>
<td>-18</td>
<td>17</td>
</tr>
<tr>
<td>Localized system: bubble/drip with booster</td>
<td>5450</td>
<td>-36</td>
<td>-34</td>
<td>-35</td>
<td>21</td>
</tr>
<tr>
<td>Localized system: bubble/drip without booster</td>
<td>2450</td>
<td>-36</td>
<td>-34</td>
<td>-35</td>
<td>21</td>
</tr>
<tr>
<td>Sprinkler system</td>
<td>2802</td>
<td>-40</td>
<td>-38</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: AFPPF, MAI (2008)

In addition other water saving measures such as the use of plastic mulch, zeolite, bio fertilizer, vermicomposting have not been applied in Yemen yet – but offer promising and low cost opportunities as well. Cost of all these measures may also change, if there is more market demand and private sector competition.

In comparison to the diesel subsidies the subsidies to the operational costs of spate irrigation systems are very low. The TDA budget can be taken as an example. The O&M Department is responsible for all O&M in TDA (including buildings) but the thrust of its activities is the maintenance of the major spate irrigation infrastructure in the three wadis (Rima, Mawr and Siham). Maintenance of Wadi Zabid was done for the time being by the Irrigation Improvement Project, but may revert back to TDA. The amount for this was YR 40 million. Out of this amount YR 4-5 M was spent on the maintenance of the earthmoving equipment. With some other financial commitments, the amount effectively available was reportedly close to YR 30 M. – which is close to USD 5/ha, which is low for international standards: in similar systems in Eritrea USD 40/ha are spent. Of course establishment costs are not incorporated in this amount, and O&M is done mainly in house. Larger budget amounts (upward of YR 140 million) have been requested, but these requests were not honoured.

### 3.2.2 Supporting investment costs

To introduce water saving on a large scale in Yemen would require a considerable investment in effort and funds that so far has not been forthcoming. Below an overview is given of investment in irrigation from external and internal sources. In section 3.3 the extent of agricultural credit is given. It is clear that to address the challenges as set forth in the major policy documents a massive overhaul of the financing system is required as well as the build up a considerable capacity within and outside the government, particularly from WUAs and private sector.

#### 3.2.2.1 External sources

The NWSSIP Update proposed an assessment of covering a substantial part of the groundwater irrigated areas with efficient irrigation systems, reaching close to 80% coverage of the groundwater irrigated area within seven years, if the area currently served piped/ conveyance systems is taken into account. The investment plan would cover nearly 250,000 ha with conveyance systems and 61,000 ha under drip/bubbler and sprinkler, so-called localized systems. Given that the area covered under localized system at present is less than 10,000 ha, the latter constitutes a quantum jump. In the seven-year plan the areas under new coverage would increase in the first three years and greatly accelerate from year 4-7. Implementation rate in the second part of the seven-year plan in fact was planned to increase with a factor 5. These disbursement rates would be a multiple of historical averages. They would require a commensurate effort in policy development and implementation and in capacity building and improving operating mechanisms. They would also require substantial fundraising. The financial targets were based on the assumption that the WSSP would develop into a multi-donor sector program with financial contributions from different parties.
The latter has not happened, and so far the irrigation component (NIP) of WSSP is solely supported by the World Bank with a commitment of less than USD 50 M.

### Table 3.6: Proposed public sector irrigation investment NWSSIP Update: coverage and costs

<table>
<thead>
<tr>
<th></th>
<th>Yr 1-3</th>
<th></th>
<th></th>
<th>Yr 4-7</th>
<th></th>
<th></th>
<th>Total Yr 1-7</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>USD M</td>
<td>Hectares</td>
<td>USD M</td>
<td>Hectares</td>
<td>USD M</td>
<td>Hectares</td>
<td>USD M</td>
<td>Hectares</td>
</tr>
<tr>
<td>Conveyance systems</td>
<td>59</td>
<td>31,318</td>
<td>209</td>
<td>218,337</td>
<td>268</td>
<td>249,655</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Localized systems</td>
<td>7</td>
<td>1,806</td>
<td>194</td>
<td>59,225</td>
<td>201</td>
<td>61,031</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spate</td>
<td>26</td>
<td>3,750</td>
<td>153</td>
<td>96,350</td>
<td>179</td>
<td>100,100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Watershed management</td>
<td>10</td>
<td>8</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small dams</td>
<td>6</td>
<td>3</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large dams</td>
<td>50</td>
<td>28</td>
<td>78</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total: Irrigation works</strong></td>
<td>159</td>
<td>596</td>
<td>755</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Policy implementation and institutional development</td>
<td>28</td>
<td>18</td>
<td>46</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>187</td>
<td>36,874 ha</td>
<td>614</td>
<td>373,912 ha</td>
<td>801</td>
<td>410,786 ha</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: NWSSIP Update (2008)

#### 3.2.2.2 Internal sources

The main national source of irrigation funding has been the Agriculture and Fisheries Production and Promotion and Fund (AFPPPF). AFPPF was created by Law no 6 in since 1993, with overall spending of more than USD 150 M since then. The fund is replenished from a mark up on petrol sales as well as some contributions other sources. The activities of the AFPPF cover crop, livestock production, water resource development and irrigation, and fish production. AFPPF does not execute any activities itself, but always works through partner agencies. Where AFPPF contracts with a partner agency, a 2% fee is paid – going up to 15%.

AFPPF has for a long time associated with the controversial construction of small dams in the upper catchment. The usefulness of these small dams has been constantly questioned. The several studies undertaken suggest a limited or even negative impact – with the majority of dams collecting small amounts water and having their bottoms sealed, making them less effective for storage or recharge groundwater (Chevalking 2008). The small dams in many cases had no irrigation outlet and were not well sited. This was very much related to the inadequate effort going into preparing and assessing these projects. Reportedly they were often primarily a source of local prestige rather than an instrument for water management.

The criticism on AFPPF has been that for many years there was no attention to the rational use of water - even though article (4) of the Law (6) stipulated that subsidy shall be given to reduce costs of modern irrigation costs. It was only after 2005 that program were developed on this front under AFPPF. Under the ILRS for instance against 50% subsidy 3200 ha were implemented under localized system within 2 years (and 2500 ha under conveyance systems) It was relatively easy to achieve these targets under ILRS rather than under NIP as the beneficiary selection process under AFPPF does allow work with large land owners too. In recent years AFPPF has also started a number of innovative activities in desert water harvesting and in agricultural water management. AFPPF would be
interested to fund more such activities but is constrained as it does not receive sufficient good proposals for funding. The turnover in the irrigation portfolio is given in table 3.7. It should be noted that also in comparison to the targets in the NWSSIP Update the funding is very modest too.

**Table 3.7 Irrigation portfolio in AFPPF and source of funding (2005-2012)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Amount (USD M)</th>
<th>Percentage of Financing by Grants</th>
<th>Exchange Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fuel price markup</td>
<td>Government Investment Program</td>
</tr>
<tr>
<td>2005</td>
<td>4.39</td>
<td>69.86</td>
<td>16.02</td>
</tr>
<tr>
<td>2006</td>
<td>9.90</td>
<td>72.36</td>
<td>27.64</td>
</tr>
<tr>
<td>2007</td>
<td>5.70</td>
<td>69.24</td>
<td>30.76</td>
</tr>
<tr>
<td>2008</td>
<td>6.85</td>
<td>78.12</td>
<td>21.88</td>
</tr>
<tr>
<td>2009</td>
<td>7.34</td>
<td>90.12</td>
<td>9.88</td>
</tr>
<tr>
<td>2010</td>
<td>6.42</td>
<td>92.26</td>
<td>7.74</td>
</tr>
<tr>
<td>2011</td>
<td>6.04</td>
<td>90.79</td>
<td>9.21</td>
</tr>
<tr>
<td>2012</td>
<td>5.36</td>
<td>100.00</td>
<td>-</td>
</tr>
</tbody>
</table>

**Source:** General Management of Irrigation and Agricultural & Fisheries Production Promotion Fund

There have been several calls to improve the governance and orientation of the AFPPF to make it eligible for external funding as well but also to make sure that its oriented towards a sustainable water use agenda and can serve a large number organizations.

A number of suggestions are made to improve the governance structure of the AFPPF too:

- Article (9) established the Board of Directors of AFPPF where MAI’s minister is the chairman and his deputy and CAC chairman, ACU, FCU and other representatives of Finance, Planning and Oil as members. But the fact is that since 1993, up to now MAI, CAC Bank and ACU are the effective managers of AFPPF with most influence on its management. The interests of the water resources sector are underrepresented. In fact, in 1994, the By-Law of the above law was issued as no (49) of 1994 where article (5) para (7) stated that AFPPF shall encourage and support all effort to be taken by the concerned authorities to limit the irrational use of water so that to ensure the best use of water to achieve an increase and development of the water resources and such shall be fulfilled on the basis of a program to be coordinated with other concerned parties in its preparation. This means that MWE should be party in that activity and should be a member of its Board of Directors.

- Article (14) stated that all activities of the Fund should be managed by independent management and through officers assigned from MAI, Fish Ministries and CAC Bank. This article should be amended to avoid control by certain groups upon the Fund and to avoid corruption.

- Article (17) stipulated that the AFPPF shall be under the scrutiny and inspection of its finances by the Central Organization of Control and Accountability, but this has not been done systematically.

- Article (11) stipulates that AFPPF shall support and encourage plans of the concerned parties in the water sector in relation research and studies of Water Basins. This would need to be actively pursued.

- Appraisal criteria and process for the small demand driven projects and soft loans should become more transparent. There should be adequate staff AFPPF to approve applications, based on clear work plans and priorities. There should be more open and pro-active soliciting of proposals.
present the Board Management of AFPPF does not represent stakeholders including beneficiaries of irrigation and there is no regular supervision to avoid abuse because it is not fully accountable and procedures are not there to ensure that money is not diverted from agreed programs. 

- Since management is not selected competitively, it is not able to avoid political pressure, and therefore it is not transparent and its performance was not in compliance with the good system.

AFPPF needs reforms and restructuring of its Board of Directors similar to that of the successful SDF with better fiduciary procedures an independent and efficient support should be given to private sector development in irrigation too and assist it to create irrigation services capacity.

3.3 Credit schemes for irrigation projects

Credit for irrigation investments has not taken large proportions in Yemen. It has not been supported by international funded projects and has been limited to activities under the AFPPF channeled through the CAC Bank. The loans that were provided came in three shapes: short-term, medium-term and long-term loans. Interest rates varied between 10 to 12% per year.

**Short-term loans** extended for period between 1- 18 months. They covered:
- Running costs
- Agri-inputs: fertilizers, seeds, pesticides and
- Sprinklers.

Medium-term loans extended from two to seven years. They covered:
- Horticultural projects—up to 75% of the loan value.
- Groundwater irrigation projects.
- Modern irrigation networks.
- Replacing water pumps or pipeline networks
- Concrete tanks for water storage
- Purchase of tractors, harvesters, and chisel plows.
- Concrete-lined water canals – such loan were not offered individually, but to agricultural organizations and associations.

Long-term loans: This type of loan had a duration 5-7 years and covered the following areas and projects:
- Plowing machines - up to a maximum of 50% of the loan value.
- Horticultural projects loans - up to a maximum of 50% of the loan value.

The agricultural credit dried up in 2010-2012. The first reason was the high risk of non-recovery, exacerbated by the political turmoil in 2011 and 2012. At the same time the CAC Bank – the prime source of agricultural credit, underwent a transformation and reoriented towards commercial credit rather than agricultural credit. Apart from CAC no other banks had an extensive network in rural areas, nor is the penetration by micro financing extensive in Yemen: total loans are USD 16.7 M but this is not used for irrigation systems. Even while CAC Bank was active, its overall portfolio in agricultural loans was negligible (USD 2.5 M in 2004-2012). The loans disbursed through the CAC Bank on behalf of the AFPPF were small too – at USD 574,000 for the period 2004-2012 for medium term irrigation loans and USD 76,000 for long-term loans.
### Table 3.7  Loans Disbursed by CAC Bank to Irrigation Sector from 2008-2012 (in M USD)

<table>
<thead>
<tr>
<th>Objectives</th>
<th>2004-2007</th>
<th>2008-2009</th>
<th>2010-2012</th>
<th>Interest Rate</th>
<th>Total Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credit Facilities Agricultural Systems¹</td>
<td>1.542</td>
<td>0.00</td>
<td>0.00</td>
<td>10%</td>
<td>1.542</td>
</tr>
<tr>
<td>Agricultural Machinery and Equipment¹</td>
<td>0.216</td>
<td>0.052</td>
<td>0.00</td>
<td>11%</td>
<td>0.268</td>
</tr>
<tr>
<td>Irrigation Projects &amp; Accessories¹</td>
<td>0.453</td>
<td>0.121</td>
<td>0.00</td>
<td>11%</td>
<td>0.574</td>
</tr>
<tr>
<td>Land Reclamation</td>
<td>0.133</td>
<td>0.021</td>
<td>0.00</td>
<td></td>
<td>0.154</td>
</tr>
<tr>
<td>Wells Deeping</td>
<td>0.004</td>
<td>0.006</td>
<td>0.00</td>
<td></td>
<td>0.010</td>
</tr>
<tr>
<td>Irrigation Projects &amp; Accessories</td>
<td>0.076</td>
<td>0.00</td>
<td>0.00</td>
<td>12%</td>
<td>0.076</td>
</tr>
</tbody>
</table>


### 3.4 Conclusions

If the ambitions of the NWSSIP have to be achieved a massive change is required in financing support to the irrigation sector. The current financial commitments, in particular NIP and AFPPF, are very limited and only a fraction of what is required. There are two major sources of meeting the targets:

- A reorientation of the diesel subsidies, i.e. an investment in water saving techniques would pay dividend in that it would reduce diesel consumption. The turn-around time here would be short. It also makes sense for a country that is in the list of five most water stressed countries to subsidize water saving through a large range of options and not to subsidize pumping.
- Donor pledges under the Friends of Yemen: so far these have not translated into substantial and significant support for sustainable water use and a strong case should be built here.

A closely related challenge however is the capacity to make this happen. Disbursement rates under NWSSIP target would have to treble, but even now with very low financial commitments progress is behind target. There is a need here to develop a system where many actors all work and make business from more efficient irrigation. This requires (see also chapter 2):

- The pro-active engagement and development of private service sector through a system of smart subsidies and other support programs;
- The activation of WUA to undertake their own water programs;
- The transition to financial self sufficiency in spate and groundwater areas – with farmers paying all costs themselves, and making use of the potential of higher yields with better farming practices (see also chapter 1)
- the revisit of subsidy levels and procedures – so that they are not pitched too high, are clear and uniform and procedures are simple and not cumbersome.

The large differences in return and water productivity between high value and high water demanding crops – such as qat, mangoes, bananas and oranges is also noted. In the interest of water saving these crops should be a prime target of irrigation efficiency programs – setting norms and standards and at the same time ensuring that improved irrigation efficiency does not lead to horizontal or vertical expansion. Here a strong link with water plans and community management of water resources is required. The high return in this segment of farming means that an independent business sector promoting a range of agronomic and water/moisture conservation measures could easily start here. On the other hand for poor farmers on marginal crops longer term targeted support mechanisms may be designed.
### Annex 3(1) Total Diesel Governmental Subsidies on Agricultural during 2005-2013 (U.S.A Dollar)

<table>
<thead>
<tr>
<th>Item</th>
<th>Exchange rate against Dollar</th>
<th>annual Consumption (Liter) per Year</th>
<th>Overall Consumption Diesel Agriculture On per Year</th>
<th>Local Price per Liter</th>
<th>International Price (Dollar) per Liter</th>
<th>Value in international price Dollar/Year()</th>
<th>Value in Local price Dollar/Year()</th>
<th>Dollar/Year) (Subsidy on Agricultural)</th>
<th>Overall Subsidy Dollar/Year()</th>
<th>Agric. Percentage of diesel Subsidy</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>192.67</td>
<td>2,765,750,000</td>
<td>829,725,000</td>
<td>0.18</td>
<td>0.16</td>
<td>129,193,699</td>
<td>150,725,982</td>
<td>-21,532,283</td>
<td>-71,774,277</td>
<td>30%</td>
</tr>
<tr>
<td>2006</td>
<td>197.05</td>
<td>2,952,625,000</td>
<td>885,787,500</td>
<td>0.18</td>
<td>0.21</td>
<td>189,699,226</td>
<td>157,333,481</td>
<td>32,365,745</td>
<td>107,885,816</td>
<td>30%</td>
</tr>
<tr>
<td>2007</td>
<td>198.95</td>
<td>4,522,375,000</td>
<td>1,356,712,500</td>
<td>0.18</td>
<td>0.83</td>
<td>1,123,149,277</td>
<td>238,677,746</td>
<td>884,471,532</td>
<td>2,948,238,439</td>
<td>30%</td>
</tr>
<tr>
<td>2008</td>
<td>199.78</td>
<td>4,684,682,136</td>
<td>1,405,404,641</td>
<td>0.18</td>
<td>0.99</td>
<td>1,387,254,956</td>
<td>246,216,650</td>
<td>1,141,038,306</td>
<td>3,803,461,019</td>
<td>30%</td>
</tr>
<tr>
<td>2009</td>
<td>202.85</td>
<td>5,142,703,553</td>
<td>1,542,811,066</td>
<td>0.17</td>
<td>0.67</td>
<td>1,026,766,053</td>
<td>266,198,606</td>
<td>760,567,447</td>
<td>2,535,224,823</td>
<td>30%</td>
</tr>
<tr>
<td>2010</td>
<td>219.59</td>
<td>4,646,517,500</td>
<td>1,393,955,250</td>
<td>0.23</td>
<td>0.89</td>
<td>1,244,206,152</td>
<td>317,399,529</td>
<td>926,806,624</td>
<td>3,089,355,412</td>
<td>30%</td>
</tr>
<tr>
<td>2011</td>
<td>212.8</td>
<td>2,760,000,000</td>
<td>828,000,000</td>
<td>0.70</td>
<td>1.12</td>
<td>928,387,218</td>
<td>583,646,617</td>
<td>344,740,602</td>
<td>1,149,135,338</td>
<td>30%</td>
</tr>
<tr>
<td>2012</td>
<td>214.91</td>
<td>3,924,950,456</td>
<td>1,177,485,137</td>
<td>0.47</td>
<td>0.84</td>
<td>986,214,344</td>
<td>547,896,858</td>
<td>438,317,486</td>
<td>1,461,058,287</td>
<td>30%</td>
</tr>
<tr>
<td>2013</td>
<td>214.88</td>
<td>152091830.2</td>
<td>49061880.7</td>
<td>0.47</td>
<td>0.84</td>
<td>41,103,740</td>
<td>22,835,411</td>
<td>18,268,329</td>
<td>56,631,819</td>
<td>32%</td>
</tr>
</tbody>
</table>

**Resource:** General Management of Oil Revenues, Ministry of Finance  
Ministry Of Agricultural and Irrigation  
Annual Report, Central Bank Of Yemen

Overall Subsidy = Overall diesel subsidy on activities such Industrial, Agricultural, Transportation etc.

Subsidy on Agricultural: It means diesel subsidy only on Agricultures

3- Overall Consumption for diesel in a year. one Barrel=158.97 Liter

Data of Annual consumptions for 2012 and 2013 has been estimated. It is not really data

4- It means Consumption of diesel on Agricultural. one Barrel=158.97 Liter

5- Local Price it means price of diesel in local market per Liter

6- International Price it means a price of Liter in international market Price

9- Amount of money which Government paid to Agricultural sector. Dollar per Year

11- Percentage of diesel Subsidy from overall subsidy
CHAPTER 4

Legal provisions
Law and regulation

WUA regulation 2011 more empowering but status unclear

After 2011 enforcement less rigid

Legal status AFPPF not so clear

Water rights system redefined in water law amendment

Water law setting framework
4. Legal Arrangements

This chapter gives an overview of the current legal arrangement as they pertain to water and irrigation in Yemen. This part of the diagnostic study reviews the Water Law as well as other relevant legislation. The aim is to assess to what extent the legal system suffices to promote efficient agricultural water management and water use as foreseen in the NWSSIP and NAS. The recent new legislation, such as the by-law of 2011 to the Water Law sets the basis for the reorientation of the irrigation sector, as it describes new responsibilities and requirements. This chapter first introduces the most important laws (section 4.1). Next it describes the legal provisions for a number of important aspects related to irrigation management: basin planning, the role of WUAs and the role of Irrigation Councils and the possibilities for water charging (section 4.2). Section 4.3 discusses the remaining ambiguities in the water-related legislation, in particular the implementation capacity and the water rights. Section 4.4 introduces the issues of decentralization, as captured in the Law on Local Authority and the Executive By-Law both from 2000. As decentralization is expected to further continue it is of high relevance to water management. The final section (4.5) summarizes the status of the current legal arrangements, emphasizing the need to foremost put them in practice.

4.1 Back ground to water legislation

Before the reunification of Yemen, YAR’s water management concerns were divided between the Ministry of Agriculture and Water Resources (MAWR), the ministry of Oil and Mineral Resources (MOMR) and the Ministry of Electricity and Water (MEW) each with different – sometimes conflicting – priorities, and representing specific political interests and stakeholders (Ismail, 2007). Since the reunification of the country in 1990 however considerable efforts were made towards improving water sector governance, as discussed in chapter 2 as well. As discussed in chapter 1 and 2, this included consolidation of water management functions under the NWRA (1995), and formation of the MWE (2003) with most water sector agencies administratively linked to it. This resulted in the water sector as a whole, and water management in particular, gaining representation at the Cabinet level (NWSSIP, 2004, 2008). The responsibility for irrigation, dams and water harvesting, remained under the Ministry of Agriculture and Irrigation (MAI). MAI has been, and still is, engaged in development of surface water infrastructure with financing by the AFPPF. Within MAI investment has reoriented from agricultural water resource development to efficient irrigation.

Yemen was united in 1990 and two years later in 1992 two drafts, one for Water Law and the other for Irrigation, were submitted to the cabinet. These were returned back as it was advised to prepare one combined draft law for water and irrigation. There were two different points of view to deal with water and irrigation backed by interests of different groups and different ministries and authorities at that time. It took ten years to prepare the draft of the Water Law which was issued in July 2002 as Law no (33), although in the meantime a provisional regulatory procedure on well licensing was set in place (see chapter 2).

Inspite of the issuance of the Water Law in 2002, implementation was unsatisfactory because of three reasons: (1) the limited institutional capacity to undertake the basic requirements of implementing the law; (2) the ambiguity on the interpretation of water and property rights and (3) the many detailed provisions that were not yet filled in in the 2002 Law. The Water Law of 2002 in fact left many issues open under the assumption that these would be stipulated in the executive by-law, which was to be prepared within six months of the issuing of the Water Law. The main issues to be addressed still were as follows:
<table>
<thead>
<tr>
<th>Article</th>
<th>Issues to be detailed in Executive By-Law (issued in 2011)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Composition and duties of Water Basin and Water Zone Committees, together with their relationship with local authorities.</td>
</tr>
<tr>
<td>17 2)</td>
<td>Standards, data and measures for the preparation of Water Plans.</td>
</tr>
<tr>
<td>23 2)</td>
<td>Minimum and maximum standards for temporary use of water.</td>
</tr>
<tr>
<td>24</td>
<td>Conditions and controls for methods to treating water.</td>
</tr>
<tr>
<td>25 4)ii)</td>
<td>Controls for co-ordination between Ministry of Agriculture and Irrigation, National Water Resources Authority and other &quot;relevant concerned entities&quot;.</td>
</tr>
<tr>
<td>26 7)</td>
<td>Qualitative and environmental standards for the treatment and disposal of wastewatwr.</td>
</tr>
<tr>
<td>30</td>
<td>Procedures and controls for constructing water installations, small irrigation structures and excavation of subsidiary canals for harvesting water.</td>
</tr>
<tr>
<td>31</td>
<td>Specification of cases where Government can withhold acquired water rights.</td>
</tr>
<tr>
<td>34</td>
<td>System and rules for maintenance of a register of acquired rights of benefit from water.</td>
</tr>
<tr>
<td>37</td>
<td>Details for the implementation of license (permits) for construction of water installations or water wells.</td>
</tr>
<tr>
<td>38 4)</td>
<td>Cases where holders of licenses and permits give his license to others without approval of NWRA and NWRA discretion to approve or disapprove such assignment.</td>
</tr>
<tr>
<td>42</td>
<td>Registration fees, rules, provision and procedures for permits for contractors and engineering offices involved in well drilling, groundwater exploration, consultancy studies, water resources works, and distribution of water well water.</td>
</tr>
<tr>
<td>51</td>
<td>Procedures for right of entry of authorized employees to enter property to carry out work associated with the law, and the compensation in the event of damage resulting.</td>
</tr>
<tr>
<td>54 1)</td>
<td>Standards and specifications related to the disposal of wastes.</td>
</tr>
<tr>
<td>54 3)</td>
<td>Notification of Forbidden Water Zones or Protective Zones where disposal of wastes is prohibited.</td>
</tr>
<tr>
<td>54 4)ii)</td>
<td>Conditions and standards of protection (in respect of disposal of wastes) by manufacturing plants before they are allowed to operate.</td>
</tr>
<tr>
<td>55</td>
<td>Basin controls and standards/criteria for the execution of studies and research on protecting groundwater aquifers in costal arrears from saline intrusion, and the construction of related water installations.</td>
</tr>
<tr>
<td>60</td>
<td>Procedural controls for the construction of pits or pools in rural villages for the disposal of domestic sewage.</td>
</tr>
<tr>
<td>63</td>
<td>Conditions for staff to be given the status of judicial enforcement for control and inspection of the law.</td>
</tr>
<tr>
<td>73</td>
<td>Rules and procedures related to licenses, permits and approvals required under the law, and the fees, charges and deposits for these and for the technical services of NWRA.</td>
</tr>
<tr>
<td>76 4)</td>
<td>Rules and controls for regulating the collection and use of fees charged by NWRA in respect of: water benefit registration fee, water benefit fee for commercial uses, and water resources protection fee against pollution.</td>
</tr>
<tr>
<td>77 2)</td>
<td>Rules and regulations for the collection and use of all charges, bonds, deposits and penalties which shall accrue to NWRA under the law, or to &quot;relevant concerned entities&quot; for services provided by them under the law.</td>
</tr>
</tbody>
</table>

Instead of six months, it took nine years from 2002 to 2011 for the By-Law to be issued by the Cabinet as Decision No (112) of 2011. All those articles mentioned above were clarified in the 2011 by-law, including the coordination and cooperation between MAI and NWRA and other relevant concerned entities in relation to procedures and controls for constructing water installations, irrigation structures and harvesting water and in particular the basis of the irrigation strategy. In the meantime the Water Law of 2002 had been amended in 2006.
It is too early for NWRA and MAI to implement the By-Law and the new decrees, as they were issued late in 2011 and the political situation in Yemen has been turbulent. The new legislation however provides a large scope for better services in the irrigation sector, on a number of issues that are discussed in the following sections of this chapter.

One of the constraints is that it is up to now there is no clear cut plan particularly in the irrigation sector to enable the implementation of the new legislation and the current Orientation/Restructuring study is meant to contribute to this. The new legislation is giving strong guidance in this direction, however, in particular in article (37) of the By-Law 2011. The most important points announcing and giving directions for the reorientation of the irrigation sector are:

1) MAI and its authorities and corporations shall operate and maintain its water structures and facilities and regulate and rationalize its usage of its water allocated for irrigation, provided that this shall comply with the Local Authority Law and in accordance with the water plan on the basis of the water resources strategy and irrigation policy.

2) MAI shall prepare policies and executive plans for irrigation, which make utmost use of the share of the water of agriculture sector, and to ensure a balance between supply and demand of water for agriculture taking into consideration the need of water of the sectors.

3) MAI shall work on crops that need less water and of high economic return, which shall ensure food security as well as conserving in the water security.

4) MAI shall concentrate upon increasing productivity per cubic meter unit of water and to stop horizontal expansion of irrigation, which depends upon groundwater.

5) MAI shall cooperate with NWRA in surveying documentation and registering the existing water rights or to grant new irrigation water rights upon lands reclaimed upon areas where spate water is available, or where it is allowed to drill new wells or to acquire new water rights in accordance with the rules of drilling licenses and water rights as stipulated in the law and its by-law.

6) MAI shall take care of rainwater harvesting and investment in constructing operating and maintaining storage dams and diverting channels and irrigation systems and controlling spate and floods in the main valleys for the purpose of irrigation and recharge of ground water.

7) MAI shall direct agricultural support and loans towards raising and increasing the efficiency of irrigation and to encourage cash crops that safe water and also to enable farmers to own new irrigation technique. MAI shall prohibit support of drilling wells and machines to agriculture of Qat.

8) To undertake research and studies and extension programs and take measures to rationalize uses of water in irrigation and MAI shall adopt itself with water allocated to it for the purpose of irrigation specifically and to conserve water and the environment.

9) MAI, shall make experiments on all kinds of water which are suitable for irrigation and which shall adapt itself with the soil and climate characteristics and types of crops and to evaluate results of such researches and experiments so that to be available to the users and those who work in the planning organization.

10) MAI shall establish water structures and operate as such for irrigation purposes and to work in accordance with the Local Authority Law so that to strengthen the role of the users in the participation of planning and financing and management, operation and maintenance of such structures and facilities and to make use of rain water and spate water. In this regard MAI, shall in coordination with NWRA and other concerned parties shall define which of the Water Basins needs priority to strengthen its water position through creating new water structures and facilities.

11) Any natural or juridical person may participate in establishing water structures for the purpose of irrigation not contradicting MAI water plan and under its technical supervision.
12) MAI shall prepare a plan for protection from spate water and making network of climate monitoring for agriculture and to convey such information with NWRA and users. MAI, shall make use of the outputs of the national network of water monitoring of NWRA.

13) MAI, shall clear valleys and channels and monitor the spate water and floods flows, as well as to monitor and control uses of irrigation water and its structures and facilities so that to safeguard such facilities and to protect and conserve such water from pollution and misuse.

14) MAI shall prepare indications of demand for irrigation water for the short and medium and long terms, including the need of the private sector projects of irrigation water.

15) MAI shall take measures as it deems fit to avoid dangers of spate water and floods if it thinks that damages to people and properties of such spate and floods might happen. Such measures shall include destruction or breaking any structure or removal of any barriers or fences or establishing new ones within narrow limits to avoid such damages provided that MAI shall pay fair compensation to the beneficiaries when the damages affect them as a result of undertaking such measures.

16) MAI, shall coordinate with NWRA, in relation to the water directions of spate water to avoid dangers of spate and floods as precautionary measures and to inform NWRA of measures that MAI takes separately and urgently to avoid spate and floods dangers when it occurs.

17) MAI shall coordinate with NWRA in relation to the monitoring and control to protect against damages of water spate and floods before it occurs and also concerning measures, precautions and activities which should be undertaken after its occurrence.

18) MAI, shall take legal measures against violators including that violators must pay for all costs of damages that occurred.

19) MAI shall issue a detailed regulation specifying the procedures to the measures to be taken as urgent as well as functions, duties and responsibilities and the rights of the field supervisors. This shall be undertaken through coordination with NWRA and the Local Council and other concerned parties.

20) MAI and NWRA shall choose the suitable locations for water treatment plants with the participation of the local councils, the protection of the environment authority and Basin Committees.

There is by now an adequate legal basis for an irrigation sector that is oriented towards higher efficiency, better water productivity and controlled ET, in line with NWSSIP and NAP. The challenge of course is to put the provisions in practice.

The next sections summarize some specific important opportunities, now offered with the legislation. Section 4.3 discusses some remaining ambiguities in the current water legislation.

### 4.2 Opportunities

Several important provisions have been included in the recent legislation. Of those very relevant for the irrigation sector are:

- The operationalization of basin management and the preparation of water plans
- The empowerment of WUAs
- The provisions for water charging

The section below discusses these improved opportunities for sustainable water use.
4.2.1 Operationalizing inclusive basin management

The By-Law 112 of 2011, issued on 26/2/2011, has helped to operationalize basin management and has defined the approach of catchment management, which is inclusive and participatory. On 3/1/2011, MWE Minister had also issued the resolution no (6) of 2011 (in Arabic), concerning regulation of management of the Water Basins and water areas in Yemen. The contents of this resolution are entirely integrated in the By-Law. Whereas earlier catchment management was also mentioned in the 2000 Law on Local Authorities (see section 4.4), the provisions in the By-Law and the Resolution (6) 2011 center around the preparation of water plans for water basins and water zones to be established by basin and zone committees with management responsibilities as defined in the by-law. It is the responsibility of NWRA and MAI to complete the development of such plans all over the Republic of Yemen and not just in a limited number of governorates, though priorities may be set on the basin to be covered first. These water plans will apart from regulating water use also make it possible to make a stronger connection with land management, which is vital to coordinate watershed activities and investment in recharge and retention of water.

Also, NWRA in coordination with MAI and local authorities, shall set up Water Basin & Water Zone Committees under the supervisions of NWRA, with appropriate representation for the relevant NGO’s and the water users thereof. Article (9) of the New By-Law provides the general principles for the public participation in the basin planning and management:

- Management and use of the water resources in any water basin to be based on an integrated management and use irrespective of its administrative divisions of those areas that compose and constitute such water basin.
- Public participation in accordance with the intentions of the law, the objective of which is to regulate beneficiaries of water resources and those users of water projects and its infrastructures to be in groups and associations at the local level and to unite them to be federated on the basin level and not to be limited to certain groups in part or parts of the basin excluding other parts unless such action is for the purpose of gradual establishment and regulation of such WUAs.
- Coordination with NWRA, and Local Councils and the Basin Committee and concerned parties provided that WUAs should regulate and manage their administrative financial and control affairs in an independent ways as other NGO in accordance with their Article of Association and regulations ratified by the concerned party.
- Participation of all population of the Water Basin within the public participation in the management of water resources so that it is a right of each beneficiary and users to join to a WUAs within their geographical area and to have elected representatives in WUA or the union on the level of the Basin and also to be represented in the Basin Committee. Consideration should be given to the purposes of use of the water and the demographic distribution of the population.
- WUAs have the right to establish a union in the Water Basin so that to be in line with the integrated water management. But no more than one union to be established in the same Basin.

Article 18-20 describes the water user engagement in Basin Planning in more detail (see box 4.1), whereas priority water uses are defined in article (21). There is clear highest priority of water use for drinking water supply followed by use for five of other purposes which are as follows in accordance with article (21):

1) Drinking water
2) Animal drinking
3) Domestic usage
4) Irrigation
5) Industrial use
6) Environment

It needs to be noted that to date no such basin plans have been prepared and endorsed, though many partial studies are have been undertaken. Such par studies often do not contribute to such water plans and generally become singular exercises that in the end do not contribute to coordinated action. There is a need to strengthen the mechanisms to bring together the results of the studies and develop basin plans and zonal plans – as a point of reference and as touchstone for investments in the area.

**Box 4.1: Water Basin Planning**

**Article (18):- Functions and jurisdictions of the Water Basin Committees**
This article specifies the as follows:-

- To participate in preparation of legislations and strategies pertinent to such Basin as far as regulation, management development and utilization of the water resources from such Basin and shall have the general supervision on implementation.
- To encourage the special and private activities in relation to rationalize uses of water in particular to develop new methods and systems of modern irrigation and to benefit from seasonal rain and spate water and treated water to reduce pressure on demand of ground water.
- To participate in coordination of efforts on the local level to confront water crisis, floods, pollution incidents that occur suddenly and to urge the concerned authorities to monitor means of transportation of water and its distribution canals and to maintain irrigation systems and protection of dams.
- To follow-up the implementation of decisions pertaining Water Basins in coordination with NWRA branch and other concerned parties, e.g. MAI branches.
- To propose priorities of water services projects and irrigation structures and systems as well as dams after reviewing feasibility studies of such projects after obtain assistance from experts and those concerned
- To coordinate with the concerned parties to make sure of the feasibility and real need of establishing dams and other water projects.

**Article (20):- Relation between Water Basin Committee and Local Councils and WUAs:-**

- All local councils in the governorate where Water Basin is located shall have equal representation in the membership of the Basin Committee.
- The Basin Committee shall coordinate with the Local Councils on all measures to be taken in their areas and upon the natural obligations to implement decisions of the Basin Committee.
- The Basin Committee may require Local Councils to submit reports concerning their plans and projects in relation to the water, irrigation and protection of the environment projects and their adverse effects on water resources and the environment.
- The committee shall circulate its decisions and recommendations to the Local Councils so that to follow-up implementation of such decisions by the concerned parties within the governorate.
- The committee shall coordinate with the Local Councils to assist in mobilizing efforts of the Local Communities and WUAs towards participation in the management of water resources as well as to contribute in managing structures and projects of water and irrigation at the local level.

**Article (24):- Relation to planning of water resources and WUAs Participation:-**

- The water plans shall include plans for protection from spate and floods and to include the activities and measures for the purpose of developing an improving the benefit and use of rainwater, surface water and to recharge groundwater.
• WUAs and beneficiaries associations and the private sector to participate in financing the management of the water resources and water and irrigation projects as it is included in the water plan.
• The water plan shall take into consideration the traditional water rights when planning and on implementation of such plan.
• The water plan shall be prepared on the basis that importance should be given in developing investment on non-traditional sources of water and treatment of its use as a replacement of drinking water so that such water to be used for agricultural purposes as irrigation.
• Priority should be given on dependence upon rainwater irrigation, rainwater catchment and modern irrigation systems in agriculture.
• Coordination and unification of operations of water projects implementation with the official sectors on one side and the Local Communities and the private sector from the other side.

### 4.2.2 Establishment of mandated WUAs

The water law and its by-law provide for water users’ associations to represent the interests of users and to play a role in the management and regulation of water and the operation and maintenance of water facilities and provide that the associations are to be established at the initiative of users. With this, the extent of decentralization and public participation in water management is defined in the Yemeni laws.

It is provided in the water law that NWRA and MAI shall delegate their authorities to WUAs. This delegation of authority shall be in a manner that will enhance decentralization and participation of the beneficiaries and their WUAs in relation to the management, regulation of the water resources at the Water Basin and Water Zone Level in accordance with the principle of integrated water resources management.

The By-Law 112 of 2011 also prescribes that water users associations and groups and committees and unions should be formed all over the country. This should be implemented by both NWRA and MAI in a coordinated way. Articles (8, 12-14) of the by-law gives the legal basis for WUAs and unions to be involved in such activities and so the participation and regulating the WUAs and unions contribution of its members to finance and manage irrigation structures and facilities is now based on the law and should be implemented. Another important breakthrough is the majority rule – where a majority decision of a WUA general assembly is binding to all users of water – provided the WUA represents two-thirds of the water users in the area.

**Article (8) provides**:- that beneficiaries and users may establish associations or groups or committees or societies or unions for the purpose of public participation and beneficiaries participation in regulating the water resources or operation and maintenance of its structures.

**Article (12), (13) and (14) stipulate the objectives of the WUAs and unions as follows**

1) To regulate WUAs and beneficiaries of the natural water resources to participate in the management of water in accordance of recognized legal and regulatory basis.
2) To ensure the fundamental basis of corporation and regular coordination between WUAs and local Communities with Governmental Authorities and Corporations and the concerned NGO.
3) To facilitate dealing with one institutional forum representing public participation in the Basin to assist NWRA to limit violations and to give its opinion in relation to licenses of drilling, water structures and registration of water rights.
4) WUAs shall give its opinion to NWRA, when requested in relation to applications for drilling water wells and construction of water facilities as well as applications to register water beneficiary rights of ground water, dams, water diversion structures and irrigation systems.

5) To participate in settlement of water disputes in relation to water rights and to give its opinion to that if requested to do so.

6) To Coordinate and regulate efforts of the beneficiaries within the general assembly and outside for the purpose to protect and maintain spate valleys and the general irrigation channels diversion weirs and gates as well as springs, wells and other water structures and facilities of public benefit so that to improve and develop ways and means of benefiting from it.

7) To participate in regulating the members of WUAs contributions to finance and administer and manage irrigation projects and structures and other water services including those water wells which the group or association benefit from.

8) NWRA chairman can issue decisions to give more functions to WUAs provided that it does not conflict or contradict the existing legislations.

9) If the percentage of membership in the general assembly of WUAs is two thirds of the total beneficiaries of the joint water source, then any decisions issued by the general assembly shall be obligatory and mandatory upon all beneficiaries of such source.

10) WUAs and unions shall abide by the water resources management plan and existing legislations, policies and strategies.

11) Representatives of WUAs shall be represented in the composition of the Basin Committees which shall be established by decree of the Prime Minister on proposal from NWRA to the minister of MWE to be submitted to Prime Minister provided that the geographical location of such Basin Committee to be defined.

The provisions above go much further than what was legally possible before and are an important cornerstone for a future reorientation of the irrigation sector. The above articles in the water law and its by-law and the Local Authority Law and its by-law as explained are the legal basis for WUAs authority to control water and infrastructure, to act against violators and mobilize fees from members for O&M. All users of water resources, not only irrigators can participate in the water basin management organizations. So, now community management of water resources and particularly WUAs in the irrigation is a strong legal basis after the issuance of the by-law of the water law in 2011. It is the responsibility now of NWRA, MAI and the governors of the different governorates to implement the Local Authority Law, its by-law and the water law and its by-law. Now that the legal authority of WUAs is clarified, it should be used to support development of WUAs including O&M of spate schemes and community management of water resources.

The role of the WUAs, Local Councils and MAI in irrigation, including the delegation of powers and functions of MAI to its branches in the governorates, is described in article (37) of the executive by-law. as follows:-

- MAI and its bodies and institutions shall operate and maintain the water structures, regulate and rationalize the usage of water allocated for irrigation in accordance with the Local Authority Law and Water Plan and in the light of the general water strategies and policies, irrigation policies, irrigation policies and other related policies; in order to comply with this, the MAI may prepare executive irrigation policies and plans that ensure optimal utilization of water allocated for the agricultural/irrigation sector. The MAI shall keep in view the equilibrium between demand and supply for water in irrigation, assess irrigated crops with less water consumption that can achieve an economic return and can contribute to food security while maintaining water security, intensify agriculture that increases productivity per cubic meter of water per unit of agricultural land and at the same time stops the horizontal expansion of irrigation based on groundwater, cooperate with the NWRA in surveying, documenting and registering the existing irrigation rights, granting new irrigation rights on rehabilitated land in areas where there is a surplus of torrents,
or where digging wells is permitted, or where new rights to water may be acquired, pursuant to the provisions of the drilling licenses and water/irrigation rights set forth in the law and its bylaw. The MAI shall also pay direct attention to the rainwater harvest activities, investment in the construction, operation and maintenance of dams, diversion dams and irrigation systems, and the controlling of torrents and floods in the main valleys for the purposes of irrigation and groundwater recharge.

It is to be noted that binding decisions and resolutions as mandatory fees of the WUAs General Assembly should be taken by two thirds of members attending such meetings and it does not mean by two thirds of the members. Some members may not attend the meeting of the General Assembly. Such decisions and resolutions taken must be legally enforced by the enforcement authorities and the Local Councils in each region against violators.

The now increased legal opportunities for WUAs should be compared with rather poor performance of WUAs so far, as described in chapter 2. The analysis in chapter 2 was that this related to the rather short-term project-based engagement and support to WUAs under external projects. If WUAs are to make the important contribution that is expected both in NWSSIP, NAP and the By-Law, they need to be made part of permanent water governance and not be limited to short term project operations.

4.2.3 Water charges

The previous chapter 3 established the largely subsidized nature of the irrigation sector. Given the strong vested interests of the holders of traditional and common water rights, particularly for irrigation purposes, it is perhaps not surprising that the Water Law is weak in the areas of water being an economic good, ownership, and equity in resource allocation. Implementation of the law will need to be supported by persuading vested interests that it is to their long-term benefit to participate in water resources management and support, the implementation of the Water Law and its by-law now.

As far as tariffs and pricing system is concerned, the current legislation allows NWRA to collect charges for licenses, permits and approvals required under the law and defined in its by-law. These are: a water benefit registration fee; a water benefit fee for commercial uses (which excludes domestic or agricultural use); and a water resources protection fee against pollution. The rules for the application of these fees are set out in executive by-law in detail. There is to be general provision for charging on abstraction (i.e. volumetric) based fee on all water users, especially on agricultural use. The effect of the law appears to be that only commercial use will be subject to this form of charge. This does not reflect water being an economic good.

Under the above Bylaw, the beneficiaries are obliged to pay price of agriculture irrigation water according to the agricultural crop water consumption (clause (4) of Article 6). It proposes to activate: “the beneficiary shall pay” principle and imposing progressive prices per cubic meter of water used for industrial, commercial or touristic purposes and not other non-basic services and varying the prices of agricultural crop water production”.

This would be a revolutionary development in Yemen and is likely to be opposed. Experience from other countries is that the safest way is to introduce water prices that are simplified and acceptable, preferably on the basis of a fixed rate per hectare depending on the type of irrigation system. It is also important that the fees collected are used either for water resource management or for operation and maintenance, as otherwise it would be mainly a tax.
In 1996 and 1997 water charges were levied in Abyan and Lahej Governorates through issue of Decrees for use of these charges for maintenance of irrigation structures. However, the Ministry of Finance did not agree and insisted that these charges so recovered from the users shall be credited to Treasury. At the same time practically no budget for O&M of these structures has been made available and many of these structures have gone into disuse, as the issues of financing O&M issue is not addressed.

### 4.3 Continued ambiguities

There are a number of ambiguities in the current legislation that may be addressed or taken into account too in due time, primarily in the institutional operationalization of some of the most promising new legal opportunities, including the registration of water rights and the introduction of water charges and the role of Irrigation Councils.

#### 4.3.1 Institutional ambiguities and implementation capacities

In the by-law some institutional ambiguities remain. The overall responsibilities of government ministries and their affiliated authorities and institutions are well defined, and the creation of Water Basin and Water Zone committees is a positive step forward towards catchment based on IWRM. However, the use of the term "relevant concerned entities" in several places in the legal documents weakens the clarity of the responsibilities of individual entities. The same applies with using the word "government" and then "the state" in different articles. An example for instance is that the Water Law and its By-law state that "the government" will intervene to regulate the rights of beneficiaries of water resources, but it did not specify clearly the word "the Government". In other articles the word "the state" is used which creates ambiguity as to who is enforcing the law, especially with current low performing and centralized institutional set-up (see chapter 2). Also at times MAI and NWRA are made jointly responsible, and it would be beneficial if roles are made as specific as possible.

However, the larger ambiguity concerns the institutional and organizational frameworks in both NWRA and MAI to support implementation. The successful implementation of the Water Law and its executive by-law depends upon the institutional and human resource capacity of both NWRA and MAI as well as local offices throughout the country to implement and enforce the law, in addition to competent and motivated staff. Many of the provision in the by-law have still not been put in practice, as they require resources and capacity to undertake, which is will be addressed among others in the reorientation of the irrigation sector. For instance, basic resources and capacities will need to be available for instance for catchment planning, the support to WUAs or the recording of water rights – as well as other elements that will help implement the strategies as set out in NWSSIP and NASS.

#### 4.3.2 Water rights

A main contribution of the 2002 Water Law is that it placed a restriction on the unbridled use of water, by making permits a requirement for well development. This changed the relations between land owners/ farmers as well development was no longer unrestricted. For surface water rights such permits do not apply. In stead surface water is regulated under traditional rules; these however are often outdated and inadequate under present situation of far more intense use of water.
The key issue regarding water right in the Water Law is the ambiguous relation with land property and ownership rights. Article 4 of the By-Law attempts to describe a situation whereby water rights are accessible to all who own land, while article 6 states that groundwater exploitation is prohibited without a permit and that the Government shall intervene to regulate the rights and responsibilities of beneficiaries of any water resource. However, article 27 states that existing and acquired water rights, whether prior to the issuance of the law or thereafter, shall be maintained and not touched except for utmost necessity. This appears to potentially weaken considerably NWRA’s ability to introduce an effective permit system based on the availability and sustainability of the resource to address the current deficiencies and overuse. The situation with respect groundwater and surface water rights is discussed below.

Access to Ground Water:
In general, in Islamic Schools the belief is that landowners have the right to utilize and abstract groundwater on their own land provided that they do not waste the water resources. This ‘free for all’ principle was clearly superseded by the Water Law that stipulated that permits had to be obtained to develop a well beyond 60 meters of depth. The announcement of the Water Law in 2002 has been taken seriously in many communities. One side-effect observed in several communities has been that prior to the announcement of the Law there was an extra spur in drilling wells, as farmers anticipated it would be more difficult to have the same done after the promulgation of the Law (sic!).

Ambiguity on the ownership and access to groundwater still exists, not so much in the Water Law as in the interpretation among lawyers and judges. This can be traced to incompatibilities in the Civil Code and the Constitution. The question of ownership of groundwater as stipulated in the Constitution is interpreted differently by the often-conservative judges in Yemen on the basis of the Civil Code no (14) of 2002. The Civil Code is interpreted to mean that a landowner is entitled to the water below it and his ownership is respected and water is a right accessible to all who own land. This definition conflicts with the Constitution, which establishes that groundwater, is public property. Although the constitution in theory supersedes any law, most judges interpret the law in favor of water rights holders and landowners. The problem is that the Water Law itself and its by-law refer to the Civil Code, which strengthens the conservative point of view in relation to ownership of water and water rights, being inseparable from land ownership. The issue is sensitive bearing in mind that in different regions of Yemen there are different schools of Islamic Sharia legislation and different sects of Islamic thoughts. Generally most courts take the Civil Code as the basis of settling water cases and disputes not the Water Law due among others ignorance of judges of the Water Law itself and lack of communication between the judiciary system and NWRA to implement the Water Law.

The Water Law was modified to stipulate that the water is owned by the general public and is a common resource. The law has been issued and amended but there has been no systematic enforcement. Also protected areas that have been identified for (domestic) water supply have not been enforced. The security situation, powerful landowners and sheikhs have at times stood in the way of enforcement.

At the same time NWRA has introduced the licensing of wells through its branch offices. There are a substantial number of illegal drilling cases identified by the NWRA’ branches, as part of daily monitoring program. The way this is supposed to work is that NWRA field monitors find any illegal drilling case they check it out, make a record and submit a notice to the local council and the district security forces to stop the drilling and catch the rig owner with the well owner in order to send them to prosecution. Meanwhile, the branches send the record to the district prosecution in order to proceed the case and the arrested people further to the court. After that, the branch lawyers can follow it up in the court.
In reality, for a variety of reasons only very few cases enter to the court. One of the main reasons is the high reluctance by the district security forces and prosecution to enforce the Water Law. For example from the Sana’a basin: around 29 illegal drilling cases were recorded in the first three months of 2013, but less than three succeeded to enter to the court. Moreover, the reporting as such depends very much on the staffing and efficiency of the NWRA Branch Offices. For example the number of reported cases dropped dramatically in the period of turmoil of 2011-2012 and in general relatively well staffed NWRA Branch offices – such as Sana’a, Amran, Dhamar, Taiz – do better than others. There are also areas where there is no NWRA branch office – either to monitor or to create awareness.

Of recent two new trends have emerged. First is that where local conflicts on groundwater development were exceptional, they are more common now - for instance in Amran and Sana’a Basins. Whereas Lichtenthaeller (2000) observed that in spite of falling groundwater tables there were no conflicts on water in Amran in 2000, in Lichtenthaeller (2010) he describes that protests and blockages are common in Amran now. These water conflicts are rarely raised to NWRA or any other agency. There are some exceptions (see box 4.2 for an example from Taiz) that underline the importance of a stronger link between NWRA and groundwater using communities and WUAs. Even when it is reported by the people to the district security, they are recorded as civil conflicts not as water conflicts. In general, there is much to gain with increased awareness and exchange between communities on groundwater availability, the rules under the Water Law and the possibility of doing local exchange of good practices and also engaging legal professionals and local councils in it.

Second is that in many areas farmers have come to local rules and regulations. Increased extraction from the common pool resources of aquifers has dried up springs and wells. Many communities have sought to prevent harm to existing users, most notably by very visible and easy to observe local regulations, such as norms restricting well spacing and banning export of water from their area by tankers. In other cases farmers have closed disputed wells, invested in groundwater recharge or have connected separate wells by a shared network of pipelines, allowing water to travel from one area to the other. The agricultural wells also double in several cases as sources of domestic water supply and private village pipe networks supplying domestic water supply services (Taha et al, 2011).

In Yemen there is scope to further promote community groundwater management, as is also a central element in the Water By-Law (2011) that assigns roles to WUAs in local regulation. Several immediate actions that can be considered to support this are:

- Document and upscale existing examples of effective local management. Engage farmer leaders from good practice areas in spreading the message and creating a movement of local groundwater management – particular in the hotspot areas. Consider and look for support of projects that will understand local groundwater systems.
- Integrating the promotion of community groundwater management in the large ongoing irrigation programs – in particular the National Irrigation Project (NIP), the Food Security Project, the activities under Social Fund for Development. In these projects an Irrigation Advisory Service (IAS) is engaged in introducing efficient irrigation systems – in particular conveyance systems and drip irrigation. An IAS Plus may be formulated which in addition to the promotion of the modern irrigation systems would (1) systematically promote the process of facilitation of community regulation of groundwater usage (2) promote a broad range of water saving measures – more than modern irrigation techniques – but also better scheduling, land leveling and field moisture conservation methods and (3) provide agricultural advise and services – on alternative crops, better marketing, better crop husbandry. At present the coverage of extension services is low but the demand from farmers is high
- Systematically engage key support groups in the local management of groundwater Working with local councils, with security forces and with well drillers – giving examples of community...
water management and the provision of the Water Law. Consider supporting local association within these groups – such as drillers groups with self-regulating rules and code of good practice.

- Work on strengthening and better connection between the different new water management organizations (Basin Councils and WUAs) and local management of groundwater. Engage existing WUAs – including the ones created in rural water supply projects – in community groundwater management.
- At the same time the capacity and understanding of the current legal professionals with respect to the Water Law and other Environmental Laws should be strengthened. Contacts were established and may be further pursued between MWE and MAI, with the former Prosecutor General to explore the establishment of special branches and courts and qualify the legal officers and the concerned judges of the Water Law and the Protection of the Environment Law.

2.4 xoB

Al-sinah, Almaafer, Taiz

Al-sinah area is located in Wadi Al-asloom, Almaafer District, Taiz Governorate. This is 30 km west of Taiz. The area consists of 12 groups of villages with a total population of approximately 18000 (2004 census). It is well known for its cooperative society. The story of cooperative society dates back to the end of 1960s, when the community decided to establish this organization to nurse water and electricity projects but also to facilitate education and health improvements. Al-sinah and its cooperative society stand out as a single example of long-term institutionalised local development and resource management.

The association also plays a role in local groundwater management. Within the area a distance between wells in the range of 500 meter is observed. One striking example of the application of this rule was in the mid 1990s, when well drilling in a neighbouring hamlet threatened the sustainability of the Al-Sinah water supply well field. The association bought up some scattered fields in this neighbouring hamlet, and then drilled wells there – and subsequently capped the wells. Because local people respect the "500 meters between wells" rule, the capped wells prevented any other water development in the area and the Al-Sinah water supply was protected.

The Al-sinah association also works together with the Taiz branch of the National Water Resources Authority (NWRA). NWRA is not issuing any well drilling permit without consulting the association and obtaining a written consent from the association. Since two years no more well drilling permits have been issued. The association is trying to affirm this rule by declaring the area as a protected zone. A study has been completed and now is considered for approval by NWRA. Neither are farmers are not allowed to dig open shallow wells without obtaining consent from the association.

Al-sinah is hence a case of local and central regulation reinforcing each others. Two years ago NWRA issued a well drilling permit to farmers without consulting the association. The association objected to the drilling. The disputed well was located outside the Al-sinah basin but at a 1000 m distance from a well owned by the association. However, NWRA gave an undertaking that the new well would not have negative effects on the Al-sinah well. In case if any interference, the new well would be closed and handed over to the Al-sinah association.

Access to Surface Water:
Rules and rights on surface water are based on urf, which are traditional law and practice as well as Islamic Sharia with its different schools in Yemen. These rights and rules create predictability and equity, as such encourage land preparation and facilitate cooperation in maintenance, as responsibilities in this regards where inseparable from having access to spate water.

The right and rules in spate irrigation are reactive – in other words they deal with situations that are every time different. This is because floods are different every year, but also in the long run there are changes to riverbed and level of land that need to be dealt with.

Usually not all rules are described in detail as described by Sergeant (1980) “many of the disputes seem to lie dormant, though not forgotten...they can spring to vigorous life with some new turn of circumstances”.

For this reason surface water rights in spate systems are complicated to deal with: they are also easily affected by new development and constructions and they are not clearly codified. Even the famous Al Jabarty rules on the distribution of flood waters in the Tihama wadi’s, such as Wadi Zabid, though well known have no original historical source document.

The customs and practices in the South of Yemen are not the same in the North as in the cases of Hadramawt and Shaba governorates as far as practices and methods of irrigation. The rights to spate irrigation usually concern a combination of traditional rules, in particular:

- Demarcation of land entitled to irrigation
- Rules on breaking of diversion bunds (at different times of the year)
- Proportion of flow going to different flood channels and fields
- Sequence in which fields along a channel are watered
- Depth of irrigation that each field is to receive
- Rules on second and third water turns
- Special preference rules
- Rules on small and big floods

Surface water rights are linked with the land and so holder of the surface water rights cannot sell his surface water rights because water rights are interlinked with the ownership of the land. In Yemen there are no large rivers and so access to surface water is important for all purposes: drinking water, livestock watering and others. Traditional customs and urfs which are recognized by the Civil Law article (79) and (80). The Water Law also give the traditional rights to rain runoff from mountains to those who by custom and traditions make use of it as they used to do in the past.

The spate surface water rights as they are in existence now are however out of tune with modern developments, As part of the discussion for this Diagnostic Report this point was raised by farmer leaders. There is a general argument for recording and reconsidering surface water rights, as they are in practice now and also to consider registering them and codifying them for the entire length of the wadis. There are a number of issues:

- Surface water rights as they have been formulated under urf usually concerns limited stretch of the river, i.e. in particular those river sections where spate irrigation systems are practiced. Over the last four decades upstream storage reservoirs have been constructed without a single consideration for the water distribution in the entire river. As a result flood hydrographs in the piedmont plains have altered. The Water Laws mention that as far as regulation that relates to construction of upstream storage reservoirs it states that no person, persons, corporation or other entity may divert water from a surface source, construct such a diversion or dam or in any other way modify the natural water flow of a
watershed without obtaining a permit, license or water use right from the Basin Committee. Yet these Basin Committee are only in effect in various degree of effectiveness in three basins in the country and water basin plans have not been prepared – so the technical and institutional basis for regulating upstream storage has not been invoked.

- The subsurface flow in riverbeds is generally ignored, even though the volume of water that comes as subsurface flow can be substantial (30-60% of total volume). The development of cut-off weirs and bed stabilizers has in several rivers (Wadi Mawr, Wadi Siham Barquqa) blocked this subsurface flow unknowingly, but at a heavy cost to downstream well owners;
- In the past the main function of the surface floods diverted from the rivers was to spate irrigate. Increasingly the spate system in Yemen have turned into conjunctive systems whereby spate and groundwater is used both. Water rights are as yet not taking the recharge from the floods into account and as drinking water is a prime priority it may be timely to modify water rights so to give more scope for recharge in wider areas;
- The urf rights were formulated in a time when the water was diverted from temporary structures (soil bunds, brush wood diversions) that would break in higher floods giving downstream areas access to such runaway floods. Where systems have modernized there is more upstream control – to the detriment of downstream residents. It may be useful to consider adjusting water rights because of this reason.

A special case is the Marib Dam, where the irrigation function was never activated, as the different tribes could not come a process of agreement. As a result a large part of the functionality of this investment is foregone. An investment in the process of settling such water rights would have been appropriate, and could have salvaged the effort.

4.3.3 Link with land use

Particularly in basin management land use and land rights are as important as water rights. At present land ownership and tenancy rights are still problematic and land use is not regulated. Another complication is that tenant farmers are often not permitted to make improvements to their farming plots, and have other disincentives to make the best use of the land they have rented or been given rights to farm. In addition, illegal land takings have been reported in many parts of the country. While there is no solution to creating more arable and grazing lands, there are a number of legislative and regulatory interventions that could be undertaken to make the best use of the land that is available.

The Republican Resolution Law no.39 of 1991 requires registration of land rights. However, only limited urban lands appear to be registered pursuant to the formal law. Most private rural land rights are documented under customary law. Traditional leaders, usually the sheikh prepares land title documents (basira) and issue land inheritance certificates (fasl). The documentation usually includes a description of the land boundaries, and history of ownership. Land may be titled individually or jointly in Yemen, but the vast majority of land is titled in the name of the male head of household or extended family. Women with individual title to land tend to be wealthy or educated urban residents. Only a small percentage of Yemen's land (an estimated 10-20%) is registered. Eighty to ninety percent of land transactions occur by basira or informal documentation. Due to the low level of official registration of land, access to credit has been affected, as all of the loan products of the leading agricultural bank require a land deed to receive even the smallest loan.
4.3.4 Status of the Irrigation Councils

The Water Law and By-Law provide for a number of stakeholder organizations, in particular Basin Committees, Zonal Committees and WUAs. In the past decades however Irrigation Councils were formed by Local Government decrees. These were meant to regulate water use within larger surface irrigation systems, and could also function as the bridge between WUAs and Basin Committees, as the distance between those two levels is very large. These Irrigation Council however are not mentioned in the current Water Law, or By-Law, though they may be rephrased as Zonal Committees.

Yemen first witnessed establishment of Irrigation Councils long time ago in Lahj (see box 4.3) and Abyan governorates. There was an Irrigation Council—and even Irrigation Court - at the time of the Sultanate of Lahj before 1967. All functions of the Irrigation Council were for spate management and settlement of disputes among farmers. Such Irrigation Councils were composed of government officials and farmers. Now, MAI’s branch officer is member of the Irrigation Council of Lahj. The same thing in Abyan governorate. Also, in Hodeidah governorate Irrigation Council was established for Wadi Zabid, but it was not functioning effectively in the last years due to lack of support from the central and local government in Hodeidah (see chapter 2). Lack of financial support and strict centralization of the government in Sana’a hindered the performance of ICs. One of the purposes of IC is to settle disputes among farmers and to provide them with essential equipment and to regulate distribution of water to their farms.

The IC prepares schedules of irrigation for each diversion structure (weir or traditional uqma) and its command areas of each canal. IC is also supposed to monitor the application of traditional rules in order to foster equity among farmers also for downstream fields. These rules are based on the concept that, at flood times, spate water will not be diverted to the fields that have received water either from base flow or from earlier floods. Kharif season’s spate water will be allocated to fields that have received no water during that year and only when these requirements have been met, the previously irrigated land will get additional amount of water.
Box 4.3 The Irrigation Council in Lahj Governorate:-

The Council was established in accordance with the 2000 Law of Local Authorities, by a resolution issued by the governor upon a proposal by the DG of the MAI office in the governorate. The council is consultative in nature. It is led and supervised by the DG of the MAI office in Lahej. It advises the Irrigation Department (ID) and helps implement these advises. The council has 3 main functions: to discuss and approve the irrigation plan and forward it to the governor, to decide how to best use floods in the delta, and to assist in the irrigation management and maintenance of structures.

-How the Irrigation Council Functions: - the ID, in coordination with the chairman of the council, prepares for the council meetings. Extraordinary meetings are held under certain conditions described in the regulations. Voting system and rules for decision-making are also defined.

-Organizing the irrigation Activities: -

- Supervision: - the ID supervises the use of water.
- Forbidding repeated irrigation: - the regulations prohibit irrigation of the same piece of land more than once during the season/year except if flood waters are "Plentiful" (as decided by the ID or the irrigation council).
- Water cut-off: - the ID may cut the water off (from an agricultural land under the following conditions: -
  - The land/areas has already received irrigation water during the season.
  - to enable undertaking of irrigation works.
  - to avoid damages to lives, property, or irrigation structures.
  - when the beneficiary misuse the water.
  - if the channels are not fit to receive the water (flow rate greater than channel capacity).

- Exceptional cases: - the ID may remove earth dikes /structures for fear of damages caused by such dikes/structures.
- Private intakes: - the regulations also allow the use of a private channels/intakes to serve another land. The regulations also give the ID the right to supervise and use that private channel/drain.
- Irrigation fees: a fee of 100 YR per feddan was supposed to be collected per irrigation per season (500 YR/year for lands irrigated from base flow). The fees were meant to operate and maintain the irrigation structures in the governorate. The regulations charged the MAI or the local authorities with the responsibility of building and maintaining the structures, the irrigation network, the main and branch canals, and the protection of land from erosion. However, the implementation of these activities is the responsibility of the ID and the MAI office in Lahej.
- Private Irrigation works: - each farmer is given the right to build private irrigation works to irrigate his land, in coordination with the ID and the MAI office in Lahej.
- Irrigation dikes: - a user must remove the earth dikes (which they build in main and branch canals) as soon as he finishes irrigation of his land and as instructed by the Irrigation Extensionist.
- Other organizing provision: that deals with: damages and compensation, prohibited activities, and irrigation of land with special irrigation rights.

3- General Provisions: - these deals with implementation and modification of these regulations, establishing regulations for irrigation at the district-level, allocation of the income from fines (75% for O&M and 25% for management expenditures). The regulations also included provisions dealing with incrimination of violators, tasks of the A'abar (intake) Sheikhs, procedures to modify the irrigation council, cancellation of the provisions, and the effective date of the new regulations.
The irrigation Council in Wadi Zabid, Hodaidah governorate:-
The irrigation Council was established in September 2005 by the Governor Decree no.124, issued by the governor of Hodeida as a higher authority and chairman of the Local Council there. The purpose of establishing this council is to serve and facilitate the work of the WUAs in Wadi Zabid that falls under the jurisdiction of the governorate of Hodeida.

The Composition of the Irrigation Council in Zabid is as follows:-
- The council has 27 members, headed by the governor of Hodeida.
- 16 members representing the water user associations (already working in the wadi and responsible for 16 flood outlet called Shereg).
- Also, 2 members representatives of TDA (director of the southern region office) and director of NWRA branch office in Hodeida,
- 3 district directors of Zabid, Aljarahi and Atuheta,
- In addition to the 3 district local councils trustee.
- Also, a representative of the local attorney general office.

The council does not have an official organogram or organizational structure; however the council has created executive committee of 7 members, and financial committee of 2 members, and 2 members as a committee of conflict resolution. The council committees were selected through secret election process by the members of the council.

The council has prepared in 2007 an internal executive roles and instruction manual, which contains description formation of the council, the rights and obligations of members, the administrative and financial working system with description of the committees tasks. Also, the manual has one page table on violations expected and the fines and punishments that will be applied on those violators.

The IC continues to exist, but as described in chapter 2 is struggling to do so. It for instance has played a relatively limited role in water distribution and has focused more on O&M. It has struggled to operate its equipment. What is required in view of the restructuring of the irrigation sector is to strengthen the ICs, as particularly in the spate irrigated coastal plains they are an adequate interface between government and farmers. They can also play a much larger role in regulating water distribution, recording water rights and in introducing conjunctive management in the coastal plains, so as to spread the flood flows over a larger area and recharge wells for drinking water, where is the highest water priority according to local norms and according to the Water Law and By-Law. The ICs may be designated as Zonal Committees and be made part of the regular water governance in Yemen. An assessment of the ICs also shows that active engagement of local government is important and preferably not at arms-length. In the Wadi Zabid IC this might require the head of the district rather than the Governor to take daily charge.
4.4 Role of the Local Councils in Irrigation Development:

As is clear from above decentralization has been set in motion and the expectation is that the outcomes of the National Dialogue may further reinforce this. ‘Management of water at the lowest appropriate level’ is one of the key principles in Integrated Water Resource Management, as advocated by the Water Law.

The Law on Local Authority (4) was issued on 10th February 2000, and immediately its Executive By-Law was issued six months later on 21th August of 2000 by the Republican Decree no (269) of 2000. This underlined its importance and a desire for quick implementation at the level of governorates and districts. This law was the first step of decentralization of functions and responsibilities of Ministries at Sana’a. It has several provisions that relate to irrigation and water resources development. As mentioned, with the still ongoing process of decentralization these are highly relevant.

The Water Law no (33) of 2002 which was issued two years and a half after the Local Authority Law no (4) of 2000 refers in many articles to the Local Authority Law and the Local Councils in particular article (61) in part seven concerning the protection from spate and floods. This article stipulates that MAI, shall - with other parties concerned - set measures to regulate catchment areas that cause spate and floods and to regulate the areas where these waters are harvested. According to the Water Law the MAI shall make plan for the catchment areas in cooperation with the local authority and all water users.

The Local Authority Law no (4) of 2000, hence plays very important role in the water management on the level of governorates and districts.

The following articles in the Local Authority Law are pertinent and relate to water management in general and water rights in particular as follows:

1) Article (145): Each minister, in the sphere of his ministry's activity in respect of the administrative units, shall undertake the following:
   (a) Inform the governors of the contents of the state's general orientations and policy, as well as whatever of technical guidelines and directives leading to improvement of the level of performance of services at the local level and control over them that he sees fit.
   (b) Co-ordinate with the governors on needs of the administrative units at the governorate level and need for technical and specialist cadres and act for their provisions.
   (c) Adopt measures to raise the level of competent performance of the executive organs of the administrative units and that through the process of training and qualification of various forms and types.
   (d) Organize management of national campaigns and fund their implementation.
   (e) Formulate and prepare the general technical specifications, designs and plans.
   (f) Issue the organizational regulations in the sphere of activity of his ministry.

2) Article (165): Specialist funds of economic and social development must co-ordinate projects and activities that are funded by them with the local councils from the planning and implementation aspects.

3) Article (168): The local council may constitute special committees from among the beneficiary public to manage, conduct and maintain services projects of the administrative unit. The Regulation or Executive decisions shall show the fundamentals governing that.
The Local Authority Law specifies the exact relationship between the ministries in Sana'a and the local councils in the governorates and districts. With the Law on Local Authorities coming into force, this relationship is between MAI and the Ministry of Water and Environment MWE in one hand with the Local Councils in both the Governorates and Districts in the other hand. This has weakened the reach of the central Ministries who now sit ‘high and dry’ in the capital. On the other hand it could have offered an opportunity for broad local engagement but this would have needed more resources and devotion than what has been made available.

The Local Authority Law defines the functions and responsibilities in regard to the supervision execution and implementation as well as management of projects within the geographical limits of the governorates and districts as follows:

4) Article (14):-
(a) The powers of the central organs, each within its sphere of competence, over the executive organs of the administrative units are determined in formulation of general policy, enactment of organizational regulations, control, qualification and training and implementation of projects which are difficult to implement by the local councils in the administrative units and that upon their request or projects that are of a general national nature.
(b) In accordance with the provisions of this law, its regulation and resolutions in implementation thereof, the executive organs of the governorate undertake the role of central authority organs, each within its sphere of competence, in implementing activity at the level of the governorate and technical supervision over organs corresponding to it in the districts, without prejudice to the contents of paragraph (a) of this article.
(C) The executive organs of the administrative unit are deemed to be local organs. They represent the technical, administrative and executive organ of the local council and under its supervision, management and control they undertake founding, equipping and management of all development and services projects incorporated in the administrative unit's annual plan and budget. The Regulation shows the levels of the development and services projects whose implementation is assigned to the governorates and the districts.

5) Article (19):- The Governorate Local Council shall undertake the study of draft comprehensive plans at the level of the governorate and supervise over their implementation. It shall also undertake direction of, supervision over and control of the work of the District Local Councils and the executive organs of the governorate. In particular, it will exercise the following tasks and responsibilities:
   a. Consider and approve fundamentals and rules organizing citizens' contributions to the funding, founding and maintenance of essential services projects funded by them or with their participation.
   b. Supervise over and control implementation of water policy, protection of water basins against exploitation and pollution and that in accordance with the provisions of laws and regulations in force and directives issued by the central authorities in this respect.
   c. Promote the founding of qualitative co-operative societies of various forms as well as association of a social, vocational and creative nature and furnish them with facilities.
   d. Supervise over co-operatives their plans and programs in a manner that ensures their complementation with the development plans of the administrative unit.

6) Article (61):- The district local council shall undertake the suggestion of the draft social and economic development plans of the district, supervise over their implementation in a manner that provides and develops essential services for the local society and its development. It shall also undertake direction, supervision over and control of the work of its executive organs. In particular, it will exercise the following responsibilities and tasks:-
(a) Care for development of water resources through promoting the founding of dams and water weirs, protecting water from depletion and pollution and that in accordance with scientific studies and water legislation in force.
(b) Promote the establishment of qualitative co-operative societies of various forms as well as associations of a social, vocational and creative nature and provide them with facilities.
(c) Supervise over co-operative activities as well as those of societies of a social nature and co-ordinate their plans and programs to ensure complementation with the integrated development plans of the district.
(d) Supervise over implementation of environmental policies and legislation, adopt the necessary measures ensuring preservation of the environment and natural resources preserves and protect them from pollution and destruction upon them.
(e) Propose fundamentals regulating citizens’ contributions to the founding and maintenance of essential services projects funded by them or with their participation and supervise over their execution after approval of the Governorate Local Council.

7) The financial resources of the administrative units are comprised of the following:
First:- The local resources of the district are the resources that are collected by the district in its own favor and can include fees on digging wells.
Second:- The joint resources at the governorate level and these are the resources that are collected in the districts of the governorates in favor of the governorate as a whole and may also include fees for digging/drilling permits.

With the issuance of the Local Authority Law no (4) of 2000 and the Water Law no (33) of 2002 decentralization has started and there are opportunities to promote water management at local levels, provided new mechanisms and institutional arrangements for local water management based upon the above mentioned laws. With decentralization, branches of Ministries and National Authorities become 'local organs' under the governorate. Local Councils and staff will be treated as personnel of the governorate. According to the law, local councils have a role in supervising the implementation of water policies and protecting water resources from overuse or pollution.

The By-Law of the Local Authority Law was issued six months after the issuance of the Local Authority Law no (4) of 2000, describes a number of more detailed arrangement for cooperation between local authorities and NWRA/MAI:

Article (12) of the By-Law specifies that all Executive offices of the ministries in the governorate shall be under the supervision, control, and management of the Local Councils in the governorate within the framework of the general policy of the state and the prevailing laws and regulations. Such executive offices in the governorate shall carry out the role of the central authority in the execution of their activities on the level of the governorate and shall take the responsibility of the technical supervision on the Executive offices in the districts of the governorate such as the supervision and control on the implementation of policies and the public plans in agriculture and irrigation and water resources and the protection of the water basins from pollution and overexploitation at the governorate level.

Article (13) specifies the functions and responsibilities of the Local Council in the districts of the governorate as follows: “To provide the urgent and future requirements of the people for water whether for drinking or other house consumption and to execute projects and provide services of sanitation. Also to take measures necessary to conserve water resources from pollution and over exploitation. Granting licenses to drill artisan wells in the district shall be in accordance of policies and national strategies and after the approval of the concerned authority in the governorate, i.e.
NWRA. Also, the local council shall carry out awareness campaigns among farmers concerning the modern agricultural systems and improve irrigation methods.”

Article (16) stipulates that the functions of the governorate in the field of implementation of development and service projects shall be defined on the following levels, firstly: establishment, management and maintenance:

Para (7) of this article mentions the dams as one of the functions. Another function in this article is the establishment, management and maintenance of projects that serves two districts or more of the governorate districts. This applies to the projects in the Sana’a Basin.

There is another function for the local council of the governorate to establish, manage and maintain any projects assigned or delegated by the central ministries to the governorate. Such projects, which are centrally financed, may have national characteristics. Also, on the basis of this article, the local council on the level of the governorate shall manage and operate and maintain any project, which is executed by any central authority and transferred and assigned through delegation of powers to the governorate. This article is in compliance with article (72) of the Water Law no (33) of 2002 which authorizes MWE to delegate some of its powers and functions to any entity whether council, committee or office provided that it does not contradict or contravene the local authority law no (4) of 2000.

Article (17) of the By-law stipulates the functions of the local council on the level of the district concerning execution of service and development projects as follows: ‘Establishment, management and maintenance of water barriers and water irrigation projects as well as local projects of water and sanitation for the district in accordance with paragraph (10) and (18) of article (17) of the By-Law.’
4.5  Recommendations

In spite of a rich tradition of water resources development in Yemen - second to none – and dating back millennia, the challenges to sustainable water management in Yemen are severe. There however is by now a strong legal basis for sustainable water management and for the role of the irrigation sector therein.

There is scope to further fine-tune the current legal provision and some secondary legislation is required – for instance on reorienting the AFPPF (see chapter 3), earmarking the recipients of the water charges and developing the system of registering water rights. There is also scope for better legislation on land use in relation to water basin planning. Yet in general the ‘best should not be the enemy of the good’ and the main challenge is to implement and execute the Laws, in particular:

- Developing water plans for Basin and Zones
- Activating Basin and Zonal Committees
- Setting up as part of regular governance (and not project activities) WUAs and Unions thereof on the basis of Basins
- Start implementing provisions on flood protection, regulating horizontal expansion
- Consider introducing the system of water charges at the minimum for the operation and maintenance of irrigation systems.

It is clear that the Republic of Yemen has issued sufficient legislations in the water sector. There are problems and difficulties in the means and ways of executing and implementing such laws and regulations due to lack of public awareness of such legislations and non-compliance of such laws in some cases due to lack of enforcement machinery. There are some bright spots, for instance the implementation by NWRA Sana’a Branch of the Water Law no (33) of 2002 as amended in 2006 and its By-Law (2011). The Water Law provides the legal framework which empowers decentralized institutions with stakeholders participation for water management, including if need be the modification of rights if there is inequity in water use and distribution or threat to the water basin itself due to over extraction of the groundwater as the case is with the Sana’a Basin, and others in Saada and Taiz.

The two major organizations are MWE and MAI. The Water Law no (33) of 2002, defines the broad responsibilities and functions of MWE and MAI. The Water Law provides for instance that MAI as others, must submit to NWRA all its water plans, whether dams, weirs or diversions and other water structure for the purpose of study, review and approval, since MWE and its executive authority NWRA, is the authority responsible to manage all water resources whether groundwater or surface water. MAI however by virtue of the importance of irrigation is an important partner in this. There must be coordination and partnership between MWE and MAI and in particular NWRA and MAI in the Basins and the governorates to avoid duplication and conflicts of functions and responsibilities, especially as now with the By-Law executive regulation of the Water Law is issued. Therefore, the co-ordination between MWE and MAI is precious as takes place in the different steering committees and also recently in the joint unit to coordinate inventory and planning of dams.

The big challenge for MAI and the irrigation and water sector at large is however capacity – to implement investment program and to perform its own supervisory, planning and regulatory functions. MAI moreover needs a to resolve its outreach to the Governorates and Districts, with clearer arrangement and enhanced skills in promoting sustainable irrigation throughout the country as part of a permanent system of irrigation sector governance.
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