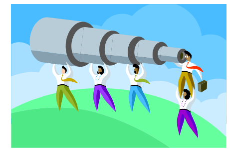
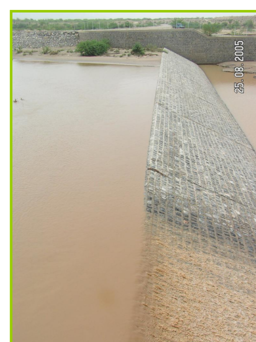
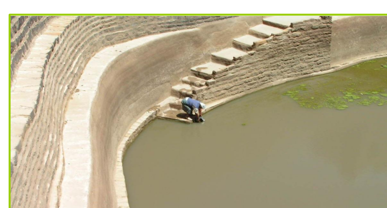
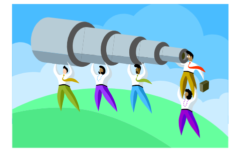


A Review of Constraints and Opportunities in Yemen







Executive summary

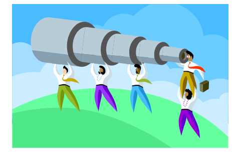
Water resource preservation and agricultural prosperity in Yemen's political debate seem to face serious contradictions. Water is a very complex sector (refer to Annex 1). This paper makes an attempt to work out the potentials for harmonized and coherent actions in water resource management and agriculture. There has been a lot of debate on the sector responsibility for water use in irrigation. There are arguments that the water law provides a clear mandate to NWRA to exercise control over water resources FOR irrigation, but that its "interference" ends at the farm-gate, at the latest. Although "equality and sustainability" in resource allocation are the overriding objectives to be watched over by NWRA, it so happens that the largest water user has widely been operating outside its control. Agriculture in general and particularly the irrigation sub-sector, on the other hand, has an understandable priority on food security and farmers' incomes. Notwithstanding, a wish for resource sustainability is evident, since there will be no agriculture without water. Thus, the AGSIP 2006-2015 clearly aims at reducing water consumption by focusing investments on irrigation improvements. It is therefore evident that irrigation and water resource management sub-sectors must and can negotiate their respective interests in the framework of a joint vision.

This paper provides an overview over the multiple congruencies and interdependencies in both sub-sectors' policies and strategies, as defined in NWSSIP and other plans. Although the data bases and the monitoring systems are weak, there is a level of basic understanding: (i) that the water crisis is still worsening and that some critical "hot spots" basins are on the verge of drying out; (ii) that present agricultural prosperity based on uncontrolled water mining is not sustainable; (iii) that a change of resource consumption speed is needed, and (iv) that significant and substantial water savings can only be obtained in irrigation.

Table 1

Some Elements of a Joint Vision for Water Resources and Agriculture in Relevant Strategies	Yemen Vision 2025	MDG 2015	NWSSIP 2009	AG Sector Plan 2006-2015	Poverty Reduction Strategy	DPPR 2006-2010	PIP 2007-2010
water rights system exacerbate inequalities					■		
water mining practice anti-poor					■		
water abstraction rate unsustainable			■	■	■	■	
water use key to food security	■	■		■		■	
agricultural water use key to reduce poverty		■	■	■	■	■	
stop irrigation area increase				⇨			⇩
control and reduce Qat cultivation	■		■				
improve crop variety and extension services	■		■	■			■
reduce incentives driving groundwater depletion			■				
increase irrigation efficiency	■		■	■		■	■
enhance water harvesting	■		■	■			■
improve spate irrigation	■		■	■			■
maintain irrigation structures			■	■			
limit construction of new dams			■	■			⇩
reduce agricultural share in water use	■		■	■		■	
support rain-fed farming	■		■	■			
develop new water sources			■			■	
increase water share for domestic use	■	■	■		■	■	
reduce water loss in networks			■			■	
water savings targets defined			■	■			⇩

The 3rd Five-Year Plan (DPPR) makes strong recommendations with regard to cross-sector water transfer. Agriculture's share has to drop from 90% to 81% within 5 years, while domestic and industrial use has to increase its share accordingly; unfortunately, this strategy not only falls short of defining real savings targets, but its corresponding Public Investment Program (PIP) basically ignores the priorities of the government approved AGSIP 2006-2015. In the essence, water savings in agriculture can not be limited to the quantities shifted to other sub-sectors, but must ultimately aim at reversing resource depletion. Approaches such as GDI NWSSIP 2009 targets, AGSIP 2006-2015, MDG needs assessment and DPPR 2006-2010 have partly been neutralized by lack of progress in some projects (such as the SBWMP) and are seemingly ignored in the 2007-2010 PIP.

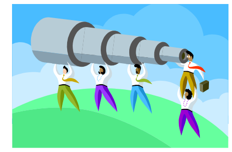


This paper proposes to combine sound policies with proven experiences and presents 3 scenarios with regard to development of the water balance: (i) the no-action scenario is an extrapolation of the present reality, which will result in the medium term in substantial economic and social imbalances; (ii) a moderate-action scenario with rather limited moves on water consumption and growth of irrigated land, which will only moderately influence the water deficit; and (iii) a more dynamic change scenario ("Agenda 2020"), which assumes a complete stop of expansion of irrigated land and a gradual reduction in water use, triggered by irrigation improvement investments. This desirable scenario takes into account the present capacities in annual implementation as defined by the General Directorate for Irrigation (GDI) and quantifies the necessary funding.

A joint vision has to harmonize good principles and agreed strategic elements (see Table 1): In practical terms it signifies that the NWSSIP targets for irrigation improvements need to be revised, that the irrigation sub-sector needs to establish its own realistic medium- to long-term plan, and that NWRA has to come to grips with its key activities being (a) establishment of water basin plans, (b) comprehensive water resource assessments and (c) a nationwide resource monitoring system.

On the water resource management side, some progress has been made as per end of 2005: (i) 338 water monitoring points were established; (ii) 135 meteorological and rainfall stations have been put into operation; (iii) 55,000 wells were inventoried in 9 governorates, 21,000 in 2005 alone; (iv) a steady increase in well license applications has been reported (from 83 in 2003 to 889 in 2005); (v) license approvals have been cautious (41% in 2005, only 33% of agriculture applications); (vi) 304 drilling rigs have been identified and 24% licensed; (vii) 504 violations were reported (104 only in last 2 months of 2005). Nonetheless, clear targets and milestone plans are missing. The most significant weakness is the slow progress in developing and implementing the basin water management plans, which only exist for 1 basin out of a total of 31 sub-basins, most of them in urgent need of this resource management tool.

In spite of these shortcomings, there is no reason to postpone any priority actions in the well known critical highland basins. By combining all efforts in the most effective way, the ***Joint Vision for Water Resources and Agriculture*** may actually have the chance to transform from wishful thinking to a coherent concept and joint actions towards a gradual reverse in water resource depletion.



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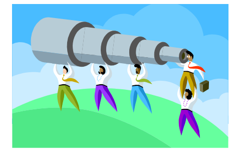

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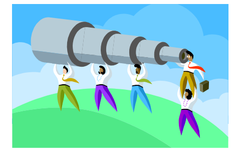
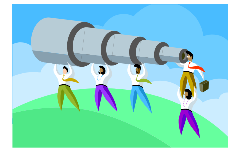


Abbreviations

AFPPF	Agriculture and Fisheries Production and Promotion Fund
AG	Agriculture
AGSIP	Agriculture Sector Long-term Investment Plan 2006-2015
BCBM	billion cubic meters
cbm	cubic meters
CWRAS	Country Water Resources Assistance Strategy (World Bank 2005)
DPPR	Socio-economic Development Plan for Poverty Reduction 2006-2010
ENV	Environment Sub-sector
EPA	Environmental Protection Authority
GARWSP	General Authority for Rural Water Supply Projects
GDI	General Directorate for Irrigation
Ha	Hectar
HRD	Human Resources Development
IIP	Irrigation Improvement Project (World Bank)
IRR	Irrigation Sub-sector
IWRM	Integrated Water Resources Management
INGO/NGO	International / Non-governmental Organization
JAR	Joint Annual Review
LWCP	Land and Water Conservation Project (World Bank)
MAI	Ministry for Agriculture and Irrigation
MCBM	million cubic meters
MoF	Ministry of Finance
MoLA	Ministry of Local Administration
MoPIC	Ministry of Planning and International Cooperation
MoPS	Ministry of Public Service
MWE	Ministry of Water and Environment
NWRA	National Water Resources Authority
NWSA	National Water and Sanitation Authority
NWSSIP	National Water Sector Strategy and Investment Program 2005-2009
PIP	Public Investment Program 2007-2010
PIU	Project Implementation Unit
PRS	Poverty Reduction Strategy
PWP	Public Works Project
RWSS	Rural Water Supply and Sanitation Sub-sector
SBWMP	Sana'a Basin Water Management Project (World Bank)
SFD	Social Fund for Development
SMC	Sector Management Committee
UWSS	Urban Water Supply and Sanitation Sub-sector
USD	US Dollars
WB	World Bank
WRM	Water Resources Management Sub-sector
WU	Water Users
YR	Yemeni Rial
YV	Yemen Vision 2025



1. Introduction

On 1st February 2006, key donors of Yemen's water sector met in Frankfurt in order to develop joint approaches of sector support. The meeting concluded with some key recommendations towards the Yemeni government regarding important priority actions. Among the identified shortcomings in key sector issues were (i) the lack of coordination between agriculture / irrigation / domestic water management; (ii) the overexploitation of ground water which seriously jeopardizes the future availability of water for domestic, agriculture and other uses, and (iii) lack of water saving incentives for farmers who are dependant on groundwater irrigation.

Consequently the recommendations made, among others focused on water resource concerns calling for (a) a statement from the government of Yemen on a coordinated vision for water and agriculture, and (b) use of substantial portions of the AFPPF for investments in irrigation efficiency improvement in identified "hot spots" such as Ta'iz, Sana'a and Sa'ada, which should be closely monitored by NWRA. The donors also stated that "…*continued substantial support in the water sector will be linked to tangible progress made on the above mentioned priority actions*…"

Another key recommendation, the conduction of a first Joint NWSSIP progress review, was already taken up by the Yemeni side, and the JAR was successfully concluded on June 28, 2006. In preparation of this event, coordination between agriculture and water resources management (MAI / GDI and NWRA to be precise) was taken from on-the-ground cooperation to a more strategic level. As agreed, sector stakeholders already worked together in defining suitable indicators for measuring the progress and success of NWSSIP. Thus, important elements for a joint vision for water resources and agriculture have already been established. In addition, the MAI has recently established a Unit for On-Farm Irrigation Improvement within the GDI and has called for support by donors.

The water law defines the role of each institution with regard to water resources:

- According to paragraph 21, **NWRA** is responsible for determining the water equations, assessment of water demand and amounts to be used for the different sectors engaged in water use, through monitoring and assessment of water use in different basins, and to cater for further development of these resources. Monitoring should be based on an extensive network of water monitoring points. NWRA should adopt the necessary measures to ensure equity in water use and to protect these resources from mining.

- According to paragraph 25, **MAI and its authorities** should manage their own structures and manage water use in irrigation as per the water master plans and in line with strategies and policies of the agriculture sector. MAI should prepare irrigation policies and plans and plans which ensure maximum use of the sector's share of water. It should conduct research and extension on rationalization of water, promote modern irrigation methods, construct manage and maintain water constructions to ensure optimal use of rainfall and floods in the light of water plans and water equations for basins, and prepare indicators for water demand in the short, medium and long terms, including projections of water requirements of the private sector.

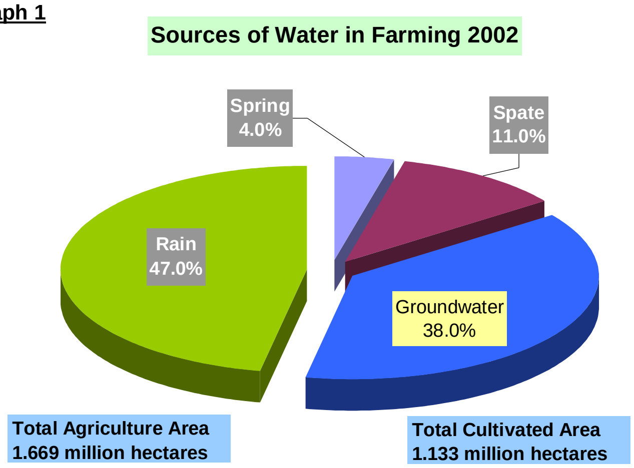
The NWSSIP objectives state that the water resource management sub-sector is charged with development of a "…realistic and holistic water vision…". Thus, the institutional responsibility for conducting the process and formulation of a **joint vision for water resources and agriculture** lies with NWRA.

This paper intends to kick-start the discussions on the subject and to provide a view on constraints and opportunities in achieving such joint vision and, more importantly, on actions conducive to its achievement. Important limitations as the percentage of farmers actually USING their improved irrigation systems (80% according to MAI/GDI) have not been factored in and will have to evolve from posterior discussions and respective project evaluations.

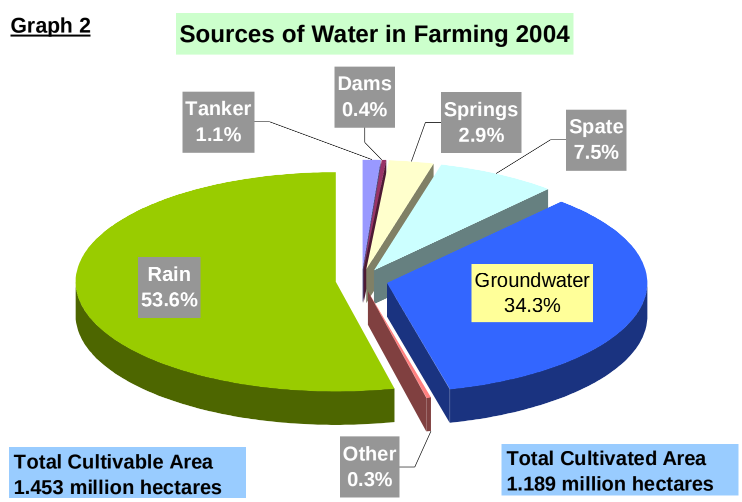
2. Water balance development and deficit perspectives

Indications regarding the deficit in Yemen's water balance are diverse. The data used in many publications have not been updated since the mid 1990s, in spite of dramatic changes in agricultural water use. Be it as it may, the gap is significant and widening. In 1995, total water use was estimated at 3.2 BCBM per year, with renewable resources estimated at 2.5 BCBM, which resulted in an over consumption of 700 MCBM. Being irrigated agriculture the largest user of water, it is necessary to look at the development of the respective "consuming surface". In 1970, irrigation was practiced on 37.000 hectares, consuming approximately 350 MCBM[1] p.a. In 1995, irrigation surface already had increased to some 300,000 hectares, requiring 2,850 MCBM of water. In 2002, groundwater irrigated area stood at 430,700 hectares, which then possibly drained 4,092 MCBM of the vital resource. For a number of reasons, this area in 2004 dropped to 407,000 hectares, demanding 3,867 MCBM of groundwater. The overall growth of irrigation groundwater demand from 1970 to 2004 would be thus eleven-fold. There are indications that the bonanza of irrigation area growth has passed its peak. Use of all potentially irrigable area depends on water availability and location and is not stable. However, in the medium-term, irrigation area may still go up by some 2-3% per year, mainly in the coastal regions. Thus, in 2006 we should calculate with 432,000 Ha and 4,104 MCBM water demand, to be on the "safe" side.

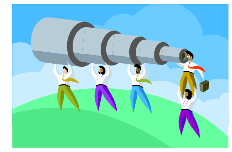
Graph 1



Graph 2



[1] According to present MAI/GDI estimates, the water demand in irrigation (2-3 plant cycles per year) is 9,500 cbm per year; in 1970 it was probably less for minor incidence of water intensive crops



The other relevant user, although small in comparison, is the rural and urban population. In 1970, total population was 7.318 million, consuming some 160 MCBM at an average of 60 l/c/d. In 2004, population had risen to 19.722 million, of which 72% was rural and 28% urban (please note that recently CSO adjusted the population census result upwards by 1.6 million). The total water consumption of the population at present is estimated at 465 MCBM, which includes most of industrial and commercial use. “Domestic & service” use has thus tripled in the reference period.

By this calculation, total water consumption in 2006 would stand at 4,570 MCBM. In irrigation, the water provided from spate, spring and dams has been increasing, but this is outside the pumped groundwater use. Given the fact that there is no significant increase in renewable water resources, the deficit today is probably in the range of more than 2.0 BCBM per year.

3. Action scenarios

Vis-à-vis the described panorama, implications of 3 theoretical scenarios are presented in this chapter. Details of assumptions and influential factors are presented in Annex 2. Results can be summarized as follows:

3.1 No action

Everything is cool… No real enforcements trying to contain the agricultural frontier, irrigation area continues to grow, although slowing down to 2% per year. Irrigation water demand continues at a rate of 9,500 cbm/hectar/year and groundwater continues representing at least 75% of irrigation water share. Increasing water scarcity on marginal land induces concentration of agricultural holdings in detriment of poor farmers. Agriculture prospers on an artificial bubble of export cash crops, exporting virtual water. Qat holds the country in its social and agriculture in its economic claws. Population growth is stabilized but does not reduce much further, rural population growth continues at a rate of 2.2% per year and urban population growth at least with a rate of 5.0% per year. Rural domestic water use stagnates at 50 l/c/d since service coverage growth is slow and many schemes fall short of water resources. Urban domestic water use is 100 l/c/d which includes supply to industry/commerce. In critical basins, water related conflicts are building up rapidly, since scarcity affects farmers and the general population alike. No additional renewable water resources are being tapped, and per capita renewable water availability drops to some 79 cbm/year by 2020.

3.2 Moderate action

We are getting worried… growth of irrigation area begins to slow down, mainly because critical areas are given up, which offset newly developed areas. Qat is not affected substantially because we don’t mind trucking water to lucrative locations if necessary, but of course, Qat gets more expensive by the year. In a combined application of options (water savings, fiscal measures, crop selection etc), all in all we manage to bring agricultural water use down by 1% per year in a linear row. Irrigation water demand thus drops from 4.0 BCBM in 2006 to 3.6 BCBM in 2020. Agricultural prosperity still relies on cash crops, but food security increases given more coherent support to spate irrigation and rain-fed farming. Population growth remains unchanged, whatever rural decline occurs is compensated by urban sprawl. Domestic water use stagnates, but in critical basins resource related conflicts are on the rise. No substantial additional renewable water resources have been tapped, and thus per capita renewable resources continue to go down to 79 cbm in 2020. At least, the downward trend in water balance deficit is contained, but the deficit still remains substantial.

3.3 Dynamic action ("Agenda 2020")

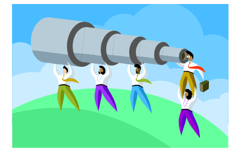
The crisis has finally gripped everybody's mind and business as usual is over … growth of irrigation area has stopped completely, and decrease has started as from 2010. High prices have started to curb demand for Qat, although its substitution is not yet working on a large scale. In irrigation, substantial reductions of subsidies have claimed their toll on pumping costs, and irrigation water use efficiency is growing on a considerable path. By this, we manage to bring agricultural water use down by 3% per year in a linear row. Irrigation water demand thus drops from 4.0 BCBM in 2006 to 2.6 BCBM in 2020. Agricultural prosperity still depends on cash crops, but food security increases given more coherent support to spate irrigation and rain-fed farming. Population growth declines gently, but domestic rural water contraction is compensated by urbanization with its higher per capita water use. Domestic water use thus stagnates, but in critical basins resource related conflicts are sharpening. Additional renewable water resources are being tapped at a rate of 0.5% per year (water harvesting, desalination, effluent reuse), and the loss of per capita renewable resources slightly decreases (still it goes down to 85 cbm in 2020). The downward trend in water balance deficit is reversed and the deficit in 2020 has dropped to some 725 MCBM. A match of water consumption with renewable resources seems to be at reach.

3.4 Conclusion

On a countrywide scale and not really knowing when the resources will dry out, all scenarios are scary. Since water resources are not distributed evenly across Yemen, in some critical basins the aquifers may collapse pretty soon and this may produce large scale internal migration and social unrest with serious repercussions. Thus, the sooner the remedial actions are unleashed, the better.

As a conclusion on the presented options it is evident that action scenario 3 (Agenda 2020) is most demanding, but has the potentials for some drastic improvements of the water balance. Of course, a variety of factors will influence its success, and many can not easily be controlled. The impact of negative and positive incentives on farmers to effectively accepting the measures proposed will much depend on the economic results obtained and the level of sustainability in operation and maintenance of modern on-farm systems (see also Box 1). In addition, a large scale switch to alternative non-farming rural employment must be triggered outside the agricultural sector.

Accumulated over-abstraction from 2006 to 2020 would still mark some 19 BCBM; available non-renewable resources in water scarcity hot spots may wipe out agriculture in such sub-basins before.



4. Elements of a joint vision

4.1 NWSSIP and IRR / WRM common elements

As regards the overall objective of improving the well-being of the rural population, NWSSIP has defined that irrigation/watershed management shall contribute to poverty reduction by improving farmers' income on a sustainable basis. On the other side, water resource management basically focuses on sustainable availability of resources, equitable allocation with priority on domestic use, and on user participation. As shown in Annex 3, many objectives, policies and approaches are basically congruent and a joint vision seems not only possible, but is absolutely imperative.

In a nutshell, Yemen faces 5 apparently incompatible, however intimately linked challenges: (i) to supply water to a rapidly growing population, (ii) to increase food security, (iii) to maintain rural livelihood based on agricultural water use, (iv) to supply water to increasingly diversified economic activities aimed at fighting poverty; and (v) to save water for the environment and future generations.

This is not only about abstract renunciation: water consumption has to drop, and cross-sector transfers will be unavoidable. Water will become scarcer not only under ground, but also on the surface and thus more expensive across the board, unless we continue to engage in unsustainable subsidy schemes. The potential success of any action will depend on a very delicate balancing act.

In overall perspective, NWSSIP has incorporated elements of political, economic and social agenda, such as the Millennium Development Goals (MDG) and the Poverty Reduction Strategy (PRS). New developments have arisen that require a fresh look on compatibilities of strategies and action plans.

4.2 Millennium Development Goals (MDG):

The MDG needs assessment is based on the AGSIP 2006-2015 which requires USD 2.2 billion. Thereof, 40% is dedicated to irrigation, 10.8% to water harvesting, and a substantial 12.5% to MAI institutional strengthening. The savings potentials estimated are 15% for upgrading and 25% for introduction of piped conveyance systems, and 35% for pressurized on-farm irrigation systems. Together with water harvesting, 51% of global sector investment is dedicated to water savings; however, part of the savings are to be used for irrigation area increases. A total of 560 MCBM p.a. are the reportedly expected water savings (Phase 2006-2010).

With regard to achievement of the general MDGs, multiple dependencies on water resources are evident:

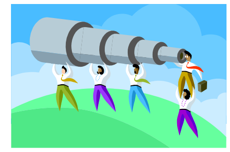


Table 2: Water and MDGs

MDG	Definition	Water relevance
MDG 1 target 1	halve, between 1990 and 2015, the population whose income is less than 1 dollar per day	*limited economic development without water*
MDG 1 target 2	halve, between 1990 and 2015, proportion of people who suffer from hunger	*No food production and processing without water*
MDG 2 target 3	ensure that by 2015, all children, boys and girls alike, will be able to complete primary education	*increase in enrolment of girls without sanitary facilities difficult*
MDG 4 target 5	reduce by two-thirds, between 1990 and 2015, the under-five mortality rate	*only limited health improvement without safe water supply*
MDG 7 target 9	… reverse the loss of environmental resources	*no sustainable environment without water resources*
MDG 7 target 10	by 2015, half the population without sustainable access safe drinking water	*no water supply without water resources*
MDG 7 target 11, indicator 31	by 2020, having achieved significant increase in access of urban population to improved sanitation	*no centralized urban sewerage systems without water*

4.3 Poverty Reduction Strategy (PRS):

The World Bank CWRAS 2005 points out that "…poor water management creates poverty." The PRSP 2002 indicates that "…efficient and equitable water resources management is critical to poverty reduction…" In that report, the poverty related water issues are specifically addressed as follows:

- *Urban water and sanitation*: (i) scarcity of water resources; (ii) low service coverage; (iii) water pollution (one might add that this largely holds true for rural population as well).

- *Agriculture / irrigation*: (i) water resource capture unsustainable; (ii) water mining practices anti-poor; (iii) water rights pattern exacerbate inequalities; (iv) agricultural water use is key to reduce poverty.

- *Environment*: (i) environmental degradation (erosion) drives poverty; (ii) water pollution affects the poor more; (iii) climate change affects the poor more, since still many depend on rain-fed agriculture; (iv) environmental health problems affect the poor most.

In conclusion it is stated that all these adverse "externalities" are hidden costs imposed by the better off on the poor. The ongoing PSIA will permit a closer look on the poverty impact of water policies.

4.4 Yemen Vision (YV) 2025

As regards agriculture, YV 2025 outlines the expansion of cultivation and the social and economic impact of Qat, and the water scarcity especially in the highlands. Innovations are called for in irrigation and agricultural biotechnology. It is recognized that much of agriculture's prosperity is facilitated by a very low cost of water. The resulting high returns of cash crops have led to neglect of rain-fed agriculture and food production. Additional allocation of water to urban and industrial use, as stated in YV 2025, has not really been a strategic and conscious transfer of the resource, but has just added to the overall abstraction. Food security and water security are a national challenge.

Agriculture is called to re-direct objectives to increased non-farm income, more water harvesting, improving spate irrigation, improved irrigation techniques, higher value crops, crops with less water demand, supporting rain-fed farms, improving agricultural research and extension. All this is to go along with gradual measures on Qat, working on demand and supply sides, and then moving into control of spread of Qat cultivation. Qat, beyond its economic importance as a crop, is recognized as a national governance challenge of significant proportions.

4.5 Third Five Year Plan / Development Plan for Poverty Reduction 2006-2010 (DPPR)

In this document, agriculture is attributed a fundamental role in achieving food security, increasing the GDP, diversifying the economic platform, creating job opportunities and reducing poverty, particularly in the rural areas, making a pivotal entry point for integrated rural development, a factor of demographic stability and cap for internal migration and its pursuant social and economic problems. It outlines a substantial growth of water structures from 1990 to 2004 (dams and dikes from 16 to 264, reservoirs/caravans from 13 to 335, and main irrigation channels from zero to 76). It is expected that improvement and development of irrigation systems and methods in the agricultural sector would alleviate the severe water crisis Yemen suffers from. For the irrigation sub-sector, the goals of the DPPR are to achieve optimal and rational exploitation of water resources, their good management and maintenance, as well as regulated and modern irrigation techniques. By increasing the irrigation efficiency to 75%, the water loss (deficit in water balance?) is planned to be reduced to half by the end of 2010.

For water and sanitation, the goals for 2010 are clear cut: (i) water supply coverage urban population = 71%; (ii) water supply coverage rural population = 47%; (iii) sanitation coverage urban population = 52%; (iv) sanitation coverage rural population = 37%; (v) reduce water loss in networks to 15%; and (vi) increase quantity of treated waste water to 100,000 cbm/day.

With regard to resource allocation, substantial cross-sector transfers are foreseen: the domestic share is planned to rise from 7% to 15%, industrial use from 2% to 4%, thus meaning that agriculture has to go down to 81%; at the same time, depletion ratio is to drop to 25% and new water resources are to be developed at a rate of 5% per year. Aside from this cross-sector transfer goal, no quantitative water savings target has been defined. Although some definitions remain unclear, one could illustrate the potential distributional impact as per the following table:

Table 3: DPPR cross-sector water transfer

Option: no overall savings target defined

All values in million cbm	NOW	2010
water consumption	**3400**	**3400**
water deficit	900	733
new sources	0	167
domestic use	238	510
industrial use	68	136
agricultural use	3094	2754

There are some concerns with regard to this scenario: (i) as established in chapter 2, water use in agriculture is most likely above 3 BCBM; (ii) since reference is not clear, it is assumed that the 5% annual new sources are a gradual reduction of 5% per year from the present deficit level, which is highly unlikely; (iii) agricultural water savings in the range of some 3% per year can only be achieved with substantial investment in irrigation infrastructure; (iv) doubling of network based domestic water use in 4 years is not

realistic, on the other hand it is evident that present domestic consumption (incl. industrial) already oscillates at some 465 MCBM; (vi) above all, no target value for water saving has been defined; this means that the present trend in water balance deficit across the sub-sectors is accepted, notwithstanding the important message that water savings must be obtained in agriculture, particularly in groundwater irrigation. The degree of compatibility of sector objectives of water and agriculture as outlined in the DPPR is shown in Annex 4.

4.6 Public Investment Program (PIP) 2007-2010 for the DPPR

For agriculture/irrigation, between 2007-2010, a total of USD 915 million are earmarked. Of these, 814 million (89%) investments belong to projects with funding gap, with a total shortfall of 677 million (83.2%). Consequently, agriculture/irrigation has the largest share of such project proposals (9.7% of total funding, and 23.5% of total number) in the PIP. Given the reduction in agricultural water use as outlined above, a clear focus on investments with water savings potential was to be expected.
Although the 20 rather sketchy project profiles (summary in Annex 5) may not allow for an in-depth analysis of the cost and benefits, the following characteristics can be highlighted: (i) 5 projects are large dams which alone amount to USD 560.6 million (57.9% of total cost); (ii) only in 6 cases on-farm irrigation improvements can be clearly identified as relevant components; (iii) in 10 cases, increase of irrigation areas are specified, totaling 132,714 hectares, which would mean an increase of 24% over and above the existing irrigated farm land, and it would also mean an overall additional water demand of 1.297 BCBM based on national average figures; the water savings potential of all projects have to be set against this, but they are not known and it is possible that an increased national water deficit will remain; (iv) in one single case, the extension of land with improved irrigation systems is specified (11,350 hectares); (v) in not a single case, the potential water demand arising from the investment measures is specified; (vi) in only 2 cases, water savings are actually quantified (51.8 MCBM).
The project profiles seemingly focus on production and farmers' income increase and general aspects of economic returns, which are of course important and justified. Water resource availability and especially the need to reduce water use in agriculture, as demanded in the DPPR itself, does not seem to be the governing criteria of the PIP.

5. From joint vision to joint action

When it comes to groundwater protection, irrigation / watershed management and water resources management (as water sub-sectors specified in NWSSIP), share a great deal of common goals which CRY for working together. Actions are widely complementary, and even congruent, and should be mutually supportive (see also Annex 6).

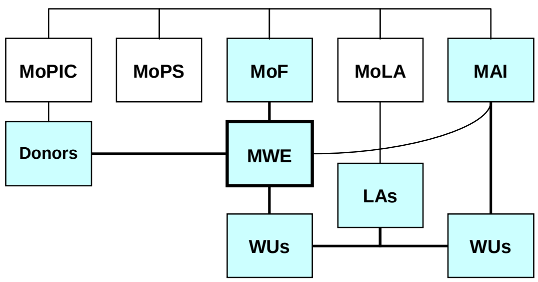
Table 4: NWRA and MAI/GDI priority tasks

NWRA needs to speed up the following key tasks	*MAI / GDI needs to coordinate / support in the following*
- establish national water resources monitoring network - develop water basin plans - kick-start priority actions in hot spots - organize water basin co-management - regulate and control drilling and pumping - conduct public awareness campaigns - strengthen involvement of local authorities and	- establish agricultural water user associations - cooperate in water basin committees - support monitoring, licensing and enforcement measures - increase outputs related to water use efficiency investments - redirect AFPPF investments

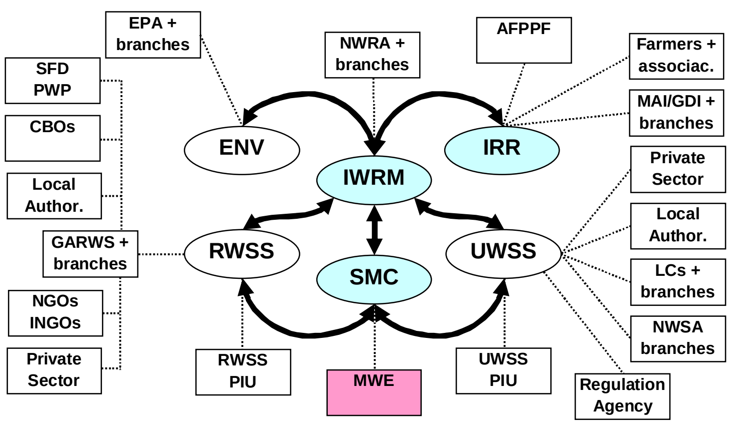
communities	- coordinate investment plans focusing on critical basins

6. Organizing the IRR / WRM interface

Graph 3: Key sector stakeholders



Key sector stakeholders on different levels are ministries, local authorities and water users. Donors support the sector in terms of sector dialogue, capacity building and investment funding. At GoY level, the creation of an inter-ministerial steering committee (IMSC) will provide opportunities to discuss cross-sector issues which need broader government support. MAI / GDI should continue to be part of this group, especially the recently established Unit for On-Farm Irrigation Improvement.

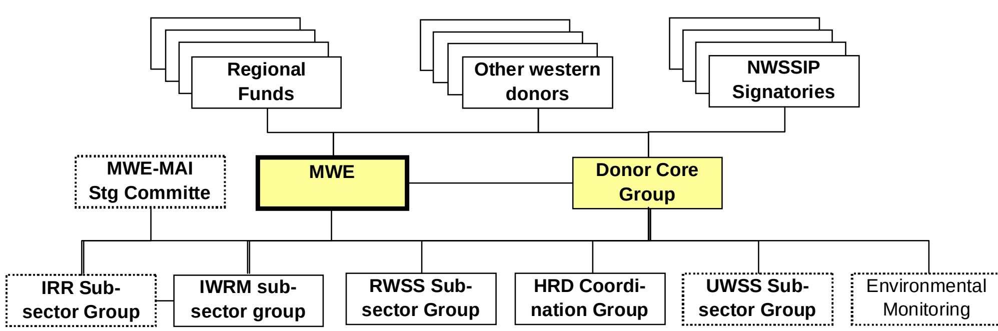


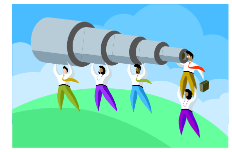
Graph 4: sector organization

As from overall sector perspective, integrated water resources management (IWRM / WRM) is the tool for coherent resource management, balancing interests of short-term benefit and long-term survival in a complex sustainability equation. MAI / DGI as the largest user and potentially the largest (water resource) looser, needs to be integrated in the sector framework as an important partner.

The water sector operates and communicates based on a functional coordination framework. Since IRR and WRM are so closely linked, the interests and inputs of the irrigation sub-sector at working level should be integrated into the IWRM sub-sector group, while issues requiring top level support can be dealt with through a bilateral MWE/MAI "steering" mechanism or in the IMSC.

Graph 5: sector coordination structure





7. The potentials for change

7.1 Water savings in domestic / industrial use (see Annex 7)

Potentials in domestic and industrial water savings are rather small: (i) internal waste water recirculation in industrial processes is limited and expensive; (ii) desalination of brackish or sea water is complex and its viability highly dependent on energy costs; (iii) technical loss reduction in urban supply systems may reduce water demand by optimally some 15-20%; (iv) water saving domestic devices are expensive and water saving quantities insignificant; (v) water harvesting for domestic use is an acceptable approach in extremely water scarce areas, but bears some hygienic risks and is often not a year-round solution; (vi) reuse of treated waste water in agriculture requires treatment quality for unrestricted use and has only very limited, location-specific groundwater substitution potential. In summary and as a very tentative estimate, a maximum of some 10-15% of domestic water consumption can very gradually be saved, without reducing effective per capita consumption significantly (which is already quite low in many provincial towns and generally in rural areas); this would add up to some 50 MCBM/year, assuming full implementation of all options combined, and which would be only slightly more than 1.2 % of agricultural water use (or 1.4% of respective groundwater use). Factoring in at least 3% pa population growth (around 5% pa urban), little savings impact is left. It is thus evident that water savings MUST come from irrigated agriculture.

5.2 Water savings in agriculture (see Annex 8)

Box 1: An example of self-expansion of modern irrigation technology

> In the Abs region in northwest Yemen, over the past 10 years (1991-2001) more than 2,800 hectares of mango trees have been planted, almost all of which are equipped with modern irrigation systems, particularly bubblers. The WB funded LWCP only provided PVC pipes for 500 hectares and bubbler and drip systems for 12 hectares; all the rest came from the market.
> There are still some serious problems with design, installation, operation and maintenance of the networks. Farmers still apply more water than is needed for plant growth. Nonetheless, in general they are satisfied with their modern systems of water transportation, distribution and application. They recognize savings in water, but also in time, fuel and labor costs. Savings range from 20% up to 50%, with an average of 35%. In terms of water volume, this corresponds to some 4,500 cbm/year/hectar, equivalent to some 13 MCBM per year in the region (2,800 hectares). This water volume corresponds to more than 160 dams of an average size of 80,000 cbm storage capacity (standard small dam design). While investment in such number of dams (without irrigation channels) would have absorbed YR 4.86 billion, the investment in irrigation systems is just above YR 500 million.
>
> Adapted from excerpts of a FAO Farming System Study conducted 2001 for the World Bank, by Dr. M. Bazza

Potentials for water savings have been specified quite modestly in the NWSSIP irrigation sub-sector summary paper of the JAR 2005/06 (gradual increase to 61 MCBM/pa savings in 2009), and rather ambitious in the AGSIP (average 560 MCBM/pa for Phase 1 = 2006-2010, and additional 429 MCBM/pa for Phase 2 = 2011-2015); thus, as from 2011, the groundwater deficit of (clearly underestimated) 900 MCBM/pa would theoretically be eliminated. While it can be assumed that the AGSIP targets are based on professional calculations, they are possibly overambitious with regard to available funding, while the GDI targets defined for the NWSSIP horizon are simply too insignificant; factoring in the documented projects of the 2007-2010 PIP, there would be a huge increase in agricultural water demand.

Box 2: Yemeni dams and their opportunity costs

The village children had waited eagerly for the onset of the rainy season. When the floods finally arrived during August 2006, the newly constructed dam filled rapidly. Mohammed and many of the village boys were pleased because the dam presented a wonderful opportunity to splash in the water. "Al-hamdulillah, no accidents have happened yet," Salih remarked. Like many of the area's farmers, he put high hopes in the small dam, which took nearly two years to complete. "It really is strange," he says, "Those with wells just downstream and in the area of the dam haven't noticed any recharge yet. But a few well owners from other villages several kilometers away report that the drop in groundwater levels has slowed." During a November 2006 site visit, only a few small portable petrol pumps were pumping water from the dam to irrigate the surrounding fields. "Why aren't more farmers utilizing the water?" I asked. "Most of us have our own well, so there's no need," Salih replied.


In 2005 the dam was filled with water.

Having been completed in 2005, the dam in question was empty in July 2006 when photographed. Following the 2006 summer rainy season, the dam (measuring 120 x 60 x 3 meters deep) contained approximately 20,000 cubic meters on Oct. 17 (see photo). To locals from the nearby village, the 2006 rains were good and in their perception, the dam had filled to promising levels.
In comparison to the 20,000 cubic meters of water in the dam after the main rainy season in 2006, a single pump in the same basin can pump approximately three times as much groundwater per year, or approximately 60,000 cubic meters. This figure is based on a well yield of six liters per second, pumping 12 hours a day and a total of 240 days per year during growing seasons.

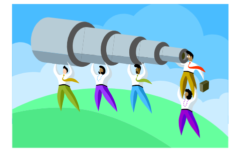

In 2006 the dam was not providing any water.

Granted that irrigation efficiency measures provide water savings of 30 percent or more, the same amount of water that was stored in the dam could be saved annually by a single pump, which usually irrigates up to five hectares of land. According to a recent well assessment for 2006, the agricultural plain where the dam is constructed has 1,500 wells and 2,600 wells in the basin's catchment.
While the cost to equip one pump and the land irrigated by it with a modern on-farm irrigation scheme comes to approximately US$7,000- US$10,000, the dam cost YR 89.5 million, or nearly half a million U.S. dollars.
Therefore, for the price of this small dam, 50 pumps irrigating approximately 250 hectares of land could be transformed into modern irrigation schemes, thus saving 50 times the amount of water the dam had stored at the end of the 2006 rainy season.
Given that average landholdings in the basin's agricultural plain are two hectares or less, 125 farming families or more would directly benefit.
Dr. Gerhard Lichtenthäler in Yemen Times, 11.12.2006

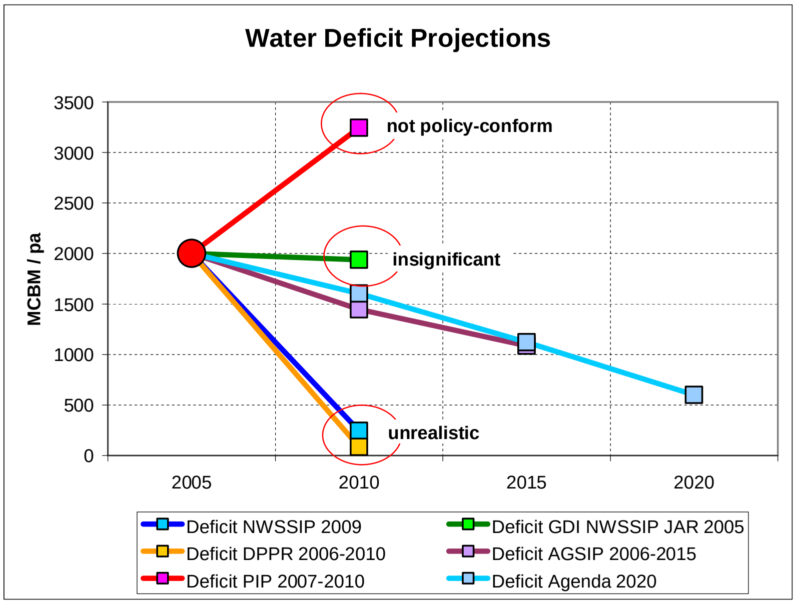
Table 5: Comparison of present water saving approaches for agriculture

Approach	Increase irrigated area (hectares)	Improve irrigated area (hectares)	Increase water demand **1)** (MCBM/pa)	Reduce water demand (MCBM/pa)	Specific water balance (MCBM/pa)	Remaining end-period water deficit (MCBM/pa)	Share of present deficit left after interv.
NWSSIP 2005-2009 **2)**	Na	na	na	1,756	- 1,756	244	12.2%
NWSSIP (GDI) 2009	Na	45,000	na	62	- 62	1,938	96.9%
DPPR 2006-2010 **3)**	Na	na	na	1,915	- 1,915	85	4.3%
AGSIP 2006-2010 **4) 5)**	1,000	247,660	7	560	- 553	1,447	72.4%
AGSIP 2011-2015 **4) 5)**	29,000	198,130	203	564	- 361	1,086	54.3%
PIP 2007-2010 **6)**	132,700	11,350	1,297	52	+ 1,245	3,245	162.3%
Agenda 2020 **4)**	-23,000	537,000	na	1,400	-1,400	600	30.9%

1) Unless otherwise specified, total irrigation water demand is 9,500 cbm/ha/yr (2006 = 4,104 MCBM)
2) Calculated based on NWSSIP target on irrigation efficiency increase (from 40% to 70%)
3) Calculated based on DPPR target on irrigation efficiency increase (from 35% to 75%)
4) Product mix provides Ø 2400 cbm/ha/yr water savings
5) AG water use and irrigation area as per chapter 2
6) PIP assessment based on partial information



<u>**Graph 6: Water deficit perspectives by approaches**</u>



There is an obvious imbalance between approaches, but except for the PIP all aim at water savings, realistically or not (see also Annex 9). On the other hand, 2006 has passed and not much has happened. Although some minor savings accumulated up to 2004, we have to face the fact that until 2006 agricultural water use has still been growing. Optimistically, we would thus consider 2006 the breaking point of agricultural water use upward trend. While the different visions and approaches have been spelled out, a realistic implementation program needs to be designed (Agenda 2020). In terms of water savings, the AGSIP 2006-2015 presents a reduction of some 900 MCBM/yr by 2015 (Ø 90 MCBM/yr), the Agenda 2020 aims at some 1.4 BCBM/yr in 2020 (Ø 93 MCBM/yr); thus, both plans fully coincide regarding the annual savings. Since the average water savings (based on assumed "product mix") to be achieved is 2,400 cbm/ha/yr in the AGSIP and Agenda 2020 (adjustments can be made by more on-farm focused interventions), there is only one major difference between both approaches: the AGSIP basically assumes that the present water balance deficit is 900 MCBM/year, and the plan thus concludes that, based on the programmed interventions, in 2015 the deficit would have basically disappeared. As was established in chapter 2, the deficit at present is more likely to be in the range of 2.0 BCBM; Agenda 2020 thus combines a short term reverse in resource depletion trend with a long-term (2020) sector goal of a drop in water deficit to some 30% of present deficit. Achieving the remaining 30% deficit would require 6-8 more years or a more aggressive move on curbing existing irrigation area further.

8. <u>Scope of projects and related outcomes</u>

The Agenda 2020 (subject of present calculation) combines the following indicators:

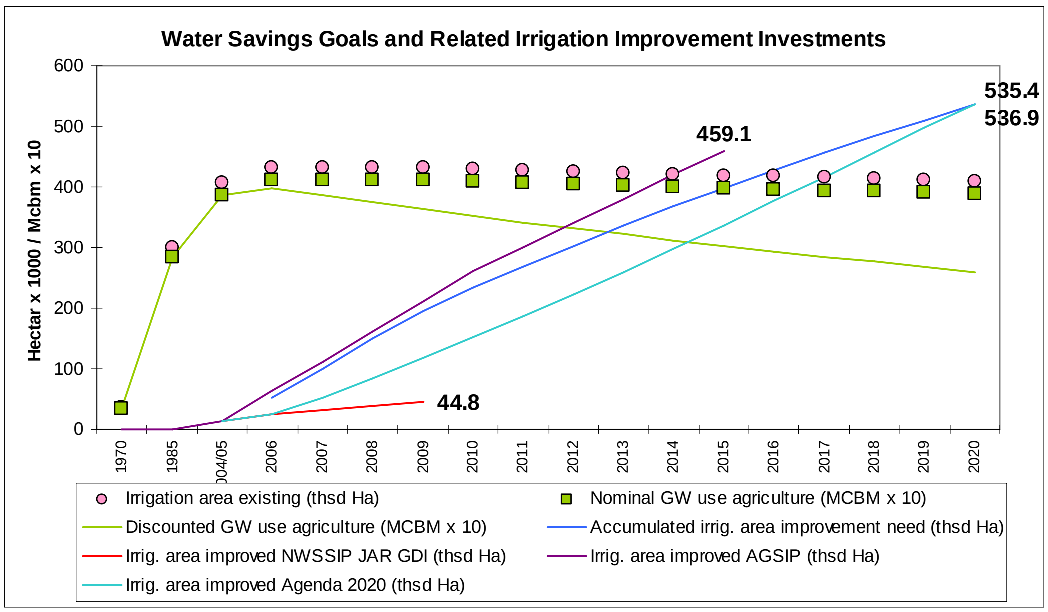
Table 6: Agenda 2020 indicators

Irrigation area development	432,000 Ha in 2006	*Stagnant until 2009, then a 0.5% pa reduction from 2010*
Water consumption in irrigation	3.981 BCM in 2006	*First water savings in 2006 at 3% pa over total irrigation consumption, shrinking to 2.6 BCBM in 2020*
Urban population **1)**	5.7 million in 2004	*Growing at 5% pa*
Urban domestic water use	36.5 cbm/capita/year	*Per capita use steady, overall growing with population*
Rural population **1)**	14.0 million in 2004	*Growing at 2% pa*
Rural domestic water use	18.3 cbm/capita/year	*Per capita use steady, overall growing with population*

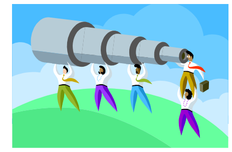
Renewable water resources	2.5 BCM in 2006	*Growing at 0.5% pa as from 2007*
Deficit in water balance	1.977 BCBM in 2006	*Total of 725 MCBM deficit left in 2020*
Water consumption in balance with renewable resources		*Achievable until 2026-2028*

1) does not yet consider recent adjustment of census data + 1.6 million

According to GDI, present irrigation improvements are distributed into achievements (10,500 Ha until 2004) and planned (4,230 modern irrigation systems, 30,040 Ha piped conveyance systems) until 2009, with corresponding targeted water savings (10.1 MCBM from modern irrigation systems, 44.9 MCBM from piped conveyance systems, and 8.9 MCBM from spate improvement). The planned water savings average 12.8 MCBM per year. Against this, we have assessed the water savings and area improvement needs for Agenda 2020 as well as the AGSIP (Ø savings 2,400 cbm/Ha/yr).



Graph 7: water savings goals and related irrigation improvement investments



The specified irrigation area is established assuming separate actions on water transportation (piped conveyance) and on-farm irrigation systems, with an average of 2,400 cbm/Ha/yr long-term savings. By combining both, the saving per hectar can go up to 4,900 cbm/Ha/yr, and thus the area requirement could drop correspondingly. In other words, the necessary intervention area is directly linked to the degree of combination of irrigation system components targeted (see also Annex 10).

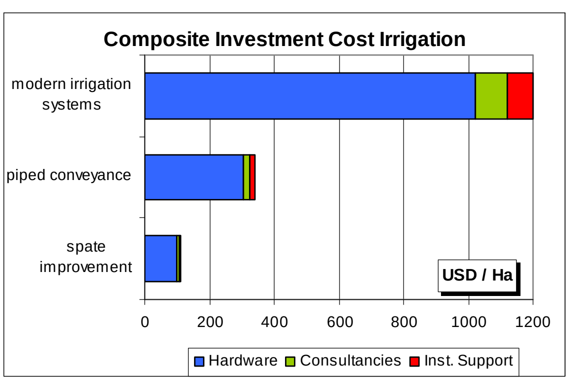
9. Financial scenario

We have now defined (i) what are the challenges to achieve substantial savings in groundwater abstractions; (ii) what are the outcome targets with regard to water savings, considering an ultimate goal to eliminate the deficit in Yemen's water balance; (iii) what are the output targets in terms of increased water use efficiency (hectares); (iv) that are the outcome and output targets defined by the different approaches; (v) how these plans deviate from or coincide with needed actions; (vi) what is the likely absorptive capacity of the sector and (vii) what could be a harmonized approach called "Agenda 2020". As from here we have to analyze the cost involved in that long-term program, and the financial sources to provide the budget.

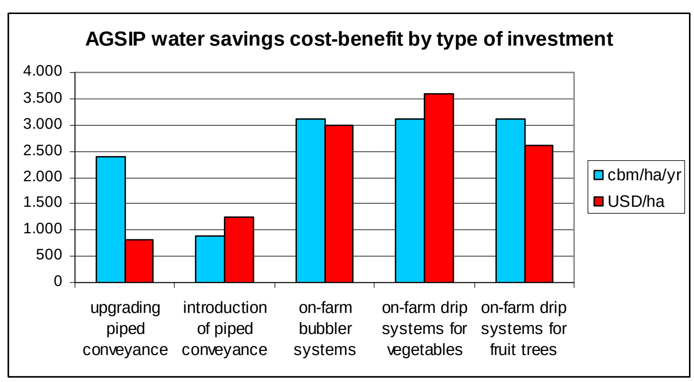
9.1 Cost structure

The investment costs for irrigation improvement have been specified by MAI / GDI (Graph 16) based on average conditions and selection of components. They can vary substantially according to local conditions, but such accuracy is not subject of this paper. It is important to state, however, that hardware investment alone does not work, and that especially in introduction of modern irrigation techniques, substantial institutional support and training is needed. This has been factored into the presented unit costs.

Graph 8: Composite cost irrigation (GDI info)



Graph 9: Cost benefit ratio irrigation improvement (AGSIP)



As can be observed, the AGSIP has provided much higher investment unit costs than the GDI. How these costs relate to each other is shown in the following table:

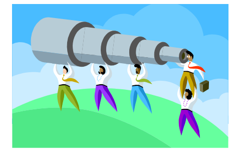


Table 7: comparison of irrigation improvement costs

Source	On-farm systems			Conveyance	
	Drip vegetables	Drip fruit trees	bubbler	Upgrading existing pipes	Introduction new pipes
AGSIP 2006-2010	3,600 USD/Ha	2,600 USD/Ha	3,000 USD/Ha	825 USD/Ha	1,250 USD/Ha
AGSIP 2011-2015	3,600 USD/Ha	2,600 USD/Ha	3,000 USD/Ha	825 USD/Ha	1,250 USD/Ha
GDI JAR for 2005-09	720 USD/Ha (only 12% on-farm systems, Ø 1,605 cbm/Ha savings)				
GDI JAR for 2005	1,092 USD/Ha (only 16% on-farm systems, Ø 1950 cbm/Ha savings)				
GDI JAR for 2006	585 USD/Ha (only 12% on-farm systems, Ø 1,720 cbm/Ha savings)				
GDI general info 2006	1,200 USD/Ha			320 USD/Ha	

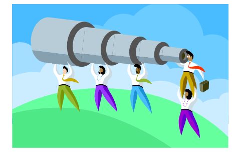
While AGSIP is a long-term perspective, the GDI plans presented during the JAR 2005 are based on concrete, however mid-term (WB-funded) projects. AGSIP does not consider inflation, which is acceptable given the long-term perspective and the number of variables not really known. Calculation with constant prices is common in all development plans, however, it should not be forgotten that present internal inflation is well above 10% pa, and this will have an impact on return on investments. Be it as it may, it is evident that quite some harmonization work is needed with regard to irrigation investment unit costs. For the financial scenario, a conservative average will be used as follows: USD 2,500/Ha for on-farm systems, and USD 850/Ha for conveyance systems. The combined cost is thus 3,350 USD/Ha for an average of 4,900 cbm/Ha/yr savings, or USD 0.68 per cbm/yr savings. If this water would be transferred to domestic use at economic price, it would mean an average tariff increase of YER 135/cbm, which is a lot considering the average going water tariffs in domestic consumption (which do not consider opportunity costs for raw water).

9.2 Finance

Table 8: comparison of proposed implementation programs for irrigation improvement

Plan Periods	Year of Implem.	GDI NWSSIP JAR			AGSIP 2006-2015			Agenda 2020		
		Ha	USD Mn	MCBM svd	Ha	USD Mn	MCBM svd	Ha	USD Mn	MCBM svd
Yemen Vision	<= 2004	10,500	6.3	21.0				10,500	6.3	21.0
NWSSI	2005	2,847	3.1	5.6				2,847	5.8	6.8
Agenda 2020, AGSIP, DPPR	2006	12,550	7.4	22.1	49,532	90.0	113.9	12,550	7.4	5.5
PIP	2007	6,291	4.0	11.1	49,532	90.0	113.9	27,000	55.4	64.8
	2008	6,291	4.3	11.1	49,532	90.0	113.9	32,000	65.6	76.8
	2009	6,291	5.8	11.1	49,532	90.0	113.9	33,000	67.7	79.2
	2010				49,532	90.0	113.9	34,000	69.7	81.6
	2011				39,625	70.7	97.5	35,000	71.8	84.0
	2012				39,625	70.7	97.5	36,000	73.8	86.4
	2013				39,625	70.7	97.5	37,000	75.9	88.8
	2014				39,625	70.7	97.5	38,000	77.9	91.2
	2015				39,625	70.7	97.5	39,000	80.0	93.6
	2016							40,000	82.0	96.0
	2017							40,000	82.0	96.0
	2018							40,000	82.0	96.0
	2019							40,000	82.0	96.0
	2020							40,000	82.0	96.0
	2021							40,000	82.04	96.0
	2022									
	2023									
	2024									
	2025									
	TOTAL	34,270	24.6	60.9	445,785	803.7	1,057.0	576,897	1,149.6	1,355.7
		1,775.9	cbm / Ha saving		2,371.1	cbm / Ha saving		**2,400**	cbm / Ha saving	
		716.7	USD cost per Ha		1,802.8	USD cost per Ha		**2,051**	USD cost per Ha	

AGSIP box: Only investment on existing irrigation areas, no new areas considered considered



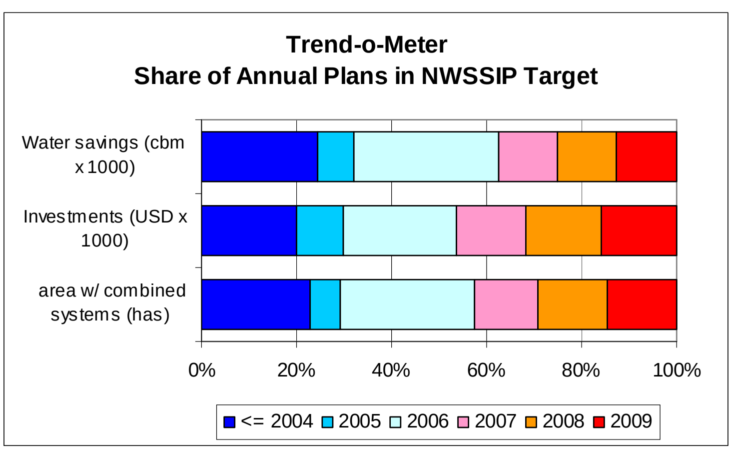
Existing financing sources are (i) the World Bank, (ii) the AFPPF, (iii) budget allocations to MAI / GDI, and (iv) cost sharing by beneficiaries. World Bank projects are all on track with defined disbursement plans. In the AFPPF, a redirection of investment priorities is still under negotiation. The informed MAI / GDI budget allocations are rather small. Investment cost sharing is still an emerging concept and needs to be regulated and supported by respective policies. Finally, there are large private farmers who do their investments without public support; their share in a potential boost in irrigation improvement investments is not known.

The financial scenario needs further investigation; however, as per Agenda 2020, annual investments of above USD 50 million (current prices) for irrigation improvement are a must. Donors are seemingly willing to invest in agriculture, and notwithstanding the usefulness of suitable water harvesting, it will be the role of the GoY to refocus these funds from questionable large dams to irrigation improvements with proven water savings impact. For this, an updated and NWSSIP-focused mid- to long-term investment program needs to be formulated as soon as possible.

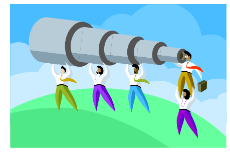
10. Monitoring the outcomes

The results and outcomes need to be monitored against NWSSIP targets as well as the overall sector goals as determined in Agenda 2020 (or any other which may be adopted). The following chart shows the data provided in the JAR summary paper for the irrigation / watershed sub-sector. What strikes here is the fact that the 2006 plan is substantially above the average annual plan outlined for the 2007-2009 period, if the 2009 NWSSIP target would be taken as definite. In other words, by maintaining the 2006 annual output quantity for 2007-2009 as well, the NWSSIP target as informed by MAI / GDI could be substantially overachieved, assuming that the 2006 absorptive capacity would not decline the years after.

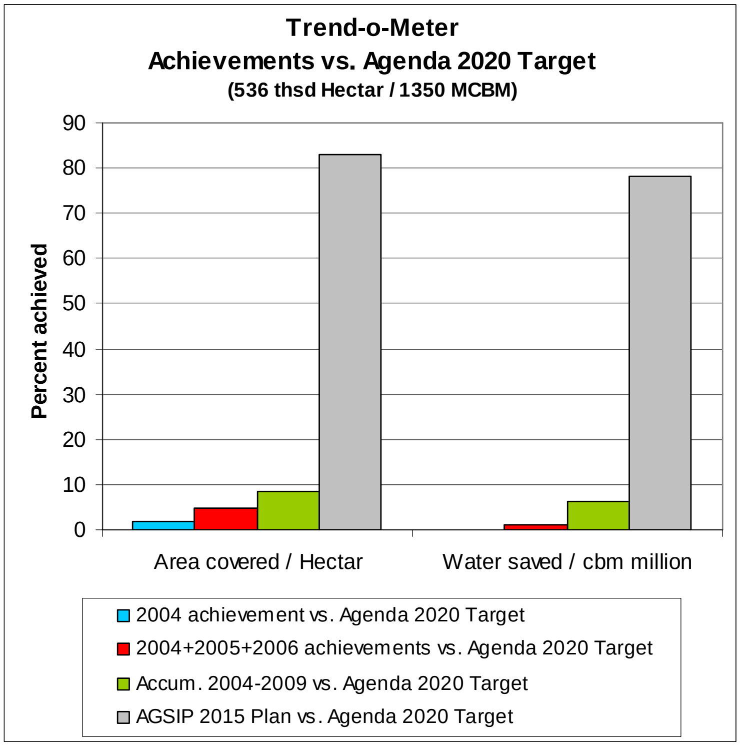
Graph 10: Water savings Trend-o-Meter 1 – NWSSIP targets by annual GDI / plans



This is a rather short vision considering that the sector goal is of a completely different magnitude. It is thus necessary to also compare achievements with these goals.



Graph 11: Water savings Trend-O-Meter 2 – Achievements vs Agenda 2020 targets



In addition, the usual input-output-monitoring must be established, such as finance, unit costs, implementation time, cost-benefit ratio etc.

In order to combine the various information streams from AFPPF, MAI/GDI, NWRA and the different project PIUs, all relevant data must be channeled to the M&E Unit at the MWE for inclusion in the overall sector monitoring framework and reporting system.