

Water Resources Management in Arid Regions Water Policy Reforms in the Sultanate of Oman

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Abstract

Oman is located within arid and semi arid areas with extreme low annual average rainfall (80mm) and limited water resources. Groundwater is the main source of water supply (92%) of the total renewable water resources where the rest is surface water (Ghaily Aflaj, wadi base flow). As a result of rapid economic growth, combined with a rapidly growing population, expansion of the productive capacity of all the economic sectors, improvement in living standard, the demand on the limited water resources will increase during the next 20 years resulting in a large deficit in water balance. The main challenges faced the water resources are increasing water demand, low agriculture return to water use and groundwater pollution. In order to face and overcome these challenges, particularly during the period 2000-2020 the government strategy emphasis on augmentation of both conventional and non-conventional water resources. This is guided by the priority for improving, the supply of safe and clean drinking water, sanitation facilities and protecting environment from increasing disposal activities.

Since the early 1970's the Sultanate of Oman has progressively moved forward with a series of policy reforms and strategies to achieve national goals and priorities in the water sector. While there has been significant progress in some areas of the sector there are also a number of challenges facing the sector and country to meet increasing demand for water, particularly the domestic and industrial use.

This paper outlines the current water situation in the Sultanate of Oman, the status of water resource management and current and future priorities, and concludes with a summary of policy reforms in place and those anticipated in the future. It is intended to contribute to the initiative by highlighting the past successes and future challenges in the reform of water policies in Oman to achieve national economic, social and resource goals.

Water Situation

Geographically, Oman benefits from a relatively high rainfall (300 mm/yr) in the northern mountains (Al Hajar Al Gharbi, Figure 1) which recharges the aquifers of the fertile coastal plain and the interior, where the mean annual rainfall is only 80 mm or less. The southern region of Dhofar also enjoys seasonally enhanced precipitation from *monsoonal* and cyclonic weather systems. Consequently, Oman enjoys an estimated per capita internal renewable water resource of 550 m³/person (WRMP, 2000). In addition, unlike many countries in the region, Oman does not depend significantly on transboundary rivers or underground water flow from neighbouring countries.

Apart from spate flow and limited desalination production, the predominant water resource in Oman is groundwater occurring as aquifers within alluvium and hard rock. Average annual recharge to these aquifers is currently estimated to be in the order of 1,186 million cubic metres (Mm³). In addition to recharge there are also significant fresh and brackish water reserves estimated to be in the order of several hundred billion cubic metres (Bm³), though the remote location and non renewable nature of these reserves, has to date largely limited their development. Desalination of sea and brackish water contributes 104 Mm³/yr for the supply of municipal water principally to the capital area of Muscat, but also for drinking water to isolated coastal and rural communities (Mott, 2003).

Since 1985 groundwater augmentation by artificial recharge of flood waters has been a major component of water policy, with the construction of 31 recharge dams with a combined reservoir capacity of 84.48 Mm³. The estimated outflow of more than 300 Mm³/yr to the sea and desert indicate the potential for additional recharge. sixty small retention or storage dams, with reservoir capacities of less than 10,000 m³ have also been constructed in upper catchments of the Al Hajar Al Gharbi mountains of northern Oman, for water supply to remote communities.

Currently about 40 Mm³/yr of treated waste water is used for landscape irrigation in the capital area of Muscat and associated suburbs. A scheme currently proposed will ultimately increase the total volume of treated water to 90 Mm³/yr. While some of this water (16 Mm³/yr) will be used for additional landscape irrigation the balance could be available for other uses such as aquifer recharge and agricultural irrigation. In Salalah in southern Oman a major waste water recycling project is currently being implemented; the scheme includes the collection and treatment of waste water for recharge to the coastal aquifer to prevent and remediate saline intrusion.

Significant volumes of water are produced in conjunction with oil production, in the interior regions and southern Oman. While this water is re-injected to maintain aquifer pressure and to assist with oil extraction in some oilfields, in others it is disposal of as waste and represents a resource for potential development. The water is of highly variable quality, generally being brackish or saline, and in some cases with phytotoxic levels of elements such as boron and heavy metals, therefore presents a number of technical and economic challenges and limitation to its reuse.

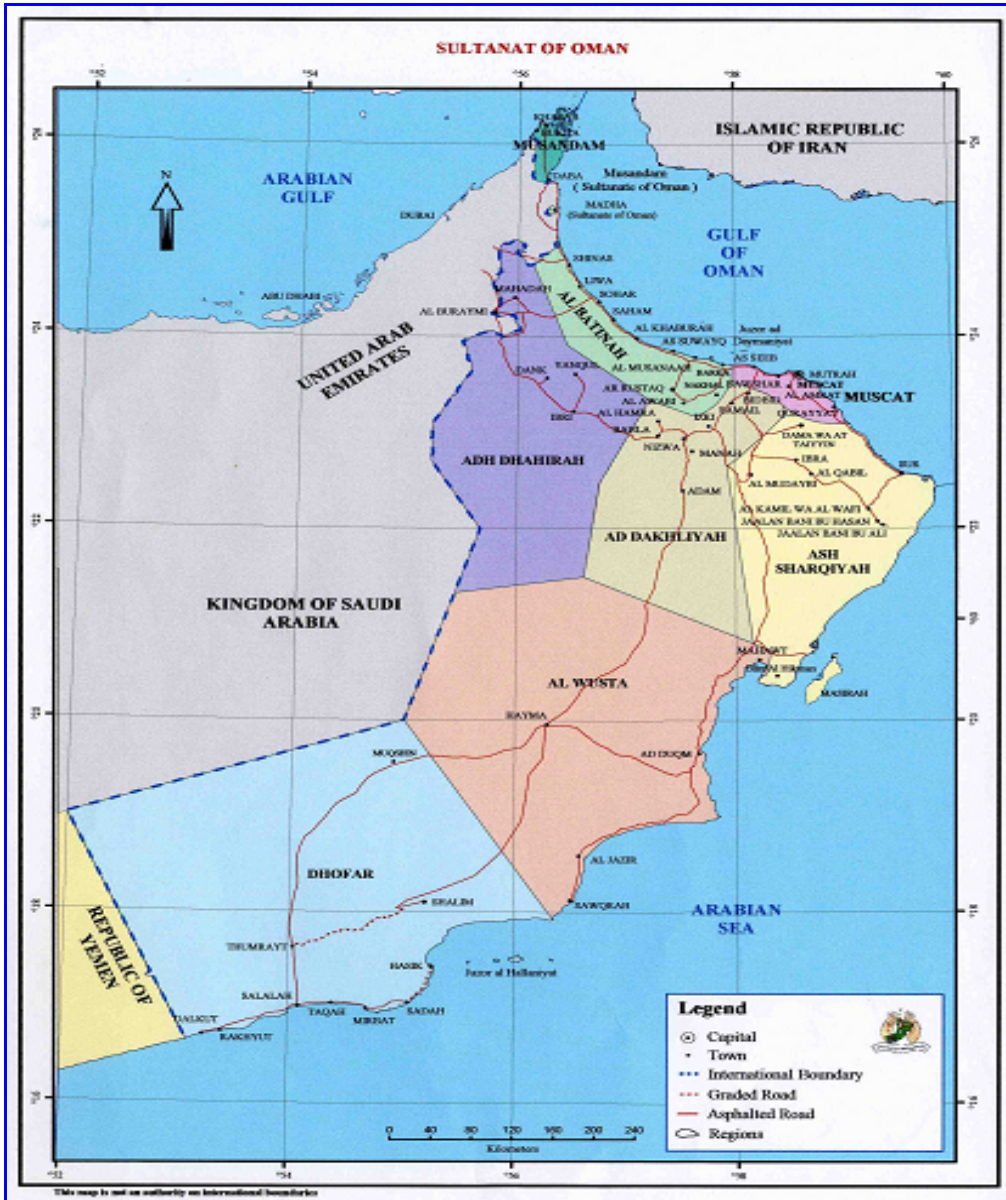


Figure 1 Sultanate of Oman - geographic features and administrative regions

Water Demand

In Oman agriculture is by far the largest water consumer, estimated to account for 1,124 Mm³/yr (MRMEWR, 2000) which is 78% of the annual national demand of 1,430 Mm³. This water irrigates a cropped area of 59,448 ha (MWR, 1998) with approximately 64% and 36% supplied principally from wells and *afraj* respectively. Cropped area, particularly on the Batinah and Salalah coastal plains expanded during the 1980's and early 90's as part of land allocation and development programmes, resulting in increased water abstraction.

While domestic and industrial water use is currently a relatively small proportion (15%) of total demand it is expected to increase rapidly over the next 20 years. The second modern census of Oman in 2003, showing the total population was 2.3 million of whom one (23.7%) were expatriates. The census confirmed the young nature of the population with more than 50% less than 15

years old. Domestic water demand is expected to more than double by the year 2020, due to population growth and increased per capita consumption. Industrial water consumption is also expected to increase significantly in response to policies encouraging diversion of the economy, away from dependency on oil revenues. Industrial estates have been established in a number of regions, and major industrial projects are currently being planned or implemented such as an aluminium smelter and steel works in Sohar and a large LNG plant in Sur, in northern Oman, and a major port development in Salalah, in the south.

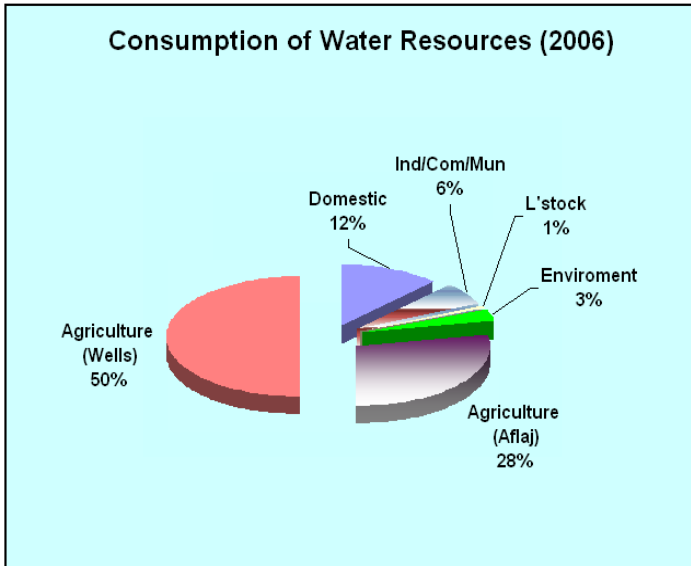


Figure 2 Water use by sector

Water Balances

Comparison of estimates of water demand and average annual recharge indicate an imbalance between supply and consumption in the order of 25%. While this is a useful comparison of overall demand, it does not indicate the variability in water balances both locally and regionally. The recent data shows the deficit, on a catchment basis, between the volume of water entering the system and the volume leaving it or being used. This analysis shows significant deficits, of more than 60%, in the region of Al Batinah, 6% in the Ad Dhahirah, 6% in the Ad Dakhliyah and 7% in the As Sharqiyah. These deficits are directly attributable in the main to over drawing of groundwater, mainly for agriculture and mainly from boreholes and wells equipped with electric or diesel powered pumps. In some areas the over abstraction of water, such as on the lower coastal plain of the Batinah, has led to progressive decline in groundwater levels, while in other areas it results in a more rapid decline in water levels between recharge events.

Water Quality

The quality of water available for agriculture varies. On the coastal plains where groundwater overdraft has been most severe, saline intrusion has occurred. In near-shore parts of the Batinah coast the water quality is now too poor even to grow salt tolerant crops such as dates and grass. The saline front is advancing in some coastal areas and is stationary in others but in general the quality of water drawn from wells within 12 km of the coast is deteriorating (Al Barwani and Helmi, 2005). In the interior regions water quality also worsens in dry periods as water levels fall and pumps draw older water from deeper in the aquifers. The fossil water in the large undeveloped aquifers is of potable or near potable quality; the Nejd aquifer suffers from high fluoride and high sulphate levels. There are no major problems of artificial contamination.

Water System Management

Legislation

Prior to 1970 access to and rights of water use were based on Islamic and local customary laws (Caponera, 1977). While Islamic Shari'a law still forms the foundation of all laws in Oman, it has been progressively supplemented with legislation defining the role and responsibilities of government and water users. The most significant of this legislation includes:

- Establishment of Water Resources Council (WRC) in 1975 with responsibilities of water resources issues.
- Establishment of Public Authority for Water Resources (PAWR) in 1979 with responsibilities of water resources assessment on national scale.
- Declaration in 1988 that water is a "public national wealth to be exploited in the interest of agricultural and development plans according to the government instructions" (Royal Decree 82/88)
- Establishment of the Ministry of Water Resources in 1989 with responsibilities for conservation and development of water resources (Royal Decree 100/89).
- Establishment of well permitting regulations in 1990 and revision in 1995 (Ministerial Decision 13/95), requiring the registration of wells and permit conditions for deepening of existing wells and construction of new wells.
- Declaration of regulations on disposal of waste water from desalination plants (Ministerial Decision 345/97).
- Declaration of the Basic Law of the State in 1996 (Royal Decree 101/96) which provided for the drafting of additions legislation, including water resource management.
- Royal Decree 29/2000, refer to a new water law "Water Protection Law" emphasis on regulations for wells and *afraj*, and regulations for desalination units on wells.
- Royal Decree 114/2001, organize the disposal of solid and dangerous wastes, environmental pollutant and untreated sewage wastes without a permit.
- Royal Decree 115/2001, refer to organizing disposal of liquid and solid waste products.

- In 2001 a series of Ministerial Decrees, refer to the implementation of water supply well fields protection zones at several regions of the Sultanate (27 sites).

Resource Assessment and Monitoring

In the first five years of the 1990's, The Ministry of Regional Municipalities, Environment and Water Resources (MRMEWR) concentrated on consolidating and extending the assessment work and monitoring networks of predecessor organisations. A National Well Inventory has been compiled which lists almost every borehole and well in the country, with its location, owner, engineering details and water quality. In 1997, a National *Aflaj* Inventory has also been completed, which identified the *falaj* type, location and irrigated area. Networks of rain gauges, wadi gauges and monitoring boreholes have been extended and databases established. In principle, water resources are managed on a catchment basis, or more widely as a basin comprising several catchments. The water balances for every catchment have been estimated by the usual hydrogeologic processes, based on extensive data from wadi and rain gauges, monitoring boreholes and *aflaj* measurements. These balances are monitored according to annual variations.

Well Permitting

Applications for abstractions from new boreholes for any purpose and proposals for industrial, commercial or residential developments are reviewed in the context of the catchment water balance and its historical variation at the pre-feasibility stage. Well permits for new wells or for deepening existing wells may be issued with conditions on abstraction rates, based on water demand for irrigation. Regional offices monitor the construction and testing of wells, and police the construction of unlicensed wells. Violations are subject to prosecution and penalties administered through the courts.

Resources Augmentation

MRMEWR seeks to augment supply in areas of water shortage through the exploration for new aquifers. There are several major aquifers in the limestones of the southern desert (the Nejd), in the alluvium of the interior plains west and south of the Northern Oman Mountains. These are mainly fossil aquifers formed during the pluvial periods of 5,000-15,000 years ago. Cautious development of these aquifers is considered, in the first instance for urgently required potable supplies rather than agricultural use.

Substantial shallow brackish water resources are known. These offer the opportunity for expanding the farming of salt tolerant crops in areas of suitable soil. It is intended to remove existing salt tolerant crops, particularly fodder grasses, from the coastal plains to brackish water areas, thus reducing the stress on the coastal plain aquifers. Large volumes of brackish water are also produced in conjunction with oil. Some oilfields produce three times as much water as oil. While some of this water is re-injected to maintain aquifer pressure, a significant volume is disposed as waste. The volume of water produced, with salinity ranges between 8,000-17,000 μScm^{-1} is expected to reach 110 Mm^3 per annum (MNE 1998).

Aquifer Development

MRMEWR is currently engaged in developing the infrastructure to supply potable water from two major aquifers assessed over the past five years. The Al Masarrat scheme ultimately provide more than 26 Mm³/yr of potable water to 215,000 people in the Ad Dhahirah region. The As Sharqiyah scheme provide about 3.3 Mm³/yr and is expected to reach 15.8 Mm³/yr by 2032. The government finance the initial wellfield development and primary distribution but the operation of the distribution to consumers will be privatised.

Resources Protection

Pollution control and protection zones around municipal well-fields and for monitoring activities within these zones that threaten water quality is the responsibility of Ministry of Regional Municipalities, Environment and Water Resources.

Resources Conservation

Conservation is promoted through public awareness among user groups, with frequent campaigns on television and radio, in schools and women's' groups. Conservation projects have included feasibility studies to promote water saving in residential/commercial buildings and demand management projects in the agriculture sector. A trial metering project on 150 farms is carried out to measure actual consumptive use and its variation between farm types and to gauge consumer reaction to meter installation.

Strategic Planning

Major improvements in our knowledge base in recent years include the first and second National Census in 1993 and 2003, a National Agricultural Census, the National Well and *Aflaj* Inventories, and preliminary or detailed water balance assessments of all catchments. A new Water Resources Master Plan is prepared which synthesise these data in the context of the development plans of other ministries and the Vision 2020 strategy statement. This Plan provide the basis for integrated water resources management for the next 20 years.

VISION 2020

'Vision 2020', instigated as a result of His Majesty's concern to concentrate on strengthening the economy. Table 1 and 2 summarise the explicit national priorities and the key national economic goals and the sectoral goals that most impact upon water resources.

Table 1 National priorities

Principal national priorities set out in Oman Vision 2020 statement

Economic

- to balance the budget, and increase fiscal reserves,
- to diversify the sources of income,
- to strengthen the private sector and reduce administrative barriers,
- to diminish government participation in public services, such as power and water,
- to maximise the participation of Omani nationals in the workforce.

Social welfare

- to continue to improve government provision of essential social and defence services,
- to upgrade health-care, education and increase women's participation in the labour market,
- to reduce living standard differentials,
- to promote community self-reliance and development.

Environmental

- to achieve optimum utilisation of available natural resources.

Table 2 List of water sector priorities

Principal water sector objectives and policies set out in Vision 2020 or other statements

1. Supply side measures

- continue exploration for water resources,
- continue construction of recharge dams and other hydrological structures,
- expedite the extension of potable water distribution networks,
- maximise agricultural productivity within the natural limitations of climate and water resources availability and sustainability,
- realignment of agricultural subsidies towards larger and more technologically advanced projects.

2. Demand management measures

- conserve water in the agricultural sector by:
 - removal of high water requirement crops to brackish water areas
 - limit cultivation of grasses and high water use crops
 - rationalise the allocation and size of new agricultural lands
 - promote seasonal crops (more water efficient) and limit perennial cultivation
 - promote further modernisation of irrigation
 - determine appropriate quotas according to water situation in different areas
 - promote use of brackish water for agricultural use
- continue to subsidise the maintenance of *afraj* systems, while transferring the onus for implementation to the recipient communities
- expedite completion of waste water collection and promote re-use

3. Control measures

- expand well-field protection zones
- expand monitoring networks
- promote involvement of the private sector in distribution, waste water collection and treatment and desalination

Policy Reforms Supporting Priorities

Since the early 1970's the Sultanate of Oman has progressively moved forward with a series of policy reforms and strategies to achieve national goals and priorities in the water sector. While there has been significant progress in some areas of the sector there are also a number of challenges facing the sector and country to meet increasing demand for water, particularly the domestic and industrial use.

Contents of Recently Implemented and Approved Reforms

Organisation of institutions and management

Responsibilities for water management have been progressively rationalised since the 1970's with the separation of duties for resource assessment and management from supply activities. This process culminated with the establishment of the Ministry of Water Resources in 1989, and consolidated responsibilities for water resource management largely within a single institution. This was further enhanced with the subsequent transfer of responsibilities for dams and *aflaj* from MAF to MWR in 1994. In 2001, Royal Decree No. 47/2001 merged the two Ministries into one, The Ministry of Regional Municipalities, Environment and Water Resources which reflects a new reforms in the sector of water resources. Responsibilities for water use within the agricultural and domestic/industrial sectors is assigned to MAF and MHEW respectively.

Planning and regulations

The water sector is an integral part of the national planning process with the development of Five Year Plans. The Plans establish goals for the sector and allocation of funding to support a range of strategies to achieve these goals. In 1990 and 1995 legislation was issued to limit the expansion of new wells and deepening of existing wells. Under the associated regulations a permit is required for the construction of a well, and is conditional on type of construction and conditional on water abstraction and use.

Water supply management

Much has been achieved in supply augmentation in recent years including:

- expansion of number and capacity of desalination units for supply of potable water for domestic and industrial use, particularly in the Muscat area.
- construction of 31 dams for recharge of strategic aquifers, such as on the Al Batinah coastal plain.
- construction of 60 storage dams in the Interior regions for supply of drinking water to remote villages.
- repair and maintenance of *aflaj*, to improve water supply to rural communities.

- water supply schemes are currently being developed for the Al Masarrat and As Sharqiyah aquifer in northern and eastern Oman for the supply of potable water for domestic and industrial consumption.

Water demand management

A number of measures have been implemented to reduce water demand including:

- implementation of a leakage detection and repair programme for Muscat water supply.
- implementation of "Modern Irrigation" programme for the conversion of farms to improved irrigation methods.
- well permit regulations as described above.
- public awareness campaigns to heighten awareness by the public and water users of the need for and benefits of water conservation.

Social and environmental protection

In the late 1980's protection zones (3) were established for major wellfields to protect them from potential pollution sources and depletion from competing water users. By 2005 these protection zones increased to reach (27) wellfields for major townships and villages in northern Oman. It evaluates water demand and pollution risk for existing and proposed wellfields, delineates protection zones and associated restrictions on activities within the zones. Protection of water resources has also been enhanced by regulations on disposal of waste, progressively issued by MRMEWR since 1990. Domestic water consumers have been protected through government policy which established fixed charges of 2 B/gallon (\$US 1.15/ m³) from reticulated systems.

Waste water treatment and reuse

A scheme for the collection of treatment waste water is currently under consideration for the area of Muscat Municipality. The scheme is projected to ultimately produce 90 Mm³ per year of treated waste water for reuse.

Reform Formulation and Implementation

Reform selection criteria

The primary economic, social and environmental criteria for selecting reforms are set out in the Vision 2020 statement. Reforms are selected to promote or strengthen the following generic aims:

Economic

- to balance the budget, and increase fiscal reserves,
- to diversify the sources of income,
- to strengthen the private sector and reduce administrative barriers,
- to diminish government participation in public services, such as power and water,
- to maximise the participation of Omani nationals in the workforce.

Social welfare

- to continue to improve government provision of essential social and defence services,
- to upgrade health-care, education and increase women's participation in the labour market,
- to reduce living standard differentials,
- to promote community self-reliance and development.

Environmental

- to achieve optimum utilisation of available natural resources.

Technical

- to conserve water, particularly in the agricultural sector,
- to optimise the sustainable development and augmentation of existing potable and brackish resources,
- to continue to subsidise the maintenance of *aflaj* systems, while transferring the onus for implementation to the recipient communities,
- to expedite completion of waste water collection and promote re-use,
- to expand protection of wellfields and *aflaj*.

Specific policies proposed in the Vision 2020 statement to promote the main objective of conservation in the water sector are:

- removal of high water requirement crops to brackish water areas
- rationalise the allocation and size of new agricultural lands
- promote seasonal crops (more water efficient) and limit perennial cultivation
- promote further modernisation of irrigation
- determine appropriate quotas according to water situation in different areas
- promote use of brackish water for agricultural use
- water saving in domestic, industrial and commercial sectors

Implementation support

Implementation of these reforms will have an impact on the existing institutional arrangements and it will be necessary to separate the roles and responsibilities for water resources development from those for monitoring and compliance control. Inter-Ministry agreements and complementary institutional arrangements will be required which clearly define responsibilities. These should:

- through institutional changes, removes areas of overlap in some activities;
- integrate water supply and wastewater services to improve the environment for investment in water services provision; and

- establish a centralised body to coordinate and advise on water sector policy and planning.

Participation, consensus building and negotiation

The implementation of these policies can only be successful through participation and consensus with key stakeholders. So far in Oman, consensus building has been largely via conventional public awareness campaigns of lectures, newspaper articles, radio and TV broadcasts. While these are valuable in raising awareness, particularly amongst the younger generation, they need to be further developed and targeted to the main stakeholders, the farming community.

Water conservation in Oman requires farmers, particularly well-owners, to reduce their water consumption, through reduction of cropped area, changes in cropping patterns and improvement of irrigation efficiency. Ideally, farmers should be persuaded that this is in their long term interests, rather than coerced. Such persuasion can only be effected by using modern consensus building and participatory methods in combination with an effective agricultural extension programme(s). It is considered that only through such a consensus approach involving personal negotiation with land owners will the ultimate need for and compliance with demand management strategies be accepted. In the first instance the dichotomy between the stated policy objectives of self sufficiency in food and the elimination of water balance deficits needs to be resolved. As indicated by virtual water imports, total self sufficiency in food production, may be an unattainable goal, but a focused policy(s) towards food security, and production of higher value and more water efficient crops would make a significant contribution to the national economy and reduce dependency on food imports.

Policy reform in the potable water sector is a less pressing concern. Improvements in building standards to introduce the many methods of water saving require consensus between Ministry of Housing, Electricity and Water, Ministry of Commerce and Industry, Ministry of Tourism and Ministry of Regional Municipalities, Environment and Water Resources. Agreement on a draft building code would be followed by trial programmes in urban areas, accompanied by public awareness campaigns and subsidised supply of retro-fit kits, as has been done successfully in many parts of USA, Canada, Australia (e.g., Langford, 1998). In general, this could be achieved through the implementation of the Integrated Water Resources Management concept as a part of ensure environmental sustainability as one of the eight's Millennium Development Goals.

The acceptance of the use of treated waste water for irrigation must also be sought as a consensual approach. The first integrated waste water collection, treatment and re-use scheme in Oman is now under operation, in Salalah. This will provide valuable experience in the problems of implementation and consumer reaction, to inform the implementation process elsewhere.

The ultimate and paramount aim of redressing the water balance deficit requires a carefully planned programme of education, negotiation, participation and consensus both within government and between government and public. Oman is confident that, in the long term, following the tradition of peaceful

cooperation that has characterised development since the Renaissance of 1970, this goal will be achieved.

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Glossary

<i>Aflaj (single falaj):</i>	A surface and/or underground channel fed by groundwater/spring or stream built to provide water to communities for domestic and/or agricultural use
Al Hajar Al Gharbi	Western Mountain
Al Hajar Al Sharqi	Eastern Mountain
MAF:	Ministry of Agriculture and Fishers
MHEW:	Ministry of Housing, Electricity and Water
MRMEWR:	Ministry of Regional Municipalities, Environment and Water Resources
MWR:	Ministry of Water Resources