STATE OF BAHRAIN

MINISTRY OF WORKS & AGRICULTURE

AGRICULTURAL AFFAIRS

NATIONAL REPORT

ON

THE IMPLEMENTATION OF THE UNITED NATIONS CONVENTION TO COMBAT DESERTIFICATION

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April 2000

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LIST OF ACRONYMS AND ABBREVIATIONS

BD	-	Bahraini Dinar
BOD	-	Biochemical Oxygen Demand
CCD	-	The Convention to Combat Desertification
COD	-	Chemical Oxygen Demand
GDP	-	Gross Domestic Product
MoWA	-	Ministry of Works & Agriculture – State of Bahrain
NAP	-	National Action Programme
PPM	-	Parts Per Million
ROWA	-	Regional Office for West Asia
SCADA	-	Supervisory Control and Data Acquisition
TDS	-	Total Dissolved Solids
TSE	-	Treated Sewage Effluent
TWPCC	-	Tubli Water Pollution Control Center - Bahrain
UNCCD	-	United Nations Convention to Combat Desertification
UNEP	-	United Nations Environmental Programme
UNESCWA	-	United Nations Economic & Social Commission for Western Asia
WRD	-	Water Resources Directorate – MoWA

EXECUTIVE SUMMARY

In view of the water crisis in the arid and semi-arid areas, Bahrain has been tenaciously following the strategy of preserving its water resources on the one hand and containing the greenery over most of the area on the other. The adverse agro-climatic conditions and soils of the country motivated the Government of Bahrain to see into the challenge of growing fauna and flora on the lands available. The socio-economic factors, although have taken their toll, yet the government policies within the framework of the region have been conducive to combating desertification.

Following the National Action Plan 1992, Bahrain entered UN Convention to combat desertification in 1997. The groundwork was thus prepared as a direction to follow.

Located in the equatorial region and having hot and humid climate, Bahrain has comparatively high population density with a growth rate of 3.6% per year. High evaporation rate of 2,600 mm/year and scanty rain of 72 mm/year together with sandy soils containing negligible of organic matter restricts the growth of natural vegetation.

Besides, the deteriorating piezometric levels of groundwater with increasing salinity from 3,400 PPM to 11,000 PPM lead to a formidable water crisis. Rapid salinization of soils and shift of rural population to urban industrial growth of the oil boom of the 1970's instigated the government of Bahrain to look into alternative sources of irrigation water, maneuvering of agricultural land and improvement of the environment.

The economic policy and the development plans have called for diversification of the production base away from oil and the promotion of the private sector. To overcome constraints in the current level of agricultural activities, the guiding strategy for Conserving the Agricultural Areas and Combating Desertification, aims at two dimensional approaches: (A) to reduce groundwater abstraction from natural aquifers, and (B) to preserve the existing agricultural land and the landscaping.

In order to implement the two approaches, Bahrain, in spite of limited financial sources, has attempted to implement several measures through formulating legislation, improving irrigation methods, replacing high-irrigation requirement crops with others, introducing tariffs for using the underground water, using the TSE (treated sewage effluent) for irrigation, constructing land drainage, zoning of agricultural land, improving agricultural research activities, enhancing agricultural extension services, and supporting agricultural inputs by limited levels of subsidies.

Legislation to strictly monitor the use of groundwater and drilling of wells is in place with effect from 1997. Besides, the Amiri Decrees in respect of organizing date palm protection and land drainage system are effective to protect the state infrastructure to combat the menace of shrinking agricultural land.

Modern irrigation methods like drip and sprinkler irrigation are willingly followed to replace the traditional methods of flood and unlined channels. It's expected that about 13 million m^3/year of groundwater will be saved in this manner.

The plantation of high-water consuming crop of alfalfa is being discouraged and is being replaced gradually by xerophytic crops like Rhodes grass, barley, oats, rye grass, Sudan grass, and others. It's estimated that this replacement will save more than 15 million m^3/year of invaluable water.

One of the main reasons for over-irrigation practices in agriculture and landscaping is the availability of underground water free of charge. This conservative method has resulted in very high proportional use of water as compared with other countries facing similar situations. Imposing a nominal charge per cubic meter would help prevent further deterioration of groundwater and would save more than 17 million m^3/year.

Realizing the importance of recycled water in agriculture, Bahrain implemented the Phase-I of utilizing the treated sewage effluent (TSE) in 1984. About 660 ha of agricultural area has already been rehabilitated using 35,000 m^3/day of the TSE.

The Phase-II has been initiated in 1997 and is on its way to implementation. A network of expanded treatment plant, storage reservoirs, transmission lines, a network of irrigation distribution lines, 150 km in length, upto the irrigation well on each farm as well as to landscaped areas for beautification and afforestation are salient feature of the scheme.

The network will be completed within next three years, and the production of TSE will reach 200,000 m^3/day in the year 2011. This will irrigate more than 2400 ha of water-thirsty agricultural land. TSE Phase-II is costing about BD 55.4 million (US$ 146.6 million). A saving of 50 million m^3/year of groundwater will result from the project.

A well-planned drainage system is a pre-requisite to maintaining the sustainable agriculture. Bahrain, being no exception, is implementing drainage network under Amiri Decree No (4) which governs the organization and maintenance of the land drainage system intact. A total of 120 km of drains will be constructed under TSE Phase-II.

In order to protect the agricultural land from the urban encroachment, zoning of agricultural land has been undertaken. The Amiri Decree No. 29/83 to protect the date palms in the country aims to preserve the heritage of natural resources and the environment. Zoning of agricultural land would lead to a symbiosis of rural and urban communities to flourish together.

Agricultural research, agricultural extension and supporting the agricultural inputs through limited subsidies are Bahrain's contribution as part of its efforts to combat desertification. However, there are certain requirements which need to be looked into.

Bahrain's agriculture contributes about 1% to the GDP. Although its resources are limited, nevertheless Bahrain has built a solid infrastructure for agriculture especially in irrigation and drainage. The TSE Phase-II is costing US$ 146.6 million. In order to strengthen further the activities to combat desertification, however, technical as well as financial supports are needed. They are to be assessed in light of requirements with a view to rehabilitate agricultural land activities.

Ministry of Works and Agriculture is prepared to form a National Committee from the concerned organizations in Bahrain and to implement the valuable findings and recommendations by the UN Convention to Combat Desertification.

1. Introduction:

In view of the water crises in the arid and semi-arid areas, Bahrain has been tenaciously following the strategy of preserving its water resources on the one hand and containing the greenery over most of the area on the other. The adverse agro-climatic conditions and soils of the country motivated the Government of Bahrain to see into the challenge of growing fauna and flora on the lands available. The socio-economic factors, although have taken their toll, yet the government policies within the framework of the region have been conducive for combating desertification.

In 1992 the UNESCWA and UNEP/ROWA prepared a National Action Plan report for the state of Bahrain in the field of combating desertification, entitled (National Plan of Action to Combat Desertification in Bahrain).

The State of Bahrain has entered the United Nations Convention to Combat Desertification (UNCCD) in 1997 which is correspondent with the national strategy of the State of Bahrain in the agricultural sector. Bahrain is well on its way for implementing the CCD while the national strategy meets the convention objectives.

2. Background:

2.1. Location: The State of Bahrain is located on the 26^0 North latitude and 50^0 30 longitude. It consists of an archipelago of 36 islands in the Arabian Gulf (Map 1). The total area is about 706 square kilometers.

2.2. Population: The population in Bahrain increased from 351,000 in 1981 (68% Bahrainis) to 508,000 in 1991 (64% Bahrainis), and to 620,378

(61% Bahrainis) in 1997 and this makes a density of about 878 person per km2. Therefore, Bahrain has one of the largest population densities in the world. The growth rate is 3.6% per year.

2.3. Climate: Bahrain climate is predominately hot with an average temperature of 35^0 C, and the average relative humidity being 80%. The months starting from May till September are very hot. The precipitation is scanty (72 mm/year) and starts falling in late October and continues intermittently in until April, and occasionally in May.

The winter months (Dec. Jan. Feb. and March) are mild and pleasant and dotted with showers and sometime heavy downpours. While the rainfall is only about 72 mm/year, the potential evapotranspiration exceeds 2,600 mm per year. This restricts the growth of dense natural vegetation.

2.4. Soils: Most of suitable soils for irrigated agricultural production, landscaping, and afforestation are mostly sandy and located in the coastal back-slope in the northwestern area of Bahrain. In addition, there are scattered pockets of suitable soils throughout the north central area and along the northeastern coastal area. These soils generally have poor structural, textural and fertility characteristics and are very permeable with low water-holding capacities. They have quite high gypsum or calcium carbonate levels and are very low organic matter. Cation exchange capacities are low and the alkalines reduce the availability of some of the essential plant microelements and nutrients. Large animal manure and other inorganic wastes, complemented by other organic fertilizers are required to achieve the optimum growth in greenery. While easy to practice cultural practices, the soils are susceptible comparatively moderate level of wind erosion if left unprotected. Many are underlain by impermeable layers at shallow depths which result in drainage problems, particularly under lack of integrated irrigation management.

2.5. Vegetation: The natural vegetation of Bahrain results from the reaction between physiography, climate, soils, and groundwater. Despite being the limited area in Bahrain, the vegetation cover consists of several hundreds of plant species.

The insignificant precipitation in the winter and the shortage of soil moisture in most areas, especially in the summer, limits the plant development and growth; and when soil moisture and temperatures are favorable, several plants (mainly halophytic) spread, and annuals complete their growth cycle in a short period. The perennials, which have relatively deep root systems, grow for longer periods.

Taking into consideration the plant ecology of the area, Bahrain is divided into four phyto-geographical regions: northeastern coastal region, west coastal region, semi-desert region, and the desert region; see Map 2.

- **The northeastern region** encompasses saline shallow waters where plant species under mangrove thrive near the coastal areas. It also includes some abandoned date palms under relatively low saline conditions.
- **The west-coastal region** is characterized by calcareous sandy soils with relatively low salt content. The vegetational cover is composed of succulent plants as well as date palms.
- **The semi desert region** comprises the largest phytogeographical region and consists of small perennial or succulent shrubs.

- **The desert region** occupies the central area of Bahrain Island and covers relatively sparse and consists mainly perennial xerphytic shrubs.

2.6. Water Resources: Bahrain draws its water from the underground aquifers of dolomitic origin. In general view, there are three zones: Alat, Khobar, and Ummereduma. The average salinity of these sources approximately varies from 3,400 PPM to 11,000 PPM.

It is obvious that the best quality water of 3,400 PPM meets only the marginal requirements of water quality suitable for irrigation. Annual abstraction exceeds 216 million cubic meters per year as shown in Table 1.

Although the safe yield is about 112 million cubic meters per year, the very high abstraction of 252 million cubic meters has accelerated the deterioration of the aquifers on the one hand and limited the agricultural and landscape activities through limited available water for irrigation, increasing soil salinity, and eventually reducing green areas on the other.

In view of the traditional irrigation methods cropping patterns, high soil & water salinities and higher leaching requirements, agricultural sector consumes for irrigation about 70% of the abstracted groundwater.

The rapidly decreasing groundwater accompanied by increasing salinity has led the Ministry of Works & Agriculture (MoWA) to look for alternative resources with a view to meet the social requirements and to maintain the agricultural and landscaping activities in the country.

Recent surveys and studies carried out by MoWA has amply proved that if the existing trend of water consumption continues, the piezometric levels of groundwater should have reached such a low level that it would be not possible to recover the lost resource. The salinity, which varied between 2,000 PPM - 6,000 PPM in 1970, now reaches much higher level (Table 2) and has resulted in the soil salinization and decrease in the planted areas.

3. The Water Crisis:

The first well was drilled in Bahrain in 1924. The number increased to 165 in 1940, 325 in 1955, and shot up to 1020 in 1979. Besides these wells, there were 1200 hand-dug wells. As of 1997, there were about 2000 wells in Bahrain.

Rapid increase in the utilization of water by drilling wells and installing pumps led to rapid decline in hydraulic head at an average rate of 10 cm per year, which resulted in intrusion of sea water and consequently in deterioration of groundwater.

The sea intrusion occurred in the eastern side of the island. The changes in the salt content reflected a very critical situation, See Table 2.

The situation continued resulting not only in the salinization of soils but also in reducing the green areas. The total area which was about 6,170 ha in 1971, reduced to about 3,731 ha in 1980.

Agricultural land decreased rapidly due to the inception of oil boom in 1970's on the one hand and deteriorating water resources on the other. In addition, as a result of the expanding oil industry forced the workers to abandon

the agricultural areas and shift to the urban environment. The land capability in fact got modified; see Table-4. Most of the moderately suitable agricultural land was converted into urban areas.

4. The Strategy of the State of Bahrain for Conserving the Agricultural Areas and Combating Desertification:

In the face of decline, the Government of Bahrain realized the importance of natural resources including water, land, and the environment. The economic policy and development plans have called for diversification of the production base away from oil and the promotion of private sector.

Scarcity of arable land and irrigation water, inappropriate climate, marine environment, high population growth, and heavy dependence of foreign exchange earnings on the oil and its byproducts are major challenges facing sustainable agriculture development, landscape environment, and food security in Bahrain. To overcome these constraints sustain the current level of production, the guiding strategy for conserving the agricultural areas and combating desertification, aims at two dimensional approaches: (A) to reduce groundwater abstraction from natural aquifers, and (B) to preserve the existing agricultural land and the landscaping. See Table 6.

4.1 Legislation: The laws, in the face of alarming water and land situation, have been formulated and made more stringent in 1997 to control and to monitor the abstraction and use of water for agriculture and landscape, beside domestic and industrial uses. Several decrees has been formulated and imposed for this part.

Introducing new plantation from abroad necessitates that only healthy trees, seedlings, and other materials for greening the areas are used. In this connection, Bahrain has been practicing anti-quarantine measures at the ports of entry.

The State of Bahrain has taken some concrete decisions through starting some important programs that are expected to make positives

impact on developing the agricultural sector in Bahrain, besides preserving the groundwater. The programs include, improving irrigation methods, changing cropping pattern, utilizing recycled wastewater or treated sewage effluent, levying tariff (to be introduced in the near future), and using the sludge byproduct from the sewage treatment plant for improving soil fertility and water holding capacity In addition, legislative approach by promulgating the Amiri Decrees in respect of organizing date palm protection and land drainage system have been the hallmarks towards combating desertification.

4.2 Improving Irrigation Methods: More than 75% of the irrigated area in Bahrain is under flood irrigation which is resulting in huge losses through deep percolation and seepage.

Modern irrigation systems such as sprinklers, center pivot, drip bubbler system, piping network to replace unlined channels, are introduced on developing farms. As of present, about 300 ha is under sprinkler/center pivot and 580 ha under drip/bubbler systems. In order to encourage farmers to install improved methods, Government of Bahrain is continuing supplying irrigation equipment on subsidized prices. It is expected that a saving of 13 million cubic meters/year will result from converting the traditional irrigation systems into the modern methods.

4.3 Replacing High-Irrigation Requirement Crops with others: Although a traditional crop for Bahrain, Alfalfa consumes huge quantities of irrigation water (70,000 m3/ha/year). It is estimated that about 40 million cubic meters/year is consumed by this crop alone in Bahrain. One of the main causes of rapid deterioration of underground water resources could be attributed to this crop.

MoWA has initiated a program to replace Alfalfa with other suitable crops, like Rhodes grass, Barley, Oats, Rye grass, Sudan grass, and others, requiring not only less volumes and frequency of irrigation but also those which could withstand higher salinity and adverse drainage situation. By replacing alfalfa with other forage crops, a saving of 15 million cubic meters per year is anticipated.

4.4 Introducing Tariffs for Using Underground Water: One of the main reasons for over-irrigation practices in agriculture and landscaping is the availability of underground water free of charge. This conservative method has resulted in very high proportional use of water as compared with other countries facing similar sad state of situation. Imposing a very nominal charge per cubic meter of water would obviously help in preventing further deterioration of piezometric levels.

In line with the above approach to control the use of water for irrigation, flowmeters has been installed on each borehole to monitor and bill for the water consumed. A saving of about 17 million cubic meters/year is envisaged through imposing the proposed tariffs.

4.5 Using Treated Sewage Effluent Irrigation: Ever since in 1984 the TSE was made available in Bahrain under Phase-I, MoWA has made all out efforts to utilize it efficiently through distributing it on the agricultural areas and to arrest their deterioration.

The Tubli Water Pollution Control Center (TWPCC), which produces the TSE used for agriculture, is the major facility for treating wastewater in the State of Bahrain. The treatment method used is one of the most advanced technologies. The treatment goes

through a tertiary treatment method, which includes both chlorination and ozonation facilities. The quality of the TSE is of a high standard (Table 7). The plant produces at present about 35,000 cubic meter per day (about 13 million cubic meter per year) of ozonated treated water. This quantity is utilized on an agricultural area of about 660 ha in Bahrain. These areas are Hawrat A'ali, Buhayr, Adari, Tubli, and Bouri. A complex network, including transmission mains, reservoirs, pumping stations, and distribution lines, was installed to cover all of these areas. This represents about 25% of the TSE utilized for irrigation. Moreover, a network of land drainage system has been constructed.

Phase-II of expanding the utilization of the TSE project is under construction now, and to be completed gradually on stages over an expected period of 3 years. The capacity of the plant will increase to reach 200,000 cubic meter per day. Although, the capacity of the domestic sewage system is only 160,000 cubic meter per day at the present, it is expected to increase over the coming 11 years to reach the full capacity of phase-II. The production of phase-II will increase gradually from the present 35,000 cubic meter per day to 60,000 cubic meter per day by the end of this year; and to 100,000 in the year 2001, and to 160,000 cubic meter per day at the end of this project. After this point, it is expected to increase gradually through the expansion in the domestic sewage network to reach 200,000 cubic meter per day, and this will cover an additional area of about 2400 ha of both agricultural and landscaping. A saving of 50 million cubic meter of groundwater per year is expected to be achieved through this scheme of replacing groundwater.

The implementation of the scheme would cost about BD 55.4 million (about US$ 146.6 million) and would comprise a

comprehensive network of the expanded treatment plant, transmission mains, storage reservoirs, and irrigation distribution system up to each agricultural holding; and to landscaped areas for beautification and afforstration. The total network in this phase will be in the order of 150 kilometers in length. The operation and controlling system in phase-II of production and distribution system will be fully monitored through SCADA (Supervisory Control and Data Acquisition) system.

4.6 Land Drainage: The survival of greenery in Bahrain is resolutely dependent on lowering the sub-soil water table and reducing salinity of soil. A well-planned drainage system is, therefore, a pre-requisite to maintaining the agricultural areas and landscaping.

Bahrain authorities appreciated the underlying problem of high water table along the low-lying coastal as well as some central areas and launched concerted efforts to plan and execute a land drainage system to have the optimum plantation growth.

In order that the greenery is preserved in Bahrain, the Amiri Decree No. (4) governing the organization of agricultural land drainage stating, among other things that it is prohibited to close any main or secondary drain or stop or obstruct the flow of water or charge its direction or to build any construction over it, has strengthened the greening forces, agricultural sector, landscaping, and environmental organizations.

Under TSE phase-II a total of 120 kilometers of open and tile drains will be constructed.

4.7 Land Use for Agriculture/Landscaping: While the water resources are being rationalized on the one hand, the date palm

plantation, which forms the indigenous part of heritage of Bahrain, has been preserved on the other. To continue keeping and protecting the existing plantation, the Amiri Decree No. 29/83 is to direct and protect the date palms and to maintain their cultivation. Similarly, landfill areas, which are landscaped or are expected to be brought under cultivation, are to be monitored and protected from the urban encroachment. Therefore, zoning of agricultural areas is now under progress in collaboration with the Ministry of Housing, Environment and Municipalities. Agricultural zoning aims to protect these areas from urban encroachment. As a result of focused attention and effective action of the Government of Bahrain, the cultivated area for agriculture has increased from 3.731 ha in 1980 to 4,100 ha in 2000; see table 3.

By following a rationalized approach in managing the indispensable water resources, dealing with land capability constraints, Bahrain has demonstrated that considerable areas could be brought under agriculture and landscaping in line with the policies for preserving greenery and the healthy socio-economic environment.

4.8 Improving Agricultural Research Activities: Research is a backbone for any agricultural development plan. Therefore, the State of Bahrain represented by the Ministry of Works and Agriculture is carrying out necessary applied researches. They include introducing salt resistant crops, which are suitable to the local condition; low water consumption crops, experiments with new irrigation methods, and others. However, the main problem facing these activities is the shortage of available funds. In order to continue the research activities, adequate funds should be made available.

4.9 Supporting and Building-Up Agricultural Extension Services: Realizing the importance of communication between the farmers and the Ministry for providing them with the information and technologies, the Ministry of Works and Agriculture is in need of supporting the extension services through the available multimedia facilities, direct meetings with farmers, seminars and workshops, and installing new methods on their farms.

4.10 Subsidies for Agricultural Inputs: The state of Bahrain provides the farmers with agricultural loans without interest. It is directed to support the agricultural development in the country, particularly the programmes for adopting modern and improved irrigation methods and constructing green houses, which help in reducing irrigation water consumption; see table 8.

5. The Requirements to Support the National Strategy:

5.1 Funding and Financial Assistance: The agriculture sector in Bahrain is a considerably small traditional sector. It contributes upto 1.0% of the GDP, thereby restricting private sector investment for encouraging sustained growth. The government of Bahrain realizing its responsibilities, has built the main agricultural infrastructure. The agricultural sector needs the required financial assistance to continue its activities and programmes through funding the technical support needed.

Assessment of funding needs is to be done in cooperation with the government of Bahrain in view of the requirements.

5.2 **Technical Support:** The technical support is very important for the success of overall projects. The technical support needed for

Bahrain includes; training, research, studies, scholarships, extension, expertise, seminars, conferences, site visits to developed agricultural countries, and others. Training plans for the technical staff, as well as other needs, is to be prepared and organized in related fields of desertification. Cooperation in this regard is required to support Bahrain's efforts.

Technical assists will be required in the following fields:

1) The impacts of using TSE in agriculture under local conditions.
2) Reducing water consumption through improving irrigation methods.
3) Operation & Maintenance of irrigation networks under TSE.
4) Using highly saline water in irrigation.
5) Low water consumption crops.
6) Introducing Salt-resistant varieties of Crops

6. National Committee for Combating Desertification:

The Ministry of Works and Agriculture -the responsible authority for combating desertification in Bahrain- is prepared to form a National Committee from the relevant organizations for combating desertification and to help organizing their activities. The Ministry will work on this subject to put it in action.

List of Other Organizations and Societies in Bahrain in relevant fields for Combating Desertification:

1- Ministry of Housing, Municipalities, and Environment.
2- Bahrain Center for Studies and Research

3- The Arabian Gulf University.

4- The University of Bahrain.

5- Water Science & Technology Association

6- The Committee for wildlife protection: related to preserve and protect the wild life in both natural fauna and flora in Bahrain.

7- Society of Youth and Environment.

8- Others.

7. Benchmark and Indicators Utilized to measure progress:

7.1 Areas under agriculture and landscaping including changes in cropping pattern.

7.2 Production and utilization of the TSE in agriculture and landscaping.

7.3 Irrigation and Drainage Networks including improved methods of irrigation and drainage.

7.4 Number of trees including date palms.

7.5 Agricultural production including fruits, vegetables, and fodder; balance of agricultural trade.

7.6 Monitoring piezometric water levels of the groundwater through 70 observation wells in Bahrain.

7.7 Recording water level changes in water table levels through 20 piezometers covering the agricultural areas in Bahrain to monitor land drainage status.

Table 1

Groundwater Abstraction (Cubic meter/year), Bahrain

Sector/Year	1990	1993	1999*
Industrial	6,000,000	6,000,000	7,560,000
Municipal/Domestic	57,000,000	61,000,000	66,060,000
Agriculture	124,000,000	139,000,000	178,390,000
Total	187,000,000	206,000,000	252,010,000

* Source: WRD

Table-2

Changes in the Salinity of Groundwater (Sitra)

Year	TDS (PPM)
1954	1940
1958	2200
1964	5200
1969	8100
1970	8200#

The flow from the spring ceased and the area abandoned.

Table 3

Land Use Pattern 2000 (Area in ha)*

Land Use	2000
Vegetables	900
Fodder & others	800
Dates & fruit trees	2400
Cultivated land	4100

* Adapted from Agricultural Relations Department economist; 2000.

Table 4

Land Capability for Agriculture

	Class	Ha (in 1976)	%	Ha (in 1979)	%	Change since 1976	Change since 1976 (%)
1	Good	1055	1.78	1055	1.77	0	0
2	Moderate	613	1.03	350	0.64	-263	42.90
3	Moderate, Liable to salinisation	4740	7.98	3100	5.21	-1640	34.60
4	Moderately low, salt tolerant crops	6918	11.65	6250	10.51	-668	9.66
5	Low	17940	30.20	17540	29.52	-400	2.23
6	Unsuitable	22473	37.83	22473	37.82	0	0
7	Urban & Industrial	5663	9.53	8634	14.53	+2971	52.46

It can be seen that urban development took place mainly at the expense of the better agricultural land, where economic farming could have been possible.

Table 5

Relation between Availability and Usage of Water Resources

(million m^3/Year)

Source	Available	Usage	% (Overused/Underused) - or +
Ground water #	112	252	-125
Desalinized	40	40	0
Tertiary Treated Sewage Effluent (TSE) *	13	13	0
Land Drainage	30	3	+90
Total	**195**	**308**	**-**

Source: Water Resources Directorate (WRD)

* The total secondary TSE produced at TWPCC is about 53 million cubic meter per year. The extension of the plant is in progress under TSE phase-II. After completion the fully quantity will be tertiary treated and utilized.

Table 6

Rationalization of Water Resources Usage (1997-2010)

Usage	Million m3/Year
Improving Irrigation Methods	13
Replacing High-Irrigation Req. Crops	15
Introducing Tariffs	17
Using Treated Sewage Effluent (TSE) for Irrigating Agricultural Crops and Landscaping	50
Other Usage	30
Total	125

Table 7

Average Chemical and Biological Analytical Results of TSE used for Irrigation in Bahrain

BOD (mg/l)	1.5
COD (mg/l)	23
TDS (PPM)	4200
PH	7.5
Fecal Coliform (numbers/100 ml)	3
Parasite (numbers/l)	2
Calcium (mg/l)	185
Magnesium (mg/l)	103
Sodium (mg/l)	792
Potassium (mg/l)	51
Sulphate (mg/l)	506
Chloride (mg/l)	1467
Boron (mg/l)	0.6

mg/l = milligrams per liter

Table 8

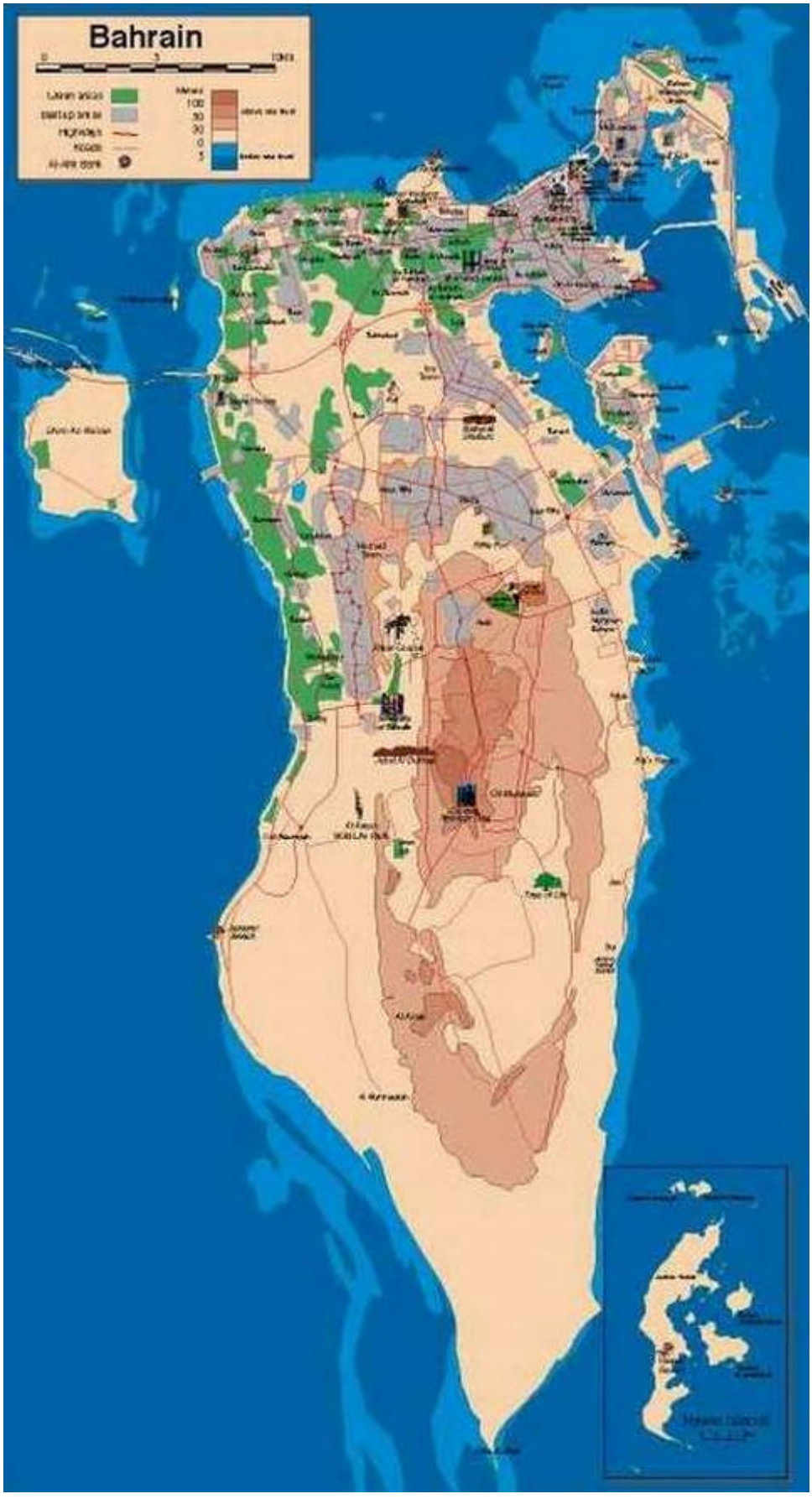
Agricultural Credit Programme – 1998*

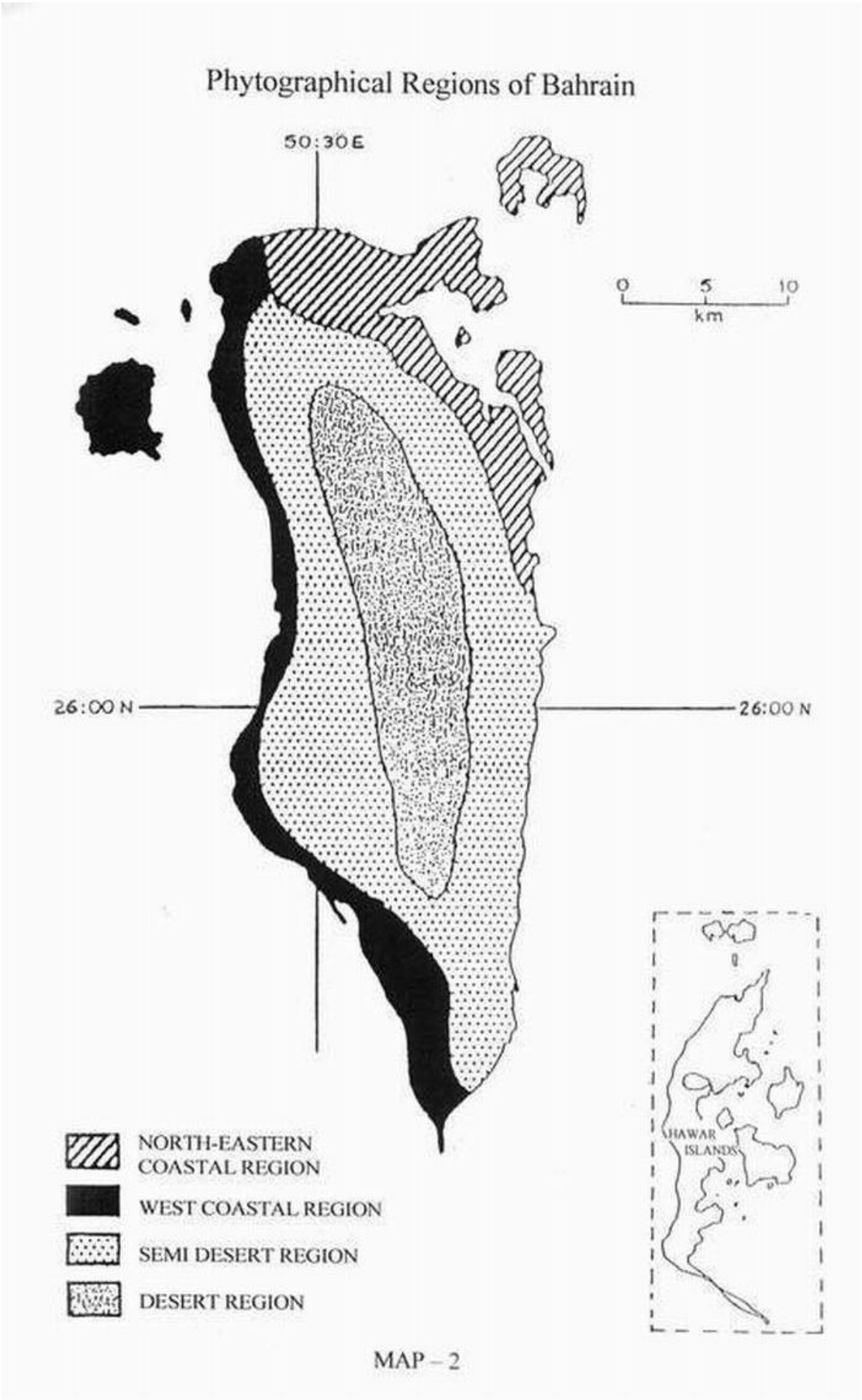
Description	Value (US $)
Total loans approved	348,148.1
Modern irrigation and drainage systems	101,322.8
Protected Agriculture	116,137.6
Animal production	26,719.6
Date farms Improvement	3,968.3
Poultry	82,010.6
Seasonal inputs	17,989.4

* Source: Agricultural Annual Statistical Report, 1998

Map 1

State of Bahrain




Phytographical Regions of Bahrain
50:30 E
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km
26:00 N
26:00 N
HAWAR ISLANDS
NORTH-EASTERN COASTAL REGION
WEST COASTAL REGION
SEMI DESERT REGION
DESERT REGION

MAP – 2

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P.S. Disclaimer: Editors of this report have tried their best to obtain as accurate and as recent data as was possible from various sources mentioned.