COUNTRY REPORT ON THE STATE OF PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE

YEMEN

STATE OF PLANT GENETIC RESOURCES FOR FOOD AND GRICULTURE IN YEMEN

(1996 – 2006)

Second National Report

February, 2009

Note by FAO

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ACRONYMS AND ABBREVIATIONS

AREA	Agricultural Research and Extension Authority
APRP	Arabian Peninsula Regional Project, ICRADA
AVRDC	Asian Vegetable Research and Development Centre
CBD	Convention on Biological Diversity
CGIAR	Consultative Group for International Agricultural Research
CGRFA	Commission on Genetic Resources for Food and Agriculture, *FAO*
CIAT	Centro Internacional de Agricultura Tropical Cali, Colombia
CIMMYT	Centro Internacional de Mejoram. del Maíz y del Trigo, Mexico City, Mexico
CITES	Convention on International Trade in Endangered Species of Wild Life Fauna and Flora
CLAN	Cereal Legumes Asian Network
EPA	Environmental Protection Authority, ROY
EPL	Environmental Protection law
FAO	Food and Agriculture Organization
FTA	Food Trade Agreement
FU	Farmers Union, ROY
GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic Product
GIS	Geographical Information System
GSMC	General Seed Multiplication Corporation
ICARDA	International Center for Agricultural Researches in Dry Areas
ICRISAT	International Crop Research Institute for the Semi Arid Tropics
IITA	International Institute of Tropical Agriculture, Ibadan, Nigeria
ILRI	International Livestock Research Institute, Addis Ababa, Ethiopia
IPGRI	International Plant Genetic Resources Institute; recently Bioversity International
ITPGRFA	International Treaty of Plant Genetic Resources for Food and Agriculture
MAI	Ministry of Agriculture and Irrigation
MVSP	Multi-Variate Statistical Package
NGRC	National Genetic Resources center
NSB	National Seed Board
NUS	Neglected and Underutilized Species
NVRSRP	Nile Valley and Red Sea Regional Program
NVRSRP	Nile Valley and Red Sea Research Program
PGRFA	Plant Genetic Resources for Food and Agriculture
PGRU	Plant Genetic Resources Unit
PSC	Potato Seed Company
RLIP	Rainfed and Livestock Improvement Project
SASP	Seed and Agricultural Services Project
TRIPS	Trade Related Intellectual Property Rights
UNDP	United Nations Development Program
USDA	United States Department of Agriculture
VSC	Vegetables Seed Company
WANA	West Asia and North Africa
WTA	World Trade Agreement

EXCUTIVE SUMMARY

The agricultural sector in Yemen contributes to about 20% of the total internal revenues of the country and employs around 54% of the total work-force. Most of the country 22 million inhabitants reside in rural areas and work in agriculture or agricultural related activities. The total agriculture area is estimated at 1 668 858 ha, of which, 1 132 910 ha (68%) is cultivated while the uncultivated area was 535 948 ha (32%). The growth rate in agricultural sector averaged only 2.4% per year, compared to the population growth rate of 3.7%, one of the highest growth rate in the world. This results in a big gap between local food production and needs. The agriculture sector currently meets the country's demand for vegetables and fruits, but only 40% of the domestic demand for grains. Improving the use of plant genetic resources for food and agriculture (PGRFA) could play an essential role in enhancing the efficiency of agriculture production and its capacity to meet food security challenges.

Yemen is the richest country in PGRFA in the Arabian Peninsula. It has been estimated that there are about 2 900 plant species belonging to 175 families in Yemen, more than 420 of which are endemic. There are about 521 indigenous plant genetic resources for food and agriculture (PGRFA), belonging to 75 families and 235 genera, out of theses 87 are endemic. Forty plant species belonging to 27 genera and 15 families are cultivated in the country; these are cereals, legumes, fruits, vegetables and industrial and stimulant crops.

In many parts of the country traditional small *in situ* conservation areas can be found. These areas are mainly situated around or near villages and are privately or communally owned. Traditional rules are applied to manage these protected areas whose main use is grazing. These *in situ* conservation areas are normally managed by local communities, village leaders or Sheikh. They represent the best managed areas of Yemen and contribute to protect existing plant genetic resources for food and agriculture.

Recently, several areas in the country have been declared as protected areas, the largest and most famous is the Soqotra Archipelago. Its area is about 3 799 km^2 and so far about 825 plant species have been recorded in these islands, out of which 307 are endemic.

Ex Situ conservation centers for plant genetic resources in Yemen have increased rapidly at the end of the 20th century and the beginnings of the current century. These centers mainly affiliated to the governmental sector mainly the agricultural research and extension authority and public universities. The number of conservation facilities has increased from 7 in 1996 to 22 in 2006, conserving more than 6 000 accessions.

Historically, Yemeni farmers demonstrated an exemplary capacity of survival under very difficult environmental conditions based on an economic and sustainable use of PGRFA. As a result of this, the country's crop diversity, comprised of cultivated crop varieties, heterogeneous landraces, and wild relatives, is utilized for different purposes by the community. These landraces have evolved through natural selection and selective breeding by traditional agricultural practices over long periods in the different environmental conditions of the country.

Sourced from local or introduced germplasm, many new cultivars have been released in the past ten years mainly of cereal and food legume crops and to a lesser extent of vegetable and fruit crops.

Presently there are no legislations or policies in force in Yemen, which deal specifically with PGRFA, and only several provisions related to certain aspects of PGRFA conservation exist.

The National Program on Plant Generic Resources for Food and Agriculture (PGRFA) comprises several sub programs linked with the Agricultural Research and Extension Authority (AREA) through its National Genetic Resource Center (NGRC) under the Ministry of Agriculture and Irrigation (MAI) , the Universities of Sana'a and Aden (faculties of Agriculture) , the Environmental Protection Authority (EPA) in the Ministry of Water and Environment and the General Seed Multiplication Corporation (GSMC) under MAI.

The coordination of the activities of different institutions in the field of PGRFA was realized through the establishment of the National Committee (NC) for PGRFA in 1999. Membership of the NC includes representatives from MAI, the Universities , AREA, EPA, GSMC , Farmers Union (FU) .

A Capacity Self Assessment Study on the implementation of the International Conventions on Biodiversity, Biosafety, Desertification and Climate Change in Yemen clearly illustrated the extent of the problem in capacity building in the country which has three dimensions: individual, institutional and system dimensions.

There are bout 29 legislations that either directly or indirectly deal with PGRFA with different levels of issuance from laws, Republican Resolutions, The Cabinet resolution, executive by laws. Nonetheless a specific and comprehensive legislation on PGRFA is still missing.

Crop improvement programs in Yemen have played an important role over the last ten years providing an increase of yield and sustainable production. Collected and conserved materials were made available to plant breeders and other specialists in crop management programs in any concerned sector which helped in the release of crop cultivars addressing production constraints and contributed to improve food security in the country both in terms of quantity and quality.

INTRODUCTION

Yemen is located in the South East of the Arabian Peninsula. It lies between 120° and 17°N Latitude and 43° and 56°E Longitude. The country has rugged surface features composed of mountains, hills, plateaus, plains, valleys and gorges. The varied topographic features and the variable climatic conditions of the country are among the major factors which resulted in diversified crop genetic resources in particular, and vegetation and flora types in general. Nearly two decades ago, many internationally known scientists and plant collectors has recognized Yemen as one of the important regions of Asia in particular and world-wise in general. They described the diversity of many cultivated crop plants in the main land and vegetation and flora types in Socotra Island. However, due to long period of human, habitation, high population density, particularly in the highlands and unwise utilization of natural resources, most of the natural vegetation of Yemen has been destroyed and some of the lands which has been under cultivation are at present highly eroded. Moreover, improved agricultural systems, urbanization and heavy constructions have accelerated the ongoing genetic erosion in the last decades.

Area 2 million hectares are as marginal areas, grown once each 3-4 years, 3 million hectares as forest and about 16 million hectares as natural range land and pasture. The population of the country in 2004 was about 22 million from which of Yemen is about 550 000 sq. km, of which 1,47 million hectares are cultivated and nearly 65% are in rural areas, and about 56% of the population are involved in agriculture. Agricultural sector in Yemen contributes about 20% to the total internal revenues of the country; it employs around 54% of the total work-force. Most of the country 22 million inhabitants reside in rural areas and work in agriculture or agricultural related activities. According to the Ministry of Agriculture and Irrigation statistics, the total agricultural area is estimated at 1 668 858 ha, of which, 1 132 910 ha (68%) is cultivated while the uncultivated area was 535 948 ha (32%). Out of the total cultivated area, 528 643 ha (47%) is rainfed, 434 207 (38%) is well irrigated, 40 801 ha (4%) is spring irrigated, and 129 259 ha (11%) is flood irrigated. The arable land is divided in 1 115 515 holdings, of which an estimated 69% are small farms (<2 ha), 29% are medium size holdings (2-5 ha), and about 2% are large holdings (>5 ha).

1. Climate

The climate of Yemen varies mainly with altitude from a hot and dry desert climate in the low lying South East and West regions to a temperate in Southern, Central and Northern highlands. Based on climate, Yemen has traditionally been divided into five climatic zones, and these are : Coast al areas, Southern Uplands, Central Uplands, Northern Highlands and Eastern plateau.

Mean annual temperature ranges from less than 12° in the highlands to above 30° in the coast al areas. In summer, temperature may rise up to 40° in low lands and above 40° in the desert of eastern region. In winter temperature may decrease below zero in the highlands, where it may cause some damages due to frost to crops. Mean relative humidity ranges from 30% in arid zones of the eastern region to above 80% in coastal areas, and generally it becomes less in winter during months of January to April.

2. Rainfall

Rainfall has generally a bimodal pattern with two rainy seasons, the first is during February, March and May, and the second in July to September and October which is the heaviest rainy season. The average annual rainfall varies from less than 50 mm in coastal areas up to 1 000 mm in the Southern uplands mainly around Ibb. In general, rainfall increases with distance from sea towards the foothills with 300-400 mm and then decreases gradually from the central highlands towards the capital Sana'a with an average of 250 mm and again increases towards Saada, Haja and eastern governorates.

3. Topographical features

Yemen generally is characterized by extremely diverse physiography, climate and soil. That is due to great changes in elevation raising from sea level to nearly 3 700 m, which form the highest peak in the Arabian Peninsula. In terms of ecology the country may be divided into four major zones, varying significantly from each other in total climatic and edaphic factors.

3.1 Coastal plain

The coastal plain lies between the Red Sea and the Arabian sea with a length of 1 920 km and it includes :

- **Western plain**

It lies between the Red Sea and the Western escapement. The altitude ranges between the sea level to about 300 m and 420 km long, and a width of 20-40 km. The plain cover a total area appr. 16 000 sq km. There are several wadis that cut Tihama plain and these are, Mor, Rima, Siham, Rusyan, Surdud and Zabid.

- **Southern plain**

It lies between the Arabian sea and the southern escarpment with altitude range between sea level to about 200 m. The plain stretch to about 1 500 km long and from 10-60 km wide. It includes the following wadies, Bana, Hassan, Ahwar, Hajer and Mayfa'a.

3.2 Mountainous regions

1. Low altitude mountains

a. Tihama foothills and low altitude Western mountains They include the mountains west of Hajja and Al-Mahweet governorate, Taiz mountains, around Madinet Al-Sharq, West Huth and West Al-Makhdeer (Ibb). The range of altitude of these mountains is between 1 000 to 18 000 m above sea level.

b. Southern mountains. They include mountains of Mukeyras, Al-Dhalaa, Yafea Al-Sufla, Jabel Eraf, Al-Awaleq Al-Sufla, Lodar, Modia and Hadramout hills. They range between 1 000 to 1 800 m above sea level.

2. High altitude mountains

They lie above 1 800 m and include mountains of Ibb, Dhamar, around Sana'a, Alturba, Saber, Reyma, Jabel Abran and Hajjah.

3. Eastern mountains

a. Hig h eastern mountains They from the division between the wadies flowing West into the Red Sea and East into the desert. They include mountains east plains of Dhamar and Amran, Huth east and north Rada, as well as mountains between Rada and Al-Bayda, and between Abyan and Al-Bayda. Their altitude is above 1 800 m above sea level.

b. Medium altitude eastern mountains They lie between 1 200-1 800 m and drop gradually into eastern desert. They include mountains east Saada, around and West Marib, North Al-Bayda, Bayhan and North Attaq.

3.3 High plains

They include plains above 1 800 m such as plains of Saada, Sana'a, Dhamar, Rada'a, Qa Bakil Qa Haql and Qa Shara and those that lie in less than 1 800 m, which include plains of Al-Qaeda.

3.4 Eastern desert (plateau)

They cover the northern boundary of Yemen and drop gradually from 1 000 m towards the north east to less than 500 m and include the area east and north Marib and Ramlet Al-Sabaateen.

4. Soil

Soils in Yemen are generally recent soils of alluvial deposits produced by water and wind weathering. They country's soils are sandy to silty and loamy in coastal regions and silty to loamy and clay loamy in the highlands. The soils are generally low in nitrogen, phosphorus and organic material. In areas in the highlands soil are shallow with often calcareous layer which leads to poor moisture retention.

5. Water resources

The country's major resources for water are rainfall and underground water represented by wells and springs. Rains water is the basic source for agriculture where about 77% of the total cultivated area depends directly on it. Nearly half of the total rainfed area receives rainfall less than 350 mm which could be considered below the minimal amount needed for rainfed agriculture. Spate irrigation is experienced in the coastal region farming, covering about 41% of the total permanent and semi irrigated area. Wells and springs are very important sources for domestic water supply and irrigation. They are common in highlands, while floods (Spate) and wells are in the coastal plains.

Water resources now days are facing shortage problems, and that is due to:

- Drastic increase in number of wells,
- Uncontrolled use of pumped water,
- Tendency to neglect the traditional spate irrigation, and
- Low quality of water for irrigation and salinization of soils.

TABLE 1

Agricultural spaces (ha) and total arable crop for the years 1997-2006,in the Republic of Yemen

Area Crops			Soures of irrigation							
Year	No of Agri Holders	Total Area	Cultivatede Area	Rains	Wells	Floods	Streams	Dams	Tank on car	Uncultivatid
1997	1 115 514	1 663 858	1 200 098	580 867	485 289	114 339	19 603	0	0	1 200 098
1998	1 115 515	1 668 858	1 279 704	678 243	383 912	153 564	63 985	0	0	2 559 408
1999	1 115 515	1 668 858	1 132 910	528 643	434 207	129 259	40 801	0	0	2 265 820
2000	1 115 515	1 668 858	1 143 441	514 550	457 375	125 776	45 740	0	0	2 286 882
2001	1 115 515	1 668 858	1 101 040	611 543	407 695	143 892	35 974	0	0	2 300 144
2002	1 115 515	1 668 858	1 133 480	532 736	430 722	124 683	45 339	0	0	2 266 960
2003	1 115 515	1 668 858	1 076 771	484 548	398 410	139 978	53 835	0	0	21 535 42
2004	1 180 105	1 609 484	1 188 888	637 416	407 869	89 363	33 924	4 215	12 517	2 374 192
2005	1 180 105	1 609 484	1 202 113	608 525	393 089	137 163	34 301	12 914	14 620	2 402 725
2006	1 180 105	1 609 484	1 309 279	656 545	424 249	148 482	36 131	26 520	17 352	2 618 558
Total	**10 233 405**	**14 841 600**	**1 1767 724**	**5 252 749**	**3 737 528**	**1 192 160**	**390 030**	**43 649**	**44 489**	**2 2428 329**

6. Crop production system

Crop production system in Yemen is generally reflected by the availability of water supply as being the most important factor. The cultivated area may very from year to year depending mainly on the amount and distribution of rainfall.

Crop production system can be divided into two as depending on water supply:

a. Rainfed farming system.This system can be classified into three categories:

1. The low rainfed system with rainfall average < 450 mm,
2. The moderate rainfed with rainfall average between 450–620 mm; and
3. The high rainfed system with rainfall average > 600 mm.

Major crops grown under rainfed farming are : sorghum, wheat, barley, millet and legumes. Barley is considered to be the base of dry land farming system in the highlands while millet is a marginal crop of low lands and sand dunes. Generally rainfed farming system is considered as the base of agriculture where more than 77% of the total cultivated area is under this system.

b. Irrigated farming system.

There are two types of irrigation under this system. These are flood irrigation which is basically used in coastal region and the deltas. Crops predominantly grown under this system are sorghum, millet, cotton, cucurbitas, legumes, sesame and groundnuts. The second system is wells and springs irrigation farming system. It forms the base of intensive agriculture mainly for cash crops such as qat, vegetables, fruits and forage crops. Under such system intercropping and crop rotations can be easily utilized.

TABLE 2

General Summary Area (HA) & Production (MT) of Agricultural Crops IN. Y.R 1997 -2006

Crop / Year		1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
Cereals	Area	721 819	770 457	624 315	619 583	657 871	593 068	532 293	685 491	688 752	756 961	6 650 610
	Prod.	646 369	833 331	693 713	672 237	700 141	559 760	417 937	490 277	495 591	726 927	6 236 283
Vegetables	Area	59 254	61 851	62 498	64 953	67 376	69 621	71 210	72 364	73 599	75 686	678 412
	Prod.	717 631	747 131	759 820	774 908	802 733	818 951	833 349	83 3416	882 053	904 889	8 074 881
Fruits	Area	81 240	84 593	88 104	91 057	95 247	97 056	98 317	80 835	82 796	84 944	884 189
	Prod.	496 139	587 956	626 307	654 954	622 785	719 701	736 216	742 408	764 790	861 984	6 813 240
Legumes	Area	57 137	62 468	51 079	51 450	52 679	51 638	51 276	35 936	38 941	47 314	499 918
	Prod.	66 109	77 973	64 219	63 080	64 033	61 845	60 804	63 940	61 180	83 239	666 422
Cash Crops	Area	179 623	188 741	192 717	200 233	208 295	209 576	210 852	194 429	197 273	216 543	1 801 009
	Prod.	145 416	162 488	16 556	177 006	177 891	174 658	174 899	184 185	190 360	228 930	1 442 029
Feeders	Area	101 379	112 125	114 197	116 165	117 636	114 547	114 862	121 878	122 803	127 832	1 163 424
	Prod.	1 090 639	1 380 571	1 399 477	1 450 669	1 467 706	1 429 455	1 432 310	1 505 204	1 541 288	1 626 911	14 324 230
Total	**Area**	**1 200 452**	**1 280 235**	**1 132 910**	**1 143 441**	**1 199 104**	**1 135 506**	**1 078 810**	**1 190 933**	**1 204 164**	**1 309 279**	**11 874 834**
	Prod.	**316 203**	**3 789 450**	**3 709 102**	**3 792 854**	**3 835 289**	**3 764 370**	**3 655 515**	**3 819 430**	**3 935 261**	**4 432 880**	**35 050 354**

CHAPTER 1

THE STATE OF DIVERSITY

1.1 Basic value of the plant genetic resources

Republic of Yemen has diverse flora, but diversity of wild crop and wild flora as well as indigenous knowledge on both domestic and wild plants are gradually diminishing. Many of these plants are used by people for food, firewood, fodder, medicinal and for other purposes.

1.2 Diversity within and between PGRFA species

1.2.1 The diversity of PGRFA species

It has been estimated that there are about 2 900 plant species belongs to 175 families have been registered in Yemen, more than 420 of which are endemic (Al Khulaidi, 2000). There are about 521 indigenous Plant Genetic Resources for Food and Agriculture (PGRFA), belonging to 75 families and 235 Genera, out of theses 87 are endemic and 15 are near endemic (Table 1.2.1).

TABLE 1.2.1
Indigenous PGRFA in Yemen

Number	Botanical family	Genus	Species	Endemic	Near endemic	Number	Botanical family	Genus	Species	Endemic	Near endemic
1	*Acanthaceae*	9	13	7		20	*Burseraceae*	2	6	5	
2	*Aizoaceae*	1	1			21	*Cactaceae*	1	2		
3	*Aloeaceae*	1	33	19	13	22	*Caesalpiniaceae*	2	2		
4	*Amaranthaceae*	2	3			23	*Capparaceae (Capparidaceae)*	2	3		
5	*Anacardiaceae*	3	6	2		24	*Caryophyllaceae*	2	3		
6	*Annonaceae*	1	1			25	*Celastraceae*	1	1		
7	*Anthericaceae*	2	3	1		26	*Chenopodiacea*	3	3		
8	*Apiaceae (Umbelliferae)*	5	5			27	*Combretaceae*	1	1		
9	*Apocynaceae*	3	5			28	*Commelinaceae*	2	2		
10	*Arecaceae (Palmae)*	5	7			29	*Convolvulaceae*	5	8	3	
11	*Asclepiadaceae*	3	3	2		30	*Cucurbitaceae*	7	12		
12	*Asparagaceae*	1	1			31	*Cupressaceae*	1	1		
13	*Asteraceae (Compositae)*	7	7	1		32	*Cyperaceae*	2	6		
14	*Balanitaceae*	1	1			33	*Dioscoreaceae*	1	1	1	
15	*Basellaceae*	2	2			34	*Dracaenaceae*	1	1		
16	*Bignoniaceae*	1	1			35	*Ebenaceae*	2	3		
17	*Bombaceae*	1	1			36	*Euphorbiacea*	3	4	3	
18	*Boraginaceae*	3	6	1		37	*Flacourtiaceae*	1	1		
19	*Brassicaceae (Cruciferae)*	1	3			38	*Juglandaceae*	1	1		
						39	*Lamiaceae*	8	10		

Number	Botanical family	Genus	species	endemic	near endemic	Number	Botanical family	Genus	species	endemic	near endemic
40	*Liliaceae*	2	3			58	*Polygonaceae*	2	2		
41	*Linaceae*	1	1			59	*Portulacaceae*	1	2	2	
42	*Malpighiaceae*	1	1	1		60	*Punicaceae*	1	3	1	
43	*Malvaceae*	3	9			61	*Ranunculaceae*	1	3		
44	*Mimosacea*	4	28	5		62	*Rhamnaceae*	2	1		
45	*Moraceae*	1	6			63	*Rosaceae*	6	3	1	
46	*Moringaceae*	1	2			64	*Rubiaceae*	3	1	3	
47	*Myrtaceae*	3	3			65	*Rutaceae*	3	2		
48	*Oleaceae*	1	1			66	*Salvadoraceae*	2	8		
49	*Orchidaceae*	1	1	1		67	*Sapindaceae*	1	12		
50	*Oxalidaceae*	1	1			68	*Scrophulariaceae*	1	1		
51	*Pandanaceae*	1	1			69	*Solanaceae*	6	6	1	
52	*Papaveraceae*	1	1		1	70	*Sterculiacaeae*	1	1		
53	*Papilionoideae (Fabaceae)*	28	64	16		71	*Tiliaceae*	2	1		
54	*Pedaliaceae*	1	1			72	*Ulmaceae*	1	3		
55	*Piperaceae*	1	1			73	*Verbenaceae*	1	4	1	
56	*Plantaginaceae*	1	3		1	74	*Vitaceae (Vitidaceae)*	4	1	1	
57	*Poaceae (Graminea)*	44	149	9		75	*Zingiberaceae*	1	1		
	Total	**148**	**378**	**65**	**15**			**87**	**10**	**22**	
								235	**521**	**87**	**15**

1.2.2 The state of diversity of major crops

Differences in environmental conditions among the agro-ecological zones of Yemen make it possible to grow a wide range of tropical, subtropical and temperate crops. Two broad farming systems are practiced in the country: rainfed and irrigated agriculture. Rainfed agriculture is practiced in about 68% of arable land. The main crops are cereals, legumes, vegetables, fruit trees, and industrial and stimulant crops including sesame, cotton, tobacco, qat, and coffee**.**

The country's crop diversity is comprised of cultivated crop species and varieties grown for different uses of the community. These have evolved through natural selection and selective breeding by traditional agricultural practices over long periods in the different environmental conditions of the country. Crop relatives and wild species also have been used for different purposes. The resultant varieties and races of crops may form homogeneous varieties or heterogeneous populations. The number of land races of each crop species is dependent on the distribution of the crop across the environment. Crop diversity is the basis for successful agriculture and the sustainable use of the country's scarce water and soil resources. Forty plant species belonging to 27 genera and 16 families (Table 1.2.2) are cultivated in the country; these are cereals, legumes, fruits, vegetables and industrial and stimulant crops.

TABLE 1.2.2
Major Crops for each Family

No	Scientific Name	Family
1	*Abelmoschus esculenthus* (L.)Moench.	*Malvaceae*
2	*Allium porrum* L.	*Liliaceae*
3	*Allium sativum* L.	*Liliaceae*
4	*Brassica oleracea* L. var. botrytis	*Brassicaceae (Cruciferae)*
5	*Brassica oleracea* L. var. capitata	*Brassicaceae (Cruciferae)*
6	*Capsicum frutecens* L.	*Solanaceae*
7	*Catha edulis* Forsk.	*Celastraceae*
8	*Citrus aurantifolia* (Christum) Swingle.	*Rutaceae*

No	Scientific Name	Family
9	*Citrus limon* (L.)Burm.f.	*Rutaceae*
10	*Citrus sinensis* (L.)Osbeck.	*Rutaceae*
11	*Coffea arabica* L.	*Rubiaceae*
12	*Cucumis melo* L. subsp. agrestis (Naud.) Greben.).	*Cucurbitaceae*
13	*Cucumis sativus* L.	*Cucurbitaceae*
14	*Cucurbita pepo* L.	*Cucurbitaceae*
15	*Daucus carota* L.	*Apiaceae (Umbelliferae)*
16	*Hordeum vulgare* L.	*Poaceae (Graminea)*
17	*Lens culinaris*	*Papilionoideae (Fabaceae)*
18	*Lycopersicum esculentum* Mill.	*Solanaceae*
19	*Mangifera indica* L.	*Anacardiaceae*
20	*Phaseolus vulgaris* L.	*Papilionoideae (Fabaceae)*
21	*Phoenix dactylifera* L	*Arecaceae (Palmae)*
22	*Pisum sativum* subsp. *pumilio*	*Papilionoideae (Fabaceae)*
23	*Sesamum indicum*	*Pedaliaceae*
24	*Psidum guajava* L.	*Myrtaceae*
25	*Solanum melongena* L.	*Solanaceae*
26	*Solanum tuberosum* L.	*Solanaceae*
27	*Sorghum bicolor* (L.) Moench	*Poaceae (Graminea)*
28	*Trigonella foenum-graecum*	*Papilionoideae (Fabaceae)*
29	*Triticum aestivum*	*Poaceae (Graminea)*
30	*Triticum dicoccum*	*Poaceae (Graminea)*
31	*Triticum durum*	*Poaceae (Graminea)*
32	*Triticum monococcum*	*Poaceae (Graminea*
33	*Triticum turgidum*	*Poaceae (Graminea*
34	*Vigna unguiculata*	*Papilionoideae (Fabaceae)*
35	*Vitis vinifera* L.	*Vitaceae*
36	*Zea mays* L.	*Poaceae (Graminea)*
37	*Gossypium arboreum*	*Malvaceae*
38	*Gossypium barbadense*	*Malvaceae*
39	*Gossypium herbaceum*	*Malvaceae*
40	*Gossypium hirsutum* var. punctatum	*Malvaceae*

Cereals remain the principal crops in the country and occupy 42% of the arable land. The grains of these crops constitute the basic food source for the majority of the population and main source of forage for draft animals. Cereal crops include sorghum, millet, maize, wheat, and barley.

Sorghum is the most important crop grown in the country as it has been the traditional food source for people for thousands of years. Local varieties of sorghum have a high adaptability to the different environmental conditions in the country. Sorghum varieties are grown under flood irrigation on the coastal plains, under rainfed conditions on mountain terraces and inter mountain plains, and under tube well irrigation in the eastern region. Some sorghum varieties have a high capability to produce on land with marginal water resources. There are thousands of varieties of sorghum that have evolved through centuries to successfully adapt to the many different environments of the country. Most of the sorghum cultivars belong to *Sorghum bicolor* (L) Moench with 5 basic races (*bicolor*, *guinea*, *caudatum*, *kafir*, and *durra)* and their crosses. Hybrid races contain many different combinations of these basic races such as *durra-caudatum* , *guinea-bicolor* and *kafir-caudatum* .

Millet is grown mainly on the western Tihama plains and on the southern and eastern coastal plain. Local varieties include three types of millet:

1. Pearl millet *Pennisetum glaucum* which includes Dukhn, Tihama, Mossaibli, Khabti and Mazraai;
2. Finger millet *Eleusina coracana* which includes Kanib; and
3. Little millet *Panicum rigidum* which includes Habah.

Genetic variability is not limited to the number of local varieties.

The main causes of millet genetic erosion are:

- Introduction of high yielding varieties which replace the local ones;
- Erosion of local knowledge about the specific differences of local varieties; and
- Shift of the human diet towards imported wheat flour which is subsidized by the government.

Maize is grown under irrigation systems, or under rainfed conditions in areas with high rainfall like Ibb and suplimentery irrigation in other Southern Uplands and Central Highlands. Local varieties of maize are identified by their growing period as early, intermediate and late varieties (Thulathi, Ruba'i and Khumasi) or by their counery of introduction (Hind, Romi, Sham, and Misri). Most of local maize populations grown in the country are generally flint or semi-flint types, and mostly yellow grain color.

Wheat is grown mainly in the highlands above 1 500 masl. Some 103 000 ha of cultivated land is devoted to wheat of which 60% is concentrated in Sanaa and Dhamar governorates. The total wheat production is about 149 000 tons which constitutes only 9% of wheat consumption in the country. There are about 40 varieties and land races of wheat belonging to five species which are currently cultivated: *Triticum monococcum* L; *T. dicoccum*; *T. durum*; *T. aestivum* L; and *T. turgidum.*

Barley is grown as dual purpose crop, for grain used for human consumption and whole plant yields for animal forage. Barley is highly adapted to water stress environments and is produced even on land with very marginal rainfall. Barley is classified as follows:

- *Hordeum vulgare* L. emend Lam, six-rowed cultivars grown under irrigation and harvested at the heading stage, mostly in Wadi Shebam representing only 1% of barley cultivation; and
- *H. distichon* L. emend Lam, two-rowed cultivars grown under rainfed conditions for dual purposes represented by Saklah, Zarabi, Aswad, Bakoor, and the hulless (naked) Habib, constituting 99% of barley cultivation.

Legume crop species are grown at different agro-ecological zones and are considered to be important sources of protein. About 54 000 ha is devoted to legume crops annually which produces about 75% of the country's demands. The most important legumes cultivated under rainfed conditions include *Vigna*, lentils, dry peas, and fenugreek. Generally, common beans and broad beans are grown under supplemental irrigation. Little attention has been given to classification of different legume crop species. There is a wide variation of *Vigna* spp. grown in different environmental conditions including *Vigna ungiculata, V. aconitifolia* and *V. radiata*.

The production of horticultural crops was part of traditional agricultural practices from early historical times as evidenced by the development of water conservation technologies such as construction of dams and terrace systems. A wide variation of deciduous, tropical and subtropical fruit crops are grown in Yemen. Every agro-ecological zone has a specialized fruit crop production; deciduous fruits are grown in the highlands and tropical and subtropical fruits are grown in the lowlands of Tihama, and in the eastern and southern plains and plateaus.

Deciduous fruits such as peaches, apples, figs, pears, and almond are sometime grown around houses or wells and along the irrigation channels. In general, farmers own few trees which receive little attention and keep the fruits for family and neighbours. There are only a few orchards that are planted with introduced varieties.

Yemen is particularly well known for its traditional production of grapes and pomegranates. Grapes are the most important fruit crop grown in the country and Yemen has been producing high quality grapes for centuries. Grapes are cultivated in areas ranging in altitude of 1 350 - 2 000 m and are concentrated in Sana'a and Sadah governorates. Different grape varieties are grown at different locations. There are about 40 local grape varieties most of which belong to the *Vitis vinifera* and the group of *Conver orientalis* Negr; others belong to the group of *Conver pontica* Negr. Several varieties are grown in the same region; however, each region is famous only for one variety which may take the name of that region. For example, Raziki is grown in different regions, but the best tasting variety is grown in Al-Rawdah and is called Rawdhi. Color, size and shape of the fruit are the main characters used for differentiating grape varieties Although, similarity in color exists among grape varieties, genetic variation exists among varieties having the same color and which are grown at different locations.

Some 40 date palm varieties have been identified in Yemen, and most are grown mainly in the Tihama lowlands and Wadi Hadramout. Date palm plantations are concentrated on the banks of five major wadis dissecting the Tihama plain from the mountain foothills to the Red Sea, which include Ressian, Zabid, Remaa, Surdod, and Mour wadis. Date palm plantations are under flood irrigation systems. Because of the shallow root systems of date palms, some plantations have even been established on the coastal areas of the Red Sea. Either naturally growing or planted, date palms depend on shallow ground water derived from rainfall in the mountains. In recent years, disturbance of the delicate balance between

the fresh rainwater and salt water near the coast has been catastrophic for the palm trees in the coastal areas. The over pumping of ground water and construction of small dams have prevented the mountain rain water from reaching palm trees close to the sea coast, which has resulted in gradual death of these trees.

Vegetable crops are grown in the most fertile soils of most agro-ecological zones of the country. The total area devoted to vegetable crops is about 57 000 ha out of which 50% is cultivated with potato and tomato crops. There are more than 20 species of vegetables, which are grown mainly under irrigation system. The areas under vegetable cultivation are gradually being increased due the expansion of irrigated lands. Ground water depletion is the main negative result of this expansion. Several exotic varieties are currently in cultivation.

Coffee (*Coffea arabica* L.) is famous cash crop in Yemen; it is cultivated in wide range of ecological zones and is best grown at altitudes between 1 000-1 800 masl. Coffee is grown under rainfed conditions as well as under irrigation from springs, wells, and wadi-based water. Different varieties of *Coffea arabica* are distinguished by differences to drought tolerance, shape of the plants, and color, size, shape, and taste of coffee fruits. The local names of coffee varieties in most cases refer to the cultivation areas or shapes of coffee trees and fruits.

The most common local coffee varieties are: Al-Odaini, Al-Hammadi, Al-Shami, Al-Sharki, Koubri, Borai Bonen, Al-Baidani, Al-Matari, Al-Bori, Al-Jaadi (Biad & Sawed), Al-Bonen, Al-Haimi, Al-Yafei, Al-Dawaeri, Al-Tofahi, and Hofaini. Comprehensive studies and classification of local coffee varieties should have priority in crop improvement programs within the Ministry of Agriculture and Irrigation.

Qat (*Catha edulis* Forsk), a high cash crop used as stimulant by most men and some women in the country, is one of Yemen's major crops and is cultivated on 91 418 ha or 5.5% of the total arable land in the country. In general, qat is best grown under irrigation in areas above 1 500 m. Qat cultivation seems to be increasing with the expansion of irrigated land at the expense of other crops. Since the most favorable environment for Qat cultivation is similar to that of coffee and grapes, these crops are the most likely to suffer from Qat expansion.

1.2.3 Minor crops and underutilized species

The main minor crops and underutilized species in Yemen account for about 55 species (Table 1.2.3). Minor crops could classified to six groups: Cereals 4 species, vegetables 16 species, spices and flavouring 7 species, fruits and beverage 18 species, oilseeds 7 species and nut 3 species. The cultivation of most of these crops have been decreased dramatically.

TABLE 1.2.3
Minor crops in Yemen

Group:/Scientific Name	Group:/ Scientific Name	Group:/ Scientific Name
Cereals:	*20.Vigna radiata*	**Fruits and beverage:**
1.Panicum miliaceum	**Spices and flavouring:**	*38.Annona squamosa*
2.Setaria italica	*21.Dianthus caryophyllus*	*39.Borassus aethiopum*
3.Eleusine coracana	*22.Foeniculum vulgare*	*40.Ceratonia siliqua*
4.Eragrostis tef	*23.Lilium candidum*	*41.Citrullus lanatus*
Vegetables:	*24.Ocimum tenviflorum*	*42.Citrus deliciosa*
5.Beta vulgaris subsp. *maritima*	*25.Piper betle*	*43.Citrus medica*
6.Capsicum annum	*26.Ruta chalepensis*	*44.Cydonia oblonga*
7.Cicer arietinum	*27.Zingiber officinale*	*45.Malus sylvestris*
8.Cichorium endivia	**Oilseeds:**	*46.Myrtus communis*
9.Coriandrum sativum	*28.Balanites aegyptiaca*	*47.Opuntia ficus-indica*
10.Cucurbita maxima	*29.Carthamnus tinctorius*	*48.Pithecellobium dulce*
11.Cucurbita moschata	*30.Ceiba pentandra*	*49.Prunus armeniaca*
12.Ipomoea batatas	*31.Helianthus annus*	*50.Prunus domestica*
13.Lablab purpureus	*32.Hibiscus sabdariffa*	*51.Prunus persica*
14.Laginaria siceraria	*33.Linum usitatissimum*	*52.Punica granatum*
15.Luffa cylindrica	*34.Nigella sativa*	*53.Pyrus communis* subsp. *sativa*
16.Petroselinum crispum	**Nuts:**	*54.Saccharum officinarum*
17.Piper betle	*35.Juglans regia*	*55.Tamarindus indica*

Group:/Scientific Name	Group:/ Scientific Name	Group:/ Scientific Name
18.Spinaica oleracea	*36.Cocos nucifera*	
19.Vigna aconitifolia	*37.Prunus dulcis*	

1.2.4 Wild crop relatives and wild plants for food production

Wild food is used here to describe all wild natural plant species, which are collected for the purpose of human consumption outside agricultural areas in woodlands, shrub lands, and other rangeland areas, these are namely fruits, seeds, leaves, roots, tubers, gums and others.

Wild crop relatives have been used and still as food supplement and as a means of survival during times of drought and famine, these wild cropes are still use in many areas, example are: *Ficus palmata*, *Olea europaea* L. subsp. *cuspidata*, *Punica granatum*, *Punica protopunica*., *Dianthus uniflorus*, Fibre wild crop relatives are *Gossypium incanum*, *Gossypium stochsii* and *Gossypium areysianum*.

Yemen contains reasonable wild crops, which provided food for thousands of year. The state of diversity of medicinal, aromatic and other minor wild plants were slightly identified through several surveys, but still more and intensive activities should be done in future time. Few books were published on the medicinal and aromatic plants of Yemen. Recent study (Al Dubae & Al Khulaidi, 1997) has described 148 plant species for food and medicines belonging to 129 families and 68 Genera. Some of these have commercial values examples are: *Dracaena cinnabari, Aloe inermis, A. vera, Phoenix dactylifera, Helianthus annus, Jatropha curcus, Ricinus communis* and others. Many local people still make some of their income from wild plant species, including fruits, of trees and shrubs (e.g. *Ziziphus spina-christi, Annona squamosa, Opuntia ficus-indica, Opuntia dillenii*) or herbs (*Pulicaria jaubertii, Rumex nervosus, Cissus rotundifolia, Cyphostemma digitatum, Thymus laevigalus* and *Portulaca oleracea*).

1.3 Factors influencing the state of PGRFA diversity

The process of modernization and continuous development in agriculture during the last decades, more or less has led to activate the dissemination of improved varieties at production level. There is no yet accurate data for percentage of area grown by improved varieties. However, from rough estimate it can be indicated that more dynamic replacement to exist in vegetables with nearly more than 90%, in wheat 15-20% as well as in maize. Active introduction of improved varieties of fruits has also increasingly been expanded. Improved varieties are more likely introduced in conditions that are more favourable and where intensive agricultural system is experienced. Varietals replacement may also account to one land race to replace the other as this may be enhanced with the expansion of road networks and better communication and transport means making the transfer of seed of plant material from location to location easier.

The cultivation of most of major crops have been subjected to genetic erosion. Among the most important factors for genetic erosion are:

1. Periodic drought;
2. Change in cropping pattern and drastic shift towards each crops;
3. Expansion of infrastructure and building in agricultural lands;
4. Terraces erosion and
5. Sand dune movement and desertification.

In wheat, it is has been found drastic decrease in the area of growing the land race. Alas, an old land race of unthreshable form (*Triticum dicoccum*), due to its relatively low yield and difficulties in threshing. Finger millet (*Eleusine crocana*), (*Eragrostis tef*) and oil rape (*Brassica napus*, var., *napus*), which were among the important traditional crops to be grown in the country, are no more grown or only grown in very specific areas. Terrace deterioration and seasonal flood destruction can be among the major factors that cause partial loss of land races. Qat (*Catha edulis*) expansion also is among the factors that lead to threaten plant genetic resources.

There is an increasing focus pressure on minor wild plant species to meet the demand of increasing population. The diversity of minor wild plants in their habitats is getting dramatically decreased. Diversity of some species that are utilized by local people as traditional food or as medicinal plants are also in danger this due to intensive utilization of these plants and lack of ecological education and protection activities.

Diversity of some plants, extensively used by people with small industrial and sale is also in danger. These plants include: *Pulicaria jaubertii, Rumex nervosus, Cometes abyssinica, Dianthus uniflorus*, *Foeniculum vulgare* and *Portulaca oleracea*. Wild plant species that have been used also in hunger & famine time enclude *Cissus hamaderohensis, C. quadrangularis, Lycium shawii,* L. *sokotranum, Commiphora kua, C. ornifolia, C. parvifolia, C. planifrons,* and *C. socotrana*, these species can be in critical conditions in future time.

The loss of plants is related directly or indirectly to population growth. Population growth brings further pressure on the natural vegetation lands for urban development and cultivated production. The movement of rural population to main cities has caused major pressure on plant biodiversity. Due to over cutting, expand of buildings and infrastructure, species like *Dobera glabra* and *Thymus laevigalus* are losing their natural areas. Few fruit trees and shrubs such as *Syzygium guineense, Lannea transulta, Punica protopunica, Rosa abyssinica, Tamarindus indica, Balanites aegyptiaca* and others are found as scattered and highly endangered.

Intensive use of some wild plants as food or as feed has threatened some species; these are *Chapmannia gracilis, Chapmannia sericea, Commiphora ornifolia, Commiphora parvifolia Commiphora planifrons, Commiphora socotrana, Lannea transulta*. Some species are also in endangered; these are *Chapmannia reghidensis, Chapmannia tinireana, Justicia takhinensis, Neuracanthus aculeatus* and *Portulaca samhaensis*.

Overgrazing is also playing an important factor in decreasing of wild palatable grasses. For example species such as *Hyparrhenia papiilipes, Hyparrhenia quarrei, Hyparrhenia variabilis, Taverniera lappacea, Seddera fastigiata, Seddera semhahensis, Neuracanthus aculeatus, Metaporana obtuse, Marsdenia robusta, Justicia takhinensis, Helichrysum nimmoanum, Heliotropium kuriense, Festuca obturbans, Eragrostis curvula, Eragrostis aspera, Croton sulcifructus, Clerodendrum galeatum, Chrysopogon aucheri, Chloris roxburghiana, Chapmannia gracilis, Chapmannia reghidensis, Chapmannia sericea, Chapmannia tinireana, Cephalocroton socotranus, Brachiaria ovalis, Brachiaria brizantha, Brachiaria chusqueoides, Brachiaria comata, Arthraxon micans, Aristida migiurtina* and *Aristida funiculate* are rare or endangered in their habitats, some of these species are endemic to Yemen.

1.4 Future needs and priorities

- Further studies and collection of information about the traditional uses of wild crops
- Studying the present state of diversity, relative important and regional important of wild crops
- Studying threats of genetic vulnerability and causes of genetic erosion of plant diversity
- Establishment and maintenance of large natural protected areas
- Developing of potential sources for the local population, such as collection and storage of wild economical crop seeds
- Cultivation and export of economic plants using small scale farms
- Mapping of important plant biodiversity areas (e.g. vegetation and land use maps)

1.5 State of arts

A large number of techniques have been employed to describe and assess the plant genetic diversity in the world. To assess and analysing the wild plant species, the following activities were conducted in different ecosystems. Intensive vegetation survey following Braun-Blanquet and TWINSPAN approaches were conducted accompanied by Taxonomical identification of the plant species. Measurement of diversity, frequency and important values of each plant species were done by using different modern softwares such as Multi-Variate Statistical Package (MVSP) and BioDiversity Professional Beta. Mapping the vegetation and the distribution of wild plant species was done using the modern technology, which apply using GIS techniques and softwares such as ArcGis, ERDAS-Imagine and DIVA-GIS.

CHAPTER 2

THE STATE OF *IN SITU* MANAGEMENT

2.1 PGRFA inventories and surveys

Natural protected areas are the *in situ* method for the conservation of biological diversity and areas with unique or rare characteristics. The protected areas preserve all elements of the ecosystem and protected them from deterioration. The protected areas provide suitable sites for field studies and research, suitable site for ecological public awareness and for monitoring environmental change, they provide grounds of studies and research on biodiversity and natural resources, they support the educational programs in school in universities and schools in the study of natural resources and field training.

In many parts of the country traditional small *in situ* management areas can be found, these areas mainly situated around or near villages and privately or communally owned. Traditional rules are used as measure to these protected areas and mainly used for grazing. The implementation of those rules are deferent from place to another, the commoner rules are formed by agreement with a specific fine or animals for cutting trees from the protected areas. These *in situ* management areas are represent the better managed areas of the Yemen, and normally managed by local communities, village leaders or Sheikh, and help to protect the Plant Genetic Resources for Food and Agriculture (PGRFA).

Several activities have been undertaken during last 5 years to inventory and the study of current state of plant genetic resources in the *In situ* conservation areas. Agricultural Research Extension Authority (AREA), Environmental Protection Authority (EPA) and other international and national organizations, has carried out these studies. The recent surveys have focused mainly on 4 priority protected areas, namely Jabal Bura', Huf (Al Mahara), Soqotra Isalnd and Utuma. Different ecological zones were surveyed in which 36 areas were proposed as protected areas, the Table 2.1 shows 5 protected areas that have been declared as protected areas.

TABLE 2.1
5 protected areas and date of declaration

Name	Type	Location	Declaration date
Utuma	Mountain	Dhamar Gover	5 June 1999
Soqotra	Mountain-marine	Hadhramaut Gover	27 September 2000
Huf	Mountain	Al Mahara Gover	August 2005
Jabal Bura	Mountain	Al Hudayda Gover	January 2006
Wet lands	Mountain-marine	Aden Gover	August 2006

Jabal Buraa is considered to be one of the richest area in biodiversity. It contains suitable conditions for floristic and wild life diversity. It represents on of the important remaining natural forest in Yemen. It is also considered as one of the richest natural reserves since it houses a diversity of plants and animals. However this are is exposed to dangerous human impact which leads to a serious degradation to the area.

Huf, al Mahara area is very rich in vegetation and composed of forest dominated by *Anogeissus dhofarica Dodonaea angustifolia* and *Jatropha dhofarica.* The area is rich in species which are endemic to Huf and Dhufar region, among the important endemic plant species: *Maytenus dhofarensis*, *Euphorbia smithii*, *Jatropha dhofarica,*, *Commiphora foliacea Anogeissus dhofarica*. It represents on of the important remaining natural forest in Yemen. It is also considered as one of the richest natural reserves since it houses a diversity of plants and animals.

Soqotra Archipelago was considered this year as World Heritage Site. Soqatra island lies off the northeast corner of Africa (between lat. 12 19′ to 12 42′, and long. 53 20′ to 54 30′) and it is about 3 799 km^2 and part of Hadhramaut governorate.

It can be divided into three main topographical zones :

1. coastal plains
2. a limestone plateau
3. mountains, reach up to 1 519 m

The island is sparsely vegetated and dominated by xeromorphic forms. The coastal plains and low inland hills are covered by open deciduous shrub land dominated by the *Croton socotranus, Dendrosicypos socotrana,* and *Adenium obesum*. On the higher altitudes we find *Boswellia* spp. and other species, which yields frankincense, such as *Psiadia, Euryops* and *Pluchea*. One of the most famous species of Soqotra is the Dragon's blood tree (*Dracaena cinnabari),* which is found on the plateaux and mountain grassland. There is about 825 plant species have been recorded in the island so far, and of these 307 are endemic (Miller and Morris, 2004). Many of these plants have traditional use, such as fodder, fuel wood, building materials, gums, foods, resins and medicines. The following Table 2.2 shows three proposed sites to be *in situ* conservation areas in the near future.

TABLE 2.2

Proposed *in situ* conservation area in near futhure

Name	Type	Location	Notes
Bilhaf, bir ali	Coastal	Hadhramaut	Coral reef
Jabal eraf	Mountains	Lahj	Juniperus procera woodland
Sharma-jathmun	Marine	Hadhramaut	Turtle hatching habitat

Many areas that are located in different ecological site of Yemen have been proposed to be protected areas. The following table shows a draft List of Important Plant Areas in Yemen for Conservation of wild plant genetic resources for food and agriculture.

TABLE 2.3

Draft list of plant areas for conservation of wild PGRFA

Name	Key Floristic description
Soqotra Archipilago	
Aden – wetlands	
Aden –Wadi Dhulnafa Protected Area	Last remaining area of Aden's unique wadi and cliff vegetation
al Luhayya mangrove	Other areas to be identified (on Red Sea islands)
Bir Ali	Mangrove woodland
Hayfan	Juniper woodland
High Mountains of Ibb (J. Takar, Jebal Bada'an, Jebal Manar etc (2800 masl)	Grasslan areas, contain segnefecnt fooder for animals
Huf (al Mahara)	Representative areas of escarpment "monsoon" woodland, plateau vegetation and representative vegetation of desertic dip-slope to be identified
Hujarayah – Wadi Adoof etc	Richest area for endemics on Arabian mainland – representative areas yet to be identified
Jebal alArays	Summit area and SW facing valley (Abyen)
Jebal Bura	Including Wadi Aswad
Jebal Fartak	Relict monsoon woodland
Jebal Lawz,	Juniper open shrubland
Jebal Melhan,	Representative areas of summit grassland and escarpment woodland to be identified
Jebal Raymah	Representative areas of summit grassland and escarpment woodland to be identified
Makalla (coastal plain)	Coastal plain E of Makalla – area to be agreed
Maifa Hajr	*Wissmannia carinensis* woodland
Plateau and escarpment above Al Mukalla	Fog-affected escarpment and plateau areas
Plateau Forest	Relict areas of Acacia origena woodland to be identified
Succuelnt Euphorbia"forest"	Representative areas to be identified
Succulent shrubland	Representative areas to be identified – both on escarpment foothills and inner plateau (Euphorbia balsamifera assocations)

Name	Key Floristic description
Tihama	Representative areas of different vegetation types to be identified (eg Dobera glabra woodland in Wadi Yur)
Al Udayn, Rayma & Wusab	Rich wadi vegetation in high rainfall area – vegetation of other high rainfall areas to be identified
Desert vegetation	**Representative of all desert vegetation types to be identified**

Several detail vegetation surveys have been undertaken in different land ecological areas during last decade, the results have been presented in report and land ecological maps. These vegetation surveys and inventories have basically focused on western and southern mountain areas. Generally, the aims of the previous studied and inventories **were not focusing** on plant Genetic Resources for Food and Agriculture (PGRFA).

TABLE 2.4
List of vegetation surveys conducted last decade

Survey	Conducted by	Year
Natural and Protection areas of Yemen	Ministry of Agriculture and Water Resources, DGFDS Project FAO/GCP/ YEM/015/SWI, (1996),	1996
A vegetation survey of wadi Rimaa catchment areas	Land and water conservation project (Forestry component) UTF/ YEM / 023 . Sana'a , Yemen.	1996
A vegetation survey of Wadi Sharis catchment areas(Hajjah)	Land and water conservation project (Forestry component) UTF / YEM / 023. Sana'a , Yemen	1996
Vegetation types of the upper Wadi Rusyan catchments area , Taiz , with a map scale 1: 50000	Natural & Water Resources Authority, UND/DSMS - YEM 93/ 010 - Dar EL - Yemen Taiz , Yemen ,	1997
Vegetation survey and mapping of J. Bura' protected area	Sustainable Environmental Management Programme, Sana'a, Yemen	2003
Studying the environmental impact on Vegetation of Wadi Edim in Wadi Hadhramaut	DOVE Energy	2005
Studying the environmental impact on Vegetation of Hadhramaut/Shibam boundary	OMV Oil Company.	2007

A number of priority areas were selected to carry out surveys. There are some difficulties to explore and inventory of biodiversity in some areas this because of insufficient financial resources and lack of experience among the staff engaged in these activities. A major limitation for the study of current state of biodiversity is the lack of experience in taxonomists and plant ecologist. Several surveys were carried out and still by some local government organizations with staff that have no any experience in wild plants.

2.2 On-farm management and improvement of PGRFA

Yemeni farmers have been practicing some sort of PGRFA by themselves without the present of any formal entities. The are no incentives system for such activities whatsoever or any forums. With the support of ICARDA a participatory plant breeding program was carried back in the end of the last century. Small scale seed production is carried out by the farmers themselves and in some cases newly introduced varieties are produced with the help if extension in some areas through what is named "Seed banks". The extension gives the farmers certain amount of seeds which they have to return and sell the extra seed to other farmers.

2.3 Future needs and priorities

- Caring on detail vegetation survey of the declared and proposed protected areas.
- Gathering information about the usage of wild plant species for food or other purposes.
- Supporting the traditional protected areas
- Staff envelopment and training to meet the international standards in the studies with up-to-date knowledge and database management.

CHAPTER 3

THE STATE OF *EX SITU* MANAGEMENT

Ex Situ conservation centers of plant genetic resources in Yemen increased rapidly at the end of the 20th century and the beginnings of the current century. These centers affiliated to the governmental sector mainly the Agricultural Research and Extension Authority (AREA) and public universities. The number of conservation facilities has increased from 7 in 1996 to 22 in 2006; and they conserve more than 6 000 accessions. There also some Yemeni plant genetic resources conserved in international centers.

3.1 Main *ex situ* conservation organizations

3.1.1 Agricultural Research and Extension Authority (AREA)

AREA is the largest public sector that holds most of the *ex situ* conservation through its research station network in the various ecological zone of the country. It also houses the National Genetic Resources center (NGRC) in its head quarter in Dhamar governorate. This center besides its conservation role coordinates and supervises other activities such as regeneration, collection and evaluation carried out in the other station of AREA. The center has the capacity of traditional and molecular characterization of germplasm and also has relations with regional and international centers. In addition to the NGRC, AREA mantains seven fruit tree field genebanks in the different agroclimatic zone of the country.

3.1.2 Faculty of agriculture, Sana'a University

The Faculty of Agriculture, Sana'a University has the second largest genebank in Yemen in terms of number of accessions conserved. The center also has a remarkable activity in documentation of traditional agricultural knowledge in Yemen. Some survey and collection missions are jointly implemented or coordinated between AREA and the Faculty through the two centers.

3.1.3 Foreign organizations

Many foreign organizations have realized the importance of Yemen plant genetic resources; amongst the pioneers was the royal botanic garden of Britain that have collected and conserved some of the rare plants of Socotra Island during the British presence in Yemen. Moreover, the USDA, USA is holding the largest collection of Yemeni sorghum germplasm collected in the late of the seventies of the 20th century. Other organizations are listed in Table 3.1.

TABLE 3.1
Yemeni germplasm conserved in some International Genebanks[b]

Name of Organization	Species or Crop	Number of accessions
USDA	34	4 885
ICARDA	8	290
AVRDC	1	4
CIAT	1	1
ILRI	1	13
ICRISAT	3	2 357
IITA	1	27
CIMMYT	1	2

Name of Organization	Species or Crop	Number of accessions
Vavilov Institute	na	150
Global Seed Vault	na	870
Total		**8 619**

[b] The information obtain from their web sites.

3.2 Types of conservation

Most of the seed genebanks still depend on small scale refrigerators except the National Genetic Resources Center of AREA and Faculty of agriculture Sana'a University center. Generally most cold storage facilities are in serious need for maintenance and upgrading in addition to training of the working staff in the proper maintenance methods of the facilities in general.

In order to improve the status of field genebanks and botanic gardens the followings have to be considered:

- Discarding of duplicates within collections.
- Introduction of new conservation methods as alternative or supplementary to field genebanks
- Transferring some the threatened bank locations by urbanization or other factors to better areas.
- Make safe duplicates in other suitable genebanks.
- Enhancing genebanks capabilities in documentation, conservation, characterization and evaluation.

TABLE 3.2
Types of conservation and number of conservation facilities

Type of conservation	Organizations	Facilities in 1996	Facilities in 2006
Seed long term storage	1	0	1
Seed mid-term cold storage	2	1	2
Seed short term storage	3	3	7
Botanical garden	3	0	4
Field genebank	3	3	8
Total		**7**	**22**

3.3 Number of accessions and important crops conserved

Traditional landraces of widely cultivated crops have dominated *ex situ* conservation efforts. In addition, field genebanks for local and exotic fruit crops have been established under favorable climatic conditions for the relevant crop. Lately collection and conservation efforts included underutilized crops, aromatic and medicinal plants, feed and forage plants and rare forest trees.

Collection and conservation approaches have depend on dividing the country into homogenous climatic zones. After that missions are carried out accordingly with the assistance of the related station or stations in that zone. Seed material then stored either in the related station and the national genebank of AREA or in the national genebank only when no storage facilities available at the station level. For field genebank storage every station of each agroclimatic zone is responsible for conserving the suitable species of that zone in cooperation with the national genebank. Other collection and conservation efforts are carried out in collaboration with other genebanks and development projects or in emergency cases such as those of fast changes in cropping patterns, disasters or sudden urbanization of an area.

There was a dramatic increase in the number of accession and the number of species conserved between 1996 and 2006. The number of conserved accession in field genebanks almost doubled. The seed accessions raised from almost hundreds to the current figure, which is about 5 000. Three cereal crops, sorghum, pearl millet and Indian millet, account for almost 50% of the germplasm conserved. Table 3.3 illustrate a comparison between the number of accessions conserved in 1996 and that in 2006, while Table 3.4 shows the group of crops conserved at different sites.

TABLE 3.3
Number of accessions conserved for the different crop species between 1996 and 2006

Genebank Name	Location	Species		Local accessions		Exotic accessions		Total of accessions
		1996	2006	1996	2006	1996	2006	
Deciduous fruit tree genebank	Al-Irra, Sana'a	9	11	36	113	28	105	218
Date palm genebank	Seioun, Hadramaout		1		43		12	67
Genebank of evergreen fruits and botanic garden of the coastal plain	Alkaud, Abian	43	65					230
Genebank	Almukalla, Hadramout		15		68			68
Mangoes and Dates genebank	Alkadan, Hodiadah	4	5					64
Genetic resources center	The capital Sana'a	0	38		1 083		84	1 528
National genetic resources center	Rusabah, Dhamar	0	56		2 866		415	3 281
Botanic garden of the Central Highlands	Rusabah, Dhamar	0						55
Evergreen and Coffee genebank	Taiz city	0	16		19		17	36
Pomegranates genebank	Dhamar city	0	1	0	22			22
Naser faculty genebank	Lahj city		9		11		28	136
Total	**11**	**56**	**227**	**36**	**4 225**	**28**	**661**	**5 705**

TABLE 3.4
Crop groups and number of accessions conserved until 2006

Crop group	Accessions
Cereals	3 625
Legumes	881
Industrials	406
Vegetables	440
Fruits	453
Forage, feed and forest	154
Under utilized, medicinal and ornamental plants	749
Total	**6 708**

3.4 Documentation

The documentation process is still manually implemented in most of the centers even where computers are available they are not appropriately used due to the lake of personal qualification. It is, therefore, very crucial to establish a computerized documentation systems network to enhance the plant material management within each genebank and fully utilized the stored material.

3.5 Characterization, evaluation and regeneration

Collected germplasm is characterized in the collection site and in the regeneration sites together with the primary evaluation. All morphological and evaluation criteria are based on the Biodiversity International descriptors and carried out by specialized breeder in the zones suitable for the specific crop under the supervision of the National genetic resources center. Field genebanks have their own nurseries and the regeneration of the material is carried out with

support of the National genetic resources center. Coordination and cooperation between the genebanks is rare and when it happened it is limited to very restricted exchange of plant material. In many cases it is easier to get germplasm from foreign country than from a Yemeni one. The main reasons that undermine characterization, evaluation and regeneration activities in addition to the lack of finance include: lack of appropriate infrastructure, absence of modern equipment either for multiplication or for molecular characterization, and lack of qualified personnel.

There has been moderate progress in the collection, characterization and conservation of plant genetic resources for food and agriculture. This is evident by the increased number of accessions and diversity of crops collected, characterized and conserved in the Gene Bank of the NGRC in AREA as well in the GRC in Sana'a University. Despite this moderate progress, there is still a big gap between what has been collected, characterized and conserved and the wide diversity of PGR of food and agricultural crops in the country. Several areas are still no covered by collecting missions and there is a need for better management practices to handle the increased number of accessions conserved in the NGRC in AREA. The situation is different in the case of horticultural crops. Here progress is rather limited and exerted efforts so far are far from addressing the challenges of conservation and characterization of PGR of horticultural crops.

Due to the lack of finance the regeneration activities are very weak and nearly 40% of the conserved material has been regenerated. Weak documentation of the quantity of material stored has caused the loss of some accessions.

3.6 Future perspectives for collection and conservation

It is obvious that there are clear gaps in the collection and conservation of local germplasm especially for many famous indigenous crops such as sorghum, ficus and many other crops that Yemen was traditionally famous for growing them under various agroclimatic zones of the country in many areas. The expansion of Qat cultivation, drought, urbanization, changes in food consumption habits, Food Trade Agreement (FTA) and other factors all pose serious threats for the local germplasm of many crops.

3.6.1 Collection

- Priority should be given to areas where there is dramatic decrease in the cultivation of traditional crops for any reason.
- Isolated areas must be included in any collection mission and difficulties should be managed.
- It is important that collection should include all germplasm that have the possibility for use by human or animal especially under low input agriculture and drought.
- Priority of collection has to be given to local germplasm and important exotic ones and avoiding conserving material that could be obtained easily from foreign genebanks.
- Collecting local germplasm of threatened crops or plants that Yemen is one of their places of origin or diversity.

3.6.2 Conservation

- Emphasis on the necessity to conserve more than one duplicate for each accession in different genebanks.
- Benefiting from international centers assistance in conservation facilities and experience.
- Reducing the number of duplicates within each center especially in the case of field genebanks.
- Introducing of advance method of conservation and regeneration.
- Use of molecular characterization techniques in determining the largest possible genetic diversity conserved rather than storing large number of accession.

CHAPTER 4

THE STATE OF USE

4.1 The importance of PGRFA utilization

Agriculture is an important sector of the Yemeni economy. Recently, agriculture production has been subject to great fluctuations, resulting in the decrease of the share of the agriculture sector in overall domestic production that is 18% of GDP. The growth rate in agricultural GDP which averaged only 2.4%, fell short of the population growth rate of 3.02% (according to 2004 Census), which is considered one of the highest growth rate in the world. Consequently, big gap between local food production and consumption has created. The agriculture sector currently supplies the country's population with most of their demand for vegetables and fruits, but only 40% of the domestic total demand of grains. In order to reduce reliance on imported food, Plant Genetic Resources for Food and Agriculture (PGRFA) improvement could be ply the significant action to improve the efficiency of agriculture production. The Yemeni farmers have sustained and enriched the diversity of these resources that they domesticated, used and conserved to overcome the ever-increasing demands of the present and future generations, if adequate PGRFA utilization policy and management are adopted.

4.2 Utilization and enhancing the use of PGRFA

4.2.1 Direct use of PGRFA by the farmer

Historically, Yemeni farmer was a good example for the economic sustainable use of PGRFA as mean of survival in the scarcely available natural resources. Therefore, the country's crop diversity comprised of cultivated crop varieties, heterogeneous landraces, and wild relatives, is utilized for different purposes of the community. These landraces have evolved through natural selection and selective breeding by traditional agricultural practices over long periods in the different environmental conditions of the country. Crop diversity is the basis for successful agriculture and the sustainable use of the country's scarce water and soil resources. Utilization of PGRFA by the farmers is indicated in the following points:

- The availability of different crops with different growing period enabled farmers to formulate suitable cropping patterns and crop rotation systems aimed at sustaining maximum benefits from the available rainfall in the region. In the rainfed areas crop choices for the seasons are based primarily on available rainfall and on the subsistence level for individual farmers, while on irrigated land, crop production is oriented towards the market need. The farm management decisions are effected by unpredictable rainfall; therefore, crops such as wheat, barley lentil, dry peas, and fenugreek are sown with the early spring rainfall. The spring crops occupy the land for 3 months after which the lands are prepared for summer sowing with the same crops, exchanging the locations of cereals and legume crops. Faba beans, wheat, and sorghum crops are planted with late spring rainfall and occupied the lands for 5-6 months. Sorghum crops planted in May efficiently utilize the spring and summer rainfall.
- PGRFA are used to find the best crop varieties suitable to specific environmental conditions. For example, the sorghum varieties with loose seed heads and high ratooning ability (Zaar, Qairaa, and Baini) are perfectly suitable for high humidity and spate irrigated areas of Tihama lowlands. The air movement through the loose head type of these local sorghum cultivars is minimizing the fungus and insect infections.
- PGRFA are perfectly used by farmers to grow grapes and date palm varieties with different maturity periods to supply the market with these commodities at different times. The grape variety "Juberi" is mature first and followed by "Razigi" variety and then "Assimi", and finally the "Aswad" is harvested the last.
- PGRFA are used to grow different crops at different agro-ecological zones. The country is self-sufficient in production of millet, fruit and feed crop production and produced above 90% of its need of sorghum, barley, and total vegetable crops. The local production also covers the country's needs in about 75% of legumes, 47% of maize and 9% of wheat.

4.2.2 PGRFA utilization for crop production improvement

Major crop improvements were achieved through selection and breeding for high yielding potential varieties of major crops. These include, improvement of cereal crops (sorghum, millet, wheat, maize, and barley), legume crops (cowpea, lentils, common bean, broad beans, groundnut and peas), horticultural crops (potato, tomato, onion, banana, citrus, mango and papaya,) and cotton as industrial crop. In addition major crop production improvements were achieved through innovation and improvement of crop managements including cultural practices, fertilizers applications, rainwater harvesting techniques, and crop protection.

Sorghum populations are improved by continuous recurrent selection carried out by the farmers. These populations provides a broad-base breeding materials to the national programs. Some of these sorghum populations have been subjected to high selection intensity. Using plant-to row pedigree methods several advanced lines were tested. Significant selection gains have been achieved in term of grain and forage yield, grain quality, plant height, maturity, and resistance to best and diseases. Advanced high yielding lines were found in Zeir and Qairaa sorghum populations in Tihama region. Similarly, high yielding lines were identified in the Southern Upland out of which the varieties Kadasi, Tajarib, Hamra Hugaria, Taiz-20 and Taiz-21 were released. Genetic enhancement between local sorghum populations and exotic stem pest resistant line made at Southern Upland Agricultural Research Station using genetic male sterility, resulting breeding population was named Yemen Sorghum Population-1(YSPop-1).

Millet local populations were subjected to current and intensive selections, which resulted in identification of the varieties Khabti. On the other hands, composite formation was done from introduced varieties resulting Dukhn Tihama; and selection from ICRISAT millet nurseries resulting release WC-C75, Tihama-1, Tihama-2, Tihama-3, Tihama-4 and Tihama-5. However, breeding efforts should be concentrated on improvement of millet for both drought resistance and high yielding potentials.

Wheat improvement program is concentrated on testing introduced high yielding hexoploid varieties. As result, several improved wheat varieties have been released including Sonalika, Aziz, Mukhtar, Bohoth-32 and Bohoth-14 . While most of the local varieties belong to the tetraploid wheat which are low-yielding but highly adapted to stress environment.

Recently, local varieties namely Bouni, Maisani, Khashabi, and Ethuary together with some introduced tetraploid wheat were included in crossing program at the Faculty of Agriculture, Sana'a University. The objective of this program is to improve the yielding ability of local varieties under low rainfed conditions. The selection for high yielding lines with short growing period was done in the second generations. Segregating generation still under investigations. Furthermore, Agricultural Research and Extension Authority has released 18 varieties of wheat namely: Bohouth-13, Taiz-10, Taiz-11, Qaa' Alhaql-7, Bohoth-3, Bohoth-37, Bohoth-10, Bohoth-5, Bohoth-15, Ahgaf, Al-swiry, Seiyun, Hadhramout, Ghnemy, Amran-4, Shibam-8, Amran-2 and Naeem-2. These varieties were the output of wheat breeding program in Southern Upland, Central Highland, Eastern plateau (Seiyun) and Northern Highland Agricultural Research Stations.

Several random mating maize local populations were included together with some introduced varieties in recurrent selection activities in early agricultural research projects. These populations were used as breeding materials. As result of these activities, several high yielding composite varieties were identified and released to the farmers. Among these varieties are Tihama-1 and Tihama-2. Beside, recurrent selection was conducted in local maize population and resulted in released Taiz-2 variety. Selections within CIMMYT maize population 33, conducted in AREA have resulted in releasing a new variety (Taiz-3), which is well adapted for the Southern Upland and Highland regions of Yemen. Many exotic maize varieties were evaluated in lowland of Yemen and resulted in releasing the Bulgarian variety Kiniga36 and CIMMYT variety SetaLagus7931.

The major legume crops cultivated in Yemen are cowpea, lentil, common bean, broad bean, fenugreek, groundnut and peas. Cowpea [*Vigna unguiculata* (L.)Walp.], is wide spread legume crop in the country. Genetic improvements of this crop are focused on introduction of international nurseries from IITA and selection within local varieties. These AREA activities have resulted in releasing three varieties: Awlaki-1, selected from local variety, Seham-1 and Seham-2 selected from IITA nurseries. Lentil (*Lens esculenta* L.) improvements activities are concentrated on introduction of new varieties from ICARDA, broadening diversity of local varieties, and mutation breeding. Four lentil varieties were released: Dhamar-1 (Percoze) and Dhamar-2 resulted from a cross between exotic and local variety; Bohoth Taqah-1 and Bohoth Taqah-2 from the output of mutation breeding.

The outcome of common bean evaluation and selection program of CIAT varieties, was the identification of two common bean varieties: Lina24 and A48, which were released for Southern Upland region. The output of common been local landraces screening and purification program was one large seeded released variety (Yemen-1). Evaluation of ICRISAT groundnut (*Arachis hypogea* L.) varieties has resulted in selection and release of five improved varieties.

Horticultures genetic improvement activities are generally, focused on evaluation of many exotic vegetables and fruits varieties under the umbrella of Agricultural Research and Extension Authority. These activities have resulted in releasing

several vegetable and some fruit crop varieties. Twenty-two improved varieties belong to seven vegetable crops were released namely: potato, tomato, onion, okra, eggplant, pepper and green bean. All these vegetable crop varieties are international commercial brand, except three onion varieties, which were selected from the local variety Bafteem; and one pepper variety, which is belong to local landraces. Moreover, AREA has released five mango varieties out of which, three are American varieties (Ott, Glen and Kent); one is the Indian variety Totapury; and the last is the famous Phonse mango variety. In Addition, Several commercial varieties of vegetable and fruit crops were disseminated including Bombay mango variety and Dwarf Cavendish banana variety. Also, many introduced fruit crop varieties of papaya, citrus, mango, guava, peach, apple and olive were actively disseminated.

4.2.3 PGRFA utilization constraints

Yemen has a wide range of plant species and crop varieties, which have been used for food and feed for thousands years. Most of the crop varieties were locally evolved and have been adapted to different environmental conditions. However, many improvement programs have been focused on high-yielding varieties with high input and high water requirement. This has negative impact on sustainable use of local PGRFA and clearly reflected in genetic and water resource degradations that have reached a critical level.

The *in situ* conservation of PGRFA is still the dominant system, where the farmers actively conserve and utilize most of the major crop landraces. However, *ex situ* conservation program has been initiated. Presently, there are two PGR centres (Gene Banks) have been established for short and medium storage: one in the Agricultural Research and Extension Authority, Dhamar, and the other in the Faculty of Agriculture, Sana'a University. Most of the activities of these PGR centres are focused on collections of PGR and although, several PGR collection missions have conducted, but the number of accessions is very small. Moreover, evaluations, characterizations, and documentations of the collected materials are absent due to several limitations:

1. Lack of capacity – qualified personnel, funds, training, facilities;
2. Weak policy development;
3. Lack of integration between conservation and utilization programmes and
4. Lack of coordination among researchers, breeders, Gene Bank managers and farmers.

Presently there is no legislation or policies in force in Yemen, which deal specifically with PGRFA, and only several provisions related to certain aspects of PGRFA conservation. Issues concerning biological resources are included in sectoral laws and by-laws of several institutions.

Record tracking mechanisms of PGRFA and their distribution to plant breeders are not established yet in a legal framework. Beside, *ex situ* PGRFA conserved in local gene banks had limited use by breeders. On the other hand, breeders of major crops are collecting samples of local germplasm, and introducing their needed of plant genetic materials directly from CGIAR centres, mainly: ICRISAT, CIMMYT, ICARDA, CIAT and IITA. In addition, plant breeders in agricultural research stations and universities are personally exchanging their elite lines and varieties among themselves.

The Law of Universities has provisions on scientific research and information exchange among national consultations or with other states, but there is no specific legislation mandating or enabling research on biological resources. Several faculties and research centers are involved in research on biological resources, and at least two central government institutions are building related databases, but there is little, if any, coordination among them.

Existing legislation does not cover all aspects of biological diversity and its sustainable use, and does not sufficiently implement the obligations of the biodiversity-related conventions, agreements and treaties to which Yemen is a Party. For example, Provisions in laws on investment and intellectual property address the issues of technology transfer and intellectual property rights generally, but not in the context of biodiversity. Neither *ex situ* conservation nor introduction of alien species, nor access to genetic resources is addressed in any existing legislation.

In order to fill these regulatory gaps, by-laws or regulations need to be issued based on the provisions of existing laws. The existing legislations provide the foundation for the legal and institutional framework for biodiversity conservation and its sustainable use in Yemen. However, the draft of Genetic Resources Use By-Law is still under preparation.

4.2.4 Priorities to overcome PGRFA use constraints

- Prepare a national policy on *ex situ* conservation addressing wild and domesticated or cultivated biological resources. Among other issues, the policy should address collecting certain biological materials, research, importation and exportation of biological materials, and property rights over the collected specimens. The policy

should also address issues related to the management of *ex situ* conservation facilities, particularly to building human and physical capacity for establishing and maintaining *ex situ* collections. The environmental impacts of reintroducing or re-establishing species conserved *ex situ* should also be addressed. This policy should be harmonized with the Environmental Protection law (EPL) and its executive by-law, and with the drafted by-law on access and use of genetic resources. The preparation should be a participatory process with all concerned institutions including Environmental Protection Authority, Ministry of Agriculture and Irrigation, Legal Affairs; AREA; universities of Sana'a, Aden, Hadramaut and Ministry of Planning.

- Increase the financial support of existing PGR Centers to accomplish the task of collection, conservation, evaluation, and characterization of PGRFA.
- Improve linkage of conservation and research institutions, and promote participatory research programs.
- Establishment of evaluation fields, and propagation nurseries in each agro-ecological region.
- Provide training for Gene bank staff and technicians

4.3 Seed systems and the role of markets

4.3.1 Conventional seed production

Traditional seed production systems for commercial purposes are not existed. However, farmers under subsistence rainfed farming secure their seed need of major and minor crops by selecting the best plants from the fields, thrash them separately, and store them until the next season. Farmers of the same village are exchanging seeds among themselves. Every 3-4 years, seeds are introduced from villages with similar environment. The seeds of the local varieties and landraces are produced by traditional systems. In addition, very high percentage of the required crop seed is secured by this systems. For example, above 90% of the required sorghum, maize and barley seeds, 70% of wheat and millet seeds are covered by traditional systems. Recently however, the traditional system was negatively affected by the introduction of improved varieties and hybrids, which caused most of the vegetable local varieties to disappear.

4.3.2 Seed multiplication institutions

The agricultural inputs assessment study conducted in 1995 had initiated the Seed and Agricultural Services Project (SASP) and the reform of the national seed program. The reorganization of the national seed sector in 1997 resulted in the establishment of three seed enterprises: (i) General Seed Multiplication Corporation (GSMC), (ii) Potato Seed Company (PSC), and (iii) Vegetables Seed Company (VSC). In addition, the establishment of Quality Control Unit, enactment of the national Seed Law and formation of National Seed Board were accomplished. Beside, Yemen is the founding member of the West Asia and North Africa (WANA) Seed Network and a leading country for a survey of rules and regulations to establish seed companies.

The Seed and Agriculture Fertilizer Law (Law No 20 of 1998) was enacted in 1998 with the main objective of improvement the agricultural sector. This law, aiming to enable farmers to have better access and use of agricultural inputs, includes the following elements:

1. registration of new plant varieties;
2. regulating production and marketing of certified seed;
3. regulating import/export of seed and fertilizers;
4. encouraging private sector investment in seed production and marketing;
5. removing restrictions on sources of breeder seed and 6) monitoring environmental impacts of fertilizer applications.

The law recommends the establishment of Consultative Council for Seeds and Seedlings. At present, there is a National Seed Board (NSB) under the chairmanship of the Minster of Agriculture and Irrigation. The members of this Board include the deputy and assistant deputy Minster for Agricultural Affairs, representatives of agricultural research, public and private seed companies and agricultural cooperatives. The law requires the establishment of a national registry for seeds and seedlings. Plant variety protection will be granted to breeders of varieties registered in the protected plant varieties registry.

In spit of the governmental support of public breeding programs, the seed law guarantees breeder's rights to encourage domestic and international private companies to participate in plant breeding and variety development. A list of quarantine pests was illustrated in the Botanical (Plant) Quarantine Law No.(32). The General Directorate of Plant Protection, Ministry of Agriculture and Irrigation is responsible institution of implementing the quarantine regulations.

4.3.3 Seed marketing and distribution

The local seed multiplication corporations (GSMC, PSC and VSC) are officially responsible for seed marketing and distribution of their mandate crops. However, seeds are also distributed through various branches and sub-branches as well as agricultural offices, extension services and cooperatives. The private sector is involved in marketing and distribution of imported vegetable seed, and some locally produced seed. However, farmer-to-farmer seed exchanges continue to play an important role. The public sector pays a premium to contracted seed growers added to the seed price, based on the seed quality. For example, GSMC pays a premium of over 20% and provides seed and other inputs to seed growers including farm machinery and equipments. The seed growers also get technical advices and their fields remain under monitoring and supervisions. Almost 75% of seed produced by growers is purchased by GSMC and PSC. The price of cereal seed covers only half the actual cost of production whereas the government subsidizes the remaining cost. While, the production and marketing of potato and onion seed is based on profitability. The cooperatives play a major role in providing subsidy to the farmers by supporting grain selling prices. For example, the cooperatives pay 20% more than market price for grain determined at harvest time. Recently, the cleaned seed price is about 30% more than raw seed purchase price. The Seed Multiplication Corporations are able to cover only small percentage of required seed, which is 4% of sorghum, 23.4% of wheat, 3.2% of maize, 42.6 of millet, 0.45% of barley, and 14% of potato (Al-Tashi and Abdul-Habib, 2001).

However, the new seed law allows free market for seed import and/or export, but the General Directorate of Plant Production should legally approve it. The Quality Control Unit and Plant Quarantine Service assist the Directorate to ensure the quality of the imported seed, which should have a necessary certificate shown the origin, quality, and health of the seed lot. Most of the imported seeds are vegetable crops. The total quantity of imported seed during last decade is fluctuated with the minimum of 24 tons in 1999 and the maximum of 58 tons in 2006 (Table 4.3.1). The mean seed quantity imported for onion, water melon and carrot were the highest, 8.4, 8.3 and 7.2 tons respectively, while the lowest quantity were for cabbage and egg plant.

TABLE 4.3.1

Vegetables seed quantity (kg) imported from 1997 to 2006

Crop	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Water melon	10 565	14 600	8 235	6 937	436	8 601	8 907	6 133	7 938	10 171
Onion	5 999	10 268	7 262	11 793	4 843	6 139	12 800	6 132	2 081	16 694
Carrot	9 507	8 009	1 396	8 637	8 399	5 132	5 654	5 637	10 802	8 610
Cucumber	1 199	1 343	1 581	505	1 728	10 071	1 619	788	580	1 121
Egg plant	137	85	-	5 050	90	436	146	225	100	60
Lettuce	0	300	886	1 350		1 174	2 550	5 352	362	137
Okra	1 500	1 500	465	400	590	1 050	4 570	8 947	600	9 733
Pepper (hot)	0	0								
Pepper (sweet)	872	1 115	254	3 021	815	505	664	501	-	1 734
Radish	2 389	2 917	-	650	200	-	1 000	4 500	400	-
Cabbage	1 050	-	-	1 300	377	709	533	490	2 314	-
Squash	1 997	1 480	2 061	10 544	7 011	2 188	3 400	1 708	1 867	4 189
Sweet melon	2 789	2 154	1 921	6 140	6 239	3 795	1 376	2 211	3 855	5 089
Total	**38 004**	**43 771**	**24 061**	**56 327**	**30 728**	**39 800**	**43 219**	**42 624**	**30 899**	**57 538**

4.3.4 Constrain of seed supply systems

- Lack of qualified technical staff in the Seed Multiplication Corporations
- Lack of infrastructure particularly in some western, southern and eastern governorates
- Lack of linkage between breeders and Seed Multiplication Corporations
- Low capacity of Seed Multiplication Corporations to meet the market demands of certified seed.
- Low capacity of Seed Multiplication Corporations to handle and deal with huge number of released varieties.
- Inefficient extension services and week linkages between extension, agricultural research, and farming communities

4.3.5 Future needs and priorities

The following points are highly recommended to improve and sustain the function of seed systems in the country:

- Review Seed and Agriculture Fertilizer Law for adopting international treaties, agreements and conventions;
- Establish appropriate linkage between Variety Seed Maintenance Programs and Seed Multiplication Activities;
- Provide infrastructure for the Seed Multiplication Corporations;
- Provide training for seed multiplication staff;

4.4 Crop improvement programs and food security

National research system is responsible of applied and adaptive research for crop and livestock improvements. The Agricultural Research and Extension Authority (AREA) and faculties of agriculture in Sana'a and Aden Universities are the main national agricultural research institutions. The roughly estimate of Ph.D plant breeders account for 26: fourteen breeders working in AREA, seven in Faculty of Agriculture Sana'a University and five breeders in Nasser Faculty of Agriculture Aden University. However, 21 MSc. and 31 BSc. assist breeders in AREA for field crops and horticulture breeding activities.

Research improvement programs have successful results in introducing high yielding varieties of sorghum, maize, wheat, barley, legumes, vegetables and fruits. Crop production also was successfully increased by improvement agricultural practices, including fertilizer application, and integrated pest and disease controls. The improved cereal crop varieties gave triple yield higher then the local chick varieties under optimal conditions. However, little efforts were devoted to improve crop production under rainfed conditions.

Several wheat and maize improved varieties have been released and the seeds are distributed to the farmers with very low price. The improved varieties characterized by homogeneity and high yielding, while the local crop varieties are low yielding and low responsive to improved environment, but highly adapted to low rainfed environment. The improved high yielding varieties cause a major threat to the local crop varieties, which give high yields, but with high inputs.

The local cropping systems are developed by the farmers to make the best use of the available resources. Deterioration of the short period local crop varieties or late sown crops is directly reflected on lose and disturb the cropping pattern and consequently less efficient production systems. Therefore, enhancing diversity within and between crops and crop improvement programs could lead to food security achievements. Beside, successful improvement of sustainable crop production is based on genetic broadening of important crop collections, active and functional National Gene Bank, and planned joint breeding programs.

4.4.1 Constrains

- Lack of financial support of research institutions and programs
- Lack of linkage of research and Gene banks and farmers
- Lack of regulating policies
- Low level of public and decision makers awareness

4.4.2 Priorities and perspectives

The lack of regulating policies and the low level of public awareness of environmental problems are increasing the rate of deterioration of PGRFA of the country. Therefore, immediate action to rescue our remaining natural resources is becoming very urgent. Since the rate of genetic erosion varies with crop species, combinations of certain actions need to be taken to slow down or to prevent genetic deterioration. These actions are included in the following recommendations.

1. *In situ* conservation of traditional landraces and local varieties is very important step toward conservation of crop species. Farmers' fields at different agro- climatical zones are the most important and suitable environments for *in situ* conservation of broad-based of genetic variability and sustainable use of natural ecosystems.
2. Preservation and documentation of traditional agriculture knowledge is a very important step for sustainable use of natural resources. Since the dawn of history, Yemeni farmers evolved crops and cropping systems and developed traditional agricultural knowledge that enabled them to survive in the extreme environmental stresses.
3. Collection and preservation of plant genetic resources could be an effective *ex situ* conservation activity only by enhancing the current gene banks and establishing botanical gardens at the Agricultural Research and Extension Authority and at faculties of agriculture, Sana'a and Aden Universities. Adoption of high input modern agriculture including introduction of high yielding crop varieties should be very carefully approached and could be restricted to areas with high potential of agriculture production.
4. Use the integrated pest management to control pests and encouraging traditional and biological methods of pest control.
5. Increasing public and governmental awareness regarding the degradation of natural resources.
6. Formulation of national strategies and environmental policies and increasing the effectiveness of law enforcement.

CHAPTER 5

THE STATE OF NATIONAL PROGRAMS, TRAINING AND LEGISLATION

5.1 The national program

The National Program on Plant Generic Resources for Food and Agriculture (PGRFA) is comprised of several sub programs linked with the Agricultural Research and Extension Authority (AREA) through its National Genetic Resource Center (NGRC) under the Ministry of Agriculture and Irrigation (MAI) , the Universities of Sana'a and Aden (faculties of Agriculture) , the Environmental Protection Authority (EPA) in the Ministry of Water and Environment and the General Seed Multiplication Corporation (GSMC) under MAI.

The coordination of the activities of different institutions in the field of PGRFA was realized through the establishment of the National Committee (NC) for PGRFA in 1999. The National Committee for PGRFA was issued by a Ministerial Order and headed by the Vice Minister. Membership of the NC included representatives from MAI, the Universities of Sana'a and Aden, AREA, EPA, GSMC, Farmers Union (FU). The National Committee was assisted by a Technical Secretariat (Sub-Committee) headed by the Assistant Deputy Minister (MAI).

The meetings of the NC concentrated on coordinating efforts of different institutions with respect to Yemen commitments towards International Treaties, Conventions and Agreements such as the Convention on International Trade in Endangered Species of Wild Life Fauna and Flora (CITES).

The Committee took a very important decision related to the nomination of the NGRC in AREA as the focal point and the National Entity for coordination with International Agencies in PGRFA. The Genetic Resource Center of the University of Sana'a became a local Genetic Resource Center and part of the national network.

Review of available literature of the NC revealed that the NC suffered from lack of funds to sustain its activities and organize meetings at regular intervals. The unavailability of a full time technical secretariat complicated further the situation. This led to the inability of this committee to come up with a coordinated national program on PGRFA as was expected in the initial stages of its formulation.

The scattered nature of institutions with mandates related to PGRFA and the dependence of these institutions on a wide range of funding sources has led to scatted formulation of projects and implementation of project oriented activities. Efforts to streamline these activities were not always on the priority list of the NC.

Activities in the field of PGRFA are carried out by different institutions with varying degree of progress. While in the EPA most activities are externally funded with limited contribution of national sources of funds. AREA is almost dependant on the Government budget with limited external support. The GSMC is also conducting project sponsored genetic enhancement of local and international landraces and varieties of field crops in its field stations.

The program of Sana'a and Aden Universities is mainly project oriented and cover the vicinity of the Academic Institutions in general or the targeted governorate in particular. The universities of Sana'a and Aden are mainly engaged in collection of genetic resources, conservation of collected genetic resources is also practiced to some extent. However, lack of storage facilities in Aden University and the breakdown of storage facilities in Sana'a University renders storage of collected genetic resources difficult. Plant breeding practices are very limited in both universities and are confined to few crops such as hybrid maize.

5.2 Networks

The NGRC has a national mandate to conduct activities related to *ex situ* and *in situ* conservation of PGRFA. It has moderate facilities for collection, characterization and conservation of PGRFA. The NGRC has fairly good storage facilities for medium and short term storage for PGRFA. Seed maintenance is carried out in different Regional Research Stations on a contract basis.

Plant characterization is still heavily relying on morphological characteristics. The National GRC is currently establishing a Biotechnology Laboratory for the use of modern molecular techniques such as genetic mapping and finger printing to ass the characterization of land races using molecular techniques as a complementary tool for PGR assessment.

Despite the fact that there appear to be fairly good facilities in the Faculty of Agriculture at Sana'a University for biotechnology research and molecular techniques, the limited running costs and the lack of funding agencies rendered these facilities not suitable and were never utilized since their installation.

Similarly AREA rely heavily on conventional techniques in characterization of PGRFA. The establishment of the biotechnology laboratory is in its initial stages and there is a need for training and technical backstopping to sustain activities in this laboratory. It is expected that technical support from ICARDA in the context of the Rainfed and Livestock Improvement Project (RLIP) will help AREA build its capacities in the PGRFA characterization and management using modern molecular techniques.

The network among national institutions in the field of PGRFA is expected to be strengthened between AREA and the Faculties of Agriculture in Sana'a and Aden Universities because the three institutions are engaged in activities sponsored by RLIP World bank Project and supported by Technical Inputs from ICARDA during the period 2007-2012

5.3 Education and training

The recently conducted National Capacity Self Assessment Study on the implementation of the International Conventions on Biodiversity, Biosafety, Desertification and Climate Change in Yemen clearly illustrated the extent of the problem in capacity building in the country. According to this study, capacity building has three dimensions in Yemen. These are individual, institutional and system dimensions. At the individual level, it was evident that the country lacks clear plans addressing individual needs of national staff in capacity building at the school and university levels. This is mainly because of outdated curricula which do not address the challenging issues of Biodiversity in general and PGRFA in particular.

On the other hand, on the job training is limited and project oriented. Degree training is limited to MSc degree in local universities. Long Term Training abroad limited and confined to university staff mainly. There is no clear job description of staff recruited in institutions dealing with PGRFA as well as the incentive and promotional systems are undermined by the majority of managements of these institutions. At the institutional level, there appeared to be serious gaps in planning of activities, provision of necessary funds and running costs.

Moreover, coordination among relevant institutions is lacking. Training opportunities are rare and mainly project sponsored. Funds from the Government budget for training and capacity building are limited. Laboratory facilities are outdated in most cases and the rehabilitation of equipments is not practiced because of funding constraints. At the system level, there appeared to be low awareness among decision makers on the importance of the international conventions and the need to adopt measures to ensure the implementation of Government Commitments towards these international treaties. Furthermore, the law enforcement is limited and related institutions are facing serious shortcomings in law enforcement pertinent to Biodiversity in general and PGRFA in particular.

5.4 National legislations

Yemen identified a large number of existing regulatory instruments that relate in some way or another to biosafety. These include the environment protection law No. (26) of 1995. According to the survey carried out by the National Biosafety Project on the current status of the regulatory instruments related directly or indirectly to biosafety. The review and analysis of the existing relevant laws – regulations etc related to biodiversity and Biosafety is summarized as shows in Appendix 2.

5.5 Information systems

The information system in Yemen on Biodiversity in general and PGRFA in particular is still primitive and relies on conventional reporting. Exchange of reports among institutions concerned with PGRFA is limited and not regular. Access to the computer became available only few years ago and the use of Web sites is still in its initial stages. Interactive data base are non existent so far. Sharing of reports with counterparts regional and international agencies is limited. Cases of duplicated efforts as a result of not sharing information are common. Tracing reports and documents prepared several years ago is problematic and not always possible.

5.6 Public awareness

Despite the numerous venues of public media (Radio, TV channels and Official newspapers) awareness on the importance of the environment and the need to conserve it for future generation is still at its initial stages, developing and slowly gaining momentum. However, the challenges are still ahead. There is a need to design programs addressing environmental issues with total participation of local communities and through different mass media. The school and university curricula need to be revised and updated to accommodate the challenges of conserving the fragile environment and sustaining the utilization of limited resources available. Extension activities in agriculture and rural areas need to be updated and revived to cover environmental issues and biodiversity domains in a simple and attractive manner, building on the rich endogenous knowledge and the traditional approaches in conservation and utilization of resources which dominated the scene for centuries and are fading away in current times. A combination of endogenous knowledge and modern approaches in raising awareness need to be developed and incorporated in the national campaigns and awareness programs addressing PGRFA at the national, regional and local levels.

5.7 Needs and priorities for program development, training and legislation

1. There is an urgent need to support the NGRC in Dhamar and the Genetic Resource Center in Sana'a University to provide better services in collection, storage and utilization of genetic resources. This is necessary in the context of the current status of these centers and the challenges imposed on them to preserve, utilize the precious national heritage of agricultural genetic resources
2. The current activities of the NGRC in AREA are collection and storage of collected genetic resources. The regeneration of these genetic resources needs to be assessed and strengthened. This is particularly important for cross pollinated crops and species.
3. The data base of conserved species and landraces is yet to be developed and made interactive. The efforts in establishing a solid data base are still in the planning stage. Training of national staff in modern data base designing and the use of software to support this are still not yet practiced.
4. Efforts in genetic resource collection, storage and utilization are still scattered and carried out without any coordination among concerned parties. The role of the NGRC needs to be strengthened to be able to perform this coordination function at the national level in Yemen.
5. There is evidence of progressive erosion of the national genetic resources as a result of climate change, periodical droughts and the negligence of traditional knowledge of seed selection and maintenance of local land races in the agricultural sector. There is an urgent need to train local staff on documentation of endogenous knowledge and revival of traditional local seed maintenance systems. This is important in rainfed areas and in areas suffering from periodical droughts.
6. The current seed law require revising and updating to accommodate recent developments in seed regulations and exchange and to cope with international treaties signed and ratified by the Government of Yemen. An international consultant should be assigned this task to ensure coherence with international laws and regulations pertinent to seed exchange, property rights and preserving the national heritage in local land races from unauthorized utilization for commercial purposes and piracy.

CHAPTER 6

THE STATE OF REGIONAL AND INTERNATIONAL COLLABORATION

6.1 International networks

Yemen has participated actively in the IPGRI/WANANET regional network since its establishment in 1992 as it was represented in the steering committee, the horticultural working group and bio-diversity working group. Yemen is also a member of the commission of plant genetic resources as well as it signed the convention at the earth summit conference held in RIO in 1992. Yemen is participating in regional and sub-regional research projects, through UNDP, FAO and AOAD as executive agencies for the sorghum and millet improvement, the oil crop improvement and supplementary Irrigation.

In the process of strengthening Plant Genetic Resources Unite (PGRU), AREA received an Italian grant through FAO, an International expatriate for one year during the establishment of the PGRU with some items for seed conservation and contributed in a number of collection missions throughout the country.

6.2 International programmes

Since the deployment of research activities in the country during the last four decades, AREA has established very strong linkage with international and regional organization and centers. The collaborative programs resulted in the enhancement of germplasm exchange, information exchange and training opportunities. Such cooperation has been strengthening with ICARDA, CIMMYT, ICRISAT, CIAT and IITA. That helped Yemen in joining regional and international research program in many crop fields. Yemen joined the Nile Valley and Red Sea Regional Program (NVRSRP) executed by ICARDA and country members: Egypt, Ethiopia, Sudan and Yemen. This program deals with improving of wheat, barley, and food legume crops from different aspects, disease and insects problems, thermo-tolerance, drought tolerance and soci-economic studies. In this respect materials of wheat, barley, lentil and faba bean have been exchange between country members. Materials were tested, selection for suitable varieties was conducted and even released varieties were done for the Highland and Plateau.

Participatory Breeding Project executed with ICARDA has helped in participating farmers in evaluating the crop material that the project dealt with. Arabian Peninsula Regional Project (APRP) executed by ICARDA deals with the improving of protected agriculture crops, range and forage management and irrigation issues. Most of the research material of maize and sorghum are received from CIMMYT and ICRISAT research centers, respectively. During the present time AREA joining the Global Rust Initiative (GRI) which deals with facing the Ug99 the new stem rust most threatening race to wheat production. Numerous of wheat varieties have introduced to Yemen for screening and evaluation. The output of this cooperative program has led to strengthening the national programs special emphasis in the establishment of a well defined commodity-wise research program. In addition it helps in increasing the number of collected and conserved accessions at the National Genetic Resource Centre (NGRC).

Due to research approach that will tend to solve direct farmer>s problems and develop sustainable agriculture, AREA is heading towards the farmer participatory research and farming system approaches. Within this frame AREA is looking forward to enhance its future cooperation with relevant international and regional centers in relation to this approach, that more likely to serve dryland agriculture with more concentration on biotic and abiotic stresses.

Increasing the awareness of the conserving plant genetic resources is drastically important. Though, awareness should be followed by actions.

Needs and priorities that should be taken in consideration for future international collaboration are:

- Finalize the set up of the NGRC in Yemen in order to insure *ex situ* conservation in proper way.
- Create suitable and affective plan for *in situ* conservation and seeking fund to support this plan
- Improve documentation following unconventional methodologies.
- Developing a proper plane to improve skills of NGRC staff in Yemen

6.3 International agreements

Yemen is giving high attention to the plant genetic resources conservation, documentation and utilization. So that, Yemen trying to do it's best to participate in most, if not all, concerned International events. Yemen has participated in meetings and workshops concerning the deployment of the International Treaty on Plant Genetic Resources for Food and Agriculture (Table 6.1).

TABLE 6.1

Participating of Yemen in International, Regional and National Plant Genetic Resources activities

S. No.	Name of Activity	Organizer	Place	Date
1	Technical support workshop to the International Treaty on Plant Genetic Resources for Food and Agriculture	FAO/ICARDA	Amman, Jordan	2005
2	The current status for the biological technology and defining national needs	Biological Safety	Sana'a, Yemen	2005
3	Scientific Symposium	Barkan Elmar Co. for Biological Science	Sana'a Yemen	2005
4	The First Scientific Symposium About Genetic Modified Food	National Society for Consumer Protection	Sana'a, Yemen	2005
5	National Stakeholders Workshop, Small Grants Program,	Global Fund Environment Facility	Sana'a, Yemen	2005
6	Development of the National Biosafety Framework of the Republic of Yemen Workshop	National Program for Biological Safety	Sana'a Yemen	2005
7	Seed Bank Management	ICARDA	Aleppo, Syria	2005
8	Contact Group for the Drafting of Standard Material Transfer Agreement	FAO/CGRFA	Hammamet, Tunis,	2005
9	Open-Ended Working Group on the Ruies of the procedure and the Financial Rules of the Governing Body, Compliance and the Funding Strategy	FAO/CGRFA	Italy, Rome	2005
10	The Symposium of the Integrated Management of Prosopis	AREA/SRS	Seiyun, Yemen	2006
11	The First Session of the Governing Body of the International Treaty on Plant Genetic Resources for Food and Agriculture	FAO/CGRFA	Madrid, Spain	2006
12	Eleventh Regular Session of the Commission on Genetic Resources for Food and Agriculture		Rome, Italy	2007
13	Second Session of the Governing Body of the International Treaty on PGRFA	FAO/CGRFA	Rome, Italy	2007

CHAPTER 7

ACCESS TO PLANT GENETIC RESOURCES AND SHARING OF BENEFITS ARISING OUT OF THEIR USE AND FARMERS' RIGHTS

7.1 Background

In the last few years we have seen a dramatic increase in public awareness and of political debates on a subject. "Plant Genetic Resources (PGR) are both the building- blocks of living matter and the raw material for the fast growing plant breeding and biotechnology industries" (Jose Esquinas, 1996). They are and will remain the principle source of genes for conventional and biotechnology- based plant improvement in foreseeable future.

At the same time that, there has developed an increasing awareness both of the values of PGRFA and of the rabid erosion of those recourses, the issues of access to PGRFA , sharing of benefit and property right become subjects of growing debates among the concerned partners and governments . Yemen is not away from these debates.

7.2 International agreements in relation to access and benefit sharing for GRFA

In the last decades Yemen subscribed to the International Agreements, Convention on Biological Diversity (CBD) singed by Ministry of water and environment in 12 June 1992 and International Treaty of Plant Genetic Resources for Food and Agriculture (ITPGRFA) singed by Ministry of Agriculture and Irrigation (MAI) in 2004.

In order to harmonize the implementation of the agreements a National Plant Genetic Resource Committee was established under the umbrella of MAI. The members of the committee include, Agricultural Research and Extension Authority (AREA), Faculties of Agricultures in two universities, Sana'a and Aden, Farmer Union, Seed Multiplication Corporations, Environmental Protection Authority and Departments of Plant Production at the MAI. Another objective of this committee is to coordinate, evaluate the national PGR activities including issues related to the access to PGRFA, share benefit and property rights. Unfortunately due to several obstacles mainly financial, committee was not able to achieve its objectives.

However, some efforts has been made to adopt the local legislation to meet international agreements so a law No.20 for 1998 "Seed and Agricultural Fertilizer law" has been issued. This law aims to improve and increase agricultural production and to enable farmers to have access PGRFA and clearly indicate in chapter 4 about breeders rights. However, this law needs a further modification, on the farmer and communities rights. Beside, Environmental Protection Authority (EPA) of the Ministry of Water and Environment has issued a national regulations and law in context with CBD as follows:

- Environment Protection Law No.26 of 1995 related to protect natural recourses and conservation of endemic plant species.
- Prime Minster decree (resolution) No.104 of 2002 related to protection of some wild animal and plant species and management of its trade

7.3 The state of access to GRFA

Yemen through AREA enhanced its cooperation with International Research Centers and became a member of some specialized research programs such as Cereal Legumes Asian Network (CLAN), Nile Valley and Red Sea Research Program (NVRSRP) and Neglected and Underutilized Species (NUS) were access to PGRFA and exchange of germplasm were a main

part of the research component of these networks and germplasm exchange agreements established not with individual countries but, with these CGIAR centers: ICRISAT, ICARDA, CIMMYT, IITA, CIAT, IPGRI-recently Bioversity International.

It is worth to mentioned that, despite the country has no clear restriction about certain types of PGRFA however all the endemic plants are restricted to access and access to another PGRFA became more difficult in the past few years because of miss management and miss coordination between different partners responsible for PGR and biodiversity (in Yemen now more than one ministry and authorities responsible for GR and biodiversity) beside to the limited financial resource thus created additional problems, including maintaining PGRFA located inside or outside the country.

In spite of these obstacles more than 1500 accessions exchange with Egypt, Sudan, Ethiopia, India and Syria to be used for research purposes for heat tolerance, drought tolerant, short duration, resistant to best and diseases, tolerance to salinity, etc.

7.4 Sharing benefit of the use PGRFA

As we mentioned Yemen so far has now clear vision and specific regulation on sharing benefit of the use of PGRFA and the regulation in law No.20 for 1998 " seed and agricultural fertilizer law has mentioned that "enabling farmers to have access to agriculture inputs and utilize it in better manner" in the objectives. However, there are no any articles or sentence indicating to sharing benefits. Therefore, the farmer rights are transgressed in Law 20 for 1998 and sharing benefits shall be regulated to implementing ITPGRFA.

7.5 Implementation of farmers and breeders' rights

AREA so far is the main institution introducing and releasing the varieties where in the last 8 years more than 60 different varieties of crops have been developed and released and registered by variety release committee which belong to the MAI. The main objective of this committee is just to register the verities, but not to protect them or to solve problems of property rights thus created some problems in implementation of farmers or breeders rights.

In spit of the seed national law No.20 for 1998 mentioned about breeder's rights and not mentioning about farmer's rights, therefore, it created difficulties in implementation farmer's rights. Farmer's rights should be considered as being complementary, and not opposed, to plant breeder's rights. The traditional rights of farmers and communities to keep use, exchange, share and market their seeds and plant material, including the rights to re-use farm saved seed is implementing by the tradition force and internal traditional regulation among farmers, but not because of the government regulation or legislation. Therefore, it is important to issue legislations and to establish mechanisms to protect farmers rights and gave them opportunity to have access to new technologies and other research achievements.

Beside, local technologies protection, cropping pattern and other, informal, innovative systems. Unfortunately, farmers and local community's rights are not considering on the local legislation on PGRFA. The concept of Farmer's Rights is even more important and more urgent following agreements like Trade Related Intellectual Property Rights (TRIPS), General Agreement on Tariffs and Trade (GATT) and World Trade Agreement (WTA) …etc. These agreements protect the rights of commercial breeders and biotechnologists and companies. The question of how farmers and local communities would benefit from the funding and benefit arising out of use of PGRFA? It is not solved yet in the country because there is no formal recognition and reward system to encourage and to enhance role of local communities and farmers in the conservation and use of PGRFA.

PGRFA are subject to sovereign rights; CBD reconfirmed this and specifies that, they are under the sovereignty of the government of the state in which they developed their distinctive properties. In Yemen as in many developing countries farmer rights provide some counterbalance to formal Intellectual Property Rights which compensate only for the latest innovation, without acknowledging the role of farmers and local communities as GR providers (main donors). The implementation of farmers rights should ensure that farmers and rural communities receive a just share of the benefits derived from PGRFA, which they have developed, maintained and make available, and thereby provide incentives and means for the conservation and further development of these resources by farmers, and through cooperation between farmers, breeders and the national and international research centers.

To achieve these goals it is important to solve the following problems or obstacles:

- Weak coordination among partners (multi-institutional system) dealing with PGRFA
- (the existing multi-institutional system dose not function properly)
- Limitation of the fund to implement farmer's rights

- Lack of harmony between local legislation and International Agreements and Conventions
- Lack of capacity building of national staff in relation to PGRFA activities
- Weak ability of farming communities to control access to germplasm
- Poor economic incentive to promote PGRFA conservation
- Weak legislation for property rights and plant variety protection

CHAPTER 8

THE CONTRIBUTION OF PGRFA MANAGEMENT TO FOOD SECURITY AND SUSTAINABLE DEVELOPMENT

Crops improvement program in Yemen have played an important role over the last ten years providing an increase of yield and sustainable production. The National Research Strategy addressed two main production systems; rainfed and irrigated. Three agro-ecological regions also, have been described: Highlands, Coastal and Plateau regions. Research program concentrate on addressing the improving performance accordingly. Due to the biotic and abiotic stresses that limiting the yield production of crop, new released crop varieties addressing the production constraints is not only attaining food security in vegetables and fruits but also ensured some food grain. The agriculture sector currently supplies the country's population with most of market demand for vegetables and fruits, but only 40% of the domestic total demand of grains.

PGRFA conservation and management are now under two main institutions: National Genetic Resources Center at Agricultural Research and Extension Authority (AREA) and Plant Genetic Resources Center at Faculty of Agriculture, University of Sana'a. The efforts and support that have been given to these institutions are respectable but not enough to create a gene bank responsible for conserving the Yemeni Plant Genetic Resources.

Major PGRFA activities in Yemen are collection, conservation, regeneration, characterization, and evaluation leading to utilization. Collection program targeted all type of crops, cereals, legumes, vegetable, fruits, range, forestry…etc. Collection is made from both indigenous (local) and introduced varieties. The active collection in AREA is carried out through the Regional Research Stations available at all agro-ecological regions with support from National Genetic Resources Center. Generally, all active collection materials are available to plant breeders and other specialists in crop management programs in either AREA and Universities or any other concerned sector.

The conservation of PGRFA is achieving through *ex situ* and *in situ* strategies. The *ex situ* conservation is made at the National Genetic Resources Center at AREA head quarter. AREA has maintained short and medium term preservation while long-term conservation is stile lacking. The *in situ* conservation ensures that the genetic diversity available in the genetic resources rich areas is conserved, while allowing the evolutionary process to continue. It is worth mentioning that farmers actively conserved *in situ* their PGRFA, while the formal *in situ* conservation is the responsibility of Ministry of Agriculture and Irrigation. This would give more attention to plant conserved under this system.

Indigenous PGRFA have been an important source for individual characteristics preferred by farmers and introduced into new varieties through breeding program. In cereals, wheat, sorghum, maize and millet color of seeds and breed making of the local varieties of these crops stile very respectable. Earliness in maturity of lentil crop is stile unbreakable by any introduced variety. Producing new variety through crossing between lentil local by introduced high yielded variety has led to maintain the earliness and increasing in yield. Screening of improved crop varieties under different environment and production systems, rainfed and irrigated with the participating of farmers has led to released varieties that farmer preferred and adopt. Recently, AREA has established a Laboratory for maintaining the fingerprints of all conserved materials. This will aim to firstly grouping the collected materials under similar categories and secondly will help in identifying the degree of relative ness of wild relatives to the domesticated and crop varieties used by the breeders and farmers. This will help in improve the conservation management methodology and documentation. The knowledge shall led to better genetic materials screening tools for PGRFA to identify materials and facilitate its utilization in the development of modern crop varieties particularly targeted for different environments including biotic and abiotic stresses.

REFERENCES

Al Dubae & Al Khulaidi, (1997). Medicinal and Aromatic plants of Yemen, (in Arabic), Obadi, Sana'a, Yemen, (1996),

Al Khulaidi, A.A. (1992): Ecological vegetation survey of three areas located Southern Tihama - Technical report 1990/91, AREA, regional station, Taiz, Yemen.

Al Khulaidi, A.A. (1993): Natural vegetation of Kuhlan Affar area -IDRC/ICARDA and AREA, Sanaa, Yemen.

Al Khulaidi, A.A. (1996). A vegetation survey of wadi Rimaa catchment areas. Land and water coservation project, Forestry component , (UTF/YEM/023) (IDA Credit TEM), Sanaa, Yemen.

Al Khulaidi, A.A. (1996). A vegetation survey of wadi Sharis catchment areas. Land and water conservation project, Forestry component , (UTF/YEM/023) (IDA Credit TEM),Sanaa, Yemen.

Al Khulaidi A. (2000). Flora of Yemen, Sustainable Environmental Management Program (YEM/97/100,.

Al-Tashi, K. M. H. and W. Abdul-Habib . 2001. Focus in Seed Programs The Yemen Seed Industry. WANA Seed Network Secretariat, Seed Unit, ICARDA, Aleppo, Syria.

Glew, Robert1; Vanderjagt, Dorothy; Chuang, L.-T.; Huang, Y.-S.; Millson, M.(2005). Nutrient Content of Four Edible Wild Plants from West Africa. Plant Foods for Human Nutrition, Volume 60, Number 4, December pp. 187-193(7). Publisher: Springer.

Kessler, J.J. (1987). A rangeland vegetation survey of Dhamar Montaneplains, RLIP commun. no.14. Agricultural Research Authority, Yemen and DHV Consulting Engineers, Amersfoort, The Netherlands.

Miller, A.G. and M. Morris (2004). Ethnoflora of the Soqotra Archipelago. RBGE. pp. 776., UK.

Miller A. & Morris M. (2004). Ethnoflora of Soqotra Archipelago. Royal Botanic Garden of Edinburgh, UK.

Westinga,E. and D.C.P.Thalen.1980.Asurvey and problem analysis of the rangelands in the rada,district RIRDP Techn. note 5. min.of Agriculture and forestry.

Department of Horticulture, Directorate of Plant Production, MAI

APPENDIX

REVIEW AND ANALYSIS OF THE EXISTING RELEVANT LAWS – REGULATIONS RELATED TO CBD AND BIOSAFETY

Name of legislation	Purpose/objective	Responsible agency	Status
The Constitution	Article (27) of the constitution specifies that the country shall guaranty the freedom of scientific research, and literary, artistic and cultural achievements that coincide with the spirit of the constitution, and provide the means to achieve that. Article (35): of the constitution specifies that environment protection is the responsibility of the country and society, and it is a religions and national obligation of every citizen	The Government	Passed
Republican Resolution No. (218) of 2004 on the organizational by-law	This resolution aims at : identifying tasks of the Ministry in developing and review laws and by-laws pertaining to authorities and institutions under the Ministry and approve amendments. Among the tasks, the protection of the environment and ensuring its safety and ensure equilibrium, rehabilitate its natural mechanisms and maintain biodiversity.	Ministry of Water & Environment	Passed
Republican Resolution No. (101) of 2005 on the establishment of EPA	This resolution stipulated that the EPA is the official Government organ specialized in environment and protection of natural resources and protection of all environment components from damages, pollution or negative effects.	Environment Protection Authority	Passed
Environment Protection Law No. (26) of 1995	This law aims to protect the environment and conserve its safety and balance and maintain its natural ecosystems. It also aims to protect the natural resources and their development and conserve the species and kinds of life in the national environment	Environment Protection Authority	Passed
The executive regulation of the law No. (26) of 1995, on environment protection issued by the cabinet resolution No.(148) of 2000	The executive regulation mentioned contains 71 articles. In the field of biodiversity, Article No (27) of the executive regulation prohibits the damaging or destruction of the wild plants of which a resolution is issued by the competent body	Environment Protection Authority	Passed
????????	Article No (3) of the Republican resolution specifies the objectives of the resolution, which are all directly related to biodiversity and biosafety.	Environment Protection Authority	Passed
The cabinet resolution No. (104) of 2002, on the approval of the regulation of protecting the species threatened with extinction of the group of wild animals and plants, and organizing their trade	Articles from (9) to (20) specify a group of restrains concerned with biodiversity and biosafety.	Environment Protection Authority	Passed
Republican Decree no 64 for 2005, on the acceptance of Cartagena protocol on Biosafety	Cartagena Protocol	Environment Protection Authority	passed
Law No (20) of 1998, on seeds and agricultural fertilizers	Article No. (3) of the law above specifies a group of objectives related directly or indirectly to biodiversity and biosafety, which are summarized in the following: Organizing and registering the approved kinds of seeds including sewing seeds and seedling, and producing and marketing them.	Ministry of Agriculture & Irrigation	Passed
Botanical (plant) quarantine law No. (32)	The law, according to the statement of article No. (3) aims to achieve a group of objectives relating directly and indirectly to biodiversity and biosafety	Ministry of Agriculture & Irrigation	Passed
Law No. 27 of 2004 on International Treaty on Plant Genetic Resources of the FAO	This treaty is about conservation of plant genetic resources by the FAO and their sustainable use and sharing benefits from this use on the basis of equal partnership in harmony with the biodiversity treaty for sustainable agriculture and food security	Ministry of Agriculture & Irrigation	Passed

Name of legislation	Purpose/objective	Responsible agency	Status
The Republican resolution No. (156) of 1998, regarding the reorganization of the Agricultural Researches Authority	The regulations of article No (5) of the Republican resolution specify that the authority aims to execute the policy and general plan of the government in the field of developing and improving the agricultural production in its both sides of plants and animals through performing scientific and applied researches and studies in the different agricultural fields, and to coordinate the activities of the agricultural guidance.	Ministry of Agriculture & Irrigation	Passed
The Republican resolution No. (52) of 2000, regarding the establishment of the Yemen Authority of Specifications, Standards and Quality Control (YASSQC)	The YASSQC is considered as the sole body in charge of specifications affairs, quality control, jewelry and valuable metals. The exceptions of those are human and veterinary medicinal products, and also, serums and vaccinations, according to the regulations of article No. (6) of the law. In the field of biological resources and biosafety, the YASSQC is functioning to assure that products correspond and fulfill the hygienic, economic and environmental protection of the country and people, and also to assure that the consumer-commodities correspond to the approved standardized specifications.	Yemen Authority of Specifications, Standards and Quality Control (YASSQC)	Passed
Law No. (44) of 1991, regarding specifications and standards, and quality control	Article No. (2) of the law specifies a group of definitions; the ones related directly and indirectly to biosfety are: Standardized specifications and Approved standardized specifications	Yemen Authority of Specifications, Standards and Quality Control (YASSQC)	Passed
Law No. 1 of 1992 on external trade ratified by Republican Resolution No. 16 of 1996.	This Law stipulates the following: Ban import of commodities which are in contradiction with Islamic "Sharea" and the Laws and Regulations pertinent to Nation security and public health, safety, ethics and environment. All Imported commodities are subjected to standards and specifications applied as per Council of Ministers resolutions.	Yemen Authority of Specifications, Standards and Quality Control (YASSQC)	Passed
The Republican resolution No. (2) of 2002, regarding the establishment of the Scientific Research Supreme Council	Article No. (3) of the Republican resolution above specifics the basic objective of the council, which is included in the following: The council aims to strengthen (or reinforce) the national capacity in adopting scientific researches and improving and widening the base of scientific and technical knowledge in order to solve the problems of economy. The council responsibilities are specified:	Ministry of Higher Education and Scientific Research	Passed
The Republican resolution by the law No. (20) of 1991, on the cabinet law	Section (21) of article No. (32) of the resolution by the law above specifies the following: Drawing the policies of higher education and scientific research, approving plans/synopses of scientific researches, and supervising and coordinating between higher education programs and the balanced plans of economy in the country.	Ministry of Higher Education and Scientific Research	Passed
The Republican resolution No. (126) of 1999, regarding the establishment of the Atomic National Energy Committee (YAPNBC)	The regulations of article No. (4) of the republic resolution above specify that the YAPNBC is the governmental organization concerned with atomic power affairs in the Republic of Yemen, and it aims to develop the peaceful uses of atomic power and participate in protecting community health and environment safety.	National Atomic Energy Committee (YAPNBC)	Passed
The Republican resolution by the law No. (38) of 1992, on food monitoring and the regulation of their handling, which was amended by the law No. (13) of 2002.	Article No. (2) of the Republican resolution by the law specifies a group of definitions directly or indirectly related to biological diversity and biosafety :	Ministry of Public Works & Urban Planning	Passed
Law No. (22) of 2002, on exploitation of Yemeni, Arab & Foreign Capitals	The law aims to encourage and regulate the exploitation of Yemeni, Arab and foreign capitals subjected to the regulations of this law, within the frame of the country's general policy, and the goals and priorities of the national plan of the economic and social development, in such a way that does not contradict the regulations of Islamic Sharea		Passed
Law No. (4) of 1993, on free zones	The regulations of article No. (8) of the law specify the licensed works in the free zone. The most important of these works and those related directly or indirectly to biodiversity and biosafety. The regulations of article No. (8) of the law specify the prohibition of the entry and handling of certain goods in the free zone; the ones related directly or indirectly to biodiversity and biosafety are: Spoiled (or rotten) and stinking goods, Radiating (or radioactive) substances, Drugs of all kinds and their derivatives, Goods violating the laws. Article No. (10) of the law above specifies that any works or activities violating the environment protection instructions are prohibited in the free zone	Free Zone Authority	Passed

Name of legislation	Purpose/objective	Responsible agency	Status
The Republican resolution by the law No. (19) of 1994, on intellectual right	Article No. (1) of the resolution by the law specifies that the law of intellectual right aims to protect the right of an author, discoverer and inventor to ensure freedom of creation, expand and promote technical advancement, arrange for each one of them to benefit from their works, and protect society and technical creation. Article No. (2) specifies that subjected to the author's right, the creative work distinguished by novelty in the field of arts, fine arts and science of whatever form, purpose, or importance and method of producing it; and whether it is classified in one of the known branches of creativity or not.		Passed
The Republican resolution by the law No. (12) of 1994, on crimes and punishments, reshuffled by the law No. (16) of 1995	Article No. (140) of the law above states that he/she is punished by imprisonment for a period of not more than ten years, who intentionally exposed people's life or safety to danger by putting poisonous/toxic or harmful substances in the territorial waters, a well, a water-tank, or any other thing for public use, which in its nature shall cause death or great damage.		Passed
The Republican resolution by the law No. (17) of 1995, on the Yemeni universities, reshuffled by the law No. (20) of 1997	According to section (e) of article No. (5), the republican resolution by the law specifies for the development of directions/trends toward sciences and technologies, and the manner of benefiting from all of that in improving and solving environmental issues, and also for the development of knowledge by conducting scientific researches in different fields of knowledge whether on the individual or collective levels. Article No. (49) of the law above specifies for the formation of a council of higher education and scientific research, in such a manner that the council shall be concerned with organizing the affairs of higher education and scientific research, encouraging it and providing support and other requirements	Yemen Universities	Passed