PART 1: GENERAL

1.1 DESCRIPTION

A. The work in this section consists of furnishing and installing plant, soils, grasses and landscape materials required as specified in locations shown.

1.2 DEFINITIONS

A. Backfill: The earth used to replace earth in an excavation.

B. Container-Grown Stock: Healthy, vigorous, well-rooted plants grown in a container, with a well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for type and size of plant required.

C. Finish Grade: Elevation of finished surface of planting soil.

D. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.

E. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

F. Planting Soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

G. Plant Material: These terms refer to vegetation in general, including trees, shrubs, vines, ground covers, turf and grasses, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.

H. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.

I. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

J. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.

1.3 DELIVERY, STORAGE AND HANDLING

A. Notify the Contracting Officer's Representative of the delivery schedule in advance so the plant material may be inspected upon arrival at the job site. Remove unacceptable plant and landscape materials from the job site immediately.

B. Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, as applicable. Keep seed and other packaged materials in dry storage away from contaminants.

C. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants. Keep bulk materials in dry storage away from contaminants.

1.4 PROJECT CONDITIONS

A. Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.

B. Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.

C. Plant trees, shrubs, and other plants after finish grades are established and before planting turf areas unless otherwise indicated.

1. When planting trees, shrubs, and other plants after planting turf areas, protect turf areas, and promptly repair damage caused by planting operations.

1.5 SUBMITTALS

A. Submit product data for each type of product indicated, including soils:

1. Include quantities, sizes, quality, and sources for plant materials.
2. Include color photographs in print, format of each required species and size of plant material as it will be furnished to the Project. Take photographs from an angle depicting true size and condition of the typical plant to be furnished. Include a scale rod or other measuring device in each photograph. For species where more than 10 plants are required, include a minimum of 3 photographs showing the average plant, the best quality plant, and the worst quality plant to be furnished. Identify each photograph with the full scientific name of the plant, plant size, and name of the growing nursery.

B. Submit samples and manufacturer’s literature for each of the following for approval before work is started.

1.6 APPLICABLE PUBLICATIONS

A. The publications listed below, form a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.

B. American National Standards Institute (ANSI):

Z60.1-04 ..... Nursery Stock

C. American Society For Testing And Materials (ASTM):

B221-08 ..... Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes

C33/C33M-11 ..... Concrete Aggregates

C136-06 ..... Sieve Analysis of Fine and Coarse Aggregates

C516-08 ..... Vermiculite Loose Fill Thermal Insulation

C549-06 ..... Perlite Loose Fill Insulation

C602-07 ..... Agricultural Liming Materials

D977-05 ..... Emulsified Asphalt (AASTHO M140)

1.7 WARRANTY

A. The Contractor shall remedy any defect due to faulty material or workmanship and pay for any damage to other work resulting therefrom within a period of 1 year from final acceptance, unless noted otherwise below. Further, the Contractor will provide all manufacturer's and supplier's written guarantees and warranties covering materials and equipment furnished under this Contract.

1.8 PRODUCTS

PLANT MATERIAL

A. See attached ANNEX B-PLANT LIST

PART 2 - EXECUTION

2.1 EXAMINATION

A. As per approved Landscape contractor maintenance manual

B. See drawings for the location of the plants.

2.2 CLEANUP AND PROTECTION

A. During planting, keep adjacent paving and construction clean and work area in an orderly condition.

B. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.
C. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.
D. Erect temporary fencing or barricades and warning signs, as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.
E. Remove non- degradable erosion control measures after grass establishment period.
F. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.

PART 3 -Landscape report:

Plants, within the greenest has been placed according to its required growth preference .And was taken in consideration to be used to provide the house surroundings and environment an aesthetic feature, Fragrance and refreshing air. As provided also to absorbed all unwanted toxins such as VOC to make the interior healthy and beautiful. It also provides calming and neutral relationship for the occupants and visitors of the greenest.

Plants were chosen and planted based on its habitual requirement and was incorporated in the design as a sustainable feature of the house. Gray water was part of this sustainable approach whereas it is reused to irrigate the plants.

We have also adapted the local plant yield to be planted in the organic farming garden in the east side of the house. This is to promote sustainable living while eating fresh and own grown vegetable and spices. There have been a list of local vegetable yield list provided by the local authority for agriculture (see attached supplemental file as annexure A) .Refer to the plant list as attached for detailed information of the plants species that was planted in the surroundings of the house(see attached plant list as annexure B)

REPORT AUTHORS:

- NINO ARCALA MANGLICMOT
  Email add: Nino-Manglicmot@hct.edu.om
- FELIXBERTO POLISON
  Email add:felixberto.polison @hct.edu.om

A. Plant Species.

P-01 "Chinese evergreen" (*Aglaonema commutatum*)

The Chinese evergreen is from the *Aglaonema* genus which also branches out to many hybrid varieties. This plant can be maintained within low light conditions. If the plant is placed in high light conditions, it is suggested to dry down the potting mix to ½ to ¾ of the way out before watering. In contrast, in a low light condition it is suggested to allow the soil to dry out completely in between watering. It should not be overwatered. The soil to be used could either perlite or sand to improve the drainage.

P-02 "**Snake plant**" (*Sansevieria*)

The Snake plant is a member of the lily family. This plant serves as an excellent house plant since it can survive such unsuitable conditions indoors. Generally, its leaves are thick and stiff. The plant should be watered moderately during growing season but less during winter season. It can survive with less watering but it should not be overwatered. It is also among the top plant's tested by NASA for removing harmful toxins such as benzene and formaldehyde within the environment.

P-03"**Dragon tree**" (*Dracaena marginata*)

The Dragon tree came from a large species of the genus *Dracaena* with many distinct variations. This variations involves the leaf colors, leaf sizes and even the trunk types. It is advised to keep the soil moist at all times for this plant. It should also be watered moderately during growth season and less during winter season. Areas with bright conditions is suitable for the plant. Exposure to direct sunlight might damage its leaves.

P-04 "Golden pothos or Devils ivy" (*Epipremnum aureum*)

Among the common species for *Epipremnum* is the Golden pothos or Devils ivy. This is a type of plant that attaches itself to other stems with the use of its aerial roots and then extends its stems downward and grow across with the soil. It requires watering when the first inch of the soil where it is planted is dry. Overwatering it results to the rotting of its roots. The watering should be reduced during fall and winter seasons.

P-05 "**Aglaonema**" (*Aglaonema Modestum*)

Aglaonema modestum is one of the members of the *Aglaonema* genus which is a foliage type plant. It has a lance-shaped and waxy green leaves. This plant is best indoors, since it has grown a useful foliage rather than flowers. It is recommended to water the plant moderately in its active growth stage but allowing the 2-3 centimeters of the soil to dry in between the waterings.

P-06"**Dumb cane**" (*Dieffenbachia amoena*)

The Dumb cane plant is a unique type of species that survives any light conditions other than exposure to direct sunlight. This plant grows in any soil mixtures except for sand mixtures. The top inch part of the soil should be moist at all times for the best result of growth. Watering it moderately will make the leaves stiffen. Less watering of the plant would result to the shriveling of the leaves. The watering should be maintained to keep the keep the soil moist at all times. The qualities it possess makes adds to the style of it being a house pla

P-07 "**Heart leaf Philodendron or Sweetheart plant**" (*Philodendron scandens*)

The Sweetheart plant is part of the Aracae family and is known as a vinedue to itsclimbing abilities in their natural habitat. It is a versatile plant for the fact that it can grow within indoor and outdoor conditions. During the spring and summer seasons, the soil should always be kept moist through moderate watering. In contrast, the soil shoulddried out in between waterings during winter season. It is suggested that a mixture of 2 parts peat and 1 part perlite would be a good option for the soil.

P-08 "**Sago palm**" (*Cycas revoluta*)

Sago palms are considered to be slow growing plants since it would take it years to reach a height of 2 feet especially when grown indoors. Its stem produces pinnate fronds which is similar to that of a fern. The plant grows best with bright light even without direct exposure to sunlight. Water the plant once the soil at the top part is dry. Over- watering or watering at the crown of the plant should be avoided since it may cause the rotting of the plant. Watering during the winter season is reduced. The plant has air filtering abilities as it is said to reduce benzene, formaldehyde, xylene and toluene in the air.

P-09"**Cornstalk plant**" (DRACENA MASSANGEANA)

The Cornstalk plant is considered an attractive when it comes to being a center plant indoors since it is easy to care and to maintain. As it grows towards the height of 4 feet, it adds up to the ideal plant of an office or a room. The plant grows with one or more canes which branches out to new stems and a crown of leaves at the top of the cane. During fine seasons, watering the soil should be kept damp to the touch while it should be slightly dry during the winter. The plant was used in the NASA's clean air study in which it was proven to remove amounts of toxins in the surroundings.

P-10"**Aloe Vera**" (*Aloe barbadensis*)

The Aloe Vera plant is commonly known for the medicinal and health benefits that it offers. It also serves other purposes such as a healthy juice drink and as a coolant for sunburns. The plant thrives on bright light conditions but not on direct exposure to sunlight. It is a succulent type of a plant in which the foliage are mainly made up of water. Watering should be maintained in order for the soil to be moist at times. Much less water is needed in the winter

P-11 "**Bunny Ear cactus**" (*Opuntia microdasys*)

The Bunny Ear cactus has the appearance of a shrub as it matures. It contains no central stem or leaves. Individual segments constitute the body of the cactus in which it looks like oval shaped pads. The plant grows the demand of full light conditions. It is also a desert species which means that it should be given water on a regularly during its first season in the pot. The soil should be kept moist at times. Sporadic watering is recommended after the first season. The cactus should not be watered at all during the winter season.

P-12 "**Busy Lizzie**" (*Impatiens walleriana*)

The *Impatiens walleriana* is popular for their attractive blooms within indoor and outdoor environments given the correct light condition. The flowering plant is considered to brighten conservatories and gardens which is why it highly sold today. Its flowers bloom in different variety and sets of colors. Growing this plant indoors requires providing enough light and water. Watering during growing season is highly suggested. Keeping the soil moist at all times plays an important role for the result of its growth.

P-14 "**Shin Dagger**" (*Agave lechuguilla*)

The *Agave lechuguilla* is one of the common indicator succulent plants in the family *Agavaceae*. It is a low growing species with characterizes a narrow and spine-tipped leaves. It can be seen that it also has spiny pads that serves as an adaptation in snow or dead prairie grass. The pads are considered to be the swollen segments. These type of plants prefer to be dry. Watering should be slow, making sure that it is dried completely between waterings. The plant can be a good choice for native gardens in outcroppings.

P-15"**Asparagus Fern**" (*Asparagus densiflorus*)

There have been several species and different varieties of Asparagus Fern that have been grown as ornamental house plants since it is suitable for growing indoors. This plant is not considered as a true fern as it is a member of the lily family. It should be planted in in a slightly acidic and well-drained soil. Water regularly on a maintained basis. The moisture of the soil should be kept always as it contributes to the factor of humidity. Some of the asparagus ferns have developed a built system which helps it prevent from drying out.

P-16 "**Purple heart**" (*Setcreasea pallida*) Tradescanthia Pallida

The Purple heart is a perennial plant with purple stems and violet leaves. This plant is mainly propagated for its foliage which exhibits an attractive color. Provide moist soil in part to full sun. An efficient color is achieved in bright light conditions and a dry root zone. Watering should be moderate and the use of fertilizers is suggested monthly during active growth. The commercial potting mix to be used may consist of peat moss, perlite or compost.

P-17 "**Song of India**" (*Dracaena reflexa*)

The *Dracaena reflexa* is popular among garden stores since it displays different leaf variations. It grows up to 3 feet tall within indoors. The *Dracaena* family in which it belongs proves that it is easy to care. This plant grows even without bright light conditions. It focuses on the humidity of the environment. Watering it regularly would keep the soil slightly moist at all times but the soil should be dry during winter. The plant was used in the studies of NASA as it was proven to remove certain amounts of toxins in the surroundings.

"**Jasmine**" (*Jasminum polyanthum*)

The Jasmine is a popular plant I warmer climates for its exotic fragrance. It is also noted for its herbal properties. The plant have a variety of species as a vine, a bush and some are evergreen. The bush type is considered a good landscape specimen with different scented blooms. The plant is sensitive to dryness in which humidity plays and important role in the surroundings. The plant should be watered only when the top half inch of the potting mix is dry allowing it to be moist at times but not soggy.

"**Bougainvillea**" (*Bougainvillea spp.*)

The bougainvillea is a tropical plant that blooms with colorful flowers and unique flowers. The flowers are usually pink, purple, red and other

varieties ranging from white to bright orange. This plant has a shrub-like vine feature that climbs up to walls and trellises. Watering should be sparingly but do not over-water the plant for it can lessen the bloom of flowers. Keep the soil moist at times but not waterlogged.

"**Yerba Buena** or **Peppermint**" (*Mentha arvensis Linn.*)

The Peppermint is a common aromatic herb of the mint family that is known for its medicinal use. Its medicinal uses can be a body pain reliever, a tea for cough and colds and menstrual pain. Its minty scent can be used to relieve nausea. The plant is also popular in the field of culinary applications for its minty flavor. It should be monitored that the watering should be at least an inch every week. Snipping the budding tips would promote its bushier growth.

"**Rosy Periwinkle**" (*Catharantus roseus*)

The Rosy Periwinkle is a plant used commonly as a ground cover. It can tolerate many growing conditions especially in annual warm seasons. In traditional medicine, the plant has been widely used to treat different ailments in different parts of the world and has also been found out that the plant contains highly toxic alkaloids that are now used in the treatment of cancer. Apply supplemental water within the hottest and driest seasons but do not overwater. The plant survives in both partial shade or partial sun type of conditions.

"**Roselle**" (*Hibiscus sabdariffa*)

The Roselle plant is a tall tropical, red and green shrub that is an excellent addition to the garden for its colorful bloom. It a short-day plant that usually grows tropical and subtropical conditions. The small leaves can be a good addition to fresh salads. You can also make use of the leaves to make a jam or a refreshing tea. The mature Roselle plant are can resist dry conditions but watering should be required during dry periods to maintain the soil moisture to avoid the wilting of the leaves.

"**Eggplant**" (*Solanum melongena*)

The eggplant is one of the most common vegetables which you can easily grow in the garden but is sensitive to cold conditions. It is also short-lived

a perennial vegetable that is usually cultivated as an annual. The plant can be differentiated in size, shape and color of the fruits. Eggplants survive in tropical and subtropical areas in which it requires high temperatures. Frequent watering of the plant is necessary. A supply of moisture should be monitors but do not make the soil soggy. It is also suggested that the use of drip systems are ideal for the plant.

"**Parsley**" (*Petroselinum crispum*)

Parsley is a biennial plant with green and feather-shaped leaves. This plant is a herb that is used in cooking soups and making salads. It is considered to promote health and is known to contain vitamins A and C. It is also used as an excellent decorative garnish. The plant can be grown in pots or out in the garden and is commonly propagated through seeds. Watering the plant deeply at least once a week is recommended to help the growth of a long taproot. It should also be watered frequently during hot and dry periods. When indoors, watering should be enough just to keep the soil moist.

"**Tomato**" (*Lycopersicon esculentum*)

Tomatoes are one of the most popular garden vegetable. The fruit of the tomato plant is generally considered as a fruit. It is widely used in the field of cooking on different varieties of dishes around the world. This plant is easy to care since it is susceptible to a range of pests and diseases. Watering should be often and deeply in which the soil should be soaked in six to eight inches deep, at least twice a week. Keeping moisture in the soil will help prevent the rotting of the plant.

"**Guava fruit tree**" (*Psidium guajava*)

The Guava is a tropical fruit tree that can grow 10 - 12 feet and can potentially reach a height of 30 feet. The evergreen leaves are stiff and elliptical in shape. The tree needs hot conditions to produce fruit. Blooms may appear annually in mild cold climates. The tree is commonly known to produce sweet fruits that are best when fresh. The harvested are also used to make jellies and preserves. The tree should be watered when the top 6 to 8 inches of soil have dried. Watering should cover at least a 2 feet depth. The lack of moisture in the soil will delay the bloom of the flower and can cause the fruit to drop.

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END OF SECTION 32 90 00

GreenNest -Landscaping Plant List

KEY NO.	Common name	Botanical name	Usage	Type	WATER REQUIREMENT	FREQUENCY OF IRRIGATION	TYPE OF WATER	soil reqirement	Size	Light	Water	Zone hardiness	Other care
P-01	**CHINESE EVERGREEN**	***Aglaonema* hybrid**	Chinese evergreens are among the best plants for removing toxins, such as formaldehyde, from tainted indoor air.	Perennial	1 LTR	WEEKLY ONCE	POTABLE WATER	Any good-quality potting mix.	2-3 ft (60-90 cm)	Low light. Too much light may cause its leaves to fade.	Keep potting mix evenly moist.	2 through 10	**Keep it warm.** This plant has no tolerance for the cold. It suffers when exposed to temperatures below 55°F/13°C. Cold air may cause grayish-yellow patches on its leaves.
P-02	**Snake plant**	**Sansevieria**	Long, creamy white flower spikes may appear on mature plants. If you're lucky enough to get the blooms, you'll love their beautiful fragrance.	Cactus and succulents	1 LTR	WEEKLY ONCE	POTABLE WATER	Soilless or cactus potting mix	Up to 2 ft (60 cm)	Bright light.	Drought-tolerant; suitable for xeriscaping Average Water Needs; Water regularly; do not overwater	9b to 11	Feed monthly spring through fall with this fertilizer for succulent plants.
P-03	**Dragon tree**	**DRACENA MARGINATA**	This beautiful tree starts out as a thick tuft of spiky leaves.	Perennial	0.75 LTR	WEEKLY ONCE	POTABLE WATER SHOULD BE WITHOUT FLORIDES	Good-quality, all-purpose potting mix.	To 6 ft (1.8 m)	Bright light. Avoid direct sunlight in summer.	Keep soil lightly moist spring through fall, slightly drier in winter. Do not let soil get	9a to 11	Suitable for growing in containersThis plant is suitable for growing indoors
P-04	**Devils Ivy**	**Epipremnum aureum**	used as a green wall plant	Vines and Climbers	1 LTR	WEEKLY ONCE	POTABLE WATER	Soil pH requirements: 5.1 to 5.5 (strongly acidic) 5.6 to 6.0 (acidic) 6.1 to 6.5 (mildly acidic)	6-12 in. (15-30 cm)	Light Shade	Average Water Needs; Water regularly; do not overwater		Suitable for growing in containersThis plant is suitable for growing indoors
P-05	**Aglaonema"**	**(Aglaonema Modestum)**		Perennial	1 LTR	WEEKLY ONCE	POTABLE WATER	Any good-quality potting mix.	2-3 ft (60-90 cm)	Low light. Too much light may cause its leaves to fade.	Keep potting mix evenly moist.	2 through 10	**Keep it warm.** This plant has no tolerance for the cold. It suffers when exposed to temperatures below 55°F/13°C. Cold air may cause grayish-yellow patches on its leaves.

P-06	**Dumb cane**	**DIEFFENBACHIA**	it tolerates average room humidity quite well and is easy to grow.	Perennial	1 LTR	WEEKLY ONCE	POTABLE WATER	Soilless potting mix to allow good drainage	6-8 ft. (1.8-2.4 m)	Light Shade Partial to Full Shade	Average Water Needs; Water regularly; do not overwater	2 through 10	Cut back your dieffenbachia if it grows too tall. Use sharp pruners to cut off the top of the plant, leaving a few leaves. New growth will sprout from where it was cut.
P-07	**Sweetheart plant**	**PHILADENDRONS**	a mainstay in interior gardens. Philodendron care is easy because if you watch for the signals, the plant will tell you exactly what it needs. Even inexperienced houseplant owners will have no trouble growing philodendron plants because they adapt readily to the conditions inside the home. This makes learning how to care for a philodendron incredibly simple.	Vines and crawlers	0.75 LTR	WEEKLY ONCE	POTABLE WATER	Any good-quality potting mix.	6-8 ft. (1.8-2.4 m)	bright, indirect sunlight	allow the top inch of soil to dry out between waterings		Feed philodendron houseplants with a balanced liquid foliage houseplant fertilizer that contains macro-nutrients. Water the plant with the fertilizer monthly in spring and summer and every six to eight weeks in fall and winter.
P-08	**Cycus revoluta(SAGO PALM)**	**Cycus revoluta**		tree	5 LTR/plant	WEEKLY ONCE	POTABLE WATER	combine 2 parts peat-moss based potting mix and 1 part sharp sand or perlite.	Up to 6 ft (1.8 m) indoors. Can be kept dwarfed by growing it in a small pot.	Bright light with some direct sun	Water thoroughly and allow the soil to dry out a bit between waterings		This plant doesn't really like to be disturbed, so repot only when necessary. Pruning can be done anytime to remove dead fronds
P-09	**Cornstalk plant**	**DRACENA MARGINATA**	This beautiful tree starts out as a thick tuft of spiky leaves.	Perennial	0.75 LTR	WEEKLY ONCE	POTABLE WATER SHOULD BE WITHOUT FLORIDES	Good-quality, all-purpose potting mix.	To 6 ft (1.8 m)	Bright light. Avoid direct sunlight in summer.	Keep soil lightly moist spring through fall, slightly drier in winter. Do not let soil get	9a to 11	Suitable for growing in containersThis plant is suitable for growing indoors

P-10	**Aloe vera**	**Savila**	medicinal and heat barrier	Cactus and Succulents	1 LTR/plant	WEEKLY ONCE	TREATED WATR IS OK	Cactus potting mix. Or add 1 part coarse sand with 2 parts all-purpose potting mix.	18-24 in. (45-60 cm)	Full Sun	Drought-tolerant; suitable for xeriscaping		Suitable for growing in containersThis plant is suitable for growing indoors
P-11	**CACTUS**	***Cactaceae* family**	All desert cacti love to bask in the sun. A south-facing window is ideal for cactus house plants. Most of them will flower if given enough sunshine, although some types of cactus will bloom only when they are a few years old.	Cactus and Succulents	0.5 LTR/plant	ONCE IN A FORTNIGHT	POTABLE WATER	Cactus potting mix. Or add 1 part coarse sand with 2 parts all-purpose potting mix.	under 6 in. (15 cm)	Full Sun	Drought-tolerant; suitable for xeriscaping		Suitable for growing in containersThis plant is suitable for growing indoors
P-12	**"Busy Lizzie"**	**(Impatiens walleriana)**	aesthetic ,Beds and borders, City, Cottage/Informal, Low Maintenance, Wallside and trellises	Bushes and shrubs	5 LTR	DAILY	TREATED WATR IS ALSO OK	Chalky, Clay, Loamy, Sandy (will tolerate most soil types)	24-36 in. (60-90 cm)	Full Sun	Average Water Needs; Water regularly; do not overwater	Hardy (H	Plant in full sun. Resents shade. Best not to plant roses in soil where other roses have previously been planted. Avoid watering from overhead
P-13	**Blue Agave**	**Agave tequilla**	bordershis plant is attractive to bees, butterflies and/or birds	Cactus and Succulents	4 LTR/Plant	DAILY	TREATED WATR IS OK	Cactus potting mix. Or add 1 part coarse sand with 2 parts all-purpose potting mix.	4-6 ft. (1.2-1.8 m	Full Sun	Drought-tolerant; suitable for xeriscaping		
P-14	**Liriope**	**Liriope" (Liriope muscari)**		Cactus and Succulents	1 LTR	WEEKLY ONCE	TREATED WATR IS ALSO OK	can grow in sand	6-12 in. (15-30 cm)	Full Sun	,Drought-tolerant; suitable for xeriscaping loam or clay type of soil		
P-15	**"Purple heart"**	**(Setcreasea pallida)**	Blooms all year	Perennials	7 LTR/SQ M	DAILY	TREATED WATR IS OK	Cactus potting mix. Or add 1 part coarse sand with 2 parts all-purpose potting mix.	12-18 in. (30-45 cm)	Sun to Partial Shade	Drought-tolerant; suitable for xeriscaping		

P-16	**Jasmine**	**Jasminum polyanthum .**	create a private room in your garden by surrounding it with vine-covered structures, or plant some vines around a sleeping porch for lovely scented breezes.	Vines and Climbers	5 LTR	DAILY	TREATED WATR IS ALSO OK	Any good-quality potting mix.	30-40 ft. (9-12 m)	Full Su	Average Water Needs; Water regularly; do not overwater		
P-17	**Song of India**	***Dracaena reflexa***			1 LTR	WEEKLY ONCE	POTABLE WATER	Any good-quality potting mix.	4-6 ft. (1.2	Bright light with some direct sun	Requires consistently moist soil; do not let dry out between waterings		
P-19	**BOUGAINVILLIA**		fence border	Bushes and shrubs	5 LTR	DAILY	GRAYWATER		12-15 ft. (3.6-4.7 m)	Full Su	Drought-tolerant; suitable for xeriscaping		
P-20	**Wild Jasmine**	**Clerodendrum iner**	fence border	Bushes and shrubs	10	DAILY	GRAYWATER		12-15 ft. (3.6-4.7 m)	Full Su	Drought-tolerant; suitable for xeriscaping		
p-21	**grass**	**Shadow Turf**	t covers one-fourth of Earth's land, feeds millions of animals and birds, and helps stop erosion	grasses	5 LTR	DAILY	GRAYWATER		under 6 in. (15 cm	Sun to Partial Shade			
P-22	**Organic vegetable garden**	The vegetables will be watered with clean potable water and will be isolated and potted to avoid contamination.all vegetables crops that will and be grown will be based on Table 2. Main species for food and agriculture of Oman (in order of importance for each category) this has adapted the weather here in oman and has proved local high yeild statistic.											

Notes: please see supplemental informations with actual photos as shown on the previous pages

THE STATE OF PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE IN OMAN

Directorate General of Agriculture & Livestock Research

2008

His Majesty Sultan Qaboos Bin Said

Table of Contents

Foreword

Oman is endowed with its rich biodiversity as it has not only diversified traditional agriculture involving almost all types of crop species but also vast rangelands especially in Dhofar having various pasture species. It has wide diversity of crop plants for diet and food or feed purpose in addition to other human use. Some field crops, vegetables, fruit trees, forest trees and rangeland pasture species have been indigenous and known to be grown in the Sultanate since time immemorial. Oman has not only several local adapted cultivars and land races or ecotypes of crop species but also wild relatives of some crop plants that form the source of material for crop breeding to transfer specific characters.

Under the leadership of His Majesty Sultan Qaboos, Oman is well aware of the importance of its own plant genetic resources and hence attained the status of constituent member to actively involve in the Global Plan of Action for food and agriculture through the Royal Decree 10/97 in 1997. Further, Oman has leaped forward to take steps of conservation of its plant genetic resources either individually or globally in collaboration with international organizations/ institutes. It has signed several agreements and passed Royal Decrees and Regulations related to the protection and conservation of plant genetic resources. Establishment of National Committees of Plant Genetic Resources– Steering and Executive, by the Ministry of Agriculture in 2007 involving all the stake holders of the country is another greater event towards conservation of plant genetic resources.

I am extremely happy to go through the Oman Country Report specially prepared for the report on the State of World's Plant Genetic Resources with the assistance of FAO involving all the stakeholders of the country and to know about the establishment of the National Information Sharing Mechanism on the implementation of the Global Plan of Action on PGRFA. I hopefully expect that this Country Report -"The State of Plant Genetic Resources in Oman" would serve as comprehensive source of knowledge about indigenous plant genetic resources in relation to each of the eight chapters covered to all the related stakeholders, ministries, policy makers and farming community of the country.

I would like to thank all the representatives the stakeholders, in general, who have successfully accomplished the job of bringing out this document going through all the processes outlined by the FAO. In this regard, concerted efforts of Dr Ahmed Al-Bakri, Director General of Agriculture & Livestock Research, Dr. Ali Al-Lawati, Assistant Director of Plant Production Research, Dr Stafano Diulgheroff, Research Officer of the FAO, Dr Saleem K Nadaf, Senior Scientist, Plant Genetic Resources, Eng. Safa Al-Farsi, Head, PGR and Eng. Saleh Al-Hinai, researcher, Plant Genetic Resources in writing, editing and finalizing the report, are praiseworthy and highly appreciated

Eng. Khalfan Saleh Mohammed Al- Naabi
Undersecretary, Ministry of Agriculture

THE STATE OF PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE

Executive Summary

This country report has been produced through a participatory process involving several national stakeholders, which has also led to the establishment of the National Information Sharing Mechanism on plant genetic resources for food and agriculture (www.pgrfa.org), a related database and a web portal.[1] It addresses and discusses relevant aspects concerning, *inter alia*, the state of diversity of Oman's plant genetic resources for food and agriculture, *in situ* management, *ex situ* management and utilization, as well as national programs, training and legislation, regional and international collaboration, sharing of benefits and farmers' rights related to plant genetic resources for food and agriculture and contribution of their management to food security and sustainable development of the country.

The Sultanate embraces diverse agro-climatic regions and the principal occupations of the population are agriculture and fishing. It is very well perceived that from the point of long-term national economy and food security, diversification of the agricultural production and sustainable utilization of existing resources are a necessity.

Oman has a wide diversity of crop plants for food or feed purpose in addition to other human use. Among the important crop plant species are 12 field crops, 7 vegetables, 11 fruit trees, 20 forest trees and rangeland pasture species and a few aromatic and medicinal plant species which are known to be grown in the Sultanate since time immemorial. Oman has not only several locally adapted cultivars and land races of crop species but also unexplored wild relatives of some crop plants that may be an irreplaceable source of diversity for traits useful for crop improvement. There are evidences of an increasing pressure on this diversity from several factors, such as soil and water salinity, drought, scarcity of irrigation water, and high grazing pressure by increased number of livestock. These factors are inevitably posing a serious threat to the very survival of Omani indigenous crop species and cultivars. It is a challenge for the institutions of Oman to revert this trend through an integrated and balanced approach, which takes advantage of the expertise and capacity of all national stakeholders.

Plant genetic resources for food and agriculture (PGRFA) inventories and surveys for wheat, barley, forages, some vegetables and fruit crops have been conducted although not systematically for describing the state and distribution of all Omani indigenous species/cultivars for food and agriculture and their wild relatives. There are protected areas under Ministry of Agriculture (MoA) in the vast rangelands of Dhofar (Southern Oman) which are monitored to conserve and protect the diversity of rangeland, pasture, and wild crop relative species. There are numerous activities towards conservation of local landraces of vegetable crops such as onion, garlic, cucumber, sweet potato etc. and grain crops such as wheat, barley, chickpea etc. through on–farm management since early 1990s. There is an urgent need in Oman for raising awareness of the importance of these local plant genetic resources for food and agriculture and of the role of on-farm management in their conservation and improvement.

Collection missions of indigenous plant genetic resources were undertaken by the Ministry of Agriculture during 1980s in collaboration with the International Bureau of Plant Genetic Resources. Further missions were conducted in late 1990s and early 2000 with international institutes like the International Center of Agriculture Research in Dry Areas (ICARDA) and the International Center of Biosaline Agriculture (ICBA). More than six hundreds of these accessions currently are conserved in International centers such as ICARDA and national institute such as USDA. These accessions need to be repatriated and subjected to conservation and utilization in the country.

Oman is fully aware of the importance of utilization of its indigenous plant genetic resources for food and agriculture. Since 1990's, activities have been started for the characterization, selection and improvement through traditional

[1] http://www.pgrfa.org/gpa/omn

breeding, as well as biotechnology and tissue culture techniques of indigenous germplasm like dates, mango, banana, sweet-lime, acid-lime, cucumber, barley, alfalfa and pasture plant species. The full compilation and publication of the results so far achieved is still pending. However, insufficient capacity for plant breeding and biotechnology in terms of qualified personnel, funds, training and facilities are making the progress slow.

Present *ex-situ* field collections of crop, pasture and medicinal plant species should be completed in order to cover existing on-farm and *in situ* diversity. A national genebank for the long term conservation of orthodox seed of plant genetic resources for food and agriculture and their wild relatives needs improvement to complement current on-farm and *in situ* efforts for preserving the country diversity and to foster utilization of these resources.

Several collaborative efforts with respect to the conservation and utilization of PGRFA have taken place since the early 1980's with IBPGR (currently, Bioversity International) and more recently with ICARDA, ICBA, AARINENA etc. Oman has ratified several international conventions and signed agreements dealing with the conservation and utilization of plant genetic resources for food and agriculture. These include the Convention of Biological Diversity in 1994, the Global Plan of Action for conservation and utilization of PGRFA in 1997, and the International Treaty on Plant Genetic Resources for Food and Agriculture in 2004.

The country has already developed some legislation and polices on conservation and utilization of PGRFA, which need to be followed up according to 20 activities of the Global Plan of Action (GPA).

Oman has its own traditional tree crops like dates and lime, which have both food and export value whereas grain crops like wheat, barley, and chickpea for local consumption. In addition, indigenous alfalfa is always grown for both local fodder consumption and export to neighboring countries. The above-diversified crops are considered as the crops for food and fodder security of the country. PGRFA management of these crops would help conserving and evolving new variants in the background of traditional cultivars to sustain varying environments, contribute to food production, and improve economic situations of the farming community.

Although a considerable effort is being paid in the country to the conservation and sustainable utilization of plant genetic resources, activities appear scattered among different stakeholders. More coordination and collaboration among stakeholders would certainly produce a multiplier effect on the results allowing for a better use of existing expertise as well as facilities and financial resources and for more viable solutions and provisions toward the conservation and sustainable utilization of our plant genetic resources. To do so all major national stakeholders should participate in drafting a common vision and a forward looking strategy, to be implemented by an integrated national program in which all the stakeholders have defined roles and responsibilities for achieving agreed common goals. In this respect, recently two committees- Steering and Executive, were formed by the Ministry of Agriculture (vide Ministry Order No.203/2007 dated 31 December, 2007).

Introduction to the Sultanate of Oman and the Agriculture Sector

The Sultanate of Oman occupies the eastern corner of the Arabian Peninsula, stretching more than 1700 km from the Strait of Hormuz in the north to the frontiers of Yemen in the south. The Musandam Peninsula, the most northern point of Oman is separated from the rest of the country by Fujaira, which is one of the United Arab Emirates (Figure 1). The country is located between latitudes 16° 40'N and 26° 20'N and longitude 51°E and 59° 40'E. It occupies total area of about 309,500 sq. km, of which mountains, deserts and coastal plains represent 16%, 81% and 3%, respectively.

It can be divided into the following physiographic regions, i. the whole coastal plain- the most important parts are the Batinah Plain in the north, which is the principal agricultural area, and the Salalah Plain in the south; ii. the mountain ranges- that run in the north close to the Batinah Plain is the Jebel Al Akhdar with a peak at 3,000 meters and in the extreme southern part of the country, with peaks from 1,000 to 2,000 meters; and iii. the internal regions- which lay between the coastal plain and the mountains in the north and south consist of several plains with elevations not exceeding 500 meters.

The climate varies from arid in the interior regions, to humid in coastal areas to tropical in the southern parts of the country with a temperature range from below zero (in Jebel Akdar and Jebel Shams) to 50°C in summer in the desert. The average annual rainfall is about 100 mm, mostly distributed between November and February, except in the Dhofar region where there is monsoon rainfall (200-250 mm) during *kharif* (July-September) period.

1. Human Population and Trends

The current population of Oman is 2.34 million according to 2003 Census with a growth rate of 3.28%. Population density is greatest in Muscat and Al Batinah (55%); 21% of the population lives in vast rural areas and nearly 5% lives in mountains and other hilly areas. About one-third of the population is related to agriculture (MAF, 2005a). Income, education, and health indices have widely increased as compared to the past decade reflecting a balanced progress across the different regions with almost equal improvement in life expectancy and education for men and women.

2. Agriculture Sector

Agriculture plays an important role in the country. The total cultivated area is about 72,588 ha of which 60% is located in the coastal areas (MAF, 2004a). Farming systems include production of crops viz. dates and fruits, vegetables, fodder and field crops, as well as livestock such as cattle, sheep, goats, and poultry. Farm holdings vary from less than 0.4 ha to more than 84 ha. Those less than 1.26 ha are about 11% of total farm holdings; those range between 1.26 to 12.60 ha are 65%, while those greater than 12.6 ha are about 23.8%.

2.1. Agriculture Policy

Agriculture and Fisheries products are among the main non-oil commodities that account for nearly 22.7 % of Oman non-oil exports in 2005 (www.moe.gov.om). The agricultural products that are exported include mainly dried and fresh dates, dried limes, fresh fruits, and vegetables. Over the past years, the government has made concerted efforts to improve productivity in agriculture through modern irrigation techniques and crop husbandry practices. As a result, during the last decade the production of dates has increased by 30% while yields of tomatoes, potatoes, and alfalfa have doubled. With the population increasing annually at a rate of more than 3.28 %, there is a need for increasing food production and new strategies are being explored for achieving sustainable food security.

2.2. Agro-ecological regions of Oman

Two main agro-climatic zones are recognized in Oman based on parameters which influence potential of land, water resources and cropping patterns:

- Northern Oman including Batinah Coastal plain, Interior Oman and Dahira plains, Jebel Akhdar and Sharqiya plains.
- Southern Oman, Dhofar including Salalah plain, Dhofar Jebel and Najd.

1.2.2.1.Northern Oman

1.2.2.1.1. Batinah Coastal plain

By far the most important agricultural area in Oman is the Batinah region. It is a low-lying alluvial plain extending for about 240 km from Muscat to the borders with U.A.E., and extending about 30 km inland from the coast. It is located between the Hajar mountain ranges and the Gulf of Oman. The Batinah region occupies almost 60% of the agricultural production and has witnessed dynamic agricultural development in recent years. Crop production depends entirely on irrigation, the main crops being dates, fruit crops, alfalfa, vegetables, and other forage crops.

The climate of the Batinah region is characterized generally by high temperatures reaching 48°C in the summer and mild temperatures ranging from 15°C to 24°C in the winter. Relative humidity may reach over 90 percent. Daily wind runs are comparatively short and mean annual rainfall ranges from 76 to100 mm.

Over pumping of water in the last couple of decades, has led to gradual seawater intrusion causing irrigation water more saline. As a result, several agricultural lands of the coastal areas have become unsuitable for cultivation.

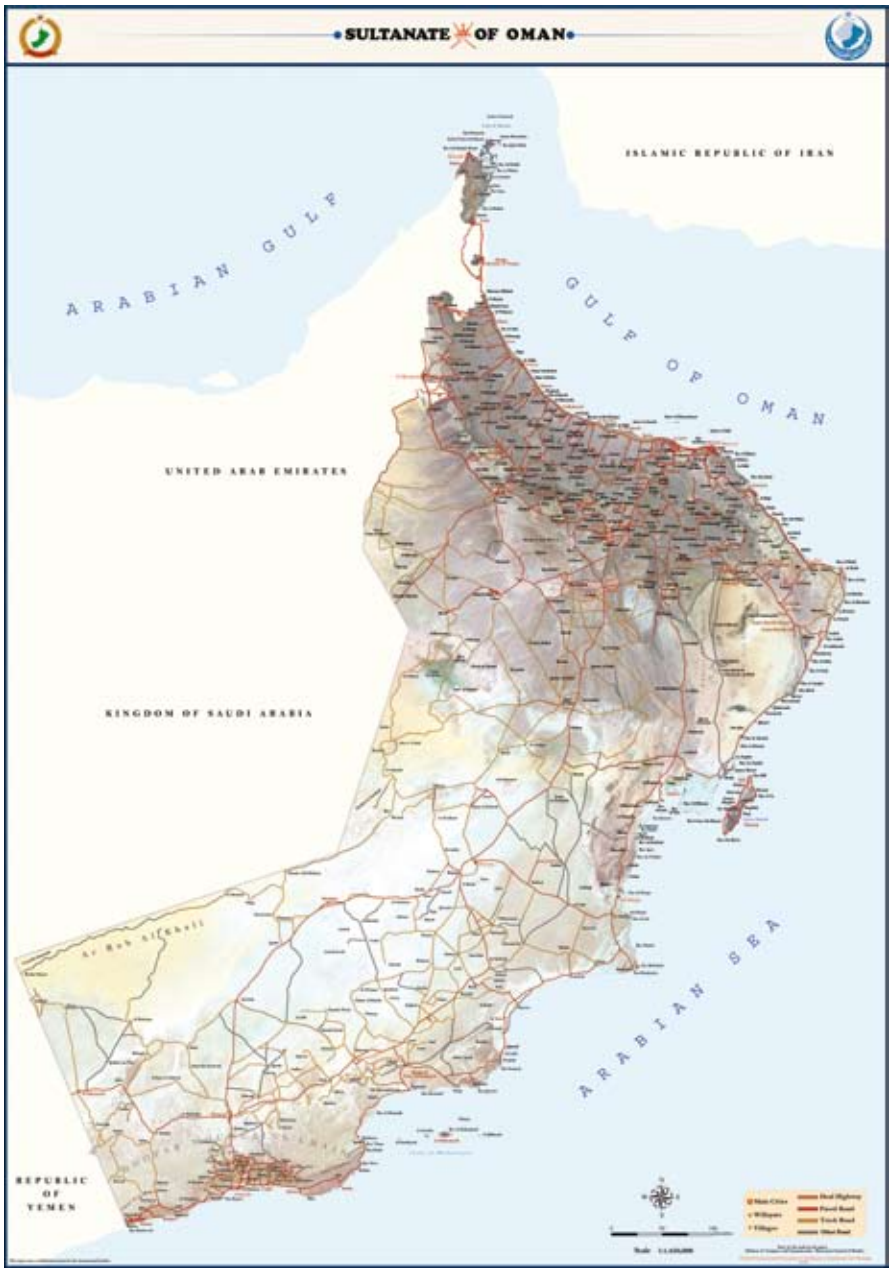

Figure 1. Political map of Oman

The Batinah region can be visualized as divided by the main highway to U.A.E. into two sub-zones, namely one extending from the main highway to the coast (the coastal sub-zone) and the other extending to the west (the inland sub-zone). Although climate-wise these two sub-zones are indistinguishable, differences exist in microclimate, in the quality of irrigation water, in the crop pattern and in the age of plantations. The inland sub-zone has developed more recently and modern systems of irrigation are in use. The coastal sub-zone includes old date plantations of low productivity because of salinity. They are usually intercropped with other tree and forage crops. The PGRFA diversity within these two sub-zones may have been affected due to changes in the quality of irrigation water.

2.2.1.2. Interior Oman and Dhahira plains

The interior plains lie within the inner foothills of the Hajar mountain ranges and constitute a transitional range classified either as the mountain region or the interior lowlands. They include Buraimi plain, Ibri, Wadi Quriyat, Bahla and Nizwa. The main crop in this zone is dates occupying 9463.2 ha (MAF, 2005a). Intercropping with fruit trees is practiced but not to the extent practiced in the Batinah. In order of importance, alfalfa follows date cultivations with 5.6% of the cultivated land, (38368.1 ha) (MAF, 2005a).

The climate of this zone is characterized by high temperatures during summer. Somewhat lower humidity prevails as compared to that in the Batinah coastal plain. The development of the ground water resources of the interior plains and the wadi region has been achieved either through the traditional falaj system or through wells. Nearly 20% of the total area under irrigation is served by the falaj system and 74% by wells (MAF, 2005a).

The range of farm size irrigated from wells is 0.5 to 3.0 ha. Water is pumped in a small distribution reservoir from where it is channeled to the fields through cement canals. Farmers in the interior plain practice basin or border irrigation. The quality of water of the interior plains varies extensively. Most falaj water is generally of good quality.

2.2.1.3. Jebel Akdhar or Saiq Plateau

Jebel Akdhar reaches an altitude of 3000 m. It constitutes a unique climatic zone as compared to any other region of the Sultanate. It is characterized by lower winter temperatures, which satisfy the chilling requirements of number of temperate deciduous fruit and nut trees such as pomegranates, peaches, apricots, apples, pears, walnuts and almonds. The summer temperatures average 30°C. Annual rainfall (300 mm) is significantly higher than elsewhere in Oman, with the exception of Dhofar Jebel, and it is distributed throughout the year.

2.2.1.4. Sharqiya Plains

In wadi Al Batha, agriculture is concentrated around Ibra, Ad Dariz, Al Ghabbi and Al Wafi. The area under crops is estimated to be 1500 ha in 26 oases irrigated mainly by falaj system. The Sur plains seem to have a very limited potential for development due to sea water intrusion. In contrast, the Wadi Batha plain seems to offer best potential for agriculture because of the existence of highly suitable soils associated with good quality groundwater in the Jalaan district around Al Kamil and Al Waif. Irrigation in this region is achieved by falaj systems. Private farms employ flood or furrow irrigation methods.

2.2.2. Southern Oman

The southern region occupies approximately one third of the area of the Sultanate. Apart from the coastal plain extending from Raysut in the west past Salalah, the woody hills reach up to 1500 m elevation behind the plain constitute a separate climatic zone. The southern slopes of the hills known as the 'Jebel' are rather steep, deeply incised narrow wadis, and receive southern monsoon rains. The northern slopes called 'Najd' are much gentle and the wadis dissecting them are wider and less deeply incised.

2.2.2.1. Salalah Plain

Salalah plain is located in the coastal area of the southern province of Dhofar. Dhofar is the only region in Oman to benefit from a substantial amount of rainfall from the southern monsoon Kharif. The average annual rainfall is about

110 mm but can range from about 70 to 360 mm. July-August is normally the 'Wet' period. Ground water derived from aquifers in the central part of plain is of good quality. Some of the spring water is utilized by falaj to provide irrigation water for parts of the plain. Recharge is by underflow from the mountains and from the springs. Irrigation practices and methods are similar to those employed in the Batinah. Modern irrigation techniques are in operation in large commercial farms mainly for the production of forage crops such as Rhodesgrass.

2.2.2.2. Dhofar Jebel

The Jebel mountain ranges form a separate agro-climatic zone of their own. Rainfall is particularly high, ranging from 600 mm to 700 mm, the highest as compared to any other area in the country, supporting a permanent vegetation cover. The rainfed pasture land is concentrated on some half a million hectares on the Jebels Qara and Qamar. The Dhofar Jebel maintains two-thirds of the total cattle and one third of the total goat populations in the Sultanate.

2.2.2.3. Najd

In contrast to the Jebel and the coastal plain, in Najd, there is a quick decrease in precipitation and moisture marked by a rapid transition from the grasslands and savannah-type vegetation found on the Jebel. Temperature is higher in Najd as compared to the plain and the southern slopes. Rainfall in Najd is only in traces.

The region is known to be underlain by an extensive carbonate aquifer. Water quality is generally poor and soils are structure less, of poor fertility and highly permeable. Although the agricultural potential of these areas is limited, investigations have identified suitable areas of Najd with potential for agricultural development.

2.3. Agricultural Commodities

A wide range of crops is cultivated in the Sultanate. The permanent tree crops particularly dates, lime and mango collectively occupy the largest part of the cultivated land followed by perennial forage crops such as alfalfa, Rhodesgrass, elephant grass etc., field crops like wheat, barley, oats, maize, sorghum, fenugreek, fababean, cowpea, chickpea etc., and vegetables like cucumber, garlic, onion, tomato, watermelon etc. (Table 1). Agricultural crops are grown mostly in Batinah, Al'Dakhliya, Al'Dhahira, Sharquiya, Musandam and Dhofar region. All the crops are irrigated in Oman except in Musandam region where crops like wheat and barley are grown as rainfed. Irrigation is by flood, drip, bubbler, or sprinklers.

Table 1. Area of different groups of crops in Oman (MAF, 2005a)

Crops	Area (ha)	% of Total area
Fruit Crops including dates	39926	58.03
Perennial forages	15956	25.08
Field Crops	5596	8.79
Vegetable Crops	5154	8.10
Total	63632	100.00

2.4. Agriculture Situation

All agriculture in Oman is irrigated and since 1970s the area under irrigation increased from about 28,000 ha to 63,632 ha in 2005 (MAF, 2005a). Although 2.2 million ha are considered suitable for agriculture, groundwater appears not sufficient for most areas. At present, groundwater depletion has taken place, especially in coastal areas, leading to seawater intrusion and deterioration in the water quality.

The Ministry of Agriculture (MoA) has made efforts since 1990s to introduce modern irrigation techniques. In order to encourage farmers to modern irrigation techniques, MAF had given a financial subsidy in irrigation systems

varying between 75 % for small-scale schemes (less than 4.2 ha), 50% for medium-scale schemes and 25% for large-scale schemes (more than 21 ha). Despite these efforts, the traditional flood system still remains the most common irrigation technique, which accounts to about 80%.

2.5. National Seed Activities

In Sultanate of Oman, seed production was started in 1979 under the direct supervision of agricultural research stations and restricted to Al'Dakhliya region. However, the program was later expanded to cover Al'Sharqiya and Al'Dharhira regions and is now under the direct supervision of the extension service. The Government undertakes the responsibility of seed production, particularly of some important crops such as wheat and barley.

Most farmers produce their own alfalfa seed. Generally, seed is harvested from alfalfa crop of 4-5 years. This practice of harvesting seed from old stands applies a strong selection pressure in favor of those plants, which have survived several years of cutting. It will tend to ensure that these important 'survival' characteristics are preserved and enhanced in successive multiplication. This may explain in part the widespread reputation of the alfalfa variety known as 'Omani' in the region.

As per vegetables and forage crops, there are no local seed production programs run either by the Government or by private sector. Several international seed companies have branches in the country in association with local seed companies or agents. These companies import seed of promising varieties from USA, Australia, Arab, Asian, African and European countries and supply the seed directly to the farmers or through the Government. However, some farmers produce seeds of local cultivars of vegetables like onion, garlic, carrot, cucumber, muskmelon, and sweet potato, and propagating materials of tree crops like date palm, mango, acid lime and other citrus species. In fruit crops, the Ministry of Agriculture has established nurseries in the different parts of the country, which undertake the production of seedlings of datepalm, mango, acid lime, and other citrus species and crops. In addition, private nurseries are also engaged in selling propagated materials of some selected fruit crops.

Chapter 1: The State of Diversity

1.1. The State of diversity and relative importance of major crops for food security

Oman has a wide diversity of crop plants for diet and food or feed purpose in addition to other human use. A number of field crops, vegetables, fruit trees, forest trees, rangeland pasture species, aromatic and medicinal plant species are indigenous and known to be grown in the Sultanate since immemorial time. Table 2 lists main species for food and agriculture of Oman. Among these the most important ones are dates, banana, acid lime, mango, wheat, barley, chickpea, onion, garlic, sweet potato, cucumber, watermelon etc. With the exception of maize, oats, and sunflower, all the other species are considered indigenous.

Oman has not only several local adapted cultivars and land races or ecotypes of crop species such as Coola, Missani, Humaira, Walidi etc in wheat but also wild relatives of some crop plants that form the source of material for crop breeding to transfer specific characters.

Table 2. Main species for food and agriculture of Oman (in order of importance for each category)

Category	Crop Species
Field crops	*Triticum aestivum* and *T. durum* (wheat), *Hordeum vulgare* (barley), *Avena sativa* (oats); *Sorghum bicolor* (sorghum), *Zea mays* (maize), *Cicer arietinum* (chickpeas), *Vigna unguiculata* (cowpea), *Sesamum indicum* (sesamum), *Carthamus tinctorius* (safflower), *Helianthus annuus* (sunflower), *Gossypium* sp. (cotton), *Saccharum officinarum* (sugarcane), *Medicago sativa* (alfalfa), *Pennisetum purpureum* (elephant grass), *Nicotiana tabacum* (tobacco)
Vegetable crops	*Allium sativum* (garlic), *Allium cepa* (onion), *Citrullus lanatus* (watermelon), *Cucumis melo* (muskmelon), *Daucus carota* (carrot), *Ipomoea batatas* (sweet potato), *Cucumis sativus* (cucumber), *Raphanus sativus* (radish), *Abelmoschus esculentus* (okra), *Lycopersicon esculentum* (tomato), *Lactuca sativa* (lettuce), *Brassica oleracea var. capitata* (cabbage), *Brassica oleracea var. Botrytis* (Cauliflower), *Cucurbita maxima* (squash) and *Solanum tuberosum* (potato)
Fruit tree crops	*Phoenix dactylifera* (date palm), *Mangifera indica* (mango), *Citrus aurantifolia* (acid lime), *C. limetta* (sweet lime), *Punica granatum* (pomegranate), *Vitis vinifera* (grape), *Carica papaya* (papaya), *Musa paradisiaca* (banana), *Psidium guayava* (guava), *Cocos nucifera* (coconut)
Pasture trees, shrubs and grass species	*Prosopis cineraria*, *Acacia tortilis*, *A. ehrenbergaina*, *A. senegal*, *Anogeissus dhofarica*, *Maerua crassifolia*, *Ziziphus*, *Olea europaea*, *Blepharispermum hirtum*, *Calligonum comosom*, *Euclea schimperi*, *Pteropyrum scoparium*, *Maytenus dhofarensis*, *Cenchrus ciliaris*, *C. setigerus*, *Apluda mutica*, *Themeda quadrivalvis*, *Dactyloctenium aegypticum*, *Panicum turgidum*, *Pennisetum divisum*.

1.2. The state of diversity of wild plants harvested for food and agriculture production

Oman has many wild plants in its ecosystems that were earlier harvested for food directly or indirectly. These include: *Amaranthus graecizans*, *Arisaema flavum*, *Remusatia vivipara*, *Glossonema varians*, *Pentatropis nivalis*, *Caralluma flava*, *Rhytidocaulon fulleri*, *Ceropegia bulbosa*, *Cibirhiza dhofarensis*, *Raphionacme arabica*, *Adansonia digitata*, *Cordia perrottettii*, *Commiphora habessinica*, *Boscia arabica*, *Hydnora africana*, *Gladiolus ukambanensis*, *Delonix elata*, *Tamarindus indica*, *Ormocarpum dhofarense*, *Abelmoschus esculentus*, *Dorstenia foetida*, *Ficus sycomorus*, *Ficus vasta*, *Moringa peregrina*, *Commicarpus boissieri*, *Habenaria myodes*, *Portulaca oleracea*, *Ziziphus leucodermis*, *Z. spina-christi*, *Z. muritania*, *Citrus aurantifolia*, *Grewia villosa*, *Premna resinosa*, *Cyphostemma ternatum*, *Pteropyrum scorparium*, *Thymus vulgaris* *Trigonella fenum-graecum*, *Prosopis cineraria*, *Monotheca buxifolia*, *Rumex vesicarius*, and *Ceratonia oreothauma* sub sp. *oreothauma*.

1.3. The state of diversity of indigenous and exotic varieties

Farmers have selected and conserved landraces and local cultivars in a dynamic way since they started cultivation of crops (Table 3). By growing a mixture of diversified local materials and, therefore, maintaining on-farm high inter- and intra-specific diversity, farmers throughout the years have been able to select varieties adapted to local environmental conditions and to reduce risks derived from too specialized farming systems.

Table 3. Indigenous cultivars and/ or landraces of different crop species in Oman

Crop	Local cultivars/landraces
Acid Lime (*Citrus aurantifolia*)	Local (Lomy)
Alfalfa (*Medicago sativa*)	Bathini, Interior, Sharqiya, Rustaq, Quriati
Banana (*Musa* sp.)	Fard, Barshi, Nagal, Somali, Malendi, Red
Barley (*Hordeum vulgare*)	Bathini, Doraqui
Ber (*Zizipus mauritiana*)	Seeded, Seedless (Maqatmani)
Carrot (*Daucus carota*)	Local
Chickpea (*Cicer arietinum*)	Local
Coconut (*Cocos nucifera*)	Local, Al-Malki
Cotton (*Gossipium arboreum*)	Brown
Cowpea (*Vigna unguiculata*)	Brown, Black, Mottled
Cucumber (*Cucumis sativus*)	Local, Dhofari
Datepalm (*Phoenix dactylifera*)	186 landraces
Garlic (*Allium sativum*)	Bahla, Rustaq, Tanuf, Jamah
Grape (*Vitis vinifera*)	Black and White
Guava (*Psidium guajava*)	Red and White
Maize (*Zea mays*)	White, Red, Yellow
Mango (*Mangifera indica*)	Al-ward, Al-khokh, Al-halqoom, Quriate-15, Rumais-89, Muscati .. etc.
Onion (*Allium cepa*)	Local
Papaya (*Carica papaya*)	Local seedy strains
Pearl millet (*Pennisetum glaucum*)	Tall local
Pomegranate (*Punica granatum*)	Malasi, Jabal akhdhar
Radish (*Raphanus sativus*)	Local
Safflower (*Carthamus tinctorius*)	Local
Sesame (*Sesamum indicum*)	Local
Sorghum (*Sorghum bicolor*)	Red, White
Sugarcane (*Saccharum officinarum*)	Bahlawi, Nizwawi, Dhofari
Sweet Lime (*Citrus limetta*)	Burgab, Daire
Sweet melon (*Cucumis melo*)	Local
Sweet Potato (*Ipomoea batatas*)	Red, White
Tobacco (*Nicotiana tabacum*)	Suwaida, Musdaria, Fannashia, Omlaein, Hitathi
Wheat (*Triticum aestivum*)	Coolah, Saraya, Hamira, Waledi, Missani

In the past 20 years, a number of improved cultivars have been introduced in Oman. Most of these cultivars are from breeding programs carried out by CGIAR centers, as well as multinational companies. Introductions have undergone an evaluation and selection process for their performance and adaptability to local conditions.

Overall the introduction of exotic improved cultivars had a great impact on the displacement of local varieties of cereals and forages (Table 4), and vegetable crops, due to improved performance and market acceptability of the new cultivars. Local varieties of these crop groups are still grown in some areas of Oman, namely, Ad'Dakhliah, As'Sharqiah and Ad'Dhahirah, where subsistence farming systems predominate.

With regard to fruit trees, such as date palm, lime, pomegranate and coconut, new cultivar introductions have been very limited as the local varieties are more adapted to local conditions and still offer comparative advantages over international cultivars in terms of yield and, in the case of date palm, quality. On the contrary, in mango and banana the indigenous cultivars have been found to be less productive.

Table 4. List of recommended exotic improved varieties in field and forage crops

Crops	Varieties
Wheat	Mexipak, Sannine, WQS 151, WQS 160, WQS 302, WQS 305, WQS 308, WQS 1, WQS 2, WQS 101, WQS 102, WQS 103, WQS 107, WQS 110, WQS 125, WQS 132
Barley	Beecher, Jimah 5, Jimah 6, Jimah 51, Jimah 53, Jimah 54, Jimah 58, Jimah 98, Jimah 136
Cowpea	Jimah 2, Jimah3, Jimah 4
Chickpea	ILC237, Jimah7, Jimah8, Jimah 1, Jimah 2, Jimah 17, Jimah 18
Dry peas	Rumais 2, Rumais 3, Rumais 4, Rumais 5, Rumais 6, Rumais 7
Mungbean	PS-16, Sona, PDM 84-13
Sesame	Giza 23
Safflower	A-300, A-1
Sunflower	Turkey-79, Miak
Maize	Giza 2, Katamani 503, Hybrid 622, Irat 8, Sohar 1, Sohar 2, Rumais Composite 1, Rumais Composite 2, Rumais Composite 3
Sorghum	Sugar drip, Honey drop, Fs x Dekalb 17
Fodder Oats	Marloo, Rumais 1
Rhodesgrass	Callide, Katamboa, Samford, Elamba, Boma, Pioneer
Alfalfa	ADLL 6725, CUF 101, Cundor, DK 187, Maxidor, Sequel
Fodder beet	Peramono, Petra, Anissa

1.4. Crop wild relatives:

Existing flora of Oman, in particular in the Dhofar region, include crop wild relatives of several species used for food and agriculture. These include species belonging to genera- *Abelmoschus, Amaranthus, Cenchrus, Chloris, Citrullus, Citrus, Cucumis, Desmodium, Dichanthium, Ficus, Gossypium, Indigofera, Ipomoea, Lactuca, Lavandula, Ocimum, Panicum, Paspalum, Pennisetum, Pistacia, Ricinus, Saccharum, Setaria, Solanum, Sorghum, Vigna* and *Ziziphus.*

1.5. Factors affecting state of diversity

Although systematic *in situ* and on-farm surveys on the state of inter and intra-specific plant diversity have not been sufficient, there is evidence of an increasing pressure from several abiotic, biotic and social factors on this diversity. These factors include: i. Soil and water salinity; ii. Overgrazing and deforestation of rangelands, iii. Replacement of local cultivars by high yielding modern cultivars; iv. Climate changes causing extreme high temperatures and drought; v. Pests and diseases, especially viruses and virus-like diseases; vi. Urbanization of the exterior range/ mountainous lands; and, vii. Scarcity of irrigation water affecting farming diversity.

The most detrimental impact of many of the above factors can be expected firstly on marginal and subsistence farming systems, By definition, these are the most vulnerable ones, and as previously discussed are those that use and conserve the widest plant diversity in the country. This is inevitably posing a serious threat to the very survival of Omani indigenous crop species, cultivars, landraces, ecotypes, and wild relatives and a challenge to the institutions of Oman for reversing this trend through activities of collection and conservations.

1.6. National Activities

The country is carrying several activities regarding conservation of plant genetic resources for food and agriculture which are as follows.

1. Surveying, inventorying, and collection of PGRFA- since late 1980s. MAF has collected independently and in coordination with international organizations/institutes indigenous germplasm accessions of vegetables, fruits, forages and pastures crop plants (Guarino, 1989). Besides the Ministry of Heritage and Culture, Royal Gardens and Farms of the Directorate General of Agriculture & Veterinary of the Royal Court and Sultan Qaboos University have been either maintaining botanical gardens involving indigenous plant species or publishing the status of flora and fauna and checklists of plant species in the country highlighting the endangered species (Ghazanfar *et al*., 1995).
2. MAF is involved consistently in seed production of indigenous crop landraces and selected pasture grass species (Nadaf *et.al.,* 2004a) and multiplication of seedlings of fruit tree species since 1980s and production of date palm offshoots and banana seedlings through tissue culture since 1990s.
3. MOA and Royal Gardens and Farms of the Directorate General of Agriculture & Veterinary of the Royal Court, are currently managing several field genebanks of fruit and rangeland species. Seed Technology Unit of MoA has been recently upgraded to National Gene Bank of Plant Genetic Resources.
4. Under the Royal Decree 6/2006, initial activities have been started to establish the Oman Botanic Garden in Seeb, Muscat by the office of the Advisor for Conservation of the Environment, Diwan of Royal Court. These included listing and collecting of the target plant species.

1.7. Needs for improving the state of diversity

The state of diversity in the country could be improved by applying the following measurements:

1. Encouraging and supporting research and developmental programs concerning plant genetic resources of the country and benefiting from the expertise and experiences of the international organizations and research institutes.
2. Capacity building in terms of improving qualifications and on-job training of the concerned staff.
3. Implementing awareness program on the importance of conservation of indigenous PGRFA.
4. Activating Royal Decrees and Ministerial Orders, and Executing rules and regulations related to conservation of PGRFA.

Chapter 2: The State of *In Situ* Management

In situ conservation and management of PGRFA in the country are carried out by both MoA and Ministry of Environment and Climatic Affairs (MECA). MoA is concentrating on the conservation and management of indigenous landraces of field crops, vegetables, and pasture plant species, whereas MECA has reserved areas in different parts of the country with aim of conserving the ecosystems.

2.1. Plant genetic resources surveys

With regards to domesticated plant species, activities of surveying have been limited to some missions for collecting ecotypes and/or varieties of wheat, barley, and some vegetables (Guarino, 1990) and rangeland species undertaken by MAF in collaboration with ICARDA-APRP in all regions of Oman (Osman et al. 2002). These activities mainly aimed at describing the state and distribution of all Omani indigenous cultivars/species for food and agriculture without involving crop wild relatives. Later, several collection missions were undertaken by the local staff. However, it is essential to improve the quality of activities of PGRFA inventorying, surveying and collection, involving participation of experts from the international organizations.

2.2. Conservation of wild PGR in protected areas

In Oman, there exist protected areas under the MoA in the vast rangelands of Dhofar (Southern Oman). These are monitored by the staff of the Rangeland and Forestry Department to conserve and protect rangeland, pasture and wild crop relative species from grazing animals. Currently, MoA has maintained as many as 20 fenced areas in the ranges that cover about 171 ha, which accommodate approximately 177 thousand pasture trees of different species. These areas include several rangeland grass and herb species as well as many wild crop relatives and wild plants for food (MAF, 2005a). Ministry of Environment and Climatic Affairs is simultaneously maintaining reserves of different dimensions throughout Oman from as low as 1 sq. km to as high as 24,785.4 sq. km. that supposedly host wild/ weedy crop relatives and rangeland species. It is expected that with the recent establishment of Steering and Executive Committees of PGR, the activities concerning monitoring and surveying of all the plant species present in these reserves, would be strengthened.

2.3. Ecosystem management of PGR outside protected areas

The Government of Oman has established several developmental projects aiming ecosystem management for sustaining biodiversity. For instance, of late, ever-increasing livestock number (camels and cattle) has exerted great pressure on grazing pasture flora of mountains and rangelands of Dhofar region and affected adversely on the integration of the ecosystem. In this respect, the project on ecosystem management for conservation of rangelands in Dhofar has been working on containing huge livestock population. There were 245 thousand cattle and 79 thousand camels during 2004. These populations were lessened significantly (174 thousand cattle and 53 thousand camels) during 2005 (MAF, 2005a), thus reducing the burden on the rangelands. However, such projects need to be continued for sustainable conservation and management of rangeland ecosystems of Oman.

2.4. On-farm management and improvement of PGRFA

There exist numerous activities towards conservation of local land races of vegetable crops such as onion, garlic, cucumber, sweet potato, and muskmelon, and grain crops such as wheat, and barley, through on–farm management since early 1990s. In case of vegetables, MoA takes responsibilities of collecting the most important indigenous ecotypes of vegetables and growing them to multiply seed in isolation in selected sites at research stations. The seed is distributed among interested farmers for commercial cultivation. In case of wheat and barley, selected landraces are cultivated in sites of selected farmer fields for seed production. The seed so produced is purchased by MoA and distributed among farmers for cultivation to promote sustainable agriculture. However, there is a need for extending such activities towards improving indigenous landraces of other crops of PGRFA.

Chapter 3: The State of *Ex Situ* Management

3.1. The state of collections and conservation

3.1.1. Collections

A rational and targeted collecting strategy of indigenous plant genetic resources is at the base of a sound *ex situ* conservation system. In the past 30 years, several missions have been conducted for collecting germplasm of crops grown in Oman. First collections were undertaken jointly with the International Bureau of Plant Genetic Resources in 1980, 1987, and 1988 (Al-Zidjali, 1996). More than six hundreds of these collected accessions of about 270 species are conserved by international centers such as ICARDA and national institutes such as USDA.

Since 1996, several missions have been carried out by the Ministry of Agriculture and Fisheries in collaboration with regional and international organizations. Two missions were conducted jointly with ICARDA: the first one in 1998 where 68 seed accessions of both forage and pasture species were collected from the northern regions of Oman (Ferguson, 1999); and the second one in 2002, where 23 seed accessions of both forage and pasture species were collected from the mountains of southern (Dhofar) region (Osman *et al,* 2002). Additional collections have been made since 2000 in collaboration with the International Center of Biosaline Agriculture addressing barley (Jaradat *et al.,* 2004a, 2004b and 2005).

Further collection missions were also conducted by graduate students and employees of institutes that deal with plant genetic resources such as the Ministry of Agriculture, the Sultan Qaboos University and the Royal Gardens. During these missions alfalfa (Al-Hinai, 2004), wheat (Al-Khanjari, 2005), and cucumber (Al-Rawahi, 2008) landraces were collected and placed in their local conservation facilities.

It is worthwhile to mention that the reported collections serve in either specific national research purposes or international collaborative programs. To better meet the needs of a rational PGRFA conservation and utilization strategy, collection missions should serve to fill the gap between the inter- and intra-specific diversity conserved *ex situ* and the diversity existing *in situ*. Therefore, collection missions should cover the whole spectrum of plant genetic resources such as major crops, minor crops, underutilized species, and forages, wild plants for food and agriculture, and wild crop relatives. The urgency to carry out planned and targeted collecting missions depends on the rate of loss of these resources both *in situ* and on-farm. In this regard, the government awareness should be timely raised in order to allocate sufficient funds for such activities either through the Agriculture and Fisheries Development Fund (AFDF) or The Research Council (TRC). Cooperation with international organizations, such as Bioversity International and ICARDA, should be sought for these activities.

3.1.2. Conservation

The Seed Technology Unit has been established during 2004 in collaboration with ICARDA that contains almost all the requirements of seed activities. This Unit has been upgraded to National Seed Gene Bank in 2007. As per locally conserved germplasm, an *ex situ* field genebank of 186 date palm accessions was established in 1988. Later, several other field genebanks were established. These include field genebanks of 100 mango accessions in Sohar, 40 banana accessions in Salalah and 23 *Citrus sps* (both indigenous and exotic) in Jimah and Sohar. In addition, field genebanks that can accommodate 244 pasture plants and 101 medicinal plant species were established at Rumais between 2004 and 2005 (Nadaf *et al*., 2004 f and MAF, 2005c). Presently, there are collectively about 100 species of pasture and medicinal plants.

Filling in the gaps of existing collections is just one of the priorities for *ex situ* conservation. Other priorities in Oman include the development and adoption of technologies for low-input conservation and for cleaning collections from pests and diseases. The national program should look for conservation technologies that are affordable especially for short term or active collections.

3.2. Documentation and characterization

Germplasm documentation is essential for an efficient utilization of conserved plant genetic resources for food and agriculture. There are many unpublished studies with respect to characterization of indigenous plant genetic resources for food and agriculture like dates, mango, banana, sweet-lime, acid-lime, cucumber, barley, and alfalfa and pasture plant species since 2001.

Ministry of Agriculture has recently initiated activities concerning documentation of PGRFA. The Ministry established a collaboration activity with Bioversity International (formerly, IPGRI) of the CWANA region in developing an information system for managing collections of the plant genetic resources. This system is currently executed and managed by the staff of the Directorate General of Agriculture and Livestock Research.

3.3. Role of botanical gardens / *'Ex Situ* (Field) Genebanks

- Two botanical gardens exist in Oman- one in the Sultan Qaboos University and another in the Natural History Museum of the Ministry of Heritage and Culture. These include not only PGRFA but also other plant species. These botanical gardens are aimed mainly for education purposes.
- '*Ex Situ* (Field) Genebank' of indigenous pasture plant species present at Agriculture Research Center, Rumais of MoA, that accommodates a total of 244 species of herb, shrub, tree and grass species was established during 2004-05. However, different ecotypes of each species are conserved in seed gene bank and utilized for characterization and other studies subsequently.
- '*Ex Situ* (Shade house) Genebank' of 101 indigenous medicinal plant species was established during 2005-06 at Agriculture Research Center, Rumais of MoA (MAF, 2005b). However, different ecotypes of each species are conserved in seed gene bank. These are utilized for characterization and other studies subsequently.
- 'Oman Botanic Garden' has been in the stage of establishment in Seeb, Muscat by the office of the Advisor for Conservation of the Environment, Diwan of Royal Court.

3.4. Major *Ex Situ* needs

Ex situ management needs to be improved. The way to improve it inevitably passes through the development of a national concerted strategy for the conservation and sustainable use of PGRFA and a National Program to implement it. The national strategy and its program should help to improve the efficiency of our activities in PGRFA by reducing duplicative efforts and making more human and financial resources available for fostering agricultural development through a more sustainable use of PGRFA. All PGRFA stakeholders in Oman need to contribute jointly to the development of this strategy and to formulate objectives, themes and mechanisms of the National Program. In this connection, experience of other countries as well as international organizations and institutes that have established their own programs may be explored.

Chapter 4: The State of Use

4.1. The importance of utilization

Oman has many indigenous PGRFA which are found valuable and important from economic and social point of view. These indigenous PGRFA have been found important in terms of the following:

i. Use of biotic (diseases and pests) and abiotic (salinity, drought etc.) resistant/ tolerant rootstocks with local fruit crops cultivars for multiplication and distribution among the farmers.

ii. Improvement of local cultivars of wheat and barley through breeding programs using high yielding, disease resistant and early to medium maturity characteristics from exotic cultivars used as donors.

iii. Improvement of indigenous lime for tolerance to diseases like witches broom through breeding program using the techniques of biotechnology and tissue culture.

iv. Improvement of local date palm cultivars for their quality through breeding program using the techniques of biotechnology and tissue culture.

v. Use of indigenous perennial forage grass species in the grass production systems.

4.2. Utilization of conserved plant genetic resources and major constraints on their use

Oman has initiated utilization of PGRFA in different crops through characterization, selection, and improvement using the tools of breeding and biotechnology (tissue culture). However, there exist certain constraints that are making the progress slow. These constraints are related to-

i. Documentation – useful information on the conserved germplasm

ii. Infrastructure in the fields of plant breeding and biotechnology

iii. Capacity- qualified personnel, funds, training, facilities etc.

iv. Integration between conservation and utilization programs

v. Coordination among researchers, breeders, genebank managers and farmers

4.3. Utilization activities

Research activities on utilization of indigenous plant genetic resources are being carried out mainly by the Ministry of Agriculture, the Ministry of Environment and Climatic Affairs, the Ministry of Heritage and Culture, and the Sultan Qaboos University.

4.3.1. Characterization

4.3.1.1. Morphological Characterization

The studies on characterization of species / accessions are being conducted since 2001-2002 at the Seed and Plant Genetic Resources Lab, Plant Production Research Center, Rumais of Ministry of Agriculture, Sultanate of Oman. During 2001-02, two cultivars of *Cenchrus ciliaris* L. viz. an indigenous collection and Australian variety were characterized with respect to as many as 15 pigmentation characters and 7 morphological traits. *Coelachyrum piercei* was characterized in respect of 12 pigmentation characters and 8 morphological traits (Nadaf *et al.,* 2002). Investigations on the characterization of two perennial rangeland forage species namely *Lasiurus hirsutus* L. (Buraimi

accession) and *Panicum turgidum* L. (Buraimi and Izki accessions) were further undertaken during 2002-2003. The Buraimi accession of *L. hirsutus* L was characterized with respect to 19 pigmentation characters and 8 morphological traits while the two accessions (Buraimi and Izki) of *P. turgidum* L. were characterized with respect to 19 pigmentation characters and 11 morphological traits Nadaf *et al.* (2003). During 2003-2004, the results of investigations have established distinct descriptors of three perennial rangeland forage species namely *L. hirsutus* L. (Mahara accession), *P. turgidum* L. (Mahara accession) and *Pennisetum divisum* (Mahara accession) with respect to morphological and pigmentation characters. The accession of *L. hirsutus* L was characterized with respect to 19 pigmentation characters and 8 morphological traits. The accessions of of *P. turgidum* L. and *P divisum L.* were characterized with respect to 19 pigmentation characters and 11 morphological traits (Nadaf *et al.,* 2004 b). Further, six indigenous accessions of *C. ciliaris* viz. MF 179, MF 185, MF 190, MF 192, MF 236 and MF 266 collected during 1998 ICARDA-Arabian Peninsula Research Program (APRP)-MAF joint collection missions, were also subjected for morphological characterization during 2004-2005 with respect to both pigmentation and morphological traits (MAF, 2005b). Besides above, Jaradat *et al.* (2004a and 2006), Al Khanjari (2005) and Al-Rawahi (2008) characterized indigenous Omani barley, wheat and cucumber landraces, respectively.

4.3.1.2. Screening for tolerance to abiotic stresses

There are no studies on screening for tolerance of PGRFA to abiotic stresses like heat, and moisture stress. However, a few studies conducted in the past seven years were concerned with tolerance to salinity in rangelands. Saline tolerant indigenous rangeland grass species are valuable either for reseeding in the degraded rangelands at corresponding salinity sites or testing/ breeding for their suitability under existing forage production system in the areas affected by salinity (Nadaf et al. 2006).

4.3.1.3. Molecular characterization

4.3.1.3.1. Date palm

DNA profiling of six indigenous cultivars was accomplished by using RAPD and AFLP analysis. Both methods showed potentialities for fingerprinting in revealing genetic variation among the cultivars (MAF, 2005a).

Molecular technology can assist plant breeder in selecting/ improving indigenous cultivar of datepalm. For this purpose, the DNA of the Backcross 1 (BC1) population (55 palms) from Khalas, the local cultivar, and of their parents were analyzed using the AFLP technique (MAF, 2005a).

4.3.1.3.2. Alfalfa

Al-Hinai (2004) characterized local alfalfa accessions using morpho-agronomic traits such as plant height, number of branches, number of leaves per plant, fresh and dry matter weight, regrowth rate and molecular markers by utilizing genomic Random Amplified Polymorphic DNA (RAPD) technique.

4.3.2. Crop improvement programs and food security

First plant breeding program started in 2001. This breeding program was directed in improving local landraces of wheat and barley. During the coming decade, breeding programs may also focus on vegetable crops such as cucumber, as well as carrots, onions, garlic, and muskmelons, and forage species such as alfalfa.

4.3.2.1. Wheat

The wheat breeding program which started in 2001 is aimed at improving local landraces of wheat by introgression of early maturity and disease resistance traits from exotic cultivars obtained through international research programs

such as ICARDA and CIMMYT. Pedigree method of breeding was applied to introduced materials, which showed stable high yielding performance and early maturity in the wheat growing regions of Oman. (MAF, 2004b and 2005b). Incorporating early maturity trait to the late maturing local landraces is very important. By shortening the growing season of wheat this trait allows to escape high temperatures that coincide with maturity time and reduce assimilate accumulation in the grains, as well as to save irrigation water otherwise required to complete the crop cycle. These improved varieties should be available to farmers in 2010.

4.3.2.2. Date palm

Activities in data palm has mainly focused on maintaining the genetic diversity as well as for developing new strains with desired traits. Cultivar Khalas was backcrossed with a male that was produced from seeds of the same cultivar. Seeds from this cross were planted to produce BC_1 population. BC_1 female palms that reached flowering were pollinated and their fruits evaluated for quality. Six date palms out of 16 evaluated were superior in yield and fruit quality to the original cultivar Khalas (MAF, 2005b).

The most common cultivar in the Batinah region, Um-Assela, which is saline tolerant but with low quality fruits, was crossed with the male KL96-13 (originated from cultivar Khalas) to produce an F_1 population. Females from this cross are being evaluated for fruit quality. The results showed improvement in shape, color and size of the produced fruits (MAF, 2005b).

4.4. Variety release, Seed production, supply, and role of markets

High yielding elite genotypes are released for general cultivation based on recommendations from scientists who are involved in carrying out variety performance trials, mainly in research stations and farmers' fields in different years and locations. MoA is responsible to enforce the law of plant variety protection and carrying out Distinctness, Uniformity, and Stability (DUS) tests as per Royal Decree 92/2000.

4.4.1. Seed Production and Supply

In the Sultanate, the national seed program has not yet been fully developed. Seed production was started in 1979 under the direct supervision of agricultural research stations and initially restricted to Al'Dakhliya area. The program was later expanded to cover Al'Sharqiya and Al'Dharhira and become under the direct supervision of the extension service.

The Government undertakes the responsibility of seed production, particularly of some major crops such as wheat and barley. Breeder (by ear to row method) and foundation seed of recommended varieties are maintained and multiplied at regional agricultural research centers.

The foundation seed is supplied to the agricultural extension service, which produces certified seed of wheat and barley involving farmers. The seed of other crops is multiplied on a limited scale at agricultural research stations. The seed is produced under the direct supervision of the extension service, and a research-extension committee monitors the program.

The extension service is responsible for the selection of contract farmers; provision of seed, fertilizers, plant protection services; technical backstopping and supervision; and financial support for roguing seed crops. It also provides seed bags and purchases seed at premium price, which is treated and stored until distribution. The farmer provides the land and irrigation and is responsible for general cultivation and harvesting of seed crops.

Most farmers produce their own alfalfa seed. Generally, the seed is harvested from the crop when this is 4-5 years

old. This practice of harvesting seed from old stands applies a strong selection pressure in favor of those plants, which have survived several years of cutting. It will tend to ensure that these important 'survival' characteristics are preserved and enhanced in successive multiplication. This may explain in part the widespread reputation of the alfalfa variety known as 'Omani' in the region.

As per vegetables, a rather limited seed production of local cultivars of onion, garlic, carrot, cucumber, muskmelon, and sweet potato is carried out by farmers. Apart from these scattered efforts, there is not an organized local seed production program either by the Government or by the private sector. Several international seed companies have branches in the country in association with local seed companies or agents. These companies import seed of promising varieties from USA, Australia, the Middle East, Asia, Africa and European countries and supply the seed either directly to the farmers or through the Government.

Research studies have been conducted for large-scale seed production of indigenous pasture species for their inclusion in the domestic grass production system (Nadaf *et al.,* 2004 a). Other studies addressed agronomic and seed harvesting techniques (Nadaf *et al.,* 2004 c, d and e).

4.4.2. Seed Processing and Storage

Seed processing is carried out by the agricultural extension services in different locations with the limited facilities available for crops like wheat and barley. After cleaning, seed is bagged, fumigated and stored in temporary facilities at the regional offices at Ibra, Ibri and Nizwa of the Ministry of Agriculture under the supervision of Directorate Generals of the regions.

4.4.3. Seed Marketing and Distribution

Wheat and barley seeds are distributed to interested farmers free of cost while seeds for other crops like vegetables, perennial forages, etc. have to be purchased by farmers from various companies that import seed for sale. Besides, some farmers sell their own seed of indigenous vegetables in the local market.

4.4.4. Seed Quality Control

Seed quality control consists mostly of purity and germination tests, which are carried out both for locally produced and imported seeds, before distribution to the farmers. The Seed and Plant Genetic Resources Laboratory conducts tests for purity and germination samples of locally produced wheat and barley seed, as well as of imported seed of perennial grasses and vegetables. At present, this is the only laboratory, which operates both for locally produced and/or imported seed.

4.4.5. Seed Import/Export

Agricultural companies that have valid permits issued by the Ministry of Commerce and Industry, import the seed of mainly vegetables and perennial forages like Rhodes grass and grafted seedlings/scions/rootstocks of fruit trees from companies in Africa, Asia, Australia, Middle East, Europe, and USA. The Ministry of Agriculture issues licenses for companies importing particular seed material.

At present, there is no specific seed law to control seed import except the quarantine regulations of the Law of Agriculture Quarantine (Royal Decree No. 49/77) concerning nursery plant and seed material. However, the new Law on Agriculture (Royal decree No. 48/2006) that will be enforced in near future includes a specific chapter covering all seed-related aspects. There are quarantine centers both at the airport and at entry borders to enforce the regulations. The Ministry of Agriculture and Royal Oman Police enforce the quarantine law.

4.5. Major Needs to improve utilization

The following are assessed as needs to improve the activities of utilization:

i. Identification of the crops and their indigenous landraces and nature of utilization such as finding indigenous landraces tolerant to witches broom in lime, dubas bug in date-palms, mango decline in mango and salinity in field, vegetable and forage crops for sustainable development in agriculture.

ii. To take steps in avoiding duplication of activities in utilization of plant genetic resources for food and agriculture among the stakeholders.

iii. Increase capacity of the stakeholders in the field of PGRFA through academic and in-service training programs.

iv. Collaboration with agricultural private sectors to develop a national project and plan of action for breeding and seed production of PGRFA.

Chapter 5: The State of National Programs, Training and Legislation

5.1. National programs

A number of institutions and organizations directly or indirectly contribute to the conservation and sustainable utilization of PGRFA in the Sultanate. These include the Directorate General of Agricultural and Livestock Research and the Directorate General of Agriculture Development from the Ministry of Agriculture, Directorate General of Nature Conservation from the Ministry of Environment and Climate Affairs, the Department of Crop Sciences, College of Agricultural and Marine Sciences, Sultan Qaboos University and Diwan of Royal Court.

Significant results have been achieved by these stakeholders, as they play key roles for the conservation and sustainable utilization of PGRFA in the country. This has occurred despite absence of formal PGRFA program, coordinating and integrating the activities carried out by national stakeholders, until December 2007 when two committees on PGRFA were established- the steering committee and the technical committee. With the aims to exchange information, assess the state of PGRFA through participatory approach and, *inter alia*, build stronger partnerships among stakeholders, a National Information-Sharing Mechanism on PGRFA has been established in 2007 by the Ministry of Agriculture under the coordination of the Directorate General of Agricultural and Livestock Research, and the participation of several national stakeholders, including the Directorate General of Agricultural Development; Ministry of Agriculture, the Ministry of Environment and Climatic Affairs, the College of Agricultural and Marine Sciences; Sultan Qaboos University and the Royal Court Affairs. Through this Mechanism, stakeholders have recognized the need to establish a multi-stakeholders National Program for PGRFA, which efficiently increases services' delivery to farmers and promotes farmers' role in the country in PGRFA management and in the preservation of the environment. The Program would count on a clear mandate for PGRFA *in situ* and *ex situ* conservation, utilization, and capacity building in line with the 20 priority activities of the *Global Plan of Action on PGRFA*, harmonize roles and responsibilities of the different stakeholders, and rely on appropriate structures.

The implementation of a strong National PGRFA Program would have also positive repercussions on the role, the country plays at regional level, where it is presently engaged in drafting regional strategy for *ex- situ* conservation of the West Asia and North Africa (WANA). With the adoption and implementation of this regional strategy, Oman will have to adjust *ex situ* conservation efforts in harmony with the regionally agreed framework in order to take full advantage from it. In particular, the country will have to enhance accessibility to conserved PGRFA as well as to their information, also in the light of its commitments towards the ratified International Treaty on PGRFA

5.2. Education and Training

Training in the field of PGRFA has so far received less attention. So far, the national scientists have not been able to undertake enough education or long-term training program in plant genetic resources. However, some short courses were held by national staff addressing existing *ex situ* collection, regenerating threatened *ex situ* accessions, expanding *ex situ* conservation activities, germplasm characterization and/or evaluation, supporting seed production and distribution, and documentation. A few nationals either graduated or post-graduated in PGRFA related subjects. Since 1996, only few scientists from the Ministry of Agriculture, one of the major stakeholders of PGRFA, had the opportunity to be trained in plant breeding and germplasm characterization and/or evaluation. Post-graduate academic training is essential to build a strong national program and set the basis for a durable impact on conservation and utilization of PGRFA. More assistance in this regard needs to be provided by international organizations in future to meet the demand for training.

5.3. National Legislations

Several legislation and regulations have been issued since the past 5 years that deal with conservation and utilization of PGRFA. Most of these were issued in the form of royal decrees addressing specific issues as follows:

i. The Royal Decree No. 92/2000 on the Law of Plant Variety Protection,

ii. The Royal Decree No. 114/2001 concerning the Law on Conservation of the Environment and Prevention of Pollution,

iii. The Royal Decree No. 55/2002 related to Ratification of Cartagena Protocol on Biosafety,

iv. The Royal Decree No. 6/2003 related to the Law on nature reserves and wildlife conservation,

v. The Royal Decree No 8/2003 on the Law of Rangelands and Animal Wealth Management,

vi. The Royal Decree No. 47/2004 on the Law of Agricultural Quarantine,

vii. The Royal Decree No. 48/2004 on setting up the Agriculture and Fisheries Developmental Fund,

viii. The order No. 35/2004 of Ministry of Agriculture and Fisheries on regulations for execution of the Law of Plant Variety Protection,

ix. The Royal Decree No. 57/2004 concerning participation in the International Treaty on Plant Genetic Resources for Food and Agriculture,

x. The Royal Decree No. 6/2006 on establishment of Oman Botanic Garden,

xi. The Royal Decree No. 48/2006 on Law of Agriculture which deals with PGRFA and issues related to seed production and distribution,

xii. The Royal Decree No. 86/2007 on establishment of International Plant Genetic Resources Institute (Bioversity International).

Additional Royal decrees were issued earlier concerning international issues of conservation and utilization of PGRFA, which are the ratification of the *Convention of Biological Diversity* (Royal Decree No. 119/1994) and the ratification of the *Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture* (Royal decree No. 10/1997).

The implementation of these laws and regulations need to be monitored effectively to have positive impacts on the conservation and utilization of plant genetic resources for food and agriculture, and to take advantage of opportunities that arise with them.

5.4. Information systems

As part of the establishment of the National Information Sharing Mechanism on plant genetic resource for food and agriculture in Oman (see para. 5.1), a database on PGRFA was developed with information contributed by major national stakeholders. This database includes information on organizations, experts, and projects that deal with *in situ* and *ex situ* conservation as well as utilization of PGRFA. It also includes a comprehensive list of taxa, varieties cultivated in the country, and PGRFA related publications. The database can be accessed through the internet since July 2007 at http://www.pgrfa.org/gpa/omn.

Plans to establish an accession level information management system to support plant gene bank management and breeding activities are on-going. Recently, the Ministry of Agriculture with assistance of Bioversity International (former IPGRI) is developed a database management system, the Genetic Resources Modeling System (GeRMS). The system is expected to help the newly established National Gene Bank in managing germplasm accessions. This system should provide stakeholders with access to information on accessions conserved at the Seed and Plant Genetic Resources Unit through the internet.

5.5. Public awareness

There have been several efforts from different governmental sectors to make public aware about the importance of plant genetic resources of the country. Recent Ministerial Order No. 203/2007 of the Ministry of Agriculture would expectedly enhance the public awareness about diversified issues of plant genetic resources through implementing its activities.

5.6. Major needs for public awareness

i. There is a need to activate national program related to activities of PGRFA.

ii. There is need for capacity building of national scientists in the conservation and utilization of PGRFA.

iii. Implementation of the laws and regulations related to conservation and utilization of PGRFA need to be monitored effectively to have positive impacts on the conservation and utilization of plant genetic resources for food and agriculture.

iv. There is a need for the expansion of public awareness.

v. There is a need for effective gathering of indigenous knowledge on PGRFA.

Chapter 6: The State of Regional and International Collaboration

6.1. Regional and sub-regional networks, and International Programs

Oman developed several collaborations in respect of conservation and utilization of PGRFA with international organizations like IBPGR (currently, Bioversity International) since early 1980's for the first reconnaissance survey to collect several accessions of indigenous crop species. Other collaborations with international organizations such as ICARDA, Kew Gardens, and the International Institute of Tropical Agriculture (IITA) were involved in collection and conservation of Omani indigenous crop species between 1997 and 2004, through international programs such as ICARDA's Arabian Peninsula Regional Program (APRP). Recently, Ministry of Agriculture has been able to establish Genetic Resources Modeling (GeRMS) for PGR in collaboration with Bioversity International. Besides, the country is also collaborating with other countries of the WANA region through the Ministry of Agriculture along with ICARDA, Bioversity International, Association of Agricultural Research Institutions in the Near East and North Africa (AARINENA) and Global Crop Diversity Trust, to draft an *ex situ* strategy of the region, which is in the stage of approval. This strategy has emphasized on promoting networks for different crop species of the region based on their common importance. Of late, Oman is also involved in collaboration with AARINENA through Medicinal and Herbal Plants Network and in the Regional Project on Date Palm Improvement initiated by ICARDA and sponsored by Gulf Cooperative Council (GCC) countries.

6.2. International Agreements

Oman has entered into several international conventions and signed agreements that deal with conservation and utilization of plant genetic resources for food and agriculture. These include the Convention of Biological Diversity in 1994, the Global Plan of Action for conservation and utilization of PGRFA in 1997, the International Treaty on Plant Genetic Resources for Food and Agriculture in 2004 and the establishment of Bioversity International in 2007.

6.3. Major needs to improve international collaboration

Oman requires international expertise and assistance in the following areas:

i. State of diversity in Oman has not been assessed exclusively as a sole objective, although there have been many activities and missions on different crops and a lot of information accumulated from different studies. Hence, there is need for undertaking systematic assessment of the state of diversity with adequate and dedicated planning and execution.

ii. Oman is still at its infancy with respect to *in situ* and *ex situ* management and use of plant genetic resources. This needs to be enhanced.

iii. Information management and early warning systems initiated through the National Information Sharing Mechanism on PGRFA (NISM) need to be strengthened.

iv. Enhancing proper training and public awareness is needed to strengthen the subject of plant genetic resources for food and agriculture.

Chapter 7: Access to PGR and sharing of benefits arising out of their use and farmer's rights

Oman has signed several international agreements that provide the country with an improved access to plant genetic resources and contemplate the implementation of farmer's rights. These international agreements include the Convention on Biological Diversity in 1994, Global Plan of Action in 1997 and the International Treaty on Plant Genetic Resources for Food and Agriculture in 2004. Under all these agreements, the country retains the responsibility to implement provisions and polices concerning facilitated access to PGRFA and the implementation of farmers' rights. Assistance from international organizations and exchange of experiences with countries from the region in both aspects would be needed. Developing such legislations and polices would help in accessing involvement of international organizations to carry out implementation of the expected 20 activities of the Treaty on plant genetic resources and of farmers' rights.

Chapter 8: The contribution of PGRFA Management to Food Security and Sustainable Development

The Sultanate of Oman is well aware of the importance of its indigenous plant genetic resources for food and agriculture, which contributes to food security and sustainable development.

8.1. Contribution to sustainable agriculture

Oman is known to grow the crops of environmental and economic importance in its traditional sustainable agriculture like dates, Omani lime and alfalfa. There have been several research and developmental programs in the country that contribute to conservation and management of PGRFA. These programs are mostly related to improvement of indigenous cultivars of strategic crops through conventional and non-conventional breeding methods for high yield and disease/pest tolerance.

8.2. Contribution to food security

The indigenous crops of Oman, such as wheat, barley, chickpea, dates, and lime with traditional food value are cultivated in almost all regions of the country. Oman considers them as strategic crops as they form the base of our diet. Oman is committed to maintain the local cultivars of these crops, which have an immense value for the future. Conserving diversity of crops is of utmost importance, as it allows breeders to take advantage of adaptive traits present in this diversity and develop improved cultivars that are able to respond to changes in the environment. This is essential to meet the growing demand of food, in terms of both quantity, and quality, coming from this country as well as the world as a whole.

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ANNEXURE –I

PROCESS OF PREPARATION OF COUNTRY REPORT

Thanks to the moments when Dr Brad who initiated a move through discussion with Dr Ahmed Al Bakri, in February 2005 during Workshop on the Technical Support to the International treaty on Plant Genetic Resources for Food and Agriculture (PGRFA)- Creating as 'inter-sectoral' dialogue on PGRFA conservation, breeding and seeds" held at Amman, Jordan in making us work together to bring-out the Oman Country Report for the report on the state of World' s Plant Genetic Resources with the assistance of FAO and establish National Information Sharing Mechanism on the implementation of the Global Plan of Action on PGRFA. Eventually the Draft Agreement with FAO was signed and the First Workshop of Stakeholders meeting was held under representation of Dr Stefano Diulgheroff for two days from 5-6 June 2007 as per tentative work-plan formulated from I-week of November 2005 to III-week of December 2005. In the first workshop, all the activities of work-plan concerned with collecting, managing and sharing the data were discussed. In the Second Workshop of Stakeholders meeting held from 19-20 September 2006 where Dr R.C. Agarwal represented as Research Officer of FAO, representatives of all the stakeholders were trained in the use of computer application for answering the questionnaire monitoring GPA implementation, understanding of the indicators and Reporting Format for monitoring GPA implementation and a detailed timetable for completing the questionnaire by the stakeholders and submitting the information to the National Focal Point (NFP) was developed for adoption. During the second workshop the computer application, including updated information on the Common Tables were distributed to all the stakeholders by the National Focal Point (NFP). All the stakeholders compiled and reported the information by the III week of February 2007. Several personal visits between NFP staff to the stakeholders were made in the follow-up process. The NFP staff was then involved in merging, revising and analyzing them to prepare a draft Country Report on the state of PGRFA, based on the data gathered on FAO guidelines. During the first week of March 2007, NFP distributed the Country Report on the state of PGRFA to the Stakeholders and accumulated the comments and critics for finalization. Meanwhile, NFP and the staff prepared few web pages for the web site of the National GPA Information Sharing Mechanism and sent to the FAO during first week of March 2007 for perusal. The feedback information from stakeholders and FAO was considered in finalizing the draft. This country report has been prepared following the guidelines of FAO in its document CGRFA-10/04/Inf.5 entitled "Indicators and Reporting Format for Monitoring the Implementation of the Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture"

ANNEXURE – II

National Focal Point (NFP) & Staff:

- Directorate General of Agriculture and Livestock Research, Ministry of Agriculture

  Dr. Ahmed Nasser Al-Bakri, Director General of Agriculture & Livestock Research

  Dr. Ali Hussein Al-Lawati, Assistant Director of Plant Production Research Center & Manager of NISM

  Dr. Saleem Kaseemsaheb Nadaf, Senior Scientist, Seed & Plant Genetic Resources Lab

  Eng. Safaa Mohammed Al-Farsi, Head & Researcher, Seed & Plant Genetic Resources Lab

  Eng. Saleh Ali Al-Hinai, Researcher, Seed & Plant Genetic Resources Lab

Stakeholders:

- Directorate General of Agriculture Development, Ministry of Agriculture

  Eng. Fatmah Al-Khaifi

  Eng. Faiza Al-Raisi

- College of Agriculture and Marine Sciences, Sultan Qaboos University

  Dr. Nadia Al-Saadi

  Dr. Rashid Al-Yahyai

  Dr. Sulaiman Al-Khanjari

- Ministry of Environment & Climatic Affairs

  Mr. Ali Al-Rasbi

  Mr. Saleh Al-Saadi

- Ministry of Heritage & Culture

  Mrs. Sadiqah Ali Remdan

  Mrs. Azza Al-Jabri

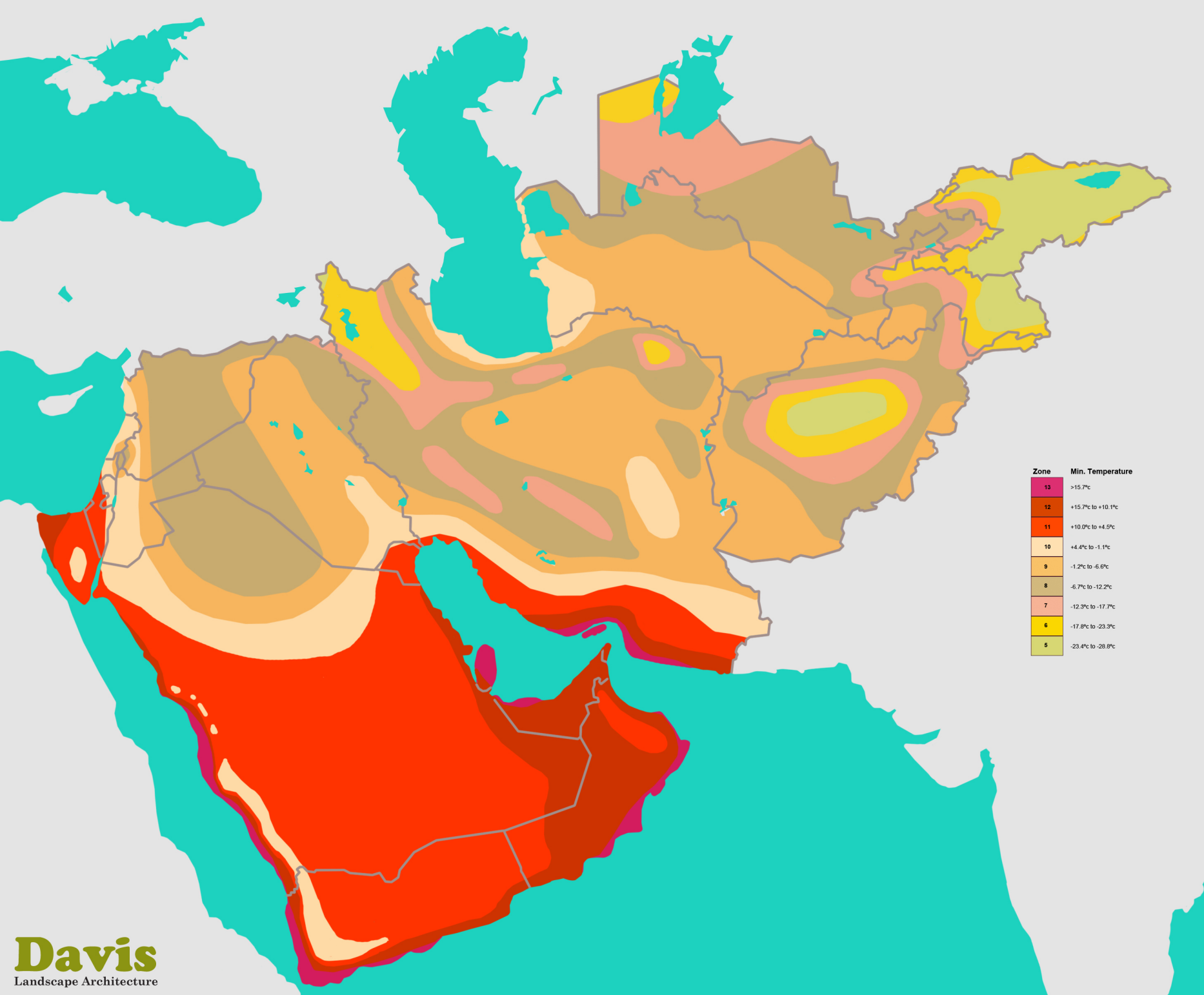
- Royal Gardens & Farms, Royal Court Affairs

  Dr. Abdulwaheed Al-Saadi

  Eng. Ali Al-Farqani

- Director General of Animal Wealth, Ministry of Agriculture

  Mr. Said Al-Alawi



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