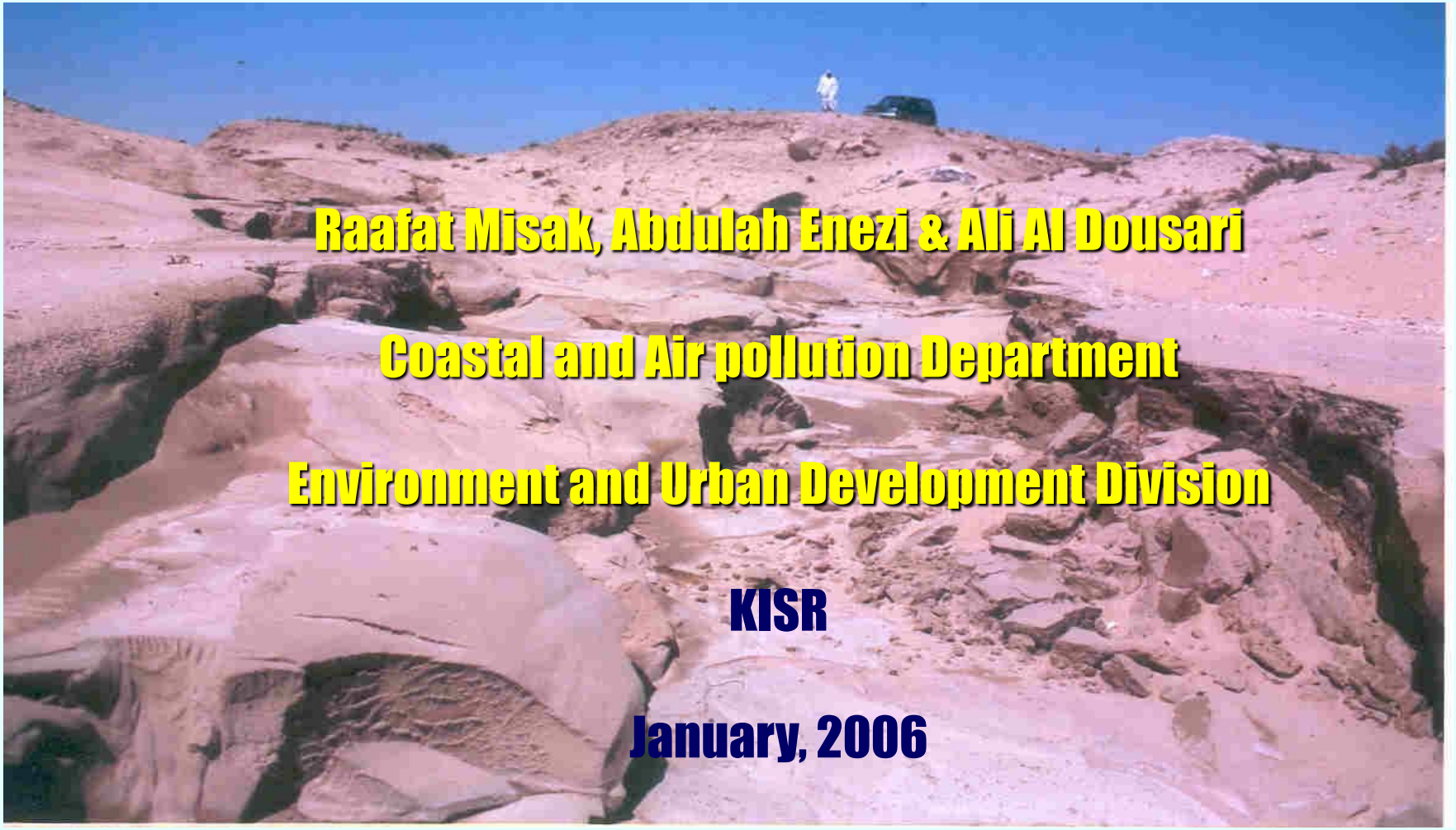
Assessing & Controlling Land Degradation in Several Areas in Kuwait (An Integrated GIS Approach)



Raafat Misak, Abdulah Enezi & Ali Al Dousari

Coastal and Air pollution Department

Environment and Urban Development Division

KISR

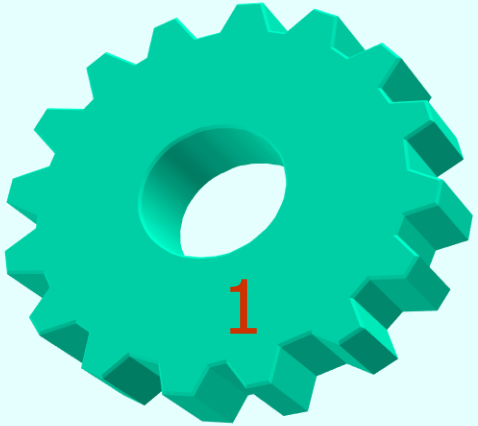
January, 2006

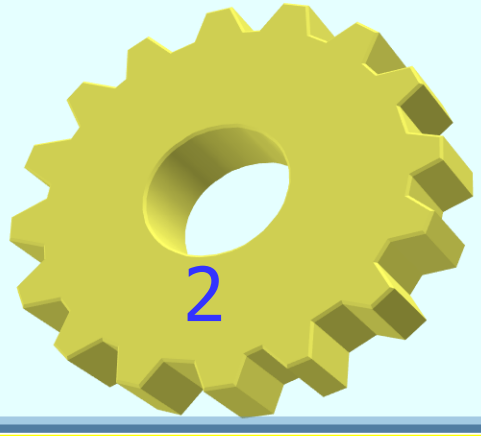
Main Topics

- Background
- Land degradation in Kuwait
- Justifications
- Benefits to Kuwait
- Objectives
- Expected Outputs
- Scope of Work
- Project Organization
- Project Schedule
- Project Budget

UNCCD (1994) Sustainable Development Approach

1: Prevention/Reduction of Land Degradation

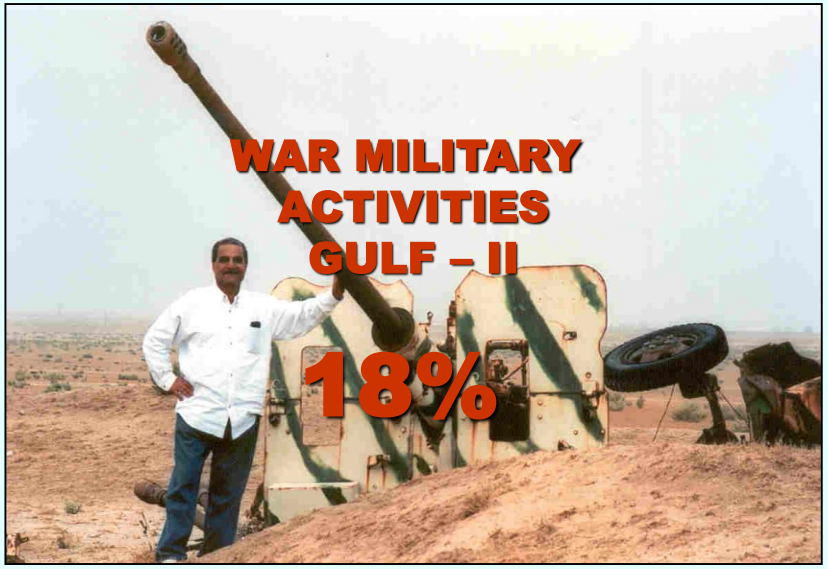


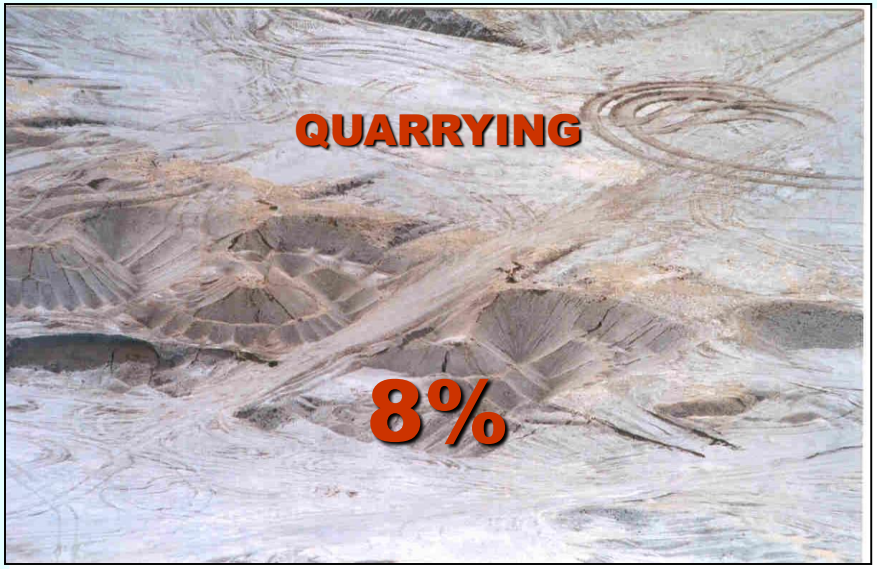


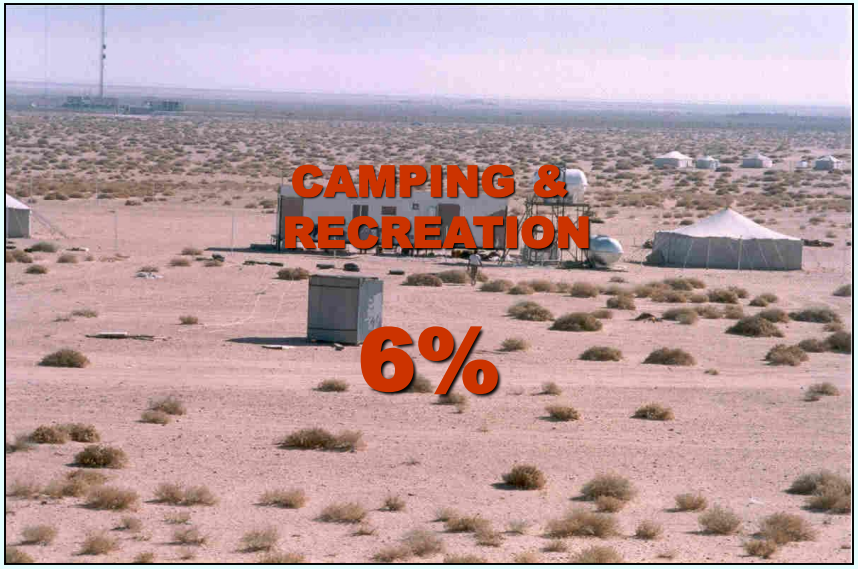
2: Rehabilitation (partly degraded lands)

3: Reclamation (desertified lands)

Main Causes of Land Degradation in Kuwait







Classes of Land Degradation (4 Case Study Areas)

- Almost Non-Degraded (Protected Lands) — 10%
- Slightly Degraded (Rocky Terrains) — 16%
- Moderately Degraded (Grazing Areas) — 43%
- Severely Degraded (Permanent Camping Areas, Gravel Quarries & Demolition Sites) — 31%

Almost Non-Degraded Terrain

Moderately Degraded Terrain

Severely Degraded Terrain

Justifications

- **Kuwait is a signatory to the UNCCD (Since 1995).**
- **The Convention calls nations to adopt an integrated approach addressing the physical, biological and socio-economic aspects of land degradation and droughts (Item 2 of Article 4).**
- **According to the UNCCD, Kuwait has to develop a National Action Plan (NAP) to control desertification/land degradation. The NAP is not established yet.**
- **The Results of the proposed study will pave the road to the NAP.**

Relation of the Proposed Study to Other KISR Projects (Examples)

- **VD006C: Controlling Land Degradation in Several Areas of Kuwait, 2000 – Phase 1 - Mapping and Assessment (Completed).**
- **FA009C: Rehabilitation and Management of Kuwait‘s Rangeland for Sustainable Yield, 2001 (Completed).**
- **EC006C: Environmental Rehabilitation Study of the Quarries in the State of Kuwait (Ongoing).**
- **FA016C: Rehabilitation of War-Damaged Areas in the Natural Park of Kuwait, 2001 (Completed).**

Benefits to Kuwait

- Minimizing land degradation in the terrestrial environment of Kuwait through corrective and rehabilitation measures.
- Enhancement of the potential of natural resources, specially soils, vegetation and wildlife.
- Providing policy makers with reliable information on the ideal development of dry lands.
- Enhancement of the Kuwaiti experience in managing fragile ecosystems.

Objectives

Overall Objective

- To assess & control land degradation in selected pilot areas in Kuwait applying advanced assessment techniques and improved, affordable and cost effective mitigation measures.

Specific Objectives

- To update information on the mechanisms of land degradation and the current status of natural resources and land uses in the pilot areas.

Objectives (Cont'd.)

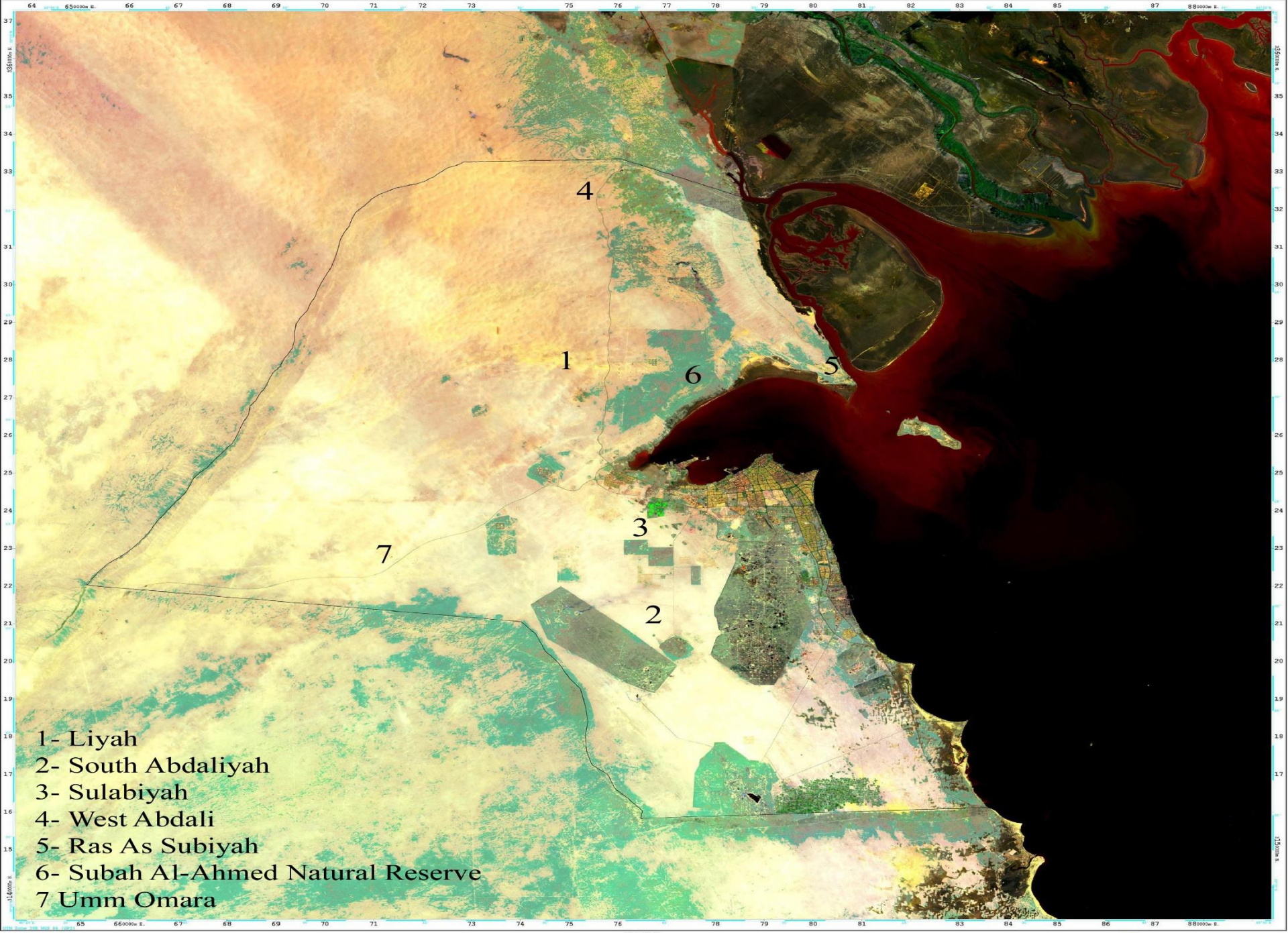
- To propose action plans to control land degradation in selected pilot areas in Kuwait.

- To develop a GIS database on land degradation in Kuwait through integration with the available databases in KISR.

Proposed Study Areas

A - Pilot Areas For Testing Various Land Degradation Control Measures (total seven areas):

1. Liyah (Water Harvesting)
2. South Abdaliyah (Biological Dune Stabilization)
3. Sulaibiyah (Mechanical Sand Dune & Sand Sheet Stabilization)
4. West Abdali {Rehabilitation of Severely Disrupted Soils Recently Affected by Military Activities (Third Gulf War)}
5. Ras As Subiyah (Treatment of Soil Crusting)
6. Sabah Al Ahmad Natural Reserve (Controlling Water Erosion in Umm Al Rimmam Watershed)
7. Umm Omara (Rehabilitation of Severely Degraded Terrains)



KUWAIT
30m resolution 2003
1:250 000 Scale

Kilometres 10 0 10 20 30
Miles 10 0 10

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Environmental and Urban Development Division
Kuwait Institute for Scientific Research

Proposed Study Areas (Cont'd.)

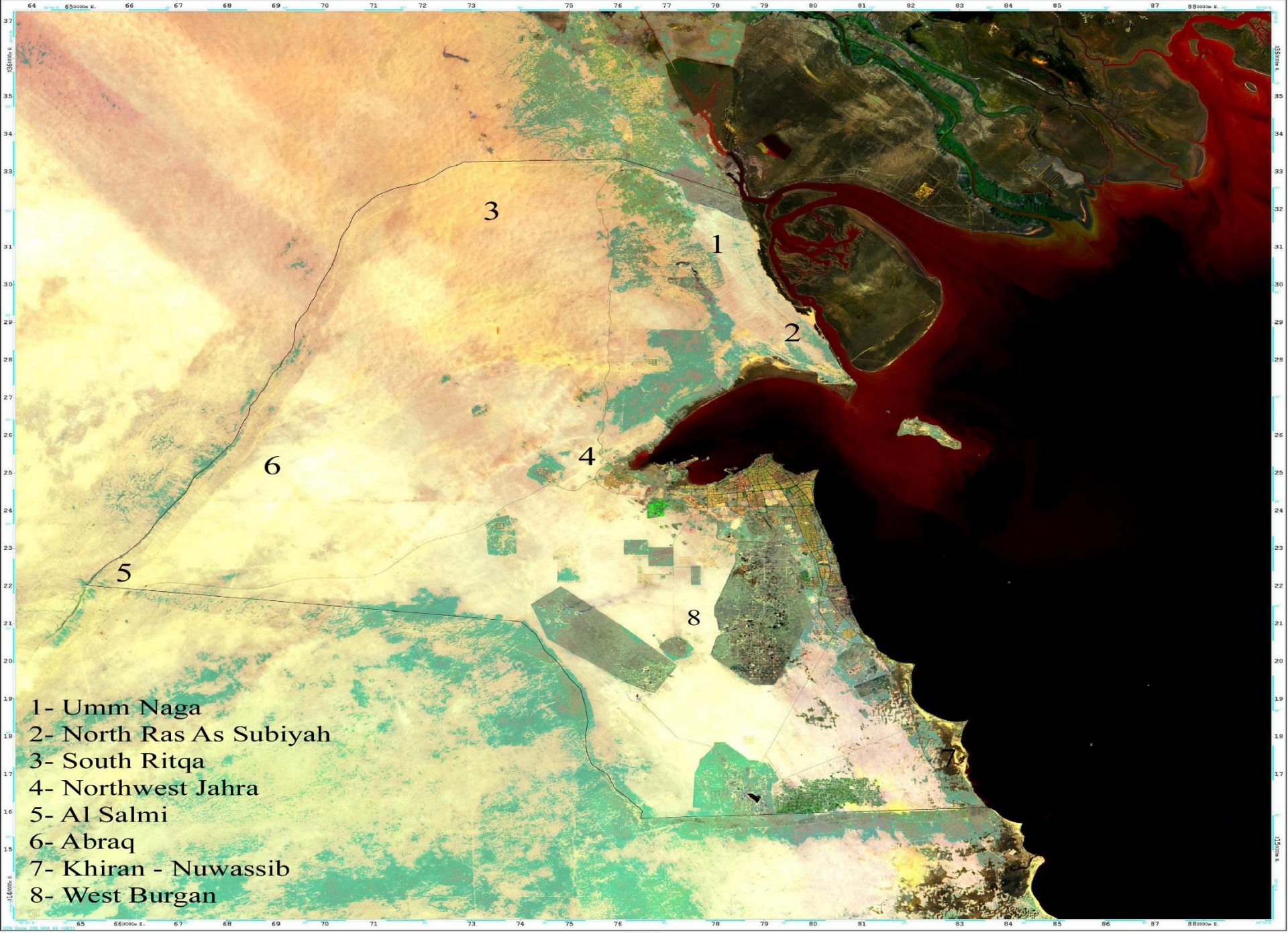
B - Pilot Areas For Recent Mapping & Assessment of Land Degradation (total 8 areas):

NE Area : Umm Naga & North Ras Sabiyah

NW Area : South Ritqa & Northwest Jahra

Western Area : Al Salmi & Abraq

Southern Area : Khiran-Nuwassib & West Burgan



KUWAIT
30m resolution 2003
1:250 000 Scale

Kilometres 10 0 10 20 30
Miles 10 0 10

Remote Sensing Lab
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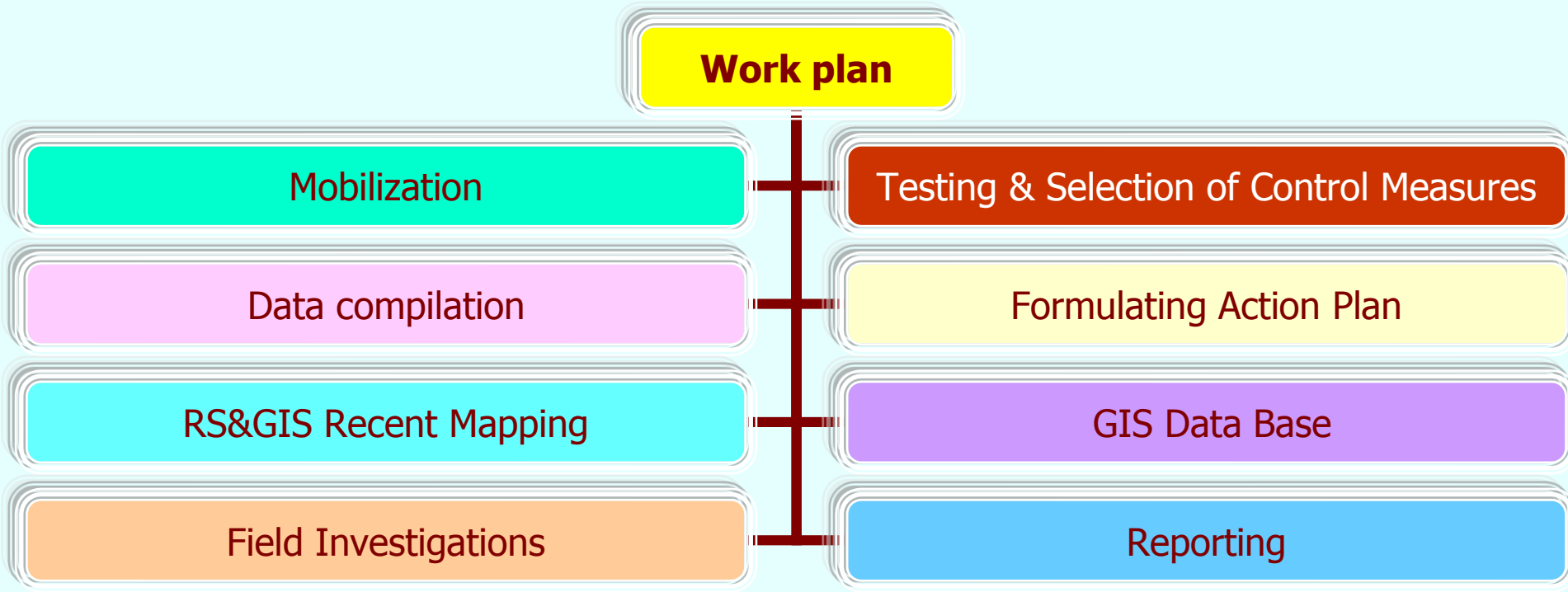
Expected Outputs

- Up-to-date maps and data on land degradation, natural resources and the current land use in the studied areas.
- Strategies, principles and practices of land degradation control.
- Action plans including packages of corrective and rehabilitation measures to control land degradation.
- Recent databases on land degradation in Kuwait.

Scope of Work



Task 2: Compilation of Existing Data & Information

Relevant Data (1975 -2005), Suitable Format for Database

- **Physical:** Climate, surface sediments, geomorphology, vegetation, degradation indicators, land degradation control, etc.
- **Socio–economic:** Population dynamics, livestock statistics, land uses, development plans, etc.
- **Remote Sensing:** Satellite images, aerial photos, field photographs, etc.

Sample of Socio-economic Information

Year	In Thousands
1976	230
1980	277
1990	252
1994	320
2000	1000

Grazing Intensity

Country	Sheep Hectare
Saudi Arabia	0.14
Iraq	2.47
Kuwait	2.47

Task 3 - Recent Mapping (using remote sensing & GIS)

The following Satellite images and aerial photos will be used:

- **Landsat (1989-2004) with resolution of 30 m.**
- **MODIS-Terra & Aqua (January 2003 - March 2005) with 250 m resolution (for regional environmental assessment).**
- **New data set from IKONOS/Quick bird with submeter resolution and IRS with 5 m resolution for detailed mapping.**
- **Set of aerial photos of 1972, 1992, 1997 and 2004.**

LOCATION OF KUWAIT INSTITUTE FOR SCIENTIFIC RESEARCH (KISR)

QuickBird Satellite Image collected on March 12, 2002 over Kuwait is around 7:28 am GMT.

Metres 100 0 100 200

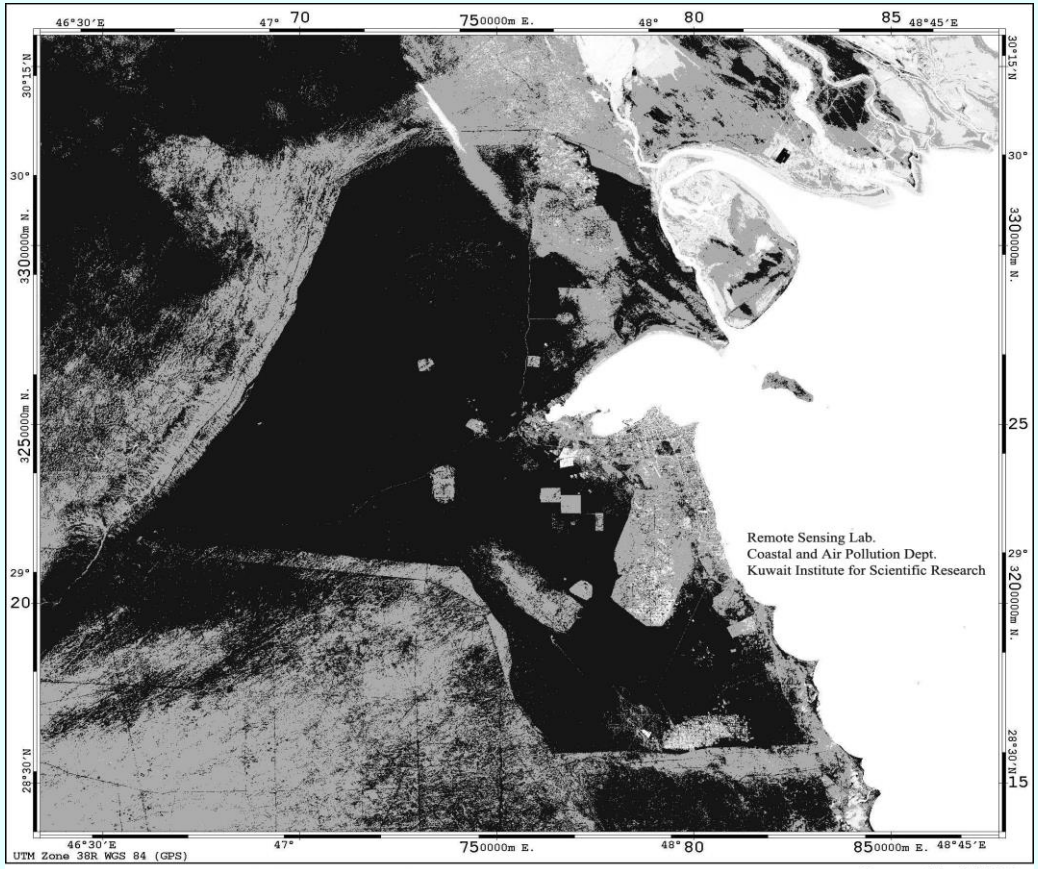
Yards 100 0 100 200

3.1. Assessing and Mapping Vegetation Degradation

Two recent techniques will be applied:

- **NDVI (Normal Differential Vegetation Index)**
- **SAVI (Soil Adjusted Vegetation Index)**

NDVI (Normal Differential Vegetation Index)



Processed by Saji Baby

NDVI image generated from Landsat Data for year 2001 showing the vegetational distribution with area of high absorbance of radiation.

3.2. Assessing and Mapping Soil Degradation (Aerial Photos and GIS)

- Four sets of sequential aerial photographs taken between 1972 and 2004 will be applied.
- A vector based GIS will facilitate the generation of maps and statistical analyses of spatial data.
- Stereoscopic Interpretation will be carried out & field checking for recent sets will be conducted.

Task 4
Field Investigations

- **4.1. Ground Truthing and Sampling**
- **Selection of ground truthing sites on the bases of image interpretation.**
- **Design field sheet for recording data and field observations.**
- **Locating sites using GPS.**
- **Ground checking of remote sensing data (mainly 10 classes of unsupervised images).**
- **Collecting of field data on soil type, vegetation types & density, micro landforms, etc).**
- **Sampling of surface sediments from different classes (at least one sample/class).**
- **Taking field photographs with GPS readings for surface sediments & vegetation.**
- **4.2. Field Assessment of Soil Degradation**
- **Measurements of Infiltration Rate (Infiltrometer of two metal rings), Soil Bulk Density (Cylindrical metal Sampler) and Soil Strength (Bush Soil Penetrometer, Sp 1000 version 2) in a number of sites based on remote sensing information.**
- **4.3. Measurements of Vegetation Cover**
- **Helicopter Flights (200m high, twice a year) along Al Huwaimiliyah-Wafra transect (167 km length, 20-50 km width), for vegetation survey using digitized video data with a 35mm Camera .**
- **Analyses of results of Helicopter flights.**
- **Confirmation of Helicopter information through field measurements of plant cover, plant density and biomass in 8-10 ground stations (100 m^2 each).**

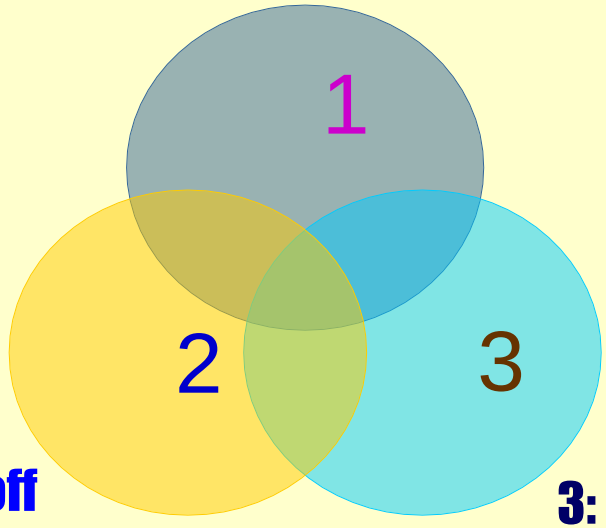
Task 5
Testing and Selection of Appropriate Techniques of Land Degradation Control

- **Harvesting of Rainwater for Soil Stabilization and Development of Vegetation Cover (Liyah Pilot Area)**

- **Delineation of the watershed (catchments) using recent aerial photos (2003) and ground checking.**
- **Quantitative geomorphologic analyses of drainage network (Bifurcation ratio, Stream order, Basin area, Stream length & Drainage density) to identify the hydrological potential of drainage basins.**
- **Hydrological assessment and meteorological analyses to estimate the amount of rainwater received by the catchments.**
- **Selecting Wadi Huban to test different techniques of collecting runoff water (reservoirs, check dikes, water cellar, cisterns.. etc).**
- **Design a water harvesting system with cost estimates.**

Principles of Water Harvesting

1: Enhancing Water Infiltration Capacity



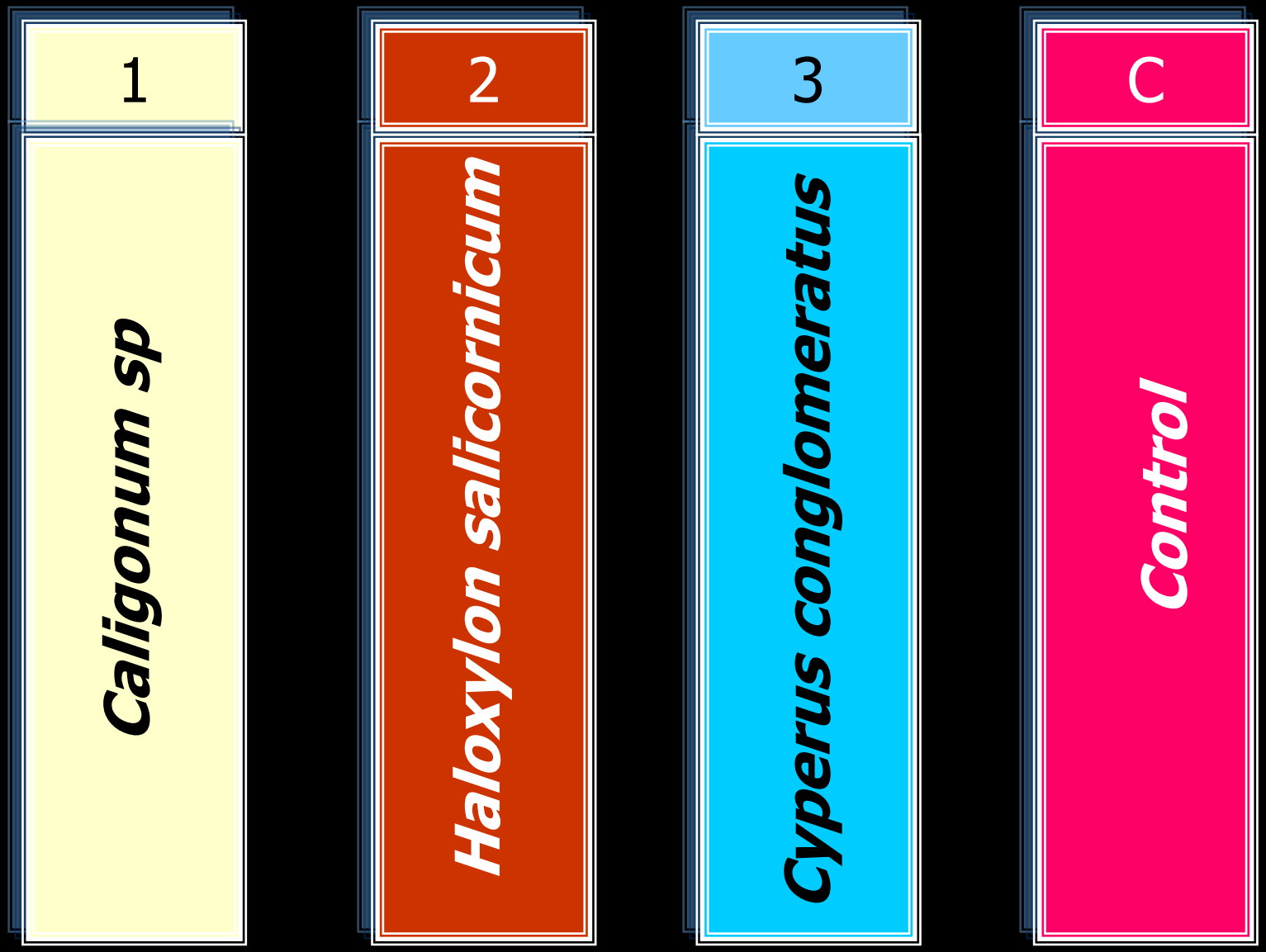
2: Collecting Runoff

3: Controlling Evaporation

Controlling Mobile Sands in the Terrestrial Environment of Kuwait (two case studies)

- First Case: Biological Dune Stabilization (South Abdaliyah Pilot Area)
  - Selection and fencing the experimental site (4 barchans).
  - Examining and sampling 6 soil profiles, 120-150 cm, depth in each barchans (5-6 samples from each profile).
  - Measuring soil moisture of the windward, slip face, horns of each barchans four times/year (depth from 0- 150 cm) using KISR Soil Survey procedure.
  - Establishing a system of mechanical sand control on the three barchans (fences of plant materials, checkerboard system and carpets of ecomats or other available materials, e.g.. unused tires).
  - Plantation of seedlings of Haloxylon , Cyperus and Caligonum.
  - On the three barchans (fourth one as control) depending on soil moisture & spot irrigation.
  - Monitoring plant growth.
  - Cost estimates.

Biological Sand Dune Stabilization
Experimental Design (four sand dunes, 1-3 & control)



Controlling Mobile Sands in the Terrestrial Environment of Kuwait (two case studies) (Cont'd)

- **Second Case:** **Mechanical Sand Dune & Sand Sheets Stabilization using different materials, e.g. Ecomat and straw checkerboard (Sulaibiyah Pilot Area).**

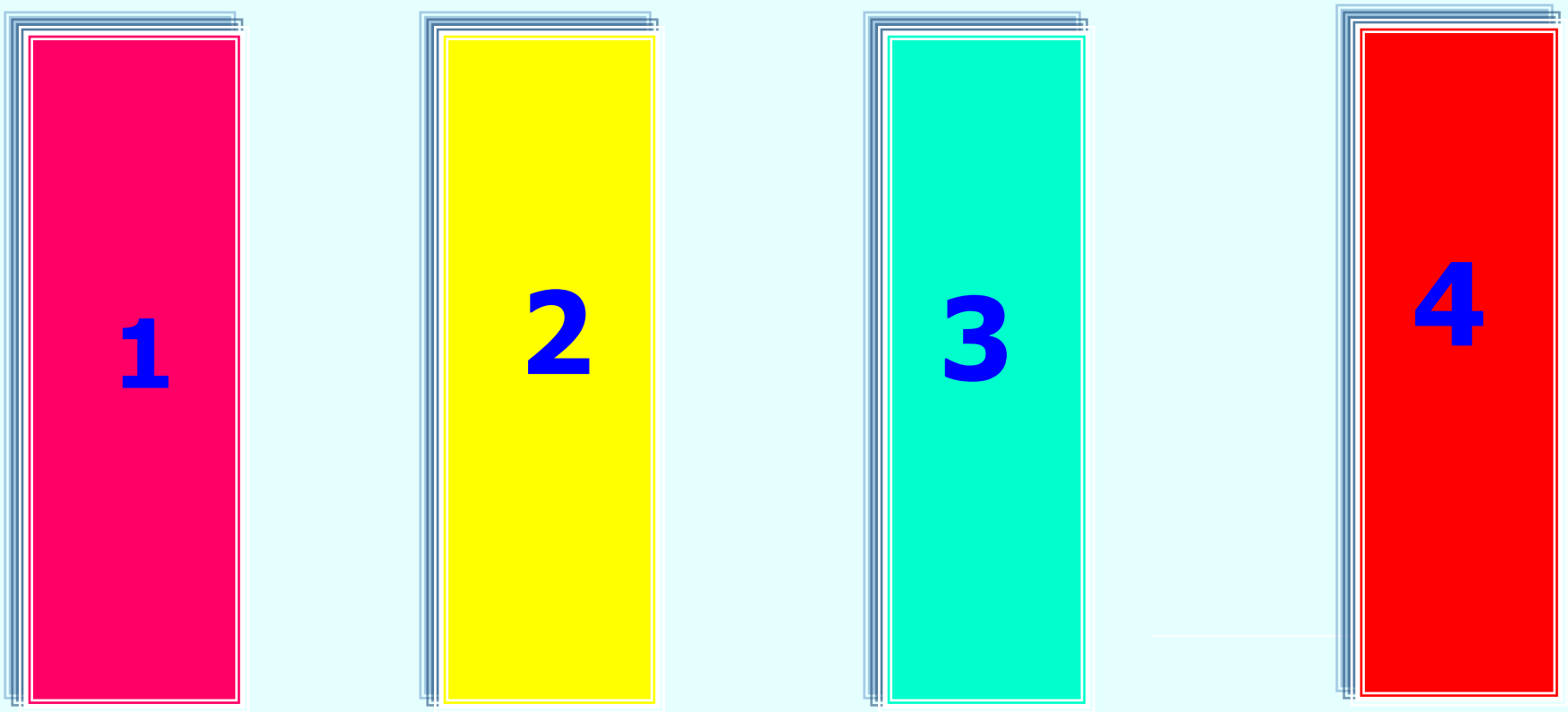
-Selecting and fencing the experimental site [2-3 sand accumulations and an active sandy sheet (50m x 50m)].

-Collecting representative samples for mechanical analyses and soil moisture measurements from the sand accumulations (8-12 samples from each) and the sand sheet (12-16 samples).

-Testing sand stabilization using Ecomat (Malaysia), Ecomat (India), and straw checkerboard (1m x1m, 30-40cm high).

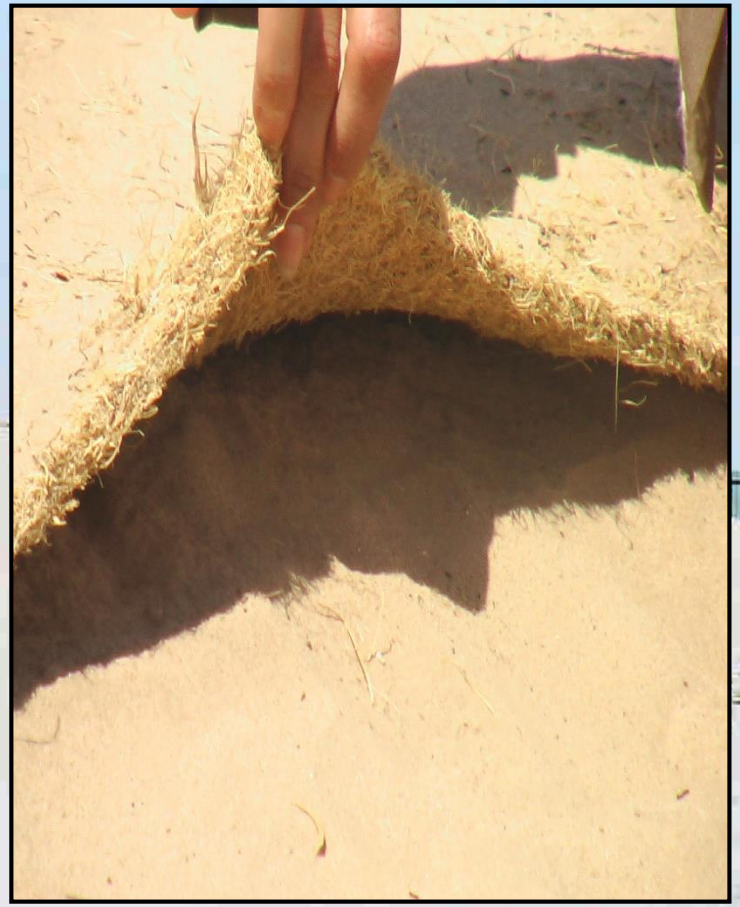
-Assessing efficiency of tested materials (comparison of moisture content, soil nutrients, plant growth & sand movement in both treated and untreated surfaces) & cost estimates.

Mechanical Sand Stabilization, Experimental Design (4 plots, 5 x 15m)




Checker
board


Ecomat

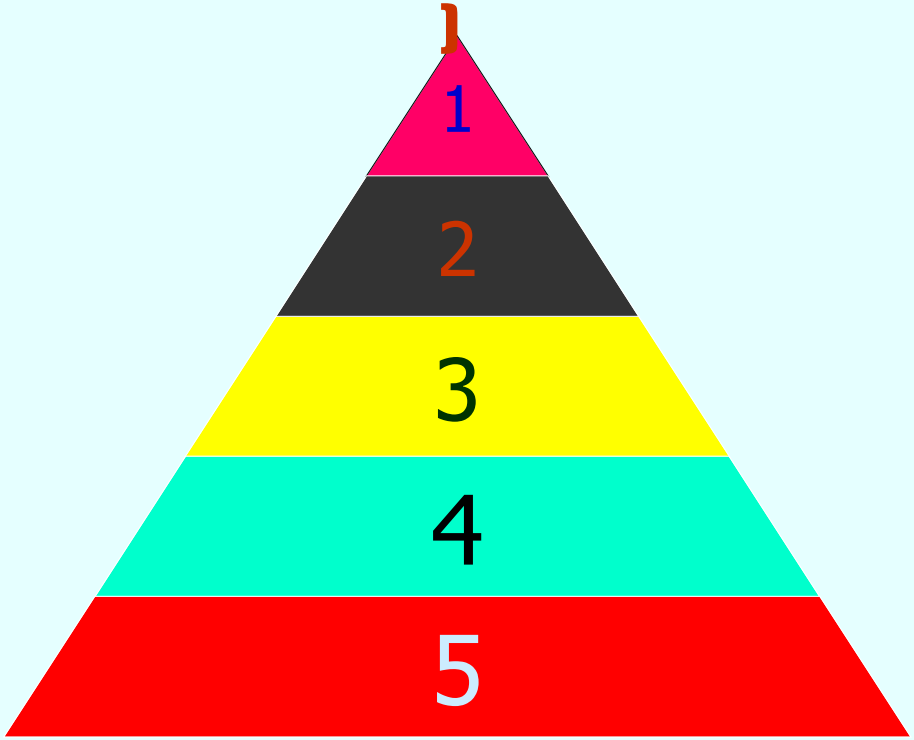


Ecomat, KISR, Sulaibiyah
July, 2004

Rehabilitation of Severely Disrupted Soils Recently Affected by Military Activities (West Abdali Pilot Area)

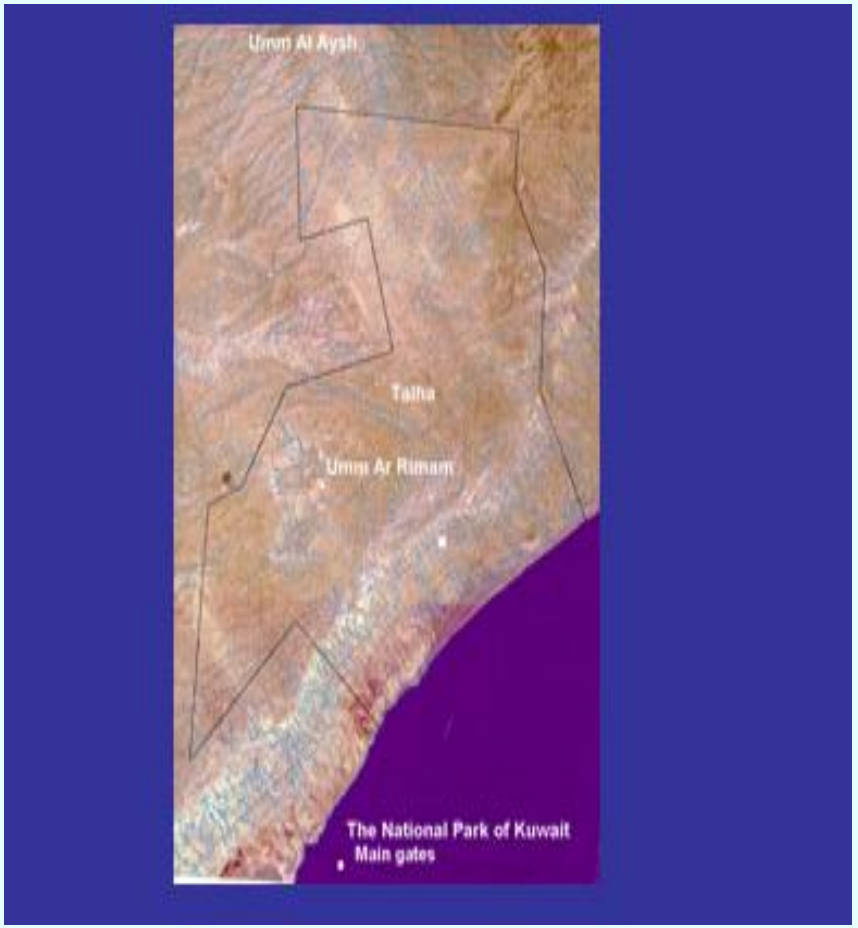
Assessment of the damage caused by collation Forces using aerial photos and satellite images before and after the Iraqi liberation war (March, 2003)

Rehabilitation of Military Affected Areas (West Abdaly Pilot Area)



1. **Field Survey & Aerial photo interpretation and change detection technique to assess the damage.**
2. **Selection of representative pilot site (100x100m) for testing rehabilitation measures.**
3. **Damage Assessment (field tests including bulk density, infiltration capacity & vegetation assessment in the site and another control site).**
4. **Testing mitigation methods e.g. soil stabilization, plantation, ploughing, etc.**
5. **proposing the most appropriate mitigation measures e.g. plantation, soil stabilization, etc.**

Controlling Water Erosion (Umm Al Rimmam Depression, Sabah Al Ahmad Natural Reserve)

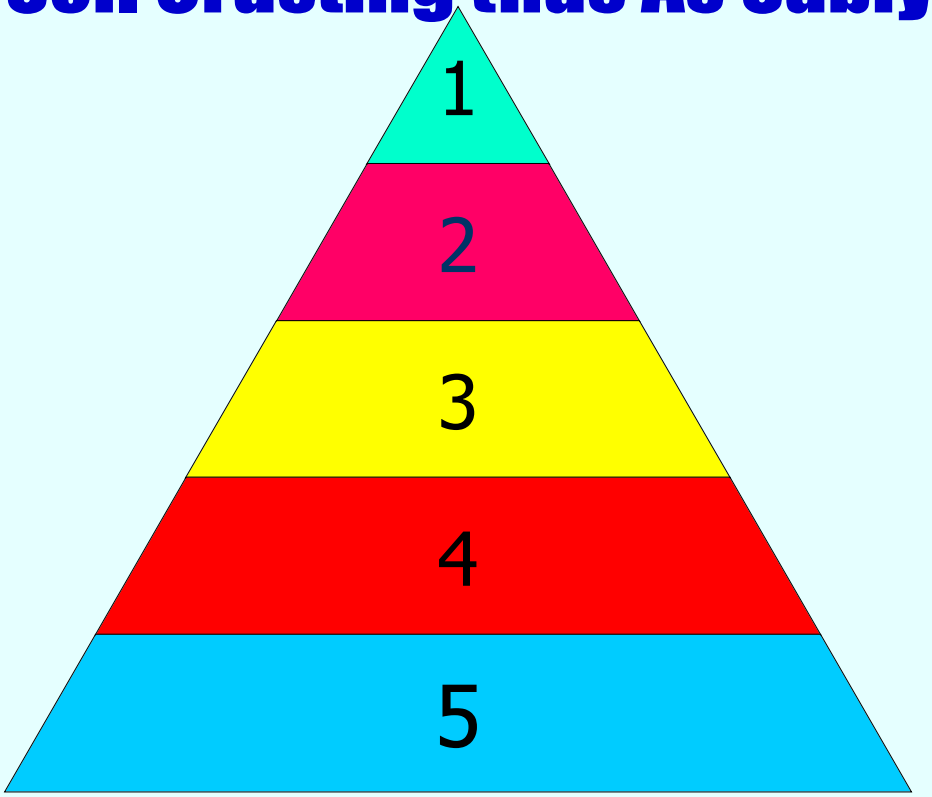


Detailed mapping of the drainage network using 2003 aerial photos and satellite images along with field survey & ground truthing

Controlling Water Erosion (Umm Al Rimmam Depression) (Cont'd)

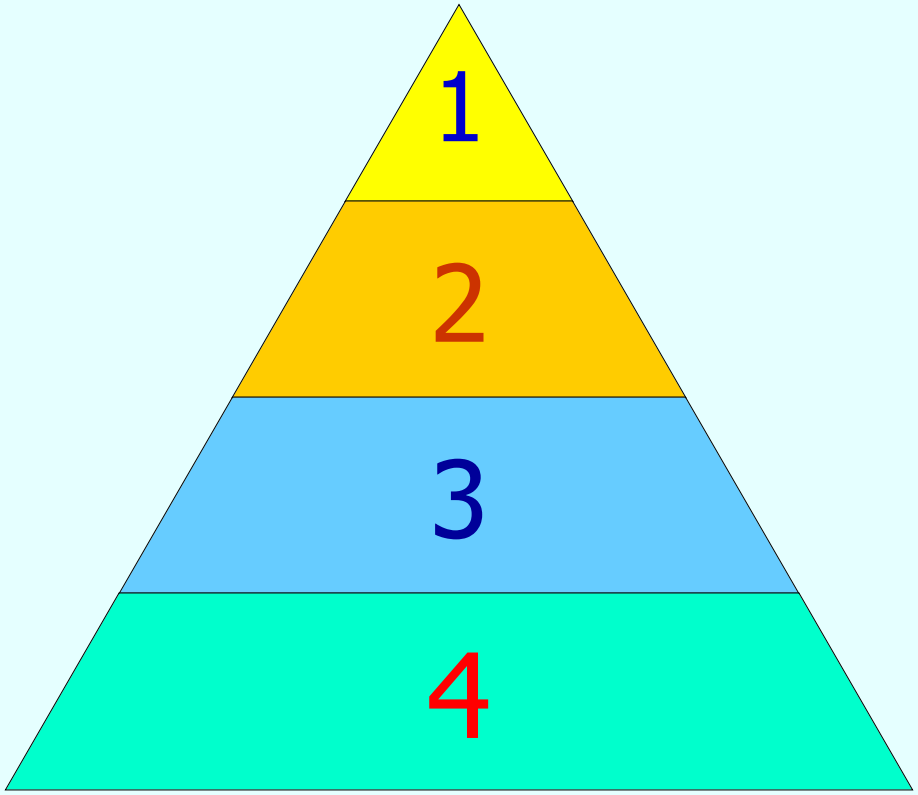
- Assessment of damages to watershed through field measurements of depth, length and width of water erosion & vegetation cover.
- Identification of different classes of water erosion through gully density analyses (gully length/unit area).
- Selection of one channel for testing appropriate restoration techniques, e.g., checking dams & soil stabilization using ecomat, gravels, plantations.
- Propose Restoration action plan with cost estimates.

Treatment of Soil Crusting (Ras As Sabiyah Pilot Area)



1. Identifying the magnitude of the soil crusting problem, producing a recent map (task 3 output) & selecting a representative pilot test site (100x100m).
2. Determination of thickness and strength of crust using Bush Penetrometer (10-12 readings).
3. Assessment of the environmental damage of soil crusting through field tests including bulk density, infiltration capacity & vegetation assessment in the site and another control site.
4. Testing four restoration measures (mechanical ploughing, manual ploughing, mulching with plant residue and plantation of drought resistance trees e,g. *Prosopis juliflora.*
5. *Selecting the most appropriate measures of soil crusting control based on the results for four tests.*

Rehabilitation of Severely Degraded Terrains (Umm Omara Pilot Area)



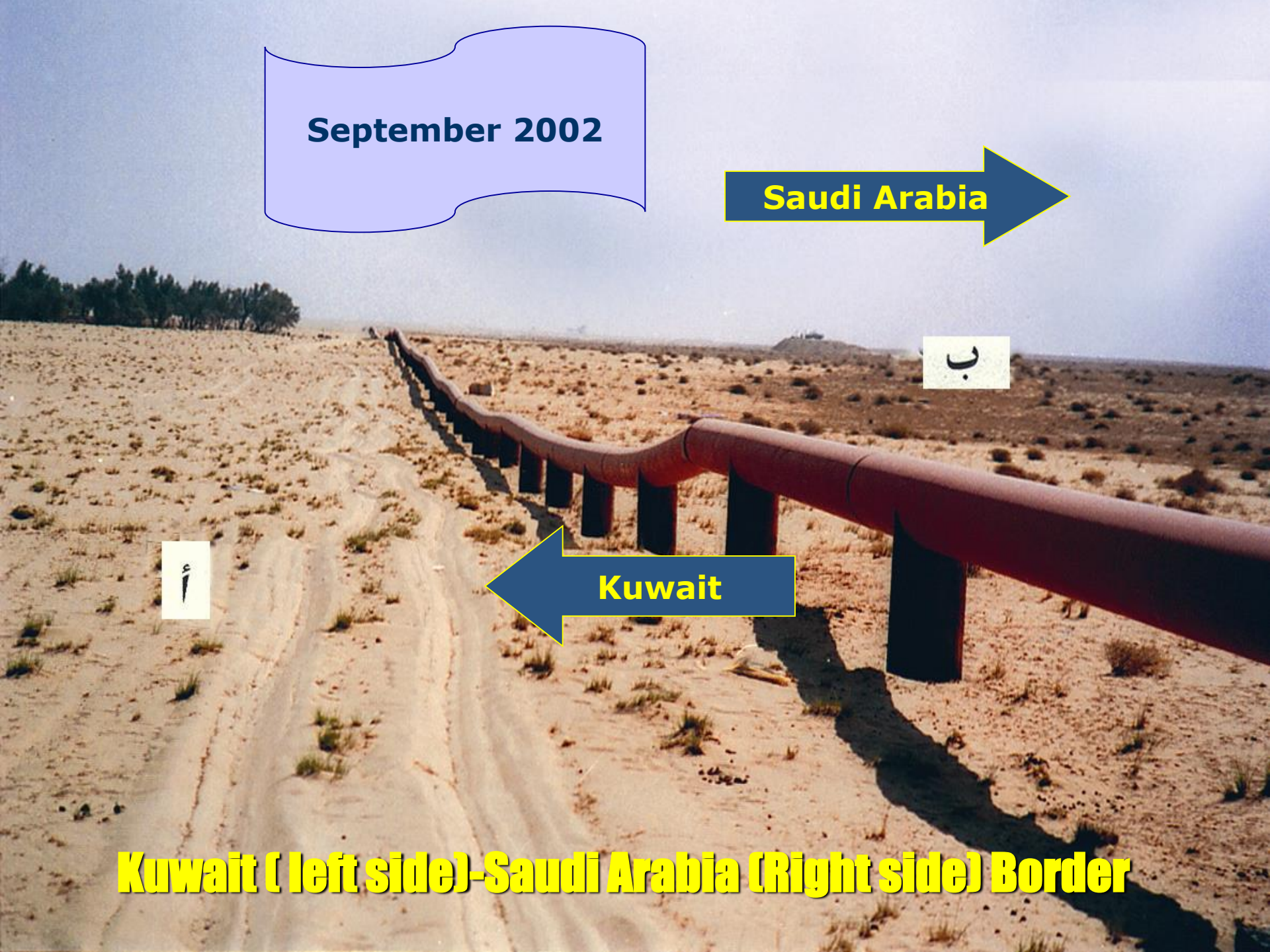
1: Establishing a recent land degradation status map using Quick bird image & aerial photos and ground truthing)

Umm Omara (Cont'd)

2-Field assessment of the damage to soils (including oil pollution caused by oil trenches), vegetation cover and micro-topographic features through conducting field tests (infiltration rate, bulk density, soil resistance and vegetation measurements) in the pilot area and in a control site (for quantitative damage assessment).

3-Selecting a representative field site (100x100 m) for testing at least 5 mitigation measures (biological and mechanical sand stabilization, plantations, mulching & shattering soil crusts).

4-Proposing action plan for controlling land degradation including both corrective measures, e.g. land use changes and reclamation measures, e.g., plantations, mobile sand control, maintaining soil crusts etc.



Kuwait (left side)-Saudi Arabia (Right side) Border

Task 6
Formulating Action Program For Land Degradation Control

- Identification of the magnitude of land degradation in different pilot areas on the bases of the results of tasks 3 (recent mapping) and 4 (field investigations and assessment of land degradation).
- Proposing a priority action program for restoration and rehabilitation of degraded lands in the pilot areas on the bases of the results of task 5 (testing and selecting of appropriate techniques of land degradation).
- Proposing regular monitoring mechanisms for natural resources (water, soils, vegetation and wildlife) depending on remote sensing and permanent ground observation stations.
- Cost–Benefit Analyses.

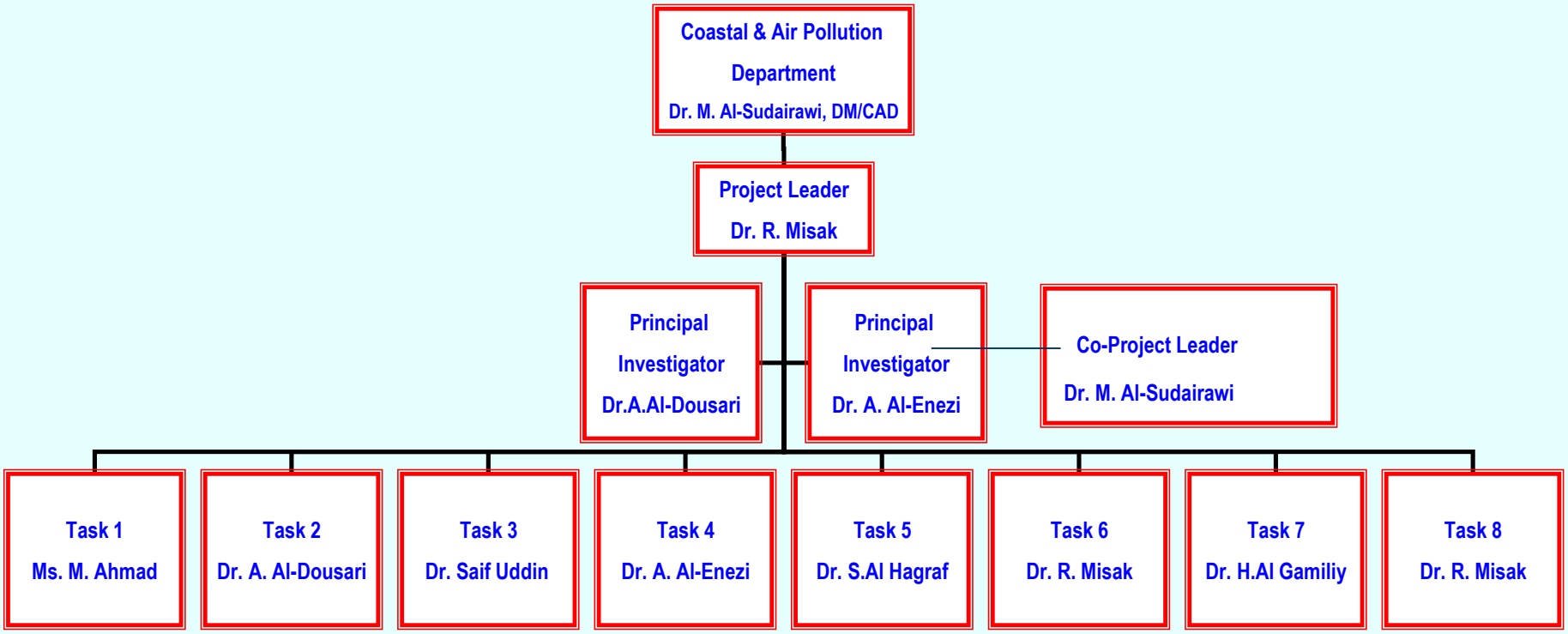
Task 7- Establishing a Geoenvironmental GIS Database on Land Degradation

- Develop GIS specifications and standards for data capture and automation.
- Identify the input GIS layers from different sources.
- Introduce the conceptual and physical database design.
- Action plan for data automation and editing.
- Insure the spatial data quality via QA/QC procedures.
- Carry out the advanced GIS analyses to monitor and assess the deteriorated land resources and suggest the mitigation measures.

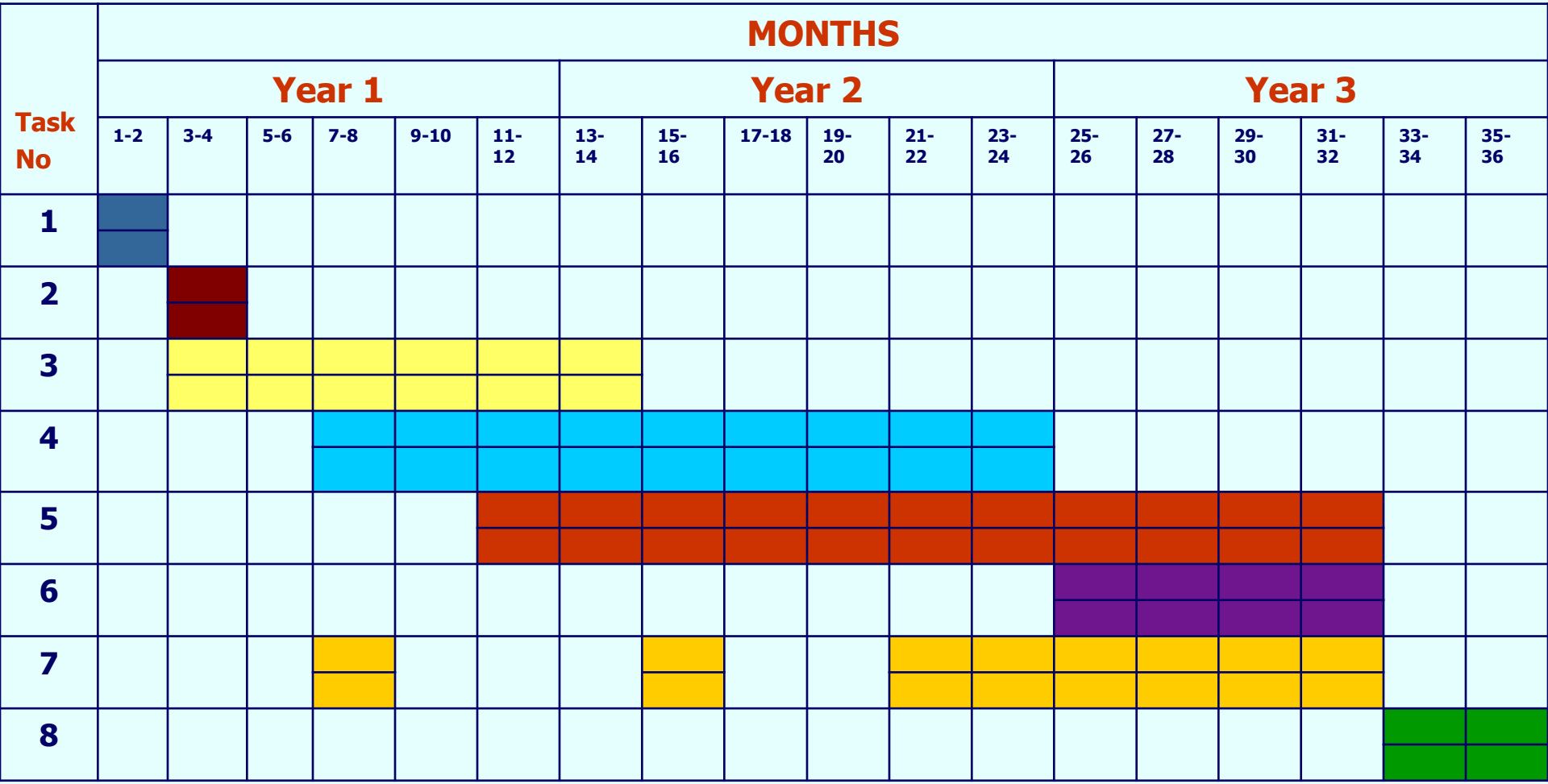
Project Organization & Management

- The project will be carried out by the Coastal and Air Pollution Department, Environmental and Urban Division of Kuwait Institute for Scientific Research (KISR) in collaboration with the Food Resources (FRD), Techno-Economic Divisions (TED) and NSTIC.

Project Organization Chart



Project Tasks Schedule



Task 1: Mobilization; Task 2: Compilation of data; Task 3: Recent mapping of land degradation; Task 4: Field investigation & assessment of land degradation; Task 5: Testing & selection control measures; Task 6: Action program; Task 7: GIS database; Task 8: Reporting.

Project Budget

Manpower Staff Salaries	1st Year	2nd Year	3rd Year	Total
Researchers (20)	10900(5)	17440(8)	15260(7)	43600
Professionals (25)	4800(5)	9600(10)	9600(10)	24000
Technicians (25)	3300(5)	6600(10)	6600(10)	16500
Secretary (6)	1120(2)	1120(2)	1120(2)	3360
Subtotal	**20120**	**34760**	**32580**	**87460**

Project Budget (Cont'd)

Operational Expenses Item	1st Year	2nd Year	3rd Year	Total
Laboratory supplies	2000	2500	1500	6000
Field facilities	3000	2000	1000	6000
Satellite Images (IKNOS & IRS)	7500			7500
Aerial Photography (Heliocopter)	3000			3000
2 Cars (4x4)	5400	5400		10800
Photographer	750	500	500	1750
Software packages	1500		1500	3000

Project Budget (Cont'd)

Operational Expenses Item	1st Year	2nd Year	3rd Year	Total
Consultants	1000	1000		2000
Travel	1000	2000		3000
Temporaries*	2500	2500	1500	6500
Petty cash	1200	1200	1200	3600
Subtotal	**28850**	**17100**	**7200**	**53150**

** Daily workers needed for the field works*

Project Budget (Cont'd)

Capital Expenses	1st Year	2nd Year	3rd Year	Total
Laptop computer	750			750
Digital video camera	500			500
PDA (Personal Digital Assistant)	1500			1500
Bush Soil Penetrometer, SP 1000, Version 2	1200			1200
Infiltrometer (Digital)	600			600
Cylindrical metal sampler (for measuring bulk density)	350			350
pH meters	150			150

Project Budget (Cont'd)

Capital Expenses	1st Year	2nd Year	3rd Year	Total
60 Sand traps	1800			1800
60 Dust collectors	1800			1800
Moisture meter	150			150
Subtotal	**8800**			**8800**
Yearly Totals	**57770**	**51860**	**39780**	**149410**
Grant Total				**149,410**

Funding Plan

The following are the potential funding agencies:

- **Public Authority for Agriculture & Fish Resources (PAAFR)**
- **Environmental Public Authority (EPA)**
- **Kuwait Foundation for Advancement of Sciences (KFAS)**
- **Kuwait Municipality (KM)**


Thank You !