

UNITED NATIONS/AUSTRIA/EUROPEAN SPACE
AGENCY
SYMPOSIUM

"SPACE TOOLS AND SOLUTIONS FOR MONITORING
THE ATMOSPHERE AND LAND COVER"
9 - 12 September 2008, Graz, Austria

RS/GIS MULTI-CRITERIA ZONING OF
200,000HA LAND FOR THE DEVELOPMENT OF 5000 HA

ACCRA PLAINS IRRIGATION PROJECT (APIP), GHANA

F.D. OHEMENG



OUTLINE

1. INTRODUCTION

2. AIM OF STUDY

3. OBJECTIVE

4. LOCATION

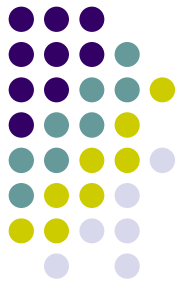
5. APPROACH AND METHODOLOGY

6. DATA ANALYSIS

7. OUTPUT

8. CONCLUSIONS AND RECOMMENDATIONS

INTRODUCTION



WHY APIP?

- A cardinal principle of Ghana Government is to ensure sustainable agricultural growth, food availability and food security for the people of Ghana
- The climate of Ghana is characterized by long periods of drought and erratic rainfall
- Ghana's agriculture is rainfall dependent and cannot sustain the growing population without extensive and intensive irrigation and effective soil management
- Accra Plains has potential for irrigation to produce adequate food to ensure food security for the nation
- The vast water and land resources must be tapped for agriculture, domestic and industrial development.

BACKGROUND HISTORY



- In 2005 the Government of Ghana made a request to the Government of Kuwait for funding of the feasibility study of Accra Plains Irrigation Project (APIP)
- The Kuwait Fund for Arab Economic Development (KFAED) agreed to finance the study.
- In February 2007 GIDA invited Consultants for the study
- In April 4th, 2005 selection of Consultants was made
- STUDI International (in association with AL OBAID ENGINEERING CONSULTANT of KUWAIT and COMPTRAN Engineering & Planning Associate, GHANA) referred to as Consultant won the bid.
- July 25th, 2005 the Consultant, submitted his technical and financial proposals to GIDA
- September 25th, 2007 an agreement was signed between Ghana Irrigation Development Authority (GIDA) referred to as Client representing the Ghana government and the Consultant
- December 12th, 2007 the study commenced

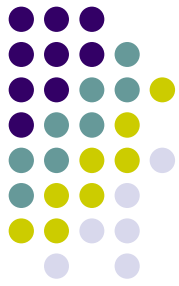
AIM OF STUDY

- 1. Zoning and prioritising of 200.000 ha area into priority sections**
- 2. Selection of 5,000ha land for detailed feasibility study and construction**

OBJECTIVE

- **Ensure sustainable land use and land management for irrigation development.**
- **Reduce time and cost of irrigation project Development**

FIG.1 LOCATION MAP OF ACCRA PLAINS IRRIGATION PROJECT



PROJECT AREA DESCRIPTION



- Located at the southern part of the country in the coastal savannah belt.
- It covers an area of about 200,000 ha
- Area has easy access to both sea and airports for export purposes
- Area is drained on the eastern boundaries by the Volta river
- Close to the Kpong hydroelectric dam
- Land is fairly flat and dominated by grassland and thicket vegetation
- Dry, humid and hot coastal savannah with bimodal rainfall

EXECUTING AGENCIES

GHANA IRRIGATION DEVELOPMENT AUTHORITY



AND

**CONSORTIUM OF STUDI INTERNATIONAL, TUNISIA AND
COMPTRAN ENGINEERING & PLANNING ASSOCIATE,
GHANA**





PROJECT COST

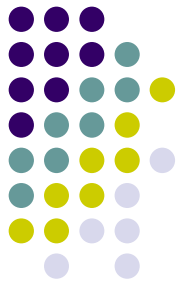
- COST OF FEASIBILITY STUDY ESTIMATED AT 1.544M USD



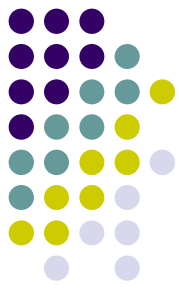
FUNDING

- KUWAIT FUND FOR ARAB ECONOMIC DEVELOPMENT (KFAED) - 91%.
- GOVERNMENT OF GHANA - 9%

EXECUTING TEAM (MULTI-DISCIPLINARY)



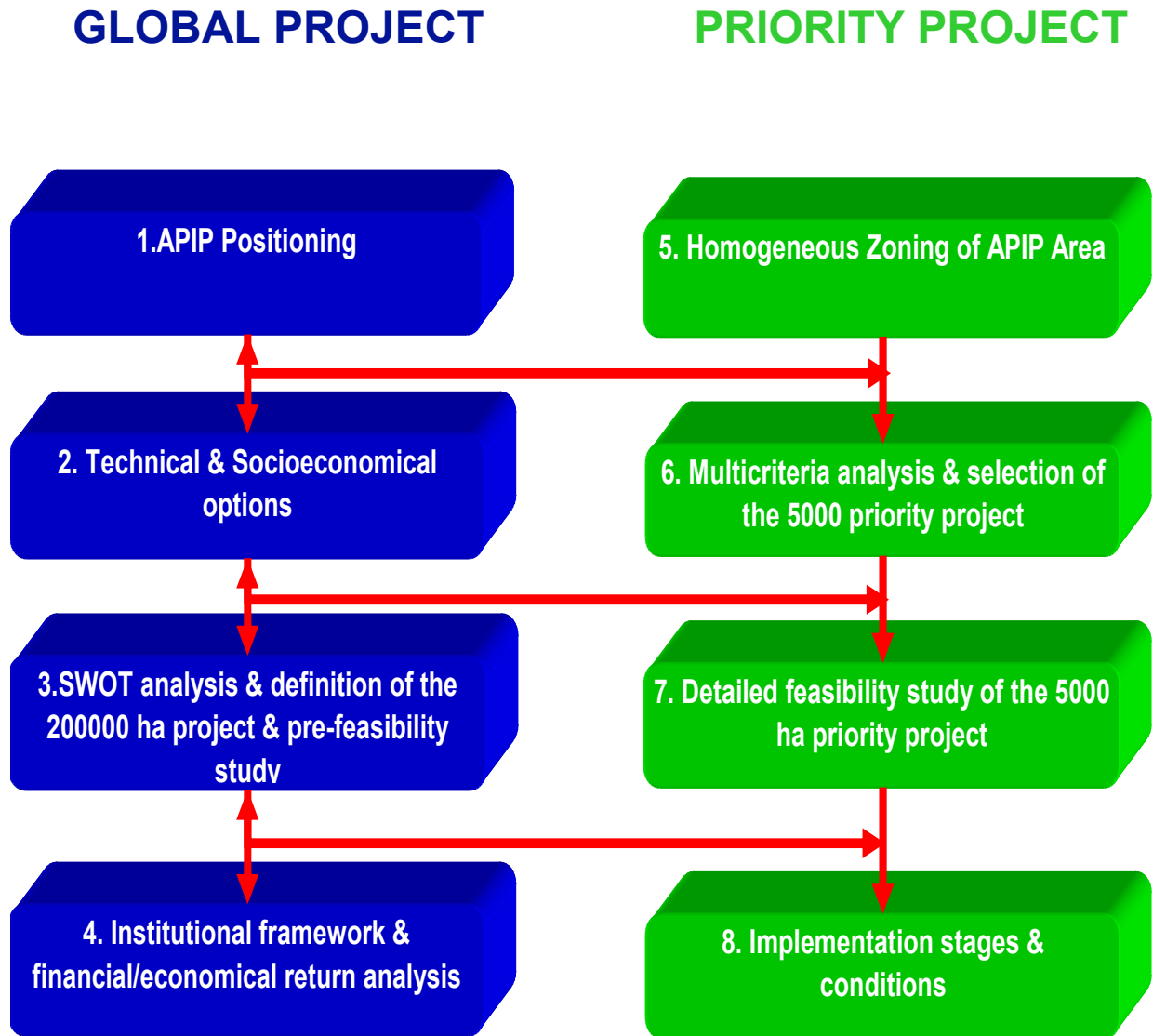
- RS/GIS Expert (landuse/landcover, zoning)
- Economist
- Financial analyst
- Agronomist
- Agro-economy and marketing expert
- Rural engineer
- Hydrologist
- Health expert
- Hydro-geologist
- Environmentalist



APPROACH AND METHODOLOGY

- **A generalised structure of approach and methodology used for the study is indicated by Figure 2 and 3**

Fig.2 GENERALISED APPROACH FOR THE STUDY





6 MAIN STAGES OF THE STUDY

- 1. APIP's Position in the Global Framework of the Ghanaian Development Issue and Identifying main aims to be achieved by the whole project (200 000 ha)**
- 2. Identifying socio-economic and technical options in terms of: production systems, potential farmers to involve in the Project and adapted irrigation system**
- 3. SWOT analysis of the different Project's options, selection of the optimal alternative (the 200 000 ha. Project) and feasibility study**
- 4. Institutional and financial framework of the Project, economic and Financial Return analysis**
- 5. Zoning of the APIP Area and**
- 6. Multi-criteria analysis and selection of the 5000 ha priority Project**

Component 1

APIP's Position in the Global Framework of the Ghanaian Development

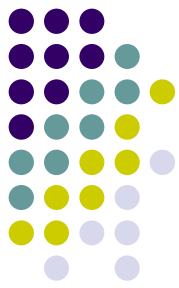


- Social and economic positioning indicators of Ghana's economy in ECOWAS.
- Ghana macroeconomic framework and the sub-regional positioning of its performance.
- Key performance indicators of the Ghanaian agricultural sector.
- Agricultural development policy.

**ALL INDICATORS ARE GOOD FOR
IMPLIMENTATION OF APIP**

Component 2

Physical, Technical, Socio-economic and Environmental Options



- **Assessment of Present Agricultural Conditions of Accra plains**
 - Agricultural Production and marketing systems
 - Crop systems
 - Components characterising Ghana's agriculture
 - Key performance indicators of Ghana's agricultural sector
- **Assessment of Project Area**
 - Description of the area (administrative boundary, climate, topography, relief and drainage etc.)
 - Soil suitability for crops
 - Hydrology (Surface & Groundwater resources)
 - Economic and social facilities and infrastructures
- **Establishment of a GIS database (Cartographic and numeric)**

Component 3:

SWOT analysis and definition of the 200,000 ha project and pre-feasibility study



- Agricultural map development / Selection of most relevant options.
- Fishery sector assessment

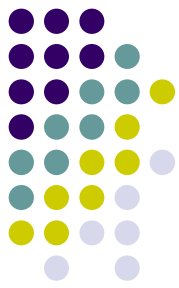
Component 4

Institutional framework and financial & economic return analysis



- Economic return and sensitivity analysis.
- Identification of the relevant institutional framework ensuring project success.
- Social, Gender and Environmental Assessment.

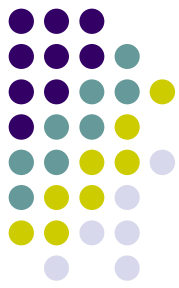
Component 5



Homogeneous zoning of APIP area

- Zoning of the different areas of APIP.
- Zones classification and macro-planning establishment.

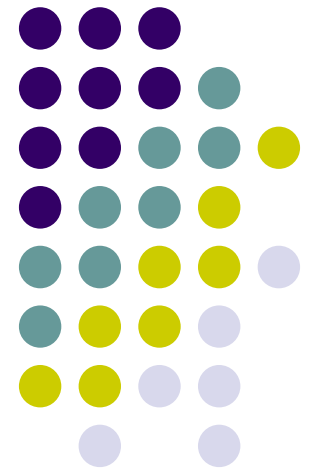
Component 6



Multi-criteria analysis and selection of 5,000
ha priority project area

- Establishment of selection Criteria
- Classification of the different APIP sub-projects by Prioritizing criteria
- Different Development Scenarios
- Selection of best Alternative Scenario

ZONING



PURPOSE



- **Prioritise available land use options**
- **Ensure judicious and sustainable use of land**
- **Obtain spatial database of available land for future agricultural and socio-economic development**
- **To establish a spatial multi-criteria decision tool for spatial planning**



WHY GIS TECHNOLOGY ?

- **To store and manage data from different sources at various scales**
- **To overlay data (maps)**
- **Capability for spatial multi-criteria analyses**
- **Develop scenarios of management.**



Tool for decision support

GIS SOFTWARE USED



- **ArcGIS 9.2**
 - **A powerful tool for**
 - **Management**
 - **Analysis**
 - **Processing**
 - **Reporting of spatial information and data**

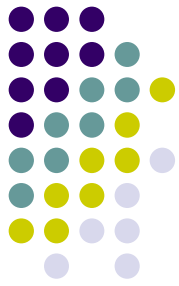
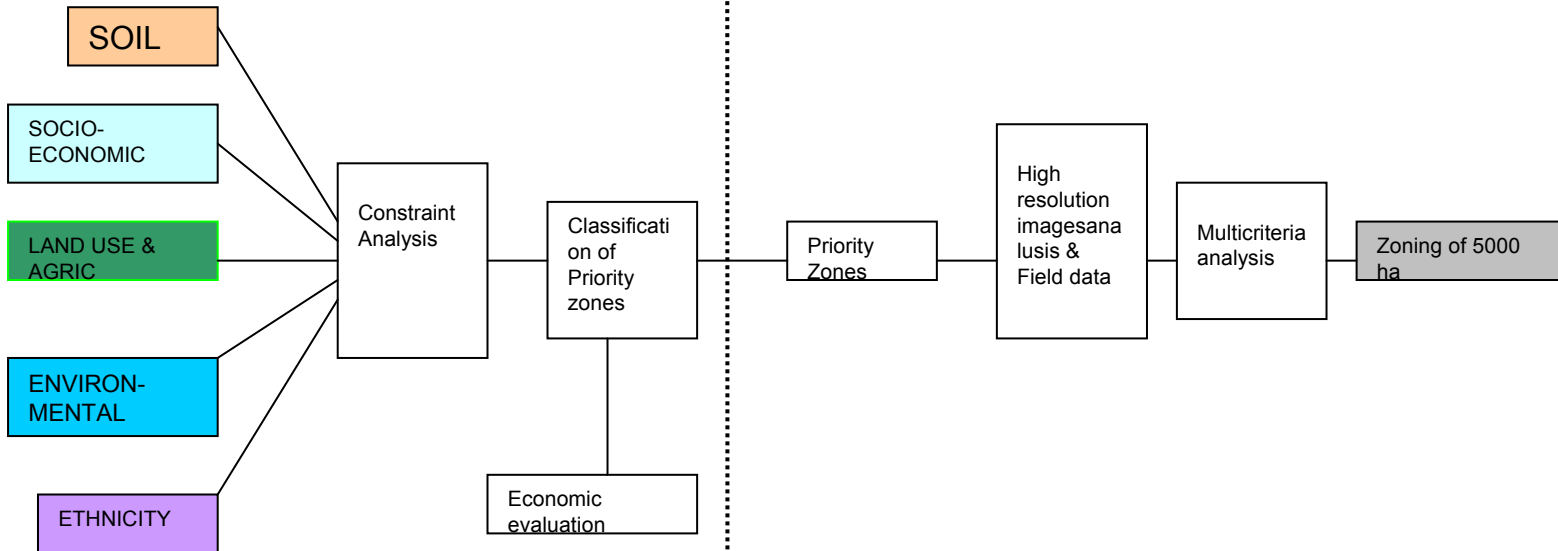


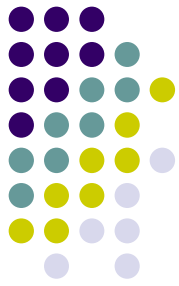
Fig.3 GENERAL PROCEEDURE FOR THE ZONING STUDY

PRE-FEASIBILITY STUDY OF
200,000HA

MULTICRITERIA ZONING OF 5000
HA LAND AREA FOR APIP

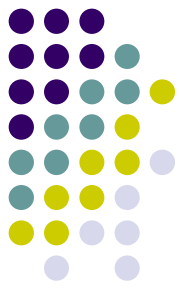


APPROACH AND METHODOLOGY



- DATA COLLECTION
 - Secondary data (Review of Existing literature etc.)
 - Reports
 - Publications
 - Other unpublished data
 - Primary data (Field work)
 - Interviews
 - Measurements
 - Sampling
- IMAGE ACQUISITION AND RECTIFICATION
- DATA COLLATION AND SAMPLE ANALYSIS
- DATA INTEGRATION IN GIS
- SPATIAL MULTICLITERIA ANALYSIS
- SELECTION OF 5000 HA PRIORITY LOCATION FOR IRRIGATION PROJECT DEVELOPMENT

Sources of data



- **Data collected from GIDA and other organizations (maps, tables, images, figures)**
- **Data directly measured or collected in the field**
- **Data elaborated through processing and spatial analyses (intermediate data).**

Data Collected



Data	Description	Sources
Topographic data	Contour map in paper (analogue) format	Survey Department
	Contour maps in (digital) vector format	
Land cover statistics	Statistic data by district on land surfaces and productivity for the last 5 years (settlements, Agriculture, recreation, water body, etc.)	MOFA
Population statistics	Plot level: Enumerated Area	Statistical Service
	Statistic data on population, education, drinking water and electrification, health	
Hydrogeology	Hydro-geological formation	Water resources research Institute
	Drillings/Boreholes	
Hydraulics	Existing and proposed Irrigation project perimeters	GIDA

Collected data



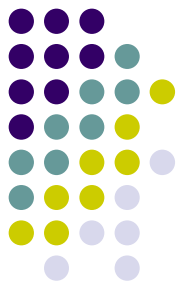
Data	Description	Sources
Facilities	Water	Centre for Remote Sensing and Geographical Information System (CERGIS)
	Electricity	
	Sanitation	
	Health	
	Education	
Land Tenure	Land ownership map	Lands Commission
Protected areas	Parks map files	Forest Commission / Wildlife Department
	Maps of Ramsar Sites and Protected sensitive areas	
Poverty	Poverty map by district	Statistical Service
Marketing, processing and storage of agricultural products	Market centres	GIDA
	Processing units	
	Storage units	
	Storage (Refrigerated conditions)	

LANDCOVER/LANDUSE MAP



- **Based on:**
 - **High Spatial Resolution Satellite Image (SPOT 5 Image at 2.5m Panchromatic and 10m multi-spectral)**
 - **The High spatial Resolution image(2.5m) was used to re-sample the 10m spatial resolution image to obtain a high resolution multi-spectral image for the landuse/landcover study**
 - **Recent Image (2007)**
 - **Ground Truth Investigation Possible**
 - **Existing Data (Database, Maps, Statistical Census)**

LANDUSE/LANDCOVER MAPPING



- Preparation for the ground survey done at office
 - Existing Spatial maps (1 / 25000)
 - Image/Investigation map (1/10000)
- Meetings with GIDA staff
 - Acquisition of preliminary knowledge of the field
 - Elaboration of draft landuse/landcover map legend
- Field work
 - 3 intensive weeks in the Field with **GIDA counterpart** (agronomist and GIS expert)
- Image processing
 - Elaborating landuse/landcover map
 - Statistical reporting

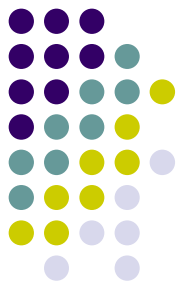
LANDUSE/LANDCOVER MAPPING Cont'd



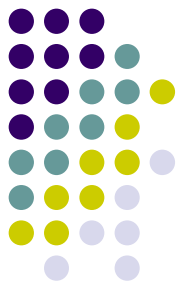
- Establishment of land use land cover **themes**
- Preliminary image element identification & classification of mapping units
- Segmentation of image map for use as training sample areas
- Field visit of segment map areas and identification of homogeneous areas for use as training samples for image classification
- Establishment of Training samples for unsupervised classification of image map
- Reclassification of image map into landuse/landcover map.

LAND USE LAND COVER THEMES

- Settlement/Urban areas
- Forest areas (natural, cultivated, riverine)
- irrigated Fields/crops
- Upland (dry) farming areas & crops
- Water bodies (Lakes, rivers, streams, Lagoons and ponds)
- Inundated (flooded) areas
- Savannah (Natural) vegetation
- Bare soils/rock
- Protected areas (military zones, Wildlife sanctuary etc.)

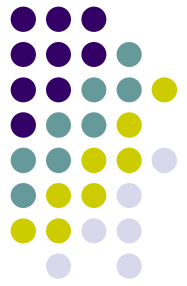
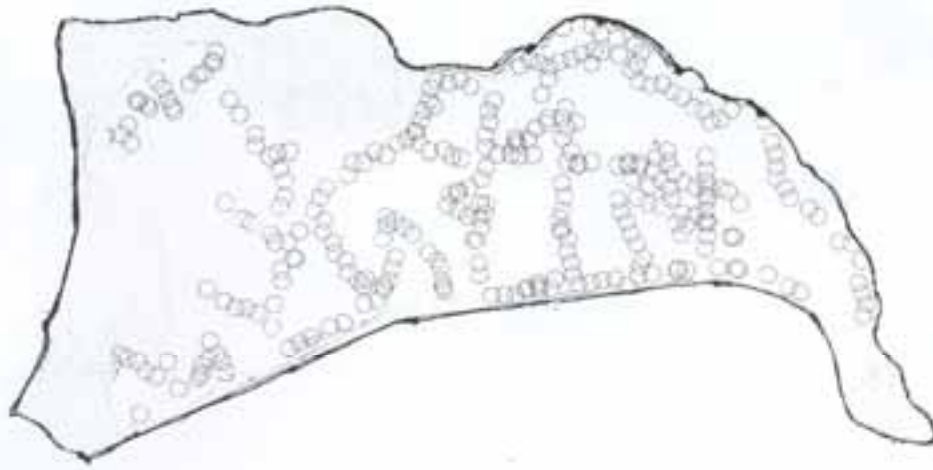


SOIL SURVEY & LAND SUITABILITY MAPPING



- A topographic base map at a scale 1:50,000 & existing soil map (scale 1: 100,000) covering the study area
- Soil sampling along Transects at 1 km apart taken along existing routes (major and minor roads, feeder roads, foot paths, etc)
- Soil identification and characterization were carried out along these routes by chiselling /auguring soil at 1 km interval
- A hand held GPS (Gamin) was used to record the coordinates (latitude and longitude) and the altitude of each sample point
- Data recorded at each **sample point** are: parent material, presence of surface materials, colour, texture, structure, presence of concretions, stones or gravel content, drainage class, root density and position of soil on the topographical sequence
- Existing soil map was reclassified and updated
- Soil suitability maps were prepared for various crops from the updated soil map

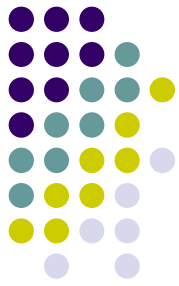
GPS POINTS FOR SOIL SAMPLES TAKEN IN THE FIELD

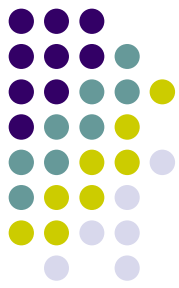


SOIL/CROP SUITABILITY ASSESSMENT

BASED ON:

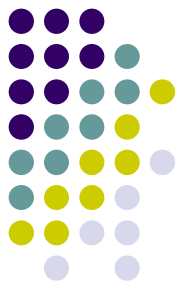
- **Agro-Climatic Suitability Classification**
 - Growing period suitability for water collecting sites
 - **Thermal Zones Suitability**
- **Agro-edaphic Suitability**
 - **Internal Requirements** (temp., moisture, aeration, natural fertility, depth, texture, no salinity etc.)
 - **External Requirements** (slope, flood susceptibility, accessibility etc.)
- **Crop edaphic requirements**
 - pH
 - Soil Characteristics





ASSESSMENTS PROCEEDURE FOR LAND SUITABILITY OF SINGLE CROP/LUTS

- SELECTION AND DEFINITION OF LAND UTILIZATION TYPES (E.G., CROP, CROPPING TYPE, PRODUCE, PRODUCTION SYSTEM, INPUTS LEVEL)
- 'MATCHING' THE AGRO-CLIMATIC REQUIREMENTS OF THE CROPS WITH THE PREVAILING CLIMATIC CONDITION
- 'MATCHING' THE SOIL AND TERRAIN REQUIREMENTS OF CROPS WITH PREVAILING SOIL AND TERRAIN CONDITIONS



SOIL SUITABILITY CLASSES ADOPTED FOR APIP

S1 – HIGHLY SUITABLE

S2 – MODERATELY SUITABLE

S3 – MARGINALLY SUITABLE

N – NOT SUITABLE

- [Table 1](#) is the soil/crop suitability obtained for APIP
(**FAO 1978-81, 1984, and FAO/IIASA 1993**)

PRELIMINARY ENGINEERING DESIGN



- Preliminary engineering (hydraulics) design established based on following considerations:
 - Type of irrigation infrastructure
 - investment costs
 - Social acceptability and
 - Environmental sustainability

- A map of Draft scheme of irrigation infrastructure for the whole Accra plain was prepared

Main features included are:

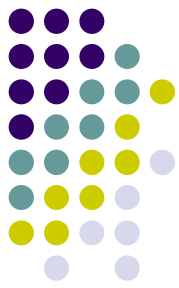
- Intakes location from the Volta River
- Pumping stations capacities
- Discharge pipelines
- Networks of primary irrigation canals.

Zoning : Priority criteria (socio-economic infrastructure)



- Health infrastructure
- **Education infrastructure**
- **Drinkable water infrastructure**
- Electrification infrastructure
- Sanitation infrastructure
- Road infrastructure
- **Urban spread**
- **Population**

DATABASE THEMES ESTABLISHED FOR THE MULTCLITERIA ZONING STUDY



- Hydraulics
- Hydrogeology
- **Land use**
- Land ownership
- **Agronomy**
- **Protected area, military zone**
- Marketing
- Socio-economy
- Health care
- **Zoning Intermediate maps**
- **Topographic map**



ZONING

ACHIEVED BY GIS MAP OVERLAY
PROCEDURE IN ARCGIS 9.0 TO
PRODUCE A FINAL ZONE MAP FOR APIP

MULTI-CRITERIA ANALYSIS



- The **zoning criteria** was a contentious issue
- Several discussion held among experts about the content of the database, the criteria to be used, the weight to be allocated for each and the approach of the multi-criteria analysis.

APPROACH USED FOR THE MULTI-CRITERIA ZONING



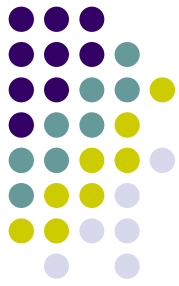
- Segmentation of study area according to important and discriminating criteria taking into account aspects of Land physical potentials, Existing infrastructure and cost of irrigation management.
- Definition of **priority criteria** that attributes a preferential development.

CRITERIA ADOPTED FOR THE SPATIAL MULTICRITERIA ANALYSIS



- **Land physical potentials** : based on the 14 land cropping suitability maps developed by the soil expert.
- **Irrigation management costs** : This criterion reflects the development cost per hectare.
- **Existing infrastructure** : This criterion is assessed through the existing road network in terms of proximity to main roads (national highway, regional road).

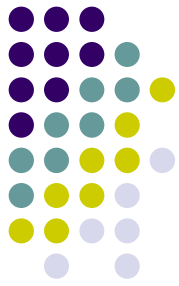
WEIGHTS FOR MULTICRITERIA ANALYSIS



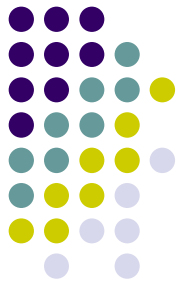
ITEM	PHYSICAL SUITABILITY	MANAGEMENT COST	EXISTING INFRASTRUCTURE
ALTERNATIVE 1	50%	35%	15%
ALTERNATIVE 2	60%	30%	10%
ALTERNATIVE 3	70%	20%	10%

OUTPUT

- Figure 3 is an interim output of the Zoning Study.
- A Final results would be available after a national workshop in September to collate opinions of public and other stakeholders on the zoning study



CONCLUSION



- THE USE OF REMOTE SENSING AND GIS HAS GREATLY FACILITATED EASY IDENTIFICATION AND SELECTION OF 5000HA LAND AREA WITHIN THE WHOLE ACCRA PLAINS (200,000 HA) FOR DETAILED FEASIBILITY STUDY.
- ENOUGH TIME AND COST HAS BEEN SAVED