Role of Agricultural Drainage and Challenges Facing it in Africa

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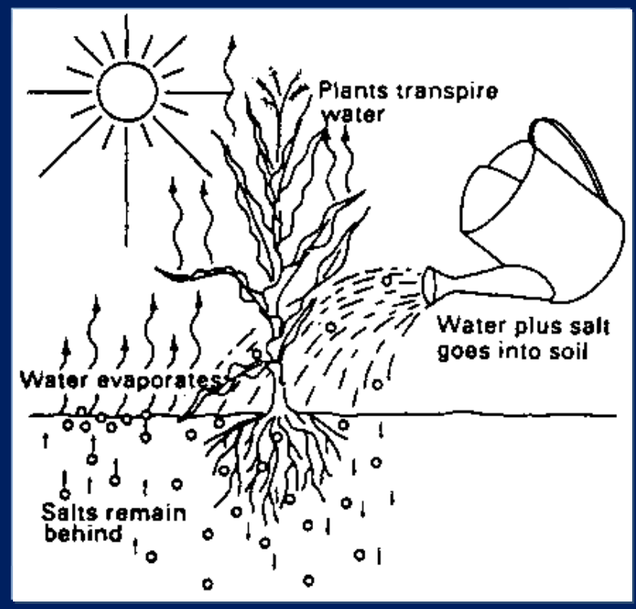
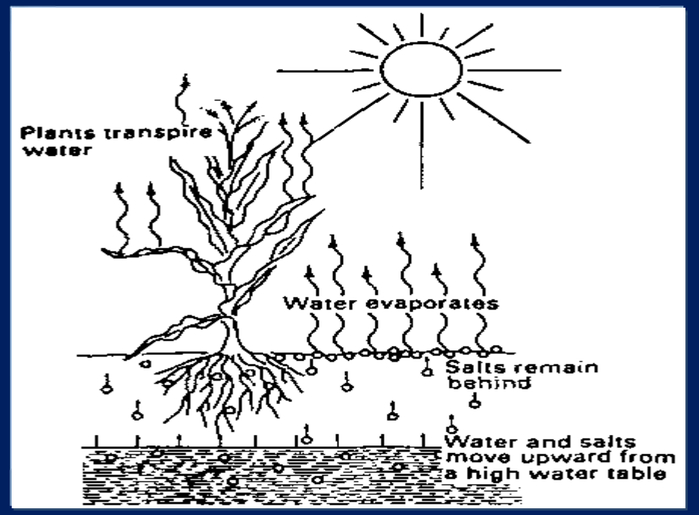
Main Challenges in Africa

- **High population growth rates**
- **Increased demand for water for various sectors (drinking - industry - agriculture ...)**
- **Limited of available water resources or not utilizing available resources**
- **The growing food gap and the need to achieve food security**
- **Lack or deterioration of irrigation and drainage networks**
- **Water ways pollution and degradation of water quality**
- **Climate change and its expected negative impacts**

Introduction about Agricultural Drainage

- **Most irrigation waters contain some salts**
- **After Irrigation, the water added to the soil is used by the crop or evaporates directly from the moist soil.**
- **The salt, however, is left behind the soil.**
- **If not removed, it accumulates in the soil and this process is called salinization**





Irrigation Practices and Soil Salinization

The practice of irrigation, if not planned and managed properly, can result in increased soil salinization.

- An estimate (Postel 1989) shows that about 25% of the world's irrigated lands are damaged by salinity, while Adams, Szabolcs (1989) states that no continent is free from salt-affected soils and serious salt-related problems occur in at least 70 countries and Hughes (1990) have reported that up to 50% of irrigated lands are affected by salt.
- It is assumed that 50 percent of the world's irrigated land has developed drainage problems and that about **25 million hectares have become unproductive** due to irrigation inefficiencies and lack of adequate drainage (UMALI. 1993).
- The FAO estimates that of the 250 million hectares currently under irrigation, **about 30 million hectares** are severely affected by salinity and an additional **60 to 80 million hectares** are affected to some extent (FAO, 1994).
- Recent estimates from the ICID Drainage Group (Abdel-Dayem 2000) suggest that out of an irrigated area of 3,150,000 hectares, **1 million hectares** would be affected by salinity and **600,000 hectares** would be waterlogged.
- SMEDEMA (2000) has estimated the drainage needs for the next 25 years, and he estimates that about **10-15 million** hectares will require drainage, including 2-3 million hectares for which subsurface drains are necessary.

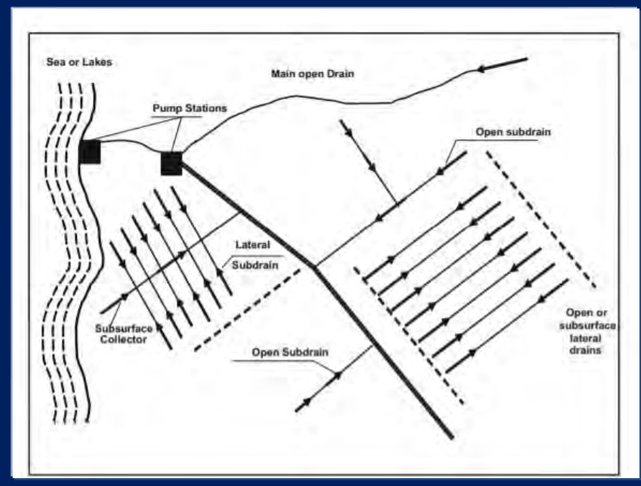
Introduction about Agricultural Drainage

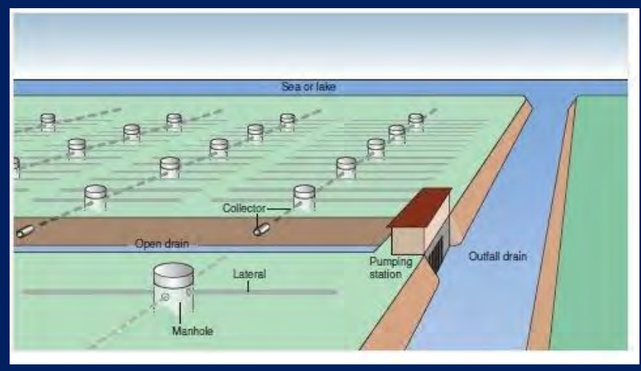
- **Soil salinization** is projected to increase in future climate change scenarios due to sea level rise and impact on coastal areas.
- The **rise in temperature** that will **surely** lead to increase evaporation and further salinization.

Save your time and take actions if you are looking for sustainability

Objectives of Drainage system

- Protection against **Soil Erosion** and Flooding
- Soil **Aeration**
- Soil Moisture and **Trafficability**
- **Salinity** and **Water-logging** Control
- Maintaining **Crop Yields**
- Reclamation of **Saline soils**
- **Toxic Substances** and **Disease**



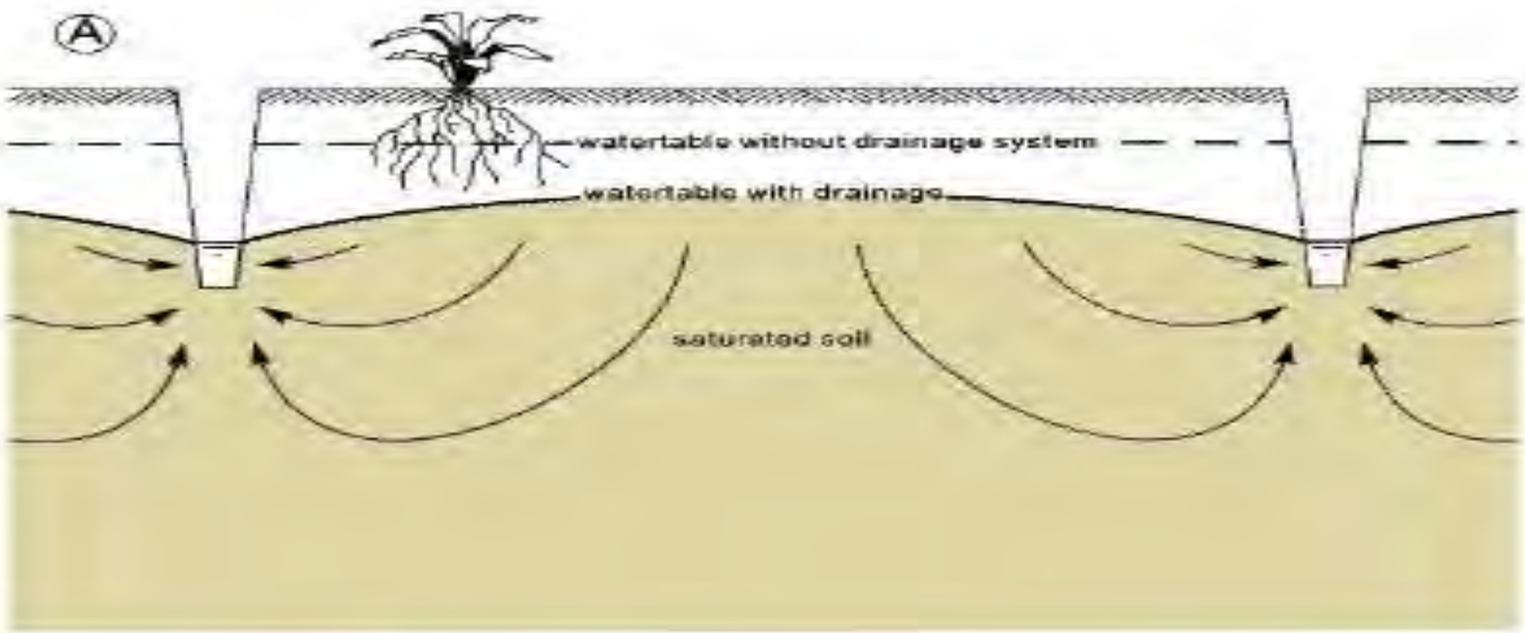


Multi Objectives of Drainage system

The basic objective of agricultural drainage is to provide for a root zone environment that facilitates plant growth and optimizes crop production.

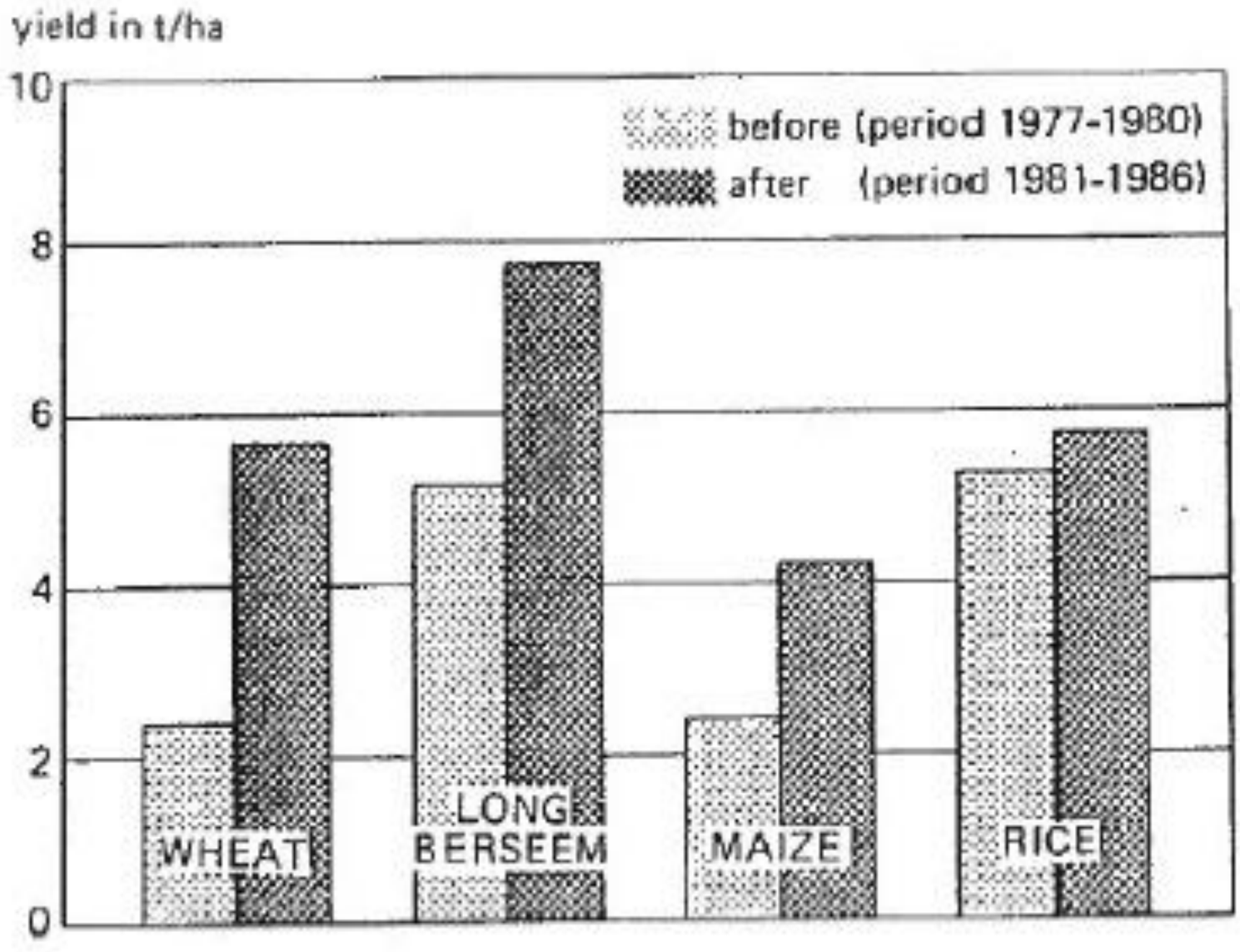
- **In arid and semi-arid regions**, drainage is linked with irrigation to make it possible to dispose of excess irrigation water and allow for the **leaching** of soils;
- in **Humid tropics** drainage facilitates the control of **high groundwater** and the discharge of **heavy rainfall**.

- **Drainage sustains and increases yields** and rural incomes agricultural productivity.
  - Drainage indicates that the **net contribution of drainage is rising production.**
  - **Wheat** yields increased by **14 %**, **maize** by **25-40 %**, and **rice** by **7-20 %** (ALI et al., 2001).

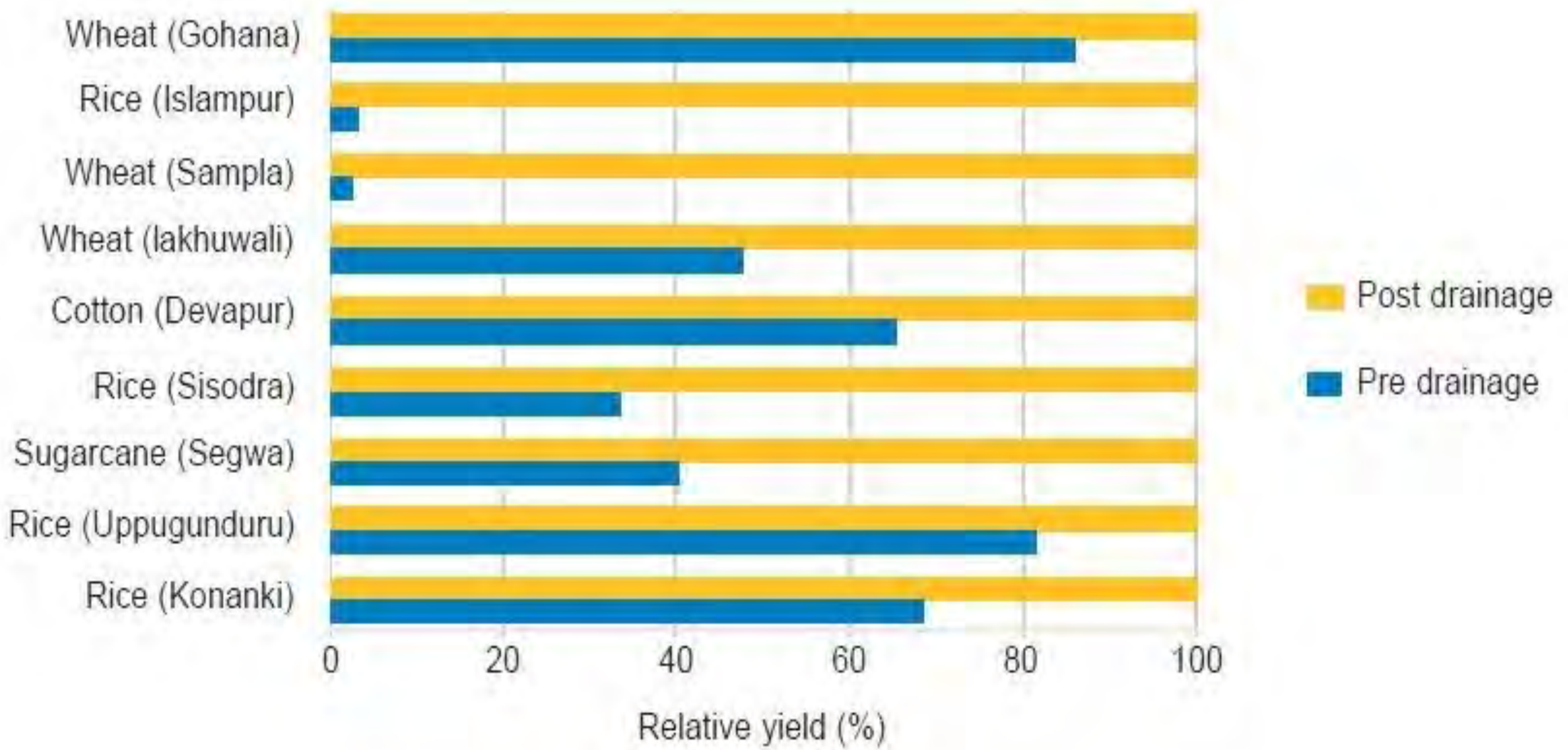


Open drain (A) or pipe drain (B) can effectively control waterlogging and salinity

How drainage can control waterlogging and salinity (Source: Alterra - ILRI-)



Yields before and after installation of subsurface Drainage, (Source: Abdeldayem and Ritzma ,1990)



Yield for some crops pre and post drainage
(Source: Alterra - ILRI-)

Facts about Agricultural Drainage

- **Irrigation and drainage** systems are designed, constructed, and managed **separately**. And almost of time the applied irrigation water exceed the crop water requirement (**over irrigation**)
- The subsurface drainage system is **over designed and** lateral drains are always designed at depths suitable for **deeper root crops** and **one depth all the time**.

All these lead to :

Losses of irrigation water.

Losses in the applied fertilizers.

Pollution of ground and drainage water.

Benefits of Water table management (Controlled Drainage)

- **Removing** excess water to permit farming of poorly drained soils.
- **Protecting** crops from excessive soil water conditions.
- **Controlling** soil salinity.
- **Saving** in irrigation water.
- **Conserving** soil water.
- **Increasing yield** by reducing or eliminating stress caused by deficit soil water conditions.
- **Reducing losses** of nutrients and other pollutions via drainage water.

Challenges in Africa from Drainage Prespective

- *Salinization*
- *Droughts*
- *Floods*
- *Health*

Challenges of Salinization in Africa

World map representing countries with salinity problems. (https://www.researchgate.net/publication/262495450)

Salinization in certain countries

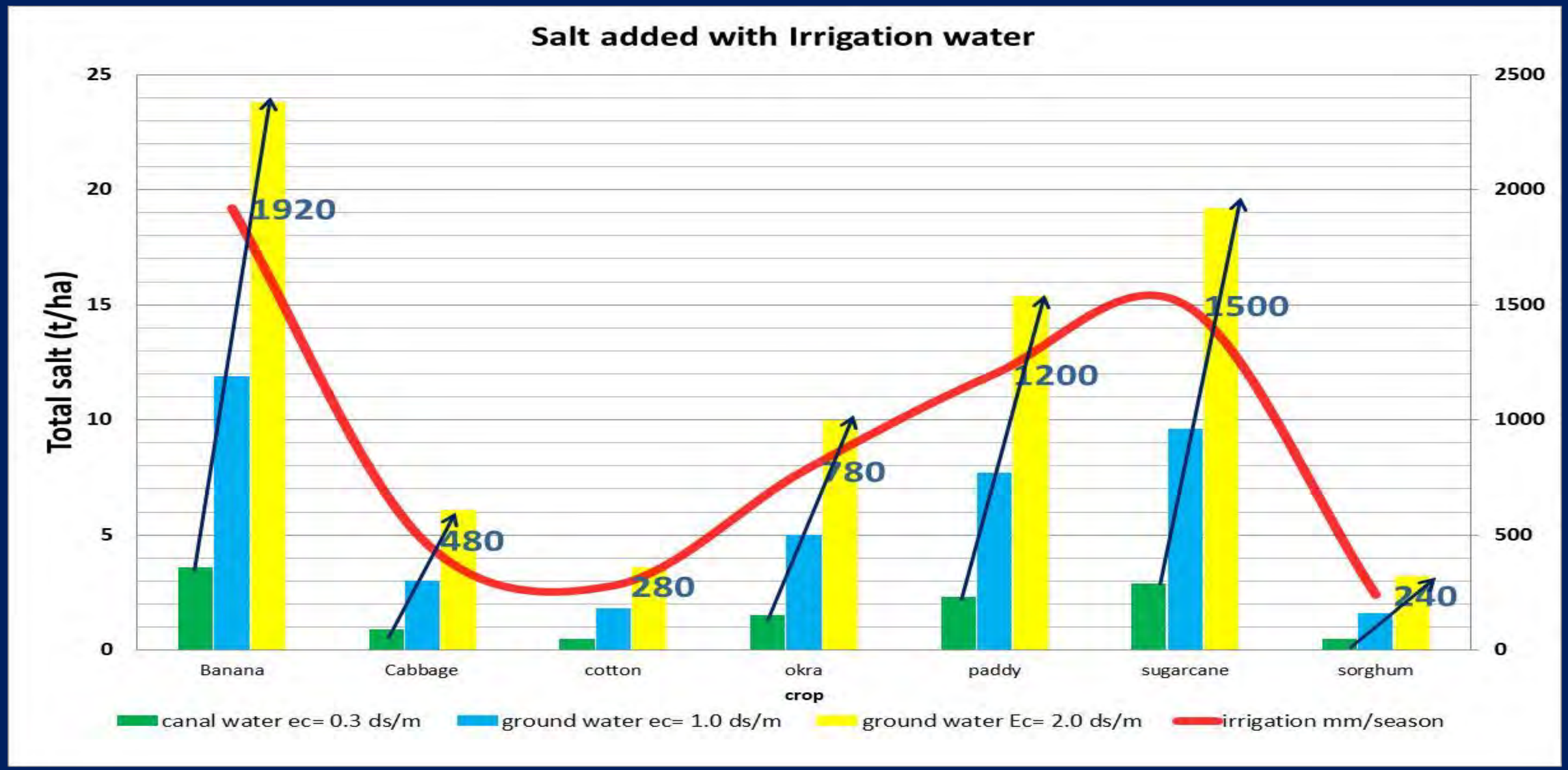
Country	Salinization		
	Year	ha	% of equipped area
Egypt	2005	250 000	7
Kenya	1999	30 000	29
Libyan Arab Jamahiriya	1998	190 000	40
Morocco	2000	150 000	10
Mozambique	1993	2 000	2
Namibia	1992	1 300	17
Niger	2000	350	0.5
Nigeria	1999	100 000	34
Sudan	1999	500 000	27
Tunisia	2000	86 000	22
United Republic of Tanzania	1999	50 000	27

Source: FAO, *AQUASTAT Survey 2005)*

Salts added to soil profile through irrigation per season.

Crop	Irrigation mm/season	Salts imported (t/ha) Canal water EC =0.3 dS/m	Groundwater EC =1.0 dS/m	Groundwater EC =2.0 dS/m
Banana	1920	3.6	11.9	23.8
Cabbage	480	0.9	3.0	6.1
Cotton	280	0.5	1.8	3.6
Okra	780	1.5	5.0	10.0
Paddy	1200	2.3	7.7	15.4
Sugarcane	1500	2.9	9.6	19.2
Sorghum	240	0.5	1.6	3.2

Salt added to soil profile through irrigation per season, (Source: Alterra - ILRI-)



Salt added to soil profile through irrigation per season, (Source: Alterra - ILRI-)

Salts buildup in furrow irrigation system

Wetting zone and salinity buildup in drip irrigation system

Source :Zaman el al,. 2018)

Salinity in Tunis Oasis

Salts buildup

Salinity management for micro irrigation under arid and semi-arid conditions

Deposition of particles of calcium carbonate and formation of hardpan layers at shallow depths

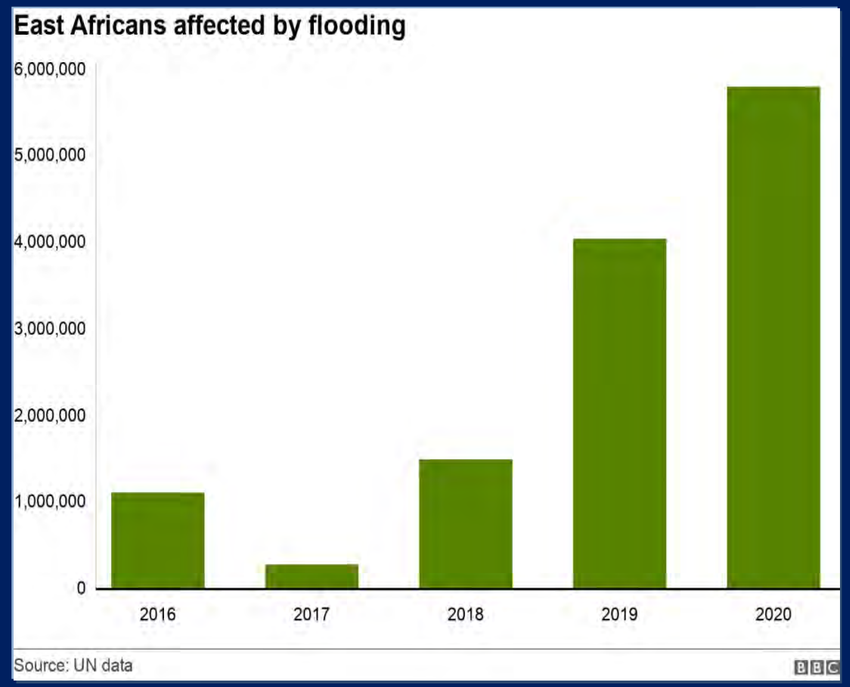
Challenges of Drought in Africa

- **Sub-Saharan Africa** has a long record of droughts that have caused extensive damage in the recent past
- **Drought impacts** in Southern **Madagascar** are widespread and severe, with 1.31 million persons targeted by humanitarian aid and agricultural losses up to 60% in the most populated provinces.
- **In Angola**, an estimated 3.81 million people are without sufficient food supply since January 2021.
- **Risk of food insecurity** is reported from Malanje province and as much as 70% of crops are allegedly affected by drought.

Global Drought Observatory: https://edo.jrc.ec.europa.eu/gdo

Challenges of Floods in Africa

- From **March - May 2020** multiple countries in central and east Africa have continued to experience heavier and more widespread than usual rainfall in the "long-rains" season, leading to **transboundary flooding and food insecurity.**
- The **most severe flood conditions** as of May 7th 2020 include those in the nations of **Kenya, Somalia, Sudan, South Sudan, and the Democratic Republic of the Congo.**
- **Flooding hits six million people** in East Africa



https://www.bbc.com/news/world-africa-54433904

Challenges of Malaria in Africa

According to the latest estimates from WHO, there were 214 million new cases of malaria worldwide in 2015 (range 149–303 million).
The African Region accounted for most global cases of malaria (88%), followed by the South-East Asia Region (10%) and the Eastern Mediterranean Region (2%).

Preventing Malaria

(while a vaccine is being developed)

- Skin cover
- Use a repellent
- Drain or screen standing water
- Screens and bed-nets (ITNs)
- Medication – Chemoprophylaxis

Role of Drainage

The role of drainage in improving human health

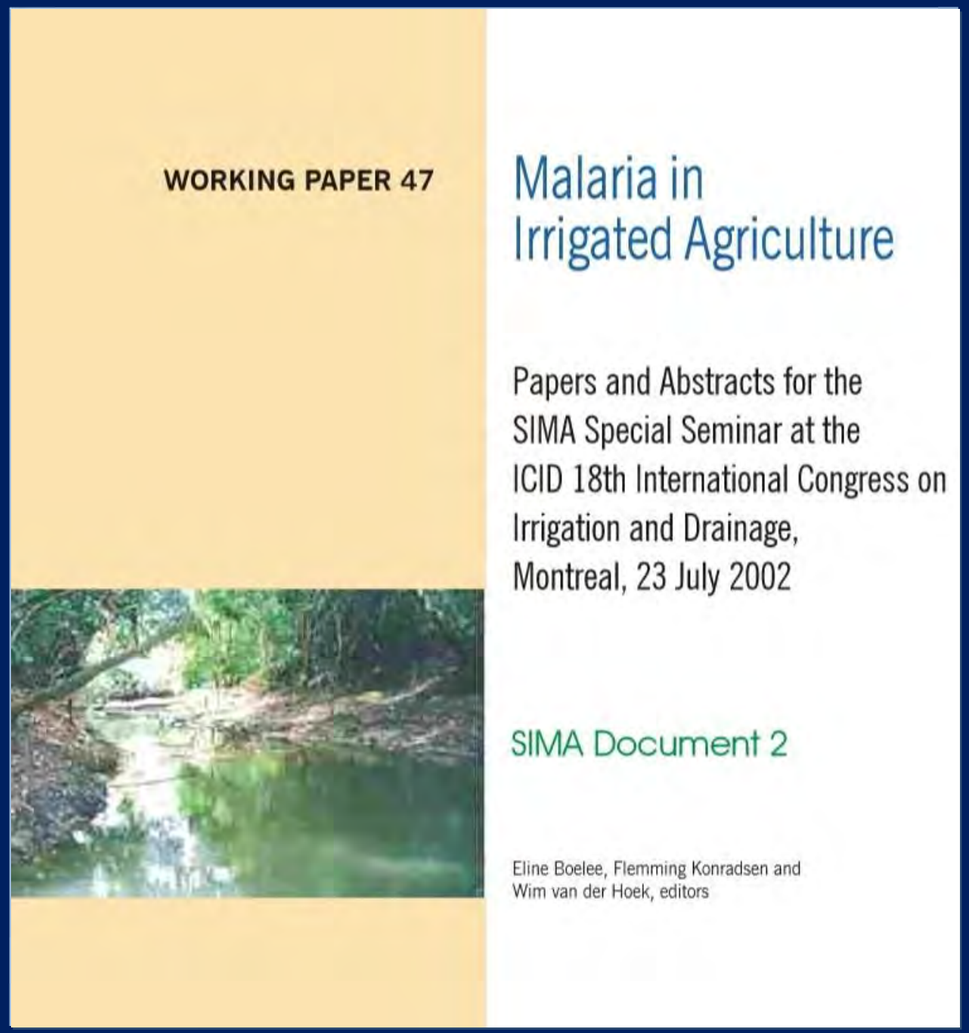
- **Drainage must** also be viewed as part of naturally present discharge systems. Other benefits of drainage are equally important; in particular, the association of drainage with public health must be fully recognized (Madramootoo, 1997).

- Improved drainage of agricultural land can significantly **contribute to control of water-borne diseases such as malaria**, Japanese encephalitis and many others. It also helps to improve sanitary conditions in areas that suffer from stagnating and polluted water.

Drainage and control of malaria

- There are many **reported cases of malaria control by means of improved drainage.** One of the earliest case studies of malaria control by drainage was in **Sibolga, Indonesia, in 1919.**

- **Construction and maintenance of an efficient drainage system eliminated malaria within three years**. (Snellen, 1987).



Some Drainage experiences from Egypt

Development of Agricultural Drainage in Egypt

- **In Egypt** there is a long history of irrigation.
- **During last decades** there has been a development in irrigation in conjunction with the construction of reservoirs.
- **Aside from huge benefits** of the irrigation projects they have also resulted in **water logging and salinization**.
- **Therefore drainage systems** are required at a large scale to enable irrigated agriculture on a sustainable basis.

National Authority for Remote Sensing & Space Sciences
Environmental Studies & Land Use Division

Egypt, Present Status and Risk of Soil Salinity.

Salt Affected Soils

Alexandria
Damietta
Port Said
El Mansura
Tanta
Ismailia
Bilbeis
Cairo
Suez

Area of salt affected soils in Egypt ranged from 30-40 %

Salinity Levels

- Non-Saline Soil (Less Than 4 mmhos/cm.)
- Moderately Saline Soil (4-8 mmhos/cm.)
- Highly Saline Soil (8-16 mmhos/cm.)
- Verey Highly Saline Soil (More Than 16 mmhos/cm.)

- Towns
- Salt Marshes
- Water Bodies
- Desert

Salinity Risk

- Slight Salinity Risk
- Moderate Salinity Risk
- High Salinity Risk

Scale 1:1000000

100 0 100 Kilometers

1
2
3

Agricultural Drainage in Egypt

In the **1970's,** the Egyptian Government started Drainage programme to implement subsurface drainage system in approximately **2.5 million ha**

Planning of drainage system

- **Planning of drainage projects** is done according to **a 5-years planning cycle.**
- For **each 5-year** plan a number of **main catchment** areas of drainage **pumping stations** are earmarked for subsurface drainage implementation.
- **A preparation for implementation** is that the drainage **pumping station** is operational and that the network of **main open drains** is upgraded **to cope** with the increased drainage discharge from the drainage project areas.

Planning of drainage system

- **A sub-surface drainage system is required**, when the following drainage conditions exist:
  - **Water table depth** is less than 1 meter below ground level in more than 10% of the surveyed area;
  - **Soil salinity** of the saturation extract, expressed in ECe is more than 4 dS/m (mmhos/cm) in more than 10% of the surveyed area;
  - **A decline in crop yield** of more than 20% as a result of poor drainage is reported in the considered area.
- **Pre-drainage investigations** are made in sub-catchment areas of about **5000 to 7000 acres** each
- After the areas are selected for drainage implementation, the **detailed design** is made and **tender documents** are prepared.

National Drainage Program

- Program components and area coverage
  - Main **Open Drainage**
  - On-farm **Subsurface drainage**
  - **Pumping stations**
- Implementation rate
  - **60,000 – 90,000 ha/yr**

By the Year 2017

- **6.4 million acre**, New Subsurface Drainage Systems
- **2.48 million** acre, Rehabilitation of Subsurface Drainage Systems
- **7.2 million acre**, Open Drainage Systems

Agricultural Drainage in Egypt

Farmer's Contribution to cost of drainage

- **Cost of drainage** (main infrastructure and subsurface drains) is borne by the Government. However, farmers **repay** the cost of subsurface drainage system **in 20 years interest free** annual installments, which **only starts 3 years after installation**.

Economic benefits from drainage

- Benefits of improved drainage have a direct positive affect on the **income of farmers**.
- The **project's key benefits** will be: (a) **Increased crop productivity** and production; (b) **Increased land area** available for agriculture; and (c) I**ncreased** household **incomes for the farmers**.
- Crop productivity is expected to increase by **between 17-21%** for a number of key crops.
- With **total construction costs** of US$1500/ha and **maintenance costs** of US$20/ha/year

Developments of Drainage Materials

- To use **appropriate drainage materials** (pipes, connections, envelopes, structures, etc.)
- To improve the **Quality of Construction**
- To overcome **construction problems**
- To increase **construction rate**
- To increase the **efficiency of subsurface** drainage systems

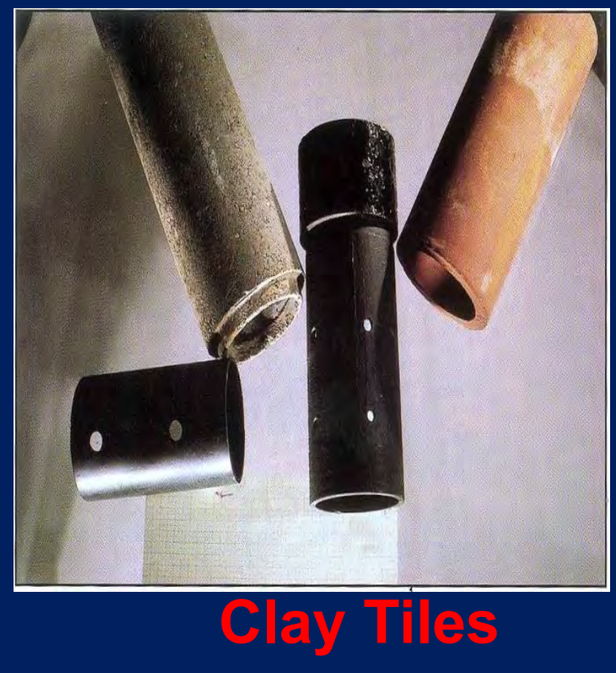
Development of Drainage Materials

It was introduced in 1942 for only lateral drains and installed manually

Diameter is 100 mm and length is 500 mm

Cement Pipes

Clay Tiles



Clay Tiles

Research in Egypt proved that both clay and concrete pipes cause severe problems therefore they were replaced by plastic drain tubes in 1979

Plastic Pipes (Rigid or Flexible and Smooth or Corrugated)

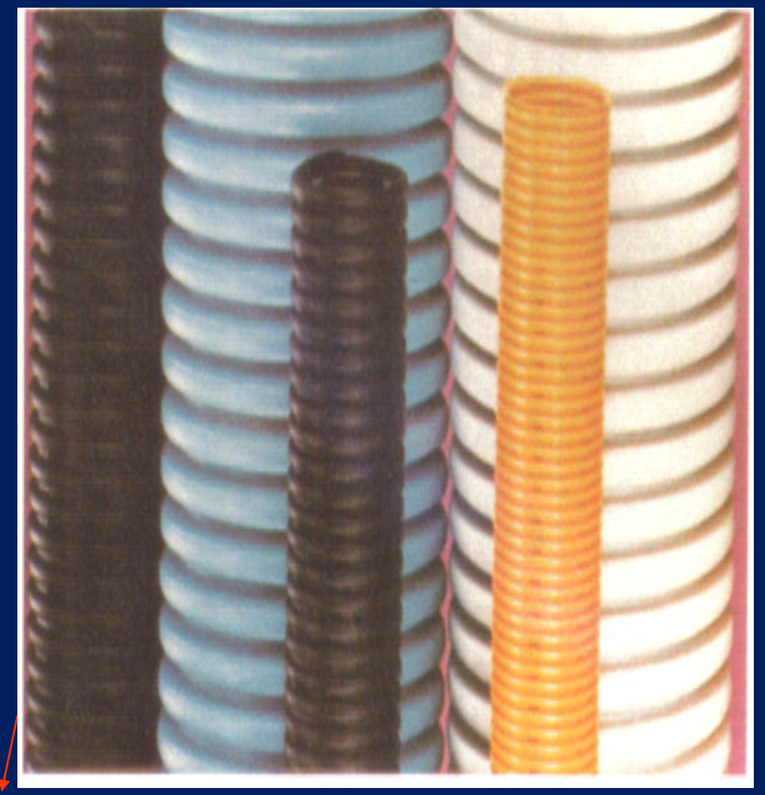
Concrete Pipes

Produced in Egypt with diameters of 18, 20, 22, and 24 inches

Reinforced Concrete Pipes

Plastic Drain Tubes

- **Types of Plastic Drain Tubes Produced**
  - **Polypropylene Tubes (PP)**
  - **Polyvinyl Chloride Tubes (PVC) (Smooth-Corrugated)**
  - **Polyethylene Tubes (PE) (LDPE-HDPE) and HDPE Produced (SW-DW)**
- **Corrugated PVC Plastic Drain Tubes for Lateral Drains were first introduced in Egypt in 1979**
- **Quality Control tests of Corrugated PVC tubes (Bending test-Impact test-Tension test-Deformation test-Elongation test)**



PVC lateral drain tubes

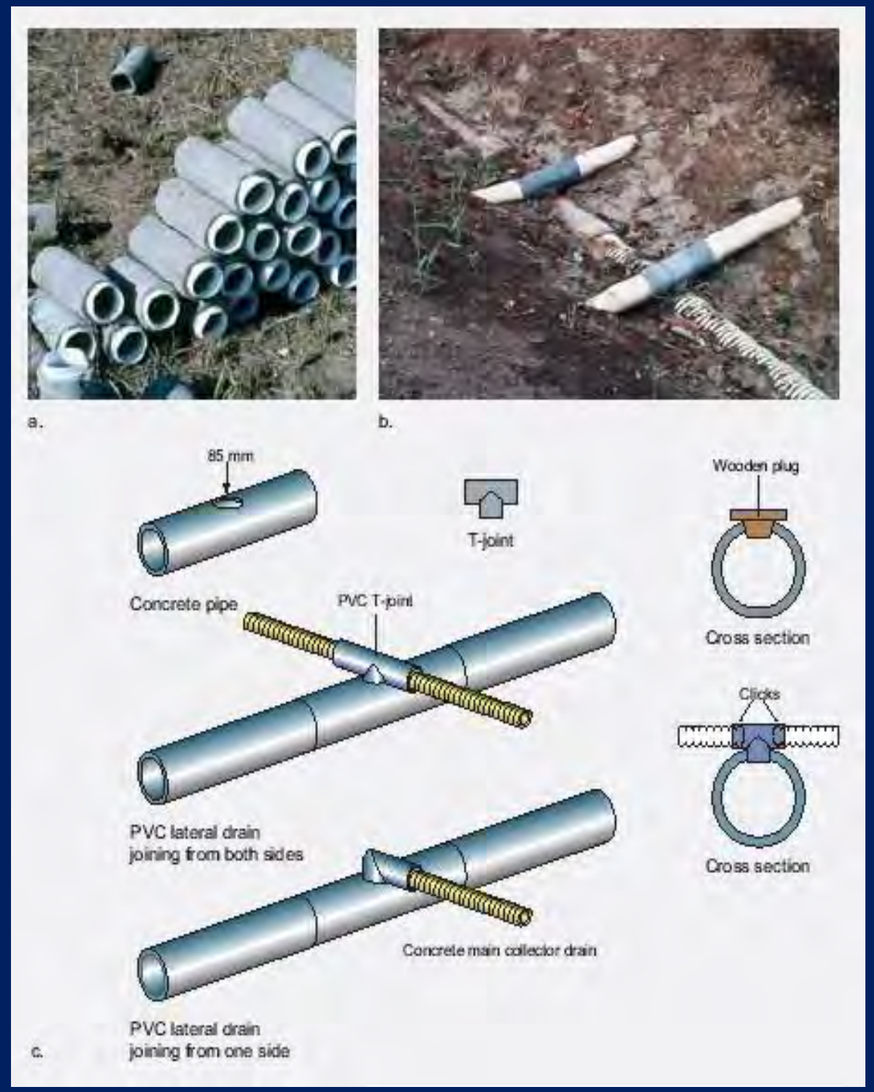
Collector PVC Drain Tubes

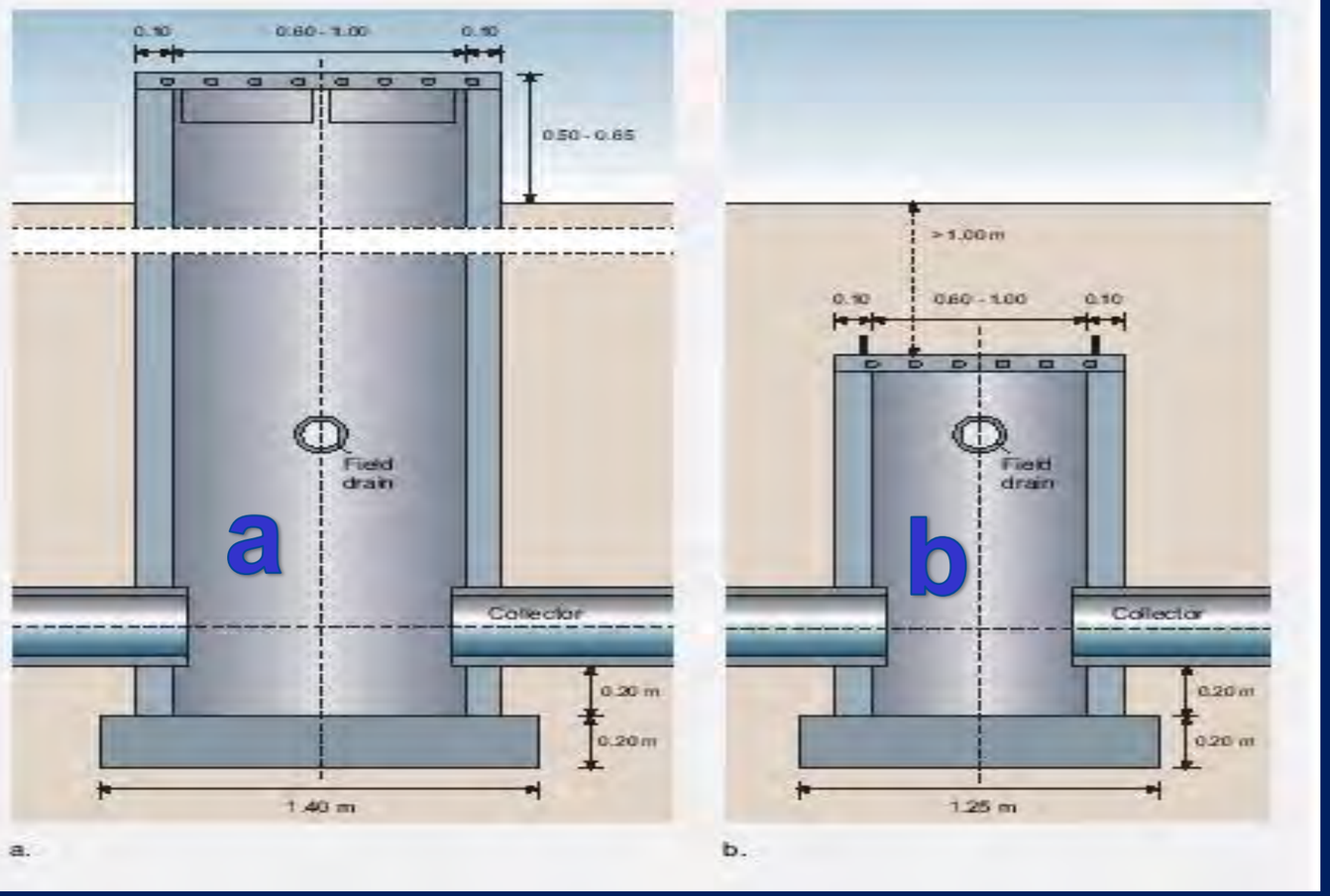
It was produced in Egypt in 1998

Collector Poly-Ethylene pipe tubes PE

Production Started in Egypt (only one pipe factory) in 1989

Connections





Manholes with a cover above (a) and below (b) the soil surface

Rehabilitation of Subsurface System

- The **life time** of drainage systems have been estimated between **30 and 40 years.**
- Since drainage started **in Egypt more than 30 years** ago, the existing drainage systems **are gradually due** for rehabilitation.
- **The lifetime** of the systems **depend on** the **quality** of the used **material, quality** of the **construction, design** factors and **external factors**, such as vandalism, **penetration of plant root** in pipes, rodents, etc.
- Normally a drainage system **has to be renewed** when:
  - **Groundwater table** is rising to unacceptable levels;
  - **Soil salinity** is increasing;
  - **Costs to maintain** the hydraulic performance of the system become unacceptably high.

Installation lateral drains

thenthytic envelope materials

Different envelope materials

Pilot area for Drainage Technology

Floating of pipes during installation

Lessons learned

As a results from study area a new experience of using trenchless machine in unstable soil for the first time in Egypt

Main Key for Success

Drainage Research Institute (DRI)

Egyptian Public Authority for Drainage Projects (EPADP)

Cooperation
Coordination

Farmers participation

Important tools for sustainable Agricultural Arid and Semi-Arid Conditions

Subsurface Drainage

Controlled Drainage

Deficit Irrigation (FW/GW)

Cyclic Irrigation FW/DW

Future Vision & Developments in Agricultural Drainage

Challenges for Agricultural Drainage In Africa

- **Gaps in capacity building** in the field of irrigation and drainage
- **Lack of understanding** the multi-functions of Agricultural drainage
- **Needs for** innovative technology
- **Climate change** effects (extremes event such as drought and floods)
- **Water scarcity**
- **High cost** of agricultural drainage system and need for financial support.
- **Financial support** from government as well as private investors
- **The delay in taking action** for implementing drainage networks and projects

Future Research Requirements in Agricultural Drainage

- **New design criteria** under floods, drought and water scarcity conditions
- **Impact of climate change** on drainage planning, design, construction, operation and management.
- **Performance evaluation** of long term impacts of drainage systems
- Protection of drainage **water quality** for safe re-use for irrigation.
- Disposal of drainage water in closed basins.
- Environmental and ecological impacts of drainage systems.

The way forward

- **Sooner or later**, agricultural drainage will be needed for irrigated agricultural.
- **No sustainable agriculture** development without agricultural drainage.
- **Irrigation must** be reinvented - with agricultural drainage with full consideration of its effects on nature and the environment.
- **Reuse of drainage** water becomes a must in arid and semi-arid countries for filling the gap between water supply and demands.

The way forward

- **Climate change** is one of the main challenges facing the future of agricultural drainage in Africa, arid and semi-arid conditions and it's impacts must be considered in the new design criteria of the ADS
- **Advanced technologies** such as RS and GIS can be a very useful and helpful decision making tool at the pre-investigation stage for technical and financial analysis with limited funds.
- **Public awareness** programs of the local farmers **and agricultural producers.**
- **Farmers association and participations** is a key element for future development and management of drainage system.

Thank you