El Hayat

Future Green-Communities: Integration of sustainable development, adaptation and mitigation to climate change for the establishment of green communities in arid regions

Dr. Hany El Kateb

Member of the Presidential Advisory Council of Egypt’s Senior Scientists and Experts

Chairman of **Foresight for Development and Innovation SAE**

Email: ecoland@t-online.de, Tel:+49 15115315510

Agenda

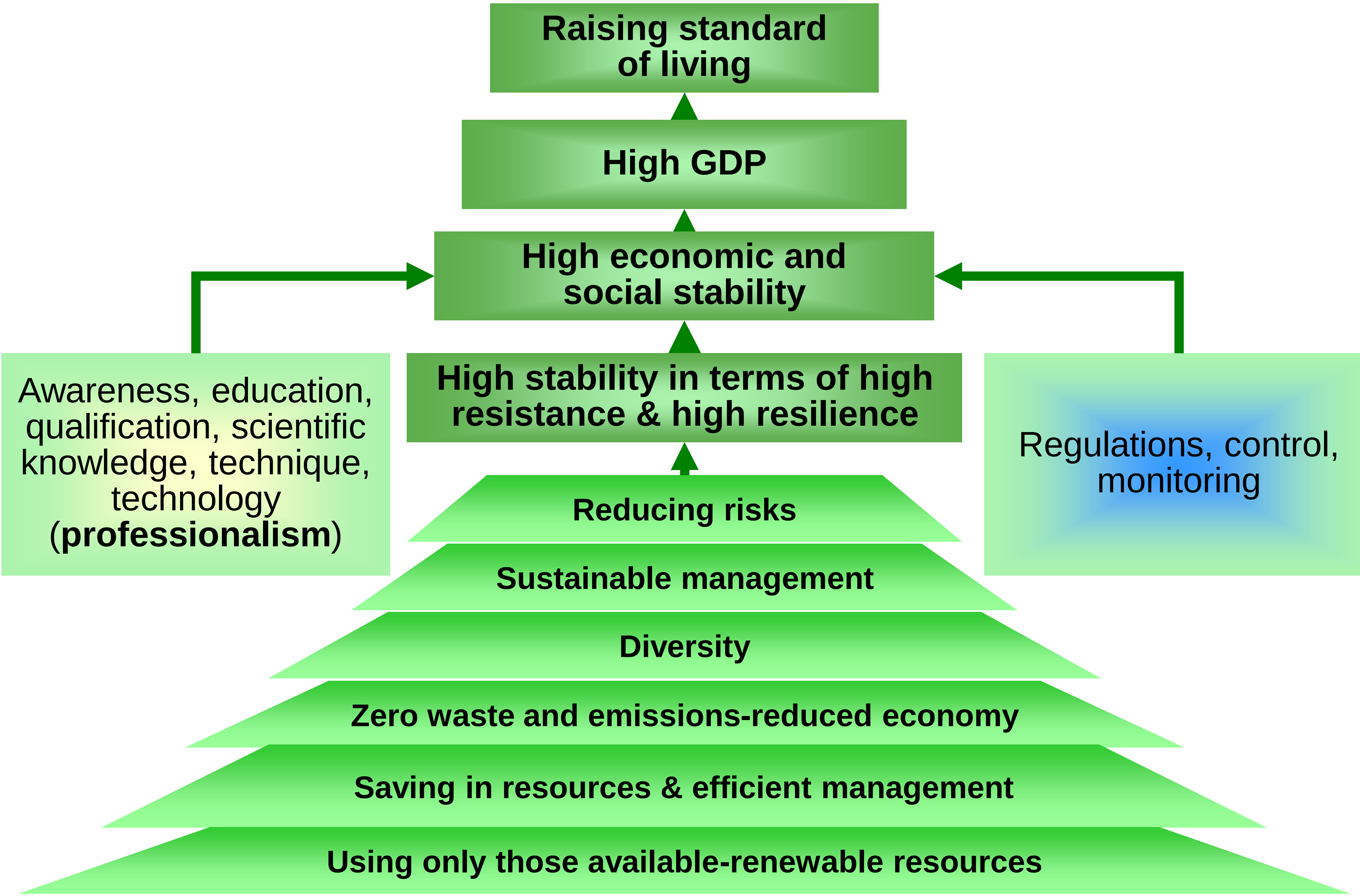
- "***El Hayat*** - **Future Green Communities**: Integration of sustainable development, adaptation and mitigation to climate change for the establishment of green communities in arid regions"
  - - Major objectives
  - - Approach
  - - Short description of the new green communities
  - - Creating favourable microclimate by windbreaks
  - - I) Short description of green urbanism
  - - II) Short description of the sustainable integrated farming in open field and under greenhouse
    - *IIa) using freshwater*
    - *IIb) using seawater or saline water*
  - - Optimisation of farming activities: Precision Farming
  - - Comparison between the sustainable integrated farming and conventional farming
  - - III) Short description of the agro-industry
  - - Benefits of the sustainable integrated farming
  - - Phases of implementation
  - - Summary of the financial model

Schematic layout of a green community including tourist area, green urban-area, and agro-industrial area surrounded by a sustainable agriculture

Major Objectives

- Development of new green communities incorporating sustainable land use that are resilient to climate change and drought and to be disseminated at national and regional levels.
- Demonstrating how to reclaim desert lands in an environmentally friendly and sustainable way.
- Settling Egyptian industries that support the creation of new green communities (e.g. energy, desalination, ecological urbanism, green mobility, modern greenhouses, etc.).
- Establishment of key knowledge industry in sustainable food production in arid regions.
- Support enhancing food security, agricultural resilience and farm productivity in a sustainable manner.
- Attracting national and international eco-tourism to desert environments and persuading residents to stay and not migrate.
- Showing how adaptation to climate change is a chance:
  - to emissions-reduced economy,
  - to efficient use of resources and waste prevention in a zero-waste system,
  - to accelerate climate change mitigation through high carbon sequestration,
  - to building systems having high stability in terms of high resistance and high resilience.

Resource-based development - Approach



New green communities

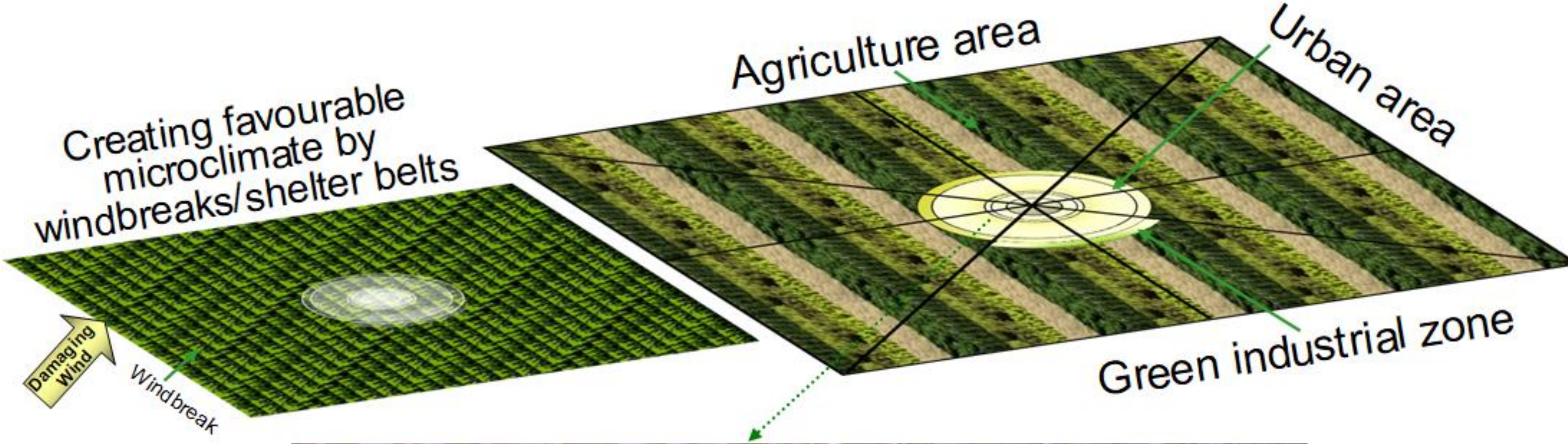
A new green community in desert lands contains an environmentally friendly and attractively designed urban area surrounded by an agriculture area (sustainable integrated farming). Green industrial zones are located in the outskirts of the urban areas.

A new community is considered as a complete integrative system and includes all services and facilities that make daily life easy and enjoyable for each individual.

A green community conserves the resources instead of wasting them (zero waste system) and it is producing instead of consuming. A green community is designed to attract national and international eco-tourism in a desert environment.

The population living in an urban area are below the carrying capacity, that is maximum number of individuals that a land area can satisfy their food, shelter, social requirements and mobility in a short time, even without using vehicles.

New green communities



https://www.architecturalrecord.com/ext/resources/Issues/2017/March/1703-Perspective-News-Massive-Astana-Expo-City-01.jpg

Schematic layout of a green community

Creating favourable microclimate for green communities by windbreaks

Despite the scarcity of water in the subtropical deserts, it is characterised by an abundance of sunlight that not only encourages the use of renewable energy but also promotes plant growth all-year-round. However, subtropical deserts are characterised by high rates of evaporation, the dominance of wind and sand, and high temperature fluctuations between day and night. Protection of communities in desert areas by windbreaks is fundamental to achieving sustainability, as it lessens the severity of these factors.

Protection by windbreaks or green belts of living trees must follow proper arrangements. Windbreaks have an aerodynamic shape and are planted perpendicular to the direction of the prevailing or damaging winds. One single windbreak is not sufficient to protect a large area. Protection and considerable reduction of wind speed takes place on an area downwind the windbreak of roughly seven to twelve times the tree height of the windbreak. Therefore, series of windbreak across the entire area should be established to achieve well-protection and to benefit from the advantages of the windbreaks.

The importance of windbreaks is not limited to protection from wind and sand, but mainly helps to create a **favourable micro-climate** for urban and agricultural areas. This is of great significance for adapting to climate change and reducing losses resulting from extreme weather and climatic events. In addition, windbreaks are an effective tool for mitigating climate change.

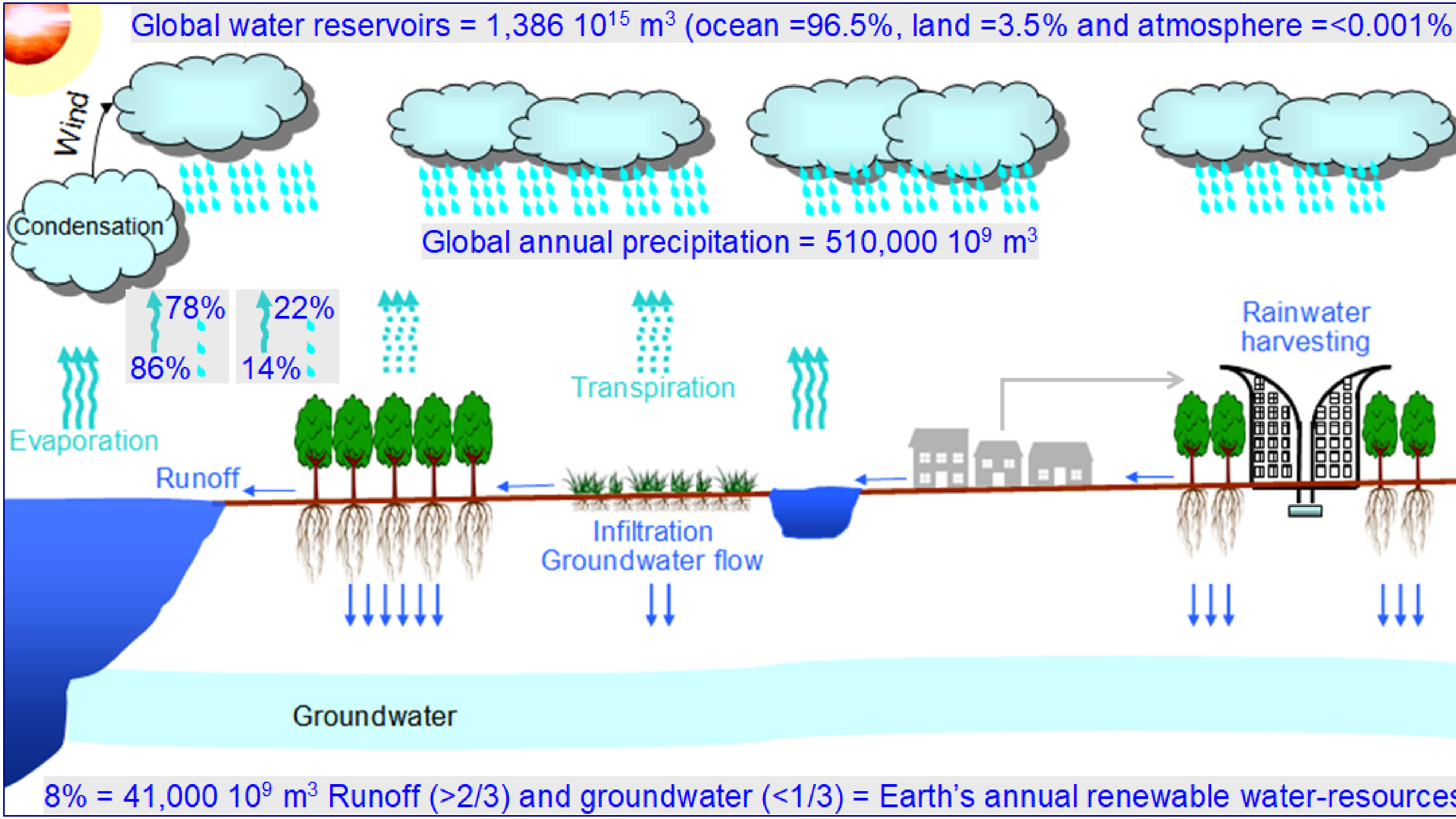
Effects of windbreaks protection on urban areas and agricultural lands in arid regions

- Protecting urban areas and cultivated lands from wind and sand.
- Lessening temperature fluctuation between day and night.
- Mitigation and adaptation to climate change.
- Increasing infiltration rate and decreasing surface runoff.
- Cooling and slight warming effects on summer days and winter nights, respectively, thus, reducing energy and enhancing the environment for plant survival and growth.

- Creating favourable urban-microclimate.
- Improving air quality and enhancing public health.
- Providing recreational landscapes.

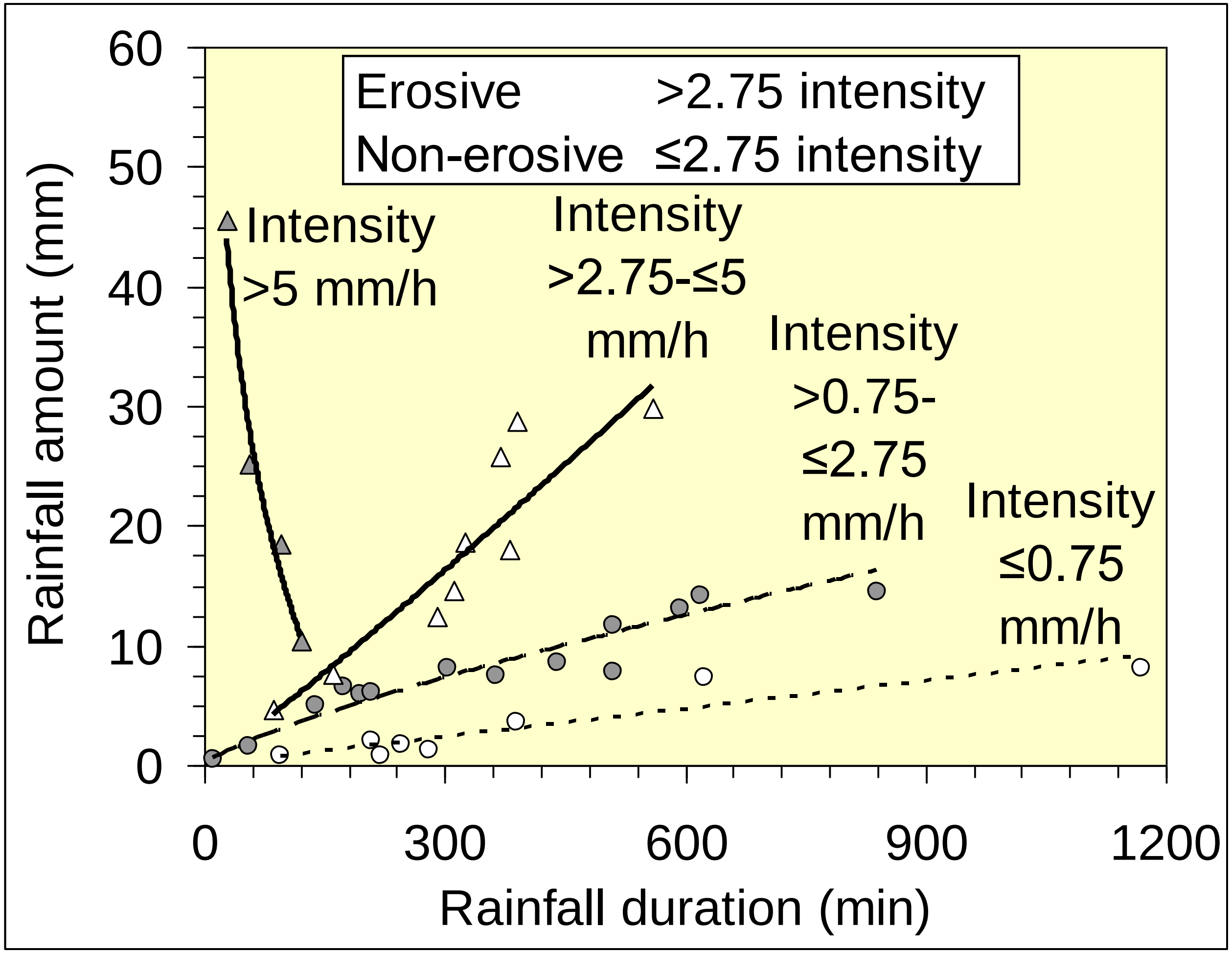
- Creating favourable microclimate for cultivated crops.
- Reducing plant damage by frost, sand deposit and insects.
- Improving the efficiency of irrigation and fertilisation.
- Conserving moisture in plants and soil.
- Enhancing habitats for decomposer organisms.
- Increasing yield of the protected crops.

Hydrological cycle & infiltration by different land use patterns



Sources:
Peixoto, J.P. and Kettani, M.A. 1973. "The control of the water cycle.". In Sci. Amer. Vol. 228: 45–61.
Yoshiteru Tsuchiya (2007): Water Quality and Standards , [Eds.Shoji Kubota & Yoshiteru Tsuchiya], in Encyclopedia of Life Support Systems (EOLSS), Eolss Publishers, Oxford ,UK.

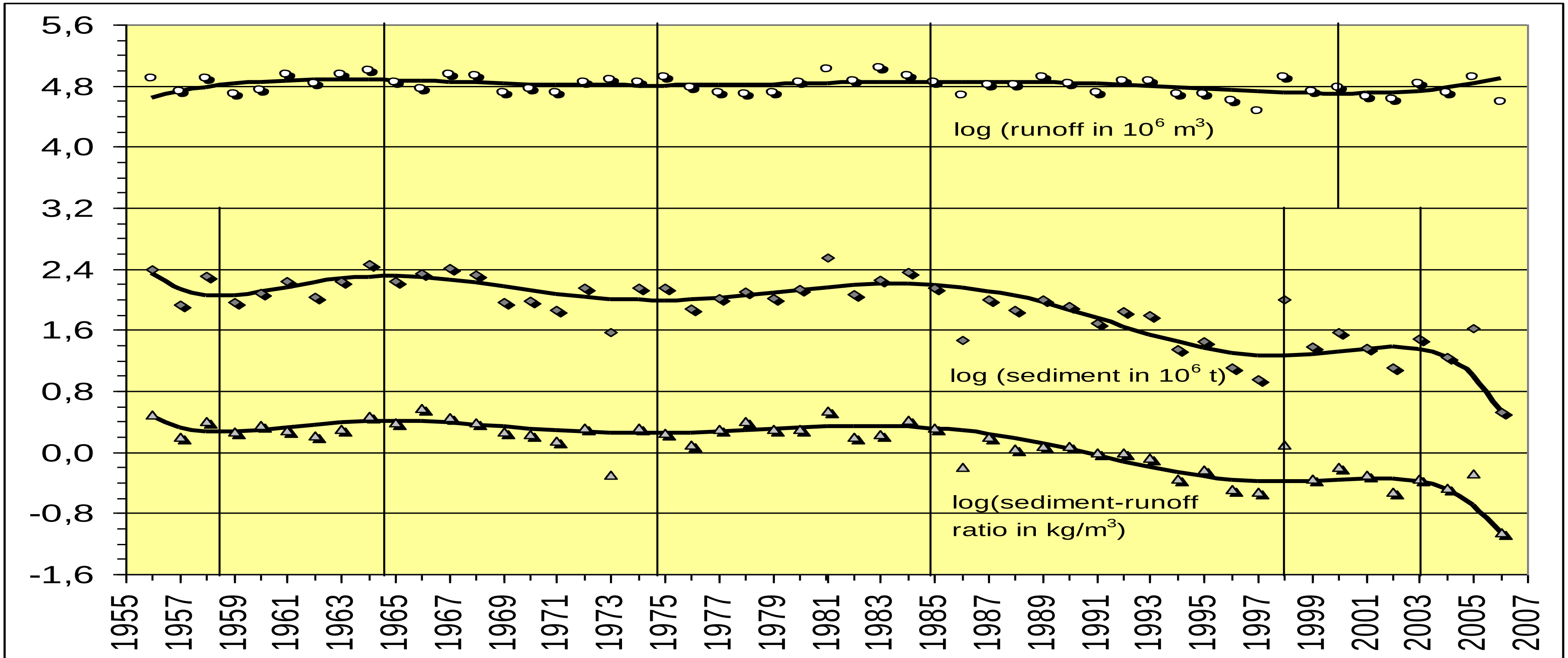
Rainfall intensity



Erosive rainfall is that produces soil loss

Relationship between rainfall amount and duration: An example of a rainy season in Southern Shaanxi Province, China (El Kateb et al., 2013).

Land use change and sediment production in Jialing River, China (Ding & El Kateb 2011)



ŷ (log (runoff))= $4.54201 + 0.11474\,x - 0.01349\,x^2 + 0.00065844\,x^3 - 0.00001410\,x^4 + 1.091533E{-}7\,x^5$

Adjusted $R^2 = 0.15$

ŷ (log (sediment))= $2.75944 - 0.54165\,x + 0.14168\,x^2 - 0.01569\,x^3 + 0.00086296\,x^4 - 0.00002479\,x^5 + 3.556995E{-}7\,x^6 - 2.01044E{-}9\,x^7$

Adjusted $R^2 = 0.87$

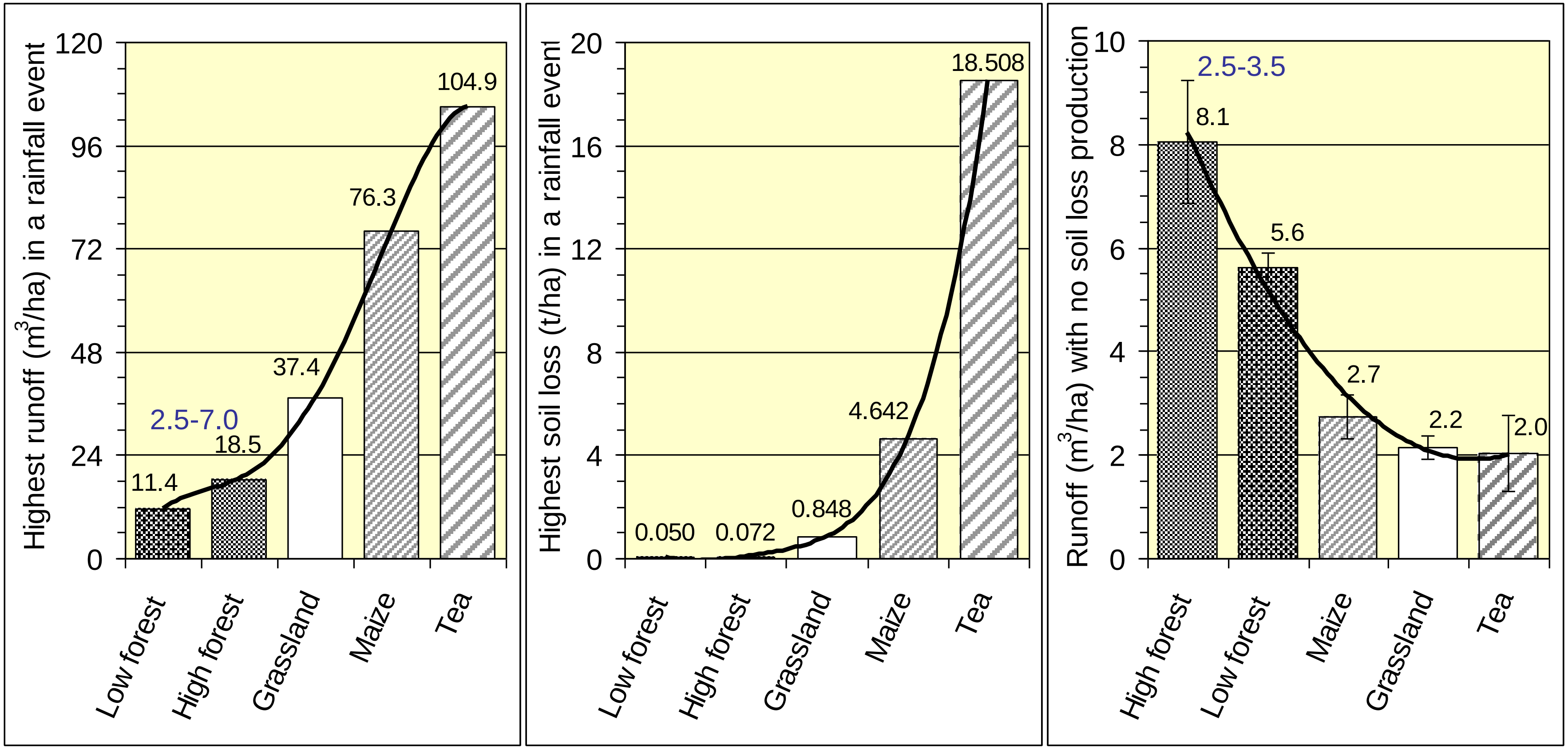
ŷ (log (ratio))= $0.73784 - 0.34678\,x + 0.08836\,x^2 - 0.00973\,x^3 + 0.00053769\,x^4 - 0.00001559\,x^5 + 2.260969E{-}7\,x^6 - 1.29179E{-}9\,x^7$

Adjusted $R^2 = 0.91$

x = year - 1955

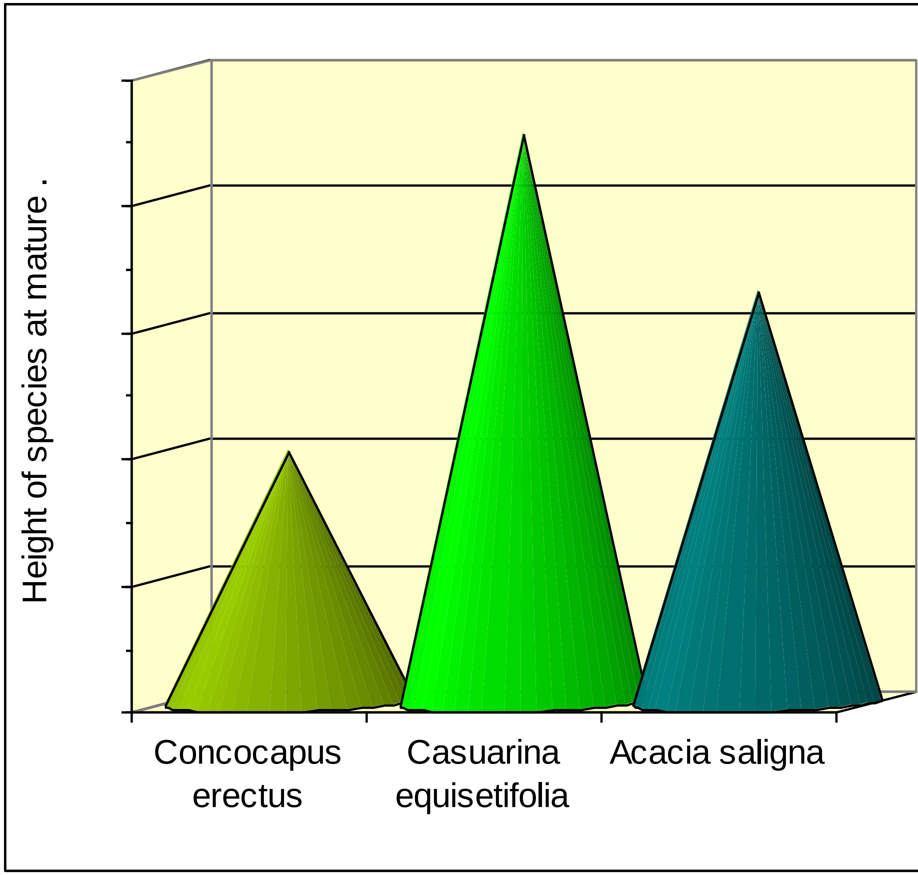
Observations and fitted models for the runoff, sediment yield and sediment-runoff ratio. The fitted models do not include the outliers and influential observations (unshaded observations). Vertical lines indicate the inflection points within the monitoring period.

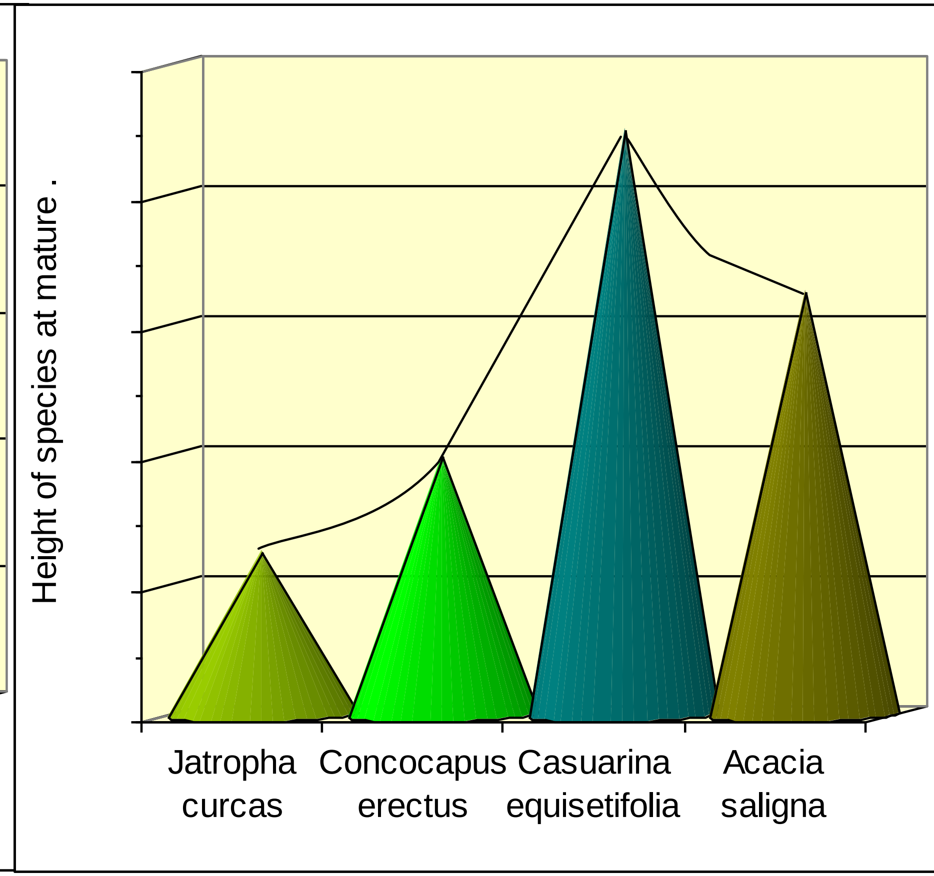
Runoff and soil loss on different land use patterns



The highest runoff (left), highest soil loss (middle) and the average of the five highest runoff values at which no soil loss was generated (right) on different vegetation covers. An example of a rainy season in Southern Shaanxi Province, China (El Kateb et al., 2013).

Examples of designs of a windbreak system



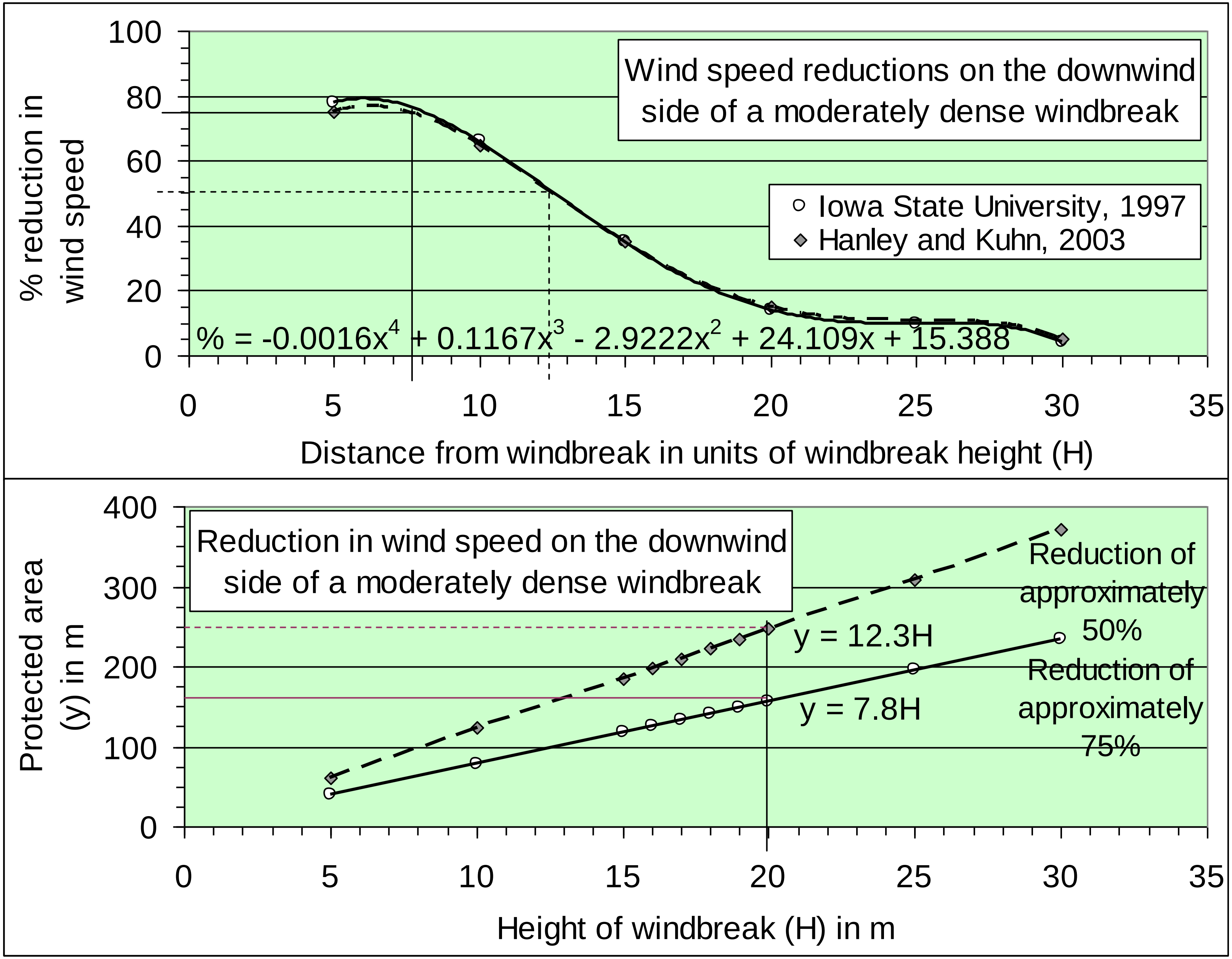


An example of species composition of a windbreak system for medium saline soils in arid climate (left without protection and right with protection against browsing)

Examples of species composition of the windbreak

Tree species	Use
1 Acacia saligna	Fodder, mulch, tannin, firewood,
1 Button mangrove (Conocarpus erectus)	Charcoal, firewood, smoking food, tannin
1 Neem (Azadirachta indica)	Pest control (non-pesticidal management), medicinal
1 Jambul (Eugenia jambolana)	Edible, insecticide, medicinal
1 Olive (Olea europaea)	Edible, oil
1 Nabq (Ziziphus spina-christi)	Edible, fodder, medicinal
2 Casuarina equisetifolia subsp. equisetifolia	Nitrogen fixation, fire wood
2 Cedrela odorata	Wood
2 Cypress (Cupressus sempervirens)	Wood, cosmetic
2 Pinus halepensis	Wood
2 Silk oak (Grevillea robustia)	Wood
2 Swietenia macrophylla	Wood, medicinal
3 Almond (Prunus dulcis)	Edible, oil
3 Carob (Ceratonia siliqua)	Edible, fodder, wood, syrup
3 Lime (Citrus limon)	Edible
3 Pecan (Carya illinoinensis)	Edible, wood, smoking food
3 Tamarind (Tamarindus indica)	Edible, oil for industrial use (adhesive)
3 White mulberry (Muras alba)	Edible, fodder, medicinal

Relationship between windbreak and wind speed reduction



Potential of the afforestation in Egypt

Tectona grandis
6 months

Corymbia citriodora
6 months

Gmelina arborea
22 months

Afforestation in desert lands of Ismailia

Acacia mangium
34 months

Khaya senegalensis
42 months

Azadirachta indica
42 months

Potential of the afforestation in Egypt (continued)

134 Forestry-relevant tree-species older than 150 years were found in only 2 parks in Cairo.

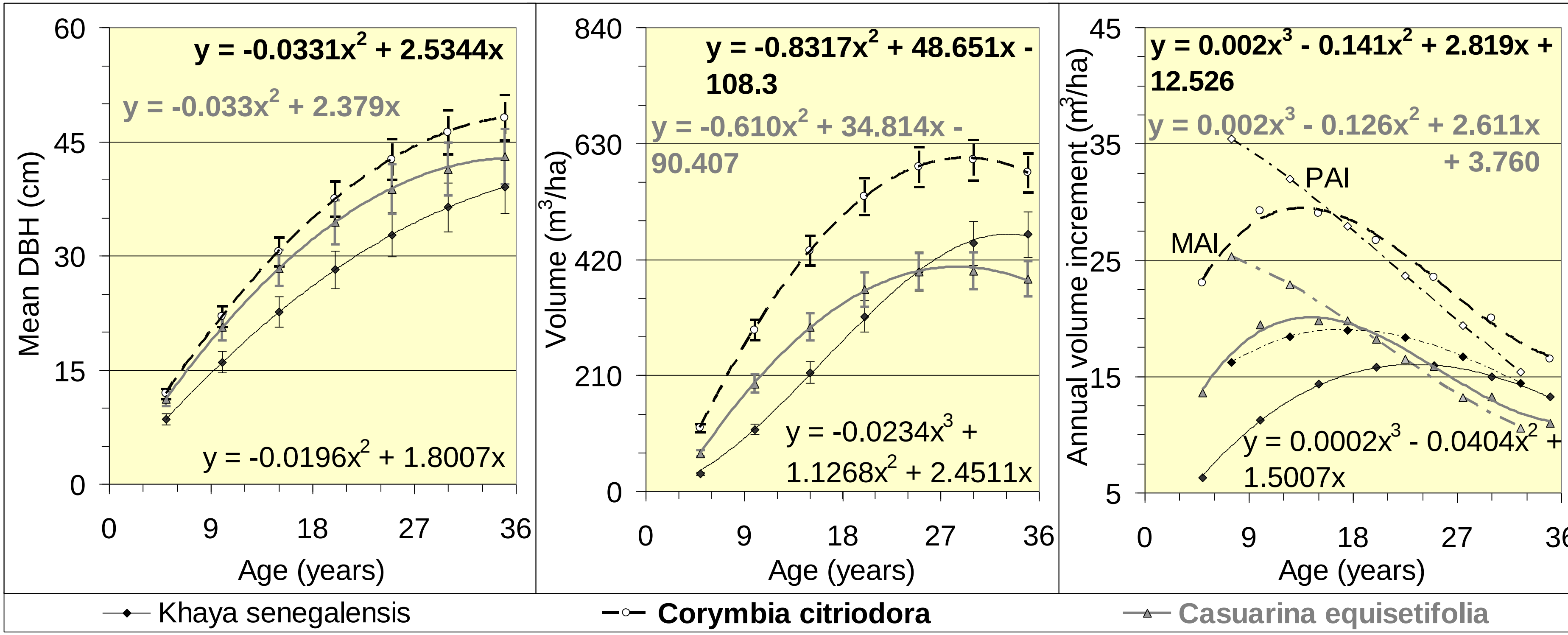
Estimated yield (El Kateb and Mosandl, 2012)

	Corymbia citriodora	*Eucalyptus camaldulensis*	*Khaya senegalensis*
Rotation period	11 years	12 years	15 years
Total volume*	348 m^3/ha	346 m^3/ha	333 m^3/ha
Annual CO_2 sequestration	51 t/ha/year	50 t/ha/year	30 t/ha/year

***Compared to Germany, the leading country in Forestry in Europe, this volume in average for all tree species is achieved after 60 years. This means that the same yield in Egypt is attained 4.5 times earlier than in Germany.**

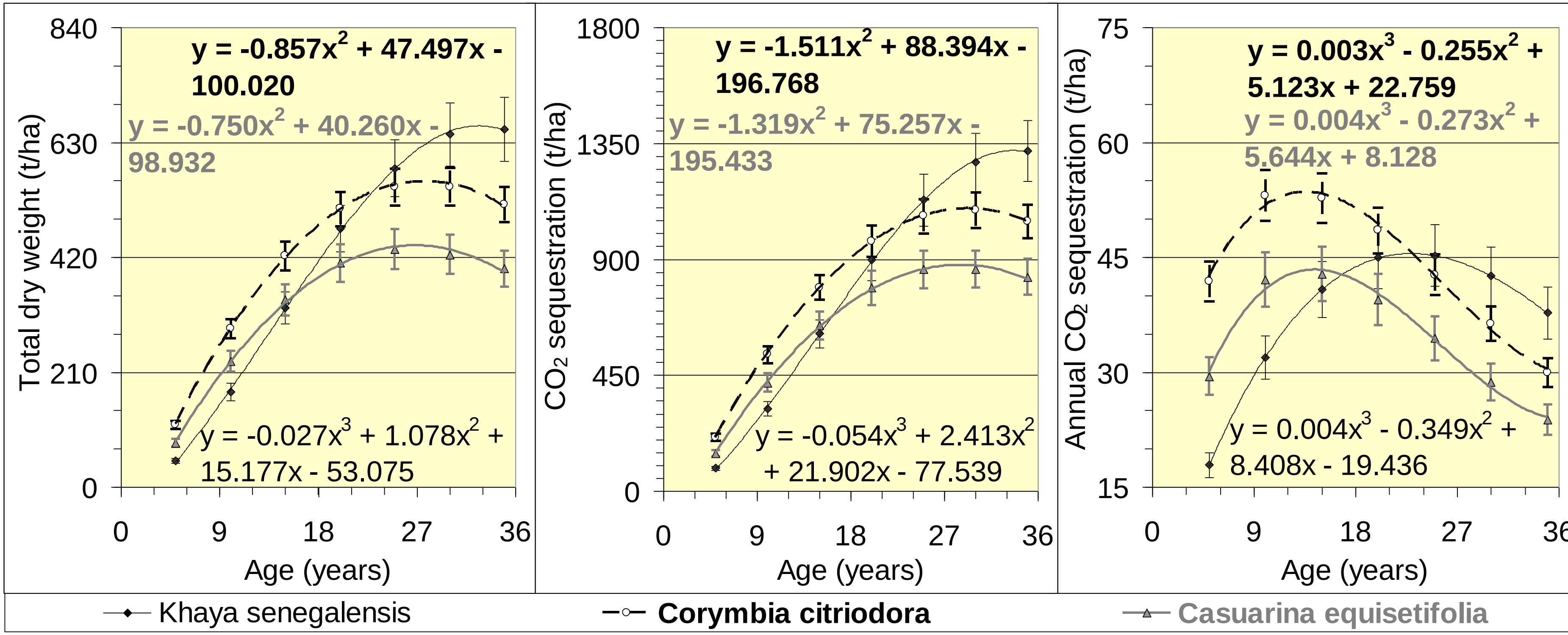
Large-scale afforestation stimulates cloud formation and increases the probability of rainfall (El Kateb and Mosandl 2012)**.**

Potential of the afforestation in Egypt (continued)



An estimate of mean DBH, volume and annual volume increment of three tree species in desert lands of Egypt (El Kateb et al. 2022)

Potential of the afforestation in Egypt (continued)



An estimate of dry weight and carbon dioxide sequestration of three tree species in desert lands of Egypt (El Kateb et al. 2022)

List of planted species in 2013 and 2014 to establishment of sustainable forestry in desert lands of Egypt

- Acacia (*Acacia nilotica and Acacia saligna*), shrub (windbreak)
- Casuarina (*Casuarina equisetifolia*), shrub (windbreak)
- Jatropha (*Jatropha curcas*), shrub (biofuel crop)
- Jojoba (*Simmondsia chinensis*), shrub (biofuel crop)
- Indian beech (*Pongamia Pinnata*), tree (biodiesel)
- Gmeline or White Teak (*Gmelina arborea*), precious hardwood
- African Mahogany (*Khaya senegalensis*), precious hardwood
- Cuban Mahogany (*Swietenia mahagoni*), precious hardwood
- Outeniqua yellowwood (*Podocarpus falcatus*), precious hardwood
- Teak (*Tectona grandis*), precious hardwood
- Mangium or Black Wattle (*Acacia mangium*), hardwood
- Neem, also Indian Lilac (*Azadirachta indica*), hardwood
- Lemon-scented gum (*Corymbia citriodora*), hardwood
- River Red Gum (Eucalyptus camaldulensis), hardwood
- Canary Island pine (*Pinus canariensis C. Smith*), softwood
- Caribean Pine (*Pinus caribaea var. hondurensis*), softwood

I) New communities and green urbanism

The urban areas is well-planed, attractive, have charming architecture and designed to maximise the use of the available physical environment and at the same time minimise the use of supplementary energy and promote the use of renewable energy.

An urban area has different zones and efficient and effective mobility system to maintain a clean environment. The layout of the urban area makes it possible to move through the different zones, in a short time, on foot or by bicycle or electric/hydrogen vehicle. The use of vehicles is based on smart and shared mobility, with sufficient mobility hubs in place.

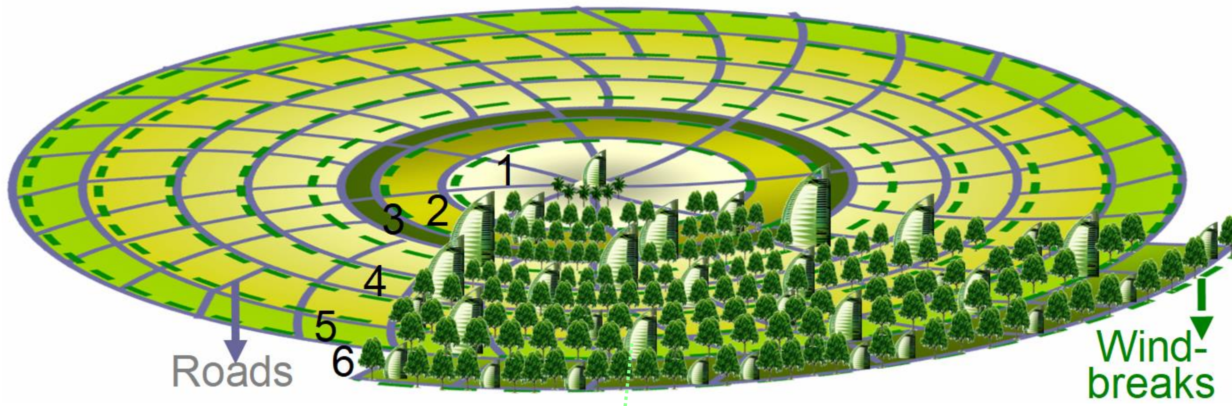
Buildings, constructed from ecological building materials and well insulated, are designed to maximise the natural flows that occur in their specific micro-environment. They are nature-based buildings that utilise passive energy savings design and technology to promote natural lighting, ventilation, cooling, and heating.

The buildings, constructed from ecological building materials and well insulated, produce energy, hot water and fertilizer sludge and make use of treated grey water for toilet flush and of sewage recycled water for gardening or greening the landscape. Buildings include:

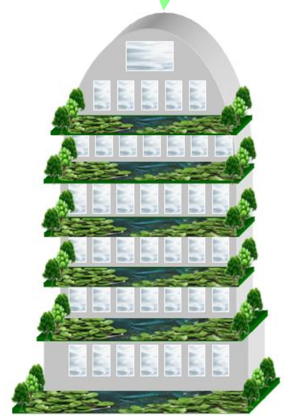
- Solar hot water panels and wind/solar electricity;
- Water recycling units and rain water catchments, if applicable;
- Waste sorting and management as well as treatment of organic waste and of wastewater.

New communities and green urbanism

1. Centre of the urban area
2. Shopping zone including restaurants, coffee shops, etc.
3. Administrative, commercial, security and non-governmental services area
4. Residential area including small shops for daily shopping
5. Educational, health, social and recreational services area
6. Green industrial zone

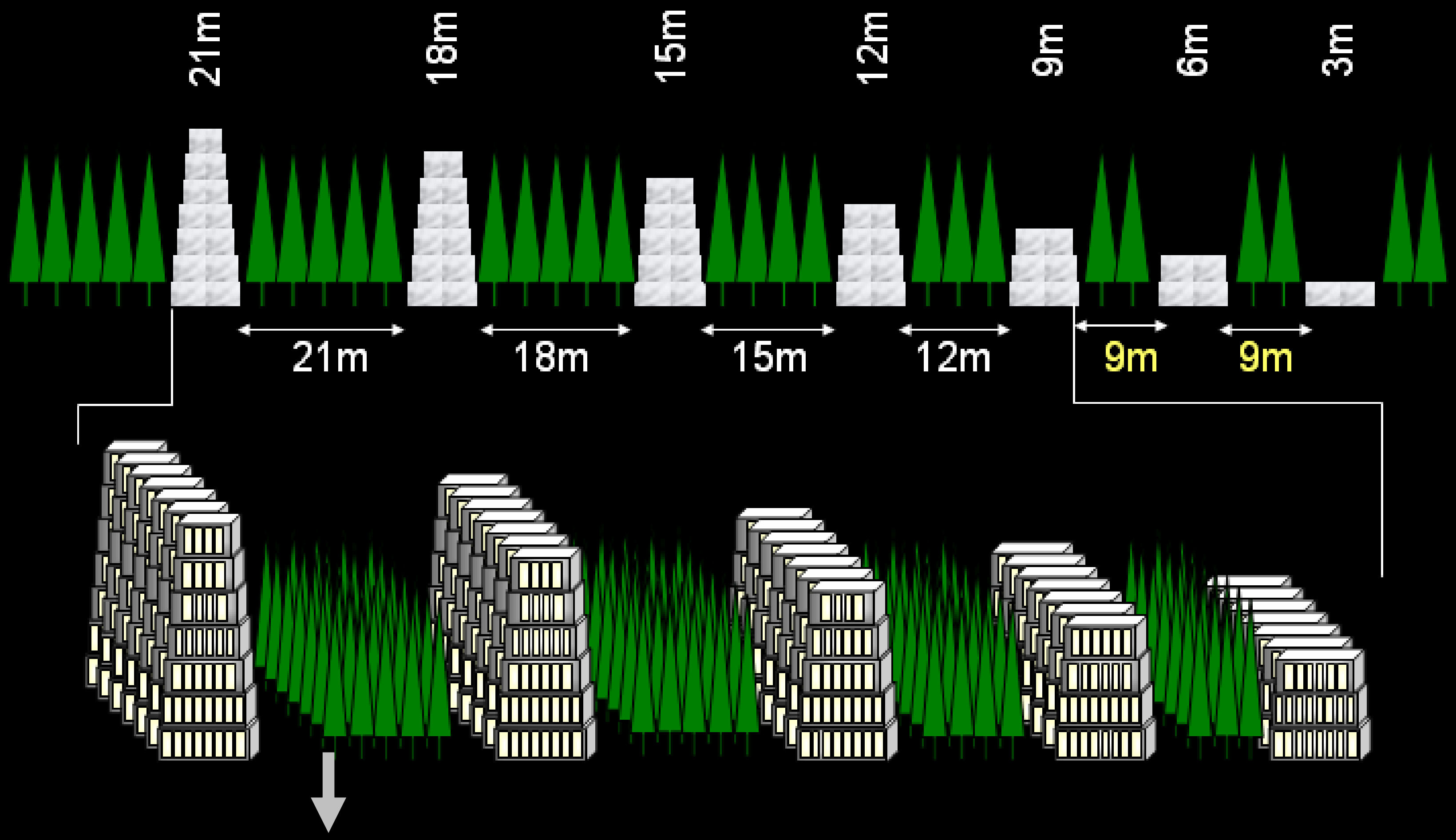


Layout of an urban area showing different zones protected by windbreaks. Mobility from one zone to another through walking, bicycles or electrical/hydrogen vehicles



https://bloggerswithoutbordersdotcom.wordpress.com/2012/05/29/singapore-shows-how-cities-and-green-can-go-together/

Distances between buildings



An example of street structure with trees to provide shade and prevent sun damage to roads

Pedestrians = 1.6m, Cyclists = 1.6m, Trees = 0.6m, Parking = 2,25m, one track each directions = 2,75m, two tracks each direction = 7,00m. Green island incorporating trees for pedestrians = 4.5-5.0m.

II) Green Communities and Sustainable Integrated Farming

The sustainable integrated farming is an agro-ecosystem that follows “natural” ecosystems in their management of resources. The system integrates many farming activities and techniques in **open fields** and under **greenhouses**. The farming and off-farm activities include the production and processing of wide-range of commodities. Almost no wastewater is to be expected in the well-designed system. However, should wastewater be produced, this water will be recycled and re-circulated in the system.

The system has high stability in terms of high resistance and high resilience. This is achieved by a) adaptation and protective measures (i.e., windbreaks or shelterbelts that create favourable micro climate for many species (flora and fauna)); b) increasing biodiversity by integrating multiplicity farming activities (livestock-poultry-aquatic farming, bees farming, field crops, vegetables, fruits, date palms and timber and non-timber products) that support the fulfilment of the entire-system requirements, without need for additional external inputs or agrochemicals; and c) reuse and recycling all waste (zero waste). The sustainable integrated farming is characterised by high resistance to climate changes, high carbon dioxide sequestration (i.e., adaptation to and mitigation of climate change), low water use, high soil fertility, and the production of high-quality and healthy food-commodities to contribute to food security.

The main irrigation system used is the sub-surface irrigation to achieve a considerable reduction in water consumption, by avoiding any evaporation, efficient control of soil moisture, and preventing soil degradation by salinisation. The supply of nutrients to the plants is in the form of compost tea that contains animal and fish manure, as well as crop residues. No external synthetic fertilisers that harm the environment and human health are used.

Maintaining a clean environment and the aesthetic appearance of the diverse plants will help attract ecotourism.

Agro-ecosystems in arid regions

An agro-ecosystem can be described as an integrated farming-system that simply aims to provide the needs of plants and animals for survival and growth in systems characterised by high stability in terms of high resistance and high resilience. This means high resistance against those factors affecting the equilibrium of the system, e. g., climate, wind, sand, pests and insects; and high ability to recoverability after disturbance.

Plant requirements

Water	Sustainable water management, provision of additional water sources[1], and water saving techniques[2]
Light	Management of light requirements for the different species
Nutrients	Raising and maintaining soil fertility by improving habitats for the soil organisms, which help soil aeration, soil improvement efficiency to retain water and nutrients, nutrient management, decomposition of organic matter and mineralization, nitrogen fixation from the air, and raising the three primary nutrients: nitrogen, phosphorus and potassium. Promoting crop rotation, inter-cropping and raising plant diversity. Using all on-farm nutrient-sources by integrating crop, livestock & aquatic farming in the system, recycling agricultural-waste and composting.
Protection, prevention & adaptation	Windbreaks, hedgerows & agri-environment measures, as mulching, no-till/reduced tillage, building and maintaining soil organic matter, increasing crop diversification & biodiversity, and establishing integrated systems.

Potential techniques to water provision and water saving in agriculture

[1]Potential techniques to support provision of water

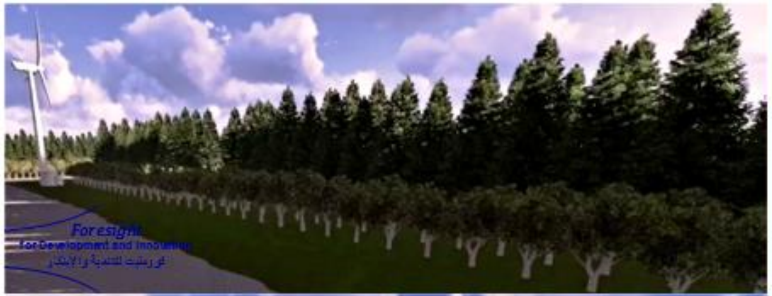
- Rainwater, fog* and dew* collection, wherever relevant
- Atmospheric Water Generation*
- Reuse of wastewater (non-edible plants as forest trees or windbreaks can be irrigated by basic treated sewage water, while edible plants by water free of any contaminations)
- Cost-effective seawater-desalination (this still remains necessary in many countries in arid regions to provide water for food security).

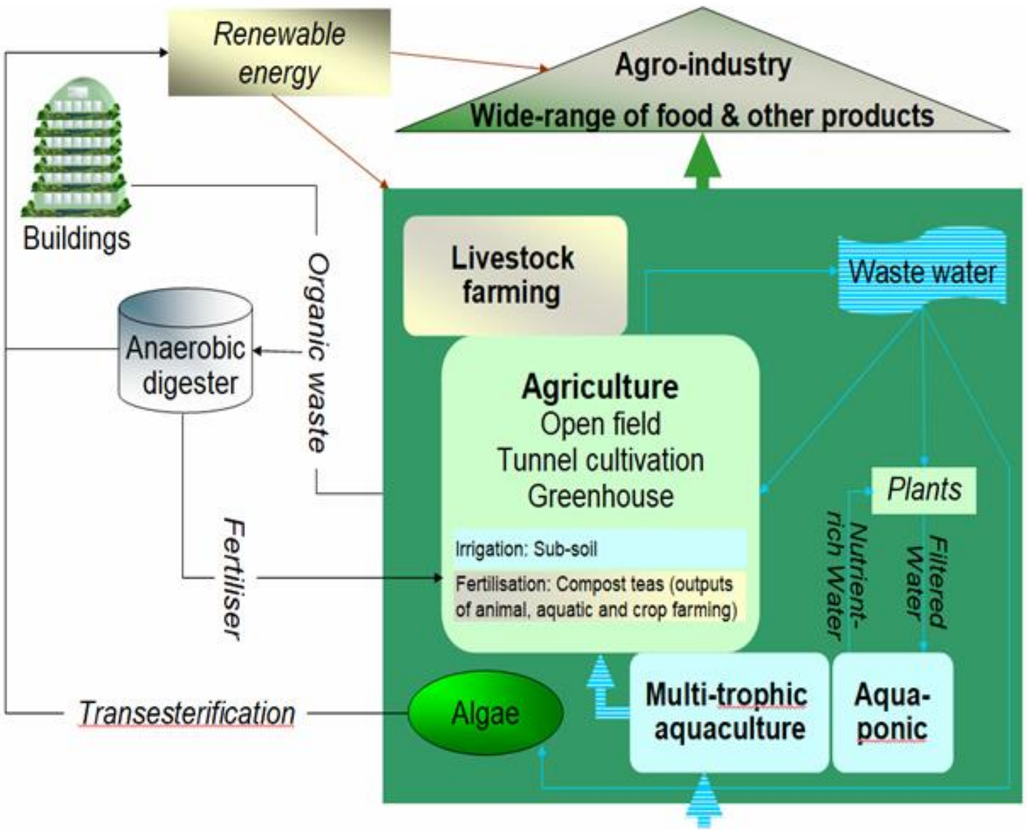
*Forestation by establishing windbreaks will lead to increase the relative humidity in place and thus enhances the efficiency of techniques.

[2]Techniques to support water saving in agriculture

- Using subsoil irrigation, when no rain-fed agriculture is practiced
- Windbreaks/shelterbelts
- Enhancing habitats for soil microbial community and building soil organic matter
- Mulching
- Multi-layers farming and intercropping
- Non production of wastewater, and if not so, then to be reused/recycled.

Green Communities and Sustainable Integrated Farming

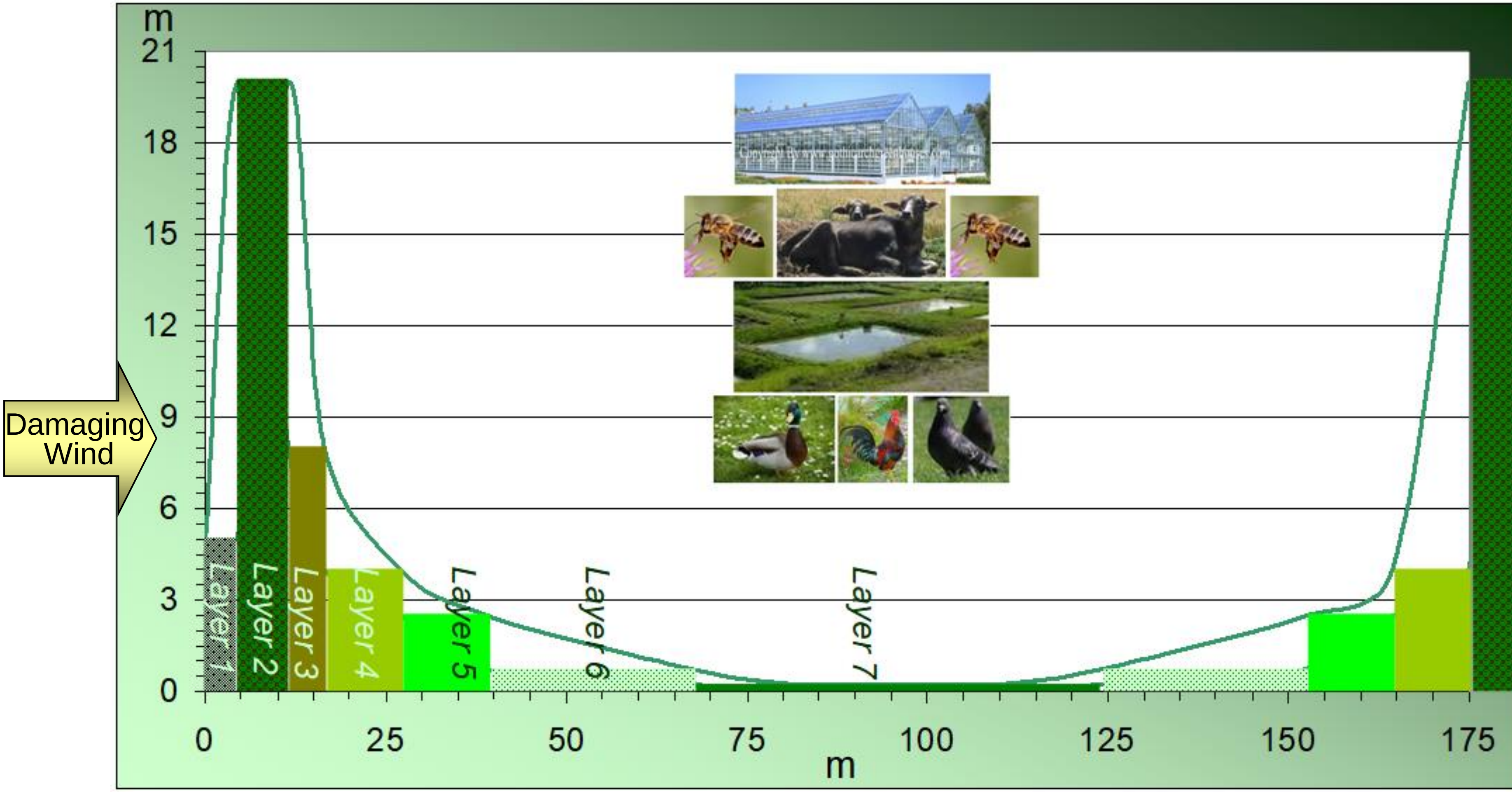




Open field

Greenhouse

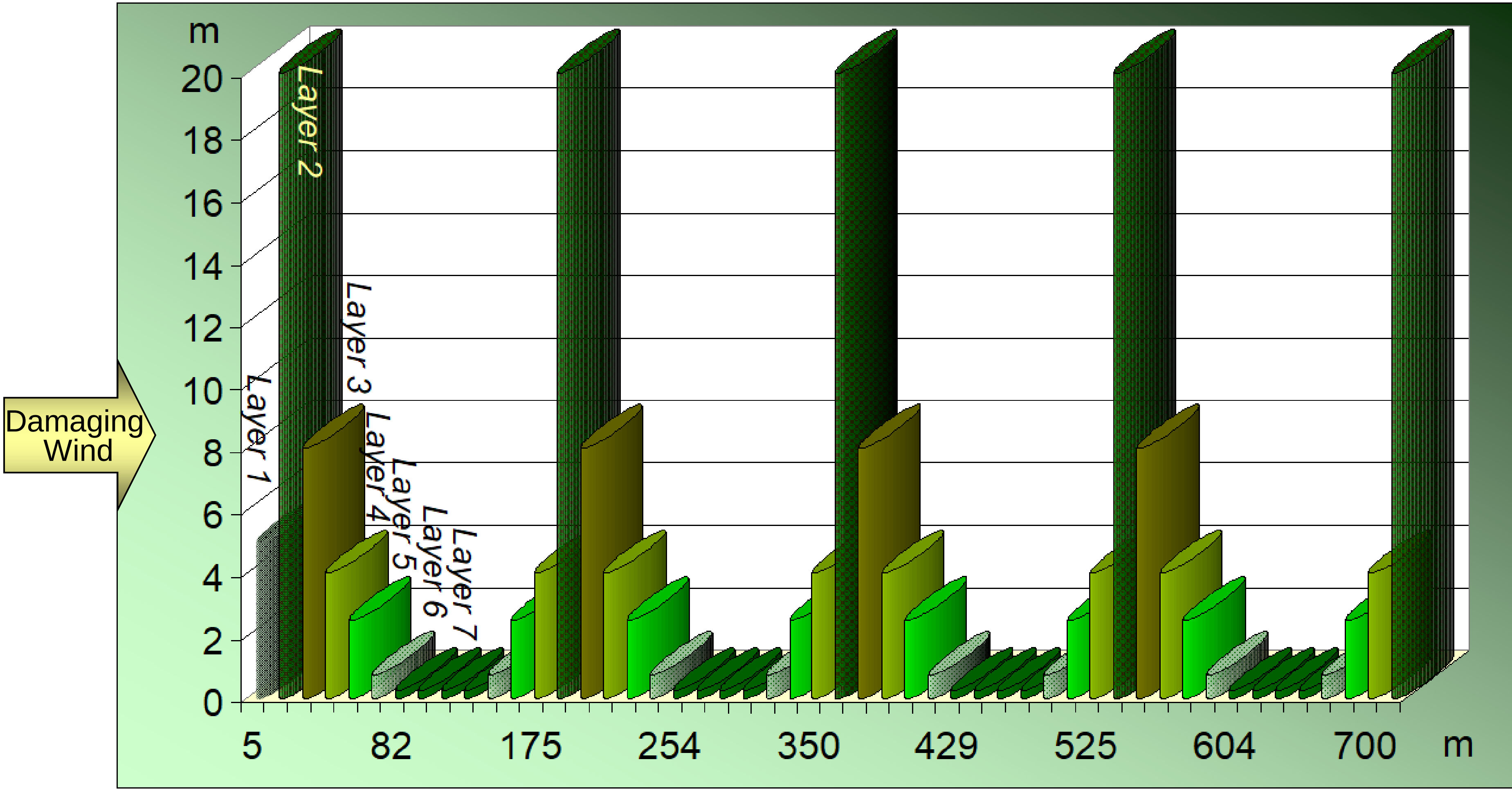
IIa) Sustainable integrated farming using freshwater in open fields – design



Vertical and horizontal arrangement in a sustainable farming system, showing 7 different multi-cropping layers: Layer 1-3: Windbreaks, Layer 4&5: Fruit trees, Layer 6&7: Grains, vegetables & herbs (layer 4-7 under **palms** canopy).
2 levels of inter-cropping (layer 8 & 9: understory crops and climber plants) are arranged under the canopy of layers 2 to 5.

Sustainable integrated farming

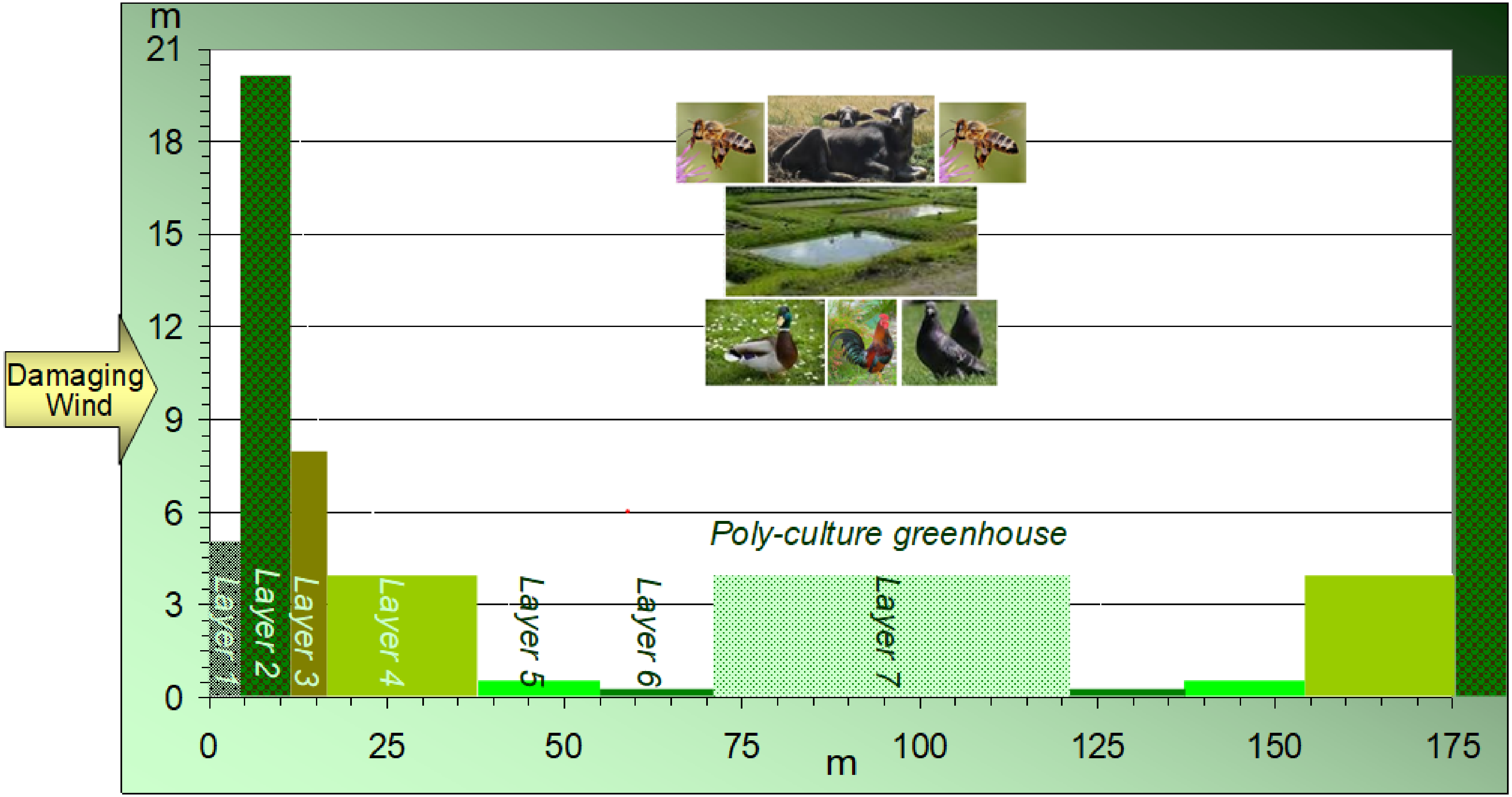
arrangement of the agriculture units



Sustainable integrated farming in open field – reality

In Egypt, in the south of the country near Luxor, integrated-farming systems have been practiced for many centuries.

Sustainable integrated farming under greenhouses



Vertical and horizontal arrangement of the sustainable integrated farming for greenhouse farming, showing 7 different multi-cropping layers: Layer 1-3: Windbreaks, Layer 4: Fruit trees, Layer 5: Fodder crops,, Layer 6: Aquatic farming, Layer 7: Greenhouses; and where layer 4-6 under palms canopy. 2 levels of inter-cropping (layer 8 & 9: under-story crops and climber plants) are arranged under the canopy of layer 2 to 4.

Sustainable integrated farming under greenhouses

State of the art technologies (soil-less cultivation, aeroponics, stacked and automated hydroponics) with high efficiency and productivity (Except Integrated Sustainability, 2019)**.**

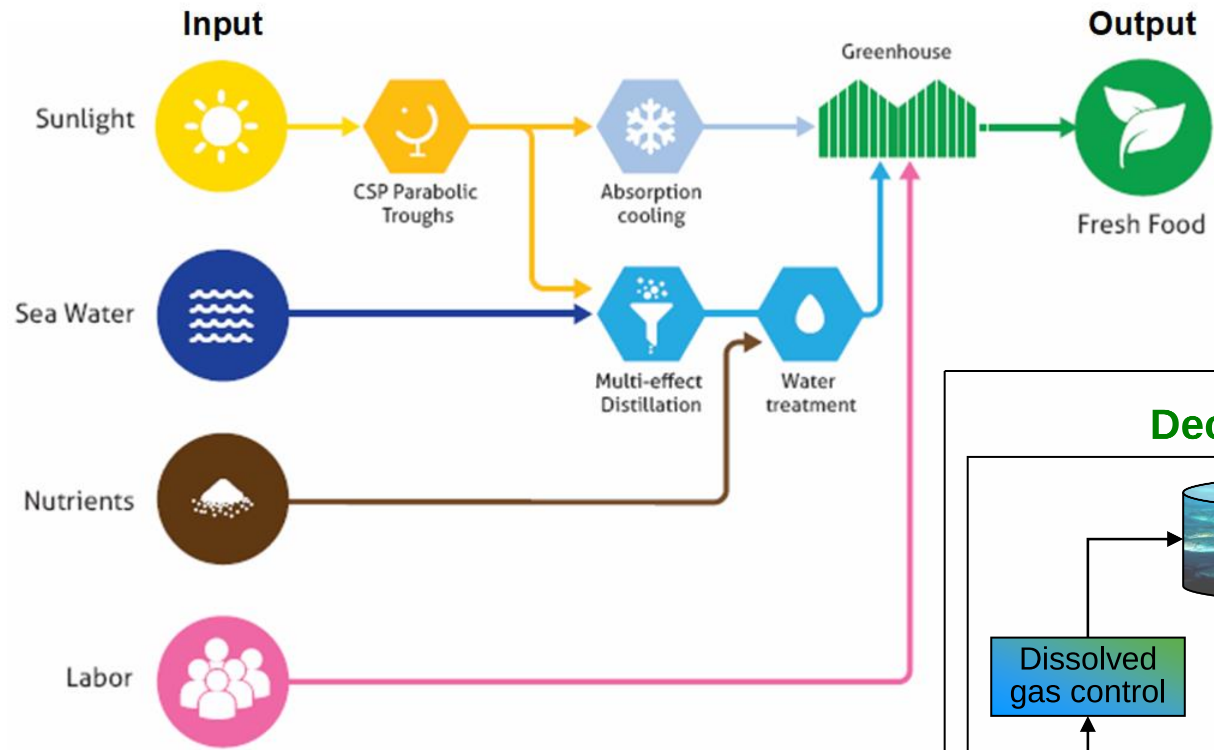
Advantages of greenhouses in arid regions

The well-known advantages of green-house farming are the considerable high yield, production during the off-season and ability to grow crops all-year-round.

These advantages are simply results of establishing and controlling optimal environment or microclimate for crop survival and growth as well as protection against unfavourable weather conditions, pests and diseases. However the most significant advantages for arid regions are:

- Substantial water saving (e.g., for tomato this can reach over 90% comparing to open fields).
- Saving in land resources due to high production, which achieves up to 10-15 times higher than in open field.
- Saving in nutrients application, particularly when hydroponics and soil-less techniques are employed.

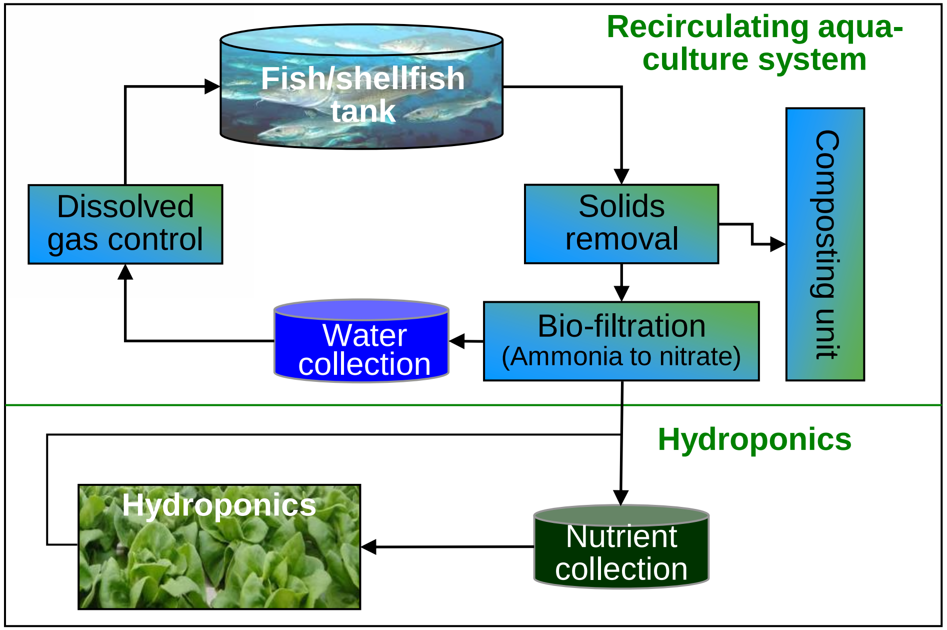
IIb) Sustainable integrated farming, using seawater



Using desalinated seawater in greenhouse cultivation

(Except Integrated Sustainability, 2019)

Decoupled saline aquaponic



(Thorarinsdottir & Unnthorsson (2018), modified)

Using seawater for open-field cultivation

Use of desalinated seawater in greenhouse farming
(energy)

Using solar heat as well as photovoltaic

Examples:

60,000 m² of CSP troughs

*13.6 MWp thermal, 7.7 MWp electric**

32,256 m² of PV on roofs of auxiliary buildings and parking lots

6.4 MWp and 11 GWh/yr

*Preliminary values. System performance depends on heating medium (molten salts, oil, steam), storage capacity, output temperature and use.

Except Integrated Sustainability, 2019

CSP (Parabolic trough)

PV panels

Use of desalinated seawater in greenhouse farming
(construction)

Greenhouse construction and light-weight service buildings

An example:

6 greenhouses of 160m x 320m

30.72 ha of productive area

326,400 m^2 of glass roofing

77 km of aluminium gutters

Except Integrated Sustainability, 2019

Greenhouse structure

Greenhouse roof

Optimisation of farming activities: Precision Farming

Optimisation of farming, whether crop or livestock or any other farming activities,

to increase yield and save in resources can be achieved using **precision agriculture**: Utilising tools and technologies*

- to identify and remediate cause of disturbance or stress;
- to raise efficiency in farming operations whether sowing, planting, irrigation, fertilisation or harvesting; and
- to monitor soil, crop, animals, and environmental conditions.

AS in many industries and businesses, digitisation (conversion of information in digital form) and digitalisation (use of digital technologies) are common, so the agriculture future is digital also.

**Tools and technologies:* Cameras, Drones or aerial vehicles, Sensors and remote sensing, GPS (Global Positioning System), Geomapping, Automated steering systems, Variable rate technology (VRT: application by machine on spot), Robots milk cows, etc.*

Conventional farming vs. sustainable farming

Conventional farming

Inappropriate use of resources
Ample import of inputs and agrochemicals
Intensive tillage
Managed for monoculture

Increased individual products in emissions-intensive economy

High vulnerability to climate change
Advance desertification
Increased erosions
Contaminated water runoff
Low stability
Soil degradation
Non-maintenance of soil fertility
Waste production

Hunger, poverty and social instability

Sustainable integrated farming

Sustainable use of resources
Using only on-farm produced resources
Non-tillage or reduced tillage
Managed for enhanced biodiversity and integrating crop-livestock-aquatic farming

Healthy and diverse range of food in emissions-reduced economy

Adaptation to climate change
Combat desertification
Reduced erosions
Clean water runoff
High stability
Enhanced soil quality
Maintenance of soil fertility
Zero waste

High economic and social stability

III) Green Communities and Agro-Industry

Off-farm activity is an integral part of the sustainable integrated farming to add value to the raw materials, maintain and enhance quality and safety of products for longer periods, and to develop competitive agro-industries.

The typical activities within this unit include post-harvesting practices and technologies with high efficiency such as drying, heating, cooling, freezing, packaging, storage, distribution, and manufacturing.

Bio-fertiliser, bio-char and biological-control agents will be also produced to support the development in organic farming in arid regions.

Environmental, economic, and social benefits of the project

The project's environmental benefits:

- Helps with reducing greenhouse gas emissions in the atmosphere.
- Helps to accelerate climate change mitigation through high carbon dioxide sequestrations.
- Establishes effective measures for climate change adaptation.
- Ensures efficient use of resources and avoidance of waste generation to achieve a zero-waste system in a low-emissions economy.
- Creates a favourable micro-climate for urban and agricultural areas.
- Considerably decreases vulnerability to climate change, drought, desertification, and soil erosion.
- Uses smart and shared mobility of electric/hydrogen vehicle to prevent pollution.
- Induces cooling and slight warming effects on summer days and winter nights, respectively, thus, reducing energy for cooling and heating, while also enhancing the environment for plant survival and growth.
- Provides protection to the urban and agricultural areas from wind and sand
- Increases the infiltration rate, reduces surface runoff and ensures that infiltrated water is free of any harmful substances.
- Reduces evaporation and transpiration, and thus decreases water consumption.
- Raises biodiversity, thereby reducing potential risks from pests, diseases and insects.
- Raises and maintains soil fertility and does not support the use of synthetic fertilisers and other agro-chemicals.
- Reduces disaster risks (e.g., heat waves, floods, storms) through several precautionary measures.

Environmental, economic, and social benefits of the project

The project's economic and social benefits :

- Supports achieving sustainable economic-growth under low-emissions economy.
- Employs state-of-the-art technologies and standards to support the development of green urbanism, sustainable integrated farming and agro-industry in arid regions.
- Supports the establishment of key knowledge industry in sustainable food production in arid regions.
- Provides sustainable solutions to water-energy-food nexus challenges.
- Attracts national and international eco-tourism in a pleasant recreation area and clean environment with high air-quality, while persuading residents in an attractive environment to stay and not migrate.
- Preserves citizens' health and reduces the harmful effects of exposure to air pollutants and emissions.
- The green communities provide numerous job opportunities and offer a wide-range of careers.
- Makes technology transfer accessible and tailored to arid environments; the utilisation of these transferred technologies is realised through effective capacity building.
- Helps raising productivity and maintaining sustainable production of a variety of high-quality, healthy food to contribute to food security.
- Adds value to the agricultural raw materials by building an integrated value chain, from harvesting the product to manufacturing and marketing, which helps improve the economic returns and support raising the GDP and living standard.
- Helps to encourage the establishment of cooperatives for smallholder farms to improve productivity and food security and guide them towards the development of an agriculture value chain to add value to raw products, create job opportunities, and improve livelihoods.

Phases of implementation of new communities

Phase 1: Establishment of the sustainable integrated farming (in open fields and under green-houses) and agro-industrial units on small land area using: a) freshwater and b) seawater. The land area is also used for demonstration and research.

Providing training programmes for the staff.

Construction of examples of greenhouses according to best available technologies and materials.

Starting local production of components and equipments of the greenhouses.

Phase 2: It includes the establishment of a new community with an urban area, as well as full activities in agriculture and agro-industry. The conception and planning of this phase will be completed one year after the start of the first phase, so that the implementation of the second phase can begin. At this stage, enhancing and streamlining the production processes of domestic manufacturers of modern greenhouses will take place.

Phase 3: Knowledge and experience gained by the well-trained staff and the Egyptian manufacturers will enable large-scale implementation around the country and region-wide.

Summary of the financial model over a 10-years period

Land area	First Phase	Second Phase
Total land area (Feddan = 4200 m^2)	200	1,482
(m^2)	840,000	6,224,037
Land area under production (Feddan)	187	1,309
(m^2) of which	785,400	5,497,800
land in m^2 using freshwater	508,200	3,557,400
land in m^2 using seawater	277,200	1,940,400
Production		
Average annual production in t	12,697	84,908
Production in kg/m^2	16.2	15.4
Manpower		
Permanent staff	491	2,681
Part-time manpower	217	1,269

Summary of the financial model over a 10-years period

Funding	First Phase	Second Phase*
Total funding in 10^3 USD	52,500	272,300
Investment per m^2 in USD	66.74	49.53
Investment in a produced kg in USD	4.13	3.21
Financial performance		
Average annual revenues in 10^3 USD	34,505	235,916
Average annual operating costs in 10^3 USD	18,647	95,672
Average annual operating profit in 10^3 USD	15,858	140,244
Average annual profit per m^2 in USD	20.19	25.51
Average annual profit per kg in USD	1.25	1.65
Average annual gross margin	58.8%	63.0%
Average annual operating profit	43.6%	57.2%
Average annual income before tax in 10^3 USD	15,472	138,220
Average annual return on net operating assets (RoNoA)	35.4%	52.8%
Average annual return on equity (RoE)	28.8%	34.9%
Internal rate of return (IRR), 7th year	26.9%	44.9%
Net Present Value (NPV) in 10^3 USD, 7th year	46,205	617,869
Non-discounted payback period, years	5.3	3.8
Payback period, years	6.1	4.1

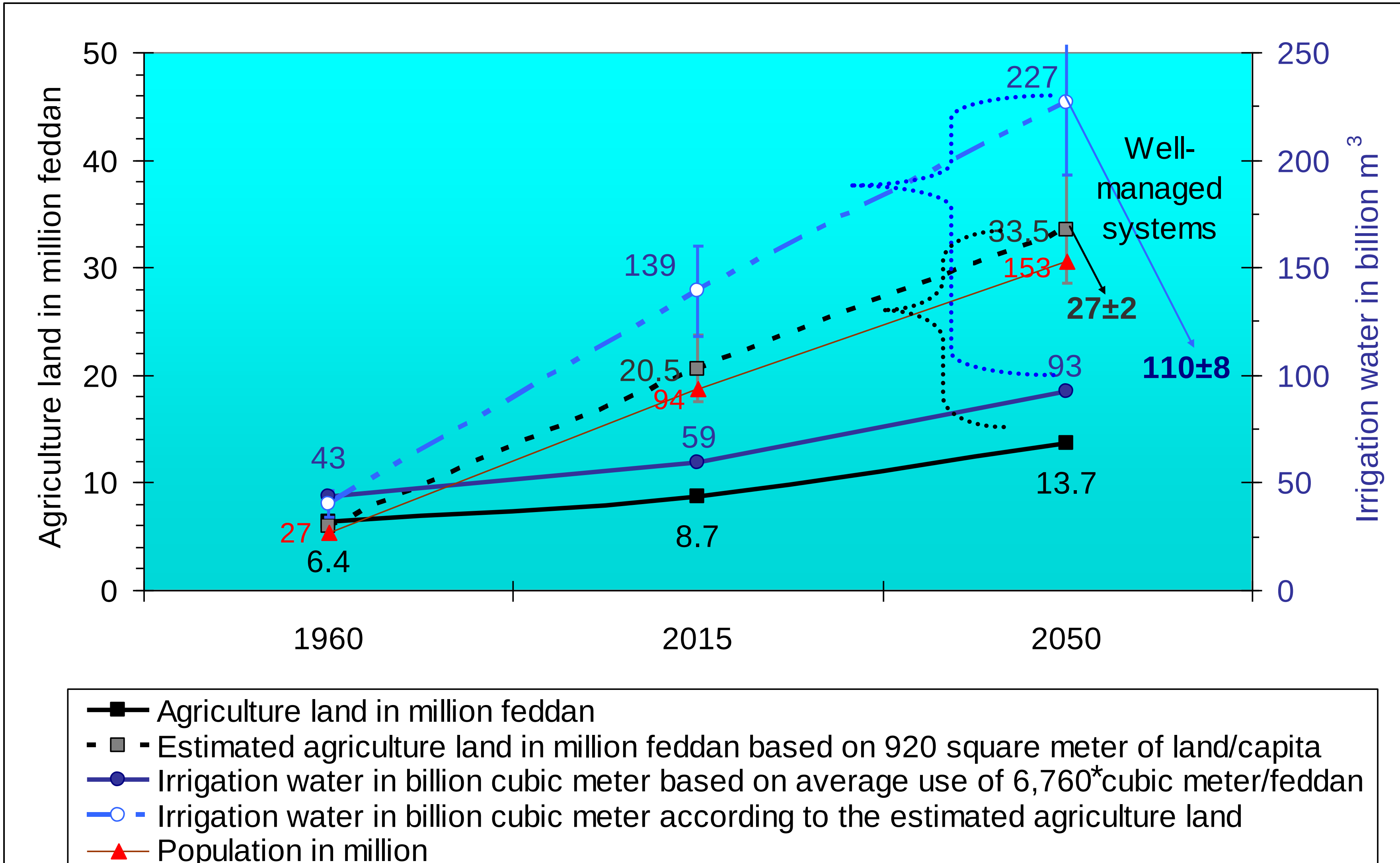
*The financial model for the second phase does not include the investment cost for the design and construction of the urban area, which was initially estimated at approximately US$ 622 million.

El Hayat

Future Green-Communities:
Integration of sustainable development, adaptation and mitigation to climate change for the establishment of green communities in arid regions

Thank you very much
for your kind attention

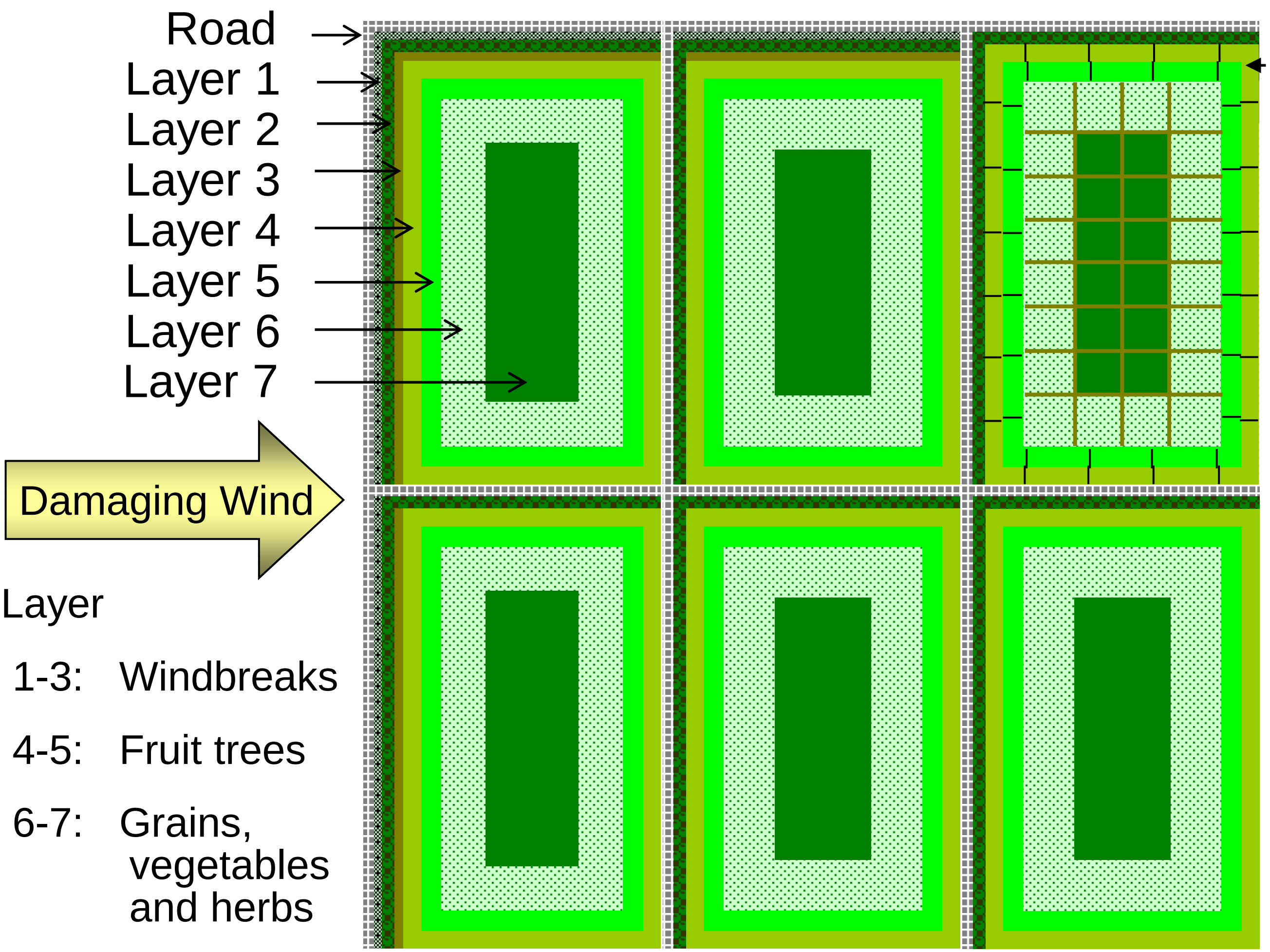
Agriculture land & irrigation water in Egypt



Deficit in 2050: 20±3.4 million feddan and 134±24 billion m^3 of irrigation water (in well-managed agro-ecosystems and using sub-soil irrigation, deficit can be drastically diminished).

*7,300 m^3/feddan according to Ministry of Water Resources and Irrigation, Egypt (2014)

Sustainable integrated farming
arrangement of the agriculture units



Examples of subunits arrangement with different species in layers 4 to 7

Cultivation is based on
a) multi-cropping between-layers and within-layers,
b) inter-cropping by planting crops under the canopy of others, &
c) crop-rotation for seasonal crops.

For optimal protection by windbreaks, each unit has a size of 4.62 ha (175m X 264m).