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N.D.Gulhati of India

IRRIGATION TECHNOLOGY

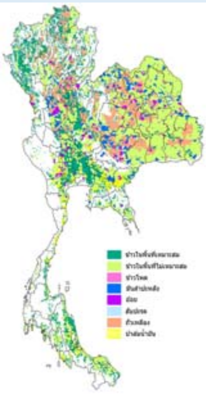
BY DR.VARAWOOT VUDHIVANICH

Important of Irrigation

Irrigation in many countries is an old art - as old as civilization - but for the whole world it is a modern science- the science of survival.

– N.D.GULHATI OF INDIA–

การชลประทาน คือศาสตร์ที่เกี่ยวกับการให้น้ำแก่พืช



คำถาม ?
1.เมื่อไรที่พืชต้องการน้ำ
2.พืชต้องการมากน้อยเท่าใด
3.แหล่งน้ำอยู่ที่ไหน
4.ปริมาณน้ำต้นทุนที่มี เพียงพอหรือไม่ ถ้าไม่พอจะทำอย่างไร
5.จะส่งน้ำด้วยวิธีไหน
6.ค่าใช้จ่ายเท่าใด
7.ใครออกค่าใช้จ่าย
8.ให้น้ำอย่างไรจึงได้ประโยชน์สูงสุด
9.ผลประโยชน์ที่ได้คุ้มค่าหรือไม่
10.ใครได้ผลประโยชน์จากน้ำชลประทาน
11.การจัดสรรน้ำชลประทานมีความเป็นธรรมหรือไม่
12.การพัฒนาแหล่งน้ำเกิดผลดีผลเสียอย่างไร มีผลกระทบต่อสิ่งแวดล้อมมากน้อยเพียงใด ถ้าไม่พัฒนาจะเกิดผลอย่างไร

การชลประทาน จึงเกี่ยวข้องกับมิติต่างๆ ทั้งด้านเศรษฐกิจ สังคม สิ่งแวดล้อม การเงิน การเมือง จึงต้องรู้ศาสตร์และเทคโนโลยีหลายด้าน และสามารถบูรณาการความรู้ด้านต่างๆเข้าด้วยกัน

THINGS THAT IRRIGATION ENGINEERS MUST LEARN

- BASIC IRRIGATION PRINCIPLE
- PLANNING
- DESIGN
- CONSTRUCTION
- IRRIGATION WATER MANAGEMENT

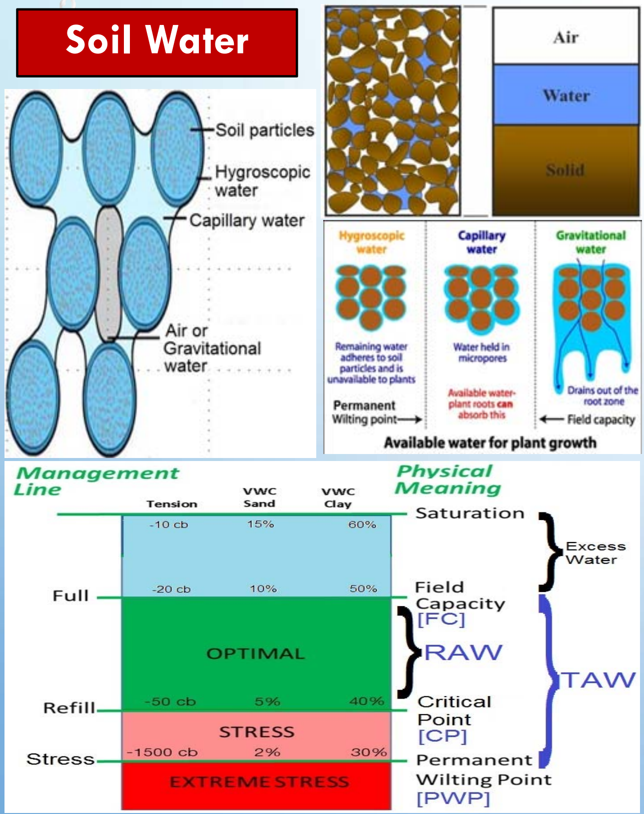
TODAY TOPICS

1. BASIC IRRIGATION PRINCIPLE
2. IRRIGATION METHOD
3. IRRIGATION SYSTEM
4. IRRIGATION MANAGEMENT

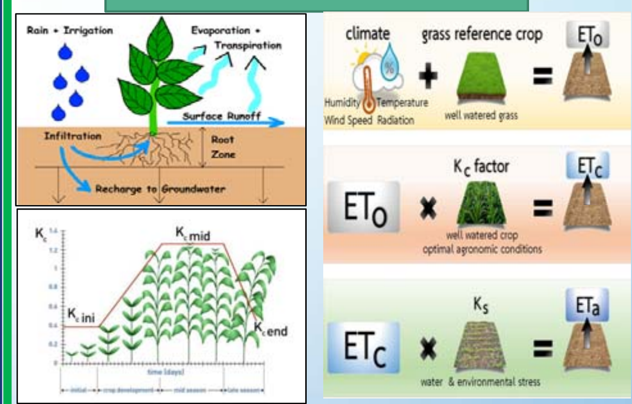
1.BASIC PRINCIPLE OF IRRIGATION

WHEN TO IRRIGATE, HOW MUCH WATER SHOULD BE APPLIED & HOW TO APPLIED EFFICIENTLY ?

Soil Water



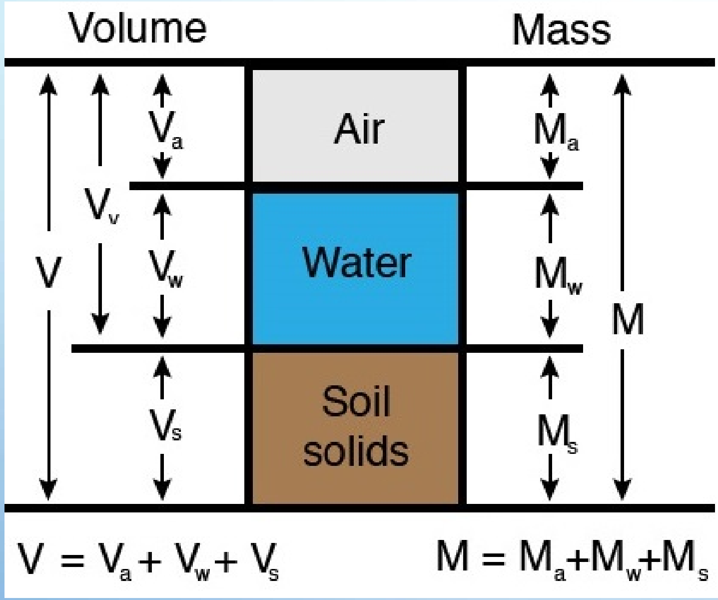
Crop Consumptive Use



Irrigation Methods

- Surface irrigation
- Sprinkler irrigation
- Micro irrigation
- Sub-surface irrigation

SOIL MOISTURE CALCULATION



Soil moisture properties

As=Ms/(V*γw)

D_B=Ms/V

n(%)=100*Vv/V

Soil moisture calculation

$\theta_M(\%)=100Mw/Ms$

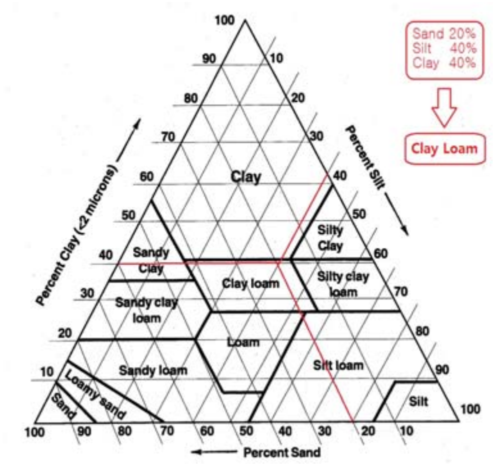
$\theta_V(\%)=100Vw/V$

$\theta_V(\%)=\theta_M(\%)*As$

$d=\theta_V(\%)*D/100$

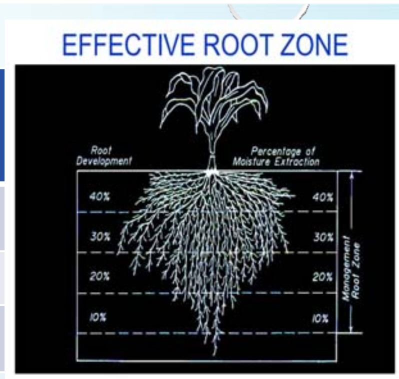
As=Apparent specific gravity(-)
DB=Bulk density(g/cc)
n=Porosity(%)
γw=Unit weight of water=1g/cc.

θ_M(%)=% soil moisture by dry mass
θ_V(%)=%soil moisture by volume
d=Depth of soil moisture(mm)
D=Depth of soil(mm)



Soil Texture Classification

Sand	ϕ>0.05 mm.
Silt	ϕ=0.002–0.05 mm.
Clay	ϕ<0.002 mm.



SOIL PROPERTIES AND WATER HOLDING CAPACITY

Soil types	FC (% dry mass)		PWP (% dry mass)		Porosity(n) (%)		Apparent Specific Gravity(As)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Sand	6-12	9	2-6	4	32-42	38	1.55 – 1.80	16.5
Sandy loam	10-18	14	4-8	6	40-47	43	1.40-1.60	1.50
Loam	18-26	22	8-12	10	43-49	46	1.35-1.50	1.40
Clay loam	23-31	27	11-15	13	47-51	49	1.30-1.40	1.35
Silty clay	27-35	31	13-17	15	49-53	51	1.25-1.35	1.30
Clay	31-39	36	15-19	17	51-55	53	1.20-1.30	1.25

When to irrigate and how much water should be applied?

Example 1 - Determine RAW for a corn growing on Loam, assuming that the maximum rooting depth=80 cm. and depletion traction(p)=0.6. From soil properties table

FC=22% by dry mass, PWP=10% by dry mass, As=1.4

TAW=(22-10)*1.4*80*10/100=134.4 mm

RAW=p*TAW=0.6*134.4=80.6 mm.

Example 2 Determine the irrigation schedule of corn, if the crop water requirement of corm(ETc) = 8 mm/day.

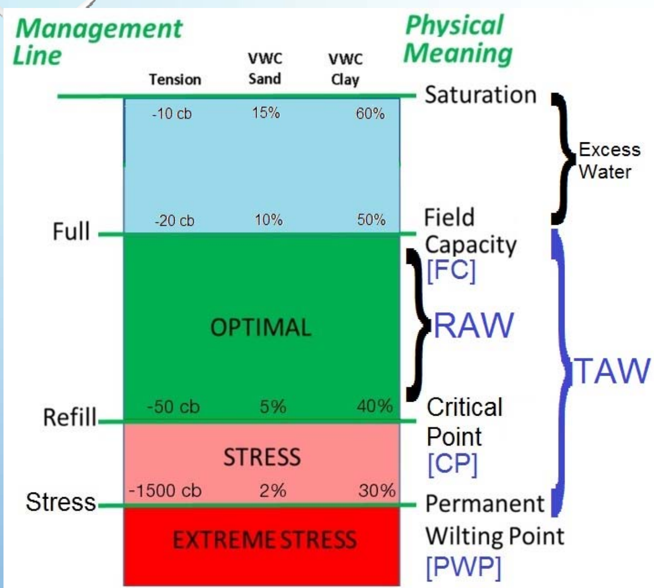
Irrigation frequency= RAW(mm)/ETc(mm/day)=80.6/8=10 days/irrigation

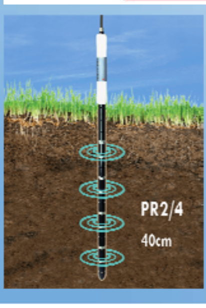
Net water applied = ETc*Irrigation frequency=8*10=80 mm for every 10 days. (No rain)

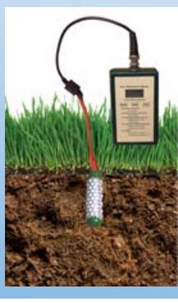
Example 3 In case of rain, assumed that there will be 2 mm. of effective rainfall available during the growing season.

Net water applied=80-2*10=60 mm for every 10 days.

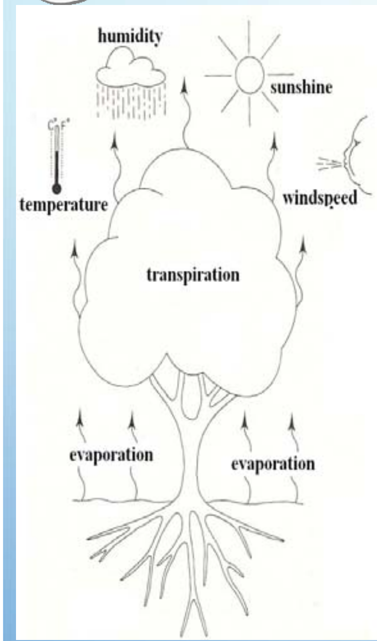
IRRIGATION SCHEDULING INSTRUMENTS



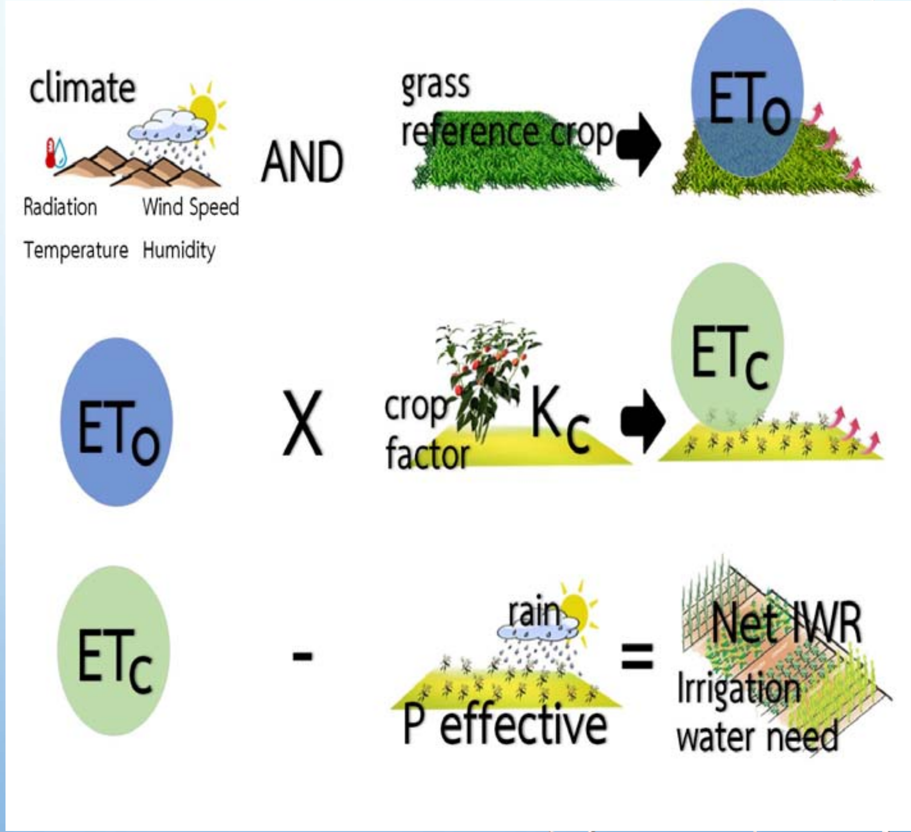




Crop & Irrigation Water Requirements

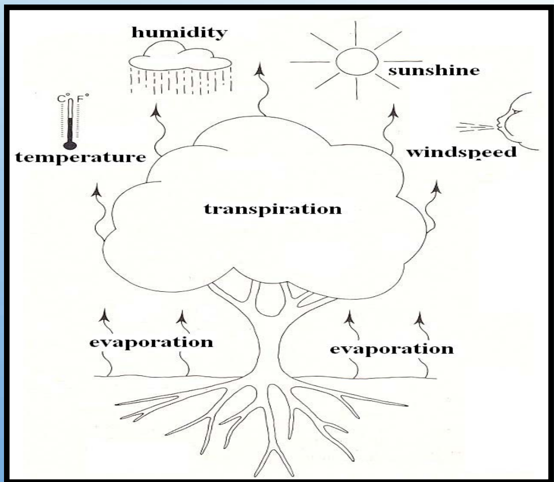


Evapotranspiration (ET) = Evaporation + Transpiration



Crop Water Requirements(ETc)

Crop evapotranspiration under standard conditions; disease-free, well-fertilized crops , grown in large fields, under optimum soil water conditions, and achieving full production under the given climatic conditions.

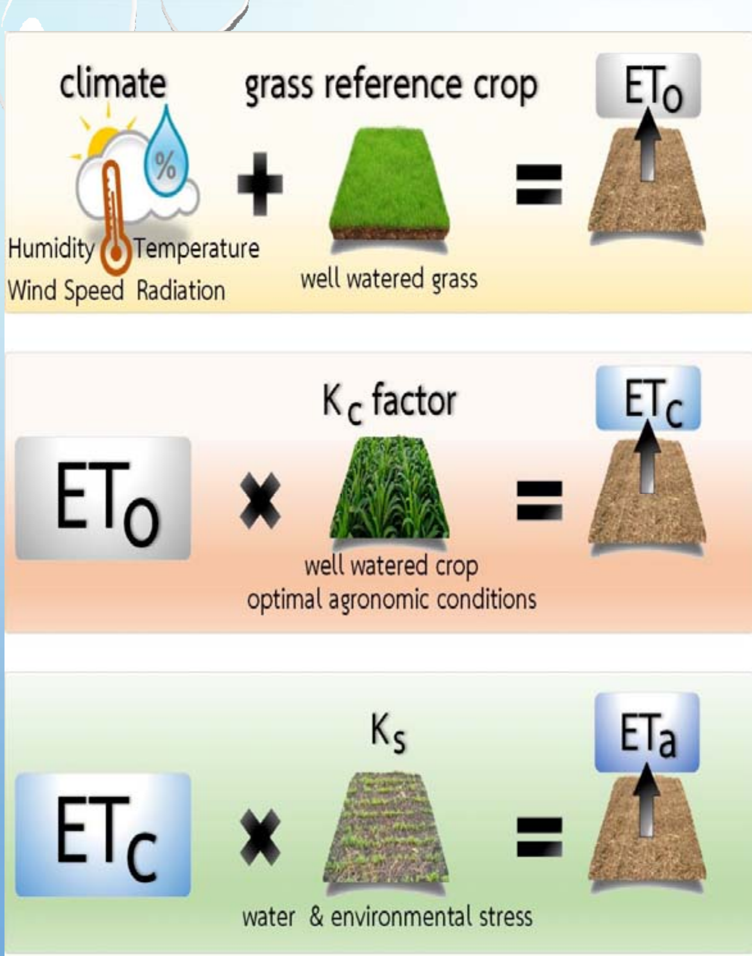


When the standard conditions are not met, the actual crop ET will be lower than ETc.

Crop water requirements for Prachuap Khiri Khan province, Central and Western Thailand
Downloaded from URL: water.rid.go.th/hwm/cropwater/CRWdata/ET

Crop No.	Crop name	Growth period	Crop water requirements	
		days	mm./season	m^3/rai
1	Rice-Rice Department High Yield Variety	100	699	1,119
2	Rice-Khao Dok Mali 105	100	629	1,006
3	Rice-Basmati	100	695	1,112
4	Wheat	100	311	498
5	Maize	100	351	561
6	Sweet corn	75	274	438
7	Sorghum	110	387	619
8	Soy bean	100	373	596
9	Peanut	105	371	594
10	Mung bean	70	215	344
11	Sesame	90	295	471
12	Tobacco	90	398	637
13	Sun flower	110	392	627
14	Water melon	85	418	668
15	Cotton	160	471	753
16	Sugarcane	300	978	1,564
17	Castor bean	200	745	1,191
18	Taro	170	1,177	1,884
19	Asparagus	365	1,526	2,442
20	Tomato	110	494	791
21	Onion	100	395	632
22	Shallots	85	304	487
23	Garlic	110	269	431
24	Potato	95	368	588
25	Bird's eye chilli	150	483	774
26	Bitter gourd	75	326	522
27	Cauliflowers	45	197	316
28	Chinese kale	55	165	265
29	Yard long bean	80	287	459
30	Graden pea	85	302	484
31	Winged bean	135	396	634
32	Chinese cabbage	60	196	313
33	Chinese radish	45	186	297
34	Baby corn	65	287	459
35	Sweet potato	125	465	744

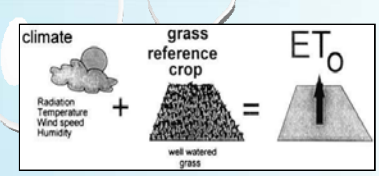
An example seasonal crop water requirement published by RID



3 ET terms

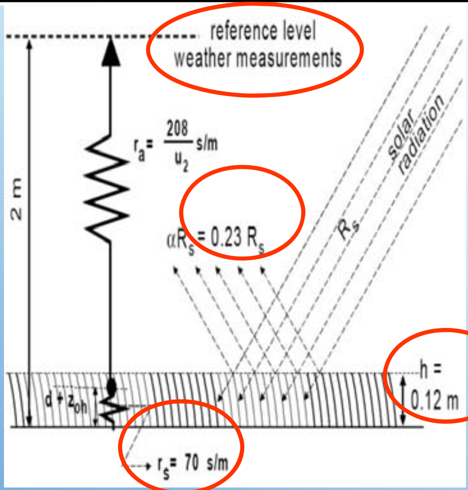
ETo → ETc → ETa

ETo= Reference crop ET depends on climatic data only.
ETc=Kc.ETo
Kc=Crop coefficient depending types of crop and stage of growth
ETa=Ks.ETc
Ks=Water stress coefficient



ET_O = f(CLIMATE)

The evapotranspiration rate from a reference surface, not short of water, is called the reference crop evapotranspiration (ETo)



The reference surface is a hypothetical grass reference crop with specific characteristics, height of 0.12 m with a surface resistance of 70 s/m and an albedo of 0.23. This crop characteristics is closely resembling the evapotranspiration of green grass of uniform height, actively growing and adequately watered.

Penman-Monteith is recommended method for ETo calculation.

Average ETo for different agroclimatic regions(mm/day)

Regions	Mean daily temperature (◦C)		
	Cool ~10◦C	Moderate 20◦C	Warm > 30◦C
Tropics and subtropics			
- humid and sub-humid	2 - 3	3 - 5	5 - 7
- arid and semi-arid	2 - 4	4 - 6	6 - 8
Temperate region			
- humid and sub-humid	1 - 2	2 - 4	4 - 7
- arid and semi-arid	1 - 3	4 - 7	6 - 9

FAO PENMAN-MONTEITH FORMULA

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma\left(\frac{900}{T+273.16}\right)U_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34U_2)}$$

ETo = reference evapotranspiration [mm day-1]

Rn =net radiation at the crop surface [MJ m-2 day-1]

G = soil heat flux density [MJ m-2 day-1]

T = air temperature at 2 m height [◦C]

u2 = wind speed at 2 m height [m s-1]

es = saturation vapour pressure [kPa]

ea = actual vapour pressure [kPa]

es - ea = saturation vapour pressure deficit [kPa]

Δ = slope of vapour pressure curve [kPa ◦C-1]

γ = psychrometric constant [kPa ◦C-1].

1 mm/day = 2.45 MJ/m^2/day ,1bar = 100 kPa

Penman-Monteith Formula

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma\left(\frac{900}{T+273.16}\right)U_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34U_2)}$$

ET_o	=	Reference crop evapotranspiration	(mm/day)
Δ	=	Slope of saturation vapor pressure curve	(kPa/°C)
γ	=	Psychrometric constant	(kPa/°C)
R_n	=	Net radiation at crop surface	(MJ/m^2/day)
G	=	Soil heat flux	(MJ/m^2/day)
T_{max}	=	Maximum air temperature	(°C)
T_{min}	=	Minimum air temperature	(°C)
T	=	Average air temperature	(°C)
U_2	=	Windspeed measured at 2 m height	(m/s)
e_s	=	Saturated vapor pressure	(kPa)
e_a	=	Actual vapor pressure	(kPa)

		1.Calculate Δ, T, e_s	
Δ	=	$\frac{4098 e_s}{(T+237.3)^2}$	[1]
e_s	=	$\frac{e^\circ(T_{max})+e^\circ(T_{min})}{2}$; (Saturation Vapor Pressure)	[2]
$e^\circ(T_{max})$	=	$0.6108 Exp\left(\frac{17.27\, T_{max}}{T_{max}+237.3}\right)$	[3]
$e^\circ(T_{min})$	=	$0.6108 Exp\left(\frac{17.27\, T_{min}}{T_{min}+237.3}\right)$	[4]
T	=	$\frac{T_{max}+T_{min}}{2}$	[5]
		2.Calculate e_a	
e_a	=	$\frac{RH_{mean}}{100} e_s$	[6]
		3.Calculate U_2	
U_2	=	$u_{z'} \frac{4.87}{\ln(67.8z'-5.42)}$; z'=*Wind vane elevation (m)*	[7]
		4.Calculate γ (Psychrometric constant)	
γ	=	0.665×10^{-3} P	[8]
P	=	$101.3\left(\frac{293-0.0065z}{293}\right)^{5.256}$; (Atmospheric pressure at altitude z m. MSL, kPa)	[9]

		5.Calculate R_n (Net radiation)	
R_n	=	$R_{ns}-R_{nl}$	[10]
R_{ns}	=	$(1-\alpha)R_s=(1-0.23)R_s$; (Net shortwave radiation)	[11]
R_s	=	$\left(a_s + b_s\frac{n}{N}\right)R_a = \left(0.25+0.5\frac{n}{N}\right)R_a$; (Solar radiation)	[12]
n	=	Actual sunshine hours (given data)	
N	=	$\frac{24}{\pi}\omega_s$; (Daylight hours)	[13]
R_a	=	$\frac{24(60)}{\pi} G_{sc} d_r[\omega_s \sin(\phi)\sin(\delta)+\cos(\phi)\cos(\delta)\sin(\omega_s)]$	[14]
		(Extraterrestrial radiation, MJ/m²/day)	
G_{sc}	=	0.0820 ; (Solar constant, MJ/m²/min)	[15]
d_r	=	$1+0.033\cos\left(\frac{2\pi}{365}J\right)$; (Inverse relative distance between Earth-Sun)	[16]
J	=	Integer(30.4M-15)	[17]
		No. of day in a year (Jan.1 =1, Dec.31=365), M=Month (1, 2, .. ,12)	
J	=	Integer(275M/9-30+D)-2 ; M=month, D=day for leap year	[18]
ω_s	=	$Cos^{-1}[-\tan(\phi)\tan(\delta)]$; (*Sunset hour angle*)	[19a]
or ω_s	=	$\frac{\pi}{2} - tan^{-1}\left[\frac{-\tan(\phi)\tan(\delta)}{X^{0.5}}\right]$	[19b]
X	=	$1-[\tan(\phi)]^2[\tan(\delta)]^2$	[20a]
X	=	0.00001 if X≤0	[20b]
ϕ	=	Latitude(radians)	
δ	=	$0.409 sin\left(\frac{2\pi}{365}J-1.39\right)$; (*Solar declination angle*)	[21]
R_{nl}	=	$\sigma\left[\frac{T_{max.k}{}^4+T_{min.k}{}^4}{2}\right](0.34-0.14\sqrt{e_a})\left(1.35\frac{R_s}{R_{so}}-0.35\right)$	[22]
		(Net long wave radiation, MJ/m²/day)	
σ	=	4.903×10^{-9} ; (Stefan-Boltzman constant, MJ/m²/day)	[23]
Tmax.k	=	Tmax(°c)+273.16	[24]
Tmin.k	=	Tmin(°c)+273.16	[25]
$\frac{R_s}{R_{so}}$	=	Relative shortwave radiation ≤ 1.0	
R_{so}	=	$(0.75+2\times10^{-5}z)R_a$; (Clear-sky radiation)	[26]
		6.Calculate G	
G	=	0.14 (T_i - T_{i-1}); (Soil heat flux)	[27]

ETo calculation

Given Data		
Month(M)	2	February
Latitude(ϕ)	26.56	°
Tmean(i-1)	18	°c
Tmax	26.3	°c
Tmin	11.9	°c
Tmean	19.1	°c
Altitude(z)	120	m
u_2(m/s)	1.2	m/s
RH_{mean}=	63	%
n	8.4	hrs.

Calculation 1			Description
Tmean=	19.1	°c	
e°(Tmax)=	3.42	kPa	Saturation vapor pressure at Tmax
e°(Tmin)=	1.39	kPa	Saturation vapor pressure at Tmin
e_s=	2.41	kPa	Saturation vapor pressure
Δ=	0.15	kPa/°c	Slope of saturation vapor pressure curve
P=	99.89	kPa	Atmosheric pressure
γ=	0.07	kPa/°c	Psychrometric constant
$(1+0.34u_2)$=	1.41		
$[\Delta+\gamma(1+0.34u_2)]$=	0.24		
$\Delta/[\Delta+\gamma(1+0.34u_2)]$=	0.62		
$\gamma/[\Delta+\gamma(1+0.34u_2)]$=	0.27		
$[900/(Tmean+273.16)]u_2$=	3.71		
$e_a=(RH_{mean}/100)*e_s$=	1.52	kPa	
e_s-e_a=	0.89	kPa	Saturation vapor pressure deficit
Aerodynamic term=	0.9006	mm/day	

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Calculation 2			
J=	45	sin	Number of days in year
ϕ=	0.4636	0.4471	Latitude
δ=	-0.2361	-0.2339	Solar declination angle
X=	0.9855		
ws=	1.4502	1.4502	Sunset hour angle
dr=	1.0236		Inverse relative distance between Earth-Sun
Gsc=	0.0820	MJ/m2/min	Solar constant
ws*sin(ϕ)*sin(δ)=	-0.1517		
sin(ws)=	0.9927		
cos(ϕ)*cos(δ)*sin(ws)=	0.8633		
R_a=	27.3794	MJ/m2/day	Extraterrestrial radiation
N=	11.0790	hrs	Daylight hours
Rs=	17.22	MJ/m2/day	
α=	0.23		Albedo
σ=	4.903E-09		Stefan-Boltzman constant
Tmax.k^4=	8,041,837,275		Tmax in kelvin
Tmin.k^4=	6,603,058,170		Tmin in kelvin
Tmean.k^4=	7,322,447,722		Tmean in kelvin
Rso=	20.5351	MJ/m2/day	Clear-sky radiation
Rs/Rso=	0.8388		Relative shortwave radiation
sqrt(e_a)=	1.2315		
R_{nl}=	4.7416	MJ/m2/day	Net longwave radiation
$R_n=R_{ns}-R_nl$=	8.5210	MJ/m2/day	Net solar radiation
G=0.14[Tmean(i)-Tmean(i-1)]=	0.1540	MJ/m2/day	Soil heat flux
Radiation term[1]=	2.10	mm/day	
Aerodynamic term[2]=	0.90	mm/day	
ETo=[1]+[2]	3.00	mm/day	
	84.1	mm/month	

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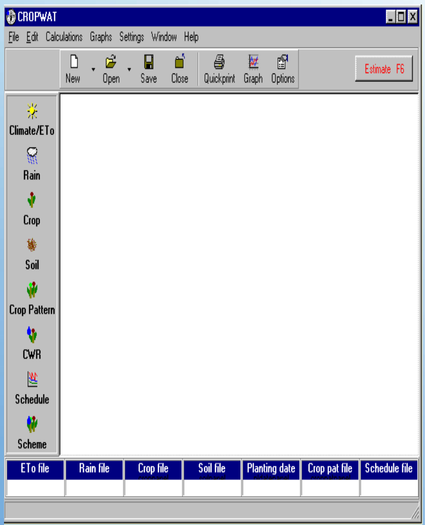


Program structure = 8 different modules

Data input & basic calculation modules

(1) **Climate/ETo**: Input the measured ETo data or climatic data for ETo calculation

(2) **Rain**: Input the rainfall data and calculation of effective rainfall

(3) **Crop**: Input the crop data and planting date for ETc calculation in (6)

(4) **Soil**: Input the soil data for irrigation scheduling in (7)

(5) **Crop pattern**: Input the cropping pattern for scheme supply calculations in (8)

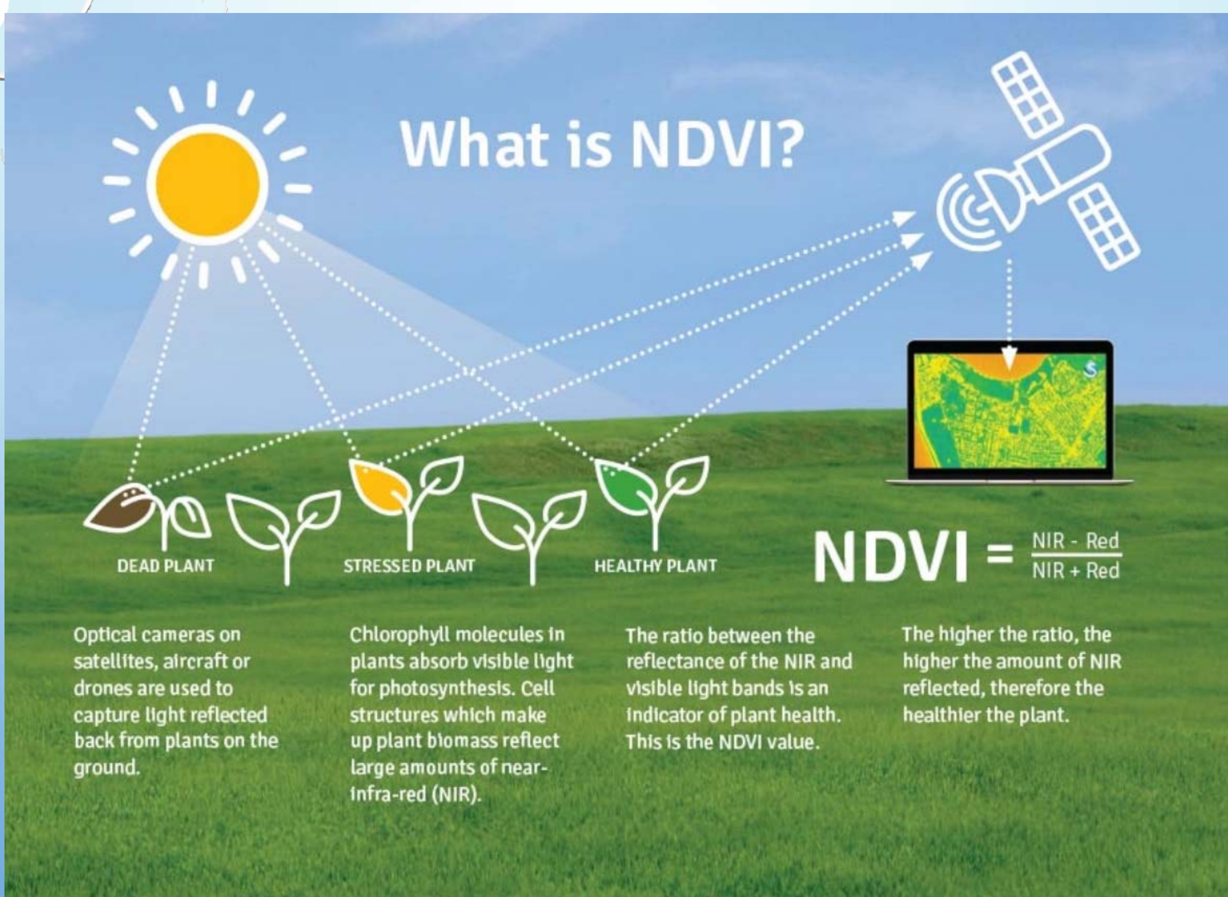
Note that in fact Climate/ETo and Rain modules are not only for data input but also calculate data, namely Radiation / ET0 and Effective rainfall respectively.

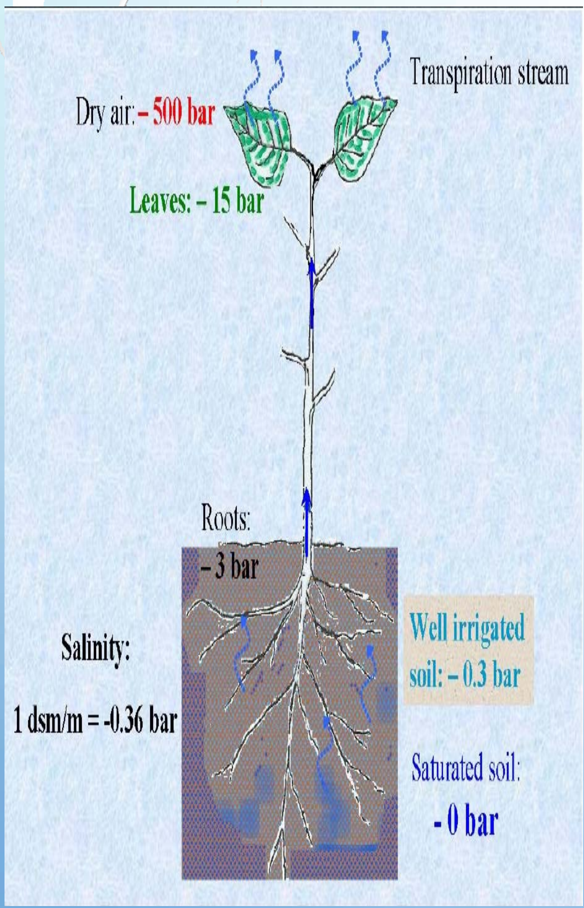
Calculation modules

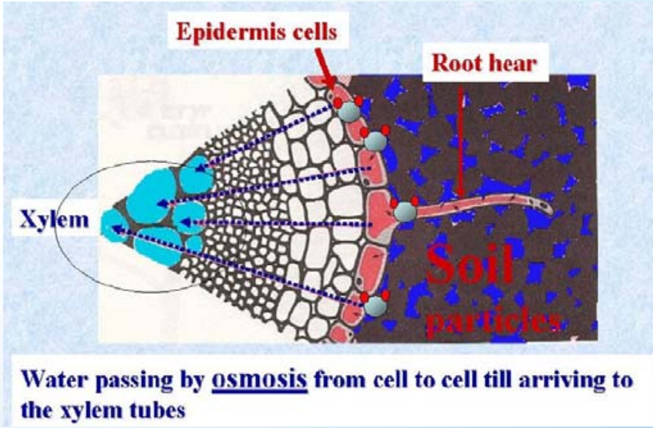
(6) **CWR** - for calculation of Crop Water Requirements

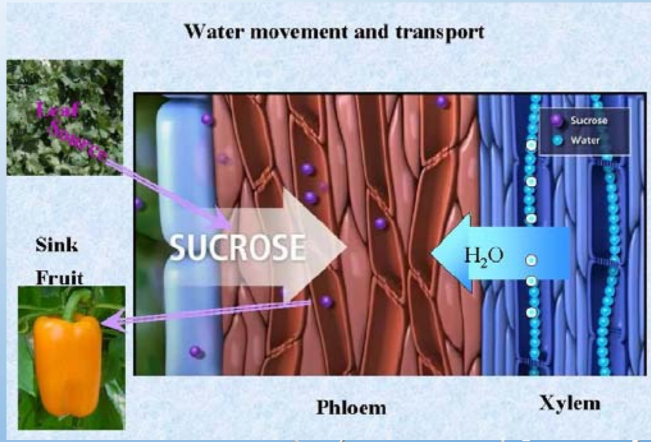
(7) **Schedules** - for the calculation of irrigation schedules

(8) **Scheme** - for the calculation of scheme supply based on a specific cropping pattern









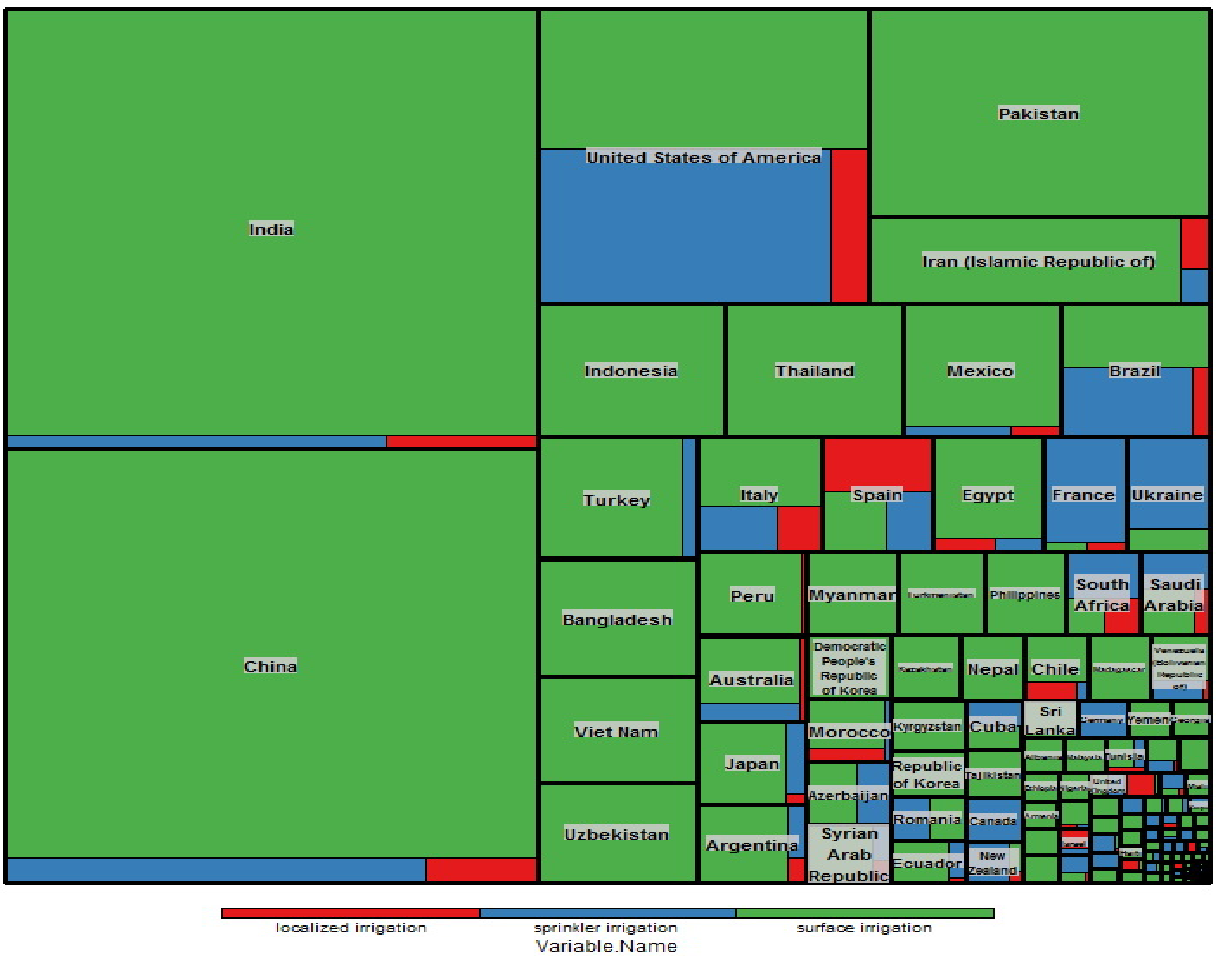
Irrigation efficiency(%)			
	Low	Medium	High
Application Efficiency (E_a)	50	80	65
Surface irrigation	50	80	65
Sub-surface irrigation		<60	
Sprinkler	60	80	70
Paddy field	65	75	70
Field Canal Efficiency (E_b)	70	90	80
Conveyance Efficiency (E_c)	65	90	78
Irrigation Efficiency ($E_i=E_a.E_b.E_c$)	23	65	44

*Doorenbos and Pruitt(1977) and Ilaco/Empire M&T(1979)

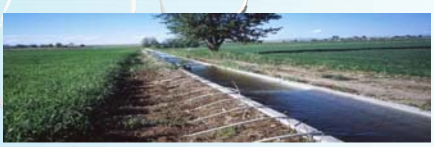
2.IRRIGATION METHODS

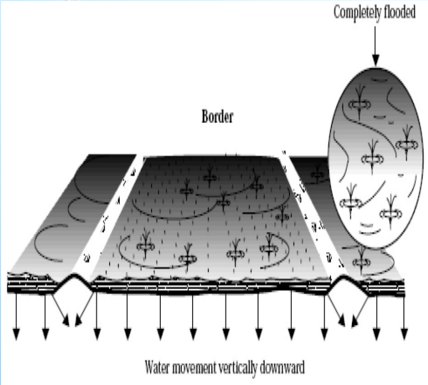
- SURFACE IRRIGATION
  - FURROW
  - BORDER
  - BASIN
- SPRINKLER IRRIGATION
  - FIXED SYSTEM
  - BIG GUN
  - CENTER PIVOT
  - LATERAL MOVE
- MICRO-IRRIGATION
  - DRIP OR TRICKLE
  - MICRO SPRAY
  - MICRO SPRINKLER
- SUB-SURFACE IRRIGATION
  - OPEN DITCH
  - BURIED PIPE

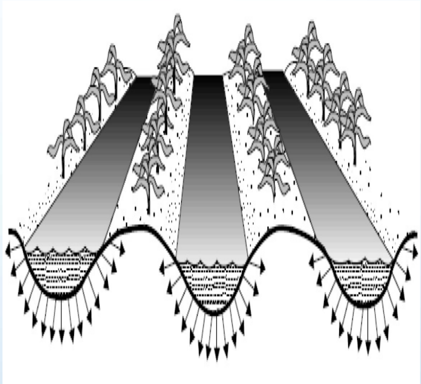
Modern Techniques:
Greenhouse, Hydroponics, Aeroponics, Aquaponics, Plant Factory, Nano Farm

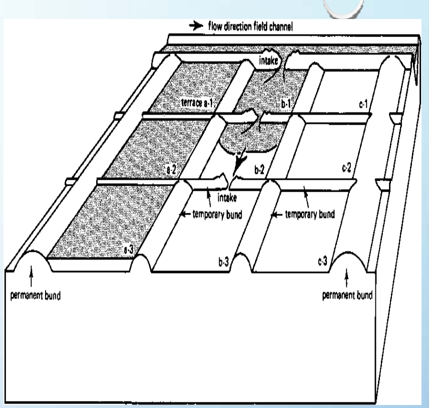


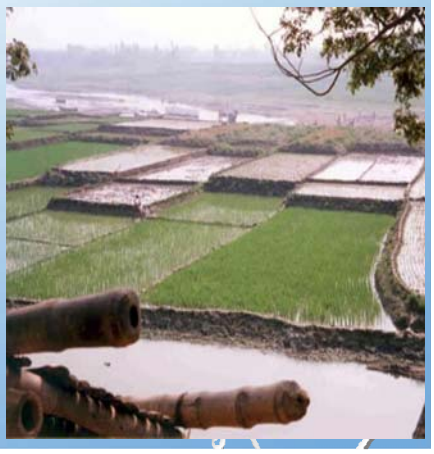
SURFACE IRRIGATION
BORDER-FURROW-BASIN



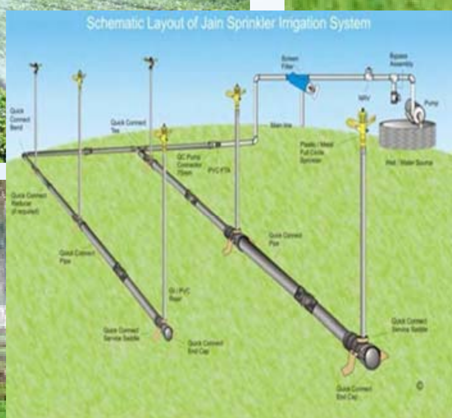








SPRINKLER IRRIGATION

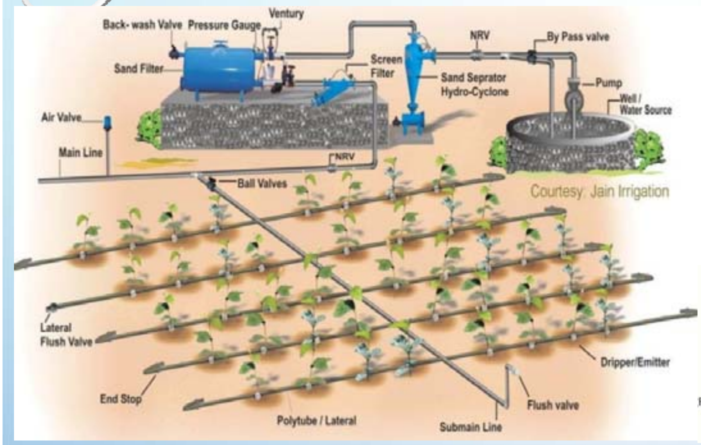


CENTER PIVOT

Precision Irrigation Technology

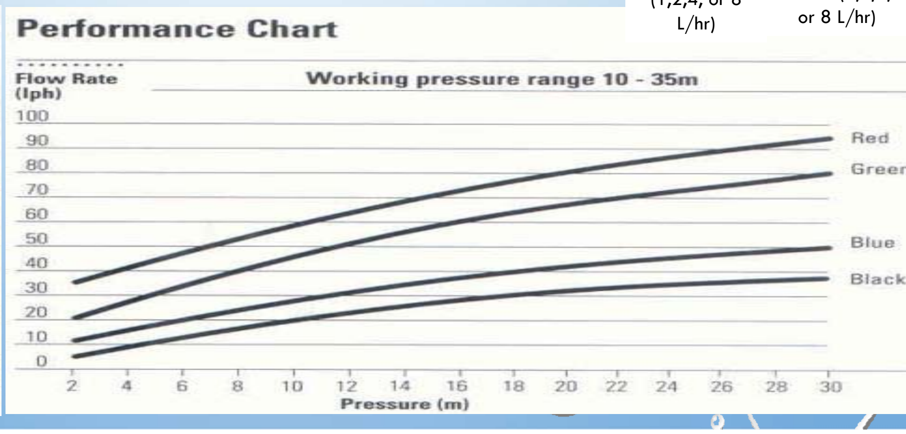
LINEAR MOVE

MICRO-IRRIGATION(LOCALIZED)

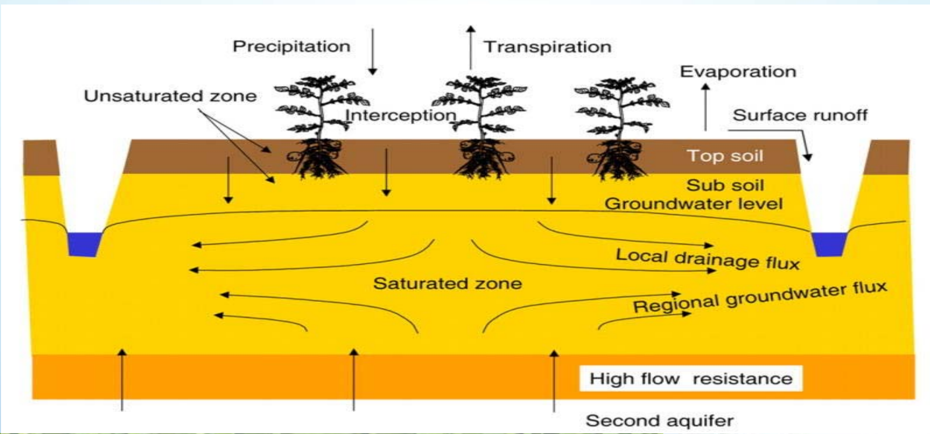


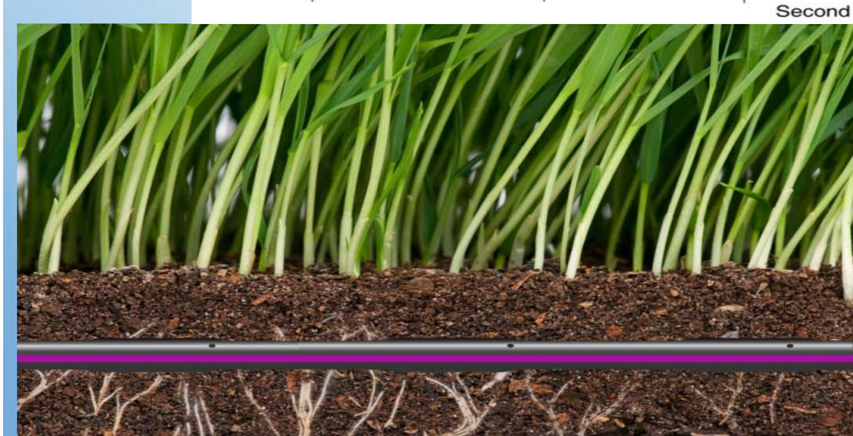
Woodpecker Nipple Outlet (1,2,4, or 8 L/hr)

Woodpecker Barbed Outlet (1,2,4, or 8 L/hr)



SUB-SURFACE IRRIGATION





Application efficiency (E_a)

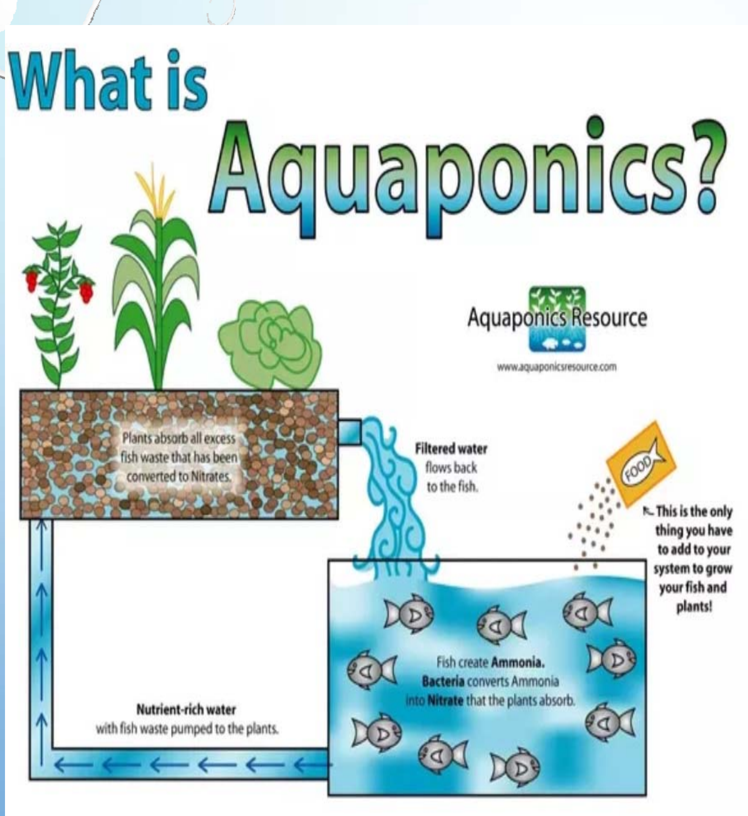
Surface Irrigation
(E_a = 50-70%)

Sprinkler Irrigation
(E_a = 70-80%)

Micro-Irrigation
(E_a = 80-95%)

SPECIAL IRRIGATION PRACTICES

OTHER MODERN TECHNOLOGY
Green Houses, Hydroponics, Aeroponics, Aquaponics, Plant Factory, Nano Farm



MGR ONLINE

"บริษัท 808 Factory มีโรงงานผลิตพืชขนาดใหญ่ มีระบบการจัดการแบบปิดที่มีการควบคุมสภาวะแวดล้อมต่างๆ ทั้ง แสง น้ำ อากาศ การให้ปุ๋ย ทำให้พืชผักที่ปลูกในโรงงานแห่งนี้ ไม่มีการปนเปื้อนจากโรคและแมลงศัตรูพืช โรงงานแห่งนี้มีพื้นที่การผลิตอยู่ที่ 1,000 ตารางเมตร สามารถปลูกพืชได้มากถึง 120,000 ต้น มีอัตราการเก็บเกี่ยวอยู่ที่ 9,000 ต้นต่อวัน การผลิตพืชระบบนี้ลดค่าใช้จ่ายด้านต่างๆ ไปได้มาก เช่น ลดการใช้สารฆ่าแมลง ลดการใช้น้ำ ลดการใช้ปุ๋ย ประหยัดพื้นที่เพาะปลูก เทคโนโลยีนี้เหมาะสมที่จะนำไปเสริมคุณภาพของผลิตภัณฑ์สมุนไพร สร้างรายได้ให้ประเทศต่อไป"

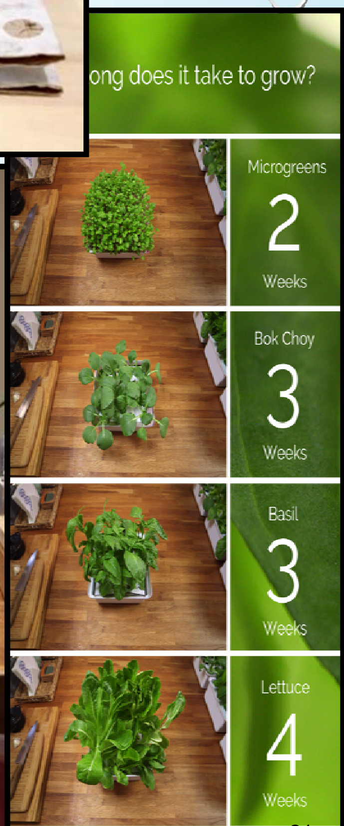
Nanofarm

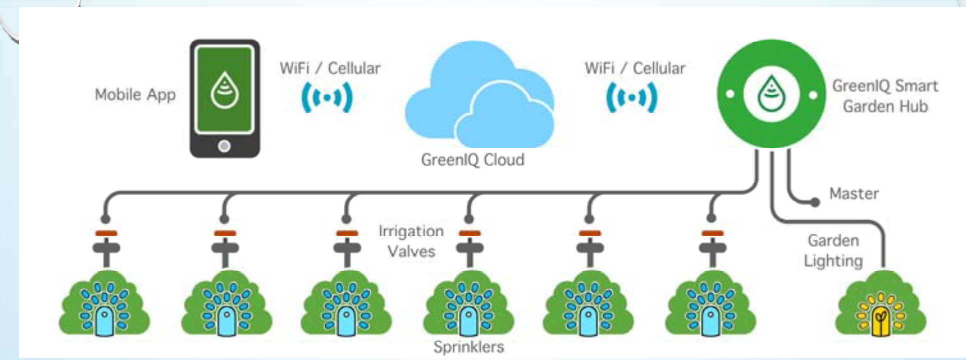
Nanofarm-to-Table
Harvest right before you eat

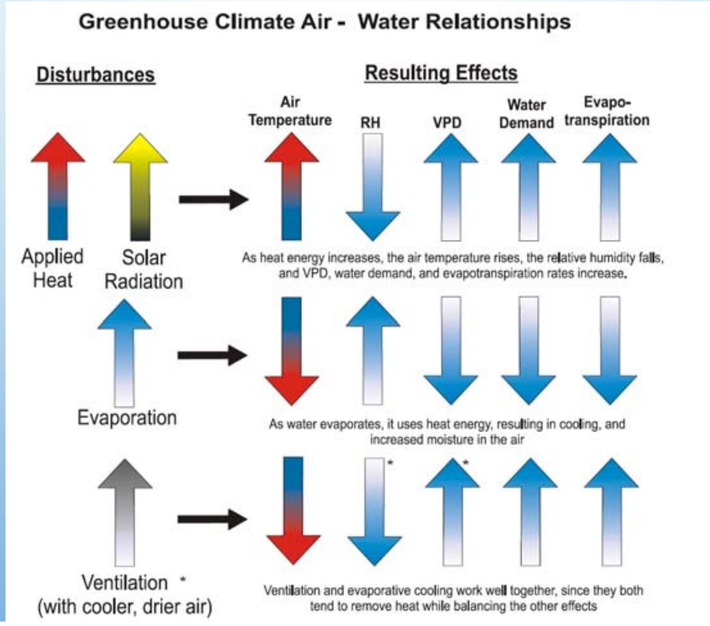
Pesticide-Free
Know what's in your food

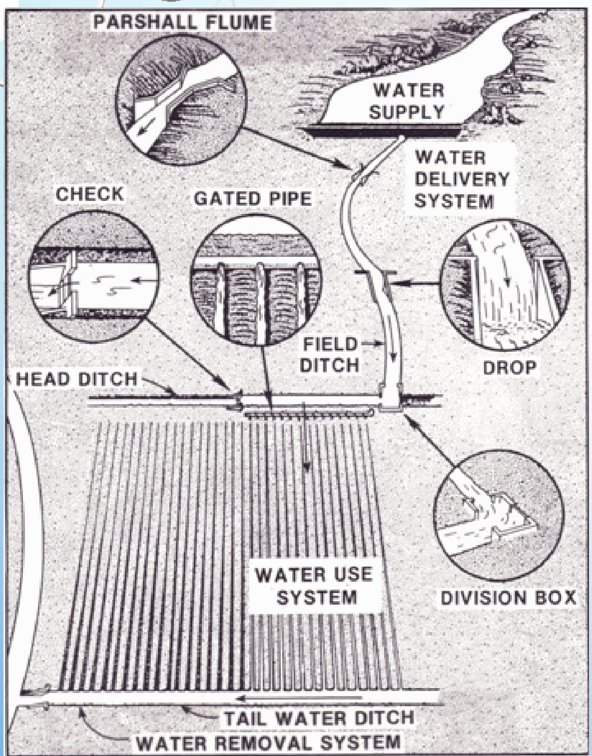
Zero Maintenance
Just Set and Forget

https://www.kickstarter.com/projects/993426736/nanofarm-the-first-appliance-that-grows-food-for-y







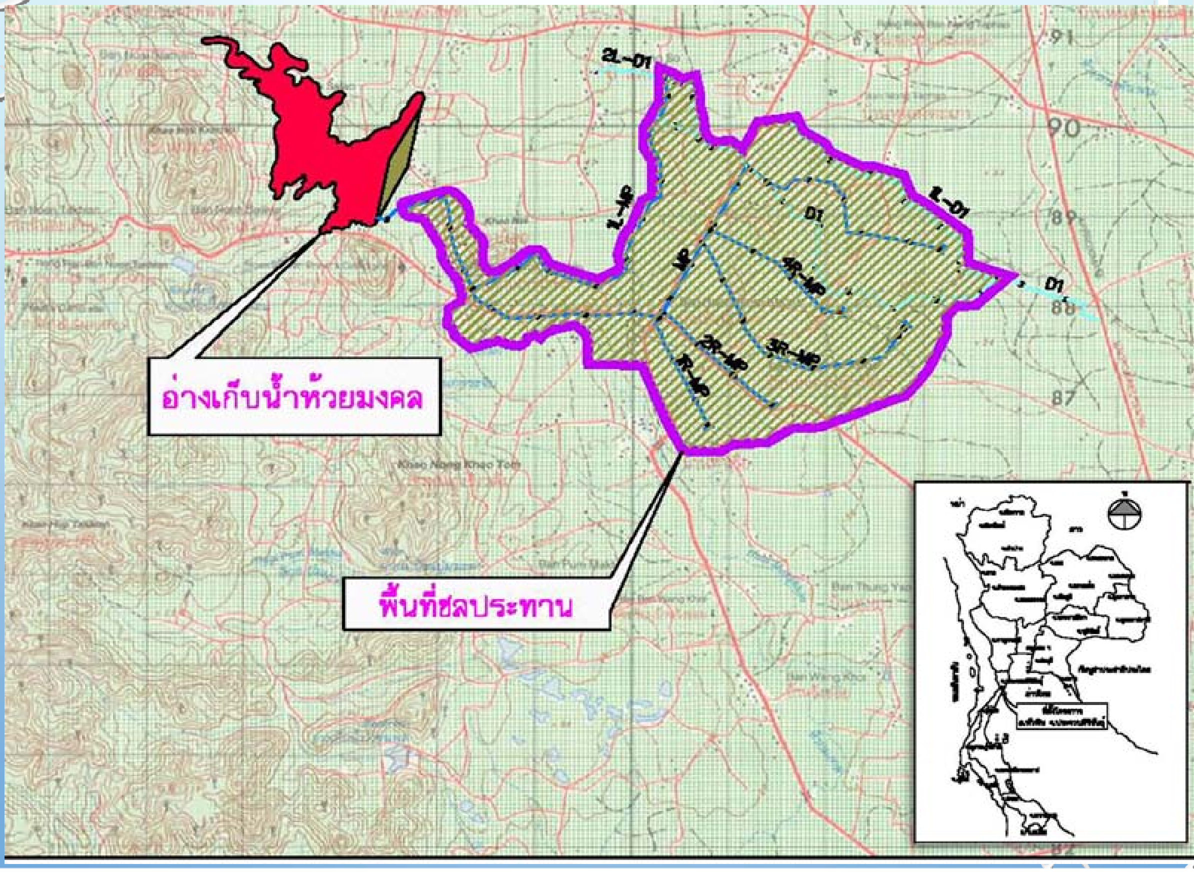


3.IRRIGATION SYSTEM

- WATER RESOURCES: RESERVOIR, RIVER, GROUNDWATER AQUIFER, ETC.
- HEADWORKS (DIVERSION DAM VS. WEIR, PUMPING STATION)
- MAIN IRRIGATION SYSTEM (CANAL VS. PIPELINE)
- FARM IRRIGATION SYSTEM
- DRAINAGE SYSTEM
- ACCESS ROAD

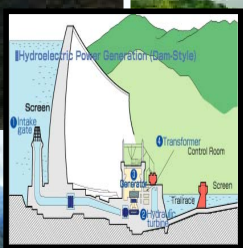
Planning, design, construction, management-operation-maintenance of irrigation system

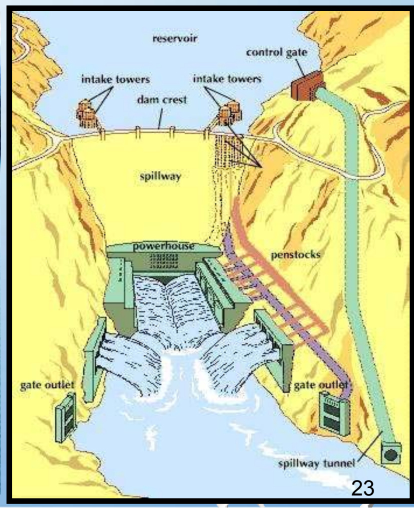
PROJECT MAP



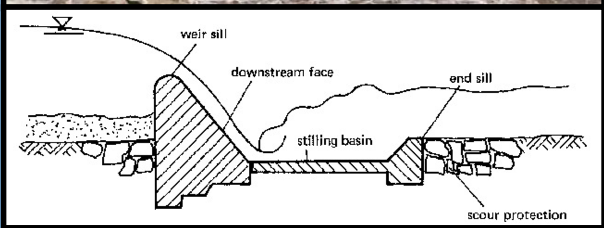
DAM AND RESERVOIR

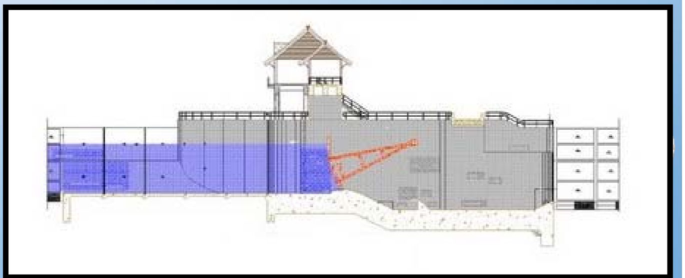




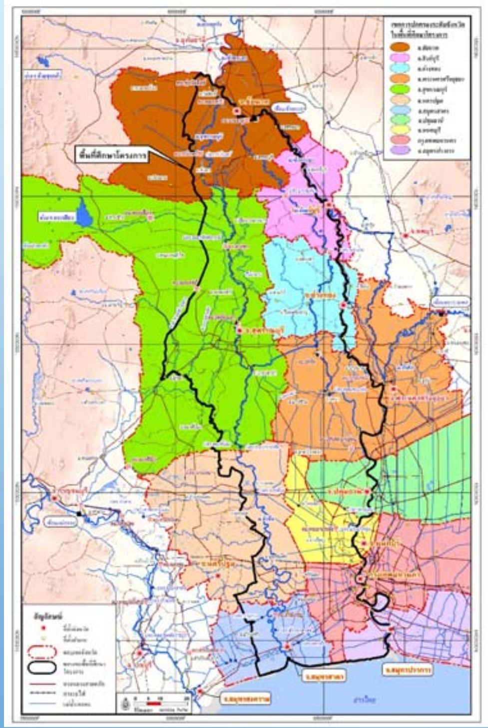


HEADWORKS-GRAVITY



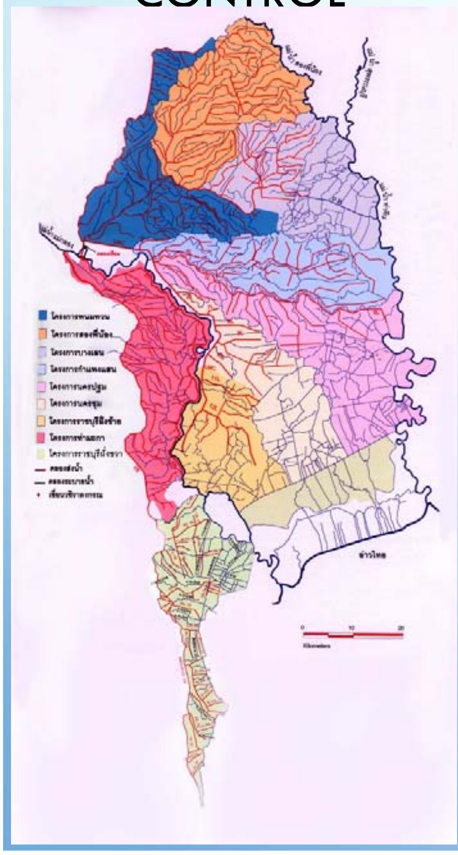


CHAO PHRAYA BARRAGE



HEADWORKS-PUMPING

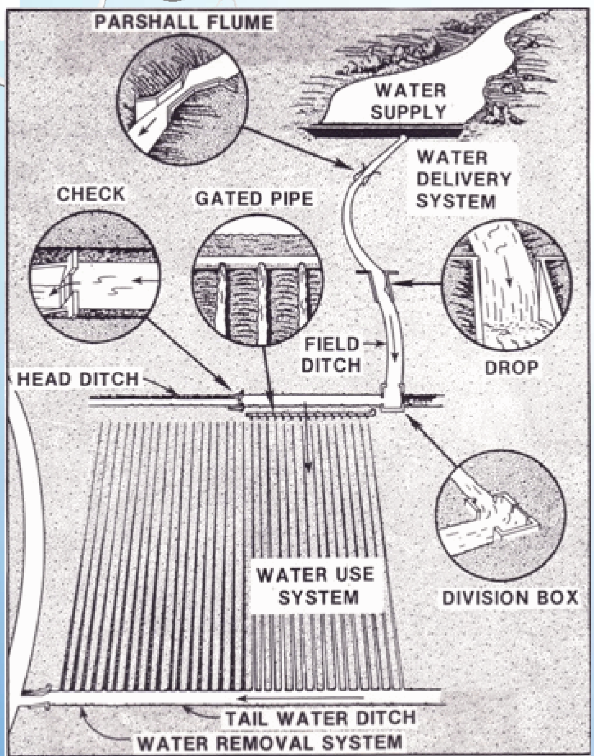
CANAL AND CONTROL



SMALL CANAL AND CONTROL STRUCTURES

FARM IRRIGATION SYSTEM

LAND CONSOLIDATION PROJECT



IRRIGATION SYSTEM

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- DRAINAGE SYSTEM
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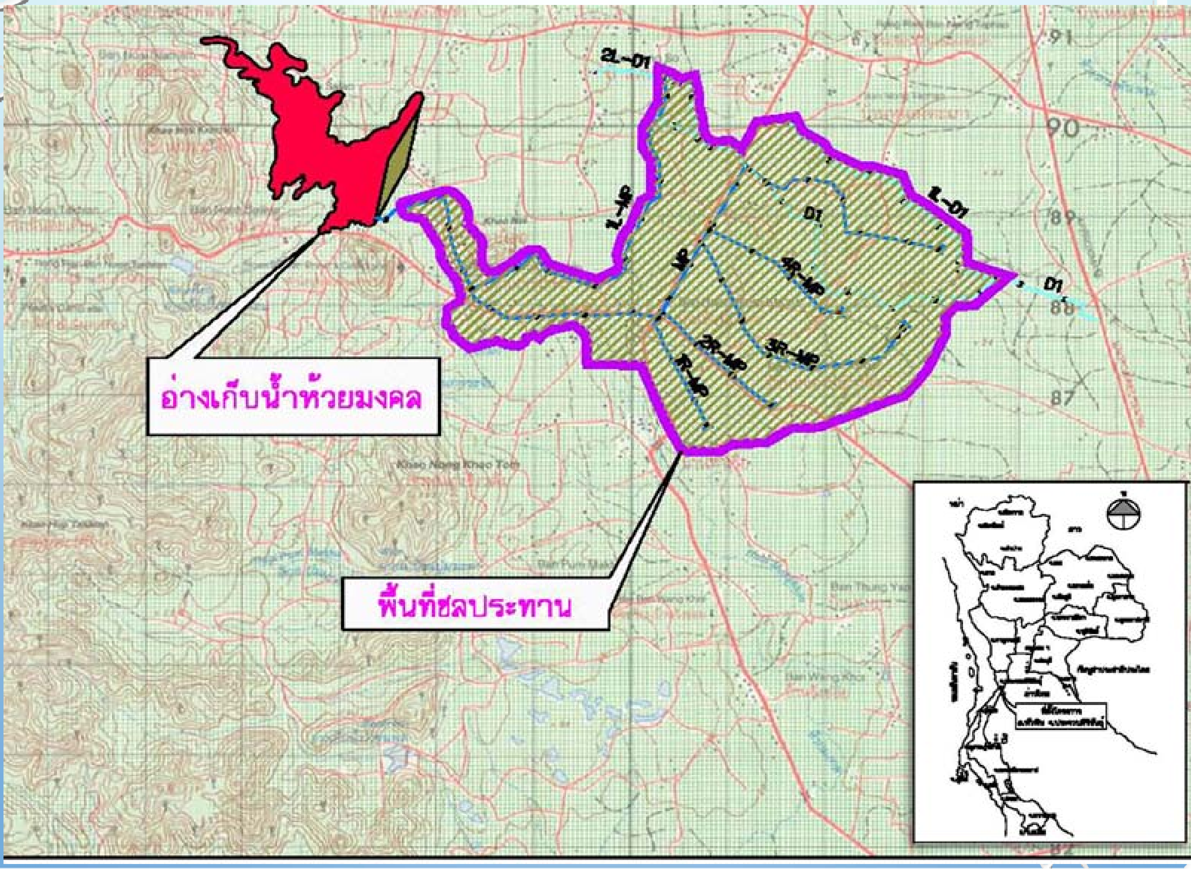
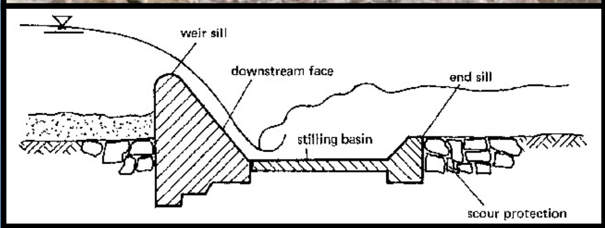
Planning, design, construction, management-operation-maintenance of irrigation system

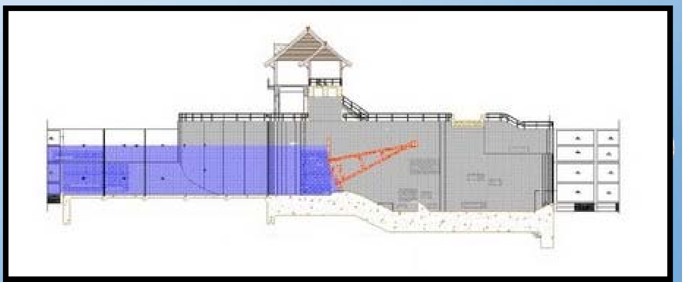
PROJECT MAP



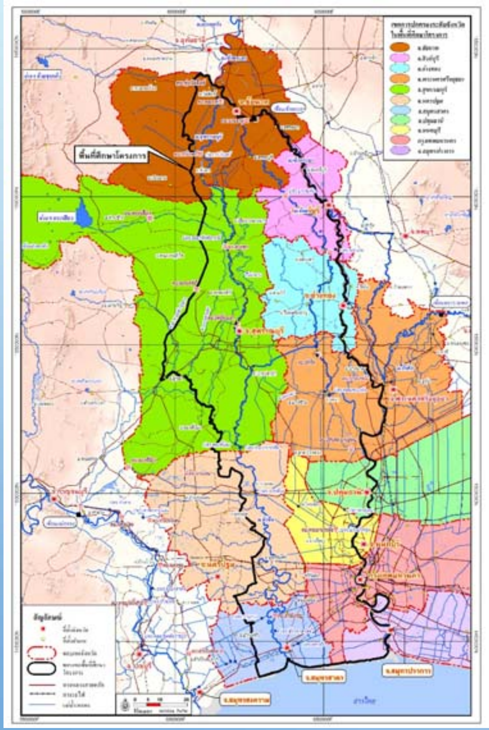
DAM AND RESERVOIR

HEADWORKS-GRAVITY



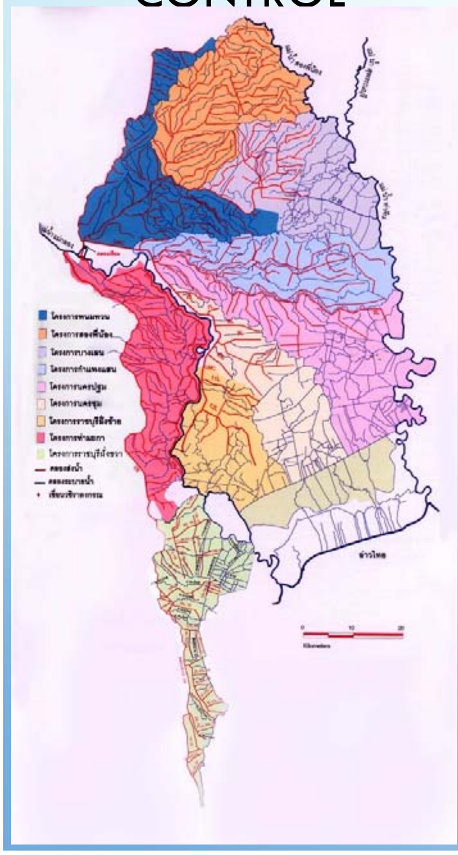


CHAO PHRAYA BARRAGE



HEADWORKS-PUMPING

CANAL AND CONTROL



SMALL CANAL AND CONTROL STRUCTURES

FARM IRRIGATION SYSTEM

LAND CONSIDATION PROJECT

4.IRRIGATION MANAGEMENT

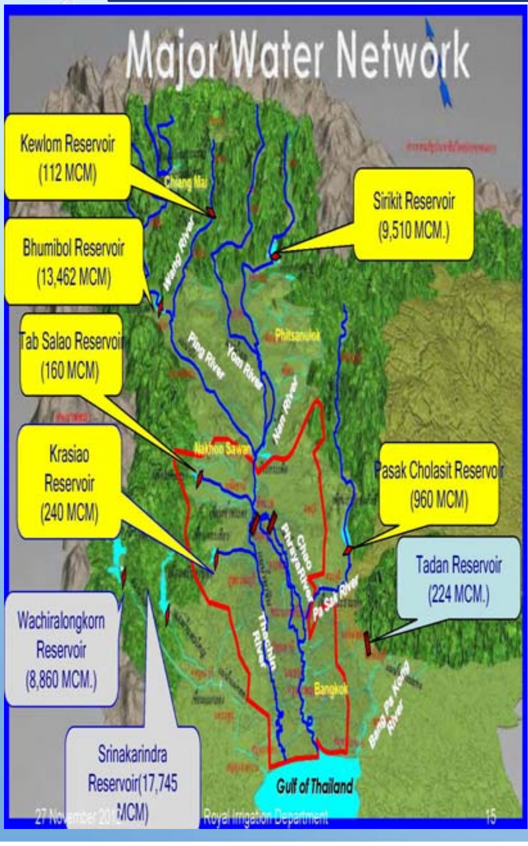
FUNCTIONS OF MANAGEMENT

= PLANNING + ORGANIZING

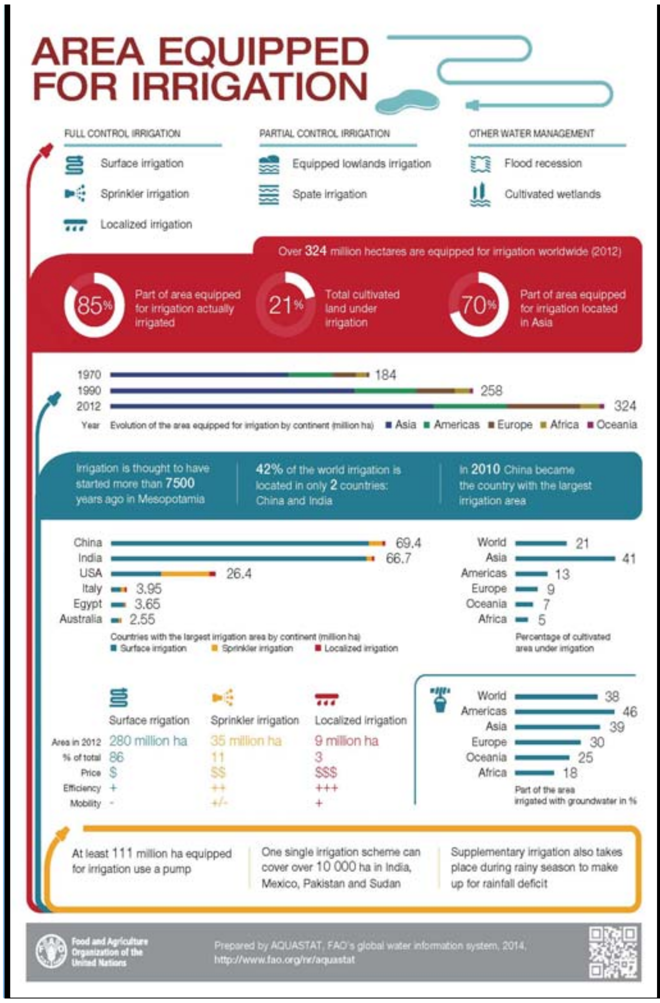
+ STAFFING + DIRECTING

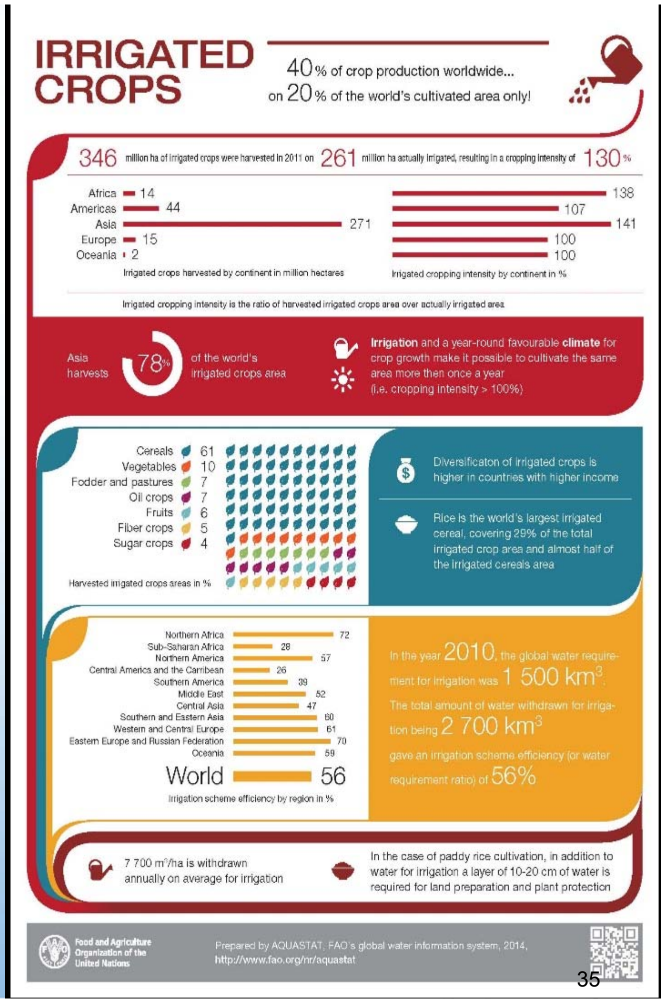
+ CONTROLING

IRRIGATION MANAGEMENT



- LEVELS
  - ON-FARM IRRIGATION MANAGEMENT
  - IRRIGATION PROJECT MANAGEMENT
  - RIVER BASIN MANAGEMENT
- CONCEPTS
  - INTEGRATED APPROACH (IWRM)
  - PARTICIPATORY IRRIGATION MANAGEMENT (PIM)
- EVENTS
  - FLOOD
  - DROUGHT
  - WATER QUALITY





IRRIGATION OBJECTIVES

- WATER SECURITY
  - REDUCE WATER SHORTAGE
  - REDUCE HARZARD FROM WATER – FLOOD DAMAGE, WATER QUALITY PROBLEM
- FOOD SECURITY
  - INCREASE CROP/LAND PRODUCTIVITY
- ECONOMIC STABILITY
  - INCREASE INCOME / REDUCE POVERTY

CROP YIELD

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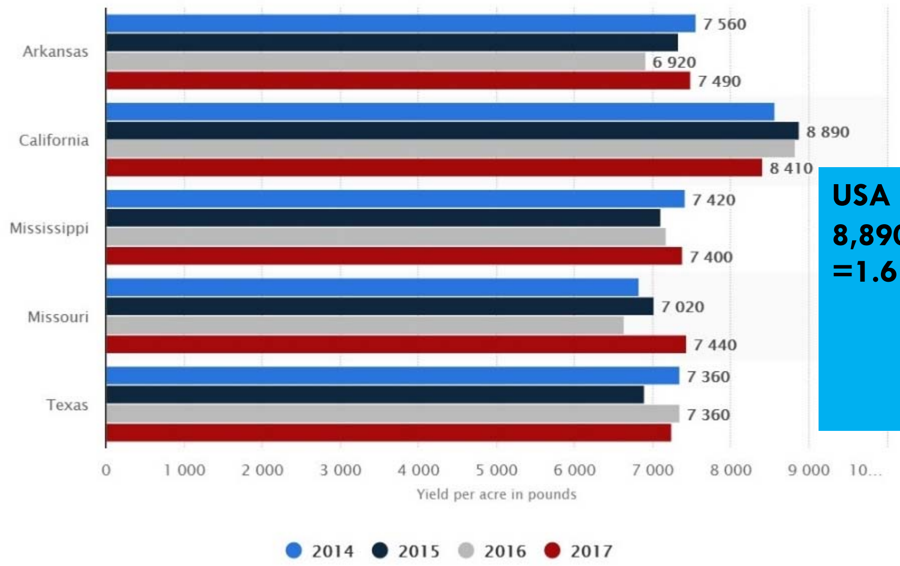
Agriculture › Farming › Leading U.S. states for rice yield per acre 2014-2017

Top U.S. states for rice yield per harvested acre from 2014 to 2017 (in pounds)



USA
8,890 pounds/acre
=1.6 ton/rai

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www.news.cn 新华网 NEWS www.xinhuanet.com

XINHUANET

Wednesday, February 14, 2018

China sets new world record for rice yield

Source: Xinhua | 2017-10-16 19:00:11 | Editor: Song Lifang

Xinhuanet App

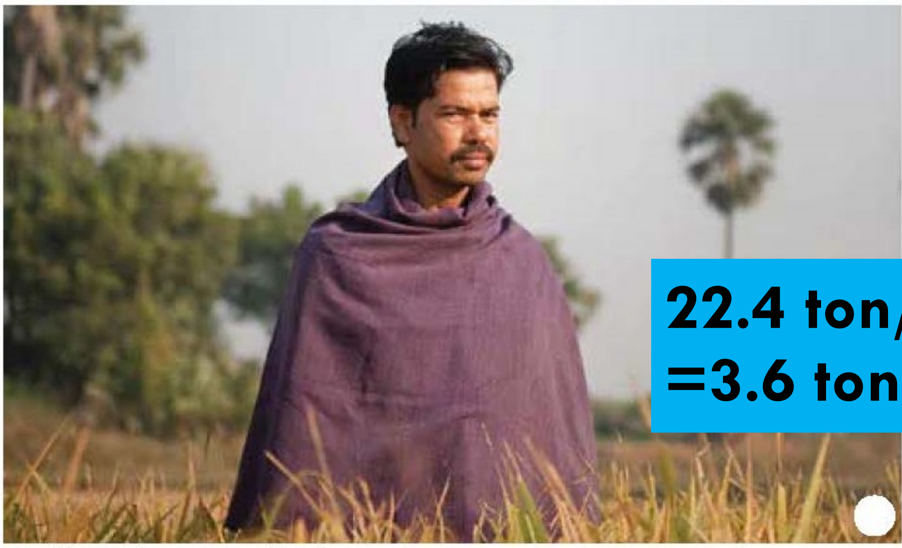
17.2 ton/hectare = 2.8 ton/rai

SHIJIAZHUANG, Oct. 16 (Xinhua) -- Yuan Longping, renowned developer of hybrid rice, has set a new world record.

A hybrid rice project headed by Yuan has achieved a yield of 1,149.02 kg of rice per mu (about 0.07 hectares), or 17.2 tonnes per hectare, in north China's Hebei Province, local authorities said Monday.

74

The Guardian



22.4 ton/hectare
=3.6 ton/rai

India's rice revolution

Sumant Kumar was overjoyed when he harvested his rice last year. There had been good rains in his village of Darveshpura in north-east India and he knew he could improve on the four or five tonnes per hectare that he usually managed. But every stalk he cut on his paddy field near the bank of the Sakri river seemed to weigh heavier than usual, every grain of rice was bigger and when his crop was weighed on the old village scales, even Kumar was shocked.

This was not six or even 10 or 20 tonnes. Kumar, a shy young farmer in Nalanda district of India's poorest state Bihar, had – using only farmyard manure and without any herbicides – grown an astonishing 22.4 tonnes of rice on one hectare of land. This was a world record and

WIKIPEDIA

Rice production in Thailand

Rice production in Thailand represents a significant portion of the Thai economy and labor force.[1] Forty percent of Thais work in agriculture, 16 million of them as rice farmers by one estimate.[2][3]

Thailand has a strong tradition of rice production. It has the fifth-largest amount of land under rice cultivation in the world and is the world's second largest exporter of rice.[4] Thailand has plans to further increase the land available for rice production, with a goal of adding 500,000 hectares to its already 9.2 million hectares of rice-growing areas.[5][6] Fully half of Thailand's cultivated land is devoted to rice.[7]

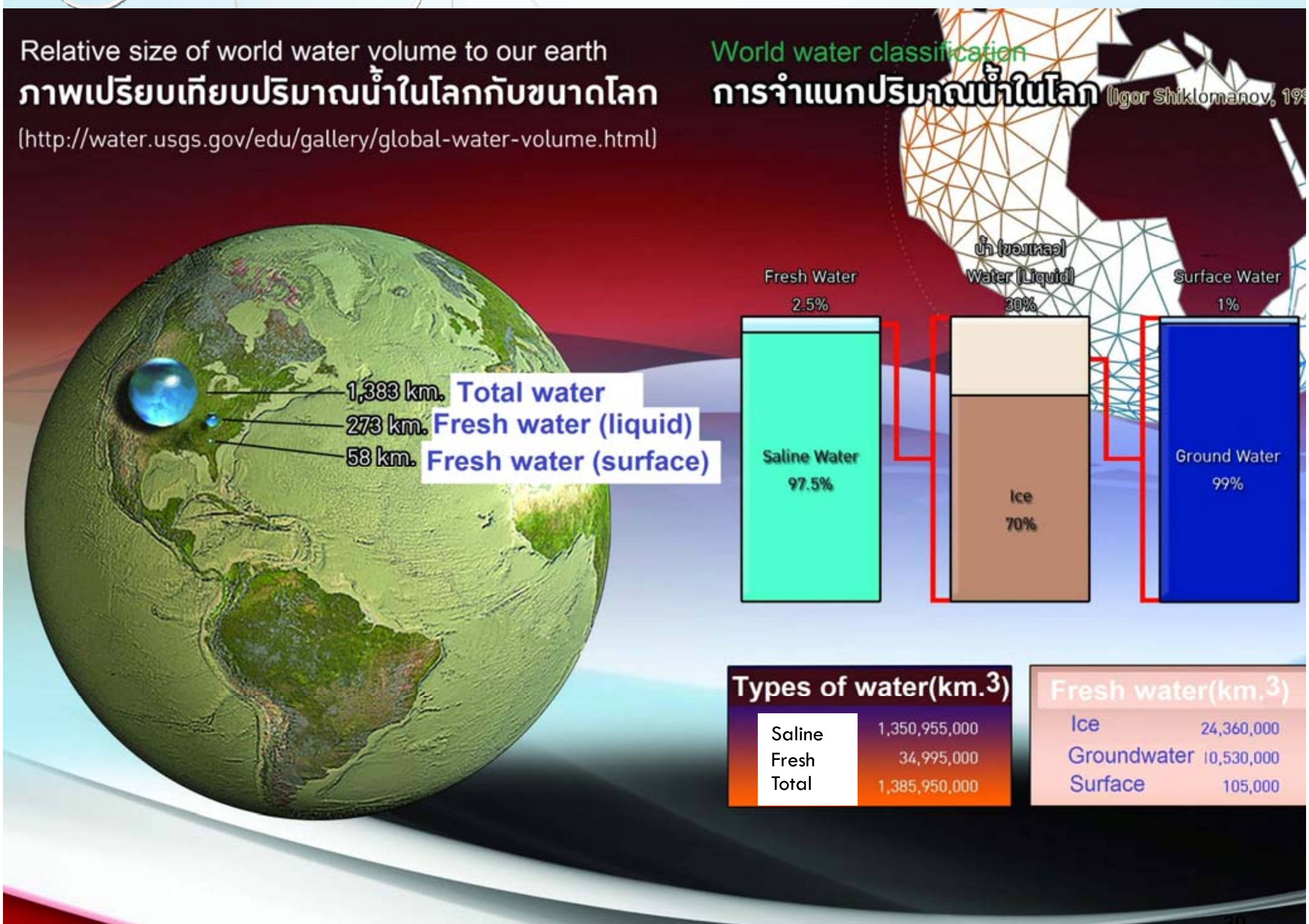
Rice plantation in Thailand

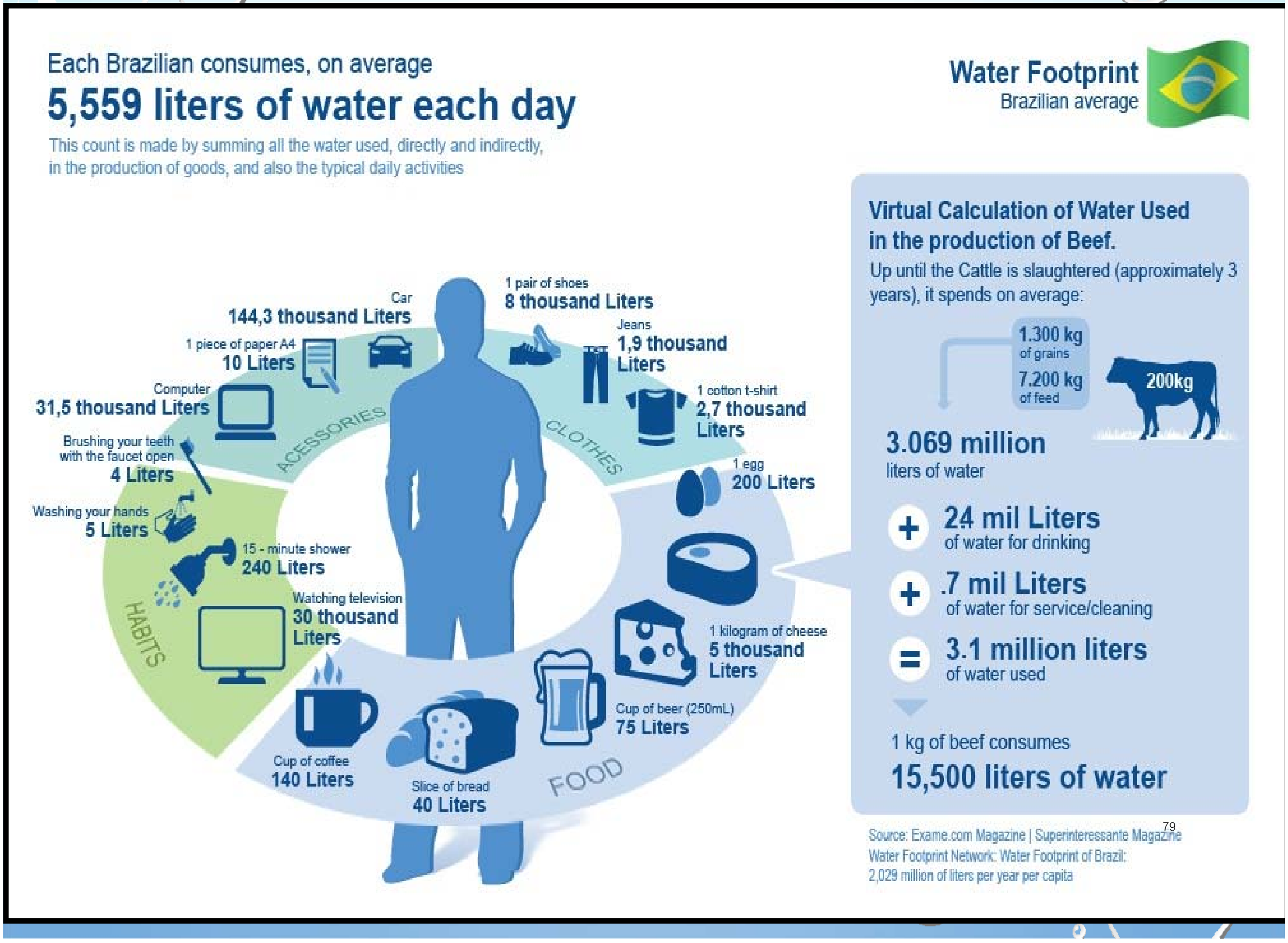
Max. recorded yield		
USA	1.6 t/rai	x3
China	2.8 t/rai	x5
India	3.6 t/rai	x7

The Thai Ministry of Agriculture expects rice production to yield around 25 million tonnes of paddy rice in the 2016-2017 crop year, down from 27.06 million tonnes in 2015-2016.[8] Jasmine rice (Thai: ข้าวหอมมะลิ; RTGS: *khao hom*

27.06 million ton/9.2 million ha.
=2.94 ton/hectare =0.47 ton/rai

FACTS ABOUT WATER RESOURCES





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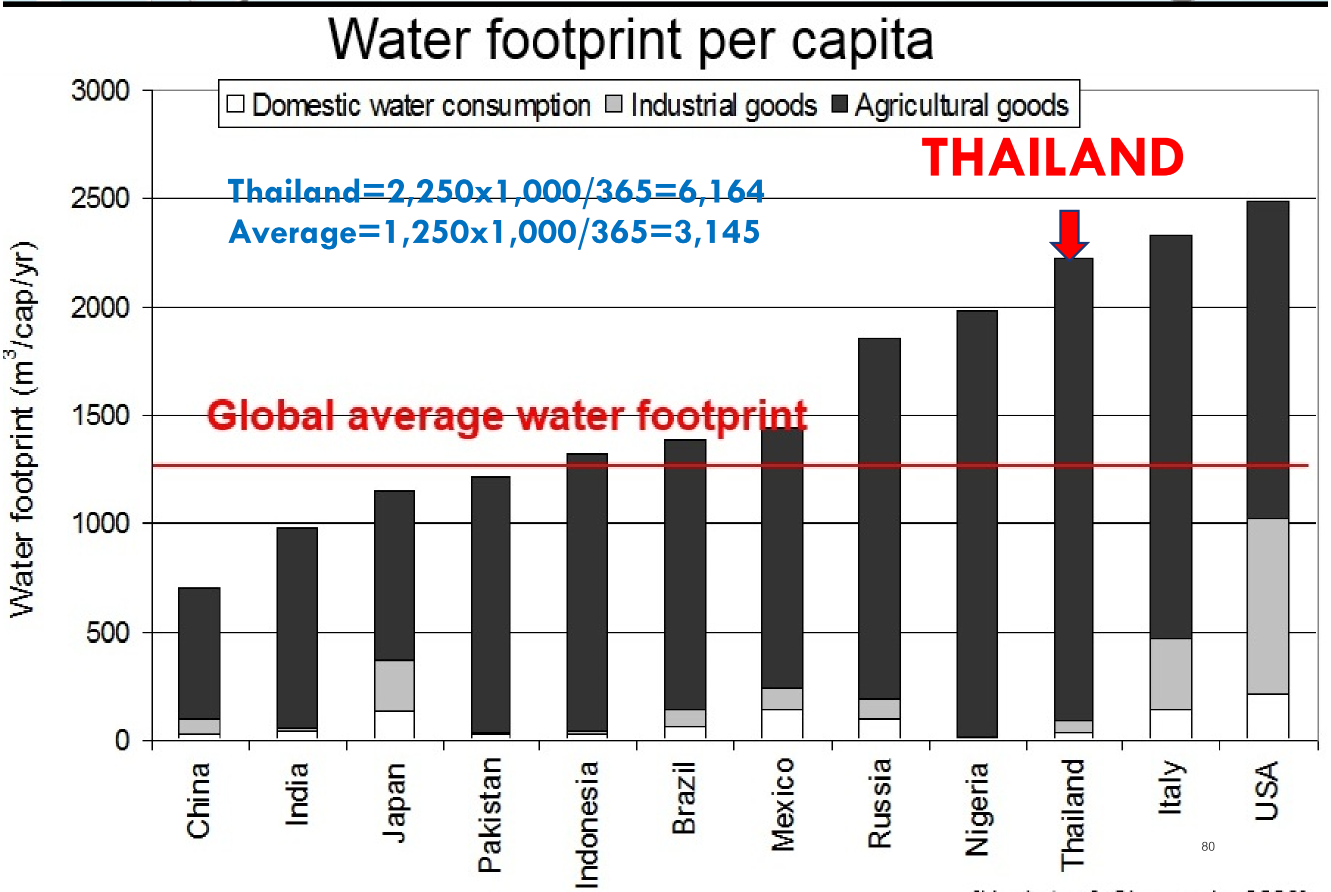
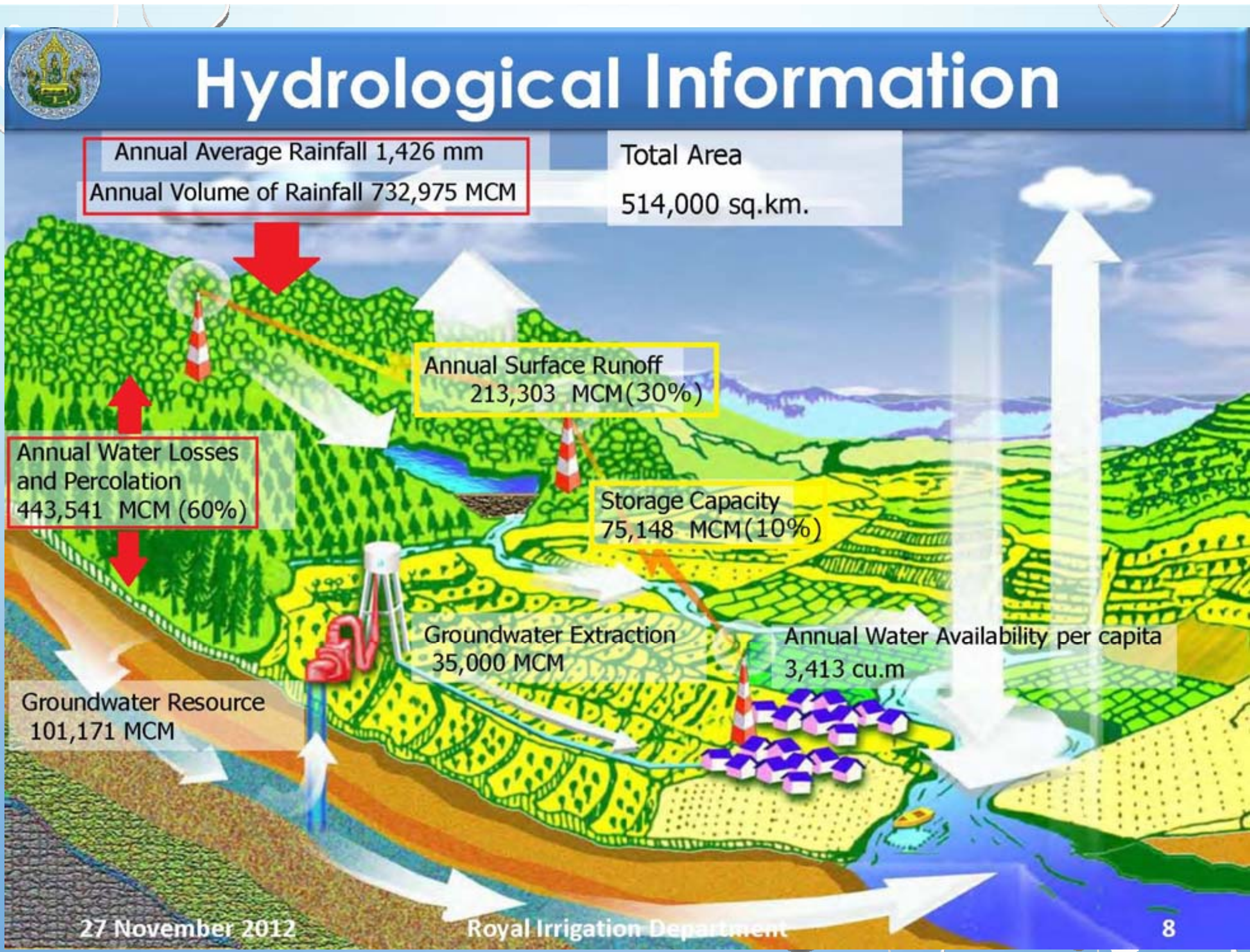
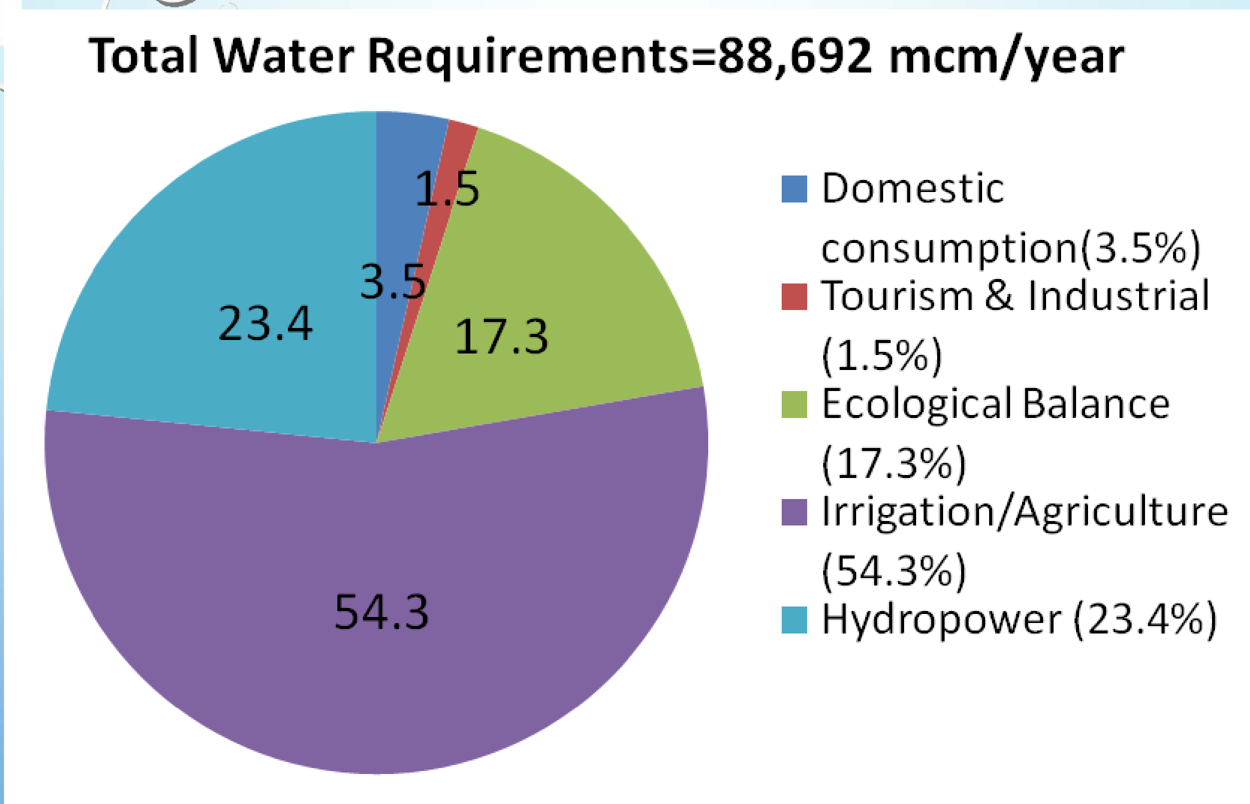


80

[Hoekstra & Chapagain, 2008]





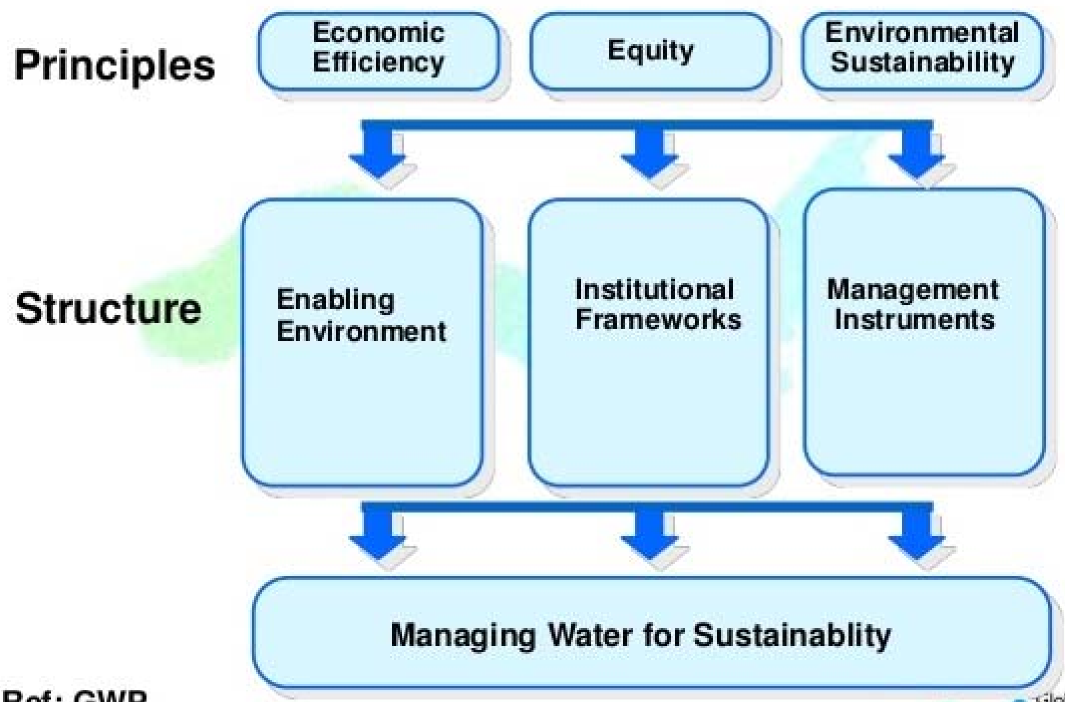
SOURCE: FAO(2010)

WATER BALANCE(THAILAND)

	Mcm/year
Surface runoff	213,000
Controllable/Utilizable	80,000
Water requirements	88,692

At present, Thailand is facing the drought situation every year when the area get rainfall less than the average. Some measures are needed to remedy the problem.

IWRM PERSPECTIVE



Ref: GWP

Global Water Partnership Southeast Asia

Modules of SIWRM

Hydro Meteorological Information System

- Real Time Rainfall Measurement
- Real time River Level & Discharge Measurement
- Automatic Full Climate
- Reservoir water Level & Outflow discharge

Flood Forecasting & Flood monitoring system with Dam Automation

- Integration to Hydro Meteorological system for accurate Reservoir operation
- Early Flood warning & inflow forecasting system
- Spillway gate control for flood Management

Canal Automation & Smart Irrigation Management System

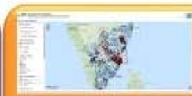
- Canal Regulation & Control System
- Water Demand & Allocation
- Crop Revenue & Water Billing
- Soil Health Card
- Fully Automated gates
- Water Audit

Smart City water Supply Management

- Water Audit
- Energy Audit
- Pumping station Automation
- WTP & Filter Bed Automation
- Water Quality parameter monitoring & control

Enterprise Management Information System

- Irrigation & Water Management
- Flood Control & Dam Safety
- Project Mgmt
- Asset Mgmt
- Billing & Revenue Collection

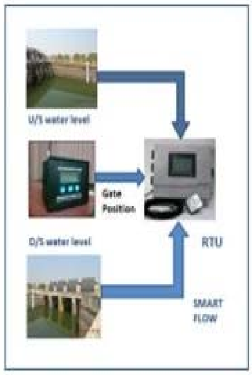


Geological Information System (GIS)

- Canal Network
- Crop Pattern Soil Health
- Land Use & Land Cover
- WUA & Farmer Information Kiosk
- Base Map, Cadastral Map

Canal Automation & Smart Irrigation Management System

- Canal Control & flow Monitoring
- Water Demand & Allocation
- Crop Revenue & Water Billing
- Soil Health Card
- Head Regulator, Cross Regulator Control



VALUE PROPOSITIONS

- One stop Info
- Operational Efficiency
- Better Visibility and Interactions
- Quick actions on IWMS
- Ready Reference of Technical data

THE END