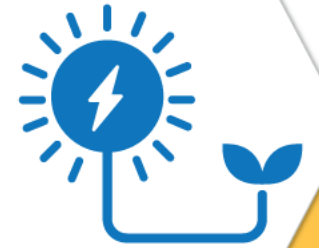




Food and Agriculture Organization
of the United Nations



FARM IRRIGATION SYSTEMS AND THEIR COMPLEXITIES

TYPES OF IRRIGATION METHODS
AND DESIGN OF A FARM IRRIGATION SYSTEM

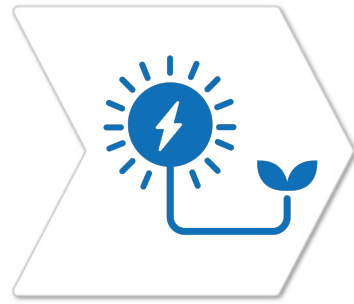
WAQAS AHMAD, IRRIGATION ENGINEER, FAO

16 February 2021



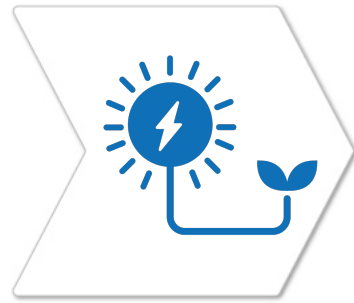
ITALIAN AGENCY
FOR DEVELOPMENT
COOPERATION

CONTENTS



- 💧 **Water Resources Systems for Irrigation**
- 💧 **Soil – Water – Atmosphere Interaction**
- 💧 **WEF Nexus**
- 💧 **Data Requirement for the Design of Farm Irrigation System**
- 💧 **Some Hydraulic Properties of Soil**
- 💧 **Frequency of Irrigation Application**
- 💧 **Complexities Affecting the Choice of Irrigation**
- 💧 **Designing a Farm Irrigation System**
- 💧 **Conclusion**
- 💧 **Recommended Literature**

WATER RESOURCES AND IRRIGATION METHODS



(FAO, UNEP, WHO; 1988)

Flood Irrigation



www.tehrantimes.com <FAO NEWS story>

Sprinkle Irrigation

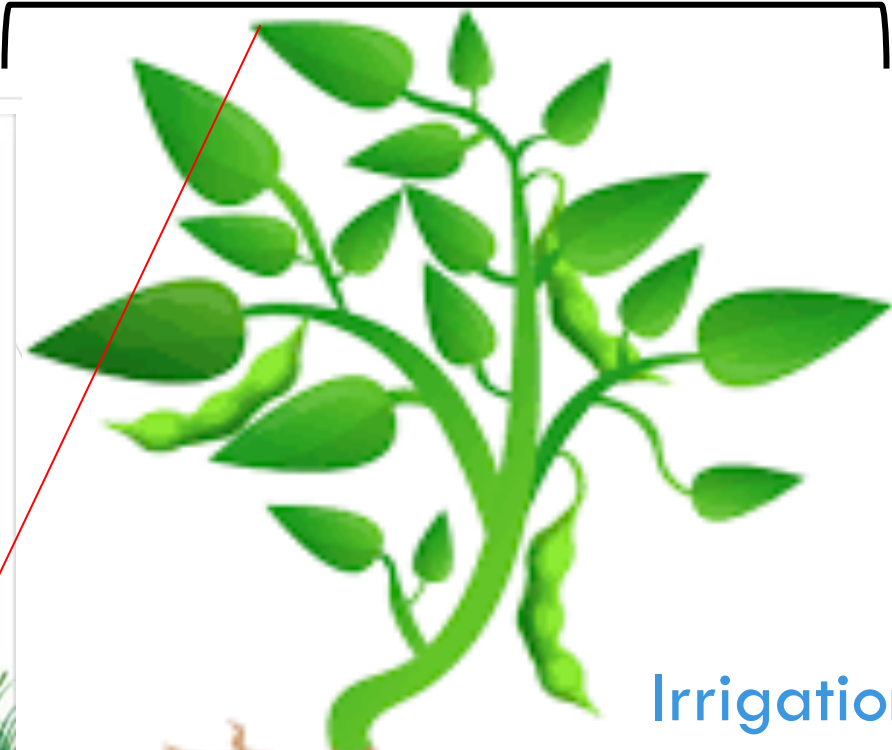


Drip Irrigation

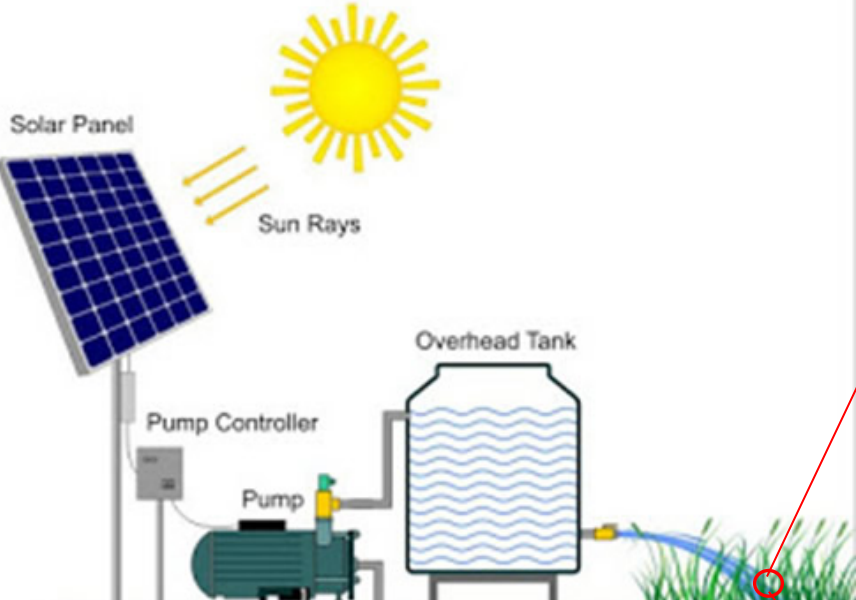
SOIL WATER AND PLANT



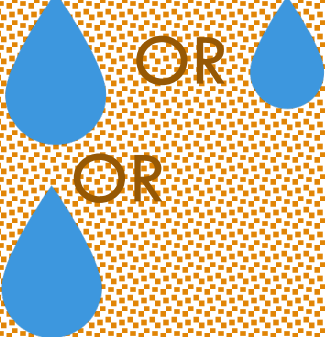
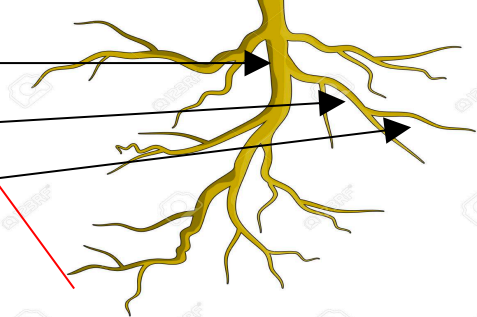
Plant canopy



Irrigation

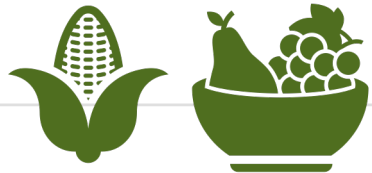


Main axis
1st order lateral
2nd order lateral



Root zone

THE INTERACTION



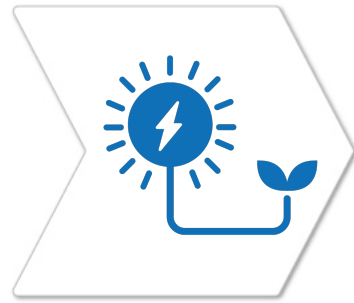
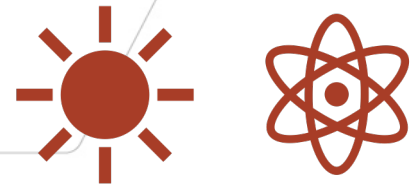
Food

Water

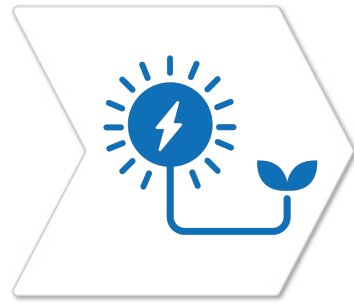


GHG

Energy



DATA REQUIREMENT FOR THE DESIGN OF A FARM IRRIGATION SYSTEM

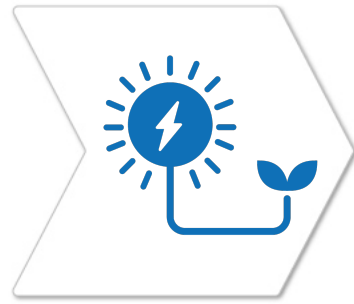


**Climatic Data
for ETo**

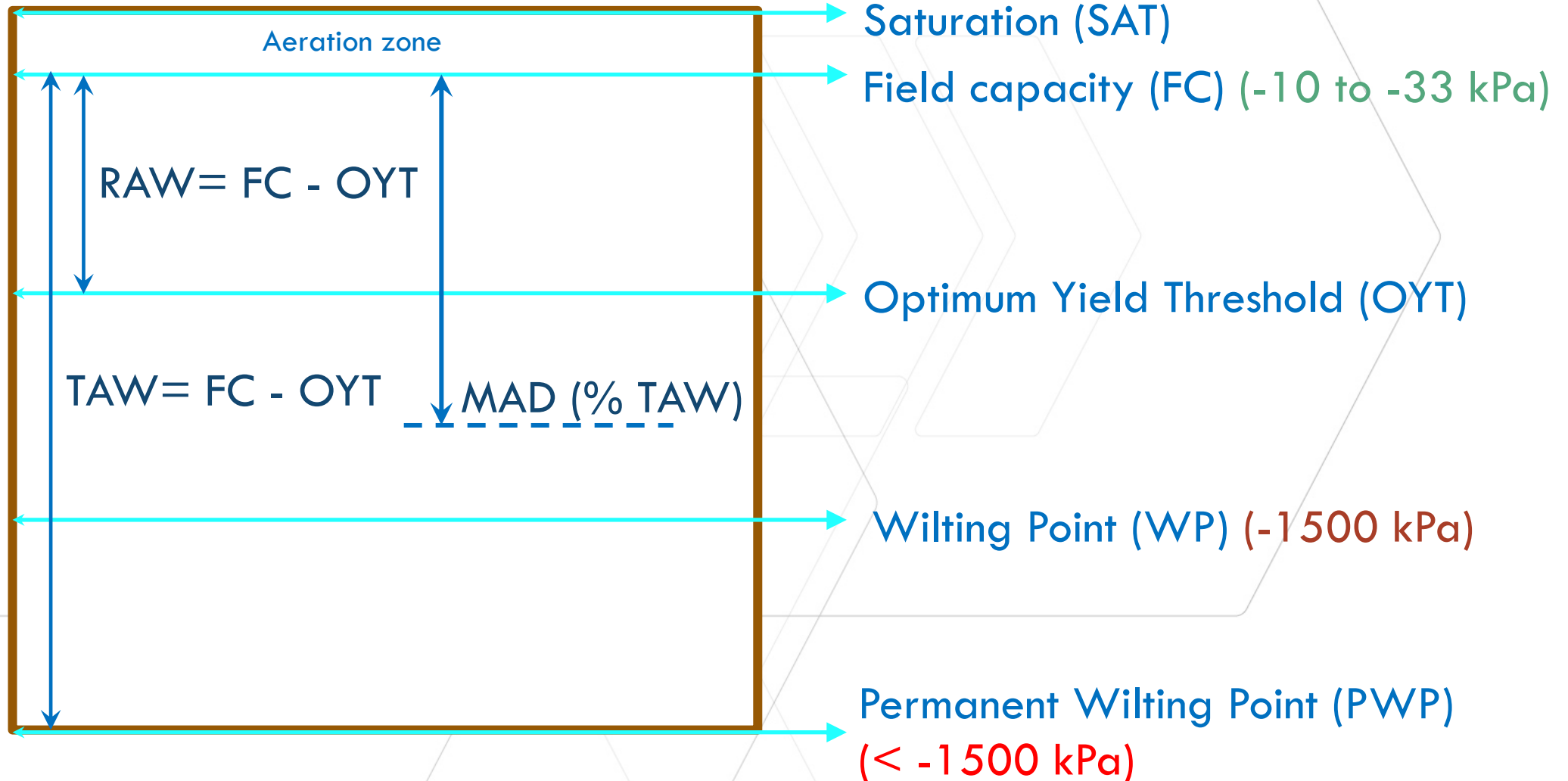
**Plant physiology:
RZD, Growing
period, Kc , salt
tolerance etc.**



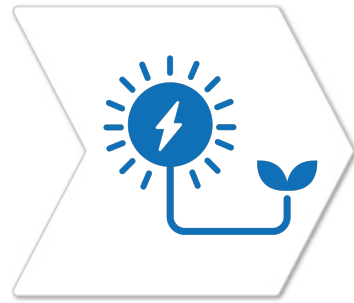
DATA REQUIREMENT FOR THE DESIGN OF A FARM IRRIGATION SYSTEM



Soil



SOIL HYDRAULIC PROPERTIES (LITERATURE)



SAT	FC	WP	tau	Ksat	Soil type
vol%	vol%	vol%	-	mm/day	-
36	13	6	1.00	1500	Sand
38	16	8	0.95	800	Loamy sand
41	22	10	0.75	500	Sandy loam
46	31	15	0.60	250	Loam
46	33	13	0.50	150	Silt loam
43	33	9	0.35	50	Silt
47	32	20	0.45	125	Sandy clay loam
50	39	23	0.40	70	Clay loam
52	44	23	0.30	20	Silty clay loam
50	39	27	0.42	75	Sandy clay
54	50	32	0.20	15	Silty clay
55	54	39	0.10	2	Clay

The *characteristics* of the soil layer are the following hydraulic properties:

SAT : soil water content [vol%] at saturation;

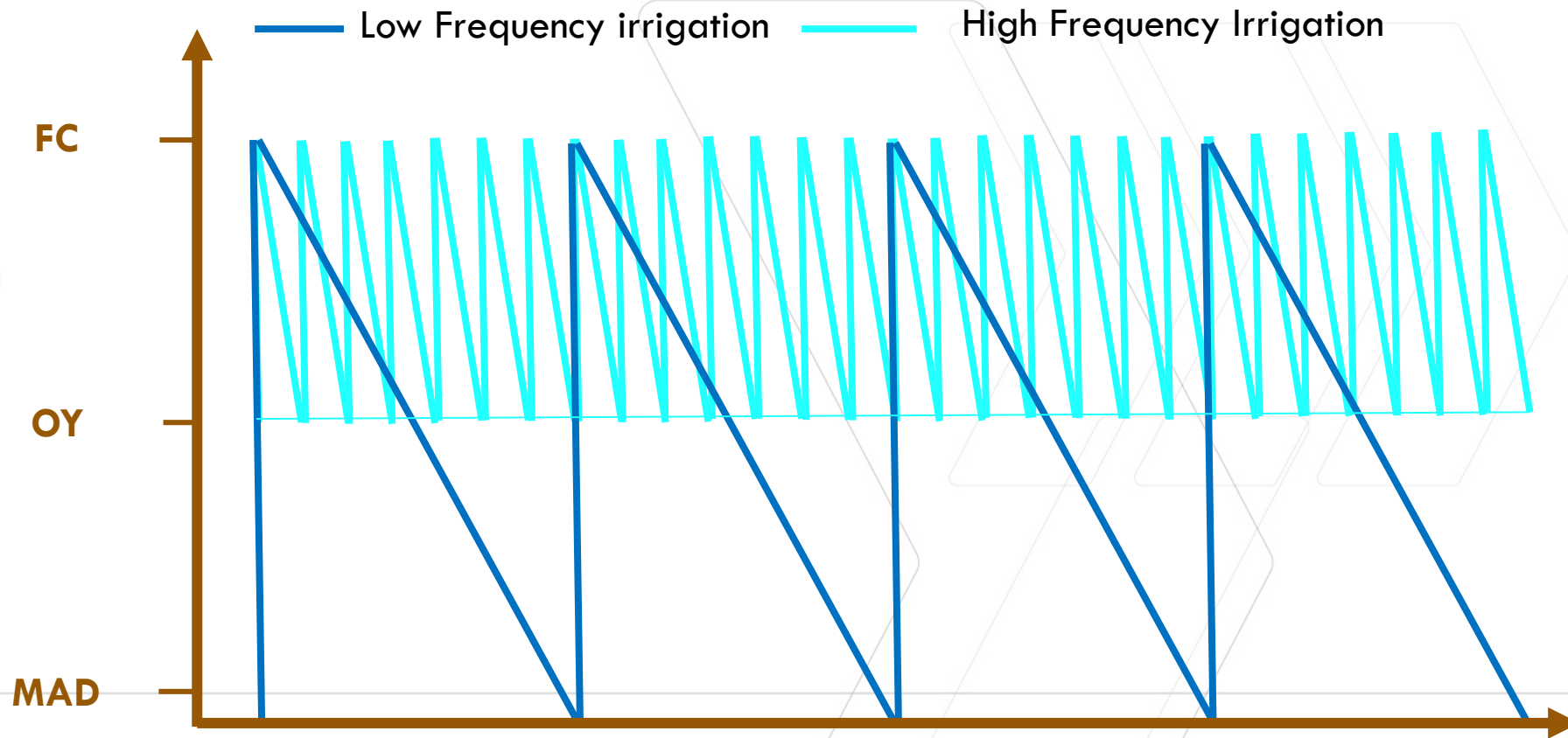
FC : soil water content [vol%] at field capacity;

WP : soil water content [vol%] at wilting point;

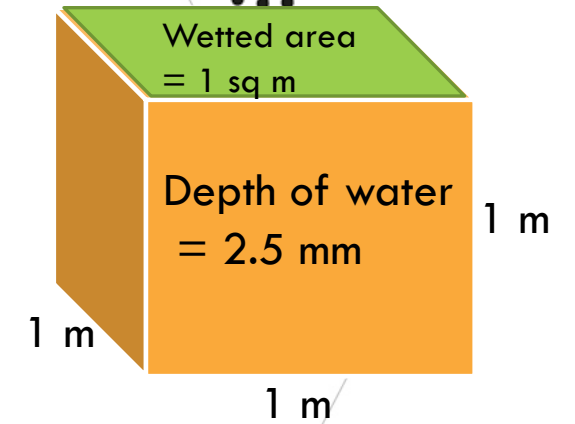
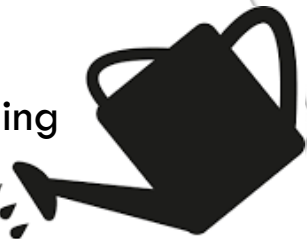
tau : drainage characteristic (value between 1 and 0);

Ksat : infiltration rate [mm/day] at saturation.

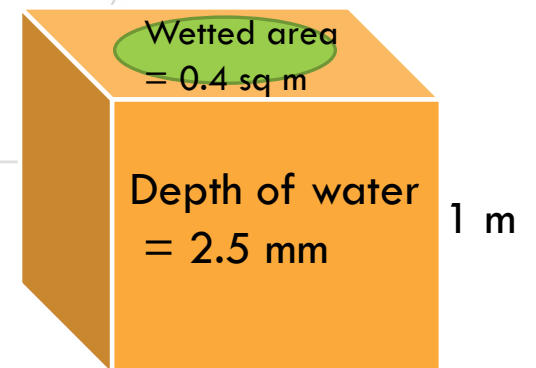
IRRIGATION APPLICATION FREQUENCY



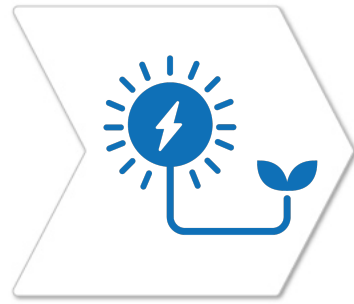
2.5 liter by flooding



one liter by drip irrigation



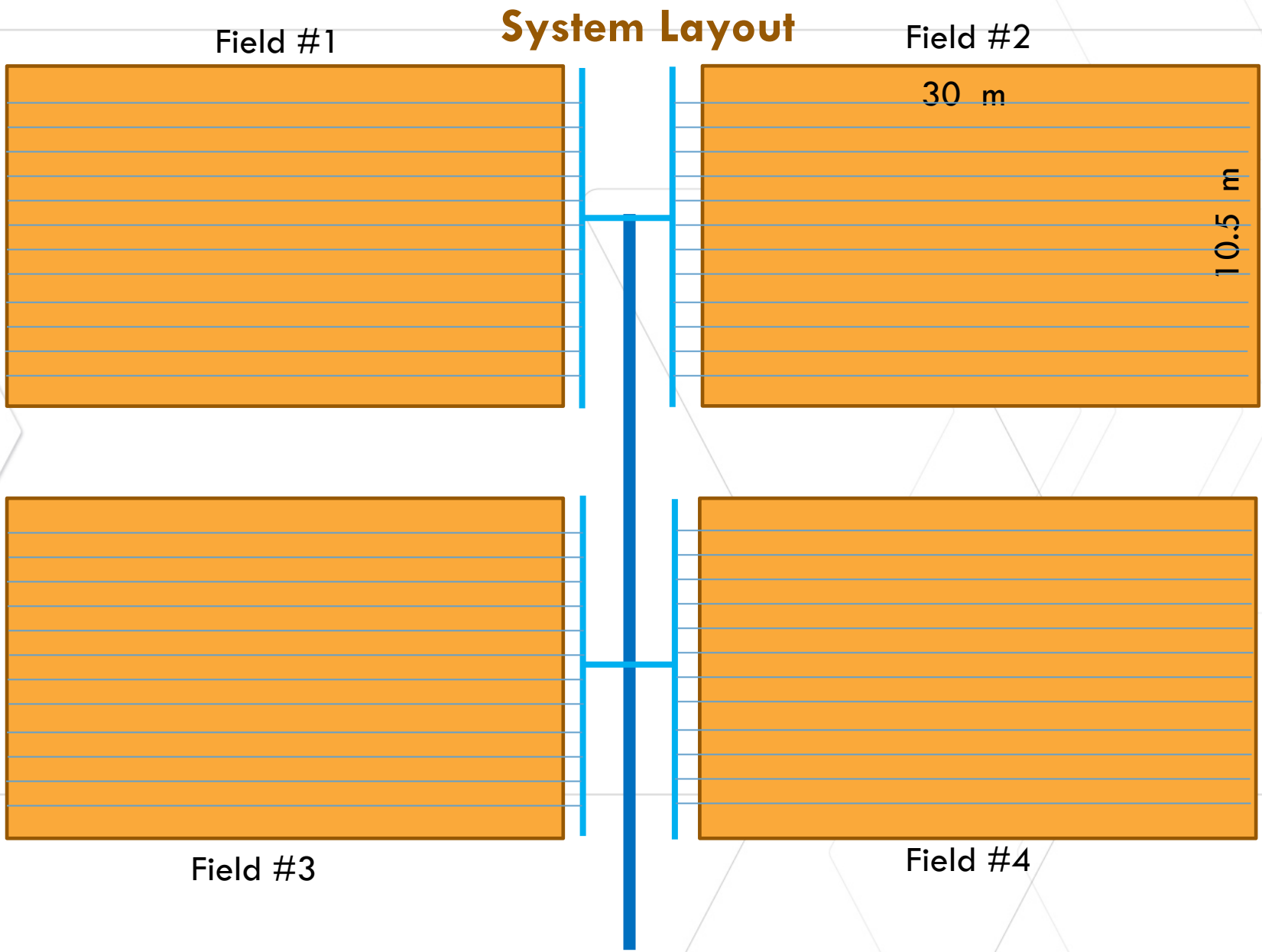
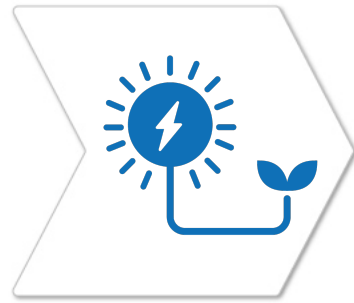
COMPLEXITIES AFFECTING THE CHOICE OF IRRIGATION METHOD



Irrigation Preference Matrix

Complexity factor	Flood Irrigation	Drip Irrigation	Sprinkle Irrigation
Crop type	Field crops, wheat, barley etc.	Row crops, vegetable and trees	Field crops and trees
Soil Type	Clay loam, clayey soils	Sandy soil	Sandy soil
Field Slope	Level fields, paddies	All types of land slopes	All type of land slopes with sandy soil
Climate	Areas with high winds	Under large number of climates	Area with up to mild winds
Water Availability	Water abundant areas (low efficiency)	Water stressed areas (with very high efficiency)	Water stressed areas with higher efficiency
Water Quality	Water with high sediments	Water with dissolved salts	Water with dissolved salts

DESIGNING A FARM IRRIGATION SYSTEM



Data

Set of 4 fields
Crop= vegetables, tomatoes, pepper
 $D_{RZ} = 0.9$ m
Field slope = 2 % (in N-S direction)
 ET_c (max) = 5.1 mm/day
Soil type: Sandy loam (FC=22%)

Drip Specs for vegetables:

Vegetable >>
Single line drip lateral
4 lit per day in peak season
2-3 hours daily operation

Orchard trees >>
Double line drip
High Q emitter

Field #1

System Layout

Field #2

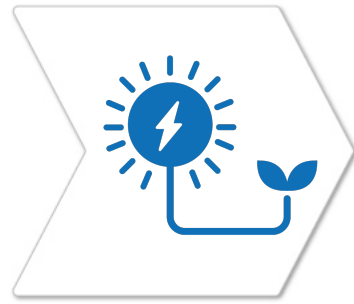
30 m

10.5 m

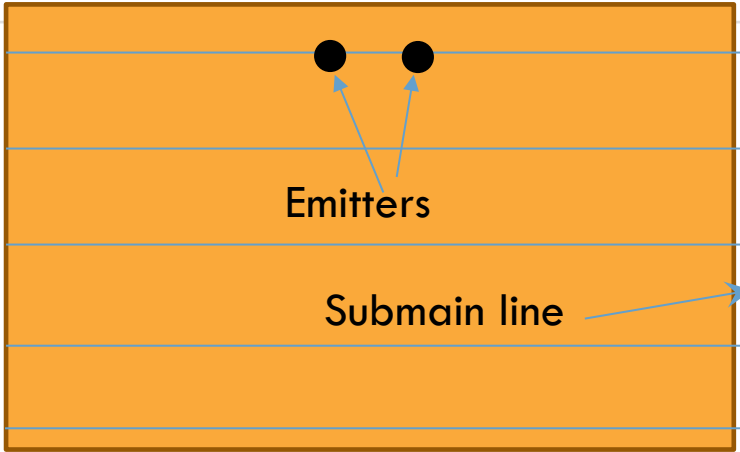
Field #3

Field #4

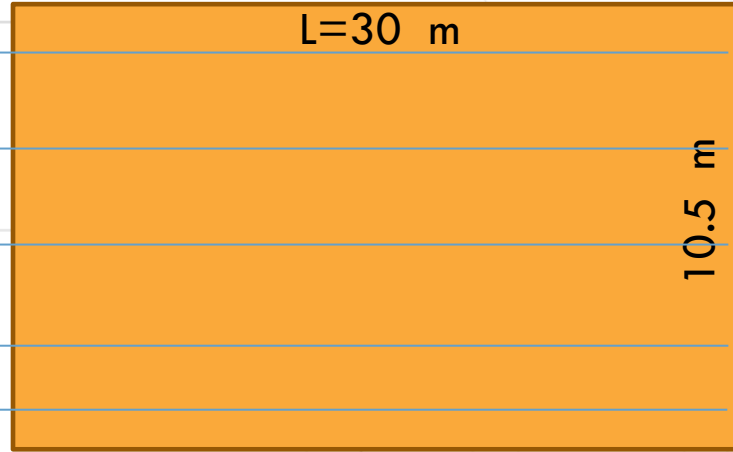
DESIGNING A FARM IRRIGATION SYSTEM



Field #1



Field #2



Drip Specs for vegetables:

Emitter to Emitter distance, $E = 0.3\text{ m}$

Row to Row distance, $R = 0.5\text{ m}$

Emitter discharge, $q_e = 2\text{ LPH}$

Emitter operating head, $H_a = 1\text{ bar} = 10\text{ m}$

No of emitter/row, $NE = L/E = 30/0.3 = 100$

No of rows/field, $NR = 10.5/0.5 = 21$

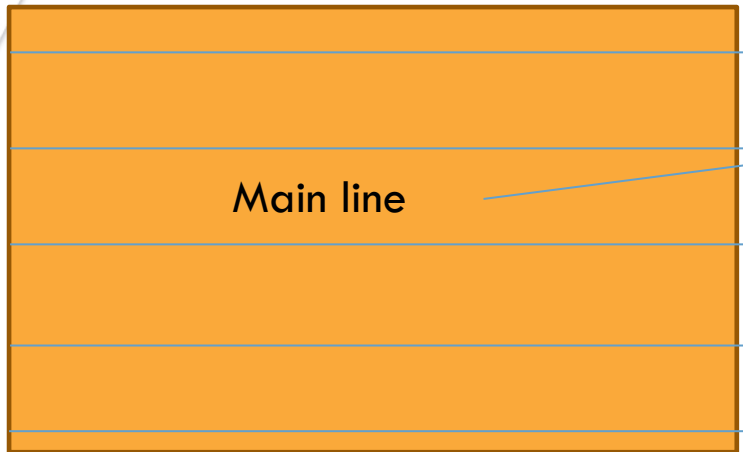
Discharge Calculation:

Lateral discharge = $q_l = q_e \times NE = 200\text{ LPH}$

Submain discharge, $q_s = q_l \times NR = 4200\text{ LPH}$

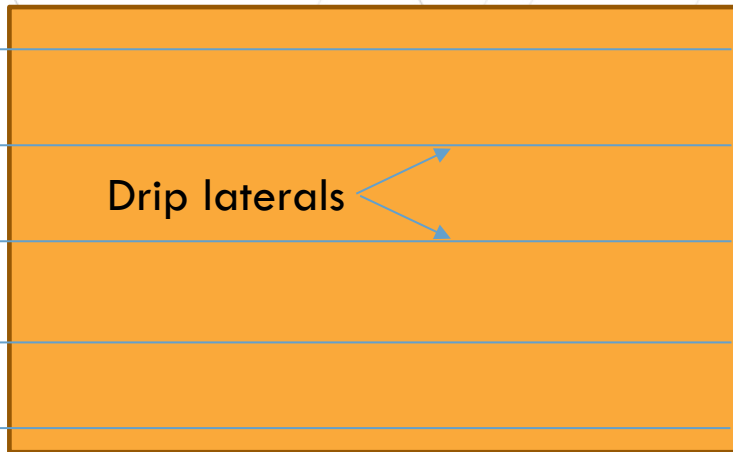
Main line discharge = $Q = 4 \times q_s$
 $= 4 \times 4200 = 16800\text{ LPH}$

Main line



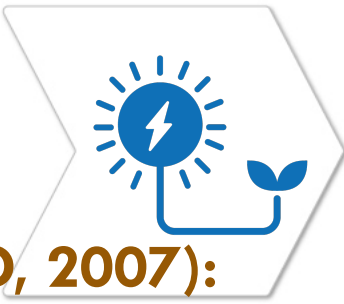
Field #3

Drip laterals



Field #4

DESIGNING A FARM IRRIGATION SYSTEM



Head loss (Pressure loss) calculation:

Total dynamic head = suction head + delivery head + head loss in fitting + head loss in Main + head loss in sub main + head loss in laterals + operating head of emitter

Calculation:

Head loss calculation for laterals, submain and main line needs to be calculated individually using Hazen-Williams equation
([Click here](#) to get Excel sheet calculator for head loss calculation)



H_m = Pressure at mainline

Rule of thumb: On level fields,

Head loss from " H_m " to " H_o " should not be greater than 20 % of TDH

Pressure Management criteria (FAO, 2007):

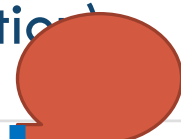
$$H_a = 1.00$$

$$H_o = 0.95 H_a$$

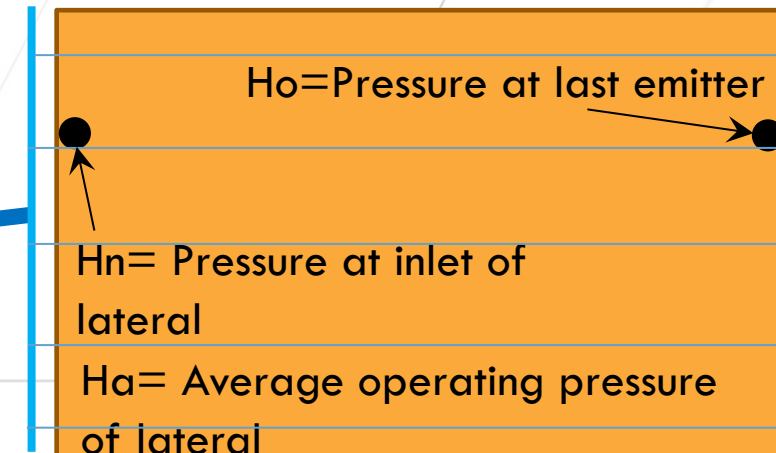
$$H_n = 1.15 H_a$$

$$H_m = 1.35 H_a$$

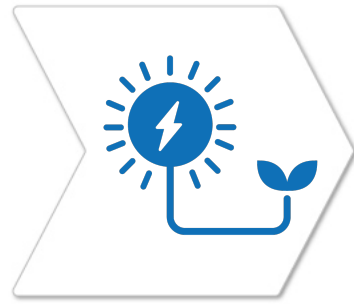
Velocity in all pipes < 1.17 m/s



Slope of delivery line



DESIGN CONCLUSION



Total Dynamic Head, TDH= 20 m

Total discharge when 4 fields irrigate simultaneously,

$$Q = 4 \times 4200 = 16,800 \text{ LPS} = 16.8 \text{ m}^3/\text{s}$$

Irrigation pump Power=?

Efficiency of Solar power pump set, $E = 50\%$

$$P = \frac{Q \times H \times SG}{367.2 \times E}$$

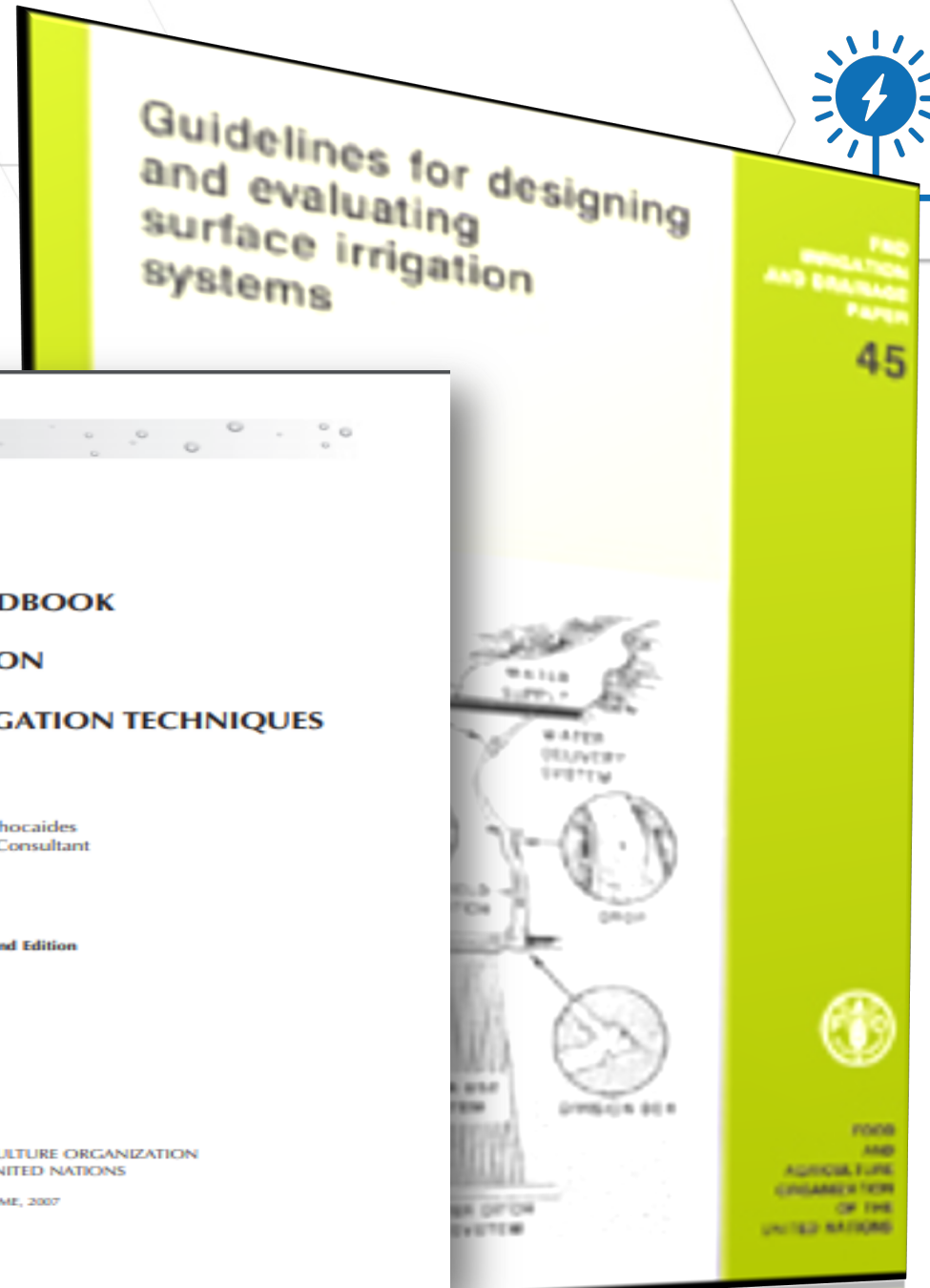
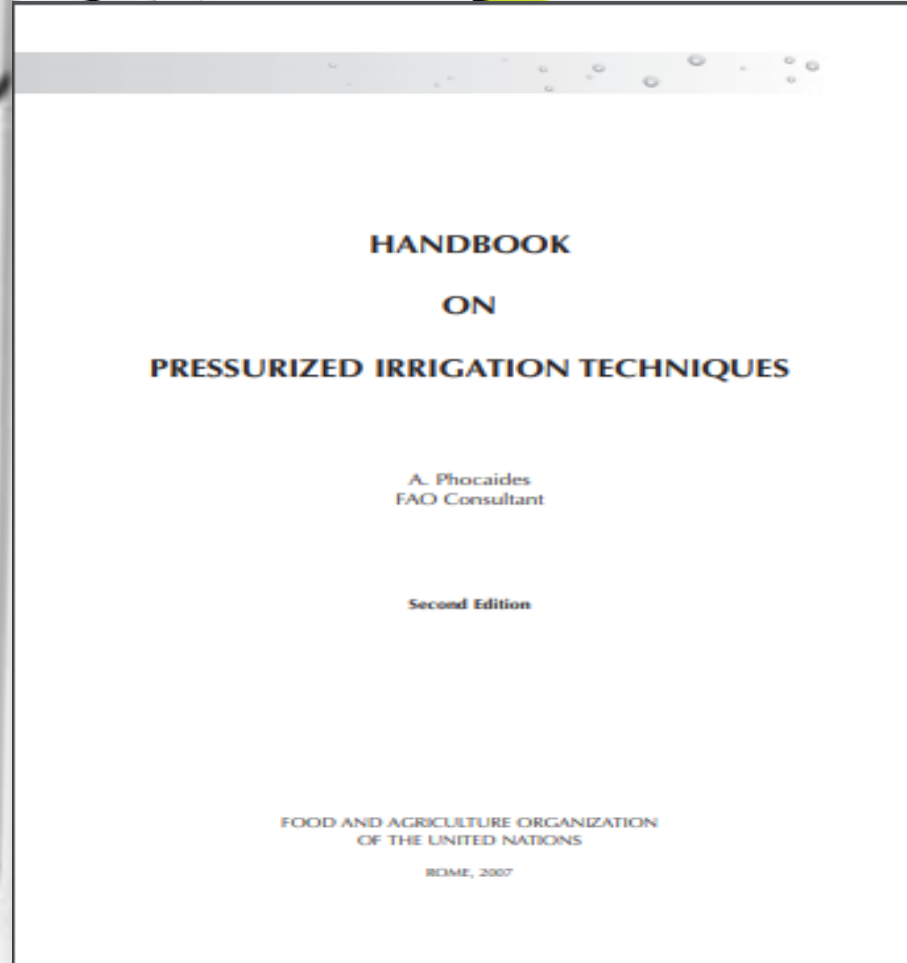
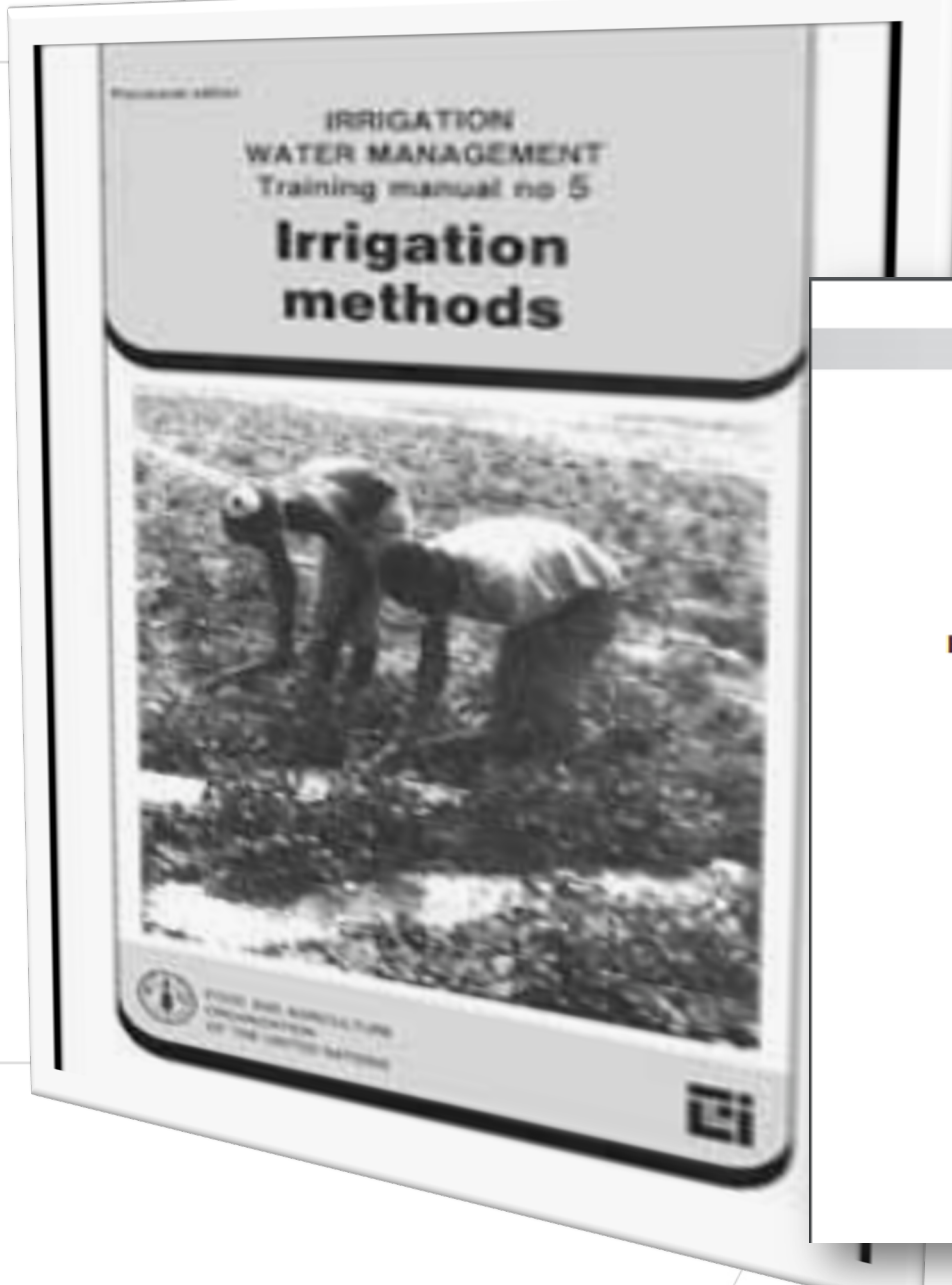
$$P = \frac{16.8 \times 13.6 \times 0.997}{367.2 \times 0.5}$$

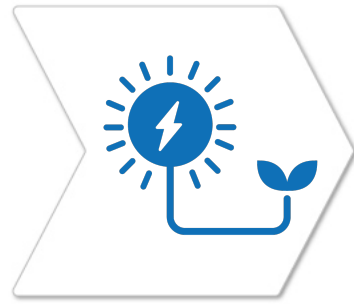
$$P = 1.82 \text{ Kwatt}$$



Handover to Solar Engineer

Recommended Literature





THANK YOU FOR YOUR ATTENTION