ENERGY EFFICIENCY ANALYSIS OF WHEAT CROP GROWN ON PERMANENT RAISED BED UNDER DIFFERENT CLIMATE AND SOIL BASED SCENARIOS

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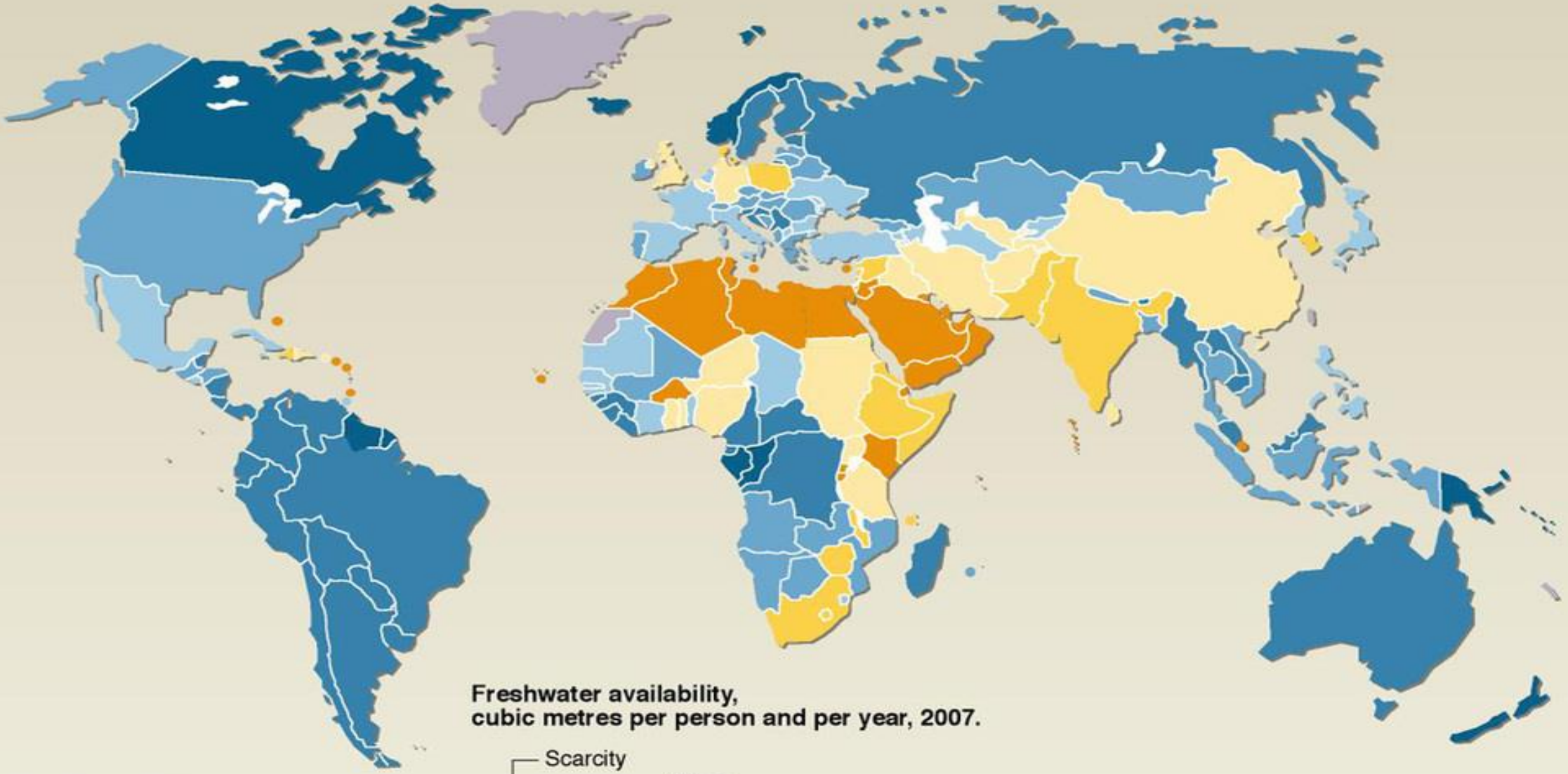
Introduction/Problem Statement

- ❖ Increasing demand for food, fiber and fodder will put great strains on land, water, energy and other resources.
- ❖ Developing countries face a difficult challenge in meeting the growing demands for food, water, and energy, which is further compounded by climate change.
- ❖ Pakistan is a water and energy scare country and both are important in agricultural production.
- ❖ Agriculture is considered as backbone in economy of Pakistan, contributing 21% to its GDP, nearly 43.7% of its work force and providing livelihood to more than 67% of its population.
- ❖ The water and energy conservation plans are directly related to the poverty reduction and raise livelihood.
- ❖ Effective application of agricultural techniques and efficient use of support inputs can minimize environmental problems and in consequence promote sustainable agricultural intensification.



Source: FAO, Nations unies,
World Resources Institute (WRI).

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FEBRUARY 2008

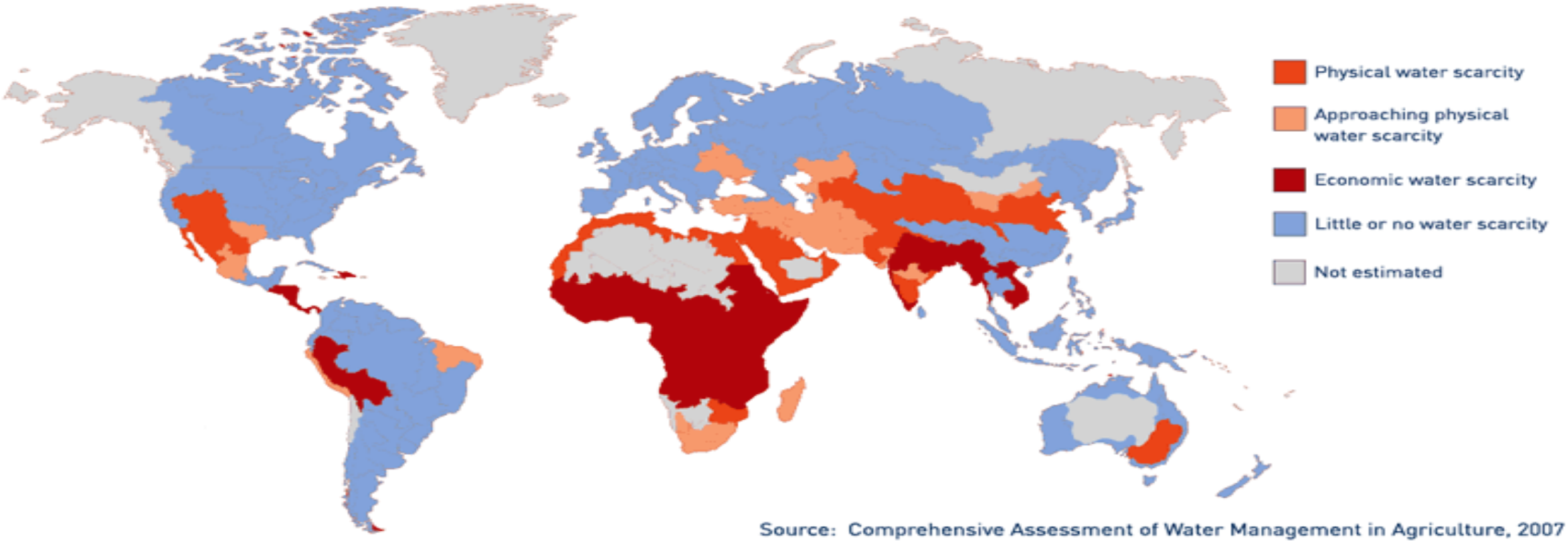
AREAS OF PHYSICAL AND ECONOMIC WATER SCARCITY

Physical water scarcity water resources development is approaching or has exceeded sustainable limits). More than 75% of the river flows are withdrawn for agriculture, industry, and domestic purposes (accounting for recycling of return flows). This definition—relating water availability to water demand—implies that dry areas are not necessarily water scarce.

Approaching physical water scarcity. More than 60% of river flows are withdrawn. These basins will experience physical water scarcity in the near future.

Economic water scarcity (human, institutional, and financial capital limit access to water even though water in nature is available locally to meet human demands). Water resources are abundant relative to water use, with less than 25% of water from rivers withdrawn for human purposes, but malnutrition exists.

Little or no water scarcity. Abundant water resources relative to use, with less than 25% of water from rivers withdrawn for human purposes.

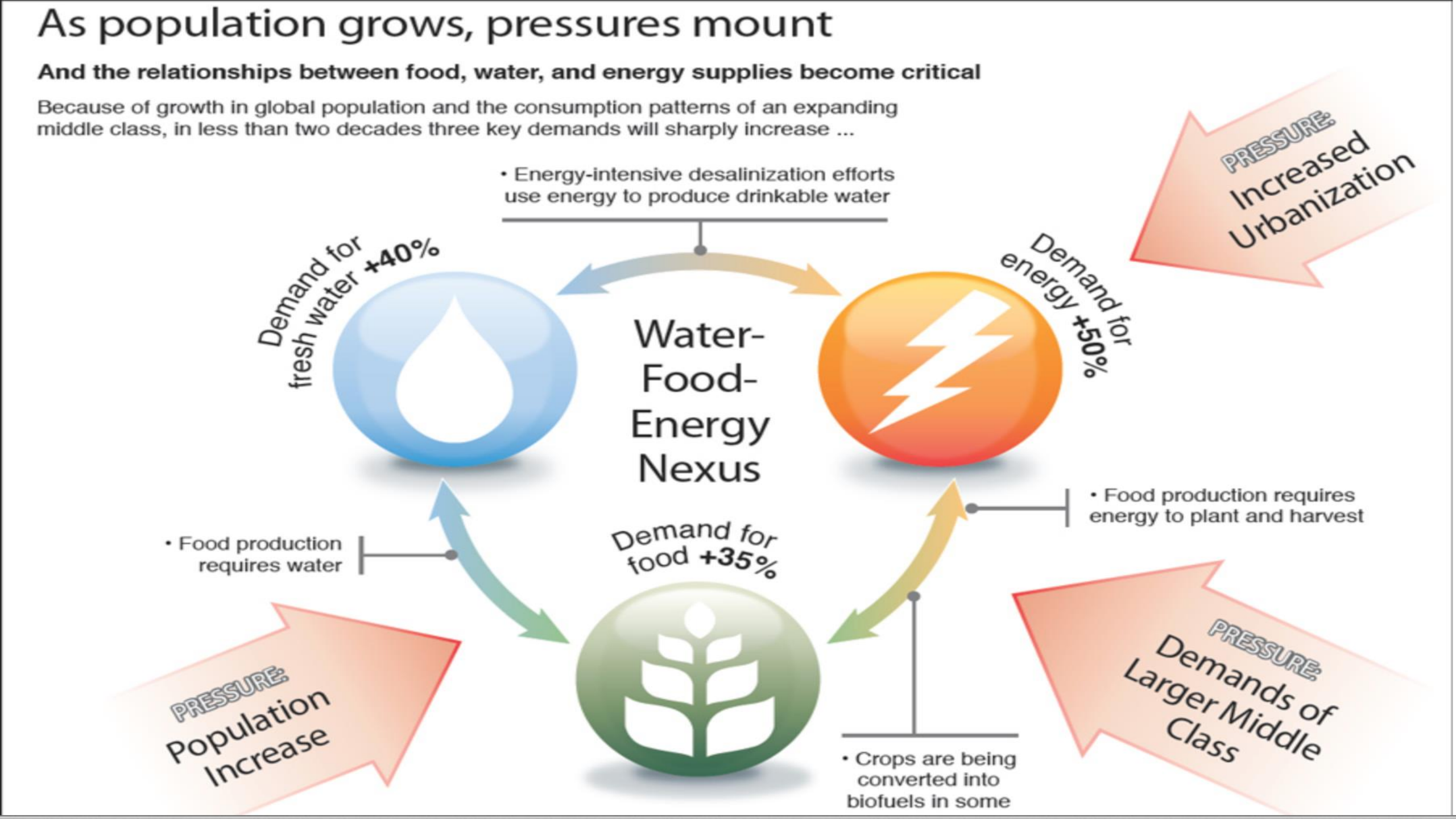


Source: Comprehensive Assessment of Water Management in Agriculture, 2007

As population grows, pressures mount

And the relationships between food, water, and energy supplies become critical

Because of growth in global population and the consumption patterns of an expanding middle class, in less than two decades three key demands will sharply increase ...



Background of Study& Objectives

❖ Energy utilization and output differs among crops, production systems and intensity of management practices.

❖ Considerable research has been conducted on energy use pattern of field crops under different management practices in the world.

❖ Very little efforts have been made to explore the relationship among water, energy and the yield in Pakistan.

Objectives:

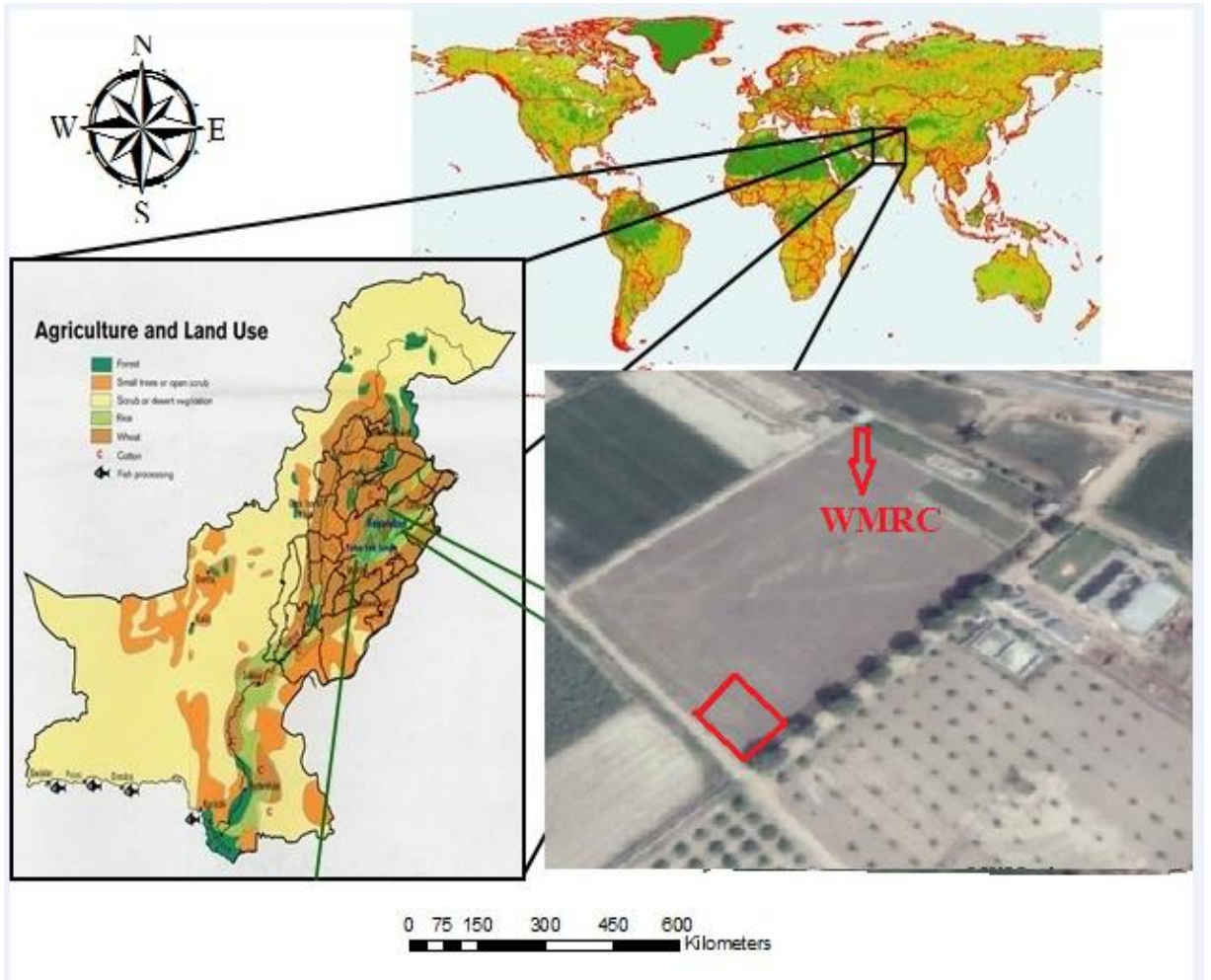
❖ To investigate the consumption pattern with regard to energy and water in wheat production under different irrigation schedules.

❖ To evaluate the differences in different energy and water indices for all irrigation schedules.

Study Area

The field experiment was conduct at the Water Management Research Centre (WMRC), Jhang road Faisalabad, on wheat crop for rabi 2014-15

Latitude: 31.38715N,
Longitude: 73.01089E
Altitude: 176 m



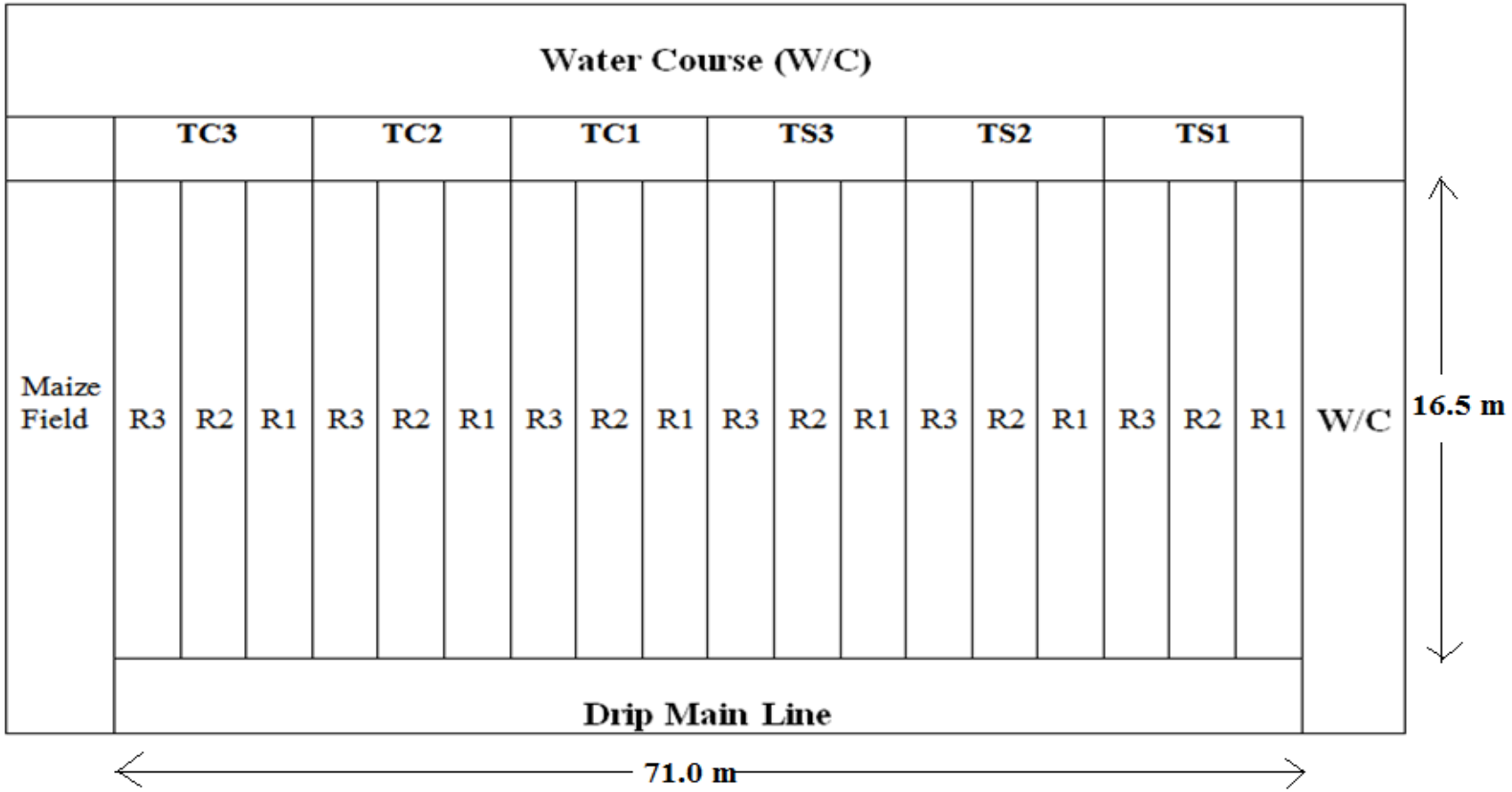
Treatment description & Energy Equivalents

T1= 30% MAD of ASM
T2= 45% MAD of ASM
T3= 60% MAD of ASM
T4= 20 mm CPE
T5= 30 mm CPE
T6= 40 mm CPE

Energy	unit	Energy Equivalent ($MJunit^{-1}$)	References
Inputs			
Human Labor	h	1.96	[13]
Machinery	h	62.7	[13]
Diesel Fuel	L	56.31	[13]
Chemical Fertilizers	kg		
a) Nitrogen		66.14	[13]
b) Phosphorous		12.44	[13]
c) Potassium		11.15	[13]
Herbicides	kg	238	[14]
Water	m^3	1.02	[13]
Electricity	kWh	11.93	[15]
Seeds	kg	14.7	[16]
Outputs			
Wheat Grain Yield	kg	14.7	[16]
Wheat Straw Yield	kg	12.5	[16]

Field Layout

Experimental Design: CRD
Total no. of plots: 18
Total experimental area = 71.0 m x 16.5 m
Plot size = 71.0 m x 0.91 m

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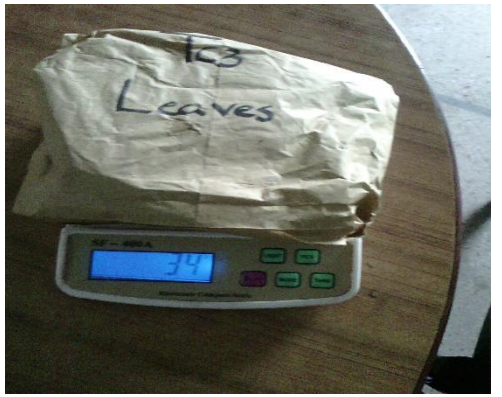
Leaves


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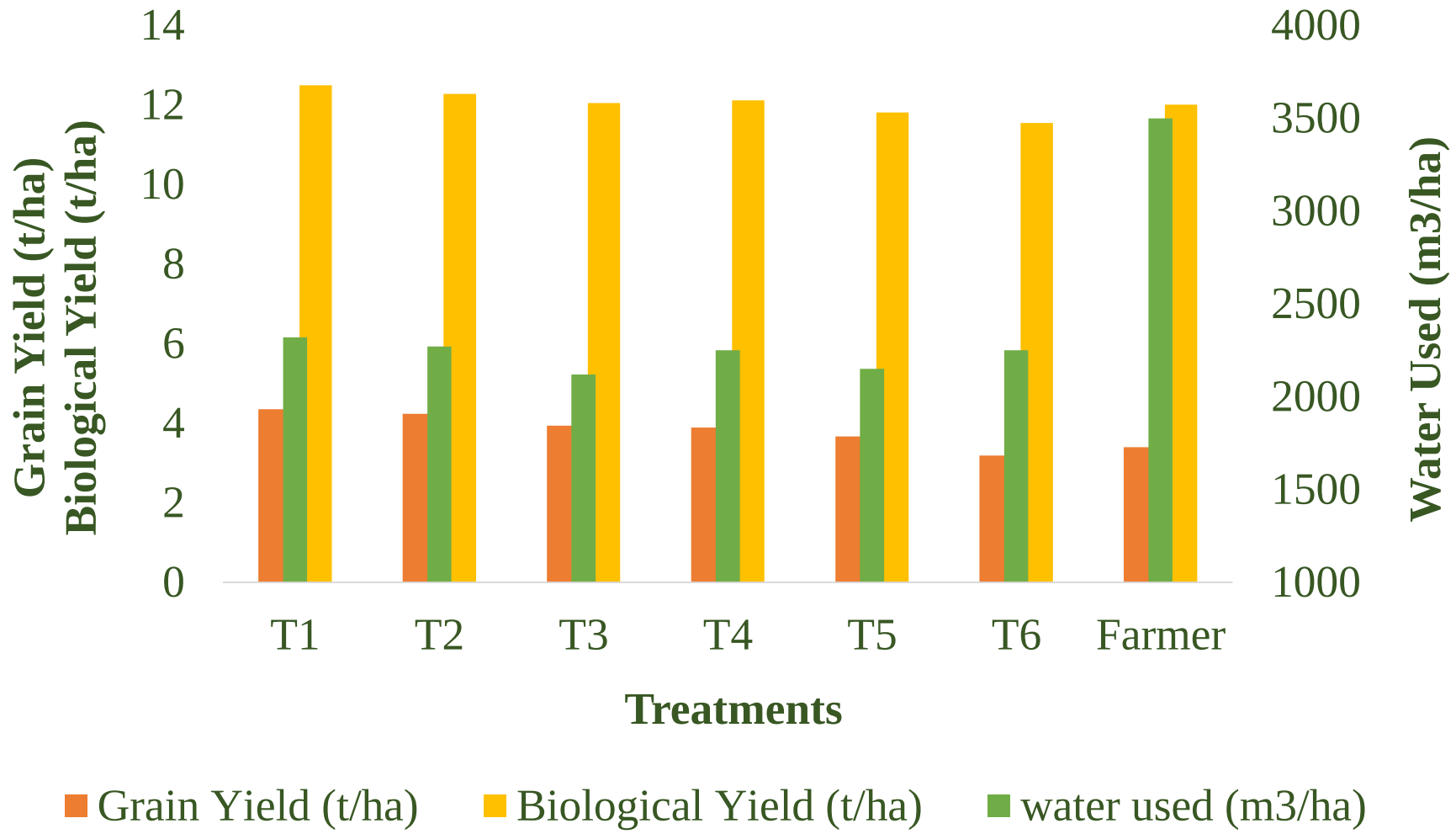
Results



Graphical representation of Grain yield and Biological yield in relation to water used

Quantity of inputs and outputs per unit hectare in wheat production

Energy	unit	Energy Equivalent ($MJunit^{-1}$)	Quantity per unit hectare						
			Farmer	T1	T2	T3	T4	T5	T6
INPUTS									
Human Labor	h	1.96	85	85	85	85	85	85	85
Machinery	h	62.7	20	20	20	20	20	20	20
Diesel Fuel	L	56.31	50	50	50	50	50	50	50
Chemical Fertilizers	kg								
a) Nitrogen		66.14	104	104	104	104	104	104	104
b) Phosphorous		12.44	212	212	212	212	212	212	212
c) Potassium		11.15	129	129	129	129	129	129	129
Herbicides	kg	238	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Water	m^3	1.02	3500	2320	2270	2120	2250	2150	2250
Electricity	kWh	11.93	618.136	409.712	400.882	374.392	397.35	379.69	397.35
Seeds	kg	14.7	125	125	125	125	125	125	125
OUTPUTS									
Wheat Grain Yield	kg	14.7	3400	4350	4240	3940	4030	3670	3320
Wheat Straw Yield	kg	9.25	12010	12500	12280	12050	12120	11810	11550

Energy Consumption and Production in wheat production

Energy	Total Energy equivalent (MJ/ha)						
	Farmer	T1	T2	T3	T4	T5	T6
INPUTS							
Human Labor	166.6	166.6	166.6	166.6	166.6	166.6	166.6
Machinery	627	627	627	627	627	627	627
Diesel Fuel	2815.5	2815.5	2815.5	2815.5	2815.5	2815.5	2815.5
Chemical Fertilizers							
a) Nitrogen	6878.56	6878.56	6878.56	6878.56	6878.56	6878.56	6878.56
b) Phosphorous	2637.28	2637.28	2637.28	2637.28	2637.28	2637.28	2637.28
c) Potassium	1438.35	1438.35	1438.35	1438.35	1438.35	1438.35	1438.35
Herbicides	357	357	357	357	357	357	357
Water	3570	2366.4	2315.4	2162.4	2295	2193	2295
Electricity	7374.362	4887.864	4782.522	4466.497	4740.386	4529.702	4740.386
Seeds	1837.5	1837.5	1837.5	1837.5	1837.5	1837.5	1837.5
Total energy input (MJ ha^{-1})	**27702.15**	**24012.05**	**23855.71**	**23386.69**	**23793.17**	**23480.49**	**23793.17**
OUTPUTS							
Grain Yield	49980	63945	62328	57918	59241	53949	48804
Straw Yield	111092.5	115625	113590	111462.5	112110	109242.5	106837.5

Analysis of energy indices in wheat production

Indices	Farmer	T1	T2	T3	T4	T5	T6
Net Energy (MJ ha^{-1})	133370.35	155557.95	152062.29	145993.81	147557.82	139711.01	131848.32
Energy Use Efficiency	5.814	7.478	7.374	7.243	7.202	6.950	6.541
Energy Productivity (kg MJ^{-1})	0.123	0.181	0.178	0.168	0.169	0.156	0.139
Specific Energy ($MJ.kg^{-1}$)	8.148	5.520	5.626	5.936	5.904	6.398	7.167
Water productivity (kg m^{-3})	0.971	1.875	1.868	1.858	1.791	1.707	1.475

Cost analysis (PKR) for wheat crop (per hectare) for Faisalabad-Pakistan, 2014-15

Treatments	Farmer	T1	T2	T3	T4	T5	T6
INPUT							
Seed	2335	2335	2335	2335	2335	2335	2335
Fertilizers - Urea - DAP - MOP	 4150 9880 17000	 4150 9880 17000	 4150 9880 17000	 4150 9880 17000	 4150 9880 17000	 4150 9880 17000	 4150 9880 17000
Spray - Topic - Bacterial Super	 250 1350	 250 1350	 250 1350	 250 1350	 250 1350	 250 1350	 250 1350
Irrigation (Energy cost)	3300	2186	2152	1996	2120	2026	2120
Fuel (Bed preparation + Sowing +Threshing)	18500	18500	18500	18500	18500	18500	18500
Labor	15000	15000	15000	15000	15000	15000	15000
Total Cost of Production	71765	70651	70617	70461	70585	70491	70585
OUTPUT							
Grain Yield	110500	141375	137800	128050	126425	119275	103675
Straw Yield	60050	62500	61400	60250	60600	59050	57750
Total Value of Production	170550	203875	199200	188300	187025	178325	161425
Net Return	98785	133224	128583	117839	116440	107834	90840
Benefit to Cost Ratio (--)	1.38	1.88	1.82	1.67	1.65	1.53	1.29

Conclusions

- Soil moisture based treatment (at 30% MAD) gave 7.94% and 27.94% more yield compared to climate based treatment's (20 mm CPE) and farmer's practice respectively.
- The pumping water for irrigation was the highest energy consumption input for wheat production after chemical fertilizers
- Pumping water for irrigation was the highest energy consumption input for wheat production after chemical fertilizers.
- T1 (30% MAD) and T4 (20 mm CPE) treatments saved 33.72% and 35.72% energy respectively due to water saving over farmer practice.
- While T1 and T4 treatments increase 11.40% and 6.38% energy output in terms of grain yield respectively over farmer practice.

Thank You!