Indus Project-Water and Food (Agriculture) Nexus

Prof. Dr. Ashfaq Ahmad Chattha

Lead PI AgMIP-Pakistan

Director External Linkages

Department of Agronomy

University of Agriculture Faisalabad

Overview

- Introduction
- Agriculture Sector Key Statistics
- Climate of Pakistan and Major crops
- Agricultural Problems in Pakistan
- Water Availability and Future Scenario
- Crop Water Productivity and Improvement
- Climate Change and its Impact on Crops (AgMIP-Pakistan: A Case Study)
- Conclusion

Introduction

- Land area of Pakistan is 79.6 mha
- Total area under cultivation 23.8 mha
- Agriculture contributes 21% to GDP
- Employment opportunities for 45% of the country's labour force
- Majority of the rural population depends upon this sector for its livelihood

(Govt. of Pakistan, 2013)

Agricultural Sector – Key Statistics

- Contribution to GDP 21.4%

- Labor Force Employment 45.0%
- Average Growth during last 6 years 3.7%
- Contribution of different Sub-Sectors in Agriculture's GDP

1. Crops (Wheat, Rice, Cotton, S. cane) 32%
2. Livestock 55%
3. Fisheries 4.0%
4. Forestry 2.0%
5. Others 7.0%

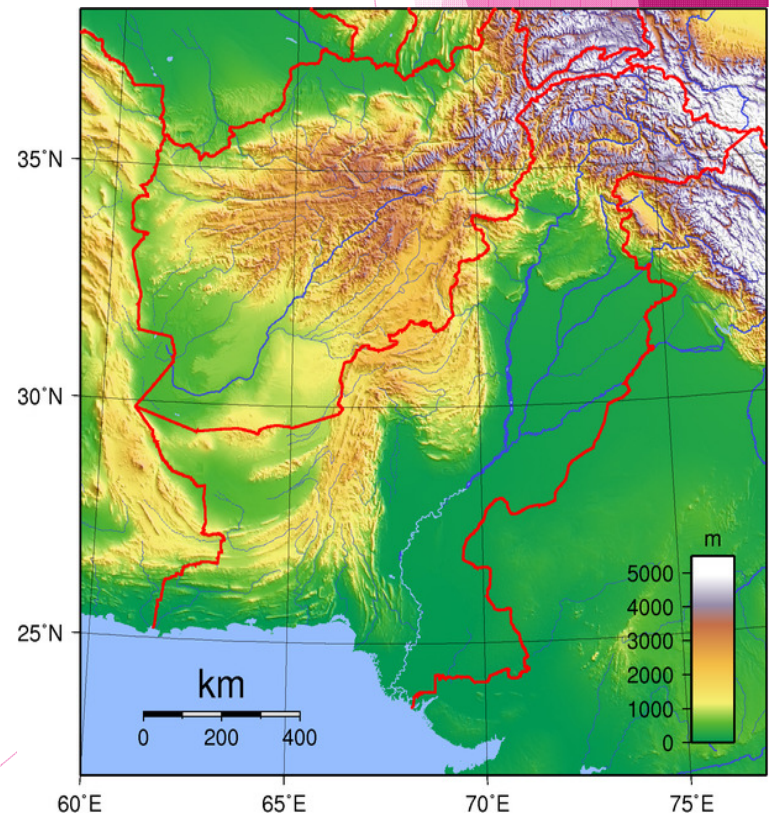
Share in Export Earnings (Raw/Processed)

1. Cotton + Cotton Based Products 64.7%
2. Fruits, Rice, Fish, Leather 18.2%
3. Others 17.1%

(Govt. of Pakistan, 2013)

Climate of Pakistan

- Subtropical arid zone to semi-arid climate
- June is the hottest month (48°C) in the plains and July in the mountainous areas, with temperatures over 38°C, while the mean monthly minimum temp is only 4°C in December/January
- Average annual precipitation is estimated at 494 mm.
- Maximum rainfall is1500 mm in the north
- Most of the rainfall in Pakistan originates from summer monsoons

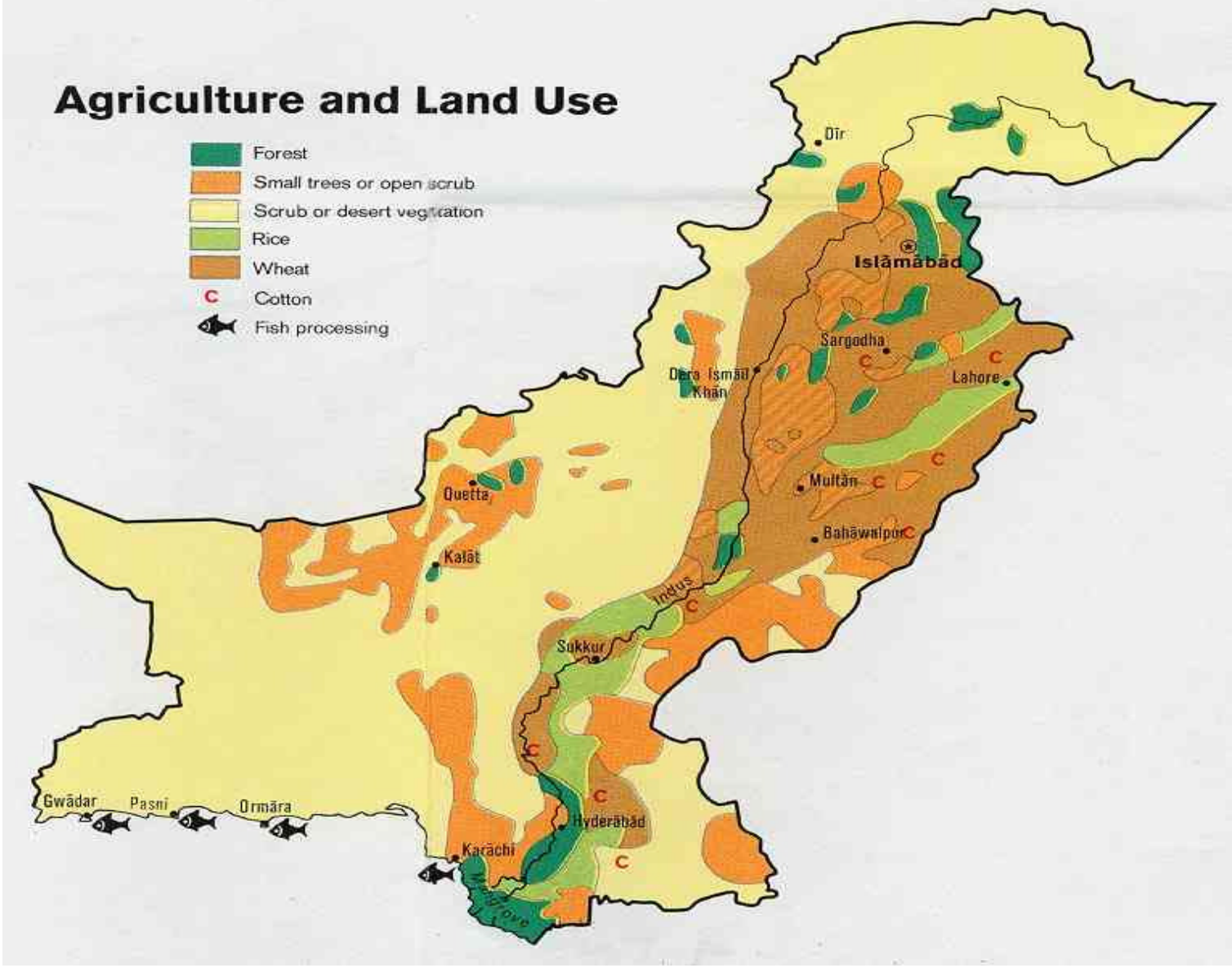


Major Crops





- Cotton
- Wheat
- Rice
- Sugarcane
- Maize



Crops	GDP share (%)	Area (Mha)	Production (MT)	Delta of Water (mm)
Wheat	2.6	9.00	25.2	475
Rice	0.7	2.78	6.7	1600
Cotton	1.4	2.8	12.7 (m bales)	600
Sugarcane	0.7	1.17	66.5	1600

Source: Govt. of Pakistan, 2013

Agricultural Problems in Pakistan

- Reducing cultivable area
- Stagnant and low yield per unit area
- Conventional methods of production
- Lack of high efficiency irrigation facilities
- Inadequate supply of agricultural inputs
- Decreasing availability of water due to climate change
- Lack of R & D and Decision Support System for site specific production technology

Water Availability

Year	Population (Million)	Per Capita Availability (m^3)
1951	34	5300
1961	46	3950
1971	65	2700
1981	84	2100
1991	115	1600
2000	148	1200
2013	207	850
2025	267	659

Source: Draft State of Environment Report 2005

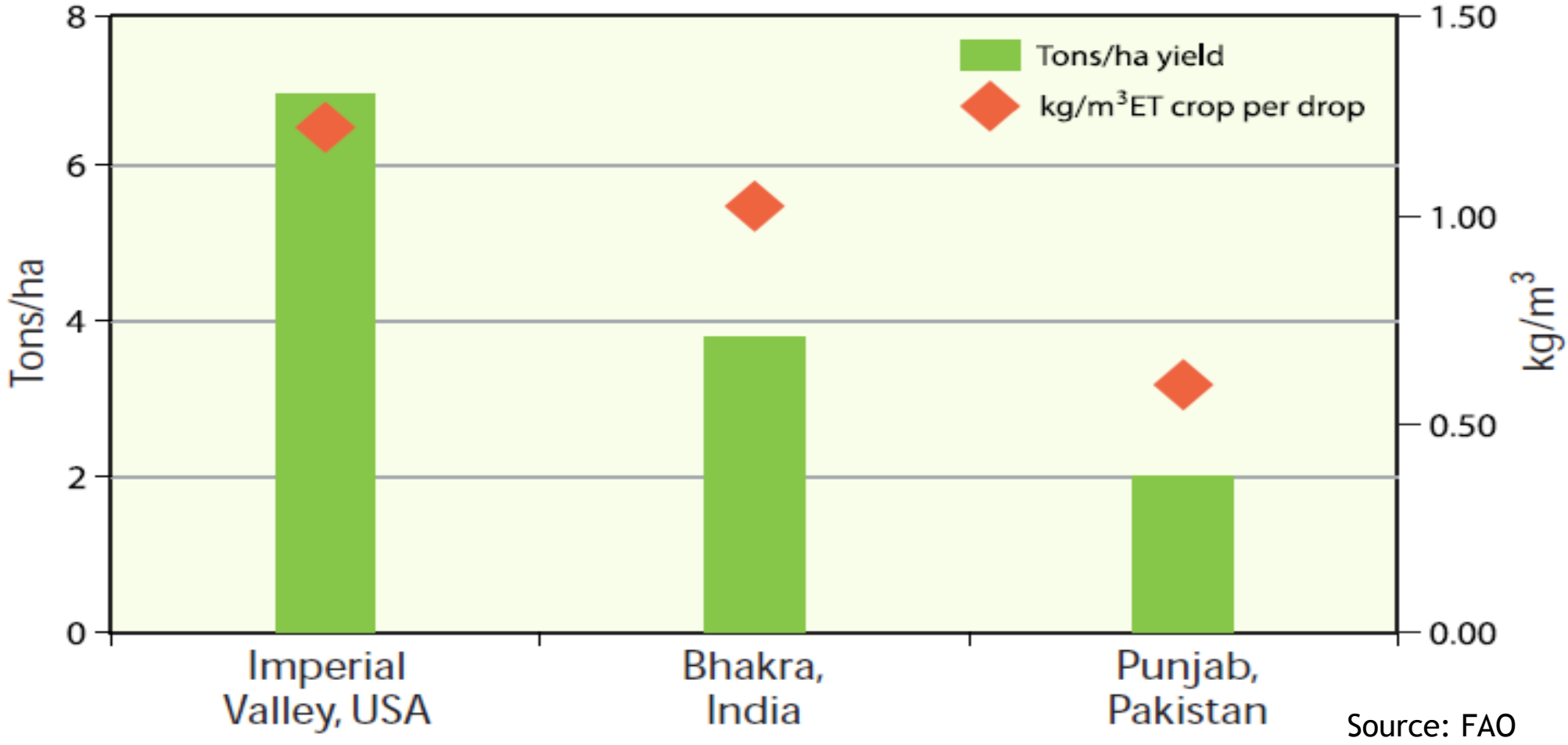
Water Related Issues and Agriculture

- Lack of irrigation water for crops because of less storage capacity
- Water productivity of wheat (0.76 kg/m^3) is 24% less than global average (1.0 kg/m^3)
- Water productivity of rice (0.45 kg/m^3) is 55% less than Asia's average (1.0 kg/m^3)
- In cotton-wheat zone of Punjab wheat water productivity was observed 0.43 kg/m^3 and 0.22 kg/m^3 for cotton

(Shabbir et al., 2013)

- France (1.42 kg/m^3) and Germany (1.35 kg/m^3) scores the highest wheat water productivity (Zwart, 2010)

Wheat water productivity Comparison



Source: FAO

Actual Surface Water Availability (Million Acre Feet)				
Period	Kharif	Rabi	Total	Decrease (%)
Average System Usage	67.1	36.4	103.5	-
2005-06	70.8	30.1	100.9	-2.5
2006-07	63.1	31.2	94.3	-8.9
2007-08	70.8	27.9	98.7	-4.6
2008-09	66.9	24.9	91.8	-11.3
2009-10	67.3	25.0	92.3	-10.8
2010-11	53.4	34.6	88.0	-150
2011-12	60.4	29.4	89.8	-13.2
2012-13	57.7	31.9	89.6	-13.4
2013-14	65.5	32.5	98.0	-5.3

Source: Govt. of Pakistan, 2013

How to Improve Crop Water Productivity

By Improving the agricultural water productivity by 40% of whole world, it is possible to reduce the additional fresh water withdrawals to 0

Climate Smart Plants

Reducing water consumption without reducing production

- Rapid stomatal closure
- Waxy cuticle production
- Cooling mechanism for leaves
- Rapid canopy closure
- Thicker, more intact casparian strip
- Sustainable production of aerobic rice

Conti….

Increase production without increasing water consumption

- High harvest index
- Short lag phase
- C4 photosynthesis
- More photosynthesis per unit water transpired
- Stay green flag leaf

Agronomic and Other Practices to Improve Crop Water Productivity

- Alternate row irrigation
- Reduced or zero tillage
- Raised beds or furrow irrigation
- Land levelling
- Mulching
- Application of organic matter
- Direct seeding rice
- Use of models for irrigation scheduling and policy interventic
- Use of Remote Sensing data for estimation of water consumption and crop water productivity

Hybrid Millet and Sorghum

- Hybrid millet and sorghum are options for both rain-fed and irrigated cropping systems
- It could be included in rotations for sustainable commercial farming instead of subsistence farming with some interventions

Alternate Crops

Chenopodium quinoa

- Can tolerate the harsh conditions, where other crops cannot grow
- Can grow at poor soil
- Tolerate salinity
- Tolerate frost
- Tolerate high temperature and high altitude
- Extreme weather
- Drought
- Have 50% more protein contents than any other grain

Conti….

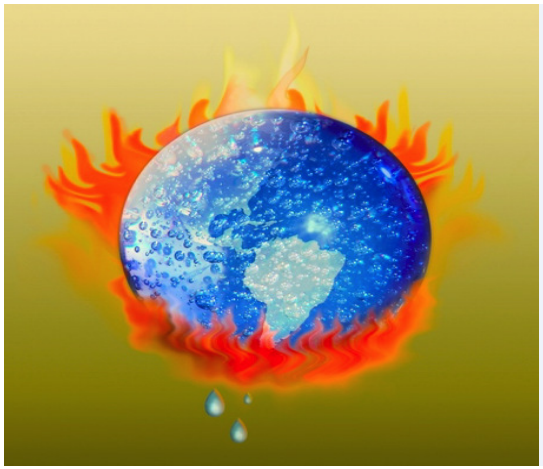
Stevia rebaudiana

- Wide adaptation
- Replacement for sugarcane
- Up to 320 times more sweet than sugarcane
- Can be sown in Feb-Mar and Oct-Nov

Our Expertise

- Decision Support System for Agro-technology Transfer (DSSAT)
- Agricultural Production Systems Simulator (APSIM)
- AquaCrop (Irrigation scheduling and to improve water productivity
- World Food Studies (WOFOST)
- Simulateur multidiscplinaire pour les Cultures Standard (STICS)
- Minimum-Data Tradeoff Analysis (TOAMD)
- Agriculture Information System to monitor and forecast crop yield using remotely sensed data

Work done at Agro-climatology Lab. with Respect to RS and Modeling the Climate Change



Agroclimatology Lab

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International PROJECTS	YEARS/ FUNDING	STATUS/ AMOUNT
1.Assessing climatic vulnerability and projecting crop productivity using integrated crop and economic modeling techniques	2012-2014 AgMIP DFID	Ongoing 400000 $
2. International grant on Biochar production, awareness and commercialization to mitigate Climate Change	British Council	Completed 60000 $
3. Climate Change Chair under Centre for Advance Studies-Food Security & Agriculture (CAS-FSA)	2013 USAID USDA	Ongoing 28.8 million $

International PROJECTS	YEARS/ FUNDING	STATUS/ AMOUNT
4. Agriculture Information System	2012 USDA-FAO	Ongoing 300000 $
5. Global Earth Observation System of Systems/Asian Water Cycle Initiative Indus River Basin Research Activities Under the Framework of the GEOSS Asian Water Cycle Initiative	2014 GEOSS AWCI	

National PROJECTS	YEARS/ FUNDING	STATUS/ AMOUNT
1. Modeling the impact of climate change on wheat productivity in Punjab	2006-2009 HEC	Completed 20000 $
2. Use of spectral reflectance to estimate growth, biomass and yield of different wheat cultivars, under moisture stress conditions	2008-2011 ALP	Completed 37000 $
3. Optimization of Bt. Cotton production technology for different agro-ecological zones in the face of changing climate through simulation modeling.	ALP	Approved 100000 $

National PROJECTS	YEARS/ FUNDING	STATUS/ AMOUNT
4. Assessing climate risk and developing mitigation strategies for cotton productivity under changing climate scenarios in Punjab	2013 HEC	Approved 38000 $

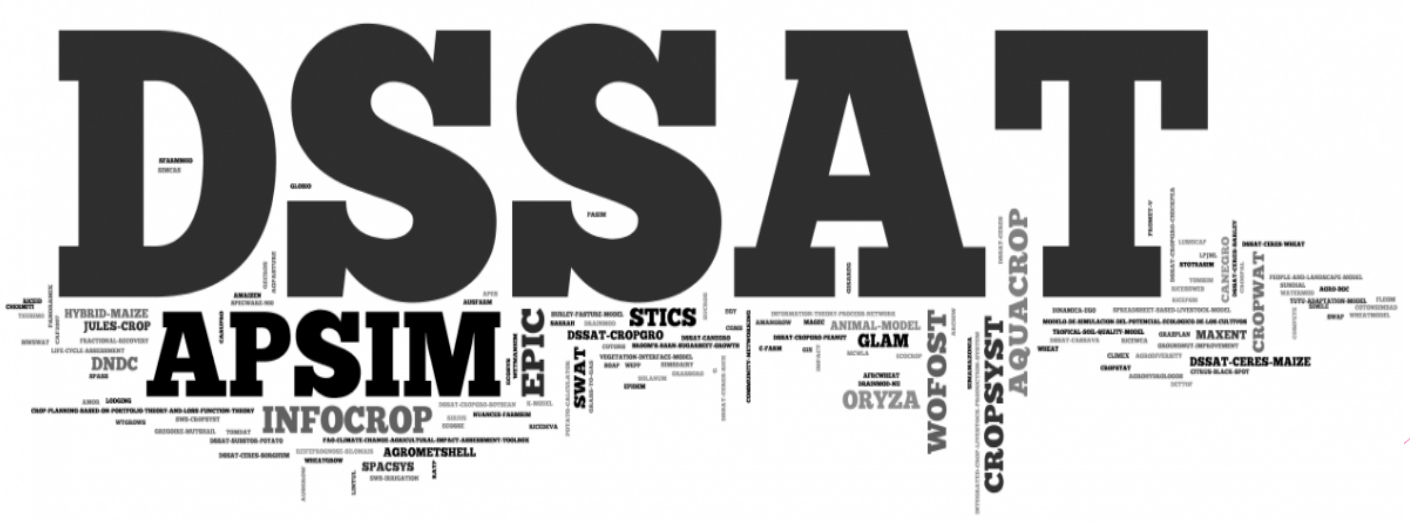
Agricultural Model Inter-comparison and Improvement Project (AgMIP)

AgMIP Objectives and Scope

- Find out the trends and impacts of climate change on crop productivity and economics of the various regions
- Calibration and evaluation of DSSAT and APSIM models for selected crops
- Application of "Minimum-Data Tradeoff Analysis" (TOA-MD) model in order to assess economic impacts on the selected crops
- Capacity building of stakeholders
- To find out the flaws in the models simulation and correction measures to improve them
- Climate change scenarios development for different regions

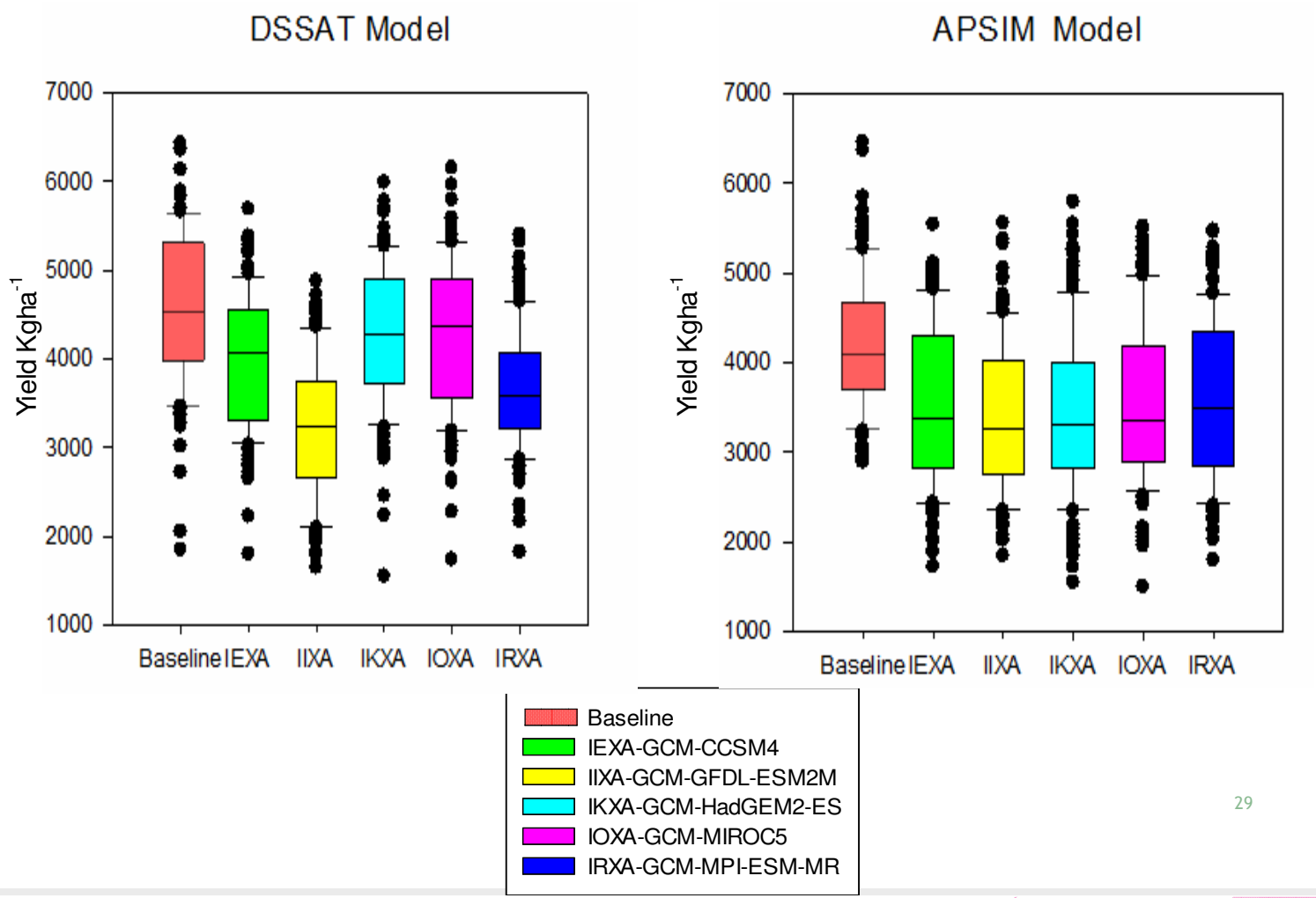
Methodology

- Five General Circulation Models (GCMs) were used to generate future weather data
- Two crop models (DSSAT and APSIM) were used to simulate yield and to assess climate change impact
- Economic model (TOA-MD) was used to quantify the climate vulnerabilities and adaptabilities



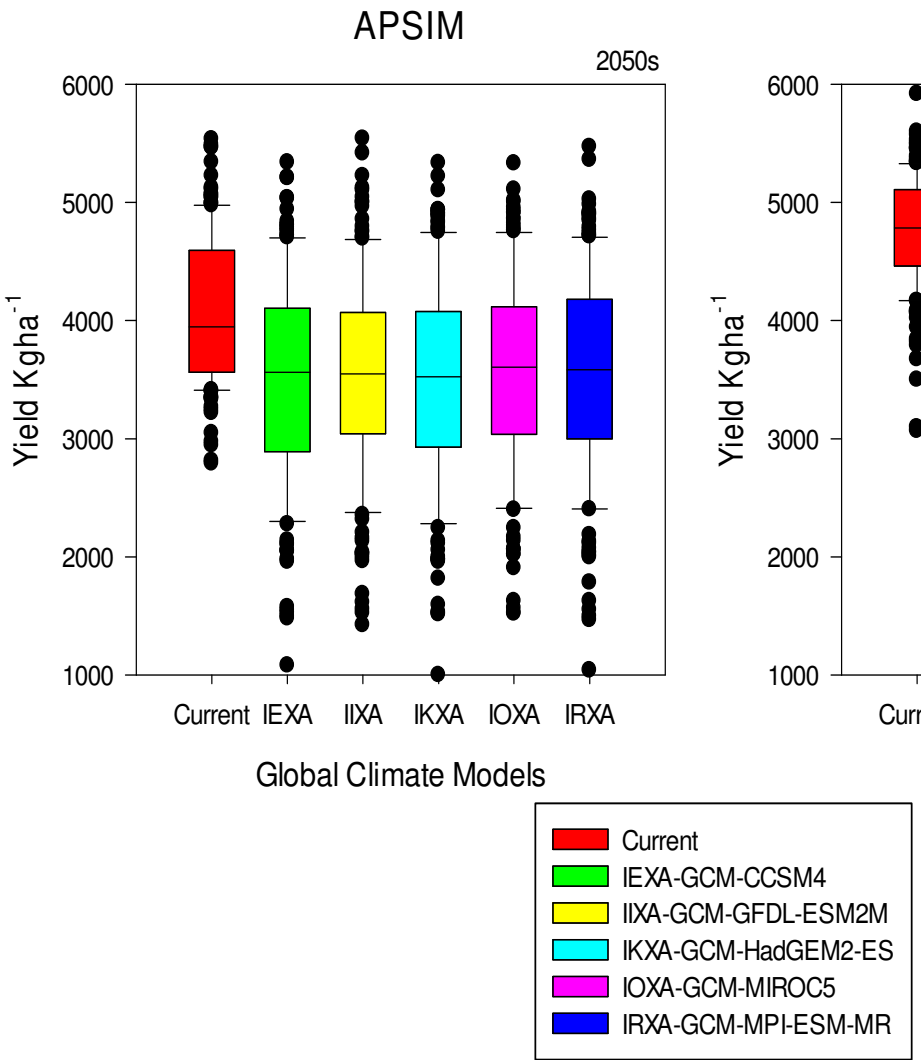
Climate Change Impact on Rice

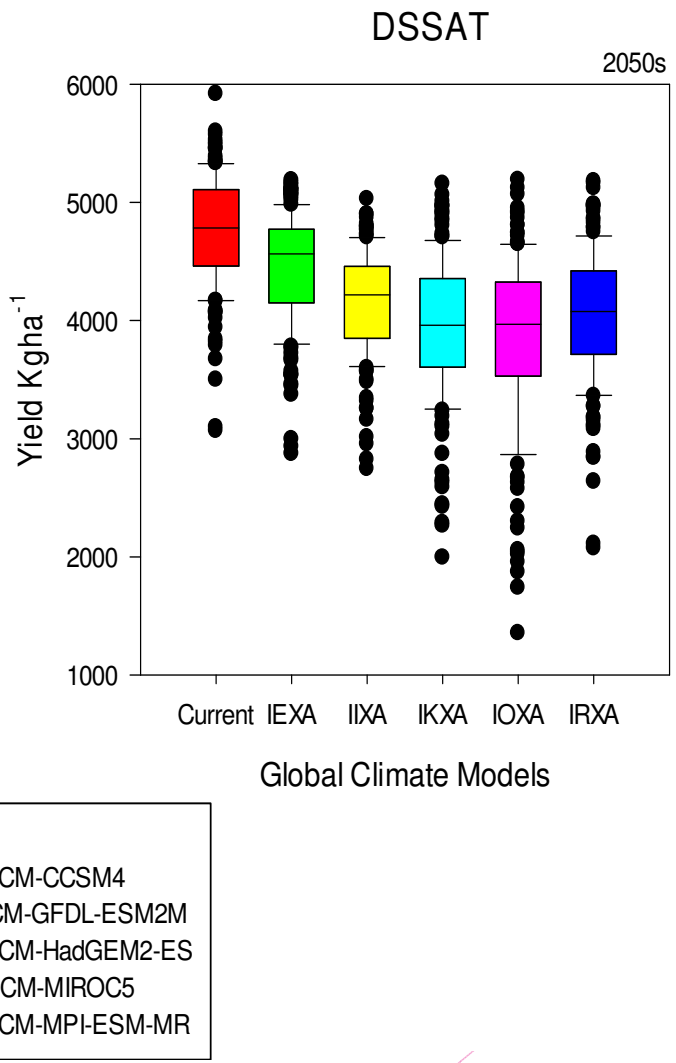
Rice results of APSIM and DSSAT for 155 Farms Variation with 5-GCMs in Rice Region of Punjab-Pakistan, Mean yield reduction by DSSAT and APSIM was 15.2 and 17.2%.



Climate Change Impact on Wheat

Wheat results of APSIM and DSSAT for 155 Farms Variation with 5-GCMs in Rice-wheat Region of Punjab-Pakistan, Mean yield reduction by DSSAT and APSIM was 14.1and 12%.





Adaptation Package

For Crop Models

Sr. #	Variable	Direction of Change	%age Change	
			Rice	Wheat
1	Nitrogen/hectare (kg)	Increase	15	25
2	Planting Density (Plant/m^2)	Increase	15	30
3	Irrigation	Decrease	15	25
4	Sowing Dates	Decrease	5 Days	15 Days

For TOA-MD

Sr. #	Variable	Direction of Change	%age Change	
			Rice	Wheat
1	Average House Hold Persons	Increase	40	40
2	Non Agricultural Income	Increase	40	40
3	Yield	Increase	55	60
4	Price of Output	Increase	65	70
5	Variable Production Cost	Increase	55	50

Conclusion

- Food security is directly linked with availability of water to grow crops
- The per capita water availability is decreasing in Pakistan because of climate change and we will have to use it judiciously for successful crop production
- Water Productivity of many crops is below global average in Pakistan
- Due to climate change and reduced water, DSSAT and APSIM predicted 15.2 and 17.2% yield loss for rice and correspondingly 14.1and 12% for wheat in rice-wheat cropping system

(AgMIP, Pak. 2013)

- Models, integrated with remotely sensed data, are the best options to improve crop water productivity and schedule irrigation in water shortage scenario

THANKS

aachattha1@yahoo.com

del@uaf.edu.pk