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EVALUATION OF CLIMATE CHANGE ADAPTATION PRACTICES IN THE AGRICULTURE SECTOR USING SATELLITE IMAGERY IN PAKISTAN

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In Pakistan, climate change is affecting water resources and also agriculture productivity. Rice-Wheat cropping zone is one of the prone regions that use water coming from upstream of the Indus Basin in Pakistan. In this study Soil and Water Assessment Tool (SWAT) model was used to evaluate the climate change adaptation practices in agriculture. The model was calibrated for the years 2005-2010 at Tarbela and Mangla reservoirs. Reasonably good performance of the calibrated model was achieved by estimated Coefficient of Determination (R^2), Nash-Sutcliffe efficiency (NSE), Percent Bias (PBIAS) at 0.87, 0.82 and 10.7 % for Tarbela and 0.70, 0.72 and 15.7 % for Mangla, respectively. Direct-Seeded Rice (DSR) practice for rice and Zero Tillage practice for wheat crops were tested in comparison to conventional methods by using SWAT. In parallel to the modeling approach, the field experiment was performed for two years i.e. 2016-17 and-2017-18 at district Sahiwal. The results showed that overall water productivity of DSR was 0.58 and 0.54 kg per m^3 in the year 2017 and 2018, respectively, which was higher than Transplanting Rice Practice (TRP) having 0.43 and 0.40 kg per m^3 in 2017 and 2018, respectively. In wheat crop trails, overall water productivity of zero tillage was 1.3 and 1.2 kg per m^3 in the years 2017 and 2018, respectively. Two climate change scenarios Representative Concentration Pathways (RCP) 4.5 and 8.5 were tested in a combination of best management practices to evaluate climate change adaptation strategies for rice-wheat cropping zones. The results showed that DSR and Zero Tillage practices would be helpful in the future to adapt the expected climate change conditions without compromising the yield and water productivity of rice and wheat crops.
Keywords: Adaptation, climate change, SWAT, Remote Sensing, DSR, Zero tillage.

INTRODUCTION

Climate change has become one of the biggest challenges of twenty first century, which is affecting meteorological parameters like temperature (max, min), rainfall and humidity. It has been observed through evidence that greenhouse gases are warming the planet Intergovernmental Panel on Climate Change (IPCC, 2014). The impacts of global climate change will be manifold but one of the most important impacts is expected to hit the agriculture sector badly. Changes in climatic factors like temperature and precipitation will affect water resources availability, irrigation water supply and demand, and agricultural production. Such changes will affect global food production, thus causing threats to food security worldwide. According to the Intergovernmental Panel on Climate Change (IPCC)'s fifth assessment report (IPCC, 2014) climate change has already negatively affected global crop production that is expected to be continued unless adaptive measures have not been taken. Pakistan's economy is heavily based on agriculture, contributing nearly 20% to the Gross domestic production. The country is also facing the threat of climate change. Studies showed that there would be an expected increase in temperature on an average of 0.9°C and 1.5°C by the years 2020 and 2050, respectively.

In Pakistan, there are two major cropping seasons, Kharif and Rabi. In the Kharif season, the dominant crop is rice, having cultivated an area of 2.74 million hectares (Pakistan Economic Survey, 2015-16). Rice crop requires 15-25 irrigations from its transplantation until the maturity stage (Ahmad *et al.*, 2007). Rice is a staple food for more than half of the world's population. It is one of the most important cash crops of Pakistan. Studies predicted that under climate change scenarios, rice production in Pakistan would also decline (Joyo *et al.*, 2018). Climate change will cause damage to the rice production sector if not addressed properly. In Pakistan, after wheat crop rice is the second most used diet item. It contributes a reasonable share in the economy of Pakistan. In Pakistan, rice contributes in agriculture almost 3.1% and in GDP is 0.7%. In the rabi season, wheat is the dominated crop of the area, having a cultivation area of 9.2 million hectares (Pakistan Economic Survey, 2015-16). The wheat crop requires 4 to 5 irrigations until the maturity of the crop. Wheat is one of the main staple crops that fulfilled almost 21% food requirement of the world (Enghiad *et al.,* 2017).

Adaptation to climate change impacts has become a major source of concern for human development and for ecosystem conservation (Shafqat *et al*., 2019). Whatever the warming scenarios and regardless of the success of mitigation measures, climate change will increase in the coming decades. Agriculture and water management practices can help to adapt the climate change effects on crop production. The DSR method is getting popularity and can be considered as best management practice of rice crop to adapt the climate change. DSR is a process in which transplanting is replaced by the direct sowing of seeds. Direct seeding avoids three basic operations, which are puddling (a process where the soil is compacted to reduce water seepage), transplanting and application of water for maintaining standing water in fields. Taking the advantages of saving water, time and increasing system productivity, dry direct-seeded rice has been believed to be an economically viable option for rice production (Joshi *et al.,* 2013). In a rice-wheat zone, Zero tillage for wheat is one of the best management practices to adapt the changing climate effects. Zero tillage involves sowing seeds into un-ploughed and unprepared land with the help of zero drill. The studies suggest that zero tillage leads to differentiated results. Economic yields from zero tillage fields are often higher than those from conventional tillage ones. (Erenstein *et al*., 2008). The time of sowing in the wheat crop is an important factor. It has also been observed that delay in the sowing of yield can cause a yield reduction on a daily basis. Zero tillage practice helps to sow the crops in time, which results in better yield (Sarker *et al.,* 2011).

In this study, an effort was made to utilize a well-established SWAT model Arnold *et al.* (1998) to map out the effect of climate change scenarios on rice-wheat cropping area. SWAT is a comprehensive semi-distributed model that uses input. Many researchers used swat model using remote sensing data to get good results (Cheema *et al.,* 2014). With the help of field and modeling approaches, the current agricultural and water management practices and their alternatives best management practices were compared to adapt climate change effects on crop production.

MATERIALS AND METHODS

Study Area**:** The study area was Indus Basin of Pakistan region but for higher flow accuracy whole Basin was considered during the modeling approach of SWAT. The Indus Basin is located in four countries China (upstream), Afghanistan, India and Pakistan (downstream). The largest area (53% of total) of the Basin lies in Pakistan. The total area of Pakistan is divided into ten Agro ecological zones based on the climate and land use out of which nine zones are located in the study area. There is large variation in the seasonal temperature and rainfall. The average annual rainfall ranges from 200 mm to 1500 mm. There are two major cropping season Rabi and Kharif. Wheat, rice sugarcane, cotton and maize are the major crops of the area. Savanna deciduous pastures and bare soil are other dominant land use classes in the Basin (Cheema and Bastiaanssen, 2010). The availability of surface and groundwater and its quality also varies across the study area.

Field Trails**:** Field trials were conducted for the DSR and zero tillage of wheat crop. The field selected for the trails was located in the district of Sahiwal in Punjab province. Sahiwal lies on 170 m above sea level. Canal and groundwater conjunctive use was adopted to fulfil the crop water requirement. The soil type was silt loam, having pH value 8. DSR was done with the help of a calibrated seed drill. The rate of seed application was adjusted to 29.5 kg per hectare. Following the rice crop, wheat was sown in the same field in Rabi season with zero drill method. The seed-drill was calibrated for wheat sowing using the metering mechanism, having a seed rate of 100 kg per hectare.

Modelling Approach**:** Land use Land cover map was developed for the year 2016. Satellite imagery from the platform of Moderate Resolution Imaging Spectroradiometer (MODIS), agriculture census data, crop calendar and cropping pattern information was utilized to map land use land cover map. To assess the vegetation cover for the study area, multi-temporal normalized difference vegetation index (NDVI) images were used in this study. The supervised classification signature auditor was created on the basis of per pixel value with the help of the study area crop sampling point. These points were gathered during field visits.

SWAT is a semi-distributed model, as the entire Basin or water catchment area is divided into small sub-basins, which in turn are divided into further smaller units known as a hydraulic-response unit (HRU's). The smallest unit of SWAT model is HRU. Thus, SWAT computes all of its calculations at HRU-scale (Arnold *et al.,* 1998). Watershed delineation and further division into sub-basin was done with the help of the digital elevation model. The Basin was divided on the basis of slope and elevation. The network of streams and canals was incorporated in the Basin at this stage. Different HRUs were created in the study area. The HRUs were based on the same landuse, slope and soil characteristics (Neitsch *et al*., 2005).

The future climatic data downscaled on the basis of IPCC Fifth Assessment Report (AR5) on 50KM resolutions was utilized in the study. One medium range RCP 4.5 and one relatively extreme condition of RCP 8.5 were utilized for the analysis of the future scenarios. In RCP 8.5 the increase in temperature is relatively higher as compared to RCP 4.5. Crop yield result showed the possible areas suitable for the cultivation of rice and wheat crop in the future. To classify suitable future land use for rice-wheat crop rotation, the area was distributed on the basis of yield and spatial variability under the climate change scenarios

RESULTS AND DISCUSSION

The overall water productivity of DSR was higher than the Transplantation Rice Practice (TRP). The results of these field experiments correlate with the findings of (Mann *et al.*, 2004), who also reported that higher water requirement of TPR than DSR. According to the results of (Joshi *et al.*, 2013) almost half of the water can be saved without compromising the crop yield with the use of direct seed rice as compared to the transplantation of rice which require the flooding of water for the eradication of weeds and to full fill the crop requirements. Higher grain yield was observed in DSR. The DSR appears to be a viable alternative to overcome the problem of water shortage. The overall water productivity of zero tillage was higher than conventional drill practice. These results were in good agreement with the findings of (Vikrant *et al.*, 2017) according to their study Zero tillage gives more water productivity than other planting techniques.

Table 1. Water productivity and crop yield under conventional and best management practices

Crop	Year	Management practice	Water productivity (kg/m^3)	Crop yield kg/ha
Rice	2017	DSR	0.58	3952
		TRP	0.43	3458
	2018	DSR	0.54	3764
		TRP	0.40	3260
Wheat	2017	Zero tillage	1.30	3850
		Conventional	1.00	3754
	2018	Zero tillage	1.20	3655
		Conventional	0.90	3556

Land use Land cover Mapping: Land use land cover mapping showed that there are different cropping patterns in the study area in which rice-wheat pattern covered major area. Indus basin Pakistan region having rice-wheat rotation area was extracted from the land use land cover map. There were 3 mha of land with cropping. The land use classification can be affected by a physical condition like temperature and slope. The presence of these conditions can affect the level of accuracy of land use land cover maps. Because of this, accuracy assessment of the newly derived maps was done. The accuracy assessment for the Land use land cover map was done in different steps. Initially, the crop phenology of the pixel showing rice-wheat area was observed. The class rice and wheat have two distinct peaks, one at the end of February and another at the end of August. Because in the month of February, the vegetation of wheat reaches its peak value and in the month of August the rice crop has maximum vegetative growth, which increases the NDVI value of both crops. The existing maps of the Basin were used to compare the rice-wheat cropping area. The previous study of (Cheema and Bastiaanssen, 2010) showed that the rice-wheat cropping area covered an area of 3.25 mha, which is in good agreement with the present study derived map. In the final step, the ancillary data available at the district level was used to investigate the level of accuracy in the map. The details of the comparison between statistical data and land use land cover map strengthen the validity of the newly derived map that has been discussed in this section.

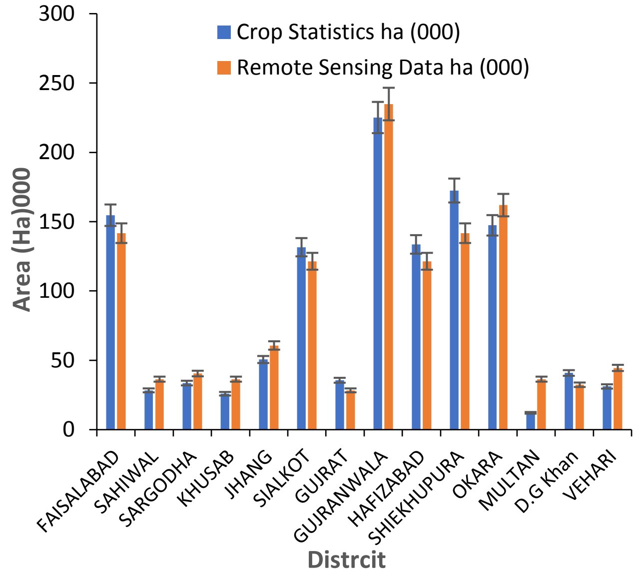

Figure 1. Rice crop area comparison between Crop statistics and Remote Sensing data

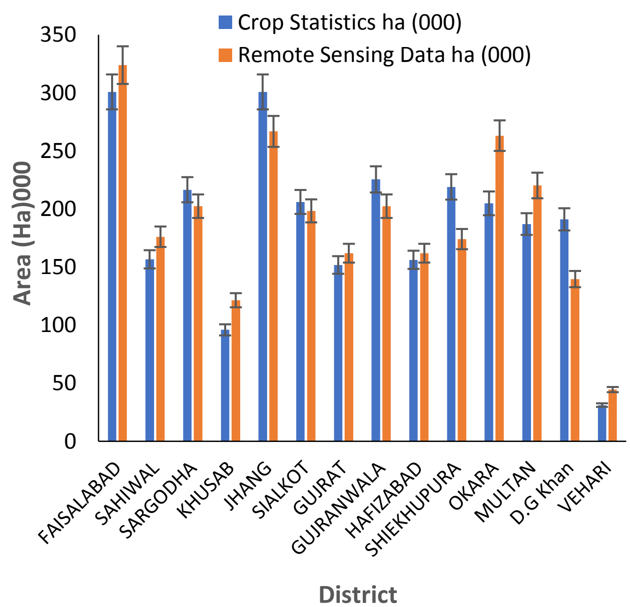

Figure 2. Wheat crop area comparison between Crop statistics and Remote Sensing data

***SWAT*:** In SWAT-CUP using SUFI-2 algorithm, different parameters were considered for the calibration of the SWAT model. After calibration, the best-fit parameters were obtained on the basis of which the further process of validation was carried out. During the calibration process, the fine-tuning of sensitive parameters made the swat model able to get the coefficient of determination at Mangla reservoir between the observed flows and simulated flow value of 0.70 for the time period of 2005 to 2010. After calibration, the validation period of 2011 to 2015 was simulated and the coefficient of determination value 0.71 was obtained between the observed flows and simulated flows. The previous studies showed that the value of R^2 above the range of 0.70 shows a good agreement for the calibration and validation process of the hydrological model like swat. During the calibration process, the fine-tuning of sensitive parameters made the swat model able to get the coefficient of determination at Tarbela reservoir between the observed flows and simulated flow value of 0.87 for the time period of 2005 to 2010. After calibration, the validation period of 2011 to 2015 was simulated and the coefficient of determination value 0.91 was obtained between the observed flows and simulated flows. The previous studies showed that the value of R^2 above the range of 0.80 indicated a very good agreement for the calibration and validation process of the hydrological model like swat.

***Sensitive parameters best fit values*:** The sensitive parameters directly affect the calibration of the swat model. The Indus Basin flow is dependent upon the snow and glacier melt. The most sensitive parameters of snow SNO50COV and SNOCOVMX were tuned during the calibration process. The adjustment in the snow parameters enhanced the efficiency of SWAT model. CN2 contributed directly to surface runoff. Soil moisture was tuned with the help of SOL-AWC and SOL-K parameters. SOL-AWC caused the variation in soil water content between the wilting point and ground (field) capacity. The saturated hydraulic conductivity (SOL-K) couples hydraulic conductivity with the soil water flow The GWDELAY parameter controlled the groundwater and change in the values of ALPHA_BF regulated the delay time between when the water discharges from the soil and when it enters into the shallow aquifer. The ALPHA-BF controlled the flow recession coefficient that accounts for changes in groundwater flow in response to changes in recharge. Reduction in the groundwater delay parameter (GW_DELAY) affects the peak discharge and the amount of available base flow water. Changes in the values of these sensitive parameters during the calibration process resulted in a good simulation in the Indus Basin at two stations of Tarbela and Mangla reservoirs.

Table 2. Sensitive parameters best fit values

Sr.No.	Parameter	Best fit values
1	CN2	68.00
2	ESCO	0.52
3	SNOCOVMX	75.00
4	SNO50COV	0.20
5	CH_K2	1.00
6	ALPHA_BF	0.12
7	GW_DELAY	20.00
8	GWQMN	3.64
9	GW_REVAP	0.15
10	RCHRG_DP	0.62
11	SOL_AWC	0.95
12	SOL_K	2.50
13	REVAPMN	500.00

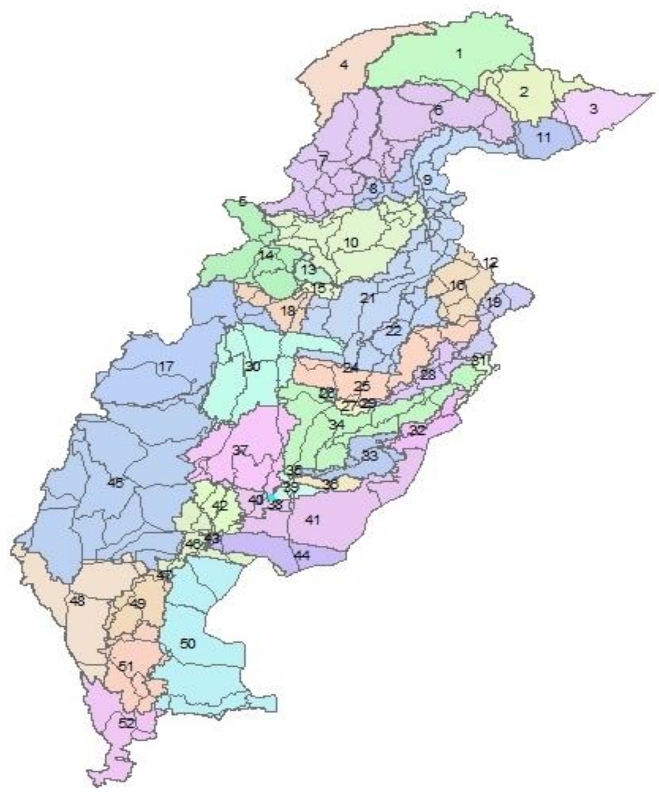

Figure 3. Sub Basin division of study area in SWAT model

***Crop yield in SWAT Model*:** To evaluate yield accuracy, random HRUs were selected to study the modeling results for rice and wheat crops in the swat model. Five HRUS no 547, 751, 890, 934, 1053 having rice-wheat crop rotation were selected from sub-basin no 16,25,34,37 and 46, respectively to evaluate crop yield. The HRUs were named as 1,2,3,4 and 5, respectively in the graphical representation. The yield result of rice and wheat was in good agreement with the data given by the Agriculture Department.

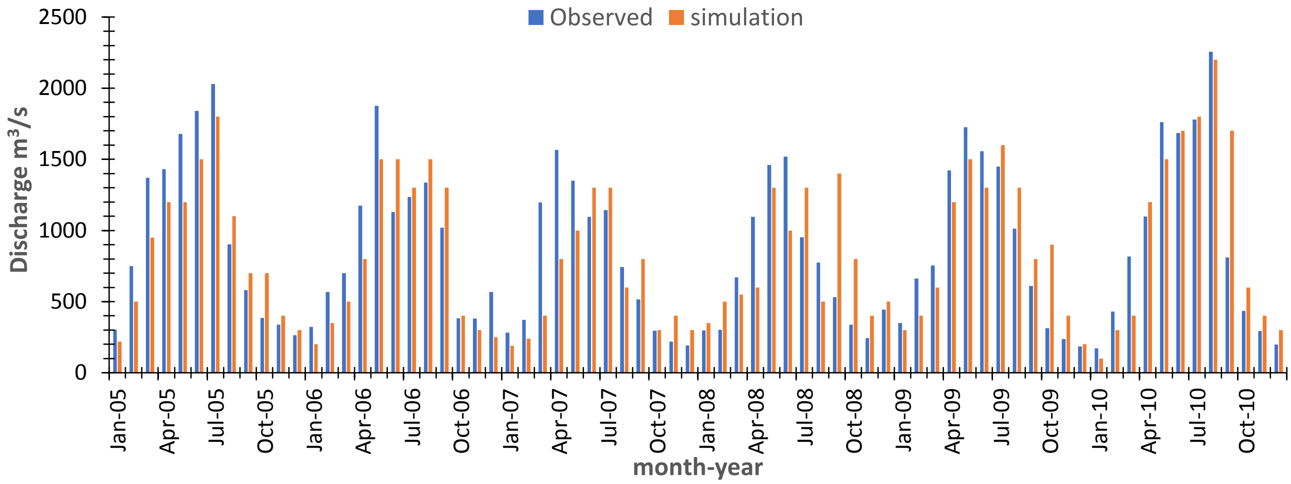

Figure 4. Monthly Discharge comparison between observed and simulation data at Mangla Reservoir for calibration

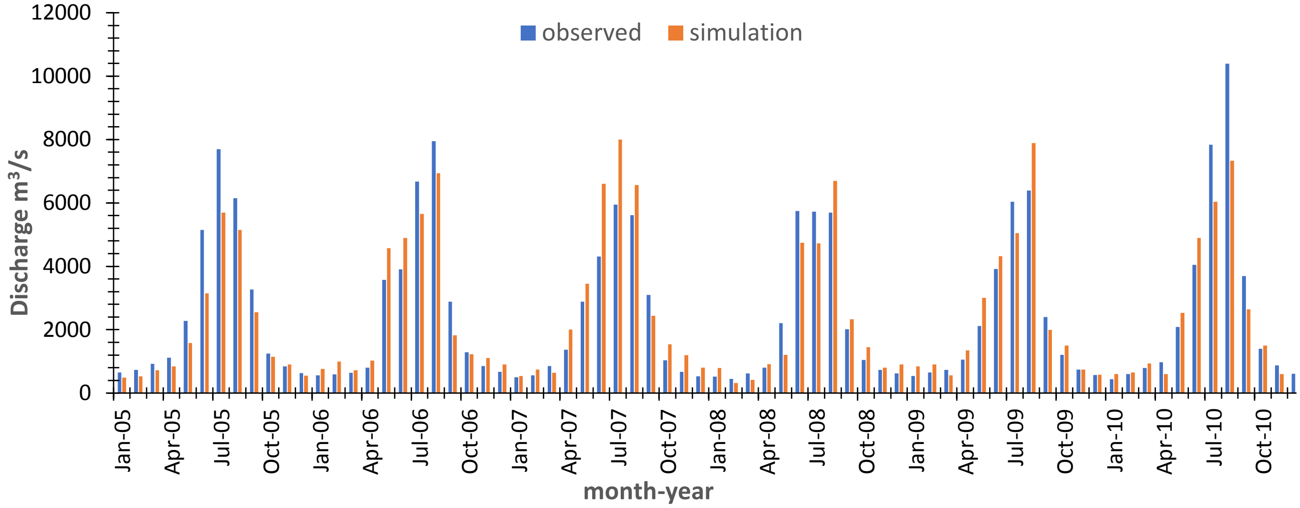

Figure 5. Monthly Discharge comparison between observed and simulation data at Tarbela Reservoir for calibration

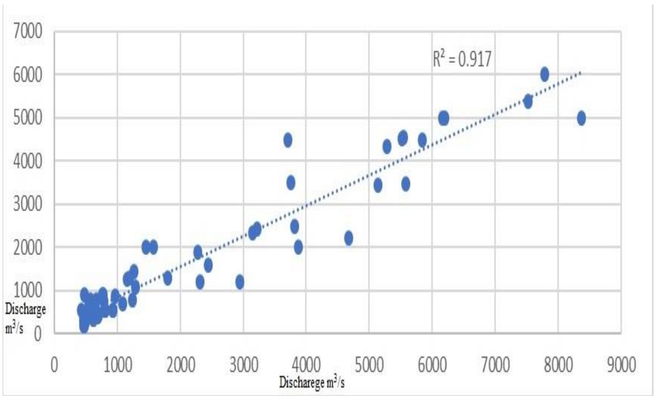

Figure 6. R^2 values plot of monthly discharge comparison between observed and simulation data at Tarbela reservoir for calibration

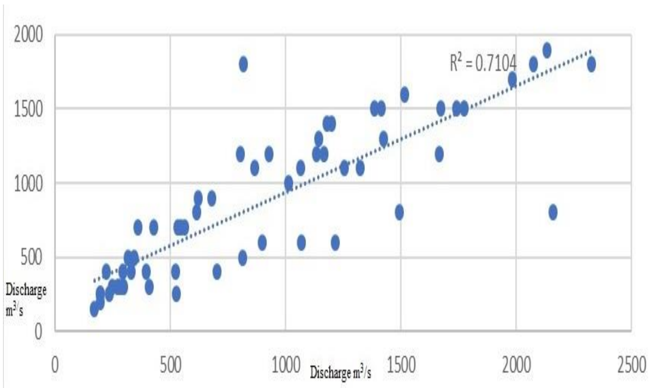

Figure 7. R^2 values plot of monthly discharge comparison between observed and simulation data at Mangla reservoir for calibration

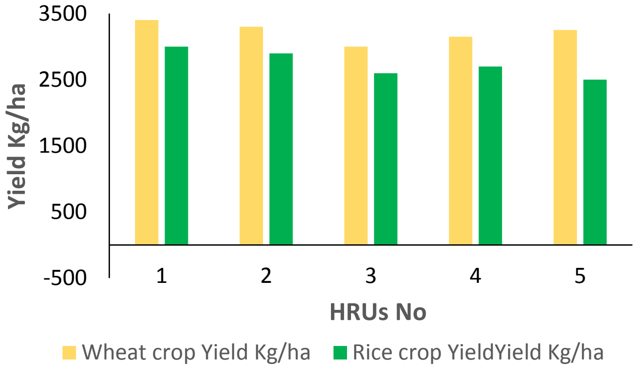

Figure 8. Crops yield at different HRUs in SWAT model

The results showed good agreement with the previous studies suggesting that SWAT can predict the crop yield satisfactorily with PBIAS values of less than 15%. The swat model crop prediction depends upon several factors, including crop management (e.g., fertilizer, tillage and harvest). Further, the modeled crop growth depends on properly predicting AET and soil moisture storage, the validity and confidence can be increased by using a well compared model on crop yield Because of change in weather as well sudden environmental condition the model some time predict over or under estimate the crop yield.

The performance of the best management practices was observed for both crops. The practices were incorporated in swat management calendar and simulation was performed for the comparison of conventional and best management practices.

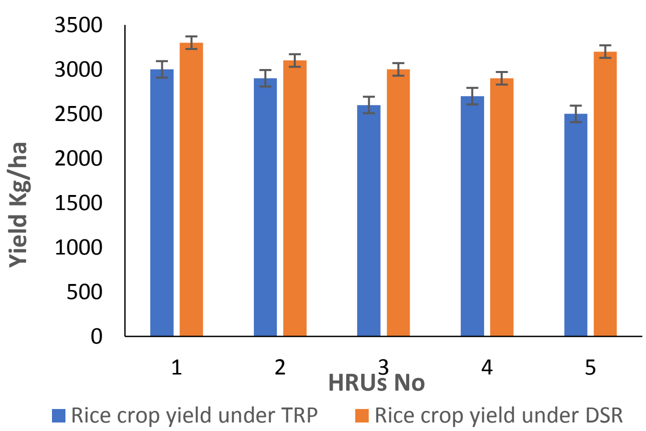

Figure 9. Rice crop yield comparison at different HRUs under TRP and DSR Practices in SWAT

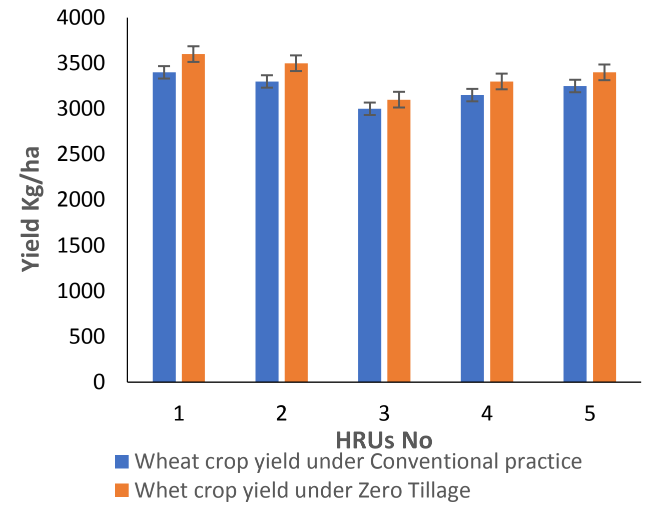

Figure 10. Wheat crop yield comparison at different HRUs under Conventional and Zero tillage practices

It was clearly observed from the results that the DSR practices performed well in the swat model as compare TRP. A significant change in the yield was observed in the 5th HRU where the DSR technique gave 700 kg/ha more yield than the conventional practice. It was also observed from the results that the zero-tillage practice performed well in the SWAT model as compared to conventional practice. SWAT model simulated better yields for both crops in the presence of best management practices.

Rice: Under RCP 4.5 scenario, a downfall in the yield of both practices DSR as well as TRP was observed. But the DSR results showed that it could help out in the future to sustain the yield and to increase climate challenges. The results showed similarity with the results of (Chenchen *et al.*, 2018), who studied the effect of climate change on rice crops in the Sichuan basin and observed a decrease in the rice yield under RCP 4.5 scenarios. Under RCP 8.5 scenario, a downfall in the yield of both practices DSR as well as TRP was observed. But the DSR results showed relatively good in comparison to the TRP practice to sustain the yield under climate challenges. These findings are also consistent with the study of global gridded crop model analysis under RCP 8.5 scenario, which shows a decrease in rice yield in the future. Temperature is one of the main changing factors in RCP 8.5 as well as RCP 4.5. Due to an increase in temperature, the evapotranspiration rate increases in rice crops, causing higher utilization of water resources. In the presence of future scenario, the DSR simulate well because of water use efficiency and availability of water for a longer time period in the study area.

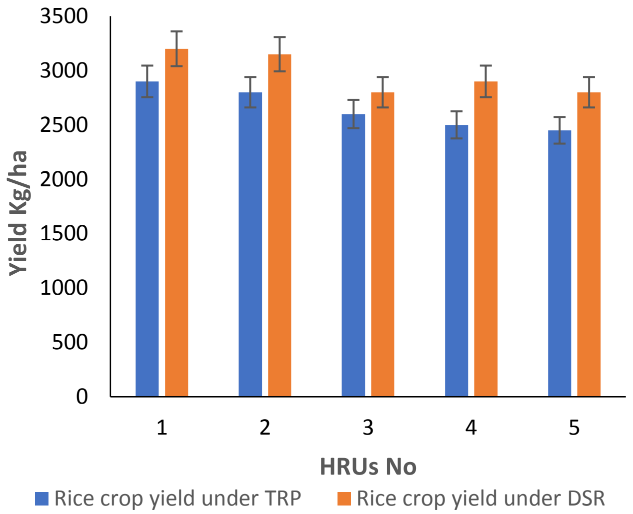

Figure 11. Rice crop yield comparison at different HRUs under TRP and DSR Practices in SWAT under RCP 4.5

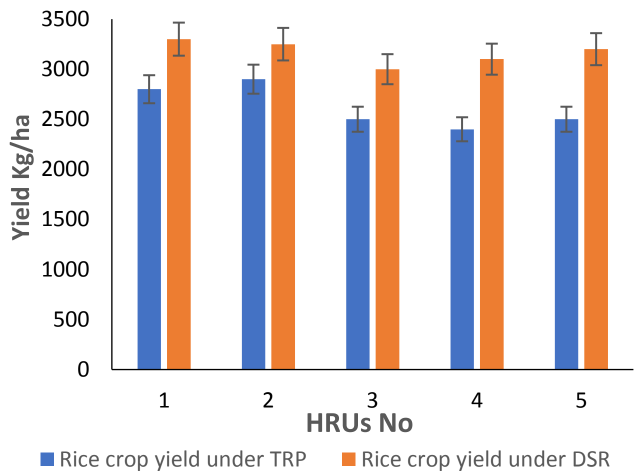

Figure 12. Rice crop yield comparison at different HRUs under TRP and DSR Practices in SWAT under RCP 8.5.

***Wheat*:** Under RCP 4.5 scenario, a downfall in the yield of both practices Zero tillage as well as Conventional was observed. But the Zero tillage results showed that it could help out in the future to sustain the yield and increasing climate challenges. The results showed good agreement with the study of (Ramachandran *et al.*, 2017) who found that there will be significant effects of climate change on C3 and C4 crops. He utilized the DSSAT modeling approach with RCP 4.5 trajectory and found a decrease in the wheat yield. It is reported that one-degree increase in temperature may reduce the yield of wheat upto 3-7%. An increase in temperature, as expected, in the RCP scenarios would result in decreased and less water availability (IPCC, 2014) which will impact agriculture production.

In case of the RCP 8.5 scenario a downfall in the yield of both practices Zero tillage as well as Conventional was observed. But the Zero tillage results were relatively better than the conventional practice of wheat sowing. Zero tillage helps to improve the soil condition and also helps to save the soil moisture. In the presence of high-temperature scenario and climatic conditions, the zero tillage can help the crop in the water availability for its production because the increase in maximum and minimum temperature shortened the crop duration. These conditions also cause increased respiration, high water consumption, a decrease in the uptake of nutrients and less dry mass. The overall performance of zero tillage suggests that in the future climate change scenario, this practice will not only help the farmer to adopt climate change without compromising on the yield but also reduce the soil degradation.

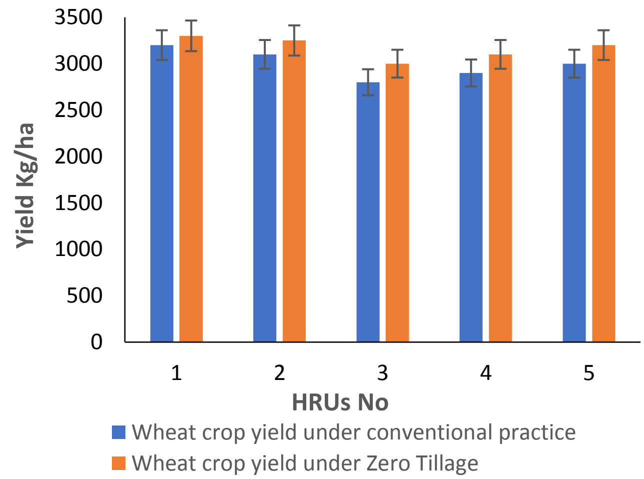

Figure 13. Wheat crop yield comparison at different HRUs under Conventional and Zero Tillage Practices in SWAT under RCP 4.5.

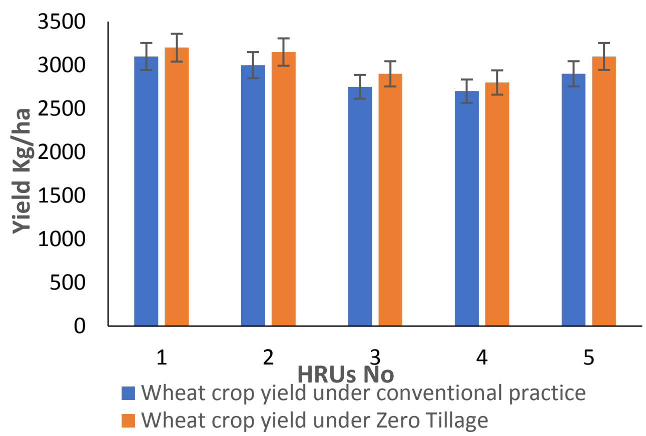

Figure 14. Wheat crop yield comparison at different HRUs under Conventional and Zero Tillage Practices in SWAT under RCP 8.5.

Future climate change scenario RCP 4.5 and 8.5 were used for the year up to 2030. The results of crop yield in 2030 were selected as a reference for future yield scenarios in the study. Best management practices were used as agricultural practices to find out the effectiveness of adaptive measures in a different region of the study area. According to the IPCC fifth assessment report, the adaptive measurement can improve the yield of wheat and rice upto 15% in the temperate and tropical regions (Jeonghyun *et al.*, 2018). The finding of this study is also consistent with the observations of IPCC reports.

In order to find out the possible future land use for rice crop area, three classes were defined to find out the spatial variability in the yield under the climate change scenarios. Class-1 consists of the areas having a forecast of >3000 kg/ha of yield in rice crop. Class- 2 consists of the area representing a yield of 2000 to 3000 kg/ha and the class-3 having the lowest yield of <2000 kg/ha. The results suggest that the areas of Indus basin region in Pakistan falling in the territory of Punjab will yield high average in the upcoming climate change scenario and there will be no severe decrease in the rice crop production in this area. The land use suggests that in future climate change scenarios, the area of central and lower Punjab will produce average yield and it becomes likely to get slightly affected due to climate change. The land use suggests that the area of Sindh is likely to get more effected under RCP 4.5 in the future as compared to other parts of the region. The production in this area will be below the average yield having less than 2000 kg/ha.

The results showed that rice yield varies significantly under possible future climate change in the different rice-growing areas. An increase in temperature and soil water stress is an important factor in determining crop growth and yield. In current conditions, the increased trend of temperature has exerted a significant impact on crop yields. The study of Lobell and Field (2007) also endorsed these results which found that there is tendency of yield reduction up to 8 % due to 1^0C increase in the temperature for different crops in previous years. In case of rice crop specifically, the temperature effect is significant. Similar results were found in the Indochinese peninsula for rice crop due to an increase in temperature. Each degree of increased temperature caused up to 10% reduction in the rice yield. In extreme cases, up to 52% decrease in the rice yield was observed. Schmidhuber and Tubiello (2007) reported that the temperature has already reached its maximum range for optimum yield of rice crop further increase in the temperature will cause severe negative effects on the rice yield. The same results were found in the other study with reduction of rice crop yield having different magnitude according to the area (Li *et al.*, 2015) under RCP 8.5 scenario, the results indicate that as compared to RCP 4.5 the area in upper Punjab will produce more yield of rice. Central Punjab, lower Punjab and lower Sindh fall in the category of producing an average yield of rice crop. The Basin no 48, 49, 50 and 51 forecasted lowest yield in the region with range having less than 2000 kg/ha. This scenario predicts relatively the same results as in the case of RCP 4.5 where most parts of the Sindh will get affected by climate change causing low yield of rice crop. In rice-wheat cropping zone increase in the day and night temperature may affect the growth and development of some critical phenological stages and thus could impact the final yield studied by (Bokhari *et al.*, 2017). A low level of yield is triggered by an increase in temperature. According to Bachelet and Gay (1993) increased temperature caused crop growth earlier than the normal crop, which leads to less time availability to crop growth. The grains filling remain incomplete, resulting in a low level of yield. Stigter and Winarto (2013) also reported that increased temperature causes reduce grain filling increase spike sterility and respiratory losses resulting in the low quality as well as yield. (Mishra *et al.*, 2014) reported upto 5% decrease in rice crop yield in the IGB region. The results of this study and the previous finding show similar trends in the rice crop yield. In the presence of climate change threats, the adaptive and best management strategies can help the growers to adapt the changes in the climate without compromising the crop yield and quality. The management practices having higher water use efficiency level can facilitate the growers to avoid the negative impact of climate change (Vaghefi *et al.*, 2011).

In order to find out the possible future land use for wheat, three classes as described earlier, were defined to find out the spatial variability in the yield under the climate change scenarios. The area of South Punjab showed yield potential of >3000 kg/ha. With present and conventional practice, the yield of wheat under the RCP 4.5 and RCP 8.5 were projected to decrease up to 20%. The agricultural management practices found to be the most effective practice in adaptive measures (Jeonghyun *et al.*, 2018). This scenario represents that the entire region is likely to become affected due to changing climate scenario in future. The area of upper Punjab and lower Sindh showed a yield capacity of 2000-3000 kg/ha. Most of the areas of Punjab and Sindh represent the lowest yield in the future for the RCP 4.5 scenario. It has been observed under RCP 4.5 and 8.5 that the area of central Punjab will perform well according to the predicted yield in the coming climate change scenario. A previous study reported that all GCMs result in a higher level of temperature. The increase in temperature will be 1 to 8°C depending upon the area and climate there. In general, the RCP 8.5 has a relatively high temperature than RCP 4.5. The wheat yield is expected to decrease by 37% and 50 % under RCP 4.5 and RCP 8.5, respectively. According to (Taylor *et al.,* 2018) the yield of wheat is likely to decrease up to 38% and 49% under RCP 4.5 and RCP 8.5, respectively in Australia. (Zacharias *et al.,* 2014) also reported that the climatic parameters influence the yields of crops. Temperature plays a basic role in the case of wheat crop. An increase in temperature can cause a reduction in the yield. To overcome the challenge of climate change and the expected scarcity of water in future best management practices can help to overcome the deficit of water Debaeke and Aboudrare (2004). In many areas, the conservation of soil moisture through the zero-tillage technique has been adopted to increase the water use efficiency in the water stress conditions. The crop residue can be utilized in case of zero tillage to save the soil moisture, avoiding soil erosion and enhance soil quality (Lal *et al.*, 2011). In a study of wheat yield under climate change scenarios (Valizadeh *et al.,* 2014) it was reported that reduction of wheat yield would occur under the general circulation model up to 37%. Other than temperature increase and water scarcity factor, which was observed, causing low yield in the wheat crop was CO_2. In general, the increase in CO_2 has a positive effect on the C3 crops but in the presence of high temperate the increased effect negatively on the crop, causing a low level of yield.

***Conclusion*:** Best management practices for rice and wheat crops were tested in the field and then incorporated into a well-calibrated SWAT model to study the strategies for adaptation of future climate change scenarios. The results showed that DSR and Zero tillage in rice and wheat crops respectively will be helpful in adapting the future climate change effects. On the basis of field and modeling approach, overall higher water productivity of rice crop was obtained by using the DSR method with 0.58 and 0.54 kg per m^3 in the year 2017 and 2018. In wheat crop, zero tillage gave water productivity of 1.3 and 1.2 kg per m^3 in the years 2017 and 2018, respectively, which were relatively higher than the conventional practice. Two climate change scenarios Representative Concentration Pathways (RCP) 4.5 and 8.5 were tested in a combination of best management practices to evaluate climate change adaptation strategies for rice-wheat cropping zones. Under RCP 4.5 and 8.5 scenarios, a downfall in the yield of both crops was observed, but the incorporation of DSR and zero tillage showed better yield results at different locations of the study area. The results showed that there would be negative impacts on the yield of both crops and in the absence of adaptive management strategies, it will become difficult to sustain the required crops yield to fulfill the desired demand of these staple foods. The suggested adaptive strategies can reduce the yield losses by improving the water use efficiency and the increasing overall grain yield.

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