

# Estimating Sectoral Water Demand for Sindh Province of Pakistan

Heman Das Lohano<sup>1</sup> and Fateh Muhammad Marri<sup>2</sup>

RECEIVED ON 24.02.2019, ACCEPTED ON 30.01.2020

## ABSTRACT

Water resources in Sindh province of Pakistan are under significant pressure due to increasing and conflicting water demand from municipalities for domestic users, agriculture and industries, and requirements of environmental flows. Population growth and climate change are likely to pose serious challenges to households and economic sectors that depend on water. This study estimates the present water demand from municipalities, agriculture and industries, and its future projections by the year 2050 in Sindh. The study also evaluates the impact of climate change on sectoral water demand and assesses the water requirements for the environmental flows. The results show that presently the total water demand for these sectors in Sindh is 44.06 Million Acre Feet (MAF). Agriculture is the largest consumer of water, accounting for 95.24 percent of the total water demand. Municipal water demand accounts for 2.61 percent while industrial water demand accounts for 1.88 percent. The demand for water in these sectors is expected to rise by 10 percent from 2018 to 2050. Moreover, depending on climate change scenario, the total water demand in these three sectors is likely to rise by 16 to 25 percent from 2018 to 2050. In additions, water requirements for the environmental flows have been indicated as 10 MAF in the National Water Accord of 1991. The findings of this study call for policy measures and strategies for management of water resources in Sindh.

**Keywords:** Water, Demand Projections, Climate Change, Sindh, Pakistan

## 1. INTRODUCTION

With a population of nearly 50 million, Sindh is the second most populous province in Pakistan. Its economy accounts for more than one third of economy of Pakistan. Sindh is the most downstream province in the Indus River Basin and depends almost exclusively on the water resources of the Indus River. Users of water resources include municipalities for domestic users, agriculture, industries and environment. Agriculture, which accounts for almost 20 percent of GDP and 70 percent of employment in Sindh, has traditionally been the largest user of water resources

[1]. Water resources in the province are distributed through the Indus Basin Irrigation System (IBIS), which comprises three main barrages on the Indus River in Sindh. These barrages divert water into fourteen main canals that serve a total cultivable command area of 6.8 million hectares [2].

Undoubtedly, the Indus River system has shaped the economic development of Sindh, and has delivered critical water services. However, water resources in Sindh – as in the larger Indus Basin – are under significant pressure, a situation which is likely to be exacerbated by climate change. This has also been underscored at the country level in National Water Policy of Pakistan [3]. Under the framework of the national water policy, each province including Sindh

---

<sup>1</sup> Professor of Economics, IBA, Karachi, Sindh, Pakistan. Email: [hlohano@iba.edu.pk](mailto:hlohano@iba.edu.pk) (Corresponding Author)

<sup>2</sup> Member, Higher Education Commission, Islamabad, Pakistan. Email: [fateh.marri@hec.gov.pk](mailto:fateh.marri@hec.gov.pk)

is required to develop its own water resources management plan keeping in view the challenges facing the province.

Water use sectors are generally categorized into four sectors, namely municipal (domestic users), agriculture, industry, and environmental flows. Three users of water including municipal, agriculture and industry place their demand for water, while the environmental flow is the water required for ecosystem, which provides various ecosystem services.

Due to diverse geography of Sindh and conflicting water demands, climate change and weather variability are likely to create a great deal of uncertainty about water sector and pose serious challenges to economic sectors that depend on water. Sindh is very vulnerable to climate shocks due to its geographic location. It is already a hot region with mid-summer temperatures shooting as high as 50°C in some regions, so further increases in temperature can be very detrimental to crops and lives in form of heat waves. Sindh being the lowest riparian province is at high risk of droughts and floods in case of relevant water activity upstream. Thus, there is a need to estimate water demand to input for formulating policies and developing strategies that would facilitate managing water resources and climate change adaptation in Sindh to mitigate the negative impacts of climate change on the water sector.

The main objective of this study is to estimate the present water demand from municipalities, agriculture and industries, and its future projections by the year 2050 in Sindh. The study also evaluates the impact of climate change on sectoral water demand and assesses the water requirements for the environmental flows.

## 2. METHODOLOGY

To estimate the sectoral water demand, this study uses secondary data and various analytical methods including descriptive analysis, regression analysis and past trend analysis. Furthermore, this study uses the parameters estimated in the literature and also estimates some other parameters using secondary data. Based on the nature of the sector, appropriate data and methods are used for estimating the water demand

separately for each sector including municipalities, agriculture and industries. The details about data, methods and assumptions for estimating and forecasting water demand for each sector are given in the following section along with the results. The requirements for environmental flow are assessed by reviewing the literature including National Water Accord 1991.

## 3. RESULTS AND DISCUSSION

### 3.1 Water Demand Projections and Climate Change Impacts

In this section, we analyze and forecast the sectoral and total demand for water and potential climate change impacts on water demand. We also assess the water requirements for environmental flows.

#### 3.1.1 Municipal Water Demand

Water demand from municipalities for domestic users depends on several factors including population, proportion of urban and rural population, and climatic conditions. Table 1 presents the urban, rural and total population in Pakistan and Sindh. Population data for 1981, 1998 and 2017 come from census conducted in the respective years. Future projections for Pakistan are provided by the United Nations [4]. Future projections for Sindh have been estimated. Data show that Sindh's share in Pakistan's population has remained 23 percent in the years 1981, 1998 and 2017, and thus the same share has been assumed for future projections. Projections of rural and urban population of Sindh have been estimated based on the growth pattern of urban population relative to total population between 1998 and 2017.

Table 2 presents the municipal water demand for domestic users. According to the National Drinking Water Policy [5], the daily per capita water requirement is 45 and 120 liters for rural and urban dwellers, respectively. Using this water requirement and population estimates given in Table 1, we estimate the baseline municipal water demand on annual basis for the years 2018, 2030 and 2050. Table 2 reports the baseline (without climate change) municipal water demand for 2018, 2030 and 2050. Table 2 also reports

**Table 1: Population in Pakistan and Sindh: Urban, Rural and Overall**

Year	Pakistan (millions)			Sindh (millions)		
	Urban	Rural	Total	Urban	Rural	Total
1981	23.84	60.41	84.25	8.24	10.79	19.03
1998	43.04	89.32	132.35	14.84	15.60	30.44
2017	75.58	132.22	207.80	24.91	22.97	47.90
2018	77.42	135.39	212.82	25.51	23.54	49.05
2030	99.39	144.81	244.20	29.96	26.33	56.29
2050	160.20	146.70	306.90	38.91	31.84	70.70

Source: Pakistan Census Reports [8], Pakistan Economic Survey [7], UN (2018) and author's calculations

**Table 2: Municipal Water Demand in Pakistan and Sindh**

Annual Water demand (MAF) under each scenario	Pakistan			Sindh		
	2018	2030	2050	2017	2030	2050
Without climate change	4.55	5.46	7.64	1.22	1.41	1.80
Climate scenario with 1 °C	-	5.51	7.77	-	1.42	1.83
Climate scenario with 3 °C	-	5.76	8.25	-	1.49	1.94

the future projections of municipal water demand under two climate change scenarios with 1 °C and 3°C increase in the average temperature. The projections of increase in municipal water demand under each climate scenario are based on the percent increase estimates provided by Amir and Habib [6].

The results show that the municipal water demand for Pakistan will increase from 4.55 MAF in 2018 to 7.64 MAF in 2050 without accounting for the climate change. Similarly, the municipal water demand for Sindh will increase from 1.22 MAF in 2018 to 1.80 MAF in 2050 if there is no climate change.

The estimated increase in municipal water demand in Pakistan in 2050 attributable to climate change show that the municipal water demand will be higher by 1.7 percent under the climate scenario of 1 °C and by 7.8 percent under the climate scenario of 3 °C. This shows that the municipal water demand will be even higher under the climate change regime. We find that if the temperature increases by 1 °C, then the municipal water demand in Pakistan will rise from the existing demand of 4.55 MAF (in 2018) to 7.77 MAF in 2050. Along the same lines, if the average temperature increases by 3 °C in 2050, it will put immense pressure on the current water resources of the country. Under

this scenario, the municipal water demand is expected to rise to 8.25 MAF in Pakistan and 1.94 MAF in Sindh in 2050.

### 3.1.2. Agricultural Water Demand

Agriculture sector includes not just crops but also livestock, fisheries, agro-forestry and rangelands [7]. We estimate the agricultural water demand using data of both surface water and groundwater. Total agriculture water is calculated by adding the water availability at farm gate and the groundwater used by agriculture sector. To estimate the demand for agriculture water in Pakistan, we estimated a trend line of total agriculture water by regressing the natural log of agriculture water on time using data for past 21 years. The upward trend was statistically significant at 10 percent level. The regression results show that agricultural water use has increased at the rate of 0.16 percent per annum in the past 21 years, which we use to compute future projections for 2030 and 2050.

Table 3 reports the average (per year) availability of surface water at farm gate and use of groundwater in Pakistan and Sindh in the last ten years, computed using data from 2007-08 to 2016-17. Data on amount

Table 3: Availability of Surface Water at Farm Gate and Groundwater per Year: Average during 2007-08 to 2016-17

	Pakistan	Sindh	Share of Sindh (percent)
Surface water at farm gate (MAF)	85.21	34.54	40.54
Groundwater (MAF)	49.87	8.10	16.24
Total (MAF)	135.08	42.64	31.57

Source: Author’s computation based data from Pakistan Statistical Yearbook (GOP, 2017)

of water at farm gate and groundwater use for Pakistan are available in Statistical Year Book [9]. As data on canal water withdrawal was available for both Pakistan and Sindh, we estimated water at farm gate for Sindh assuming that the ratio of farm gate to canal water withdrawal is the same in Pakistan and Sindh. Table 3 shows that, during last ten years, Sindh’s share was 40.54 percent in surface water at farm gate and 16.24 percent in groundwater. Overall, Sindh used 31.57 percent of total agricultural water in Pakistan. We compute the future projections of total agricultural water demand for Sindh assuming that the growth in water demand in Sindh will mimic the pattern in Pakistan and Sindh will require 31.57 percent of total agricultural water demand of Pakistan.

Table 4 presents the agricultural water demand for Pakistan and Sindh. The table reports the baseline (without climate change) water demand for 2018, 2030 and 2050, and future projections of water demand under two climate change scenarios with 1 °C and 3 °C increase in the average temperature. The projections of increase in agricultural water demand under each climate scenario are based on the percent increase estimates provided by Amir and Habib [6]. The results show that the agriculture water demand for Pakistan will increase from 132.91 MAF in 2018 to 139.78 MAF in 2050 without accounting for the climate change. Similarly, the agriculture water demand for Sindh will increase from 41.96 MAF in 2018 to 44.13 MAF in 2050 if there is no climate change.

The agricultural water demand in 2050 in Pakistan attributable to climate change shows that the agricultural water demand will increase by 6 percent under the climate scenario of 1°C and by 14.2 percent under the climate scenario of 3°C. This shows that

under the climate change regime, it is expected that the agricultural water demand will be even higher.

We find that if the temperature increases by 1 °C, then the agricultural water demand in Pakistan will rise from the existing demand of 132.91 MAF (in 2018) to 148.24 MAF in 2050. Similarly, the agricultural water demand in Sindh will rise from the existing demand of 41.96 MAF (in 2018) to 46.80 MAF in 2050. If the average temperature increases by 3 °C in 2050, it will put immense pressure on the current water resources of the country. Under this scenario, the agricultural water demand is expected to rise to 159.70 MAF in Pakistan and 50.41 MAF in Sindh in 2050.

### 3.1.3 Industrial Water Demand

For estimating the industrial water demand in Pakistan, we assumed water requirement per rupee of industrial value addition in GDP in 2008. Data on industrial water withdrawal in 2008 were collected from AQUASTAT [10] while data on industrial value addition in GDP were collected from Pakistan Economic Survey reports [7; 11]. For future projections of industrial value addition in GDP, we used its average growth rate (3.74 percent) during 2007-08 to 2017-18. For estimating the industrial water demand in Sindh, we estimated the water share based on Sindh’s share in industrial value addition in GDP of Pakistan, which was 42.2 percent in 2012-13 according to Pasha [12]. For future projections, we assume that Sindh’s share in industrial value addition in GDP of Pakistan will remain the same.

Table 5 presents the industrial water demand for Pakistan and Sindh. Table 5 reports the baseline (without climate change) water demand for 2018, 2030 and 2050, and future projections of water demand under two climate change scenarios with 1°C

Table 4: Agricultural Water Demand in Pakistan and Sindh

Annual Water demand (MAF) under each scenario	Pakistan			Sindh		
	2018	2030	2050	2018	2030	2050
Without climate change	132.91	135.45	139.78	41.96	42.76	44.13
Climate scenario with 1 °C	-	140.14	148.24	-	44.24	46.80
Climate scenario with 3 °C	-	145.62	159.70	-	45.97	50.41

Table 5: Industrial Water Demand in Pakistan and Sindh

Annual Water demand (MAF) under each scenario	Pakistan			Sindh		
	2018	2030	2050	2018	2030	2050
Without climate change	2.08	3.00	5.52	0.88	1.27	2.33
Climate scenario with 1 °C	-	3.21	6.17	-	1.35	2.60
Climate scenario with 3 °C	-	3.44	6.82	-	1.45	2.88

and 3°C increase in the average temperature. The projections of increase in industrial water demand under each climate scenario are based on the percent increase estimates provided by Amir and Habib [6].

The results show that the industrial water demand for Pakistan will increase from 2.08 MAF in 2018 to 5.52 MAF in 2050 without accounting for the climate change. Similarly, the agriculture water demand for Sindh will increase from 0.88 MAF in 2018 to 2.33 MAF in 2050 if there is no climate change.

The industrial water demand in Pakistan in 2050 attributable to climate change shows that the industrial water demand will increase by 11.8 percent under the climate scenario of 1°C and by 23.5 percent under the climate scenario of 3°C. This shows that under the climate change regime, it is expected that the industrial water demand will be even higher.

We find that if the temperature increases by 1°C, then the industrial water demand in Pakistan will rise from the existing demand of 2.08 MAF (in 2018) to 6.82 MAF in 2050. Similarly, the industrial water demand in Sindh will rise from the existing demand of 0.88 MAF (in 2018) to 2.60 MAF in 2050. If the average temperature increases by 3 °C in 2050, it will put more pressure on the current water resources of the country. Under this scenario, the industrial water demand is expected to rise to 6.82 MAF in Pakistan and 2.88 MAF in Sindh in 2050.

### 3.1.4 Analysis of Total Water Demand

Table 6 summarizes the total and sectoral water demand from municipalities, agriculture and industries in Sindh. Agriculture is the largest consumer of water in Sindh. In 2018, out of total water of 44.06 MAF, agriculture used 41.96 MAF, accounting for 95.24 percent of total water used by these three sectors. Municipal (domestic) water demand was 1.22 MAF (2.77 percent) while industrial water demand was 0.88 MAF (1.99 percent).

The total water demand from these three sectors in Sindh will increase from 44.06 MAF in 2018 to 48.26 MAF in 2050, which is 10 percent increase, if there is no climate change.

Under the climate change scenario of just 1°C increase in temperature by 2050, the total water demand in these three sectors from 2018 to 2050 will rise by 7.18 MAF (16.29 percent). The total water demand is expected to increase by 11.18 MAF (25.38 percent) under the climate change scenario of 3 °C increase in temperature.

We find that if the temperature increases by 1°C, then the total water demand in Sindh will rise from the existing demand of 44.06 MAF (in 2018) to 51.23 MAF in 2050, which 16 percent increase. If the average temperature increases by 3 °C in 2050, it will put more pressure on the current water resources.

Table 6: Summary of Sectoral Water Demand in Sindh

Annual Sectoral Water demand (MAF) in Sindh under each scenario	2018	2030	2050	Increase from 2018 to 2050	
<b>Municipalities (domestic users)</b>	MAF	MAF	MAF	MAF	Percent
Without climate change	1.22	1.41	1.80	0.58	48
Climate scenario with 1 °C	-	1.42	1.83	0.61	50
Climate scenario with 3 °C	-	1.49	1.94	0.72	59
<b>Agriculture</b>					
Without climate change	41.96	42.76	44.13	2.17	5
Climate scenario with 1 °C	-	44.24	46.80	4.84	12
Climate scenario with 3 °C	-	45.97	50.41	8.46	20
<b>Industries</b>					
Without climate change	0.88	1.27	2.33	1.45	165
Climate scenario with 1 °C	-	1.35	2.60	1.73	197
Climate scenario with 3 °C	-	1.45	2.88	2.00	227
<b>Total</b>					
Without climate change	44.06	45.44	48.26	4.20	10
Climate scenario with 1 °C	-	47.02	51.23	7.18	16
Climate scenario with 3 °C	-	48.91	55.24	11.18	25

Under this scenario, the total water demand in Sindh is expected to rise from 44.06 MAF in 2018 to 55.24 MAF in 2050, which is 25 percent increase.

### 3.2 Water Requirements for Environment

Environmental flows for escapage to sea are the most important for sustaining ecosystem and minimizing the losses due to sea intrusion. Low environmental flow has threatened the mangroves, disturbed the ecological balance and created extreme hardship for the fisher folks and other communities residing in the Indus delta and near the coastline. Furthermore, maintaining a continuous flow throughout the year in downstream of Kotri Barrage is critical for sustaining the ecosystems of the Indus Delta [13]

The National Water Accord of 1991 [14] recognized the need to ensure a minimum environmental flow below Kotri for escapage to sea. The proposal of a minimum 10 MAF for environmental flow was discussed at length. However, as the other studies *have* suggested more/less than 10 MAF as a minimum environmental flow each year, it was decided in the accord that further studies would be conducted to determine the minimum environmental flow below Kotri for escapage to sea [14]. Thus, Sindh needs to

meet the water demand not only from the municipal, agricultural and industrial sectors but also for the environmental flows for sustaining the ecosystem in the Indus delta.

### 3.3 Challenges of Water Resources Management

The sectoral water demand analysis given above shows that due to population growth, urbanization and climate change, the demand for water will increase in future.

The ecosystem of Indus Delta has already been degraded as discussed above and the situation can further be aggravated with continuous increase in water demand from other sectors and due to climate change. In order to ensure adequate water for the three economic sectors and for the environment and ecosystems including wetlands, mangrove forests and irrigated forestry, substantial quantity of water will be required in Sindh.

Historically, groundwater use has been increasing to meet part of the increasing demand. However, there are limitations of groundwater due waterlogging and salinity issues in Sindh and declining water table across the country. Thus, there will be immense

pressure on the Indus river water from different sectors.

To ensure food and water security and protection of environment and ecosystems, Sindh needs to develop integrated water resource management (IWRM) plan that not only has the sectoral water demand management plan but also the plan for increasing water supply by reducing the water losses in the Indus river system and exploring rain harvesting.

The overall water efficiency in the Indus River system in Sindh is only 35 percent, indicating huge water losses [15]. Furthermore, total water productivity in Pakistan is very low – USD 1.38 per cubic meter of water. Pakistan ranks eighth lowest in the world in terms of total water productivity [13]. Agriculture sector is using water inefficiently. Despite using 95.24 percent of total water, there is a lot of farmland uncultivated mainly due to unavailability of water. Total cultivated area in Sindh is 5.198 million hectares while culturable waste is 1.607 million hectares, most of which is not cultivated due to water shortage [2]. Similarly, there is a limited access to safe and reliable water for household and industries.

### 3.4 Impact of Adaptation Investment

A study by the World Bank [15] evaluated the impacts of adaptation investments in Pakistan. The results are presented in Table 7. They evaluated three adaptation investment options (i) investments in agricultural technologies to increase crop yield (such as developing new seed varieties), (ii) investment for canal and watercourse efficiency improvements, and (iii) construction of new reservoirs to introduce an additional 13 MAF. Table 7 presents the main findings of the World Bank study, showing the impacts on GDP, agricultural value-added to GDP, and household income. The findings show that the climate change is likely to reduce agricultural value-added to GDP by around 5 percent if there is no investment made for climate change adaptation. The investment in agricultural technologies to increase crop yield is likely to increase the agricultural value-added to GDP by around 17 percent and the investment for canal and watercourse efficiency improvements would increase it by 9 percent.

## 4. CONCLUSION

The sectoral water demand analysis of municipalities, agriculture and industries shows that due to population growth, urbanization and climate change, the demand for water in Sindh is expected to increase substantially in future. Depending on climate change scenario, the total water demand in these three sectors is likely to rise by 16 to 25 percent from 2018 to 2050. Furthermore, the environment and ecosystems require minimum annual water flow as well as a continuous flow throughout the year in downstream of Kotri Barrage for escape to sea. This shows that substantial quantity of water will be required in Sindh for the three economic sectors, environment and ecosystems.

For food and water security and protection of ecosystem, Sindh needs to develop integrated water resource management (IWRM) plan that not only has the sectoral water demand management plan but also the plan for increasing water supply by reducing the water losses in the Indus river system and exploring rain harvesting. In the following sections, we present the way forward.

## 5. RECOMMENDATIONS

The findings of this study call for policy measures and strategies for management of water resources in Sindh, with focus on integrated water resources management (IWRM) plan, water demand management and conservation, investment in infrastructure and technology, and water information management.

Integrated water resources management aims to achieve economic efficiency as well as equity among all users of water. Since all water users are competing for water share, it is very important to encourage a multi-sectoral approach rather than focusing on single sector only. Integrated water resources management is a framework of interrelations between sources of water, its uses and better stakeholder engagement. It is a holistic and participatory approach to decision making spanning the entire watershed, management and development of resources such as land, water and related assets. This plan would require policy framework for institutional reforms, capacity building,

Table 7: Impact of Adaptation Investments in Pakistan

	Change in GDP (percent)	Change in Agricultural value-added to GDP (percent)	Change in Household Income (percent)
<i>Average change without investments</i>			
No investment	-1.10	-5.10	-2.00
<i>Average change with investments</i>			
Investments in agricultural to increase crop yield	3.66	16.70	5.42
Investments for canal and watercourse efficiency improvements	2.09	9.32	3.21
Construction of new reservoirs	0.29	1.50	0.64

Source: Yu et al. [15]

review of water pricing, spatial water distribution, improving water productivity and water efficiency, investment in infrastructure and technology adoption, raising awareness, and participation of all relevant stakeholders.

Sindh needs to develop policies for water demand management and conservation to ensure food and water security and protection of ecosystem. Policy makers are increasingly recognizing the need for consideration and implementation of water demand management. For example, recently, Government of Sindh has imposed a ban on rice cultivation in some parts of Sindh along Ghotki feeder, Rohri canal and Nara canal, as rice crop not only uses high amount of water but may also cause waterlogging, salinity and land degradation in some type of soils. Water demand management is required for all sectors but most of the contribution for saving water is expected from the largest user of water, that is, agriculture sector.

Investment in Infrastructure for Access to Safe Water by Households: Households place a high value for access to safe water and are willing to pay for better quality of water and reliable access to piped water [16]. There is a limited access to safe water for household. Around 33 percent of households in Sindh use hand pump as the main source of drinking water while majority of households in rural areas of Sindh (63 percent) use hand pump as the main source of drinking water [17]. Sindh needs to give priority to domestic use of water and charge water tariffs to ensure maintenance of the infrastructure.

Sindh can save a lot of water by making investments in improving canal and watercourses. More food and fiber products can be produced with development of agricultural technology and new seed varieties and breeds that give higher yields and are water efficient, drought tolerant and salinity tolerant.

The investments in water informatics can assist in timely alerts for flood management, information of flow at barrages, optimum water escape to sea and timely weather forecasts through SMS and other channels to farmers, households, business community and other stakeholders.

## REFERENCES

- [1] Commonwealth Scientific and Industrial Research Organisation (CSIRO). Sindh Water and Agriculture Transformation (SWAT) Project. ACIAR, Australia. 2019.
- [2] Government of Sindh. Development Statistics of Sindh. Bureau of Statistics, Karachi. 2018.
- [3] Government of Pakistan. National Water Policy 2018. Ministry of Water Resources. 2018.
- [4] United Nations, Department of Economic and Social Affairs, Population Division. *World Population Prospects: The 2017 Revision, Key Findings and Advance Tables*. Working Paper No. ESA/P/WP/248. 2017
- [5] Government of Pakistan. National Drinking Water Policy. Ministry of Environment. 2009

- [6] Amir, P., and Z. Habib. Estimating the Impacts of Climate Change on Sectoral Water Demand in Pakistan. Islamabad, Pakistan: Action on Climate Today. [https://cyphynets.lums.edu.pk/images/Readings\\_concluding.pdf](https://cyphynets.lums.edu.pk/images/Readings_concluding.pdf). (accessed June 2019).
- [7] Government of Pakistan. Pakistan Economic Survey 2018-19. Islamabad: Ministry of Finance. 2019
- [8] Government of Pakistan. Pakistan Census Report. Pakistan Bureau of Statistics. 2017
- [9] Government of Pakistan. Pakistan Statistical Yearbook 2017. Pakistan Bureau of Statistics. 2017
- [10] FAO. AQUASTAT Main Database - Food and Agriculture Organization of the United Nations (FAO). Website accessed on [29/06/2019 12:32]. 2019
- [11] Government of Pakistan. Pakistan Economic Survey 2009-10. Islamabad: Ministry of Finance. 2010.
- [12] Pasha, H. A. Growth of the provincial economies. Institute for Policy Reforms (IPR). <http://ipr.org.pk/wp-content/uploads/2016/04/GROWTH-OF-PROVINCIAL-ECONOMICS-.pdf>. 2015.
- [13] Young., William J., Arif Anwar, Tousif Bhatti, Edoardo Borgomeo, Stephen Davies, William R. Garthwaite III, E. Michael Gilmont, Christina Leb, Lucy Lytton, Ian Makin, and Basharat Saeed. Pakistan: Getting More from Water. Water Security Diagnostic. World Bank, Washington, DC. 2019.
- [14] Government of Pakistan. Apportionment of Waters of Indus River System between the provinces of Pakistan. Indus River System Authority. 1991
- [15] Yu, Winston, Yi-Chen Yang, Andre Savitsky, Donald Alford, Casey Brown, James Wescoat, Dario Debowicz, and Sherman Robinson. The Indus Basin of Pakistan: The Impacts of Climate Risks on Water and Agriculture. Washington, DC: World Bank. doi: 10.1596/978-0-8213-9874-6. License: Creative Commons Attribution CC BY 3.0. 2013.
- [16] Asim, S., and Lohano, H. D. Households' Willingness to Pay for Improved Tap Water Services in Karachi, Pakistan. The Pakistan Development Review, 54(4): 507-526.
- [17] Government of Pakistan. Pakistan Social and Living Standards Measurement Survey 2014-15. Islamabad: Pakistan Bureau of Statistics. 2016.