

Article

# Willingness to Pay for Improved Water Services in Mining Regions of Developing Economies: Case Study of a Coal Mining Project in Thar Coalfield, Pakistan

Hina Aslam <sup>1,2,3,\*</sup> , Jian Liu <sup>1,3,4</sup>, Abeer Mazher <sup>5</sup>, Dagne Mojo <sup>1,2</sup>, Muhammad Imran <sup>6</sup>  and Chao Fu <sup>1,2</sup>

<sup>1</sup> Key Laboratory of Ecosystem Network Observation and Modeling, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, 11A Datun Road, Chaoyang District, Beijing 100101, China; jian.liu@unep.org (J.L.); dagnemojo.yadate@unep-iemp.org (D.M.); chao.fu@unep-iemp.org (C.F)

<sup>2</sup> International Ecosystem Management Partnership, United Nations Environment Programme, Beijing 100101, China

<sup>3</sup> University of Chinese Academy of Sciences, No. 19 Yuquan Road, Beijing 100049, China

<sup>4</sup> Ecosystem Division, United Nations Environment, P.O. Box 30552-00100 Nairobi, Kenya

<sup>5</sup> CSIRO, Deep Earth Imaging-Future Science Platform, Perth 6151, Australia; abeer.mazher@csiro.au

<sup>6</sup> Institute of Geo-Information & Earth Observation, PMAS Arid Agriculture University, Rawalpindi 46300, Pakistan; imran.gis@pu.edu.pk

\* Correspondence: hina.aslam@unep-iemp.org; Tel.: +86-10-6480-6992; Fax: +86-10-6488-9976

Received: 1 March 2018; Accepted: 12 April 2018; Published: 14 April 2018



**Abstract:** Local communities in mining regions are vulnerable to water scarcity risks caused by extensive mining and changing climate. To mitigate such risks, we adopt a non-market valuation of low income communities' preferences for improved access to water services, as an effort to develop pro-poor policies that bring long-term water security and benefits to the local people. Using data collected from 268 households from the mining site in the Thar coalfield (Pakistan), we examine the household willingness to pay (WTP) for all major uses based on hypothetical policy scenarios. Results show that the mean WTP was estimated to be PKR 3921 (USD 38) for risk averting services (S1) and PKR 4927 (USD 48.13) for domestic pipelines and more decentralized water systems (S2) per month. We found that the mean WTP for S1 is 11.8% and for S2 is 16.6% more than the existing water-related expenditures of households. Age of household head, income level, project employment, livestock, farm income, and water quality are the significant factors influencing their WTP. These findings provide empirical evidence to policymakers and resource managers to implement cost-effective water management plans that provide multiple ecosystem service benefits, thereby potentially aiding pro-poor and sustainable economic growth in mining regions.

**Keywords:** water scarcity; coal mining; Thar coalfield; contingent valuation; groundwater; sustainable development; China-Pakistan Economic Corridor (CPEC)

## 1. Introduction

Water scarcity is a major environmental constraint to economic development in several regions worldwide, including mining regions where there are insufficient resources to cover environmental, domestic, and industrial requirements [1]. Some of these regions in developing economies are experiencing the rapid expansion of mining projects [2] which, some argue, are expected to deliver substantial benefits to local, regional, and national stakeholders [3]. These benefits usually range from

employment and tax payments to community investment in projects to promote development and compensate for damages generated by mining operations [3]. Literature highlighting these benefits is based on the synthesis of empirical evidence on the relationship of mining, regional development, and benefit sharing instruments for more inclusive development [4].

On the other hand, mining operations are also known to result in a series of negative impacts on natural ecosystems and human well-being. In particular, increasing water extractions for mine development may lead to environmental and socioeconomic costs associated with the loss of ecosystems, drawdown of the water table, deterioration of water quality, and the decrease of social and economic value [5]. Large quantities of water, up to  $10,000 \text{ m}^3 \text{ h}^{-1}$ , are displaced during mine dewatering, which can lead to sharp decreases in the groundwater table [6,7]. Furthermore, the removal of overburden layers not only causes soil erosion, but also contributes to serious water cycle problems and groundwater pollution [8]. This, in turn, may have an impact on the functionality of downstream ecosystems and on water supply [9], considerably affecting local communities who rely on these resources for their livelihood [10]. Other social impacts may include human displacement, pressure on subsistence resources, and the degradation of cultural and aesthetic resources [10], which may aggravate economic conditions in the region [11]. These factors put enormous pressure on water resources in terms of their availability, and can lead to some of the worst environmental disasters in mining regions [9,12].

This research considers the case of an open-pit coal mining project site in the Thar coalfield, located in the Thar Desert of Pakistan. The region has estimated reserves of 175 billion tons of coal, spanning an area of  $9100 \text{ km}^2$ , and is divided into several blocks for exploration [13]. Currently, only one block, Block II, is in an operational phase, while the rest are still having feasibility studies conducted. The demographics and socioeconomic settings of all blocks are relatively similar. The region is highly susceptible to climate change, has a high dependence of household livelihoods on natural resources, has witnessed severe environmental degradation, and has been worsened by weak governance. Since there are no perennial surface water flows, groundwater is the main source of water for the local people, which is extracted from wells that range in depth from 50 to 90 m [14]. The other sources include private boreholes, handpumps, public and private tube wells, and Tarais (underground storage tanks to store rainwater). Groundwater is already classified as saline and brackish, and is highly contaminated with arsenic [15]. In addition, a physiochemical analysis of the groundwater found high concentrations of heavy metal and total dissolved solids, exceeding the quality standards of the World Health Organization (WHO) [16]. Environmental and social impact assessment reports state that surface water and groundwater inflows into the mine pit require dewatering at a rate of 990 L per second (l/s) [17], which will generate a drawdown of the water of around 3 m during the first mining operation (10–20 years) [17]. The extent of drawdown (cone of depression) is about 20 to 25 km from the center of the mining block, with the greatest drawdown in the adjacent areas of mining activity [17]. It was also reported that the thickness of the water column within the water wells is less than 1 m [17], which means that any decrease in the water table would result in the drying out of wells, hence increasing the risk of water scarcity [18,19] in the region.

In addition, the region has high levels of poverty, occupying one of the lowest human development indexes (HDI) (0.343) in Pakistan [20]. The main sources of income are rain-fed agriculture and livestock; thus, as the region is severely drought-prone (with an average rainfall of 150 mm, focused on the monsoon season of July and August [21]), water scarcity can have major economic impacts (as seen in the 2013–2015 period) [22]. Furthermore, results of general circulation models (GCMs) in the region show that climate change is likely to exacerbate this situation [23] due to the increased temperatures (from  $1.75 \text{ }^\circ\text{C}$  to  $2.5 \text{ }^\circ\text{C}$  in winters, and from  $2 \text{ }^\circ\text{C}$  to  $2.25 \text{ }^\circ\text{C}$  in summers), and decreased annual precipitation [24,25]. Using these climate uncertainties and socioeconomic scenarios, the country is ranked amongst the top most water stressed regions of the world by 2040 [26].

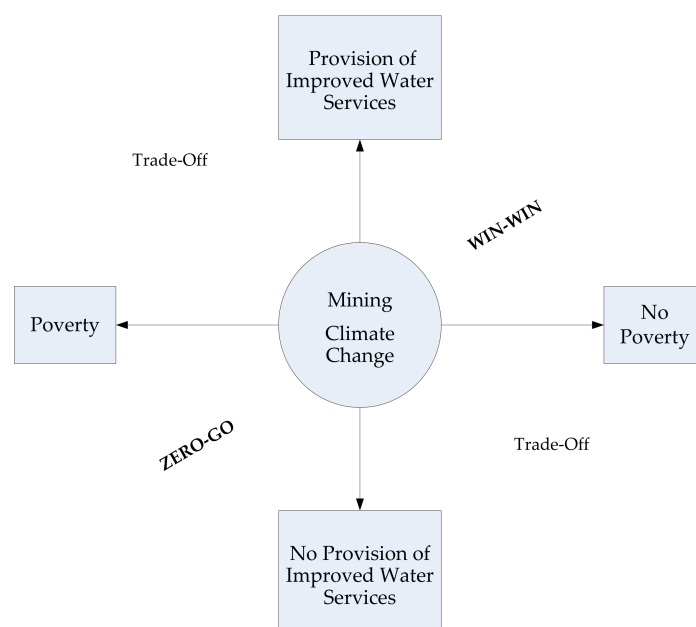
This situation calls for appropriate water planning and management in this mining region, if escalating conflicts are to be avoided and environmental degradation has to be reversed [25]. This should include an economic analysis of all the benefits and costs of Thar coal projects, particularly



those that are difficult to monetize with market methods [27], so as to define policies that bring economic revenues to the national, regional, and local economies without risking the livelihoods of those communities. The latter point is of particular importance, as it requires developing policies that reduce water scarcity risks, maximize the economic benefits obtained from water, and help communities in mining regions escape poverty (Figure 1).

This paper addresses this policy challenge by employing a non-market valuation of low income communities' preferences for improved access to water services in the region during the planning and operation stages of projects. The specific objectives of the paper are to:

- Elicit household willingness to pay (WTP) for the provision of improved water services for different uses,
- Examine the adaptation priorities of rural households against the hypothetical scenarios of improved water services, and
- Analyze the factors influencing people's preferences.



**Figure 1.** Conceptual framework of the study.

The paper is structured as follows. Section 2 provides the description of the case study, the methodology, and the design of the CVM survey. Section 3 provides quantitative and qualitative analysis of the results. Section 4 discusses the main findings, and Section 5 provides the policy recommendations based on the conclusions drawn from this research.

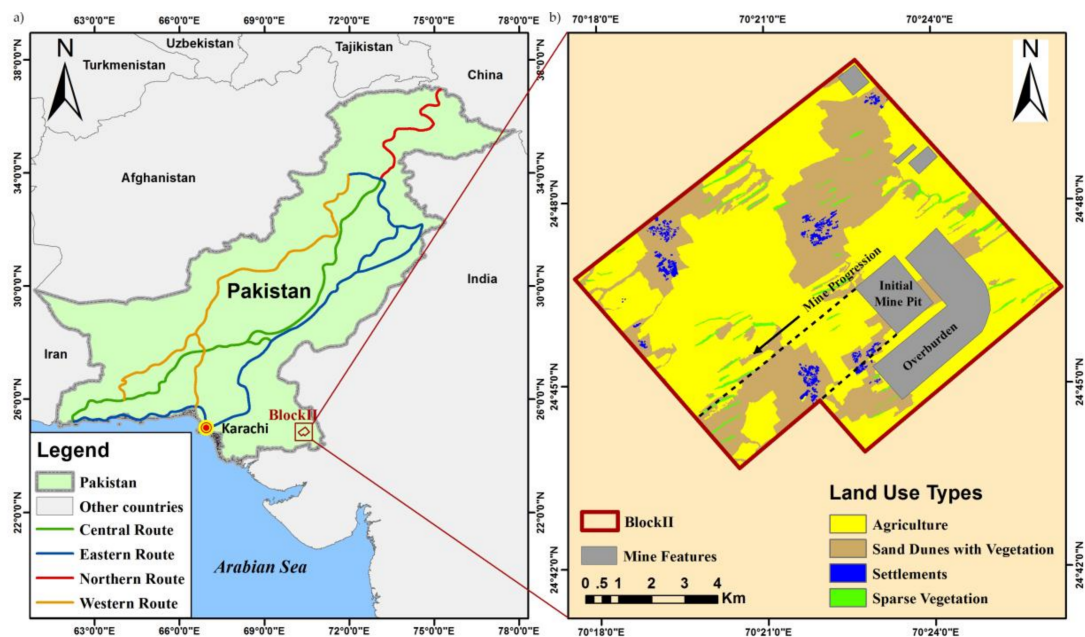
## 2. Materials and Methods

### 2.1. Description of the Study Area

The study area is located at a latitude of  $24^{\circ}43'38''$ – $24^{\circ}50'18''$  and longitude of  $70^{\circ}17'36''$ – $70^{\circ}26'16''$ , Tharparkar District of Sindh Province, Pakistan. It occupies an area of around  $95.5 \text{ km}^2$  and is one of the 12 blocks of the Thar coalfield in Pakistan, and the only one that is currently being mined and where power plants are being constructed. This project is a part of the China-Pakistan Economic Corridor (CPEC), which is an extension of China's One Belt One Road (OBOR) initiative [28]. The proposed project entails an open-pit mine development to produce about 360 to 380 million tons of lignite at a maximum rate of 22.8 million tons per annum [17,29], which is equivalent to around 4000 MW of electricity [17].

Figure 2 shows the project location in south-east Pakistan. Land use in the area includes agricultural fields (56%), sand dunes, and plains that extend to an average depth of over 80 m [17]. It has extreme climatic conditions characterised by hot temperatures during the summer (up to around 48 °C), and dry conditions, but relatively mild winters (9–28 °C) [30].

The area has nine villages and a population of around 9600 people (primary data). The region of Tharparkar is home to the largest Hindu population (more than 40%) in the country, living in harmonious relationship with Muslims [31]. The main sources of livelihood are livestock rearing and farming (only in rainy season for two months). The households are mainly dependent on stored rainwater and groundwater aquifers to meet their needs (through centralized systems). The nearest surface water reservoir is located at 65 km from the mine water, designated to provide the raw water to meet the needs for mining operations (6000 cubic meter per day ( $\text{m}^3/\text{day}$ )) [17].



**Figure 2.** (a) Map of Pakistan, Central, Eastern, Northern, and Western routes of CPEC; (b) the Study area of coal mining project under assessment (block II).

## 2.2. Data Sources and Types

Data were collected from 268 randomly selected households from nine villages (settlements) using an interview and a questionnaire. These villages are divided into several small units or stratum, known as “Paras” in local language. The size and population of each para vary significantly from a few households to several households and are divided based on cast and religion, and members of the same caste, religion, or even extended family tend to live together. For sampling, the households were equally selected from each para of each village differentiated according to the accessibility and willingness of the household to participate in the survey.

The study collected information on (see Table 1):

- Demographics and socioeconomic settings of the household,
- Characteristics of the existing sources of water and its attributes (Figure 3),
- Household’s perception of the mine project and the impacts on natural resources, their livelihoods, and well-being.

The primary respondent of the survey was the head of each household. However, in some cases, the most educated family member was interviewed to avoid misunderstanding of questions. The interviews were done in local dialects (Sindhi and Thari). The survey was conducted between

November and December 2016. Data analysis was done using the Stata Statistical Software, version13, developed StataCorp, TX, USA.

**Table 1.** Description and statistics of data variables.

Variable	Definition	Mean	Std. Dev.	Min	Max
AGE	Age of the respondent (in years)	43	13.55	20	80
Gender	Gender of respondent (0 = Male, 1 = Female)	0.19	0.39	0	1
LE	Level of Education	2.23	1.74	1	7
	1 = Illiterate	0.50	0.321		
	2 = Primary	0.23	0.420		
	3 = Middle	0.02	0.10		
	4 = Metric (grade X)	0.14	0.34		
	5 = High school (grade XII)	0.02	0.13		
	6 = Undergraduate (14 years of education)	0.05	0.22		
	7 = Graduate (16 years of education)	0.04	0.19		
HS	Household size	8	2.93	3	15
Income	Household Income per month (Amount in PKR/USD)	20,958/\$205	12,957/\$127	5000/\$49	75,000/\$733
HME	Household members employed in the coal project, both in direct and indirect employment (Number of persons)	3	2.06	0	7
NWR	No. of water sources (in numbers)	2	0.40	1	3
WCL	Water consumption in Liters per day per household (approximated from the number of containers used)	495	158.42	50	600
DFW	Distance from water source (in minutes)	36	20.98	10	60
Frequency ~wc	Frequency of fetching water per day	1	0.44	0	4
ALO	Area of land owned (in acres)	11	6.50	5	50
farm_inc	Agricultural income; Dummy variable: 1 = Yes, 0 = No	0.74	0.43		
CPI	Annual crop production in PKR/USD	24,835/\$243	25,403/\$248	0	150,000/\$1465
WRH	Water related health issues in the last year? (1 = Yes, 0 = No)	0.83	0.37		
ET	Expenditure/amount spent on household health treatment (PKR/USD) per month.	1856/\$18	2994/\$265	500/\$4.8	10,000/\$98
NLO	No. of livestock (in numbers)	35	31.65	0	300
ELW	Amount spend on water related diseases per household per month (PKR/USD)	738/\$7.2	2023/\$19.8	0	12,000/\$117
PS	Crop Production status as compared to previous years: 1 = increased, 0 = decreased?	0.18	0.39		
LO	Own livestock? 1 = Yes, 0 = No	0.94	0.23		
ELH	Expenditures on livestock health (% of household income)	3.30	1.73	1	5
LH	Livestock death? In the last year (0 = No, 1 = Yes)	0.83	0.37		
WQ	Water quality, 0 = very poor/poor, 1 = fair/good	0.51	0.50		
SLH	Satisfaction level of household regarding project development, 0 = Unsatisfied, 1 = Satisfied	0.51	0.50	0	1
ILH	Household perception on impact level of the mine project, 0 = negative, 1 = positive	0.31	0.46	0	1
PLH	Perception of damage: concerns and fears	4.57	1.79	1	6
	1 = Scarcity of water/pollution	0.05	0.20		
	2 = loss of land	0.23	0.42		
	3 = Immigration of outsiders	0.02	0.17		
	4 = Loss of livelihood	0.10	0.30		
	5 = Loss of Trees, plant/biodiversity	0.04	0.19		
	6 = All of the reasons described above (1–5)	0.56	0.49		

Note: 1 USD (\$) = 102.35 PK. (Average exchange rate for 2016, retrieved from: <https://www.poundsterlinglive.com/best-exchange-rates/us-dollar-to-pakistani-rupee-exchange-rate-on-2016-12-31>).



**Figure 3.** (a) Water wells, (b) Women carrying the mud container to fetch water, (c) Rain water storage containers “TARAIIS”.

### 2.3. Experimental Techniques and Survey Design

Scholars have developed a number of economic valuation approaches to estimate the non-market values of environmental goods and services [32,33]. Of all these methods [34], contingent valuation methods (CVM) remain some of the most common and preferred techniques to elicit the values that people place on commodities or services [35]. These methods draw upon survey research, and have been widely applied for conducting valuations of ecosystem services [36], assessing land fill mining projects [37], and researching household WTP for improved water services and ecological compensation [38]. Furthermore, many international donor agencies, including The World Bank, have taken an interest in CVM to support water-related projects in developing countries [39].

CVM can be done in multiple ways, and sometimes it is important to do pilot studies or pre-testing of surveys, in order to avoid biases and errors arising from the limitations of the methods [31,36]. The latter was quite important for this project, as the initial design of the survey involved an iterative bidding approach during the interview, to elicit the participants’ WTP for improved water services [37–40]. After getting the demographics and socio-economic background of the household, participants were given an initial value (in Pakistani rupees—PKR) that the surveyor would increase and decrease until the respondent accepted to pay for the services.



This approach proved to be unsuccessful for the pilot group (90 households), because respondents could not elicit any amount as their WTP, even if they had answered yes when asked if they were willing to pay for improved services. The reasons for this could be a persistent fear in households about future financial responsibilities, taking into account they are already struggling with financial pressure. In addition, it was found that participants got tired of the bidding process and wanted to finish the interview as soon as possible, which meant that their answers could have been biased or erroneous. Furthermore, some participants seemed to suggest to surveyors that they considered water a free commodity, thus, they could not elicit a WTP.

Several alternatives were considered, including binary referendums, take-it-or-leave-it approaches, and structured haggling, amongst others [40–42], but after analysing them it was decided that most of them would suffer from similar flaws. Thus, it was decided that we should use an approach that provides a hypothetical incentive to participants, to facilitate him or her to elicit their WTP [43]. These monetary incentives are designed to have an indirect psychological effect to increase respondents' willingness to answer [40], reducing the fear of future financial burdens, without considerably affecting their WTP [41]. The incentive used in this project was a hypothetical increment of PKR 10,000 (USD 97.7) in the household income levels, which is about 50% of the average income of households in the region. This amount was defined based on the pre-testing experience and expert opinions in the study area. The new design involved an open-ended questionnaire, in which respondents of all 268 households (including pilot group of 90 households) were able to elicit their WTP for improved water services by means of a valuation of two water policies in terms of a percentage of the hypothetical income.

These policy scenarios were developed considering availability, quality, and reliability attributes, as described in Table 2. As already mentioned, the present system includes private wells, owned by individual households, to extract groundwater using pulleys or animals and shared with the neighborhood. Reverse osmosis (R.O) plants are provided by the government authorities at no cost, which were found to be the least maintained and providing an unreliable quality of water [42]. The mining company is obligated by the provincial Environmental protection agency (EPA) to mitigate the impacts on ground water and propose solutions for effective management (personal communication). Hence, a baseline condition was included as a benchmark for both scenarios, proposed as: (i) S1, which denotes the provision of risk averting services including the installation of more R.O plants and other filtration technologies; and (ii) S2, which includes the provision of decentralized and sustainable solutions such as domestic pipelines, water conservation strategies (such as recycling of water used in bathing and kitchen can be used to irrigate farms), separate watering systems for livestock, and an irrigation system for crop production. These scenarios are proposed for both public sector (government) and public-private partnership (Mining company, NGOs, international donor agencies) investments. The solutions in each scenario would mostly address availability problems, while only providing water of the quality required.

Using the hypothetical payment vehicle, the respondents were then asked to elicit their WTP for improved water services for different uses, including domestic, crop production, and livestock, considering the two scenarios individually.

**Table 2.** Attribute levels and Scenario description.

Attributes	Policy Scenarios		
	Baseline: Status Quo (No Change)	S1: Filtration/Purification Plants, Other Technologies	S2: Domestic Pipelines and Services/Watering Systems/New Irrigation System
Availability	Scarce	Available on distance, public posts for water collection.	Available 24 h in houses through direct pipeline system and infrastructure.
Quality	Saline	Potable water	Potable water
Reliability	Unreliable and not suitable for agriculture	Can be diverted to irrigate small farms.	Reliable services provided by water management authorities.



#### 2.4. Empirical Model

Numerous demographic factors including the existence of alternative sources of water, and the quality of water services, determine WTP for water services [43–45].

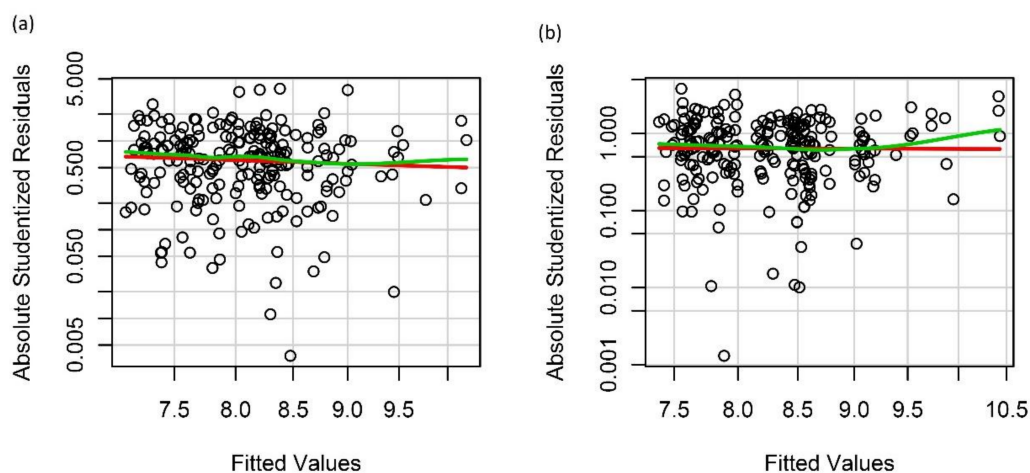
Taking this into account, we used a multiple linear regression model described as follows:

$$\log(Y_i) = \beta_0 + \beta_j X_{ij} + \varepsilon_i \quad (1)$$

where,  $Y_i$  is the dependent variable, i.e., the value of WTP in PKR of each household  $i$  ( $i = 1, 2, \dots, 268$ ; and  $j = 1, 2, \dots, 11$ ); and  $\alpha$  (Alpha) is an intercept term and interpreted as an unconditional expected mean of  $\log(Y_i)$ . However,  $\beta$  (Beta) is the regression coefficient of an independent variable; and  $X_{ij}$ , i.e., is the  $j$ th variable in the  $i$ th household, and is interpreted as the expected change in  $\log(Y_i)$  with respect to a unit change in  $X_{ij}$  by assuming that all other independent variables are fixed. To predict the expected value of  $Y_i$ , the exponential of the regression coefficient ( $\exp(\beta_j)$ ) will be interpreted as  $Y_i$  changes by 100 (coefficient) percent for a unit change in  $X_{ij}$ . Whereas,  $\varepsilon_i$  is the random component or error term in household  $i$ , showing the unknown variables affecting WTP other than the specified one.

Here, it is important to mention that the log transformation of the dependent variable ( $Y_i$ ) is used to estimate the expected geometric mean of the original variable ( $Y_i$ ) instead of the expected arithmetic mean. The same log transformation was applied to highly skewed independent variables (HME, NSC, and ET) in order to satisfy the assumptions of multiple linear regression, which were further tested as [46]:

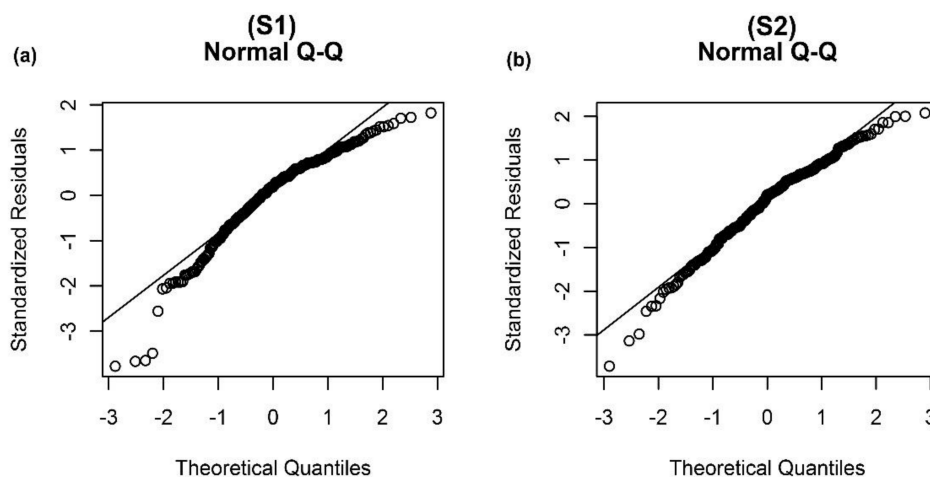
- i) Multicollinearity occurs when there is a high correlation between the multiple independent variables [47], which needs to be treated as it affects the regression model analysis and interpretation. Therefore, a Variance Inflation Factor (VIF) test was used to check this assumption, which quantifies the severity of multicollinearity by how much the variance (the square of the estimate's standard deviation) of an estimated regression coefficient is increased because of a correlation between independent variables in a model [48]. Considering a rule of thumb of  $VIF < 10$  [49], the collinear variables were eliminated, and a set of 11 least correlated variables (Table 2) were selected to model the respondent's WTP to meet the objective of this study. The results of VIF are given in Table 3.
- ii) Homoscedasticity shows that the variance of residuals does not depend on the fitted value for both scenarios (as shown by the plots of standardized residuals vs. fitted values in Figure 4).
- iii) Multivariate normality test shows that the residuals (predicted minus observed values) are distributed normally (i.e., follow the normal distribution) (as shown by the QQ plots in Figure 5).



**Figure 4.** The plots of standardized residuals vs. fitted values for (a) regression model in Scenario 1 (S1); (b) regression model in Scenario 2 (S2). The red line shows the linear fit and the green line as less smooth fit.

**Table 3.** Variance Inflation Factor of variables used in the model.

Variable	AGE	lgHME	LE	lgNSC	Farm_inc	Lo	Sex	Income	WQ	ILH	lgET
VIF	1.35	1.35	1.11	1.18	1.10	1.16	1.05	1.26	1.10	1.04	1.08



**Figure 5.** QQ plots of multivariate normality for (a) normality plots for S1; (b) normality plots for S2 (i.e the line showing normal distribution of residuals).

### 3. Results

#### 3.1. Descriptive Statistics

Table 1 provides the summary statistics of the sampled households in the study. Out of the surveyed population, there were 17.5% Hindu and 82.5% Muslim households, comprising 81% of male and 19% female heads of the household. The population surveyed was 1654 and the average income of the household was found to be PKR 20,958 (\$205). A total of 58% of the work force was occupied in agriculture and livestock rearing, 10% in handicraft making, 3% in government and business, and 29% of the population was reported to be employed in the project, including both direct and indirect jobs, skill development programs, and other programs (primary data). A total of 51% of the respondents had no education, 22% had a primary education (up to grade V in Pakistan), only 10% had grade X education, 1% had grade XII education, and 5% and 4% for undergraduate and graduate levels, respectively.

Furthermore, according to the primary data collected, the households are dependent on more than one source to meet their daily consumption of water. These sources include traditional public wells and purification plants provided by the government at a shared point. The average consumption of a household is around 495 L per day. Water collection takes around 36 minutes including the time required to travel to and from the source, and the time spent filling their containers. A large portion of surveyed households (83%) were found to face water-related health issues such as diarrhoea, as they describe water quality to be very poor.

Most households perceive the impact of mining on the environment to be negative: 23% show concerns about loss of land; 10% about loss of livelihood; 5% about the scarcity/pollution of water; 2% about immigration of outsiders; and 4% about loss of trees and biodiversity. Since all these factors are interrelated, 56% of the households have all of the concerns and fears related to mine development (mentioned in factors 1 to 5). That could be the reason why only 51% of the households were satisfied with the mine development. This satisfaction level is regarded as an important aspect in influencing the desire for improvement in water services [50].

### 3.2. Household's Water-Related Cost Estimation

The monthly water-related costs were estimated based on their monthly travel cost to reach the water source and the proportions of income spent on health due to water-borne diseases (ELW) (given in Table 1).

The travel cost was calculated using the frequency of trips and the time required to reach the water source, which was found to be 18 h for 30 trips. Assuming that the individuals can get the minimum wage [51] in a formal job market, their total travel cost per month was estimated as:

$$\begin{aligned} \text{Total Travel cost per month} \\ = \text{Total time spent to collect water} \times \text{Minimum wage per hour,} \end{aligned} \quad (2)$$

Although the expenditures on water-related diseases (such as diarrhea) were specifically requested, separately from the overall health of household, the estimation could be quite subjective. Assuming the uncertainty in that value, it was useful to estimate the household's water-related cost with and without it.

It is important to note that the minimum wage of labor per hour in the Sindh province of Pakistan is PKR 15,000 (USD 146.55) per month, which is lower than the average income of the household found in this study. This could be due to the reason that many households were involved in formal and informal economic activities such as project employment, which could lead to high localized wages when measuring economic status of the household. These wages could be subject to changes with mine development as it may lead to further increase in their income, or a decrease caused by loss of other livelihood sources such as farm land. This uncertainty could also affect the relative amount that households are willing to pay for improved water services. Considering this uncertainty, a minimum wage of PKR 72.13 (\$0.70) was used as the best approximation available to estimate the travel cost per month.

Results are presented in Table 4.

**Table 4.** Water-related cost estimation.

Activities	Cost in Rupees (PKR/USD) per Household
Total travel cost per month	1298 (\$12.68)
Expenditure on household health (due to water borne diseases) (ELW) per month	738 (\$7.21)
Total water-related cost/expenditure per month (with ELW)	2036 (\$19.89)
Total water-related cost/expenditure per month (without ELW)	1298 (\$12.68)

This reveals that the households spend 9.71% of their monthly income on water-related activities considering ELW, and 6.91% without considering ELW, and both exceed the water utility expenditures in other developing countries of the world [52,53].

### 3.3. Scenario Comparison for Willingness to Pay (WTP)

To find the preference for major uses of water, a household's WTP for improved provision of water services was compared against the two hypothetical scenarios, S1 and S2, given in Table 5. These values were calculated from the household's WTP, obtained in the form of a percentage of their income.

The results highlight that the household's WTP for S1 is 11.8% (i.e., 18.71–6.91%) more than their current water-related expenditures and for S2 is 16.6% (i.e., 23.51–6.91%).

Additionally, considering a household's expenditures on health, WTP for S1 is 9% (i.e., 18.71–9.71%) and for S2 is 13.8% (i.e., 23.51–9.71%) more than their current water-related expenditures.

**Table 5.** Mean WTP for domestic, agriculture, and livestock purposes.

Mean WTP	S1 (%)	S1 (PKR/USD)	S2 (%)	S2 (PKR/USD)
Domestic use	19.66	4120 (\$40.25)	25.61	5367 (\$52.44)
Crop production	16.38	3432 (\$33.34)	19.04	3990 (\$38.98)
Livestock rearing	20.12	4216 (\$41.19)	25.87	5421 (\$52.97)
Mean	18.71	3921 (\$38)	23.51	4927 (\$48.13)

### 3.4. Determinants of WTP

The factors which influence a household's WTP are determined by using the results of multiple linear regression given in Table 6.

Statistically, OLS results under the S1 scenario show that household members employed in the project (HME), household owning livestock (LO), sex, income, water quality (WQ), and amount spent on household health (ET) are significantly influencing the household's WTP at a 5% significance level. Under scenario 2 (S2), AGE and farm\_income, in addition to HME, LO, sex, income, and WQ, have a significant effect on WTP at 5% significance levels. Only 61% ( $R^2$ -value) of the variation in WTP is explained by S1 as compared to S2 (73%), which somehow supports the preference of S2 over S1 as less percentage is assigned to the random variation. Furthermore, Standard error (SE) represents the variation of the observed values from the regression line and for both S1 and S2, the SE is smaller for all significant variables, which indicates that the observations are closer to the fitted regression line and therefore the fit is best. As the RMSE is the standard deviation of the residuals (also known as prediction errors), therefore, by comparing models for S1 and S2 (RMSE i.e., 49% and 36%, respectively), we may conclude that S2 is a better fit as compared to S1 based on less RMSE=36% and high  $R^2 = 73\%$ .

**Table 6.** Results of Multiple Linear Regression for scenarios S1 and S2.

Variables	S1		S2	
	Coefficient	Standard Error	Coefficient	Standard Error
Constant	6.689 *	0.394	6.912 *	0.289
AGE	0.002	0.003	0.004 *	0.002
lgHME	0.112 *	0.067	0.187 *	0.049
LE	-0.003	0.063	-0.010	0.046
lgNSC	-0.091	0.094	-0.032	0.069
Farm_inc	0.026	0.071	0.046 *	0.052
LO	0.183 *	0.135	0.247 *	0.099
Sex	0.122 *	0.077	0.110 *	0.056
Income	0.000 *	0.000	0.000 *	0.000
WQ	-0.053 *	0.063	0.018 *	0.045
ILH	0.025	0.065	0.024	0.047
lgET	0.013 *	0.030	-0.029	0.022
R-squared	61%		73%	
Root MSE	49%		36%	

Note: \* Indicates statistically significant variables at 5% significance level.

Based on these results, we identify that

- Older household heads (AGE) with more assets are willing to pay larger sums for S2 services, possibly due to their long-term experiences with water scarcity and salinity issues. Further, approximately less than 1% change for WTP in S1 and S2 is observed for a unit change in AGE.
- Our findings highlight that households with more members employed in the project (HME) were willing to pay more for both S1 and S2 services. If HME is increased by 1%, we expect WTP to increase by 11% for S1 and 18% for S2 (keeping other variables constant).
- Although we found a negative relationship between WTP and LE (for regression, LE was run as 0 = illiterate, 1 = literate including all levels of education), it was non-significant. However, this is not consistent with our a priori expectation and suggests that people have a willingness to pay for improved water regardless of being educated or not. The non- or less educated people are equally conscious of the value of improved and safe water for their household's consumption.

- The households having a higher number of storage containers (NSC) were found to have a negative and insignificant relationship with WTP. This is consistent with our expectation that the households with a lower number of storage containers would be willing to pay more as they require better and reliable services for their major uses. From this model, we could say that a one percent decrease in the average daily number of storage containers used would yield a 9.1% increase in WTP for S1 and 3.2% increase for S2.
- Income generation from farming was found to have a positive relationship with WTP, and a significant factor influencing a household's WTP for S2. For a unit increase in number of households having farm income, there would be a change of 2.6% and 4.6% increase in WTP for S1 and S2, respectively.
- WTP for improved water services is higher among households owning livestock (LO) for both S1 and S2. In our model, the results identify that a unit increase in household owning livestock would result in 18.3% and 24.7% change in WTP for S1 and S2.
- The results show that an increase of one female household head would result in an increase of 12% and 11% in WTP for S1 and S2 improved services, respectively. The relationship is found to be significant for both S1 and S2 improved services since females are more responsible for collecting water from the wells, thus exhibiting a positive relationship with WTP.
- Income (INCOME) of household was found to have a positive and significant relationship with WTP for both S1 and S2. According to the results, we would say that an increase of one PKR in the average monthly income of the household would result in 0.004% change in WTP. This contributing factor relates to a general agreement in ecological economics literature on the positive relationship between income and WTP for the improved provision of water services [54].
- The households perceiving water quality to be fair are found to be significant, yet a negative relationship with WTP for S1 and positive relationship with S2. The results suggest that a decrease in one household perceiving water as having a poor quality would yield a 5.3% increase in WTP for S1, and for S2, would lead to a 1.8% decrease in WTP. According to the survey results, 51 percent of the households perceive water to be fair as they might be adapted to the same quality of water. The positive association with WTP indicates a preference for both S1 and S2, accounting for availability issues and reliable services.
- The perception about the impact level of the household (ILH) is found to be positively related to WTP. This could be justified as the households may have regarded it as positive in terms of getting jobs in the project, and other socio-economic development programs in education and health.
- The amount spent on household health (ET) is found to have a significant, yet positive relationship with WTP. One percent change in the amount spent on household health would lead to 1.3% change in WTP for S1, and 2.9% for S2.

#### 4. Discussion

Results of this study highlight that the households are willing to pay for the provision of improved water services, both for income generation and wellbeing. Their WTP was found to be PKR 4424 (USD 43.22), which is more than the WTP estimates of drinking water collected from the meta-analysis of sixty studies [55]. Also, the estimates reveal that the WTP was 11.8% (for S1) and 16.6% (for S2) more than their estimated existing expenditures on water-related activities. Eighty three percent of the households reported water-related health problems (WRH in Table 1). Assuming the uncertainty in the amount spent on the treatment (ELW), the mean WTP was 9% (S1) and 13.8% (S2) more than their estimated existing expenditures on water-related activities.

The mean WTPs for domestic and livestock uses were considerably higher and tended to show a preference for the S2 service. Most of the households reported deaths due to several problems, including a lack of water, the consumption of saline water, and malnutrition. This problem is coupled with severe drought conditions, causing the loss of small animals due to disease and a severe shortage of fodder and water, which has aggravated food insecurity and caused acute malnutrition in the region [56]. That is why



94% of the households (owning livestock) were found to have a significant and positive relationship with WTP, as determined by the model results. This means that the provision of improved water may also save the amount spent on water-related health expenditures. This highlights the paramount importance of the provisioning of improved water services to bring an upsurge in the functions performed by livestock, such as in being a source of income, livelihoods, food supply, asset savings, sustainable agriculture, and transport. The results suggest that it may bring economic returns of 3.3% of a household's monthly income that was spent on livestock health, which might have been caused by water-related issues. Similar challenges are being faced by herders in the regions where the rapidity of mining development is outpacing the capacity to manage the potential land and water impacts [57].

Likewise, the provisioning of improved and reliable water services is important for crop production, since the poor communities of the region are mainly dependent on farming income. The survey results highlight that the area owned by a household is 11 acres on average and the annual crop production was found to be PKR 24,835 (USD 242.64) per year (source: Primary data), which is far less than the other water-stressed regions [58]. Although a household's WTP is comparatively lower for agriculture, their WTP shows no considerable preference for S2 over S1 services. The estimated mean WTP for crop production is a big percentage of their income, which is higher than the mean WTP of farmers in other arid regions such as India [59]. Owing to the high salinity of groundwater, the households could only depend on rain water for crop production and 88% of the households reported to have decreased crop production due to less rainfall as compared to last year. This means that they expect the benefit of an increased crop production value with the provision of improved water services. The results also suggest that despite having other opportunities for income generation, the households still prefer increased agriculture to improve livelihoods and enhance food security. The policy implications of these results could be the public-private investments to treat the water to the usable form and used for irrigation purposes.

The results clearly imply that an increase in household income shifts their demand curve for clean and potable water to the right, wherein they would have better chances of maximizing utility [60,61]. A previous piece of research conducted in the Thar coalfield revealed that the potential contribution of coal development would create significant benefits for the region, such as local job opportunities, socioeconomic progress, and infrastructure development [31]. Our findings show an increase in income levels for households whose members were employed in the project. The maximum number of employed people in a household was found to be seven. These changes in the income levels among the sample households could be attributed to direct and indirect employment in different sectors of the project and the socioeconomic development in the area, including land compensations to the landowners, infrastructure development, and skill development programs.

The results also highlight that the provisioning of improved water services can benefit women of the region, who are mainly responsible for the activity of water collection. The reduction of time spent on water collection could be used productively elsewhere and could bring minimum economic returns of PKR 1298 (\$12.68) per month (Table 4) if the woman were to be employed in a formal market. More socioeconomic gains could also be achieved if they were involved in other income generating activities, including farming. These findings are also consistent with other studies, which focused on women's productive activities and equal participation in activities other than water collection [62]. Information on water's economic value can enable decision makers to make informed choices on water development, conservation, allocation, and use in the face of increased scarcity [63].

Based on the analysis, we also identify a lower preference for S1 services, as compared to S2 services, which could be attributed to the fact that residents have experiences of bad management and lack of maintenance of existing similar services such as Reverse Osmosis (RO) plants provided by the government (personal communication [42]). This lack of trust is consistent with many studies [64,65]. This also relates to our results, which identify that the households are conscious of the impact of mining on the groundwater related to mining activities and 69% perceived it as negative. In addition, people have great concerns and fears about the level of impact in terms of water scarcity, loss of land

and livelihoods, and immigration of outsiders in their region that could impact their cultural values. The households expected the delivery of improved water services from the mining company as a part of their community development programs (corporate social responsibility, CSR). So far, the mining company has installed few R.O plants to compensate for damages and avoid social conflicts in an adjacent community. However, these services can only be extended to all communities if the operations of these installed plants are seamless and well monitored. This factor is considered important to foster a pleasant and congenial atmosphere for the growth of other socio-economic activities, which could improve their willingness to pay via an increase in a household's income, rise in level of education, livestock management, conservation of natural resources, and preservation of their cultural assets and values. Hence, these benefits can collectively contribute to overcome the challenges of water security and poverty eradication in the mining region of the Thar coalfield.

## 5. Conclusions and Recommendations

Groundwater is a productive asset for the livelihoods of people in the Thar coalfield region, which can be destroyed through over-abstraction in coal mining and years of forgone consumption. This problem is coupled with the uncertainties of climate change, which can further push the poor into poverty. Consequently, this study provides a valuable insight into the marginal benefits of improved water services for the social, cultural, and economic attributes of households in the Thar coalfield. The study highlights that the households are willing to pay more for S2 services (23% of their monthly income, i.e., PKR 4927 (USD 48.13)), indicating their high expectations for long-term and sustainable solutions, thereby increasing communities' resilience to change in ecosystems and their services, and to bringing efficiency in agriculture productivity and improved health conditions for livestock and humans. The mean WTP for S1 is 18% of the average income of the household, i.e., PKR 3921 (USD 38.30), which shows that the households are willing to pay for water services, providing that the reliability, availability, and maintenance of those services would be improved. Furthermore, the project employment increases the likelihood of their willingness to pay, attributed to their increased income levels and higher capacity to meet their water needs.

It is also recognized that households are aware of the impact level of mining on their wellbeing and livelihoods based on their fears and perception about the damage. The communities are wisely concerned about the provision of improved water services which can be overcome by public-private investments, demonstrating the positive impact on local communities throughout the mine's development and the whole project's lifecycle. The proposed S1 and S2 services can also be embedded in CSR programs of the mining company, having external funding and partnerships from donor agencies. This would also enhance the local and institutional capacity to strengthen regulatory frameworks and effective monitoring of existing water resources, including groundwater management strategies, improved environmental standards in the extractive sector, and governance using regulatory and incentive-based tools (e.g., credit-based systems), as well as outreach and education. In this way, the various environmental externalities and social conflicts can be avoided, and improved governance and political support for the continued development of mines in the Thar coalfield can be achieved.

Moreover, critical to the success of these mining projects, climate adaptation and mitigation strategies must be adopted by combining the best of green and green infrastructures in order to strengthen the water resilience. All these measures can collectively contribute to advocate pro-poor economic growth in the region.

**Acknowledgments:** This research is supported by: International Ecosystem Management Partnership-United Nations Environment Programme, and National Natural Science Foundation of China (Grant No. 31361140360). The first author would also like to thank "Sindh Engro Coal Mining Company (SECMC), Thar Pakistan", for providing the secondary baseline data and facilitating field investigations. We are very grateful to "Juan Ossa-Moreno", The University of Queensland, Brisbane, Australia, to provide useful suggestions and comments to improve the paper.

**Author Contributions:** The first author Hina Aslam conceived, designed, and conducted the survey and the experiments; Hina Aslam and Muhammad Imran performed the statistical analysis; Abeer Mazher and Dagne

Mojo provided valuable and critical comments to improve the whole paper including the statistical analysis and results; Jian Liu and Chao Fu are the research supervisors of the first author, and Hina Aslam wrote the paper.

**Conflicts of Interest:** The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

## References

1. Aitken, D.; Rivera, D.; Godoy-Faúndez, A.; Holzapfel, E. Water scarcity and the impact of the mining and agricultural sectors in Chile. *Sustainability* **2016**, *8*, 128. [[CrossRef](#)]
2. Kitula, A. The environmental and socio-economic impacts of mining on local livelihoods in Tanzania: A case study of Geita district. *J. Clean. Prod.* **2006**, *14*, 405–414. [[CrossRef](#)]
3. Wall, E.; Pelon, R. *Sharing Mining Benefits in Developing Countries*; The World Bank Extractive Industries and Development Series 21; World Bank: Washington, DC, USA, 2011.
4. Söderholm, P.; Svahn, N. Mining, regional development and benefit-sharing in developed countries. *Resour. Policy* **2015**, *45*, 78–91. [[CrossRef](#)]
5. Rupérez-Moreno, C.; Senent-Aparicio, J.; Martínez-Vicente, D.; García-Aróstegui, J.L.; Calvo-Rubio, F.C.; Pérez-Sánchez, J. Sustainability of irrigated agriculture with overexploited aquifers: The case of Segura basin (SE, Spain). *Agric. Water Manag.* **2017**, *182*, 67–76. [[CrossRef](#)]
6. Fernandez-Rubio, R.; Lorca, D.F. Mine water drainage. *Mine Water Environ.* **1993**, *12*, 107–130.
7. Almeida, D.R.V. Mining, Environments and People: Depicting Environmental, Socio-Economic and Political Understandings of Mining Conflicts in Cajamarca, Peru and Cordillera Del Condor, Ecuador. Doctoral Dissertation, McGill University, Montreal, QC, Canada, 2016.
8. Zhao, Y.; Long, R.; Lin, H. Study on pastoral ecosystem security and its assessment. *Acta Pratacult. Sin.* **2008**, *17*, 143.
9. McIntyre, N.; Woodley, A.; Danoucaras, A.; Coles, N. Water management capacity building to support rapidly developing mining economies. *Water Policy* **2015**, *17*, 1191–1208. [[CrossRef](#)]
10. Bury, J. Mining mountains: Neoliberalism, land tenure, livelihoods, and the new Peruvian mining industry in Cajamarca. *Environ. Plan. A* **2005**, *37*, 221–239. [[CrossRef](#)]
11. Suich, H.; Howe, C.; Mace, G. Ecosystem services and poverty alleviation: A review of the empirical links. *Ecosyst. Serv.* **2015**, *12*, 137–147. [[CrossRef](#)]
12. Garcia, L.C.; Ribeiro, D.B.; Oliveira Roque, F.; Ochoa-Quintero, J.M.; Laurance, W.F. Brazil's worst mining disaster: Corporations must be compelled to pay the actual environmental costs. *Ecol. Appl.* **2017**, *27*, 5–9. [[CrossRef](#)] [[PubMed](#)]
13. Japan International Cooperation Agency (JICA). *Data Collection Survey on Thar Coal Field in Pakistan*; Nippon Koei Co., Ltd. & Coal Resources & Mining Engineering Co., Ltd.: Karachi, Pakistan, 2013.
14. Rafique, T.; Bhangar, M.; Vasandi, A. Sanity and drinking water quality problem in the Thar desert-its health and social impact on local population. In Proceedings of the National Symposium on Social, Cultural and Environmental Impacts of Water Scarcity in Sindh, Jamshoro, Pakistan, 15–16 January 2004; pp. 15–16.
15. Ali, J.; Kazi, T.G.; Baig, J.A.; Afridi, H.I.; Arain, M.S.; Ullah, N.; Brahman, K.D.; Arain, S.S.; Panhwar, A.H. Evaluation of the fate of arsenic-contaminated groundwater at different aquifers of Thar coalfield Pakistan. *Environ. Sci. Pollut. Res.* **2015**, *22*, 19251–19263. [[CrossRef](#)] [[PubMed](#)]
16. Singh, R.N.; Atkins, A.S.; Pathan, A.G. Water resources assessment associated with lignite operations in Thar, Sindh, Pakistan. *Arch. Min. Sci.* **2010**, *55*, 425–440.
17. Hagler Bailly, P. *Environmental and Social Impact Assessment, Thar Coal Block II Mining Project*; Sindh Engro Coal Mining Company: Karachi, Pakistan, 2012.
18. Singh, A.K.; Mahato, M.; Neogi, B.; Tewary, B.; Sinha, A. Environmental geochemistry and quality assessment of mine water of Jharia coalfield, India. *Environ. Earth Sci.* **2012**, *65*, 49–65. [[CrossRef](#)]
19. Tripathy, D. Determination of Trace Elements Concentration in Mine Water and Trace Elements Index in Some Coal Mines of Jharia Coalfield. Doctoral Dissertation, Department of Mining Engineering, National Institute of Technology, Odisha, India, 2002.
20. Hussain, A. *Pakistan National Human Development Report 2003: Poverty, Growth and Governance*; Oxford University Press: Oxford, UK, 2003.

21. Qasim, H.; Luqman, M.; Khan, S. A study of forest land cover changes using satellite remote sensing in Thatta district Pakistan. *Sci. Int.* **2016**, *28*, 4069–4075.
22. Food Security Cluster, Pakistan. *Sindh Drought Needs Assessment, the State of Agriculture, Livelihood, Food Security, Nutrition, Water and Sanitation in Drought Affected Communities in Sindh*; Food Security Cluster: Islamabad, Pakistan, 2016.
23. Khan, S.R. *Adaptation to Climate Change in the Context of Sustainable Development and Equity: The Case of Pakistan*; Sustainable Development Policy Institute: Islamabad, Pakistan, 2002.
24. Carabine, E.; Lemma, A.; Dupar, M.; Jones, L.; Mulugetta, Y.; Ranger, N.; van Aalst, M. *The IPCC'S Fifth Assessment Report: What Is in It for South Asia*; Overseas Development Institute and Climate Development and Knowledge Network: London, UK, 2014.
25. Ragab, R.; Prudhomme, C. SW—Soil and water: Climate change and water resources management in arid and semi-arid regions: Prospective and challenges for the 21st century. *Biosyst. Eng.* **2002**, *81*, 3–34. [[CrossRef](#)]
26. Maddocks, A.; Young, R.; Reig, P. *Ranking the World's Most Water-Stressed Countries in 2040*; World Resources Institute: Washington, DC, USA, 2015.
27. López-Morales, C.A.; Mesa-Jurado, M.A. Valuation of hidden water ecosystem services: The replacement cost of the aquifer system in central Mexico. *Water* **2017**, *9*, 571. [[CrossRef](#)]
28. APP. CPEC project: China approves \$1.2 bn for coal mining, power plant in Thar. *DAWNNEWS*, 16 December 2015.
29. Singh, R.; Atkins, A.; Doulati Ardejani, F. Hydrogeological issues concerning the thar lignite prospect. *Int. J. Min. Geo-Eng.* **2012**, *46*, 141–156.
30. Imran, M.; Kumar, D.; Kumar, N.; Qayyum, A.; Saeed, A.; Bhatti, M.S. Environmental concerns of underground coal gasification. *Renew. Sustain. Energy Rev.* **2014**, *31*, 600–610. [[CrossRef](#)]
31. Makki, M.; Ali, S.H.; Van Vuuren, K. 'Religious identity and coal development in Pakistan': Ecology, land rights and the politics of exclusion. *Extr. Ind. Soc.* **2015**, *2*, 276–286. [[CrossRef](#)]
32. Krieger, D.J. *Economic Value of Forest Ecosystem Services: A Review*; The Wilderness Society: Washington, DC, USA, 2001.
33. Agudelo, J. *The Economic Valuation of Water: Principles and Methods*; IHE Delft: Delft, The Netherlands, 2001.
34. Loomis, J. *Valuing Environmental and Natural Resources: The Econometrics of Non-Market Valuation*; Oxford University Press: Oxford, UK, 2005.
35. Venkatachalam, L. The contingent valuation method: A review. *Environ. Impact Assess. Rev.* **2004**, *24*, 89–124. [[CrossRef](#)]
36. Damigos, D. An overview of environmental valuation methods for the mining industry. *J. Clean. Prod.* **2006**, *14*, 234–247. [[CrossRef](#)]
37. Marella, G.; Raga, R. Use of the contingent valuation method in the assessment of a landfill mining project. *Waste Manag.* **2014**, *34*, 1199–1205. [[CrossRef](#)] [[PubMed](#)]
38. Kong, F.; Xiong, K.; Zhang, N. Determinants of farmers' willingness to pay and its level for ecological compensation of poyang lake wetland, china: A household-level survey. *Sustainability* **2014**, *6*, 6714–6728. [[CrossRef](#)]
39. Alberini, A.; Cooper, J. *Applications of the Contingent Valuation Method in Developing Countries: A Survey*; Food & Agriculture Organization: Rome, Italy, 2000; Volume 146.
40. Ahlheim, M.; Börger, T.; Frör, O. *Respondent Incentives in Contingent Valuation: The Role of Reciprocity*; Center for Research on Innovation and Services (FZID) Discussion Papers; University of Hohenheim Stuttgart: Stuttgart, Germany, 2011.
41. Hoehn, J.P.; Randall, A. A satisfactory benefit cost indicator from contingent valuation. *J. Environ. Econ. Manag.* **1987**, *14*, 226–247. [[CrossRef](#)]
42. Government of Sindh, P. Report of Commission of Enquiry. Available online: [http://www.supremecourt.gov.pk/web/user\\_files/File/Enquiry\\_final\\_Report\\_06\\_03\\_2017.pdf](http://www.supremecourt.gov.pk/web/user_files/File/Enquiry_final_Report_06_03_2017.pdf) (accessed on 8 April 2018).
43. Farolfi, S.; Mabugu, R.E.; Ntshingila, S. Domestic water use and values in Swaziland: A contingent valuation analysis. *Agrekon* **2007**, *46*, 157–170. [[CrossRef](#)]
44. Banda, B.M.; Farolfi, S.; Hassan, R.; Perret, S.; Farolfi, S.; Hassan, R. Determinants of quality and quantity values of water for domestic uses in the steelpoort sub-basin: A contingent valuation approach. In *Water Governance Sustainable Development*; Earthscan Publications: London, UK, 2006; pp. 167–188.

45. Phiri, L.B. *An Assessment of the Quality of Water Services in Low-Income Areas of Malawi—A Case Study of Mtandile-Mtsiliza in the City of Lilongwe, Malawi*; University of Zimbabwe: Harare, Zimbabwe, 2007.
46. Menard, S. *Applied Logistic Regression Analysis*; SAGE Publications: Thousand Oaks, CA, USA, 2018; Volume 106.
47. Robinson, C.; Schumacker, R.E. Interaction effects: Centering, variance inflation factor, and interpretation issues. *Mult. Linear Regres. Viewp.* **2009**, *35*, 6–11.
48. Thompson, C.G.; Kim, R.S.; Aloe, A.M.; Becker, B.J. Extracting the variance inflation factor and other multicollinearity diagnostics from typical regression results. *Basic Appl. Soc. Psychol.* **2017**, *39*, 81–90. [[CrossRef](#)]
49. O'brien, R.M. A caution regarding rules of thumb for variance inflation factors. *Qual. Quant.* **2007**, *41*, 673–690. [[CrossRef](#)]
50. Kaliba, A.R.; Norman, D.W.; Chang, Y.-M. Willingness to pay to improve domestic water supply in rural areas of central Tanzania: Implications for policy. *Int. J. Sustain. Dev. World Ecol.* **2003**, *10*, 119–132. [[CrossRef](#)]
51. Pakistan, G.O.S. Minimum Labour Wage 2016/17. Available online: <http://efp.org.pk/wp-content/uploads/2017/09/Increase-In-The-Minimum-Wages-Notice-2017.pdf> (accessed on 7 February 2018).
52. Yepes, T.; Foster, V. *Is Cost Recovery a Feasible Objective for Water and Electricity? The Latin American Experience*; World Bank Publications: Washington, DC, USA, 2006.
53. Van Ginneken, M.; Netterstrom, U.; Bennett, A. *More, Better, or Different Spending? Trends in Public Expenditure on Water and Sanitation in Sub-Saharan Africa*; The World Bank: Washington, DC, USA, 2011.
54. Aklilu, A. Households' willingness to Pay for Improved Solid Waste Management: The Case of Addis Ababa. Master's Thesis, Addis Ababa University, Addis Ababa, Ethiopia, 2002.
55. Van Houtven, G.L.; Pattanayak, S.K.; Usmani, F.; Yang, J.-C. What are households willing to pay for improved water access? Results from a meta-analysis. *Ecol. Econ.* **2017**, *136*, 126–135. [[CrossRef](#)]
56. Food and Agriculture Organization of The United Nations. *GIEWS Country Brief of Pakistan*; Global Information and Early Warning System on Food and Agriculture (GIEWS): Rome, Italy, 2017.
57. McIntyre, N.; Bulovic, N.; Cane, I.; McKenna, P. A multi-disciplinary approach to understanding the impacts of mines on traditional uses of water in Northern Mongolia. *Sci. Total Environ.* **2016**, *557*, 404–414. [[CrossRef](#)] [[PubMed](#)]
58. Rananga, H.; Gumbo, J.R. Willingness to pay for water services in two communities of mutale local municipality, South Africa: A case study. *J. Hum. Ecol.* **2015**, *49*, 231–243. [[CrossRef](#)]
59. Biswas, D.; Venkatachalam, L. Farmers' willingness to pay for improved irrigation water—A case study of Malaprabha irrigation project in Karnataka, India. *Water Econ. Policy* **2015**, *1*, 1450004. [[CrossRef](#)]
60. Kanyoka, P.; Farolfi, S.; Morardet, S. Households' preferences and willingness to pay for multiple use water services in rural areas of South Africa: An analysis based on choice modelling. *Water SA* **2008**, *34*, 715–723.
61. Moffat, B.; Motlaleng, G.; Thukuza, A. Households willingness to pay for improved water quality and reliability of supply in Chobe ward, Maun. *Botsw. J. Econ.* **2011**, *8*, 45–61.
62. Verhagen, J.; James, A.; Wijk, C.V.; Nanavatty, R.; Parikh, M.; Bhatt, M. Linking water supply and poverty alleviation: The impact of women's productive use of water and time on household economy and gender relations in Banaskantha district, Gujarat, India. In *Linking Water Supply and Poverty Alleviation: The Impact of Women's Productive Use of Water and Time on Household Economy and Gender Relations in Banaskantha District, Gujarat, India*; IRC International Water and Sanitation Centre: Delft, The Netherlands, 2004.
63. Ward, F.A.; Michelsen, A. The economic value of water in agriculture: Concepts and policy applications. *Water Policy* **2002**, *4*, 423–446. [[CrossRef](#)]
64. Ntengwe, F. The impact of consumer awareness of water sector issues on willingness to pay and cost recovery in Zambia. *Phys. Chem. Earth Parts A/B/C* **2004**, *29*, 1301–1308. [[CrossRef](#)]
65. Raje, D.V.; Dhobe, P.; Deshpande, A. Consumer's willingness to pay more for municipal supplied water: A case study. *Ecol. Econ.* **2002**, *42*, 391–400. [[CrossRef](#)]

