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Socio-economic Impacts of Wastewater Irrigation on Local People in the Outskirts of Chandigarh Urban Areas

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Abstract The use of wastewater for irrigation is a valuable strategy to maximize available water resources, but the fringe quality of the water can present innumerable challenges. Water scarcity pushes the farmers to use wastewater for irrigation as an available alternate source. The present study was conducted in the peri-urban areas of well-planned city Chandigarh with a primary objective to obtain information about the current status of wastewater use for irrigation and socio-economic reasons for using wastewater from the farmers' perspective. Therefore, nineteen (19) villages were selected nearby four seasonal choes around the study sites. At the site, we found that 64% of farmers were using freshwater, and the remaining farmers were using wastewater for crop irrigation. In this study, two contrasting perceptions were observed among the farmers about wastewater irrigation. Results indicated that farmers have a piece of relatively good knowledge about the inappropriate quality of wastewater and its adverse effects. Although they were concerned about the health, environmental and social impacts of wastewater yet, they believed that using this water resource is economically profitable for them. Thus, the present study highlighted the need for planning to improve wastewater treatment along with appropriate policies and methods to enhance farmers' commitment to environmental conservation and human health.

Keywords: *wastewater irrigation, agriculture, farmer's perception, environmental impact, health risk, sustainability*

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1. Introduction

Water is one of the essential natural resources that sustain livelihoods. Freshwater consumption and demand have increased over the years, due to population growth, agricultural and industrial intensification. Currently, almost a quarter of humankind (1.6 billion), is facing acute water shortages, and this number is likely to double in the subsequent decade [1]. But water scarcity is a critical problem for crop production in third world countries, especially for Pakistan, Ethiopia, India and Iran. Farmers of these countries where water is short, incline to use wastewater often for irrigation purposes. It is a significant inducement for the poor farmers to use wastewater as it can reduce the crop production cost by 10-20 %. In peri-urban areas, untreated or partially treated wastewater is frequently used to irrigate vegetables and other crops due to non-availability of freshwater [2]. Farmers are usually not familiar with the drawbacks of this practice and have a different opinion [3]. Use of wastewater in agriculture helps to recycle useful nutrients in the soil. However, this practice, in particular, can lead to serious health consequences for farmers and consumers as well, because the broad spectrum of pathogenic organisms, toxic chemicals and heavy metals in the wastewater is transferred to food chain via consumption of sewage irrigated crops [4].

Furthermore, wastewater contaminants can also lead to pest attack on crops, reduction in crop yield, and worsen soil quality in long-term [5]. Previous studies reported that the main drawback of wastewater irrigation is the presence of heavy metals and their potential accumulation in soil [6]. These heavy metals enter the food chain and can result in human health hazards in the long run when their concentration in the human body exceeds safe limits [7]. Moreover, the alleviation policies to reduce heavy metal exposure through the food chain are often overlooked [8]. Wastewater reuse remains as the alternative and useful source of water that can help to reduce pressure on freshwater for crop production and poverty alleviation in third-world countries. Great research strides have been demonstrated on wastewater reuse for agricultural use, but much remains unknown concerning adoption rates and health risks, especially in developing countries. So, Farmers' acceptance or rejection of the wastewater is influenced by their economic conditions, local cultural, religious, and socio-economic conditions. Despite all facts, farmers are key stakeholders in the reuse of wastewater for irrigation of crops, yet their role is often compromised in water resource decision making [9]. Previous work on Farmer's perceptions of wastewater reuse can be grouped according to Farmer's acceptance of wastewater due to economic benefits or a negative perception due to its environmental economic and health risks. In a study [10] it was reported that the lack of fresh water resources for irrigation was the major driving force for farmers willingness to use wastewater in Greece. However, farmers in Nepal connect the reuse of wastewaters with negative health conditions particularly skin disorders [11]. Research findings around the world regarding farmers perception on health risks due to wastewater irrigation shows that the awareness of health risk is deficient among farmers, therefore, there is a need to explore farmer's perception and attitude towards wastewater use for irrigation. This is not necessarily just in terms of their willingness to use the wastewater as a resource or their awareness on its health and environmental risks instead; it is salient to examine the underlying factors leading to either a positive or negative perception of wastewater use in agriculture. Our goal in this research is to identify those factors; therefore, the present study was designed to execute the following objectives:

i. To identify the current status of wastewater irrigation in the study area.
ii. To know the perception of farmers of study area towards wastewater irrigation.
iii. To obtain socio-economic reasons for using wastewater for crop production by local farmers.

2. Materials and Methods

2.1. Study Area

A reconnaissance survey was conducted at selected study sites in the peri-urban area of Chandigarh Union territory to collect information on about Farmer's opinion about socio-economic impacts of wastewater use for irrigation purposes. Chandigarh (Figure 1a-c) is situated at foothills of the Himalaya (lower Siwalik) with area of 114 km^2 at Longitude 76° 47' 14E and Latitude 30° 44'14N. The city experiences four seasons: (i) Summer or hot season (mid-March to Mid-June) (ii) Rainy season (late-June to mid-September) (iii) Post monsoon autumn/transition season (mid-September to mid-November) (iv) Winter (mid-November to mid-March). May and June both months are the hottest months of the year with the mean daily maximum & minimum temperatures being about 37°C & 25°C, respectively. Maximum temperatures can rise up to 44°C. Southwest monsoons with high-intensity showers commence in late June. The variation in annual rainfall on year-to-year basis is appreciable, i.e. 700 mm to 1200 mm. The survey was conducted in 19 villages situated alongside four seasonal rivulets locally called as choes (N Choe\ Attawa Choe, Choi Nala, Sukhna Choe and Patiali Ki Rao) that have become highly polluted due to wastewaters (treated/untreated) released by slums and unauthorized residential colonies situated at outskirts of the Chandigarh city, sewage treatment plants (STPs), junk yards, storm water, hospital effluents and small industrial units situated nearby. The selection of villages was made on the basis of their proximity with the level of polluted choes (Figure 1 d).

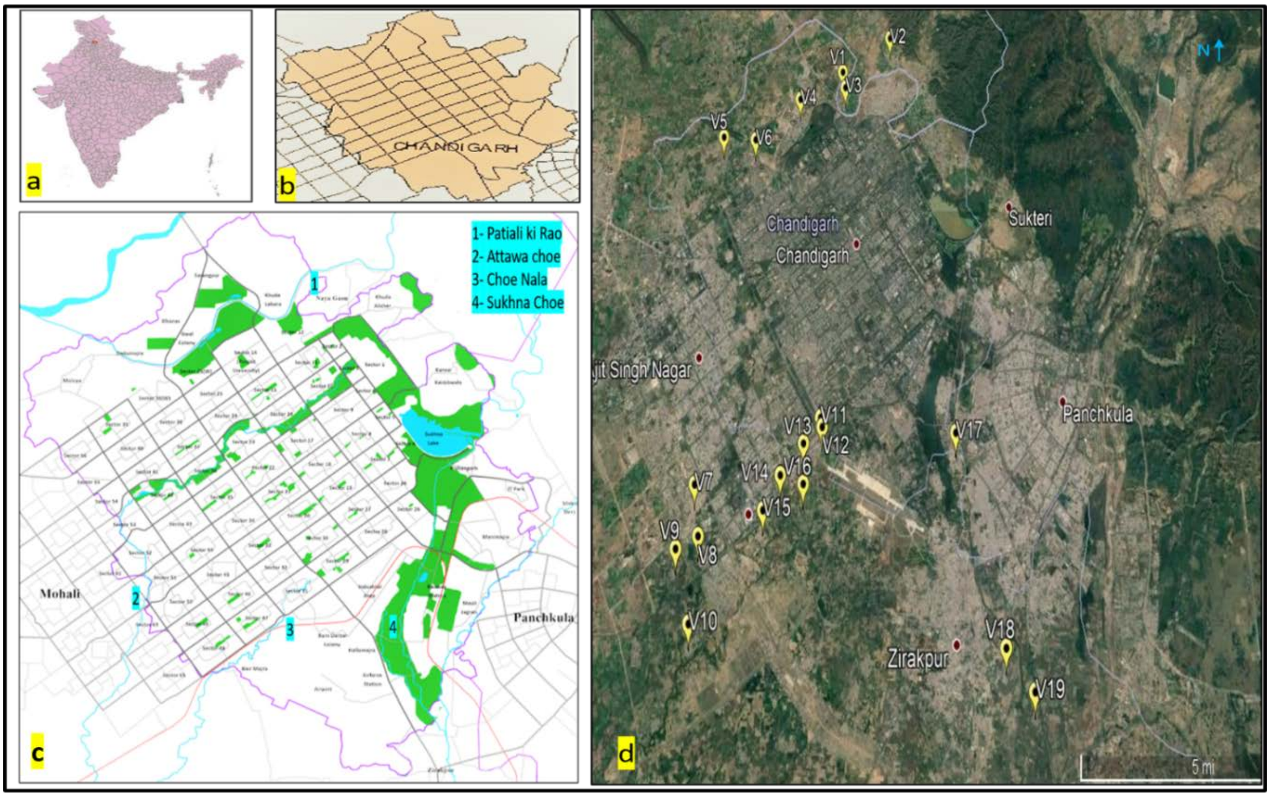

Figure 1. Map showing study areas: Country map (a), Chandigarh and its peri-urban area (b), water bodies of the Chandigarh and its peri-urban areas (c) and villages in the adjacent areas where study sites are located (d)

2.2. Sampling Method

Selection of each respondent (farmers) was accomplished by a multi-stage sampling technique embedded with simple random sampling method among the farmers of the study area. One adult (>18 years of age) from each household was further selected and interviewed. From the chosen household with more than one adult (>18 years of age) if available, then only one respondent was designated as a respondent by using the lottery method. However, the selection of study sites (19 villages) in the study area was made on the basis of presences of the agricultural fields of villages nearby four seasonal rivulets (currently wastewater canals).

2.3. Sample Size Determination

The sample size was determined by using a 95% confidence interval and 7% desired level of precision. Because there were no previous studies conducted on wastewater irrigation in the study area, the expected prevalence was taken as 50%, and the size was determined by the formula for the infinite population given below [12].

$$n = \frac{Z^2 P(1-P)}{d^2}$$

Where, n= required sample size,
Z= level of confidence according to the standard normal distribution (for a level of confidence of 95%, Z= 1.96), P= Expected prevalence or proportion of the population that presents the characteristic (when unknown we use p = 0.5) d= tolerated margin of error (in present study 7%).

Based on the above-given formula, the total sample size was expected to be 196. However, for representativeness of our sample size, adding 25 respondents for non-response rate, the required sample sizes rise into 221.

2.4. Questionnaire and Survey

Data collection tool was a questionnaire-based survey. A structured questionnaire was designed to collect the information from each respondent about the current scenario of wastewater use, its impacts and perception of farmers on the concerned issues. The questionnaire was made however consisted of mixed type of questions such as open and closed questions, binary questions (Yes or No), multiple-choice type and some based on Likert scale, measuring the intensity of problem on one to five scale. The questionnaire was only open to farmers those were above 18 years in age.

The questions addressed the farmers' profile, crop preferences, irrigation practices, farm inputs, their knowledge about impacts of wastewater irrigation on agriculture, environment and their health and also regarding problems faced by farmers during use of wastewater. Thus, this survey was conducted across19 villages of the peri-urban area of the Chandigarh in a lower Siwalik region. Therefore, total 221 farmers of the study area were included in the survey, and this survey was conducted from October 2019 to March 2020.

Figure 2. a & d showing a survey of respondent farmers, b and c is depicted for the use of pumps to fetch wastewaters from choes for irrigation in the study area

3. Results & Discussion

3.1. Farmers Profile

In the study area, most of the respondent (farmers) were male (98.19%). Only minimal ratio (1.80 %) reported to be female farmers who were involved in farming independently, such ratio (male to female Farmer) have also been reported [13] from Pakistan where 84% farmers were male, and 16 % were female because most of the males do farming and females are involved in household chores as per the local tradition. In our study, majority of farmers in the study area were found in the age group of 39 to 59 years (51.13 %), 27.14 % in 18 to 38 years and 20.36 % in between 60 to 80 years, respectively (Figure 4). However, the least number of farmers (0.45 %) were found to be above eighty years age. This finding shows that farmers are still in a position to be economically active and efficient. In agreement with this, a similar observation was reported [14] from Iran. The literacy rate of the farmers was found to be significantly diverse since the percentage of illiterate farmers was found to be 13.12 %, and those farmers who took education till primary classes, Higher Secondary certificate (HSC) and Senior Secondary certificate (SSC) were 16.74 %, 23.98%, 28.50%, respectively. However, among the total respondents, several farmers were found to be graduate (17.64 %) as well as few in number as post-graduate (0.45%) in the study area. Through this observation, it is found that literacy was not a determinant factor in stopping wastewater irrigation in cultivation, because, farmers were educated at a level that they were very well aware of the impacts of wastewater irrigation.

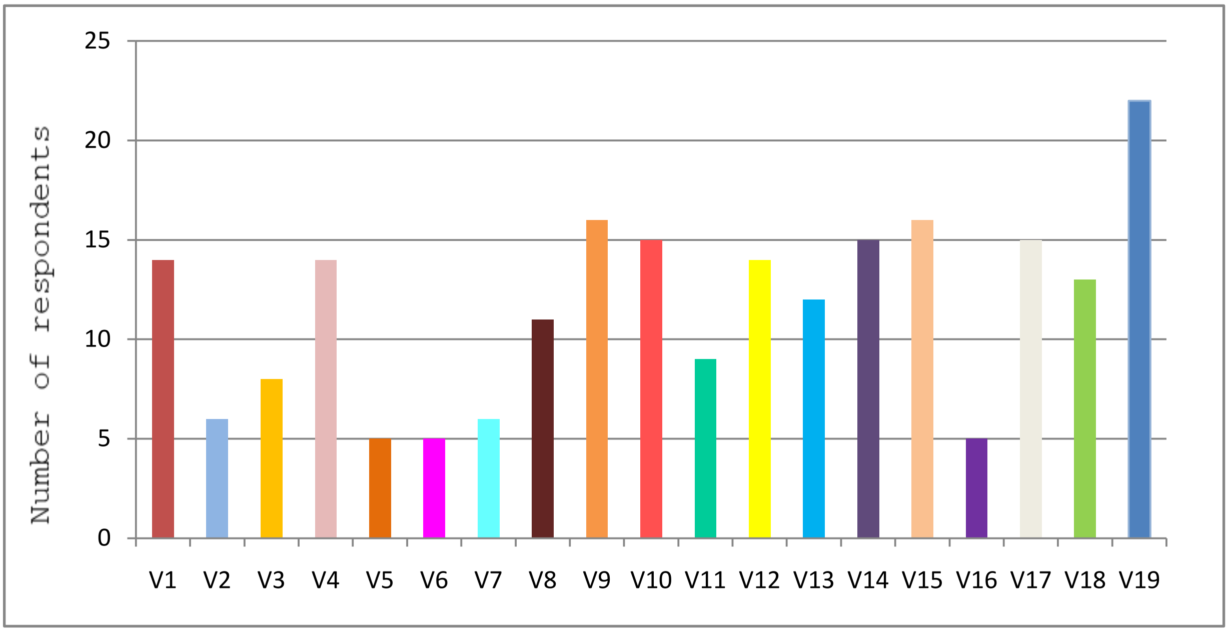

Figure 3. Number of respondents in each village interviewed during the survey

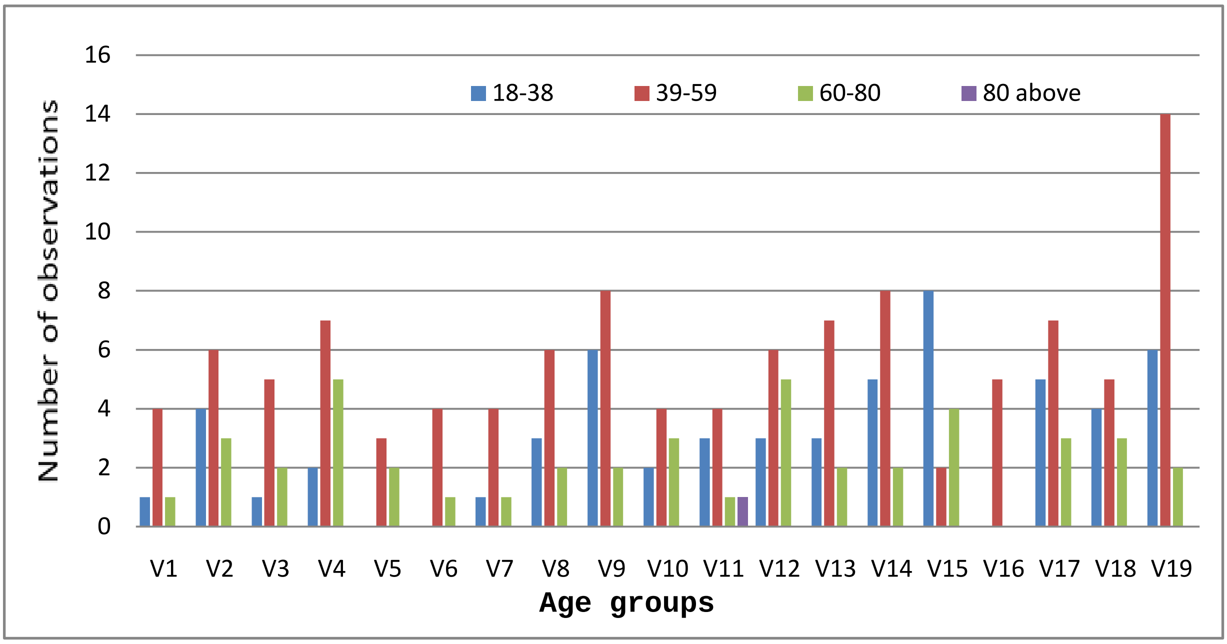

Figure 4. The age group of the respondents

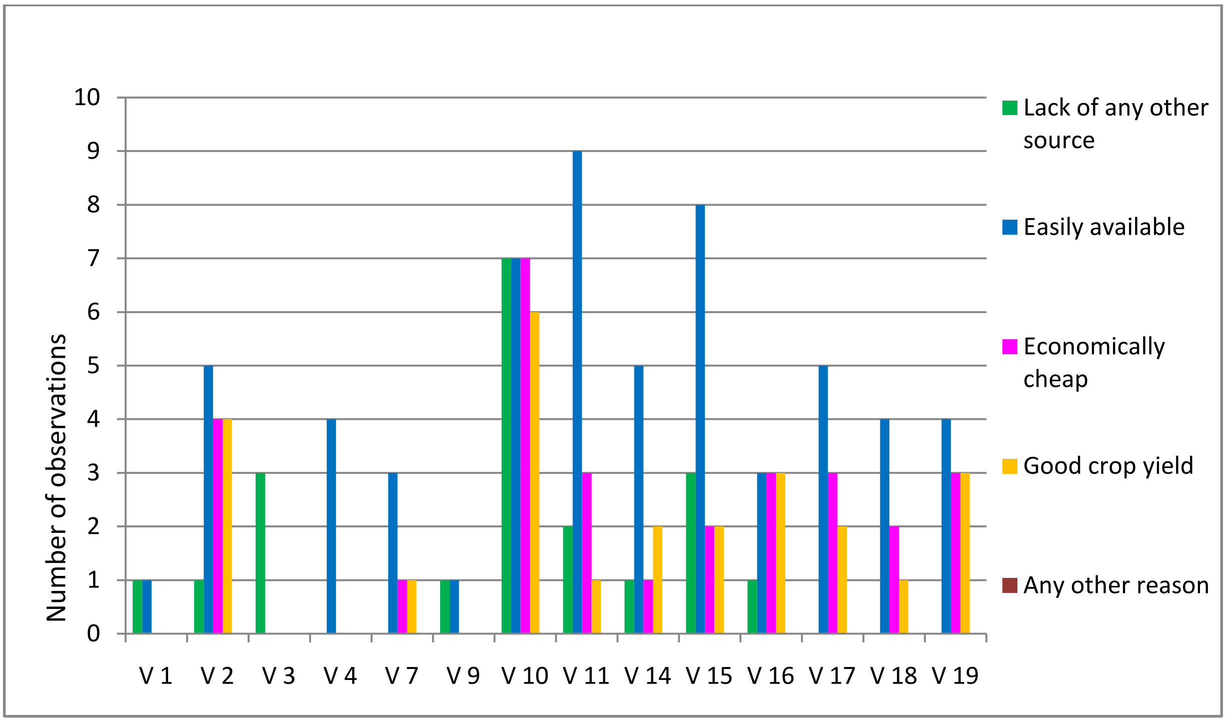

Figure 5. Driving factors behind wastewater irrigation by Farmers of the study area

3.1. Wastewater Usage and Driving Factors

Most cities in developing countries fail to treat their wastewater comprehensively. Consequently, farmers are inclined to use poor-quality water for irrigation. This practice implies risks for farmers, consumers and to the environment. In this study; of the total respondents, 27% of farmers had accepted to use wastewater as sole source of irrigation, while 9 % involved as occasionally. However, majority of the respondents (64% farmers) agreed that they are not dependent on wastewater for irrigation, and they were utilizing water from tube well pumps (government and self-installed). Among villages, astonishing results have been found for use of wastewater for irrigation into various scale as 100 %, 78% and 60%, respectively in the village of V11, V10 and V16. The main driving factor behind using wastewater was perhaps easy availability of wastewater (47%) near the agricultural fields attracted more along with consideration of economically cheaper (22%) as wastewater is available free of cost, good crop yield (19%), as well as more choice, bent as rich in nutrients which support and promote crop growth, and lack of any other water sources (17%) for irrigation (Figure 5). Out of 19 villages, respondents of following villages viz: V10, V11 and V15 reported the lack of fresh water source for farming was the main driving factor (25%, 13%, and 14 %, respectively) behind the use of wastewater. Similar observations were reported by several researchers [13,15] in their studies that due to scarcity of freshwater source for irrigation and high cost of supply water, the farmers were forced to use wastewater for crop irrigation. Generally, awareness and mindset play a vital role in dependency on wastewater for irrigation as it was found that farmers those who were using wastewater for irrigation occasionally revealed that they did not want to use it but during the peak time of crop irrigation due to some unforeseen issues like pump failure or unavailability of freshwater etc. made them move towards wastewater present in nearby choes to save the crops and they were keen to use fresh water for irrigation if availability of fresh water was made throughout the year. Analogous reports were found in a study in Kustia peri urban area in Bangladesh, farmers left the wastewater irrigation when provided with fresh water supply for free of cost by the government [16]. Since wastewater is freely available it saves the farmers cost on tube-well water (dull charges/electricity) as compared to fresh water and many farmers believed that they observed more yield of crops by using wastewater rather than using fresh water; which reduced the overall crop production cost so with these reasons they were using it thoroughly; these results are in agreement with studies in Iran, where farmers were motivated to use wastewaters as irrigation source because it saved their crop production cost in several aspects [17,18]. Majority of the farmers (75%) admitted that they were involved in wastewater irrigation for more than 14 years. Perhaps, prolonged wastewater irrigation may lead to accumulation of heavy metals, because diverse group of harmful microorganisms that can further cause several types of diseases. In agreement with this, some works have reported similar observations [14,19]. They reported high concentration of heavy metals from agricultural areas those were irrigated for prolonged wastewater irrigation. The medium of fetching wastewater from choes was found to be mainly Pumps (83%) followed by using buckets manually (12%) by those farmers having smaller fields adjacent to the choes due to topographical status of choes that flow in depression throughout the study area.

3.2. Perception of Farmers towards Quality of Wastewater and Its Practice

When the farmers were asked about their observation towards the quality of wastewater flowing in the choes of their villages, they were quite receptive and had good observation on water quality. While speaking generally about the wastewater in choes, farmers used the term “ganda Paani (bad water) or naale ka Pani” (drain water). They found solid wastes, plastics, shoes, scrapes, batteries, fecal matter, dead and decayed or rotted plants and animals (dog/mice etc.), greasy substances, and sometimes liquid chemicals too flowing in the wastewaters. Respondents were asked to rate the quality of water on a scale of 1 to 5 designated with these characters (5 = very good, 4 = good, 3= moderate, 2= bad and 1= very bad, respectively). Majority of the farmers (43%) stated that the quality of wastewater in their village was very bad followed by low (34%) and moderate quality (21%). These results are in agreement with a previous study [20] that showed social acceptability of untreated wastewater in the community is low and found a “yuck” factor towards wastewater use among farmers. Only a few farmers (2%) reported the wastewater quality was right in their area, the reason they gave behind their rating was the presence of Sewage Treatment Plant nearby. They believed that water released into the choes was good as it was already treated by the STP. However, none of the Farmer accepted that quality of wastewater flowing in the choes of their village was very good. When asked about their perception towards the wastewater irrigation practice, we got mixed results from farmers. Majority of farmers (36%) thought that using wastewater as a source of irrigation was a bad practice.

In comparison, 34% farmers stated that it is an unacceptable and awful practice as it may affect the soil and crops severely and may lead to several health issues (Figure 6). These results go in agreement with a study conducted in Nepal where the majority of wastewater users were well aware of the negative impacts of wastewater on the environment and reported it as a bad practice [11]. On the other hand, farmers those were using wastewater for irrigation rated it as a reasonable practice (21%) and not that bad, however, there were also a few farmers (9%) who thought it is good to use wastewater for irrigation purpose as it brought them several benefits in terms of both money saving and crop yield which is supported by previous studies where wastewater application has reduced the crop production cost by saving money on fertilizers [21]. On asking about the consumption of crops growing in their fields 97% farmers accepted that they and their families consume the crops however 3 % farmers indulged in wastewater irrigation, admitted that they don’t consume crops growing in their field irrigated with wastewater instead they grow crops separately on their other areas using freshwater (tube-well) for their consumption because they believed that wastewater irrigated crops might be harmful for their health. This shows that farmers were aware of the health risks of wastewater irrigation and substandard quality of crops irrigated with wastewater.

3.3. Problems of Working with Wastewater

Problems associated with wastewater irrigation were categorized into two groups, one related to general issues (Figure 7) that farmers had to deal with during this practice and other related to health issues of the farmers (Figure 8). Majority of the farmers reported atrocious odour that was the main problem they had to deal with followed by pump damage due to silt and solid waste present in the wastewaters; however, some farmers reported that they used wire mesh at the edge of the pipe to filter solid waste from sewage to avoid this problem. Some farmers also encountered pest attack and crop damage due to wastewater irrigation. However, surprisingly 10 % of farmers believed that they did not face any of the above or other problems while working with wastewater irrigation.

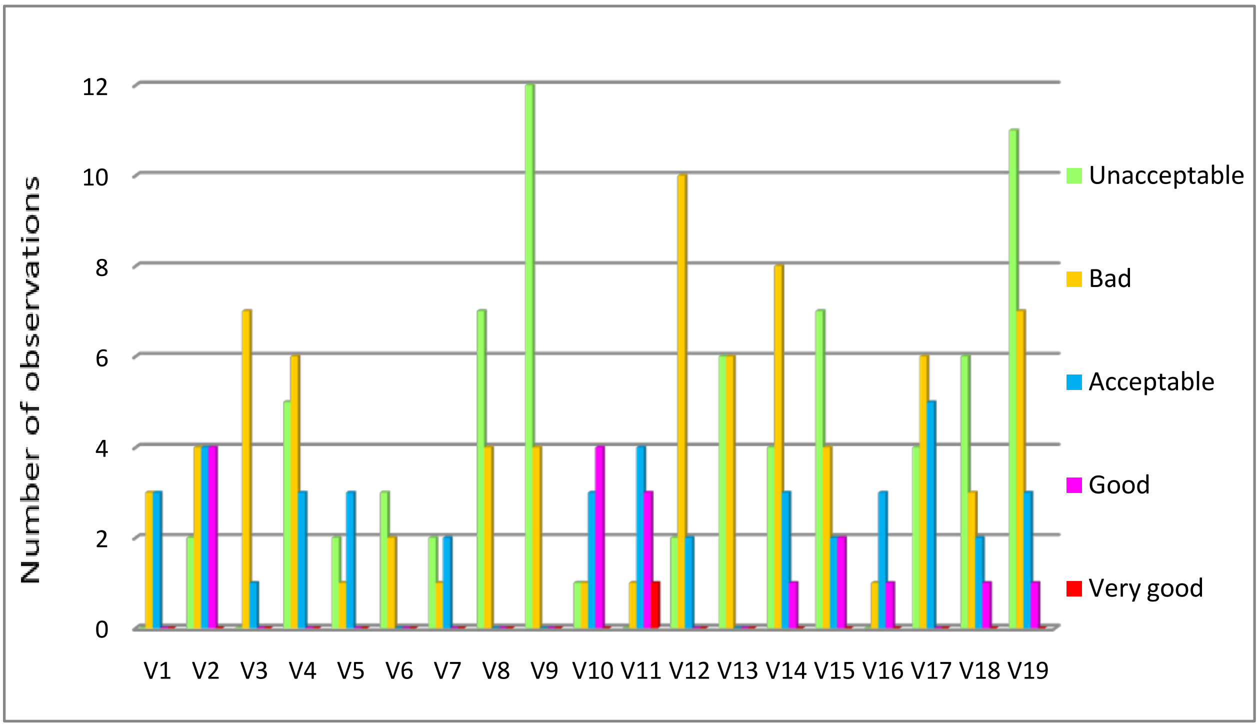

Figure 6. Perception of respondents towards wastewater irrigation practice

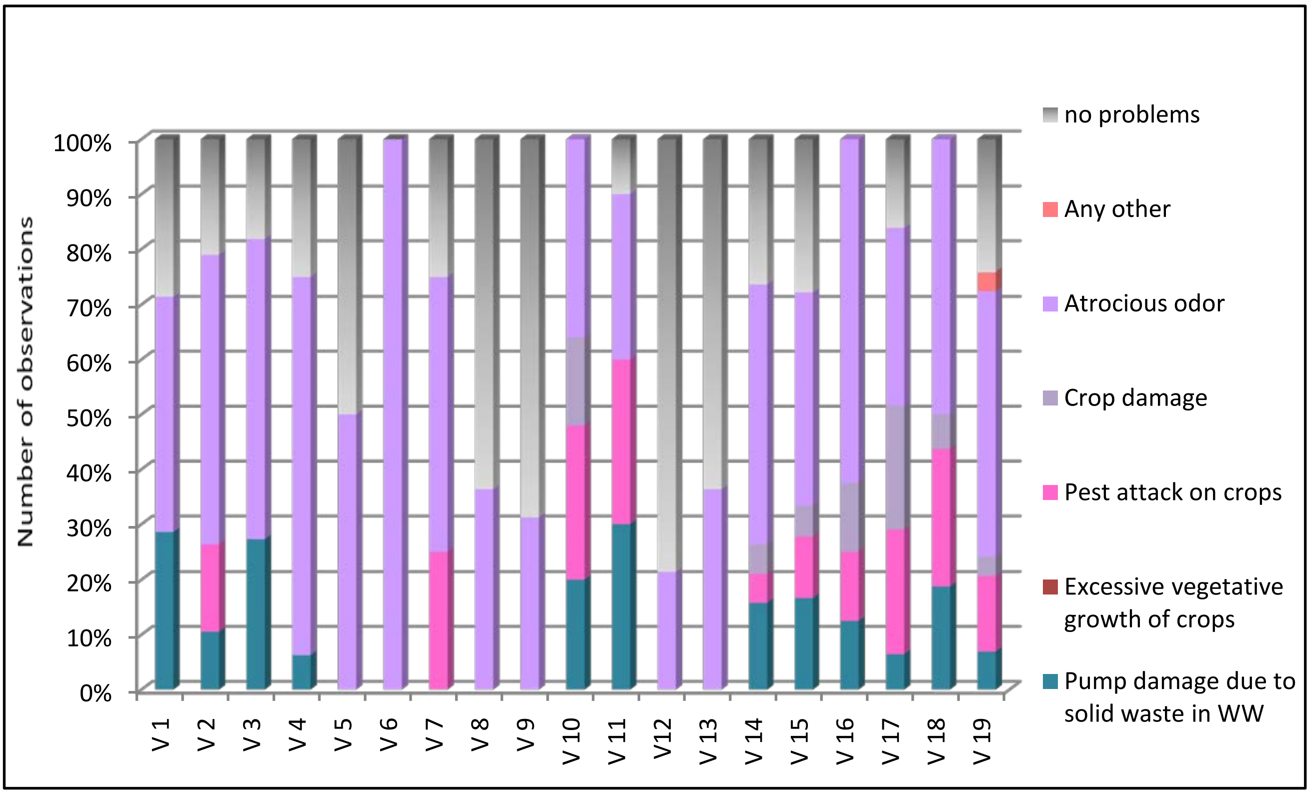

Figure 7. General problems while working with wastewater faced by Respondents of the study area

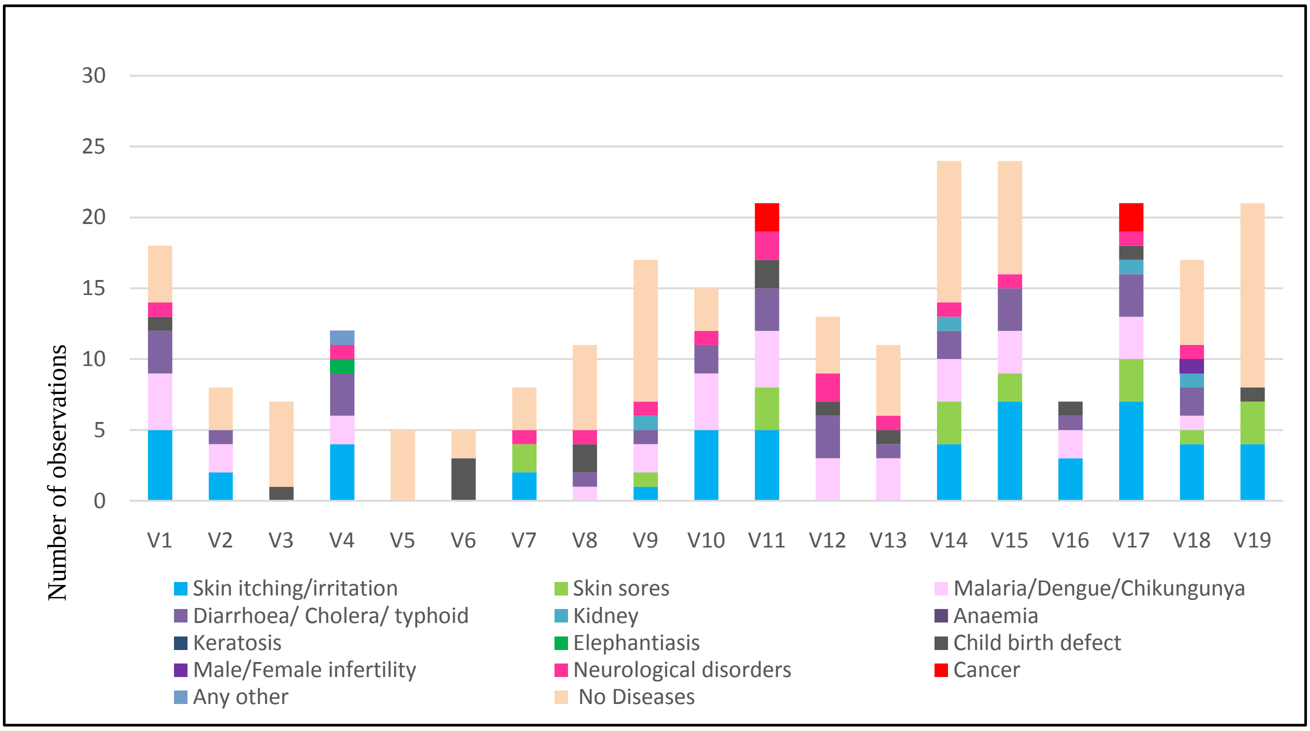

Figure 8. Health-related issues among respondents of the study area

Since several forms of pathogens (microbial organisms) including viruses, bacteria, protozoa, nematodes and helminths and hazardous substances (mostly heavy metals) can be present in wastewater, other contaminants such as harmful chemicals, and many different kinds of pollutants which can cause acute or chronic health apprehensions for people working in wastewater-irrigated fields or consuming wastewater-irrigated foods, especially when eaten uncooked (e.g. some vegetables used as salad). Therefore, farmers were questioned to assess the health risks of wastewater application. However, we found that regarding health hazards skin itching was more common among farmers who had to enter in the choes while working, a lot of farmers reported having skin sores or blisters occasionally when wastewater in the choes had some chemical waste input they faced skin itching and irritation (21 %) during and after working in wastewater, since some of the farmers were marginal, poor and mostly used for bare hands and barefooted, did not have rubber boots and gloves which caused them to work with direct contact of wastewater. blistering and skin infection, injury to hands and legs were other common issues, cases of vector borne diseases such as Malaria, Dengue etc. were also reported by a number of farmers (14%) from study sites that may be due to presence of mosquitoes in the wastewater choes that is a familiar breeding spot for them.

Our observations were supported by a study from Bangladesh; who reported that majority of farmers (39%) of the study area experienced skin itching and blistering after working in wastewater, and also reported prevalent diseases due to mosquitos among farmers [16]. Stomach upset, diarrhoea like water-borne diseases were reported by 10% farmers that may be due to consumption of raw or uncooked vegetables irrigated by wastewaters, such findings are supported by a study [22] that reported many bacterial diseases, such as diarrhoea and cholera, can spread by wastewater use in agriculture and transmit to those people who are consuming wastewater-irrigated crops and raw vegetables. A few respondents reported congenital child disability and neurological diseases in their family. However, some farmers (2%) revealed to have kidney and cancer-related health issues in their families. A health risk from harmful contaminants arise from heavy metals and many organic compounds (such as pesticides) due to prolonged wastewater irrigation and further leads to their accumulation in the soil to toxic levels. Crops and vegetables raised on the contaminated soils also accumulate heavy metals in excessive quantities that cause health problems [18].

3.4. Crop Preferences and Farm Inputs

The Union Territory, Chandigarh has a limited area under agriculture. The agricultural land is being gradually acquired for the expansion of Chandigarh City, and the cultivated area has shrunk from 5441 hectares in 1966 to 1208 hectares in 2006-07 as per the revenue report most of the crop cultivation is being done in peri-urban area of this city [23]. Farmers of the study area produced different types of crops using freshwater (tube wells) and wastewater. These crops included cereals, vegetables, fodder crops, legumes, pulses and a few fruit crops (Figure 9). It was found that majority of farmers using wastewater to irrigate their crops, preferably to grew cereals (48%) followed by vegetables (27%). However, 19% of farmers preferred to grow other crops which included mainly fodder crops for their cattle. Significantly fewer farmers grew some pulses (5%) and fruits (1%) like banana, mango and guava but on a small scale. Among cereals and pulses during Rabi seasons they preferred to grow Wheat, Mustard, Gram, Mung bean, groundnut etc. Kharif season cereals chiefly included maize, pearl millet and paddy. However, farmers growing vegetables using wastewater grew a variety of vegetables. Majority of farmers (35%) grew leafy vegetables such as Spinach, Fenugreek, Coriander, Mustard, Amaranthus, Mint and other green leafy vegetable (saag in Hindi) due to high rate of growth of leafy vegetables (Figure 10) which is in agreement with a study on farmers of Rajshahi town, Bangladesh preferred to grow leafy vegetables by wastewaters as reported that it supports the good growth of leaves [16].

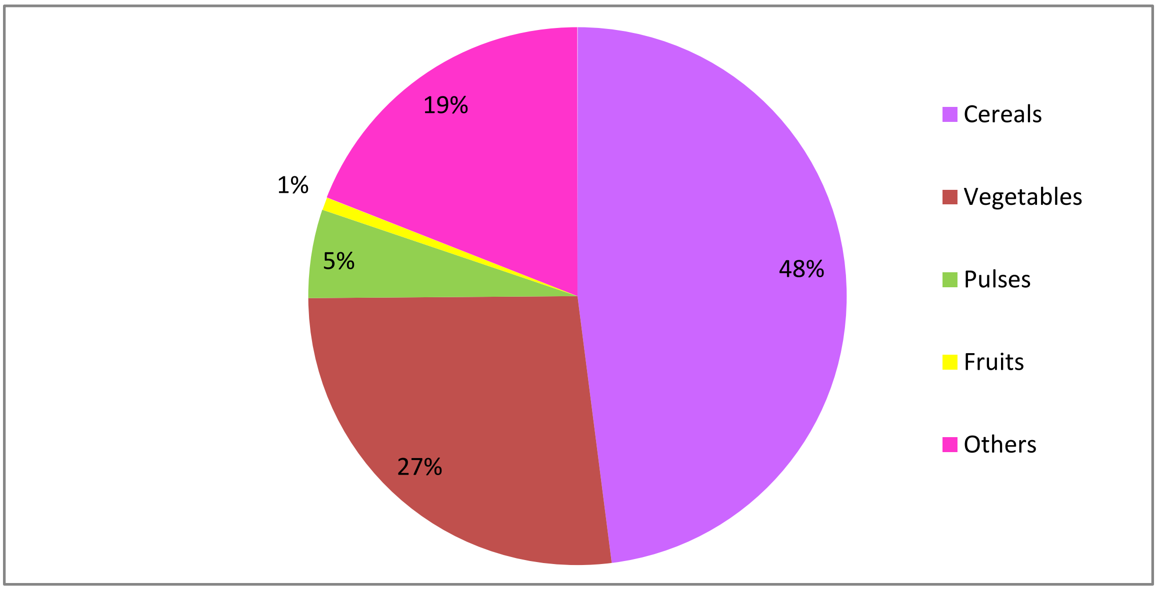

Figure 9. Crop preferences in the study area

However, in a study it was [24] reported that leafy vegetables have a high tendency to accumulate heavy metals in their leaves which may contaminate the food chain. In another study at the peri-urban area of Faisalabad district Pakistan, it was reported that high concentrations of heavy metals in edible parts of leafy vegetables, perhaps it was accumulated due to prolonged wastewater irrigation [13]. A small number of farmers (19%) grew fruit vegetables such as tomato, brinjal, capsicum, bitter gourd, pumpkin, luffa etc. farmers growing root crops (18%) mainly grew radish, carrots, turnips, beetroot and Colocasia followed by flower vegetables (12%) such as cauliflower, bulb vegetables (10%) such as onion and garlic and Tubers (6%) such as potatoes, sweet potatoes and a few yams. A recent global survey found that vegetables (32% frequency of responses) are besides cereals (27%) the most common crops produced with diluted or raw wastewater [11,25].

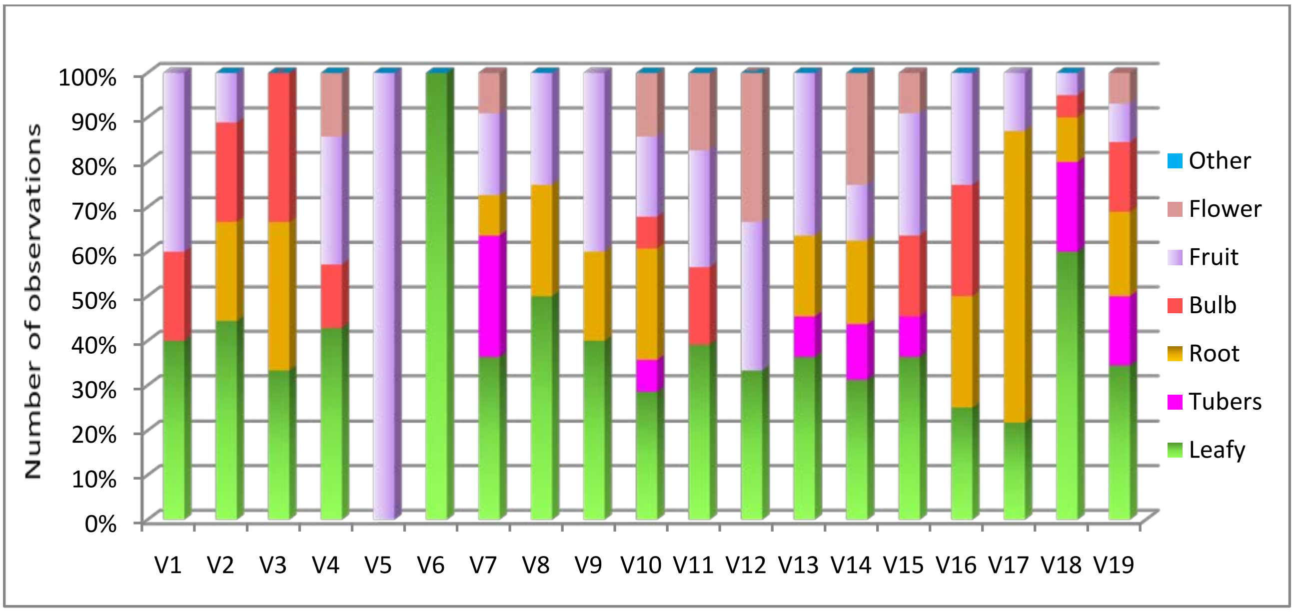

Figure 10. Variety of vegetables grown in study area using wastewater

However, in most cases, restrictions are difficult to enforce because the demand for vegetables is high in cities and only certain cash crops achieve the level of profits farmers need to maintain their livelihoods [26]. Majority of the farmers reported that wastewater harmed the quality of crops except for one positive impact (yield). In a previous study in Pakistan, all farmers agreed that wastewater irrigation had negatively affected the crop quality and taste as compared to crop grown under irrigated with freshwater [13]. To investigate the economic and environmental impacts of wastewater on agricultural systems (i.e., reduction of production costs and improves fertility levels of soil), its effects were evaluated in the present study and compared the amount of synthetic fertilizers usage in both wastewater and freshwater irrigated.

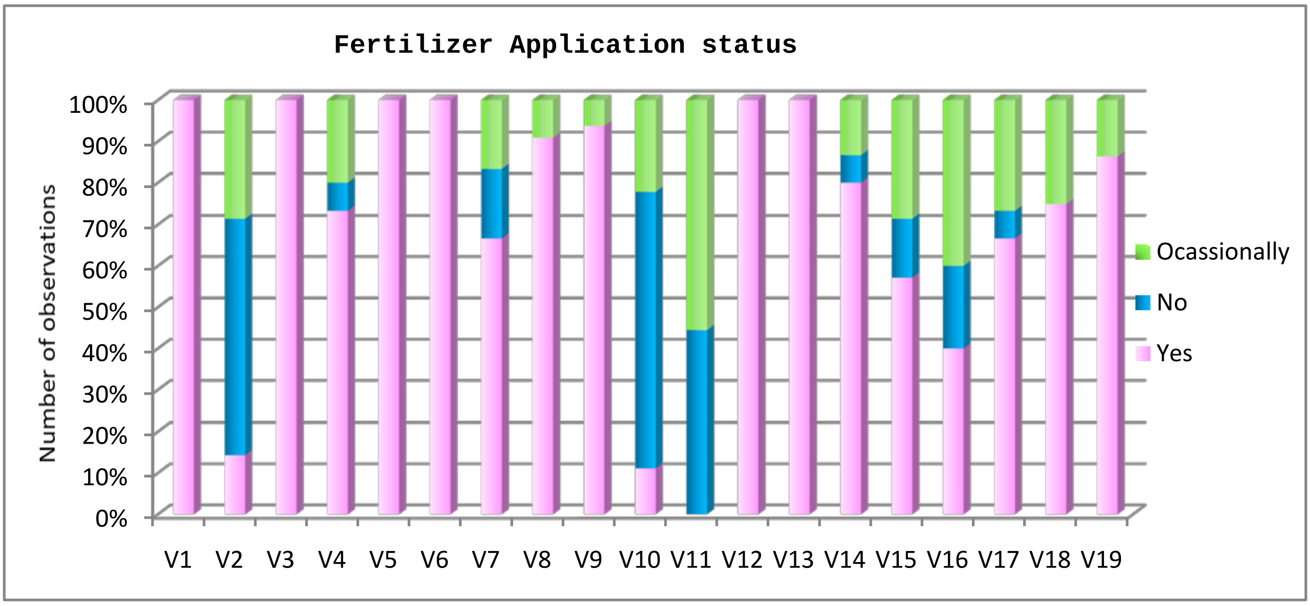

Figure 11. Fertilizers usage in the study areas

The most chemical fertilizers that were added to the soil, including Nitrogen (N), Phosphorus (P) and Potassium (K) in the form of urea and murate of Potash. On asking about the application of fertilizers, 70 % of farmers of the study area accepted the use of urea in their fields regularly. However, among the farmers involved in WWI practice, 48% farmers accepted the use of fertilizers in their areas occasionally, and 29% farmers have used applied fertilizers regularly, and 23% farmers accepted that they don't involve any inorganic chemical fertilizers (Figure 11). The reason behind not using fertilizers was the use of wastewater that was full of nutrients and supported profitable growth of crops as told by the farmers. These results are following a study where wastewater irrigation improved soil properties and prevented excessive use of N fertilizer by farmers since crop yields of wastewater users were higher than freshwater users [17]. Similarly, [14] reported that farmers of his study area revealed that vegetable products grow well (including lettuce salad, radishes, and carrots) when irrigated with wastewater compared to freshwater. They believed that untreated wastewater, by adding organic matter to the soil, provides the food needed for the plants and hence reduces the need for fertilizers, thus reducing the cost inputs.

3.5. Farmers' Perception of Ecological & Environmental Aspect of Wastewater Irrigation

Wastewater application can result in several problems such as heavy metal accumulation in the soil, underground water and crops at toxic levels, pathogenic infection [27]. Accumulation of high levels of heavy metals in agricultural land is a serious problem related to crop productivity and polluting the environment [28]. In the present study, when farmers were interviewed about their observation regarding changes in environmental aspects of wastewaters and their fields, majority of the farmers (49%) revealed that they had seen a constant reduction in fish population and other small aquatic animals since last few years, which may be due to increasing load of urban wastewater with harmful contaminants in the choes. Of the total, 15 % farmers reported that they had been facing the problem of yellowness in their ground water, especially farmers of the village 19, located adjacent to the Sukhna Choe which might be due to ground water leaching of salts and other contaminants, which is in agreement with a study [29] that reported application of wastewaters might contribute to a nitrate surplus that may be leached towards the lower horizons, causing its accumulation in the groundwater and therefore leading to nitrate pollution. However, 36 % of the farmers denied observing any negative impact of wastewater on the environment. Farmers acknowledged that soil might be poorly affected due to increase in salts as a result of wastewater irrigation but none of them reported this in their agricultural fields.

4. Conclusions

From this study, it was evident that although respondents (farmers) generally viewed wastewater unfavorably, wastewater users had a more positive attitude towards the economic sustainability of wastewater. They perceived that the crop production was cheaper under irrigation with wastewater as freshwater requires a high pumping cost and a more considerable amount of inorganic fertilizers too. Moreover, many wastewater users did not perceive any problem with the soil quality, and only a few farmers were concern about the deteriorating quality of groundwater. While the environmental reliability of wastewater was not confirmed in this study, economic profits of wastewater irrigation stood approved. All dimensions of sustainability should be considered in the planning and implementation of wastewater use. Further studies are highly recommended in the study area to investigate the effects of wastewater to understand mechanism and linkage with ecological- environmental and health aspects.

5. Future Recommendations

Water scarcity is a critical problem for crop production in the arid and semi-arid areas all over the world. Where water is scarce, wastewater has been cited an often choice for irrigation. However, reuse of treated wastewater for irrigation is a valuable strategy to maximize available water resources, but the often-marginal quality of the water can present agricultural challenges. Following steps are recommended for future aspects:

1. In the context of climate change, application of treated wastewater for irrigation is an appropriate approach to cope with the water scarcity in arid and semi-arid regions. Farmers will adopt treated wastewater if they perceive it as an economically beneficial, socially acceptable, environmentally sound, and have little or no health risks.
2. Policymakers should have an essential role to play through facilitating the process and identifying mechanisms by which farmers can become integrated into management decisions surrounding reclaimed wastewater quality.
3. These research areas require a multi-disciplinary approach to encompass both social and technical aspects. Finding the means to ensure that reuse continues in a sustainable manner is vital.
4. Farmers' capacity to manage the agricultural challenges associated with treated water (salinity, irrigation system damage, marketing of produce), their actual and perceived ability to control where and when reclaimed water is used, and their capacity to influence the quality of the water delivered to the farm and overcame the scarcity of water.
5. The urban/industrial effluents should be monitored at regular intervals for the presence of heavy metals and other toxic materials, and a provision of effluent treatment within the premises should be made to avoid industrial wastewater released into the local water bodies.
6. Regular monitoring of STP is must, and facilities for detection of toxic chemicals and heavy metals in urban /domestic wastewaters should be installed.
7. Legally mandated regulation and the strict implication is an essential tool for pollution control and alleviation programmes.
8. Strict land use and land remediation policy should be implicated. Outdated legal frameworks should be tailored or suspended.
9. There is a need to test and analyze food crops to ensure that the levels of contaminants meet the agreed international limits postharvest and before import or export of food crops. Regular survey and monitoring programmes of the concentration of heavy metals in food products should be carried out.
10. Kits for fast and easy detection and monitoring of effluents released from various industries and regular monitoring of industrial effluents should be made available at low cost.

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Competing Interests

Authors declare that they have no competing interests.

Author Contributions

First and second author (S.S. and R.Y.) drafted the manuscript and questionnaire and third author (AK) assisted in the survey and data collection. Corresponding author (ANS) conceptualized research idea, designed experiment and supervised the whole progress of the experiment and manuscript preparation. All authors have read, given feedback and approved the current version of the manuscript for the publication.

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