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Causes and consequences of conflicts in surface irrigation: Micro level study from Northern India

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ABSTRACT

This study was conducted in the Eastern Yamuna Canal (EYC) command areas and used the data collected from 295 farmers from three districts of Uttar Pradesh during 2017-2020. The results indicated that the growth rate of deep wells were very high for Saharanpur and Baghpat districts, whereas Ghaziabad district has recorded negative growth rate. Monthly water release data in the EYC has indicated that water release was regular every month during 2003-2013. However, for the period of May to November during 2018 the water release was negligible which may lead to high pressure on ground water. The main causes conflicts were observed as draught, water scarcity, irregular supply of canal water, small size of land holdings, and agriculture dependency. The water conflicts management was done through *panchayats*, friends and relatives, government departments and through police. Irregular supply of water, poor response of irrigation department during the conflicts, increasing cost of power were the major constraints. This study suggests that regular supply of water in canal irrigation system will reduce the pressure on groundwater.

1. INTRODUCTION

Water scarcity and increasing demand for water have turned access and consumption of water into competition, causing conflicts among stakeholders, where people depend on water sources for their economic livelihood (Bijani and Hayati, 2011, 2013, 2015; Bijani *et al.,* 2019). A conflict is a social situation, where two or more actors attempt to have additional access to the sources at a time (Swedish Water House, 2004). The conflict does not mean violence or armed engagement but rather an indicator of the status of disagreement over access to water and distribution rights. Social scientists have developed a range of theories on social, economic, demographic, and competing reasons for the exploitation of natural resources (Green, 2002 and Namboodiri, 1988). Studies have shown that theory-based interventions can encourage people to change their attitudes and behaviors in dealing with conflicts (Aquilina *et al.,* 2004 and Ebrahimi *et al.,* 2018). In general, there are two main approaches in the field of evaluation of water conflicts (Abadi, 2018 and Ataei *et al*., 2019), traditional economic approach and the ethical approach. The rational human approach that involves theories such as planned behavior theory (Ajzen, 1991) considers human behavior as a situation of logical choosing. However, the ethical approach that involves theories such as norm activation theory considers the human behavior as an ethic-oriented situation. Keivan *et al*. (2020) and Mohammadinezhad *et al.* (2020) pointed out that water conflicts are mainly due to water scarcity and non-cooperation among the stakeholders. The first approach indicates that the water conflict behavior of villager is a conscious action, and they try to behave in a way that they could receive the most benefit (Boazar *et al*., 2019). The villagers do not just have personal beneficial considerations in water conflicts and might act in a way that they would receive no profits. Therefore, water conflicts need to be understood thoroughly and analyzed for creation of harmony among the stakeholders. The water conflicts may cause social unrest among the stakeholders and some time it proves to be brutal.

Background of the study area

At the national level, India is facing problems of inter-state river disputes (Richards and Singh, 2002). Similarly, sometimes at grass root level the water conflicts become unmanageable. As per Indian constitutions, water is a state subject; states are empowered to enact legislation on water. About 40% of Indian are facing droughts and 500 million

people severely affected, is an alarm being sounded by the media, academia, environmental activists and even politicians, India is on the brink of an acute water crisis. A study by the NITI Aayog (2018) (https://social.niti.gov.in/water-index) shows that around 600 million people in India facing a severe water shortage. However, the EYC, which is the source of irrigation for three states *i.e.* Uttar Pradesh, Haryana and Delhi is one of the oldest canal of India. Present institutional arrangement in India is consist of all central, state and local institutions, which includes both formal and informal structures, unable to bring about water allocation, planning and management on a comprehensive or scientific basis. The complexities and constraints in canal irrigation management needs to be understood and policy instruments are to be used for equitable and sustainable existing water use. This study aimed with the specific objectives *i.e.* to understand the trend and types of dispute at grassroot level, to examine the understanding and perceptions of farmers on reasons for water conflicts and their consequences. Therefore, purposively existing best canal network in terms of coverage was considered for this study. The monthly time series data collected from the EYC department shows that there is no or minimal discharge particularly in those months when water demand is at peak. This often resulted in conflicts among the stakeholders. Fig.1 clearly indicates that water discharge pattern varied during the years 2003, 2010 and 2018. The lowest release during some months in the year have implications on farmer's income, cost of cultivation and high pressure on groundwater resources. For instance, during paddy transplanting season, the supply of water in EYC goes down to the level that farmers do not get sufficient water. The tail ender will not get even a drop of canal water and make strong reasons of conflict. Therefore, policy decision is very much required for regular supply of canal water to all the stakeholders.

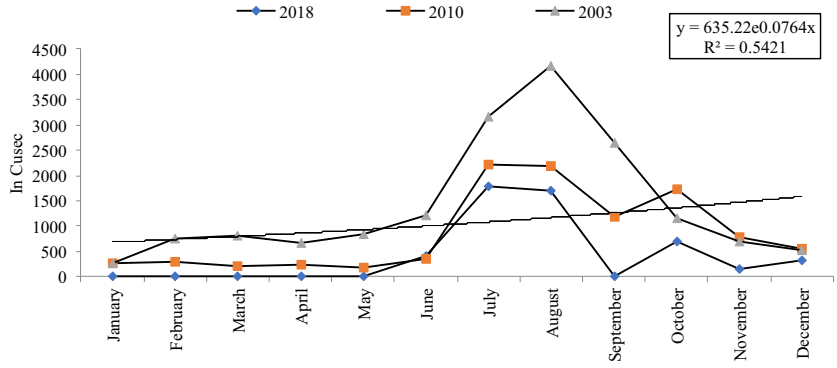
Irrigation system in India

Due to the unstable nature of the monsoon regime, 50% of the precipitation being received in one or two months and 90% of the river flows in 4 months only. In fact, irrigation has helped to raise land productivity and enhancing the incomes of farm households. After independence more emphasis was on projects where water was impounded and stored behind large dams. The growth in irrigated acreage was remain the key element in India's agricultural strategy, particularly in the Green Revolution regime. At that time tube wells were rare and traditional wells accounted for about 29% of the net irrigated area. Groundwater irrigation now accounts for over 60% of the net irrigated area. Therefore, a significant area was brought under irrigation in India. The declined importance of surface irrigation is serious concern because of Government of India has already made huge investment. Moreover, pressure on groundwater and climate variability is posing threats for agriculture sustainability. Hence, we have selected western part of Uttar Pradesh, India for our study, wherein surface irrigation plays a significant role in agriculture production. Due to surplus water availability farmers generally practice flood irrigation system in western Uttar Pradesh particularly in EYC command areas. This method of irrigation required more quantum of water resulting water scarcity at peak of cropping season.

2. MATERIAL AND METHODS

Sample and data

This study was conducted in EYC catchment, covering three districts of Western Uttar Pradesh namely Saharanpur, Baghpat and Ghaziabad. The selection of the districts was done purposively since, agriculture in these districts is widely depend on surface water irrigation. Six villages from three districts were chosen in such a way that farmers use surface as well as other sources for irrigation. A total of 50 respondents were selected from each village comprising different landholding sizes. The respondents were administrated with interview schedules, which centered around the structured questions on water related conflicts. Out of 300 respondents interviewed, 5 were discarded due to non-availability of consistent information and finally 295 respondent's information were analysed.



Source: EYC, Management Department Report, Saharanpur, Uttar Pradesh, 2018

Fig. 1. Monthly water discharge in Yamuna Canal (in Cusecs)

Analytical framework: The trend analysis of water discharged in the EYC during 2000 to 2018 was done. Generally, the identified factors consist of farm household characteristics such as farm size, age, education, socioeconomic factors such as extension service and information (Boazar *et al.*, 2019). Analysis of these factors gave us insights about the dynamics of water conflicts resolving mechanisms. The scale is named after its inventor, psychologist *Rensis Likert*, and these were treated as continuous variable (Lien *et al.,* 2007). We have used this scale in this study to understand the attributes of water conflict. We have computed the average score and standard deviation to understand the variability in the reply of the respondents. The higher value of score indicates that the particular attribute is very important and lower value indicates the least important. The standard deviation more than one indicates there was a variability in the opinion of the respondents for water conflict attribute and standard deviation less than one indicates most of the respondents were in same opinion for a particular attribute.

A binary logistic regression model was employed to find the determinants of taking part in a water conflict events among the sampled farmers. The dependent dummy variable is responses of a farmer, ever being a part of the conflict. If he said yes, value was one, otherwise, taken as zero. X is a vector of independent variables *viz.,* education, family size, land holding size, management of water, regulation of water distribution, unemployment, unity among the farmers, over use of water, water scarcity. The specification of logistic model can be represented of this study as follows:

$$Y_i = X_i'\beta + \varepsilon_i$$

The subscript i indicates the i^{th} respondent, β is the vector of associated parameters estimated from the model, $\mathcal{E}_i$ is the error term assumed to be normally distributed.

In terms of log odds: $\ln\left(\frac{p_i(Y_i|=1X)}{p_i(Y_i|=0X)}\right) = X_i'\beta$

In terms of Odd ratio: $\frac{p_i}{1-p_i} = e^{X_i'\beta}$

Where, $p_i / (1 - p_i)$ is the odd ratio in favour of having conflict over not having any conflict situation.

The model's parameters are estimated under probabilistic framework called maximum likelihood approach, *i.e.* the regression function is optimized to find the set of parameters that resulting maximum sum of likelihood over the dataset. The sum of the independent variables weighted by the parameters yields the log-odds of taking part in water conflicts. In general, odd-ratios are easily interpretable than log-odds, and hence, to interpret as odd-ratio, antilog of log-odd needs to be used. The odd-ratio simply is a ratio of probability of success to probability of failure of particular event, that can be interpreted in this case as the ratio of probability of being part of water conflicts to probability of being not part of conflicts.

We have also analyzed the constraints encountered by the respondents while accessing canal water. A percent and simple tabular analysis was used and results are logically interpreted.

3. RESULTS AND DISCUSSION

Over the year from 2000 to 2020, the trend of surface irrigated area, especially in canal irrigation, has declined in selected districts. During the same period ground water irrigated area has increased. Yet, area irrigated by ground water remains more than 80% in all the districts. Among three district, Bhagpat has higher percent of irrigated area. The cropping intensity was observed higher (more than 160%.) in Bhagpat and Saharanpur. Ghaziabad district's cropping intensity was observed to be lower than former due to ongoing urbanization; more area is being diverted to non-agriculture activities and yet agriculture is a significant source of livelihood. From Fig. 2, 3 and 4, it can be observed that the share of surface irrigation has declined over the years by 7% in case of Baghpat, 5% in case of Ghaziabad and in case of Saharanpur (6%). Whereas, the share of ground water irrigation has increased over the year. The cropping intensity score reached high for Baghpat and Saharanpur districts was low for Ghaziabad from 2011 onwards.

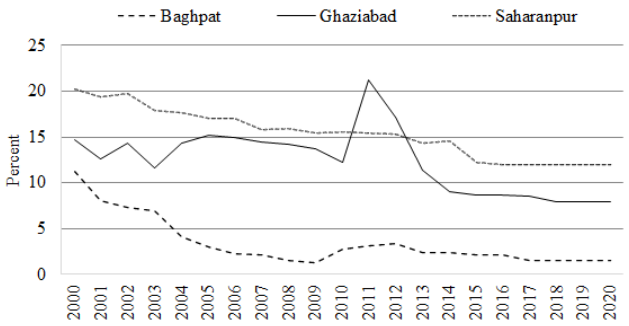


Fig. 2. Surface irrigation (%)

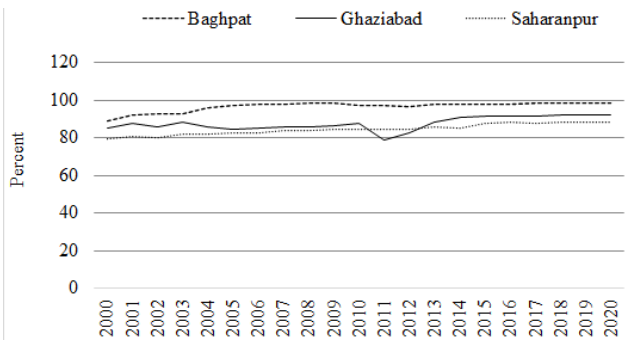


Fig. 3. Ground water irrigation (%)

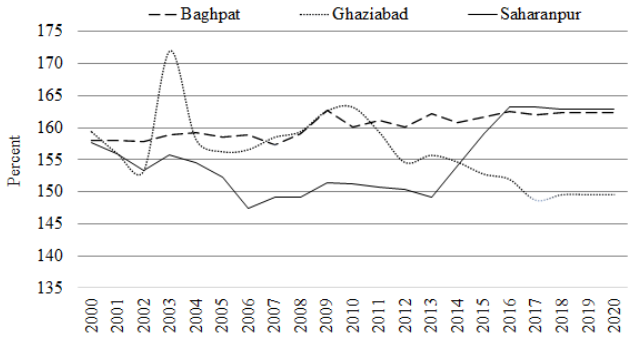


Fig. 4. Cropping intensities (%)

Table: 1
Socio-economic characteristics of the respondents

Particulars	Mean	SD
Age of family head (years)	48.24	11.85
Educational attainment (no. schooling years)	6.32	4.85
Family size (no.)	4.76	1.35
Occupation (agriculture = 1, agriculture + dairy = 2, agriculture + dairy and others = 3)	1.99	0.15
Total returns from farm (₹ in lakhs)	1.23	1.17
Total income from all sources (₹ in lakhs annum^{-1})	1.81	1.47
Number of milch animal	1.61	1.24
Land holding size (ha)	1.36	1.4
Total number of tubewells	0.75	0.57
Source of irrigation (tubewells = 1, canal = 2, both = 3)	1.95	0.59
Number fragmentations last 50 yrs (times)	1.82	1.29
Loan balance as on March 2020 (₹ in thousand farmer^{-1})	42.07	30.08
Canal water irrigation charge (₹ ha^{-1})	509.2	50.09

Source: Authors calculation

Socio-economics characteristics of stakeholders

We used descriptive statistics to study the socioeconomic characteristics of sample farmers and presented in Table 1. The average age of the family head was about 48 years means they were at middle age level. The education level indicates that head of family on an average attended schooling up to six years. The mean family size is about five. The occupation pattern indicates that main livelihoods depends around agriculture and allied activities. The major share in total income is accounted from farm and on an average each farmer possessed at least one tube well with the land holding size of 1.36 ha. Mostly farmers use both the source *viz.,* canal and tube wells for irrigation. During the last 50 years on average landholdings were fragmented at least two times. The farmers have also availed the loans from financial institutions as well as from money lenders. The average loan availed by the farmers was about ₹ 0.42 lakh, mainly to procure capital inputs. The knowledge about socio-economic features of the respondents gave us some insights about type of farmers, their resource endowments and economic conditions.

Analysis of water conflict causes

The data on Likert type scale were collected and analyzed to identify the important attributes of water conflict. The results are presented in Fig. 5. The agriculture is practiced by the respondents in general influenced by number of factors *i.e.* water accessibility, landholding size, resource availability and their socio-economic background etc. Some of these factors are very often beyond the control of the farmers. However, farmers have to run their livelihood

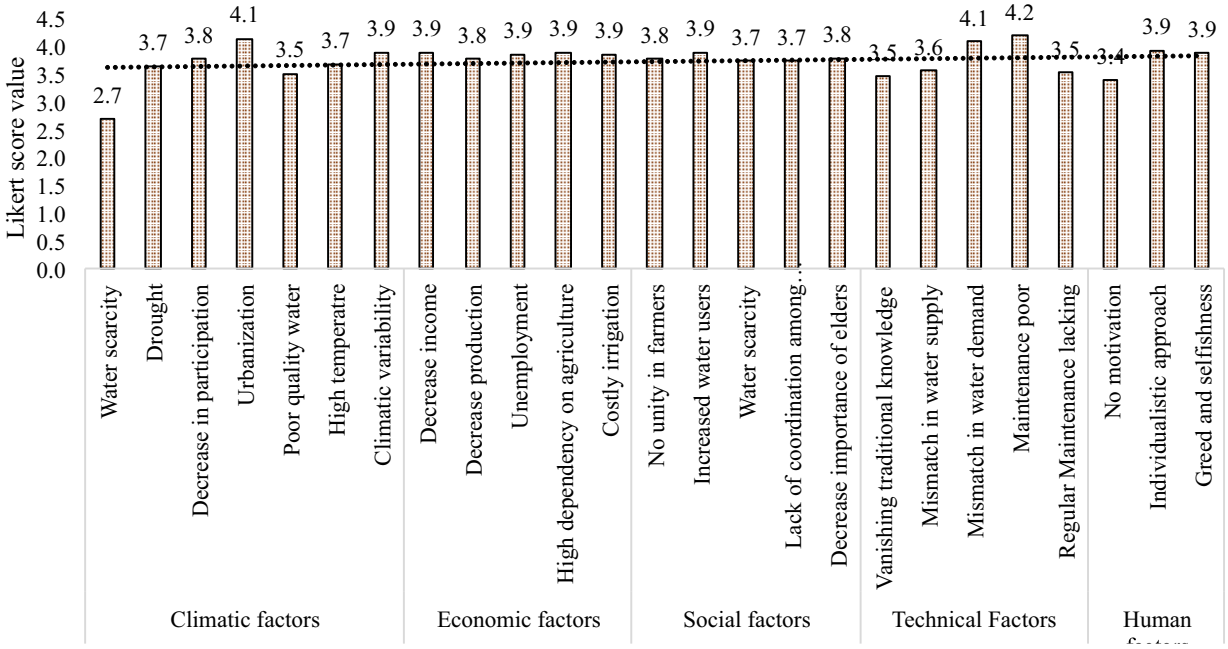


Fig. 5. Causes of water conflicts

alongwith the existing circumstance and socio-economic, technological and surrounded ecosystem. We have analyzed the opinion of the respondents to understand the seriousness and possible impact of these attributes on individual farmer in the water conflicts regime. It was observed that under climatic causes of water conflicts, urbanization, depletion of water quality, drought, low rainfall and climatic variability were the important causes of water conflicts. The scale value was nearly 4.0 which indicates that these factors are very important. However, under socioeconomic factors, it is observed that increased usage for irrigation leads to higher water demand and farmers move towards water intensive crops may be the reasons of water conflicts. However, the standard deviation is found to be more than one for some of these attributes indicating that there was a high variability in the opinion of the respondents. Similarly, causes of conflicts, for decreased income, rural unemployment, higher dependency on agriculture, increasing cost of inputs, fragmentation of skewed landholding size and livelihood obligations farmers have increased the number of water usages. Moreover, cropping season remains the same for all and less availability of water from canal for cultivation lead to water conflicts. Another important cause of water conflicts was emerged from analysis is due to lack of coordination Among farmers and the by-passing of the advice of elders. The technical causes of water conflicts include that the traditional methods of irrigation / cultivation. Similarly, there is mismatch in demand and supply of water and that may be the important causes of water conflicts. The stakeholders were in the opinion that surface water resource is not maintained properly resulting in reduced water supply and as a result of this farmers get less water supply and at the same time water does not reach to the tail enders. Poor distribution of water resources leads to water conflicts.

In our study, the major causes of water conflicts emerged were: attributing individualistic approaches, lack of motivation, greed and selfishness of the stakeholders attributing to water conflicts. The Likert scale value varies from 2.7 to 4.2. Higher side of the scale indicates for particular cause of conflict dominant and if scale value decreases towards zero that means the cause of the conflict is not strong determinant. Similarly, the value of standard deviation goes towards zero indicates that collective opinion is in same line. However, when standard deviation values are more than one, it indicates that there is high variability in the opinion of stakeholders (Chand *et al.*, 2019a). Therefore, this study indicates that those factors where Likert scale value was more than three are important and need to be addressed properly while planning for the surface irrigation water distribution system. However, three attributes like urbanization, poor water management and mismatch in water demand and supply got score value more than four that might be the important factors.

Conflict resolving mechanisms: In India, several agencies are reporting the water conflicts occurring in the society. Report of National Crime Records Bureau indicated that at least 232 people have lost their lives in water related conflicts from 2017 to 2019 (Dubey, 2021). Meanwhile, more than 2,000 cases linked to water conflicts have also been registered across the country and 432 cases of violence related to water conflicts were reported in the year 2017. In 2019, most of the cases of killings over water conflict were reported from Bihar (44), followed by Rajasthan and Maharashtra with 13 and 7 cases, respectively, (https://en.gaonconnection.com/water-crisis-india-conflict-crime-data-ncrb-climate-change-26797). Inequity in the access to a resource as fundamental as water is bound to trigger migrations, socio-cultural resentment, pressure on urban resources, and competition and conflict. At micro level, we have collected the data analyzed and the results are presented as below for the year of 2015-2020. It was observed that there were 75 water related conflicts faced by the stakeholders. The degree of quarrels and misunderstanding varies from farmer to farmer. The conflicts reported were in social organization and government functionaries intervened and resolved the conflicts. The highest number of conflicts were resolved by local Panchayat Raj Institutions (PRI, 19 No.) followed by mutual agreements (18 No). Since, PRIs are elected democratic body at local level in India, villagers have to follow the instructions given by PRIs. About 30% water conflicts were resolved through relatives and friends (22 No). Only 13% cases were reported to police (10 No) and most of them were resolved by mutual agreement in the presence of police. However, about 8% water related conflicts were resolved through irrigation department. It could be observed that in the surface irrigation, water conflicts are occurring and it may be due to big gap between demand and supply of water. Thus, public water resource distribution mechanisms should be strengthened. The *warabandi* / *osrabandi* / rotational* water distribution system needs to be modified and refined in order to give equal accessibility of water resources to all the farmers in the command area.

Note: The warabandi / Osrabandi / rotational irrigation means irrigation of crops turn by turn in canal irrigation system.*

Determinants of water conflicts: A binary logistic regression model was used to find out the determinants of water conflict in the canal command area. Based on the review of literature, several variables noted to have positive or negative relationship. In this study, variables such as education, family size have proved to be negative relationship with conflict. As expected, with more education farmers solved the issues amicably and avoided misunderstanding and acted with water sharing.

Family size also negatively contributed to water conflict, as greater the family size, personal relationship and

family relationships have reduced the conflicts. Besides, the coefficient of drought years is statistically significant as drought years have fueled increased number of conflicts due to widespread water shortages. Large agricultural land holding was positively related with occurrences of conflict as large agricultural field requires more amount of water for cultivation. Besides, big farmers often exercised their money to satisfy their egoistic nature. The overall fit of the model is statistically significant as shown by the calculated probability value of the likelihood ratio (LR) and Chi-square test (Table 2). The odd-ratio of education is 0. 96, implies that with one-year increase in education, odds of being involved in conflicts reduces to 0.96, but the variable is not significant. With a unit increase in family size, odd ratio of being part of conflict reduces significantly. With a unit, increase in land holding size, odd ratio increases to 1.28. If the year of cultivation is drought prone, then, the probability of conflict increases. If the regulation on water distribution becomes nil, the odd ratio of conflict increases to 1.5 times more. If there is lack of water management, odd ratio of conflict reduces to 0.69.

Constraints faced by respondents in surface irrigation: The constraints faced by the farmers in the canal command areas were collected and analyzed and the results are presented in Fig. 6. The usage of the surface irrigation, stakeholders face several constraints while accessing for water. The farmers realized problems with associated irrigation as well as with implications of water policy in the rural areas. Farmers reported that whenever they wish to contact irrigation departments, either officials are not available in office or they are not approachable. If there is some conflict related to canal water sharing, farmers revealed that there is very complicated process of settlement of these conflicts. The irregular supplies of water, lack of information on correct date and timings while releasing canal water, insufficient water are the important constraints. This is important to know that government of India has made huge investment in establishing canal network in the country. Due to several constraints and poor quality of services from canal irrigation system, farmers are forced to invest in ground water pumping. Therefore, the canal system has to be kept alive to reduce the pressure on ground water resources. Though there were respondents who could not reply these questions. However, they were in opinions that surface irrigation has many constraints resulting decline its usages (Chand *et al.,* 2019b). The problems related to canal irrigation system can be minimized through adoption of participatory irrigation management system in the state.

Table: 2
Determinants of water conflicts in irrigation water management

Conflict (Y = 1, N = 0)	Coefficients	P > |z|	Odd ratio	Std. error
Constant	0.128	0.847		
Education (yrs)	-0.022	0.206	0.964	0.033
Family Size (no.)	-0.223***	0.004	0.704	0.123**
Landholding (ha)	0.107*	0.072	1.283	0.105**
Drought condition (Y/N)	0.168**	0.023	1.307	0.136*
Poor water management (Y/N)	0.192**	0.037	0.664	0.159**
Farmers unity (Y/N)	-.209***	0.008	-0.310	0.194*
Number of observations = 295	McFaddaen	R^2 = 0.1557		
Mean dependent variable = 0.247	Adjusted	R^2 = 0.4556		
S.D. dependent variable = 0.432	Log likelihood	= -149.53		

Source: Authors calculation

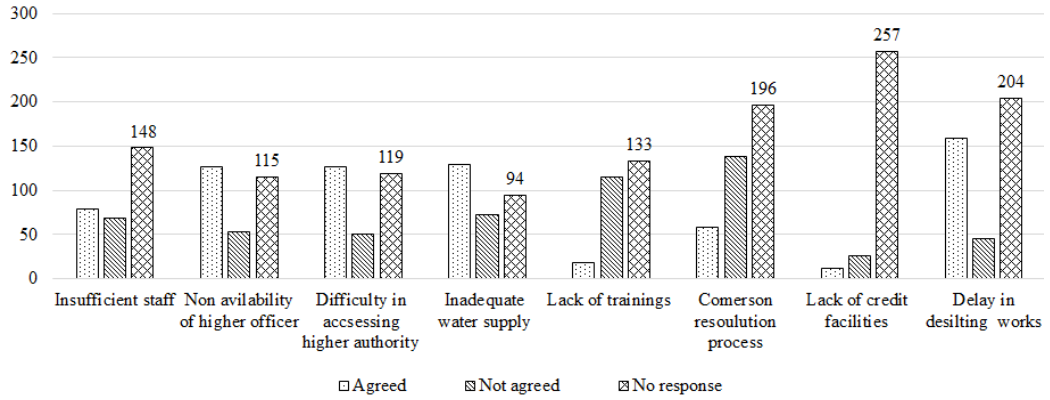


Fig. 6. Administrative constraints in irrigation management

3. CONCLUSIONS AND POLICY IMPLICATIONS

This study is based on 295 sample farmers from EYC command areas of three districts of Uttar Pradesh. The pattern of canal water discharge from 2003 to 2020 shows that the monthly discharge of water was regular up to 2013, which become irregular since 2014. The quantum of water also progressively become lesser and lesser thereafter, even there was no release of water during 2018. This led to conflicts in surface irrigation sharing and mushrooming growth of tube wells installations in the study area. The factors of water conflicts like decreasing size of land holdings, shortages in water supply and less frequency of water release etc. The analysis indicates that focus on development of surface water and irrigation system has been declining over the year and farmers have been moving towards development of individual water resources by installing deep tube wells. Therefore, canal irrigation system is the need of revival, to ease tremendous pressure on ground water resources. This study draws the attentions of policy makers to strengthen and scale up the canal command area and also with right policy interventions on tube well installations. So that groundwater exploitation can be reduced and sustainability of water use be safeguarded.

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