# INVESTIGATING THE POTENTIAL OF THE COMMUNITY MANAGEMENT PLUS MODEL FOR GOVERNING COMMUNITY DRINKING WATER SYSTEMS IN BARIND TRACT OF BANGLADESH: A CASE STUDY OF DEEP TUBE-WELL WATER SUPPLY INSTALLATIONS

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**Abstract**

Community Management Plus (CM+) has recently been promoted as a better alternative approach for governing community drinking water systems (CDWS) in Bangladesh and elsewhere in the global south. However, it is still largely unearthed under what condition this model is likely to work for ensuring the sustainable performance of CDWS. The study, therefore, aims to explore the conditions that are likely to explain variation in the occurrence of the CM+ model in the Northwestern Barind Tract of Bangladesh. The study employed a case study approach where a deep tube-well water supply installation (DTWSI) was selected as a case for the study. Computing correlation (n=30 DTWSI), the study finds small group size, high dependence on a resource system, interdependency among user groups, heterogeneity of endowments, affordability and willingness to pay, locally devised rules, monitoring users' behavior, and public agency's support strongly influence the variation in occurrence of collective action among the end-users of DTWSI. The study also finds effective collaboration between public agency officials and end-users is affected by trust, commitment, participatory decision-making, and transparency in the decision-making process. These findings are expected to contribute towards developing a scalable drinking water governance model and thereby ensure sustainable solutions for safe drinking water scarcity in Northwestern Bangladesh and elsewhere of similar context.

**Keywords:** Community Drinking Water System, Deep Tube-well Water Supply Installation, Pond Sand Filters, Community Management Plus, Collective Action, Bangladesh

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## Introduction

Safe water is vital for human survival, ecological processes, and socio-economic development (Abbas *et al.*, 2023; Aguirre & Cuervo, 2023) It is of paramount importance for improving human lifestyles and thereby constitutes an essential component of any effort to attain sustainable development goal (SDG) 6 (to ensure access of all people to clean water and sanitation by 2030) (Lu & Bandara, 2019). Despite a remarkable improvement, the scarcity of safe drinking water remains a major concern in the global south including Bangladesh (Islam 2019). Bangladesh experiences potable fresh water scarcity due to increasing population growth, unplanned urbanization, industrialization, and climate change impacts (Abedin *et al*., 2019). The latest statistics indicate that although 98% of the total population gets potable water, however, only 58.5% of them gets water from safely managed drinking water systems (WHO/UNICEF JMP, 2020). The use of unsafe sources leads to public health concerns, which in turn thwarts the socioeconomic development of the country.

This drinking water scarcity is more acute in the Northwestern Barind Tract of Bangladesh comprising Rangpur, Dinajpur, Bogra, Pabna, Joypurhat, Naogaon, Chapai Nawabganj districts of Rajshahi division due to overeuse of groundwater for irrigation, decline of the groundwater layer , decrease in summer rainfall, increase in overall temperature, evaporation, arsenic contamination, the presence of excessive iron and construction of Farakkah barrage (Hossain *et al.*, 2021; Rashid & Islam, 2013a) To address this drinking water scarcity, both government and non-government organizations have been implementing various drinking water systems, for example, tube-well, dug well, rainwater harvesting systems (RWHS), piped water supply system, and more recently, managed aquifer recharge (MAR). However, they often fail to deliver the expected outcome, *i.e.*, sustainable functionality of community drinking water system. Existing literature indicates that this sub-optimal performance of CDWS is largely attributed to the governance crisis (Jiménez *et al*., 2020; Rogers, 2006). Graham *et al.* (2003) define governance as "the interactions among structures, process, and traditions that determine how power and responsibilities are exercised, how decisions are taken, and how citizens or other stakeholders have their say" Water governance implies the interplay of policies, process and institutions that are put in place to allocate and manage water resources (Jiménez *et al.,* 2020). It includes a variety of issues, *i.e.*, water provision and distribution, water quality control, participation of stakeholders and safeguarding aquatic ecosystem.

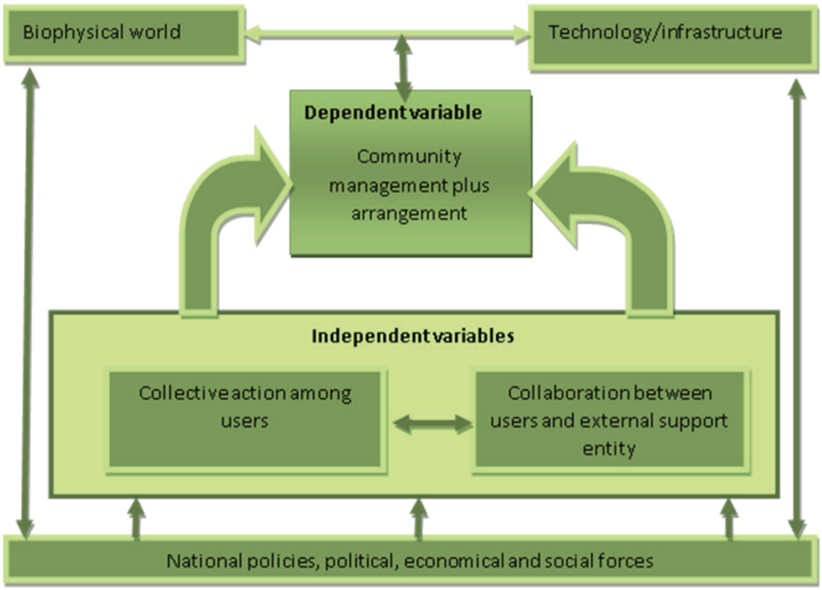
Until recently, a variety of water governance models ranging from state control, and privatization to community management have been experimented with in rural Bangladesh. Especially, since the International Drinking Water Supply Decade (1981-90), a demand-driven bottom-up community management approach has been followed where communities hold the key position in the management of their drinking water systems (Carter *et al.,* 1999). However, none of those approaches seem to succeed in delivering the expected outcome (*i.e.* sustainable functionality of the drinking water system) which has been reflected in the fact that many community-run drinking water systems become dysfunctional within a very short period after their installation. Thus, in recent times, the community management plus (CM+) (*i.e.* joint responsibility of the community and implementing agency in the management of the drinking water system) approach has been promoted as a better alternative in many developing countries, including Bangladesh (Baumann 2006; Hasan *et al.,* 2020; Hutchings *et al.,* 2015). Under this approach, both government agencies and the community share the responsibility of the planning, operation, and maintenance of drinking water systems (Baumann, 2006).

Local drinking water users are given an increasingly prominent role in such an approach. However, very few studies conducted so far which investigate the enabling conditions under which the CM + model is likely to occur successfully. In their recent study on the governance of pond sand filter systems (PSFs)—a shared drinking water system in Southwestern coastal areas of Bangladesh. Hasan *et al.,* (2020) found a bunch of conditions leading to the occurrence of the CM+ model. However, those findings are based on a homogeneous geographical location and socio-economic contexts in the Southwestern coastal zone of Bangladesh. We do not know yet whether these findings can be replicated in other parts of the country across heterogeneous geographic locations and varying socio-economic settings. The study, therefore, aims to examine if and to what extent the CM + model works in Northwestern Barind areas of Bangladesh to ensure the sustainable functionality of CDWS. To achieve this objective, the study sets the research question 'under what conditions, the CM+ model is likely to occur for the governance of community drinking water systems in the Northwestern Barind Tract of Bangladesh? To answer this research question, the study carried out an empirical study on a community drinking water system, *i.e.*, deep tube-well water supply installation (DTWSI) in the Northwestern region of Bangladesh.

## Theoretical Framework

In the context of the failure of both public and private governance models for governing CDWS, interest grew in the community management (CM) model in the 1990s, where the users are responsible for the operation and management of the drinking water systems (*i.e.*, shared drinking water systems as a commons) (Madrigal *et al.* 2011; Naiga et al., 2015; Whaley & Cleaver 2017). However, although the local communities can craft rules to counteract free riders – *i.e.*, excluding those from the user community who do not contribute optimally, or who tend to overuse, but it is also hard for them to overcome this without external support (Hasan *et al.* 2020; Hutchings *et al.* 2017; Lockwood and Smits 2011; Moriarty, Butterworth, and Franceys 2013). Therefore, besides solving the problems of collective action, the CM model needs a plus in the form of effective cooperation from an external support entity *e.g.*, a public agency. Hasan *et al* (2020) developed a theoretical framework of the CM+ model (shown in Figure 1) for the study of the governance of the pond sand filter system in southwestern coastal areas of Bangladesh. This study adapts that framework to achieve the research objective. Now, the question is what is the theoretical foundation for enabling conditions that describe variation in (i) occurrence of joint action among the end-users of CDWS and (ii) occurrence of effective collaboration between CDWS end-users and external support entity *e.g.*, a public agency?

**Figure 1: Theoretical Framework (adapted from Hasan *et al.* 2020)**

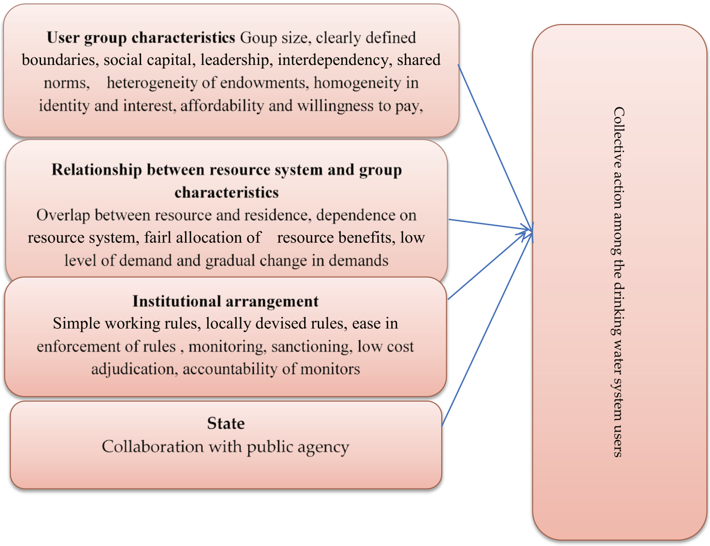


### ***Conditions of Collective Action among Community Drinking Water Systems Users***

In the governance of CDWS, individual beneficiaries frequently confront a provision (*i.e.*, when costs involved in investment in water resource system are private, while the fruits are distributed among all beneficiaries of that service. Thus, rational users tend to less invest in the provision of service) and appropriation dilemma (*i.e.*, when the fruits involved in the extraction of harvestable units from the water resource system are private, whilst the costs of doing that are distributed among the whole group of resource users. Thus, rational actors are tempted to over-harvest units from the water resource system). The combined effect of under provision in and over-appropriation from the resource system would lead to unavoidable destruction of the resource system which Hardin (1968) termed a 'tragedy of commons' To overcome those dilemmas, both CPR and drinking water supply scholars suggest the adoption of the enabling environment (Agrawal 2001; Baland & Platteau 1996b; Hasan *et al*. 2020; Madrigal et. al. 2011; Naiga et. al., 2015; Ostrom 1990).

Hasan *et al.* (2020) offer a set of conditions for collective action among the CDWS users. In depicting their findings, they employ the Institutional Analysis and Development (IAD) framework (Hess & Ostrom, 2005) and differentiate between conditions regarding user group characteristics; the relationship between resource system and user group characteristics; the institutional arrangements; and the external environment, respectively. We, therefore, employ the enabling conditions (see Figure 2) offered by Hasan *et al*. (2020) in our study to see whether and to what extent these conditions work for the Northwestern Barind region of Bangladesh as well.

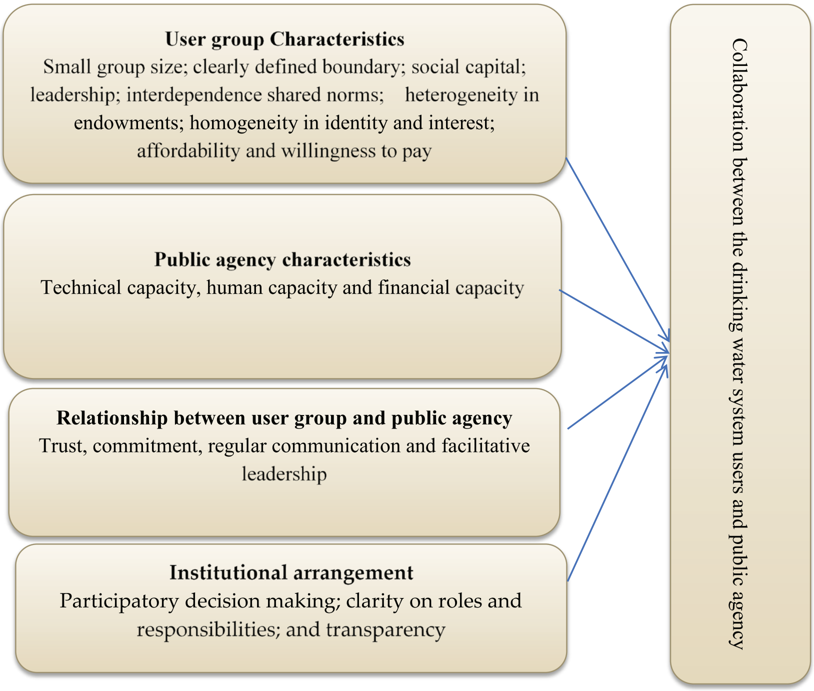
**Figure 2: Conditions of collective action among the end-users of the community drinking water system (adapted from Hasan *et al.*, 2020).**




## *Enabling Conditions of Collaboration between End-users of Community Drinking Water Systems and Public Agency*

Hutchings *et al.* (2015) hold that for the community management approach to be durable at a scale, community institutions require long-term external support. External support could come from local NGOs (Hasan *et al.,* 2020) but also from public agency (Agrawal 2001; Mansbridge 2014) In governing commons, state agencies play an effective role by providing reliable information for mitigating the problem of self-serving bias; an arena for negotiation promoting low-cost agreement; and monitoring compliance and sanction mechanism in the implementation phase (Mansbridge, 2014) In the case of governing community drinking water systems as a commons, we expect that government agency promote community management by collaborating the local community. Thus, in determining the success of CDWS governance, collaboration between CDWS users and public agency officials is likely to play a positive role and will therefore, seek to identify the conditions for effective collaboration between the users of CDWS and public agency officials. Papadopoulos (2016) holds that "collaborative arrangement can only be successful if a government agency can create the chance for interplay and organize different actors to contribute resource, time and knowledge in the collaborative production of public service." Now, the question comes to the fore under what conditions both the users and public agency officials are likely to engage in effective collaboration for the governance of CDWS? Hasan ***et al.*** (2020) offered a group of conditions of effective collaboration (see Figure 3) relating to user characteristics; public agency characteristics; the link between the users of CDWS and the public agency officials; and the institutional arrangements. We, therefore, adapted the enabling conditions (see Figure 4) offered by Hasan *et al* (2020) in our study to see whether and to what extent, these conditions work for the Northwestern Barind tract of Bangladesh as well.

**Figure 3: Conditions for collaboration between users of community drinking water system and public agency (adapted from Hasan *et al.*, 2020)**




## Materials and Methods

The study employed the case study approach to achieve its objectives where the DTWSI was selected as a case. This infrastructure was selected for the study on the following grounds: first, DTWSI is a community-run drinking water system; second, different actors are involved in the implementation process of DTWSI, and finally, the DTWSI experiences variation in its success in terms of sustainable performance.

***Deep tube-well Water Supply Installation: Design, Functions and Governance Arrangement***

Deep tube-well water supply installation (DTWSI) (shown in figure.4) is a community-based drinking water system supplying safe drinking water all year round to the rural people in Northwestern Barind region of Bangladesh (Hossain *et al.,* 2019; Rahman & Mahbub, 2012). Since 1997, the Barind Multi-purpose Development Authority (BMDA)- a public agency has initially started installing 26 DTWSI in the 13 Upazilas of Rajshahi, Naogaon, and Chapainawabganj districts of Bangladesh to supply safe drinking water in Barind region of Bangladesh. By now, they installed 1592 DTWSIs under the project entitled "Drinking Piped Water Supply from Irrigation Deep Tube-wells" in 25 Upazilas—second tier of local government in Bangladesh, under the Rajshahi, Naogaon, and Chapainawabganj districts of the North-western Barind tract of Bangladesh. The DTWSI consists of a deep tube-well, an overhead tank and a pipe network. In the DTWSI system, water is first abstracted from the underground through a deep tube well and then passed into the overhead water tank using an electric motor. This tank water is then directly supplied to the households through a pipeline (Iquebal Hossain *et al*., 2020).

**Figure 4: Deep tube-well water supply installation (DTWSI) system**

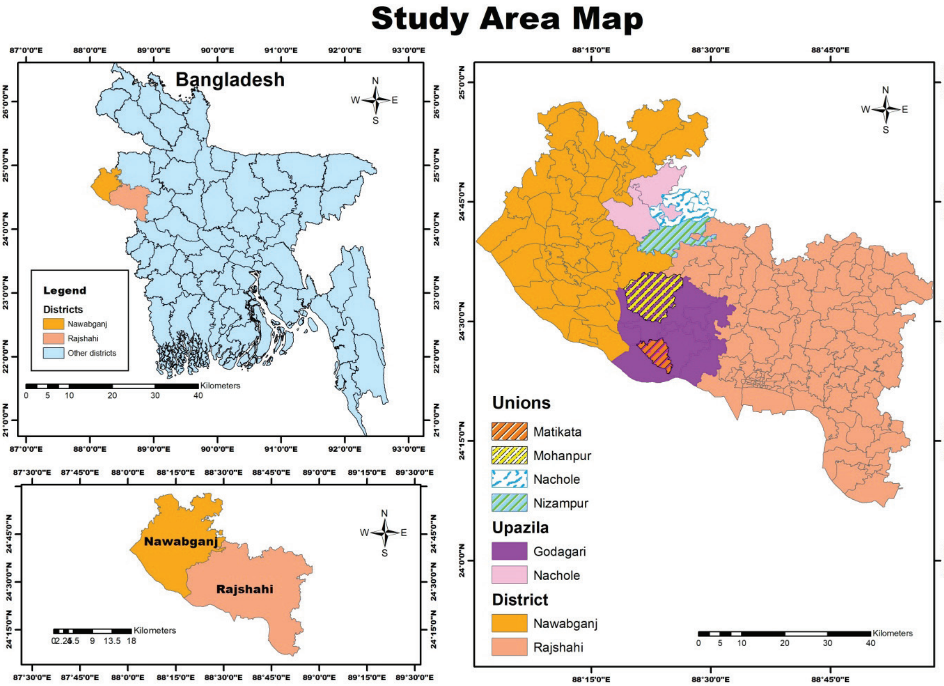
Regarding the governance arrangement of DTWSI in Barind region of Bangladesh, the national water policies (*i.e.,* the National Policy for Safe Water Supply and Sanitation 1998, Water Act 2013, and Water Rules 2018) guide the drinking water provision and management. As per those policies, the Upazila BMDA is assigned to install DTWSI for supplying year-round fresh water to the local community people.

The local users are supposed to operate and maintain their DTWSI by bearing its operation and maintenance costs. For the smooth operation and maintenance of DTWSI, a maintenance committee namely, the water user association (WUA) is supposed to be formed with a member from the beneficiary households. An operator is selected from the users to perform regular operational tasks of the installation. The Union Parishad—the lowest tier of the local government of Bangladesh, does not have a direct role but it plays an indirect role in the maintenance of deep tube-well. The Upazila BMDA provides support to the communities in case of major repair. Therefore, this case offers the unique chance to examine the enabling conditions for the occurrence of CM+ as a drinking water governance model in the Northwestern Barind region of Bangladesh.

### *Study Area*

The study was conducted in two sub-districts (Upazila) of Northwestern Barind Tract of Bangladesh such as Godagari (Rajshahi district) and Nachole (Chapainawabganj district) as these areas are drought-prone and water-stressed (Rashid & Islam, 2013b). The study area map is presented in figure 5. These areas experience fresh drinking water scarcity due to overexploitation of groundwater, the decline of the groundwater table, a decrease in summer rainfall, an increase in overall temperature, evaporation, and the construction of Farakkah barrage (Islam *et al*. 2020). Due to its topographic features, the resources of surface water resource is very limited. The amount of annual rainfall in these areas is less which is almost half of the national average (Rahman & Mahbub, 2012). These areas are characterized by low socio-economic conditions, hot and humid climatic conditions, extreme weather events, (drought), and fresh drinking water scarcity.

**Figure 5: Study Area (drawn by authors)**




This region is also more prone to severe drought that often destroys the drinking water sources. Moreover, the Farakkha barrage constructed by India on the Ganges (Padma) river in 1975 decreased the freshwater flow in the Northwestern areas of Bangladesh (Islam *et al*. 2020). The major source of drinking water in this locality are tube-well, dug wells, rainwater harvesting systems (RWHS), submergible pumps, piped water systems, and more recently, managed aquifer recharge (MAR) systems. The tube well is affected by arsenic contamination, excessive iron and manganese. Moreover, surface water is also affected by seasonal fluctuation which is exacerbated by climate change impacts.

### *Sample Selection*

We purposively select 30 DTWSIs from four unions of Rajshahi and Chapainawabganj based on the variation in the level of their functionality (*e.g.* functional/dysfunctional). The details of the sampling are mentioned in table 1. Due to a lack of a complete and reliable list of DTWSl, we could not employ a simple random sampling technique rather, we had to employ a purposive sampling method. Considering the limited time and resources that we had, and also the length of the questionnaire, we determined that we could incorporate only 30 DTWSI communities for our study. From each sub-district, we chose a sample of 15 DTWSI sites (9 are functional and 6 are dysfunctional) based on the ratio of the functional and dysfunctional condition of DTWSI available in the study areas. These 15 communities accounted for between 7-8% of all deep tube-well communities available in the respective sub-district in our sample.

**Table 1: Sampling of the study**

| **Union** | **Sub-district** | **District** | **Level of functionality** | **Number of samples** |
|---|---|---|---|---|
| Mohonpur/ Matikata | Godagari | Rajshahi | Functional/ dysfunctional | 15 |
| Nachole/ Nejampur | Nachole | Chapainawabganj | Functional/ dysfunctional | 15 |
| **Total** | **02** | **02** | **02** | **30** |

### *Data Collection*

We collected data from both primary and secondary sources. The primary data were collected through group surveys with local users, key informant interviews (KIIs) with officials of public agency (BMDA), physical observation, and stakeholders' workshop. Primary data was collected in February-March, 2022. Per the DTWSI site, we carried out a group survey with the local users composed of eight to twelve users including the maintenance committee members (*i.e.* 30 group discussion in total) and with 6 key informant interviews of the relevant branches of the government agency (*i.e.*, BMDA) to examine the enabling conditions that are likely to influence joint action among the DTWSI users in one hand and collaboration between the BMDA officials and DTWSI users, on the other. To that end, we developed a semi-structured questionnaire aims to operationalize the conditions for (i) collective action among the users of deep tube-well and (ii) collaboration between deep tube-well users and BMDA. We used separate semi-structured questionnaires with different categories of respondents *(i.e.* deep tube-well users and BMDA officials), in particular, the questionnaire for BMDA officials contained questions on the agency's perceived capacity. The questionnaire came accompanied by prompt examples for the interviewer to use if participants were deemed to have any confusion in sensing the questions. We pre-tested the questionnaire in 6 deep tube-well communities of our sample. The questionnaire set for BMDA officials was also pretested at the district level from which our sample of unions was chosen. Pretesting did not lead to any remarkable change in the original design of the questionnaire except for some wording.

In the group survey with local users, we created answers to the questions from the questionnaire by consensus. Interviewers facilitated reaching a consensus on answers and ensured the user committee chief did not dominate the discussion on a question. The interviewer always tried to include the view of female participants. With few exceptions, the end-users were able to generate consensus-based responses. We recorded all interviews on a digital voice recorder. In addition, we collected data by reviewing official documents, field reports, and annual reports collected from the BMDA office and Union Parishad. Finally, a stakeholders' workshop with the participation of all relevant stakeholders (*e.g.* local users, maintenance committee members, elected representatives of local government institutes, officials of BMDA, and local NGOs) was held to triangulate the data extracted from them during the fieldwork and thereby ensure the reliability of our data.

### *Data Analysis*

Following the analysis technique of the study of Hasan *et al.* (2020), firstly, we compared the cluster of DTWSI sites with proof of moderate to strong collective action with the cluster of sites with no proof of collective action in terms of their average scores on the variables listed in our framework (figure 4). Similarly, we compared the cluster of DTWSI sites with proof of collaboration between the users and BMDA officials with the cluster of DTWSI sites with no proof of such form of collaboration in terms of their average scores on variables listed in our framework (figure 5). We compared these aimed at identifying if we can start understanding variation in (i) collective action among the users of a DTWSI and (ii) collaboration between the users of DTWSI and BMDA officials.

We could not carry out the regression analysis as the number of observations of the study was very small (n-30). Instead, we calculated Pearson Chi2 coefficients since we compared two groups (*i.e.* DTWSI sites with vs. sites without collective action or collaboration) in terms of their average scores on a bunch

## Findings of the Study

### *Conditions for Collective Action among DTWSI Users*

The extent of collective action among DTWSI users was determined by adding scores for five indicators of collective action shown in Table 2. It is found that

that there is moderate or high collective action among the users of 20 DTWSI communities and little or no collective action among the users of 10 communities.

**Table 2: Estimation of Collective Action among DTWSI Users**

| Collective action variables | Response (In %) (N=30) |
|---|---|
| 1. Presence of maintenance committee in the community | 70.0 |
| 2. Regular meeting of the maintenance commit | 53.3 |
| 3. Sharing of operation and maintenance tasks by all members of the community. | 46.7 |
| 4. Contributions of all or many members of the community to make up part of the installation costs. | 73.3 |
| 5. Contribution of many members of community to make up the costs related to operation and maintenance | 66.7 |
| **Estimating the value of Collective Action Variables:**<br>• Adding scores for indicators 1-5<br>• Total= 0-2: no or low collective action (0)<br>• Total = 3-5: moderate or high collective action (1) | |

The derived scores for collective action among deep tube-well users were associated with the scores for each of the enabling conditions of collective action prescribed in the pieces of literature on the shared resource governance. The results of correlation analysis (see appendix 1) show that among twenty-two explanatory variables, eight factors correlate significantly at the 5% level with our outcome variable (*i.e*. occurrence of collective action). As per our expectation, small group size; interdependency among the user group; heterogeneity of endowments; affordability and willingness to pay; a high dependence on resource system; monitoring; locally devised rules; and state support are strongly correlated with the organization of joint action among the DTWSI users.

**Conditions for Collaboration between DTWSI Users and the BMDA**

The extent of collaboration between DTWSI users and the BMDA officials was determined by adding the scores for three indicators of collaboration depicted in Table 3. We find that there is a moderate or high level of collaboration between end-users and BMDA officials in 18 deep tube-well communities and little or no collaboration between two parties within 12 deep tube-well communities.

**Table 3: Estimation of collaboration between DTWSI users and BMDA officials**

| Collaboration Variables | Response (In %) (N=30) |
|---|---|
| Cooperation of BMDA officials regarding the installation of the DTWSI | 60.0 |
| Cooperation of BMDA officials concerning the formation of a maintenance committee of DTWSI | 43.3 |
| Cooperation of BMDA officials concerning the repairing, maintenance and monitoring activities of DTWSI | 20.0 |
| **Estimating the value of Collaboration Variables :**<br>• Adding scores for indicators 1-3<br>• Total = 0 = no collaboration (0)<br>• Total = 1-3 = moderate or strong collaboration (1) | |

It is found that the derived scores for collaboration between DTWSI users and BMDA officials are strongly associated with the scores for each of the requirements of collaboration found in the scholarship on shared resources governance. The results of the correlation analysis (see appendix 2) indicate that small group size, interdependency among group members, affordability and willingness to pay as user group characteristics, and capacity of public agency in terms of technical and financial resources significantly correlate with occurrence of collaboration between DTWSI users and BMDA officials. We also found that effective collaboration between deep tube-well users and public agencies is helped by trust between DTWSI users and BMDA officials, the commitment of BMDA public agency officials, inclusive decision-making, and transparency in the decision-making process relating to the management of DTWSI.

## Discussion and Conclusions

Regarding the requirements of collective action among the users of DTWSI, our analysis reveals that for none of the 30 DTWSI communities we find users sharing that they have a low level of demand for deep tube-well water. Instead, they have a high level of demand for DTWSI water as they have no other better alternative option of fresh drinking water in their possession. These results slightly differ from the earlier study (Hasan *et al.* 2020) which found that most of the PSF site users have low-level demands of PSF water in the Southwestern coastal zone of Bangladesh. This exception might be justified by the fact that in the study areas of Northwestern Barind Tract of Bangladesh, local people have no other better alternative sources of fresh drinking water than that of the DTWSI.

It is furthermore noticeable that very few of 30 DTWSI sites had clearly defined boundary rules. It was found that although in a few of the DTWSI sites in our sample, the maintenance committee makes a list of user groups, however, they do not refuse access to individuals who do not members of that group and who consequently have not provided any input to installation, operation and/or maintenance of the DTWSI. This is consistent with the findings of earlier studies (*e.g.,* Naiga *et al*., 2015; Hasan *et al*., 2020; Hasan *et al*., 2020) which finds that social norms ward off the devise of rules restricting peoples' access to drinking water systems. However, definition of boundary for a shared resource is still among the most effective drivers of successful collective action among the resource users (Cox *et al*., 2010). Our analysis shows that small group size, interdependency among group members, high level of dependence of users on a resource system, locally formulated rules, monitoring, and collaboration with public agency officials are strongly correlated with the organization of collective action among the DTWSI users. Regarding group size, it appears that small user groups have more chance to engage in collective action as it increases the chance of interaction among the DTWSI users and hence the trust-building between users which in turn lowers the transaction costs related to collective action. This is somewhat divergent from the findings of an earlier study (Hasan *et al*., 2020), which finds that large group size positively influences the collective action among the PSFS users in the southwestern coastal zone of Bangladesh. This difference might be explained by the fact that there is a variation between the two areas of Bangladesh in terms of socio-economic conditions. Still, small group size is one of the major factors of effective collective action among the shared resource users. (Agrawal, 2001; Baland & Platteau, 1996; Poteete & Ostrom, 2004). Our findings also demonstrate the importance of interdependence among the DTWSI users to the occurrence of collective action among them. This implies that the more the group members are dependent on each other's efforts for the operation and maintenance of the deep tube well, the more likeliness of the organization of collective action among them. This is convergent with the earlier studies (Baland & Platteau 1996; Hasan *et al.*, 2020). We also find that joint action takes place significantly more often in our sample communities when deep tube-well users share having no alternative drinking water system at their hands. This is similar to the findings of earlier studies *(e.g.*, Hasan *et al.,* 2020). Likewise, locally devised working rules appeared as another significant factor leading to joint action among the DTWSI users. The drinking water scholarship considers the importance of locally devised rules as one of the crucial design principles for the successful governance of community drinking water systems (Naiga, Penker, and Hogl 2015; Hasan *et al.* 2020). We also find that monitoring the DTWSI and behavior of DTWSI users promotes the chance of collective action among the users as it helps to ensure compliance with access and management rules by the users. This is congruent to the results of past studies (*e.g.*, Naiga *et al.*, 2015). Furthermore, we find that support of public agencies in terms of monitoring and repairing strongly affects the occurrence of collective action among the DTWSI users. These findings are consistent with earlier studies (Lockwood & Smits, 2011; Moriarty *et al.*, 2013; Hutchings *et al.,* 2017; Hasan *et al.,* 2020).

Our analysis also indicates at the significance of (i) having local users with heterogeneous endowments and (ii) affordability and willingness to pay of users to the organization of collective action. The associations are significant but not very strong. About heterogeneous endowments, it is observed that solvent households frequently play a decisive part in establishing and operating successful drinking water systems. This informs the argument of Olson (1965) that effective collective action necessitate a different effort from some users. On one side, such households can come forward when require (and others are not able to). Conversely, one could also find how excessive dependence on only one individual or household could aggravate the existing inequality and dependence relation (Vedeld, 2010). We also find that the affordability and willingness to pay of the users make them able to financially contribute to the operation and maintenance of DTWSI and thereby, increase the likelihood of joint action among the users. This is similar to the findings of an earlier study (Zvobgo, 2021) found that users' ability and willingness to pay for water ensure the continued supply of drinking water in Zimbabwe. However, this association is so weak in the context of deep tube-well comes as a bit of a surprise.

Concerning the factors of collaboration between DTWSI users and the BMDA, the most noticeable result from our analysis appears that there is almost a lack of clarity on the roles and responsibilities of deep tube-well users and the BMDA regarding DTWSI management. Although some water policies guiding the tasks and responsibilities of stakeholders involved in drinking water service provision in Barind areas are available, however, these policies may be too generic. They do not specify the roles and responsibilities of concerned stakeholders which they should perform in forging effective collaboration regarding DTWSI management. This is consistent with the findings of an earlier study (Hasan *et al.,* 2020).

Regarding the user group characteristics, the analysis reveals that small group size accounts for variation in the occurrence of collaboration between DTWSI users and BMDA. It implies the smaller the DTWSI users are, the greater the likeliness of collaboration between users and BMDA officials as it helps to maintain greater interaction that ultimately increase trust between the parties. In addition, affordability and willingness to pay of users, interdependency among group members, and shared norms also appear to have some impacts on the organization of effective collaboration. This is consistent with the findings of earlier studies (*e.g.* Hasan *et al.,* 2020).

As expected, public agency characteristics seem to account for the variation of collaboration between DTWSI users and BMDA. It is found that BMDA'S capacity in terms of technical knowledge and financial resource is strongly associated with whether or not they engage in a cooperative relationship with DTWSI users. This implies that these resources enable the employees of BMDA mandated with co-productive water provision to mobilize the community meaningfully engage in the implementation process of DTWSI. These findings are somewhat divergent from the observations of earlier study (Hasan *et al.,* 2020) This divergence might be explained by the fact that there is variation between two public agencies involved in drinking water supply *i.e.* the Department of Public Health Engineering (DPHE) in Southwestern coastal areas and BMDA in Northwestern Barind areas of Bangladesh. Still, public agency capacity and resources are very important conditions for promoting collaboration as these help to create opportunities for interaction and mobilize communities to invest their knowledge and resources in the management of DTWSI (Kekez *et al.*, 2019; Ostrom, 1996).

Regarding the relationship between user groups and public agencies, our findings show that trust is strongly associated with the presence or absence of collaboration between users and BMDA. This is consistent with findings of earlier study (Hasan *et al.,* 2020). Similarly, commitment appears to be strongly associated with the occurrence of effective collaboration. This implies that if both public agency officials and DTWSI users are strongly committed to performing their respective roles and responsibilities assigned to them by the existing drinking water policies, there is more chance of collaboration between both parties. This observation is very much aligned with the findings of earlier studies on collaboration in the context of shared resource management (Ansell & Gash, 2008; Margerum, 2001). The institutional setting also seems to explain some of the variations in collaboration.

Our analysis reveals that the correlation of collaboration with (i) inclusive decision-making and (ii) transparency is significant but weak. These findings are consistent with the findings of an earlier study ( Hasan *et al.* 2020).

It is observed that most of these conditions of collective action are similar to those of earlier study conducted in the Southwestern coastal areas of Bangladesh (Harun *et. al,* 2000). A few of conditions *i.e.,* affordability and willingness to pay, monitoring the users' behavior and CDWS conditions appear significant in the context of Barind areas of the country. Another dissimilarity between two studies is noticed on the ground that whereas in the Southwestern coastal areas of Bangladesh, collective action is more likely to occur if the group size is large, it is small group size which is found significant in the Northeastern Barind areas. These variations might be attributed to variations in the socioeconomic conditions of the two regions. And, an effective collaboration between local users and public agency seems to occur when there is trust between the users and public agency; both users and public agency officials are committed to performing their assigned tasks and responsibilities; and local users are opportune to participate in decision-making process held under the transparent manner. Only one condition newly emerges as significant in forging collaboration in the Northweastern part of Bangladesh which is the commitment of both users and public agency officials to perform their assigned tasks and responsibilities to the management of DTWSI

Derived from the findings of this study, the following recommendations can be made for those who are involved in rural potable water supply in the Northwestern Barind tract of Bangladesh or similar regions, and elsewhere of the similar context. First, form a small user group to increase interaction and trust among the users. These would decrease the monitoring cost and thereby promote collective action among beneficiaries about the management of community drinking water systems. Second, endeavor should be made to devise the boundary rules that define who have access to the CDWS water. This will help to ensure that access to water is proportional to contributions made to the operation and maintenance of the system. Third, form a user group composed of members with different types of resources to make sure that every member of the user group is dependent on each other's effort for the smooth operation and maintenance of CDWS. Fourth, ensure that the introduction of a new CDWS is demand instead of supply-driven – *i.e.* the system you introduce should be aligned with preference of the local community people. Fifth, make sure that local users are involved in the devise of working rules guiding operation and maintenance of the CDWS. Sixth, invest enough time and effort to make the people aware of the importance of hygiene so that are willing to pay for the operation and maintenance of CDWS. Seventh, ensure that users receive continuous support from external entity (*e.g.,* public agency) in the form of financial, monitoring, training and equipment etc. Finally, in doing that, adequate time and effort should be given in building trust and in creating commitment between the local users and the external entity that is to promote their community management endeavor, and in transparency about the making and enforcing of rules.

The study has some limitations. First, due to time and resource constraints, the study could not select a large number of the sample. Second, due to a small number of samples, the study did not employ sophisticated statistical tools (*i.e.* regression analysis) for the analysis of the data. Finally, this study is based on the North-western Barind Tract of Bangladesh which might not replicate in other parts of Bangladesh. Addressing the limitations mentioned above, future research is suggested to carry out in other parts of Bangladesh to check whether this CM+ model is workable across the whole country.

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**Appendix 1: Correlation results for collective action among DTWSI users**

| Conditions for collective action among deep tube-well users | Indicators | Answer categories | Frequency Collective action = moderate/ high (n=20) | Frequency Collective action = weak/absent (n=10) | Pearson $Chi^2$ | Sign. (2-tailed) |
|---|---|---|---|---|---|---|
| ***User group characteristics*** | | | | | | |
| 1. Small group size | Number of households having access to this deep tube well. | 0= >100<br>1= ≤100 | 0=5<br>1=15 | 0=8<br>1=2 | 8.213 | 0.007*** |
| 2. Clearly defined boundaries | Definition of households having access to the deep tube-well. r | 0=no<br>1=yes | 0=16<br>1=4 | 0=8<br>1=2 | .938 | .633 |
| 3. Social Capital- Past successful experiences of collective action | Engagement of collective action of the memebrs of deep tube well community beyond the deep tube-well.<br>If yes, how is/was this collective action functioning? | 0=0-1<br>1=2-4 | 0=8<br>1=12 | 0=6<br>1=4 | .000 | 1.000 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4. Appropriate leadership—young, familiar with changing external environments, connected to the local traditional elite | Presence of worthy leadership. (composed from the answers to questions about capacity, connectedness, and fairness of leader) | 0=no<br>1=yes | 0=7<br>1=13 | 0=7<br>1=3 | 3.281 | 0.122 |
| 5. Interdependency | Dependency of users on each other's effort for the well-functioning of the deep tube-well (composed of the answers to questions about interdependence regarding money, knowledge, and labor) | 0=weak<br>1=strong | 0=3<br>1=17 | 0=8<br>1=2 | 12.129 | 0.001*** |
| 6. Shared norms | Common understanding of users about the operation and maintenance of deep tube-well (composed of the answer to questions about the importance of deep tube-well, formation of a maintenance committee, and compliance with rules) | 0=no<br>1=yes | 0=3<br>1=17 | 0=5<br>1=5 | 4.176 | 0.078 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 7. Heterogeneity of endowments | Presence of users having different types of inputs required for operation and maintennace of deep tube-well. | 0=no<br>1=yes | 0=6<br>1=14 | 0=7<br>1=7 | 4.344 | 0.056* |
| 8. Homogeneity of identities and interests | Coomon political identity of deep tube-well users | 0=no<br>1=yes | 0=2<br>1=18 | 0=3<br>1=7 | 1.920 | 0.300 |
| 9. Affordability and willingness to pay | Capacity and willingness of all users to pay the cost required for the installation of a deep tube well. | 0=no<br>1=yes | 0=4<br>1=16 | 0=7<br>1=3 | 7.177 | 0.015** |
| ***Relationship between resource system characteristics and group characteristics*** | | | | | | |
| 10. Overlap between user community residential location and resource location | Total time required for collection of water from the deep tube-well. | 0= >.5h<br>1= ≤ .5h | 0=5<br>1=15 | 0=2<br>1=8 | 0.093 | 1.000 |
| 11. High levels of dependence by community members on the resource system | Major source of drinking water of the community during the dry season. | 0=not deep tube-well<br>1=deep tube-well | 0=3<br>1=17 | 0=7<br>1=3 | 9.075 | 0.005*** |

| | | | | | | |
|---|---|---|---|---|---|---|
| 12. Fairness in the allocation of benefits from the resource system | Maintenance of fairness in the allocation of deep tube-well water among the memebrs of users | 0=no<br>1=yes | 0=2<br>1=18 | 0=1<br>1=9 | 0.000 | 1.000 |
| 13. Low levels of user demand | Quantity of drinking water (liter) used by a household on average per day. | 0= >50 liters<br>1= ≤50 liters | 0=20<br>1=0 | 0=10<br>1=0 | n.a. | n.a. |
| 14. A gradual change in levels of demand | Increase of demand for deep tube-well water over the last few years | 0=yes<br>1=no | 0=13<br>1=7 | 0=6<br>1=4 | 0.072 | 1.000 |
| ***Institutional arrangements*** | | | | | | |
| 15. Rules are simple and easy to understand | Easiness of the rules guiding operation and maintennace of deep tube-well. | 0=no<br>1=yes | 0=3<br>1=17 | 0=4<br>1=6 | 2.329 | 0.181 |
| 16. Locally devised access and management rules | People who made the operation and maintennace rules for DTWSI usage and its maintennace. | 0=others<br>1=users | 0=4<br>1=16 | 0=8<br>1=2 | 10.000 | 0.004*** |
| 17. Ease in the enforcement of rules | Absence of difficulties in enforcing the working rules that guide DTWSI usage and maintenance. | 0=yes<br>1=no | 0=3<br>1=17 | 0=4<br>1=6 | 2.329 | 0.181 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 18. Monitoring | Presence of monitoring mechanism to surveil the water collection, and financial contributions by users of DTWSI? | 0=no<br>1=yes | 0=5<br>1=15 | 0=8<br>1=2 | 8.213 | 0.007*** |
| 19. Sanctions | Presence of mechanism regarding the sanctioning of rule-breaking? | 0=no<br>1=yes | 0=14<br>1=6 | 0=10<br>1=0 | 1.071 | 0.540 |
| 20. Availability of low-cost adjudication | Arrangement of resolving internal disputes among the members of user community related to DTWSI. | 0=no<br>1=yes | 0=7<br>1=13 | 0=3<br>1=7 | 0.075 | 1.000 |
| 21. Accountability of monitors and other officials to users | Presence of mechanism to hold monitors and/ or maintenance committee members accountable. | 0=no<br>1=yes | 0=14<br>1=6 | 0=6<br>1=4 | 0.300 | 0.690 |
| ***State*** | | | | | | |
| 22. Public agency support | Receipt of cooperation from the BMDA officials regarding the management of DTWSI. | 0=no<br>1=yes | 0=5<br>1=15 | 0=8<br>1=2 | 8.213 | 0.007*** |

**Note: *p<0.10, **p<0.05, ***p<0.00;**

**Appendix 2: Correlation Results for Collaboration between DTWSI Users and Public Agency (BMDA)**

| Conditions for collaboration between users and public agency | Indicators | Answer categories | Frequency Collaboration = moderate/ strong (n=18) | Frequency Collaboration = absent (n=12) | Pearson $Chi^2$ | Sign. (2-tailed) |
|---|---|---|---|---|---|---|
| **User group characteristics** | | | | | | |
| 1. Small group size | Number of households having access to this deep tube well. | 0= >100<br>1= ≤100 | 0=2<br>1=16 | 0=11<br>1=1 | 19.027 | 0.000*** |
| 2. Clearly defined boundaries | Definition of households having access to the deep tube-well. | 0=no<br>1=yes | 0=16<br>1=2 | 0=8<br>1=4 | 2.222 | .184 |
| 3. Past successful experiences—social capital | Engagement of collective action of the memebrs of deep tube well community beyond the deep tube-well. If yes, how is/was this collective action functioning? | 0=0-1<br>1=2-4 | 0=7<br>1=11 | 0=5<br>1=7 | 0.023 | 1.000 |
| 4. Appropriate leadership | Presence of worthy leadership. (composed from the answers to questions about capacity, connectedness, and fairness of leader)) | 0=no<br>1=yes | 0=7<br>1=11 | 0=7<br>1=5 | 1.094 | 0.457 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 5. Interdependency | Dependency of users on each other's effort for the well-functioning of the deep tube-well (composed of the answers to questions about interdependence regarding money, knowledge, and labor) | 0=weak<br>1=strong | 0=2<br>1=16 | 0=9<br>1=3 | 12.656 | 0.001*** |
| 6. Shared norms | Common understanding of users about the operation and maintenance of deep tube-well (composed of the answer to questions about the importance of deep tube-well, formation of a maintenance committee, and compliance with rules) | 0=no<br>1=yes | 0=2<br>1=16 | 0=6<br>1=6 | 5.568 | 0.034* |
| 7. Heterogeneity of endowments | Presence of users having different types of inputs required for operation and maintennace of deep tube-well. | 0=no<br>1=yes | 0=6<br>1=12 | 0=7<br>1=5 | 1.833 | 0.264 |
| 8. Homogeneity of identities and interests | Coomon political identity of deep tube-well users | 0=no<br>1=yes | 0=2<br>1=16 | 0=3<br>1=9 | 1.000 | 0.364 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 9. Affordability and willingness to pay | Capacity and willingness of all users to pay the cost required for the installation of a deep tube well | 0=no<br>1=yes | 0=2<br>1=16 | 0=9<br>1=3 | 12.656 | 0.001*** |
| ***Public Agency Characteristics*** | | | | | | |
| 10. Technical capacity | Technical capacity of the BMDA officials at Upazila level to carry out its activities with regard to the DTWSI of this community | 0=no<br>1=yes | 0=6<br>1=12 | 0=10<br>1=2 | 7.232 | 0.011** |
| 11. Human resources | Adequate human resources of the BMDA at Upazila level to cary out its activities regarding the DTWSl of this community | 0=no<br>1=yes | 0=13<br>1=5 | 0=8<br>1=4 | 0.106 | 1.000 |
| 12. Financial resources | Adequate finanial resources of the BMDA at Upazila level to carry out its activities about the DTWSI of this community | 0=no<br>1=yes | 0=5<br>1=13 | 0=11<br>1=1 | 11.808 | 0.001*** |
| ***Relationship between User Group and Public Agency*** | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 13. Trust | Presence of trust of the users on BMDA officials regarding their cooperation for tthe operation and maintennace of deep tube-well. (composed of the answers to questions about users trusting BMDA to help with training the caretaker,, running the user groups and effectuating repairs) | 0=no<br>1=yes | 0=4<br>1=14 | 0=7<br>1=5 | 8.167 | 0.008*** |
| 14. Commitment | Presence of commitment of Upazila BMDA officials to give the agreed-upon training to the caretaker on the operation of DTWSI | 0=no<br>1=yes | 0=4<br>1=14 | 0=8<br>1=4 | 5.926 | 0.024** |
| 15. Communication | Maintenance of regular communication between DTWSI users and BMDA officials regarding the operation and maintenance of DTWSI? | 0=no<br>1=yes | 0=10<br>1=8 | 0=9<br>1=3 | 1.172 | 0.442 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 16. Facilitative Leadership | Presence of individual or organization who can facilitate contact between BMDA officials and users of this DTWSI | 0=no<br>1=yes | 0=13<br>1=5 | 0=11<br>1=1 | 1.701 | 0.358 |
| ***Institutional Arrangements*** | | | | | | |
| 17. Inclusive decision-making | Consideration of the opinion and interests of user community regarding this DTWSI | 0=no<br>1=yes | 0=6<br>1=12 | 0=10<br>1=2 | 7.232 | 0.011** |
| 18. Clarity on roles and responsibilities | Lucidity of roles and responsibilities of the users community and BMDA officials regarding the management of deep tube-well. | 0=no<br>1=yes | 0=16<br>1=2 | 0=10<br>1=2 | 0.192 | 1.000 |
| 19. Transparency | Openness in decision making process regarding the management of deep tube-well. | 0=no<br>1=yes | 0=4<br>1=14 | 0=8<br>1=4 | 5.926 | 0.024** |

**Note: *p<0.10, **p<0.05, ***p<0.00**