Factors determining farmers’ strength of access to the irrigation system in Kaksi district of Nepal
Kapil Khanal¹*, Kalika Bahadur Adhikari¹, Shiva Chandra Dhakal¹ and Santosh Marahatta¹

Abstract: Irrigation is the most important input to Nepalese agriculture as most of the irrigation system here is rainfed. Farmers managed irrigation systems are a more efficient way of providing irrigation facilities to the farmers. Irrigation System is an essential proactive for farming in the Kaksi district of Nepal. This study analyzed the factors affecting the farmers’ strength of access to the irrigation system in the command area of the system. The study adopted a simple random sampling procedure. The study was conducted in the Shardikhola Puranchaur Irrigation System of the Kaksi district of Nepal. The data for the study were collected in 2019. Cross-sectional data of 184 farmers were collected using a simple random sampling method. This included the users of the Shardikhola Puranchaur Irrigation System. Logit regression and descriptive statistics were used for data analysis. The result showed that the insufficiency of irrigation water is not a major problem for the user group of this irrigation system but there is some level of dissatisfaction among the user group which affected their strength of access to the irrigation system. Gender of household head, the physical condition of the canal, agricultural knowledge of the farmers, the gradient of the canal, and location of the household with respect to the canal significantly influenced the farmers’ strength of access to the irrigation system. Governing rules of the irrigation system, level of trust among

ABOUT THE AUTHORS
Kapil Khanal is a Ph. D. scholar at Agriculture and Forestry University (AFU), Nepal. He is Assistant Professor at Mahendra Ratna Multiple Campus, Ilam, Nepal. He has published articles at various national and international journals.

Kalika Bahadur Adhikari (Ph. D.) is Professor at the Agriculture and Forestry University, Nepal at Department of Agricultural Economics and Agribusiness Management. He previously served as the Assistant dean of the AFU and Principle of College of Natural Resources Management, Pokhara, Nepal.

Shiva Chandra Dhakal (Ph. D.) is Associate Professor at the Agriculture and Forestry University, Nepal, and is the Head of Department at Department of Agricultural Economics and Agribusiness Management. He is currently serving as the Deputy Director at Directorate of Research and Extension at the AFU.

Santosh Marahatta (Ph. D.) is Associate Professor at the Agriculture and Forestry University, Nepal, and is the Head of Department at Department of Agronomy.

PUBLIC INTEREST STATEMENT
A huge amount of expenditure is being made on the development of irrigation systems in the developing and underdeveloped countries either through farmers-managed or agency-managed irrigation system but the return to investments is not satisfactory. Irrigation is the most important input in these countries as they cannot invest heavily on improved seeds and plant protection measures. Ensuring farmers’ access to irrigation system is an effective way to enhance irrigation efficiency for increased production. This paper identified and analyzes various factors affecting farmer’s strength of access to the irrigation system. Based on this paper we present various factors and how they impact the access to the irrigation system. This paper concludes that various socio-economic factors should be addressed for ensuring equitable access to and distribution of irrigation water for the betterment of the farmers.
farmers, the caste of the farm family, years of schooling of the household head, and farm size did not significantly affect the farmers’ strength of access to the irrigation system. The study concluded that, while the irrigation system is of immense importance to the farmers in its command area, farmers’ strength of access to the irrigation system is significantly influenced by a mix of different factors. Therefore, more equitable distribution of water at different regions of the canal, proper maintenance of the canal, and transparent use of funds of the irrigation system should be ensured to realize the required results.

**Subjects:** Agriculture & Environmental Sciences; Plant & Animal Ecology; Development Economics

**Keywords:** irrigation; access; factors; logit; farmers

1. **Introduction**

   Agriculture is the source of livelihood for 60.4% of the total population of Nepal and it contributes 26.5% of the national GDP (AITC, 2020). Nepal has 2.7 million hectares of agricultural land (Pradhan, 2012) of which only 54% is irrigated (CBS, 2013). Farmers Managed Irrigation System (FMIS) is the indigenous irrigation system on which the Nepalese agricultural economy was always based (U. Gautam, 2012). Although 70% of irrigated land areas in Nepal fall in the category of the farmer-managed irrigation system (Pradhan, 2012), the produce contributes only 40% of the country’s food requirement (U. Gautam, 2012). The government of Nepal had tried to improve and maintain the irrigation system by incorporating local communities in the management of the irrigation system (Dhakal et al., 2018). Irrigation systems are used all year round when the water source is perennial which is a rare case, as in most of the cases irrigation systems are used for supplementing the main crop, i.e. paddy during the rainy season (Sijapatii & Paudel, 2010). Agriculture can significantly improve the economic condition of a country but to do so it is a must to improve the efficiency of water resource use. Nepalese farmers understood the importance of water resources for a long time and that is why they have developing irrigation systems on their own for increasing their agricultural production (Pradhan, 2000).

   Irrigation has contributed to increasing agricultural land, productivity, made double-cropping feasible and protected from the adversity of irregular rainfall but the benefits of the irrigation system are not distributed in an equitable and equal manner throughout the world (Schogold & Zilberman, 2004). Irrigated agriculture is of prime importance in Nepal to ensure food security and poverty reduction. Irrigation helps households to improve their incomes and employment increase their productivity, food availability, and grow high-value crops (Hussein & Hanjra, 2003). We are in need of a more reliable, flexible, and diversified water services for shifting towards a commercial and diversified agricultural system from a traditional subsistence farming (FAO, 2018). Nepal along with other Asian countries have invested billions of their scarce resources on developing their irrigation sector as agriculture will always be the dominant sector contributing to GDP, employment, food security, and alleviating poverty (Sampath, 1992; Shrestha, 2009). There is a sharp decline in investment in irrigation infrastructures in recent decades as compared to the 1970s-1980s (Kajosa, 2019; Rosegrant & Svendsen, 1993). This decline in investment calls for better water resource management to maintain its sustainability.

   Agency managed irrigation systems are being transformed into locally managed systems for better irrigation performance as they have not increased their performance despite recurrently increasing maintenance and operation cost (Pradhan & Belbase, 2018; Yoder, 1994). Individuals while using common pool resources have developed sustaining institutions by establishing commonly accepted rules and strategies and communicating with each other, thus successfully cooperating in the utilization of common pool resources and addressing social dilemmas through self-governance arrangements (Baerlein et al. 2015; Ostrom et al., 1994). There is increased dependence on water user groups
as there is a transition to improved management of present projects rather than the development of new irrigation projects along with an urgency for productivity maximization within the sustainable management of irrigation water resources (Evans et al., 2014; Yoder, 1994). Irrigation management means a multidisciplinary activity for increasing productivity per unit of water used that includes farmers’ participation in irrigation management as the managers to bring about a sense of ownership among the farmers leading to the sustainable and improved efficiency of land and water use for crop production (Pradhan, 2000). The better management and allocation of water resources can be ensured by the community participation or participation of local stakeholders as their knowledge, experience, and opinions are of prime importance in resource conservation (Dungumaro & Madulu, 2003; Ostrom et al., 1994). Farmers-managed irrigation system is significantly contributing to rural livelihood through their evolution and dynamism and use of self-governance and cooperation (Sijapati & Paudel, 2010). The capital cost of construction of an irrigation system is very high thus to ensure the high efficiency of the irrigation system, they need to be managed by local stakeholders. The major objective of this study is to determine the factors affecting the farmers’ strength of access to the irrigation system.

2. Materials and methods

2.1. Study area
The study was conducted within the Shardikhola Puranchaur Irrigation System of Puranchaur and Bhurjungkhola locality of the Kaski district of Gandaki province of Nepal. Kaski district is located in the mid-hills of Nepal. This district was selected as the representation of the majority of the hilly region of Nepal. Kaski district is located within latitude and longitude.

2.2. Sample size
There were 342 farmers in the water user group of the Shardikhola Puranchaur Irrigation System. The sample size was determined using Slovin’s formula at a 95% level of confidence and a total of 184 samples were selected using the technique of simple random sampling. The sample household was the representative of the irrigation system (about 53% representation). The study of the farmers’ strength of access reflects the situation of the irrigation system as a whole because the sample is 53% representative of the study area.

2.3. Data collection
Pretesting was done by presenting the interview schedule among 25 members of the study area. The necessary corrections and amendments were done before conducting the actual household survey in the interview schedule. Focus Group Discussion (FGD) and Key Informant Interview (KII) were done to validate data collected during face to face interviews. The household survey or field survey was conducted from November—December of 2019.

2.4. Data analysis
SPSS version 26 and Stata 13th edition software were used for data entry and analysis. Data quality was improved by working on cleaning and missing data. Descriptive statistics and a logit regression model were used to reach the desired results.

Logit model

The model used in this analysis was the logit regression model which is a dichotomous analysis model i.e. it is used when there is the condition of whether an event occurred or not rather than when it occurred (Boateng & Abaye, 2019). Social scientists generally use the logit model when an outcome variable is binary and logit transformation is an easy way of modelling the relationship between the outcome and the predictor variables (Breen et al., 2018). In this study, the logit model was used to analyze the factors affecting the farmers’ strong or weak strength of access to the irrigation system. Let y be the farmer’s strong access to the irrigation system and x be the vector of factors affecting the strength of access.
\[ Y = \text{Logit}(P) \]
\[ = \ln\left(\frac{P}{1-P}\right) \]
\[ = a + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 \ldots \ldots + \beta_9X_9 \]

Where, \( P \) is the probability that the farmer has strong access to irrigation system; \( 1-P \) probability that farmer does not raise goat; \( Y \): farmers (with \( 1 = \) strong access to irrigation system, \( 0 = \) weak access to irrigation system); \( X_1 \): governing rules (\( 1 = \) simple, \( 0 = \) complex); \( X_2 \): level of trust among farmers (\( 1 = \) high, \( 0 = \) low); \( X_3 \): gender of the household head (\( 1 = \) male, \( 0 = \) female); \( X_4 \): presence of agricultural knowledge (\( 1 = \) yes, \( 0 = \) no); \( X_5 \): physical condition of the canal (\( 1 = \) cemented, \( 0 = \) non cemented); \( X_6 \): caste of the household (\( 1 = \) brahmin (higher caste, \( 0 = \) others); \( X_7 \): gradient of the canal (\( 1 = \) North-South, \( 0 = \) East-West); \( X_8 \): Farm size (\( 1 = \) Medium size, \( 0 = \) others); \( X_9 \): location of the farm (\( 1 = \) head, \( 0 = \) tail).

The independent variables used for this study are shown in the Table 1.

### 3. Results and discussions

#### 3.1. Description of the socioeconomic and demographic characteristics of the respondents

The descriptive statistics of the respondents are as shown in Table 2, the average age of the household was 56.24 years. The average income of the household from agriculture was Rs. 65,444 per year. The average years of schooling of HHHs were 7.01 years. The average family size of the study area was 5.54 and the average number of economically active family members in the study area was 3.56. The total landholding of the household was 0.37 ha and the average area under SPIS was 0.22 ha.

The gender of the HHH was male in 79.90% percent of the HHs and 20.10% of the HHHs were female. Brahmin was the major caste in the study area with nearly 45% of the respondents belonging to the brahmin community followed by janajatis (Ethnic communities) at about 35%. About 55% of the family in the study area were nuclear whereas the remaining 45% family were joint family. The primary occupation of 58.70% of the HHs in the study area was agriculture followed by business and government jobs.

#### 3.2. Factors affecting farmers’ strength of access to the irrigation system

Table 3 presents the physical and sociodemographic characteristics affecting the strength of access to the irrigation system in the study area. Governing rules are the basic rules on which the daily operation of the farmers managed irrigation systems is based. The way these rules are perceived by the farmers or users significantly determines whether the farmers are satisfied with

| **Table 1. Dependent and Independent variables used for the study of strength of access to the irrigation system** |
|------------------------------------------|
| **Variables**                           | **Code**     | **Data entry**                            |
| Governing rules                         | R            | 1 = Simple, 0 = Complex                   |
| Level of trust among farmers            | TF           | 1 = High, 0 = Low                         |
| Gender of HHH                           | G            | 1 = Male, 0 = Female                      |
| Agricultural knowledge                  | KA           | 1 = Yes, 0 = No                           |
| The physical condition of the canal     | PC           | 1 = Cemented, 0 = Non cemented            |
| Caste of the HH                         | Caste        | 1 = Brahmin, 0 = Others                   |
| Gradient of canal                       | NS           | 1 = North-South, 0 = East-West            |
| Farm size                               | FS           | 1 = Medium, 0 = Others                    |
| Location of the farm                    | POF          | 1 = Head, 0 = Tail                        |
| Strength of Access                      | SOA          | 1 = Strong, 0 = Weak, (Dependent variable) |
their irrigation system or not. Here, in the study area, 83.15% of the respondents found the governing rules to be simple, meaning the rules are easy to understand and implement.

Mutual trust and cooperation are important factors affecting the efficiency and access to the farmers’ managed irrigation system. Whenever there is proper cooperation among the members of the user group, they can improve the overall efficiency of their irrigation system. Here, in the study area, 56.72% of the respondent suggested that there was a high level of trust among farmers and the remaining 43.48% of the respondents suggested a low level of trust among the farmers.

The gender of the HHH plays a significant role in how the resources of a farm family are utilized. In the patriarchal Nepalese society, males are generally more educated, their social and political awareness and exposure are more which directly differentiates their analysis of a particular situation from women. It was found that about 80% of the HH were male-headed in the study area.

Agricultural knowledge of a farmer directly affects a farmer’s agricultural decision, how he/she utilizes their resources including the irrigation water. There always remains the tendency that the farmers with sound agricultural knowledge will plant high-value crops and practice water-efficient farming. Some sort of agricultural technical knowledge was found to be present in 26.63% of the farmers whereas a vast majority consisting of 73.37% of the respondents lacked sound technical knowledge.

| Variables                                      | Mean value |
|-----------------------------------------------|------------|
| Age of HHH                                    | 56.24      |
| Numbers of years of schooling of HHH          | 7.01       |
| Total land holding in hectare                 | 0.37       |
| Land under SPIS in hectare                    | 0.22       |
| Family size                                   | 5.54       |
| Economically active population in HH          | 3.56       |
| Income from the agriculture sector            | Rs. 65,444 |

| Variables                                      | Frequency | Percent |
|-----------------------------------------------|-----------|---------|
| Gender of the HHH N = 184                     | 100       |
| Male                                          | 147       | 79.90   |
| Female                                        | 37        | 20.10   |
| Caste of the HH N = 184                       | 100       |
| Brahmin                                       | 83        | 45.10   |
| Chhetri                                       | 11        | 6.00    |
| Janajatis                                     | 65        | 35.30   |
| Dalits                                        | 19        | 10.30   |
| Others                                        | 6         | 3.30    |
| Family type N = 184                           | 100       |
| Nuclear                                       | 101       | 54.90   |
| Joint                                         | 83        | 45.10   |
| Primary occupation N = 184                    | 100       |
| Agriculture                                   | 108       | 58.70   |
| Business                                      | 27        | 14.70   |
| Government job                                | 19        | 10.30   |
| Private job                                   | 14        | 7.60    |
| Abroad                                        | 16        | 8.70    |

Table 2. Socioeconomic and Demographic characteristics of the respondents in the study area
The physical condition of the canal either cemented or non-cemented greatly affects the water delivery of the irrigation system. Physically cemented canal ensures the better delivery of the water but for that, they must be properly constructed. If the cemented canals are not properly constructed, they get easily damaged and affect the delivery of water negatively. Since the farmers managed irrigation systems are a traditional form of the irrigation system, most of the canal structures are still earthen which can efficiently deliver the water from the source to the field, but these earthen structures are generally present for a long time, they have maintained their structures without any repair from a long time. Thus sometimes, earthen canals can provide better results than improperly constructed cemented canals also. About 55% of the farmers had cemented canal to their fields whereas the remaining 45% of the farmers had non-cemented canal structures carrying water to their fields.

Caste systems are prevalent in the developing and underdeveloped countries and play a significant role in various socio-economic dimensions. Families belonging to the upper caste tend to have better
social status. Nepalese society is composed of a multi-caste system and Brahmins are considered as the superior of them all. Brahmins alone consisted of 45.11% of the household in the study area.

The gradient of the canal also plays a major technical role in the delivery of water. The topography of Nepalese hills is gradually sloping from north to the south which facilitates the easy flow of water from northern high altitude to the southern low altitude. Farm households with North-South gradient of the canal were 66.85% and the remaining 33.15% of the household had East-West gradient of the canal.

The land size of the family can be attributed to the better social status of the family along with the economics of scale. The majority of the households were found to have a medium size of landholding consisting of about 80.43% of the total HH in the study area.

The location of the household concerning the canal system also greatly affects their water using capacity and their access to the water resource. In this study, the users at the head end of the canal receive water once in 3 days whereas the users at the tail end of the canal receive water twice in 3 days because there was more cultivable land in the tail region. The head end of the canal is more urbanized and densely populated with small landholdings in comparison to the tail end.

Strong strength of access to the irrigation system was perceived by 75% of the respondents in the study area whereas only 25% of the respondent suggested they had weak strength of access to the irrigation system.

The variable level of trust among farmers (TF), has a coefficient of 0.812 and significance level of 0.082, which is below 0.1 (Table 4), this means that the farmers who perceived high level of trust among farmers have higher tendency to have a strong strength of access to the irrigation system than the individuals who perceived presence of low level of trust among the farmers. The marginal effect of 0.116 suggests that if the farmer thinks of a high level of trust among the farmers, the chance of his strong strength of access to irrigation system increases to 11.6% compared to those who think of a low level of trust among the farmers. A high level of trust among the farmers has a positive correlation to the access of the irrigation system (Pariyar et al., 2018).

### Table 4. Factors affecting the strength of access to the irrigation system in the study area

| Variables | Coefficient | dy/dx | Std. Error | t-value | P-value |
|-----------|-------------|-------|------------|---------|---------|
| R         | 0.258       | 0.037 | 0.591      | 0.44    | 0.663   |
| TF        | 0.812*      | 0.116 | 0.466      | 1.74    | 0.082   |
| G         | −0.608      | −0.074| 0.512      | −1.19   | 0.235   |
| KA        | 1.319**     | 0.149 | 0.602      | 2.19    | 0.028   |
| PC        | −0.495      | −0.067| 0.455      | −1.09   | 0.276   |
| Caste     | 0.296       | 0.040 | 0.476      | 0.62    | 0.534   |
| NS        | 1.002**     | 0.154 | 0.467      | 2.15    | 0.032   |
| FS        | 0.196       | 0.028 | 0.594      | 0.33    | 0.741   |
| POF       | −2.532***   | −0.348| 0.589      | −4.30   | 0.000   |
| Constant  | 1.720       | 0.914 | 1.88       | 0.060   |

| No. of observations | 184 |
|---------------------|-----|
| Prob>chi2            | 0.000 |
| Pseudo r-squared     | 0.241 |

Note: * Level of significance at 0.1, ** Level of significance at 0.05, *** Level of significance at 0.01
The variable agricultural knowledge of farmers (KA) has a coefficient of 1.319 and a significance level of 0.028 which is less than 0.05 (Table 4). This implies that the farmers with some level of sound technical about agriculture have a higher chance of strong strength of access to irrigation systems than the farmers with the absence of sound agricultural knowledge. The marginal effect at 0.149 means that the farmers with some sort of sound technical knowledge on agriculture have an increased tendency at 14.9% of the strong strength of access to the irrigation system, compared with those with no sound agricultural knowledge. If a farmer has no sound knowledge on irrigated agriculture or if he has been practicing rainfed farming his transformation to irrigation agriculture will be difficult but if the farmer has proper knowledge his transformation will be fine, thus strengthening his access to irrigation (Sagardoy et al., 1986).

The variable gradient of the canal (NS) has a coefficient of 1.002 (Table 4) with a significance level of 0.032 which is less than 0.05 and a marginal effect at 0.154. This means that the farmers with North-South gradient of an irrigation canal to their field will have an increased tendency of strong strength of access to irrigation system by 15.4% compared to those with East-West gradient of the canal. In the hills of Nepal, the canals flowing North-South have steep gradients (Pariyar et al., 2018) and as water flows under the influence of gravitational force from a higher altitude to lower altitude, the terrains of Nepal facilitate the movement of water from North to South.

Finally, the variable position or location of the farm (POF) concerning the canal has a coefficient of −2.532 (Table 4) and a significance level of 0.000 which is less than 0.01 and the marginal effect at −0.348. Here, the tendency of the farmers with the location of their farm being at the head of the canal for having strong access to the irrigation system decreases by 34.8% compared to the farmers having the location of their farm at the tail end of the canal. Since our irrigation system was established for supplying water at the agricultural land at the tail end portions and farmers at the head end not being involved in year-round crop production as the tail end, the strength of access was weak at head end which was opposite to most of the literature currently found.

4. Summary

Irrigation contributes positively to farm household agricultural production and income. The main findings of this research are that the strength of the access to the irrigation system is affected by both farmer’s socioeconomic and the physical attributes of the irrigation system. The difference in the characters of the household and the attributes of the irrigation resource for different farm households has created a difference in the strength of access to the irrigation system. Farmers at the head end of the canals are marginalized here because the irrigation system was specifically designed for the users at the tail end. Further, the allocation of water is regulated by providing the water for head-end once in 3 days and for the tail end for two days in 3 days.

The results highlighted that farmers with a high level of trust among each other tend to have a strong strength of access to the irrigation system. Mutual trust, cooperation, and understanding among each other are of prime importance for maintaining and preserving the irrigation resource. The absence of these features in a community or water user groups leads to the mishandling and mismanagement of the resource leading to the delivery of water deprived of equity, equality, reliability, and adequacy.

The results suggested that the presence of sound agricultural knowledge in farmers contributed to a strong strength of access to irrigation systems as they utilized water resources with better efficiency leading to greater satisfaction from the resource.

The elevation drops dramatically from North to South in Nepal (Gautam & Acharya, 2012). The farmers having the north-south gradient of the canal to their field have a natural advantage increasing the per unit of the flow of water in their field. Since the water is allocated based on per unit of time per unit of land. The fields with North-South gradient of canal receive more water than the fields with the East-West gradient of the canal.
5. Conclusion
The results suggested that farmers should be provided with proper agricultural knowledge regarding irrigated agriculture to make them efficient farmers so that they turn responsible for the irrigation system and its use. Farmers at the head end should be motivated for the increased involvement in agriculture and cultivate high-value crops or commercial crops to increase their income from agriculture. Farmers should be provided with the proper agricultural extension services and agriculture-related trainings so that they can increase their efficiency in agricultural activities. Further, the laws and regulations of the irrigation resources should be implemented properly leading to the equitable adoption of the resource by all levels of users. Transparency should be developed in the management of the irrigation system, its fund, and distribution of water leading to a higher level of trust among the farmers. The construction of the canal should be done considering the topography of the area for better performance of the irrigation system for better access to the irrigation system. The distributory canals should be built in North-South direction as the Nepalese topography for better flow of water to the farmers’ field.

Acknowledgements
The research was funded by the University Grant Commission, Nepal. We would like to express our heartfelt gratitude to Post Graduate Committee of Agriculture and Forestry University, Nepal for their constructive and valuable suggestions.

Funding
This study was funded by the University Grant Commission of Nepal.

Author details
Kapil Khanal
E-mail: kapilkhonal46@gmail.com
ORCID ID: http://orcid.org/0000-0002-5071-3282

Kamal Bahadur Adhikari
E-mail: kamal_adhikari@yahoo.com

Shiva Chandra Dhakal
E-mail: scdhakal@gmail.com

Santosh Marahatta
E-mail: smarahatta@yahoo.com

1. Agriculture and Forestry University, Bharatpur, Nepal.

Authors contributions
Kapil Khanal designed and conducted the research and he analyzed and interpreted the data. Prof. Dr. Kamal Bahadur Adhikari, Assoc. Prof. Dr. Shiva Chandra Dhakal, and Assoc. Prof. Dr. Santosh Marahatta guided, advised, suggested, and provided constructive feedback to finalize this manuscript.

Competing Interests
The authors declare no competing interests.

Declaration of interest
All authors declare that there is no conflict of interest.

Citation information
Cite this article as: Factors determining farmers’ strength of access to the irrigation system in Kaski district of Nepal, Kapil Khanal, Kamal Bahadur Adhikari, Shiva Chandra Dhakal & Santosh Marahatta, Cogent Food & Agriculture (2020), 6: 1843751.

References
AITC. (2020). Agriculture and livestock diary 2077. Agriculture Information and Training Centre, Ministry of Agriculture and Livestock Development, Government of Nepal.

Boeke, T., Kasymov, U., & Zikos, D. (2015). Self-governance and sustainable common pool resource management in Kyrgyzstan. Sustainability Switzerland, 7 (1), 496–521. https://doi.org/10.3390/su7010496

Boateng, E. Y., & Abye, D. A. (2019). A review of the logistic regression model with emphasis on medical research. Journal of Data Analysis and Information Processing, 07(4), 190–207. https://doi.org/10.4236/ jdaip.2019.74012

Brein, R., Karlson, K. B., & Holm, A. (2018). Interpreting and understanding logits, probits, and other non-linear probability models. Annual Review of Sociology, 44(1), 39–54. https://doi.org/10.1146/annurev-soc-073117-041429

CBS. (2013). Statistical year book of Nepal - 2013 (14th ed.). Central Bureau of Statistics, National Planning Commission Secretariat, Government of Nepal.

Dhakal, T. R., Davidson, B., & Farquharson, B. (2016). Factors affecting collective actions in farmer-managed irrigation systems of Nepal. Agriculture (Switzerland), 8(6), 1-11. https://doi.org/10.3390/agriculture8060077

Dungumaro, E. W., & Madulu, N. F. (2003). Public participation in integrated water resources management: The case of Tanzania. Physics and Chemistry of the Earth, 28(20–27), 1009–1014. https://doi.org/10.1016/j.pce.2003.08.042

Evans, W. R., Evans, R. S., & Holland, G. F. (2016). Conjunctive use and management of groundwater and surface water within existing irrigation commands: The need for a new focus on an old paradigm. Sinclair Knight Merz, Australia https://sswm.info/sites/default/files/reference_attachments/conjunctiveuseandmgmt.pdf

FAO. (2018). Guidelines on irrigation investment projects. Food and Agriculture Organization of the United Nations, 122. https://doi.org/10.18356/c9807184-en

Gautam, M. R., & Acharya, K. (2012). Streamflow trends in Nepal. Hydrological Sciences Journal, 57(2), 344–357. https://doi.org/10.1080/02626667.2011.637042

Gautam, U. (2012). Nepal: Food security, a localized institutional irrigation perspective on public irrigation systems. Hydro Nepal: Journal of Water, Energy and Environment, 11(1), 95–99. https://doi.org/10.3126/hn.v11i11.7223

Hussain, I., & Hanjra, M. A. (2003). Does irrigation water matter for rural poverty alleviation? Evidence from South and South-East Asia. Water Policy, 5(5–6), 629–642. https://doi.org/10.2166/wp.2003.0027

Kajjo, K. (2018). Role of community and government in irrigation management in emerging states: Lessons from Japan, China, and India. In Keijiro, O., & K. Sugihara (Eds.), Paths to the emerging state in Asia and Africa (pp. 273–292). Springer. https://doi.org/10.1007/978-981-13-3131-2_12

Ostrom, E., Gardner, R., & Walker, J. (1994). Rules, games and common-pool resources (2006 ed.). The University of Michigan Press.
Pariyar, B., Lovett, J. C., & Snell, C. (2018). Inequality of access in irrigation systems of the mid-hills of Nepal. *Area Development and Policy, 3*(1), 60–78. https://doi.org/10.1080/23792949.2017.1353886

Pradhan, P. (2000). May 31 - June 4. Farmer managed irrigation systems in Nepal at the crossroad. 8th Biennial Conference of the International Association for the Study of Common Property (IASCP) (pp. 1–14), Bloomington, Indiana, USA.

Pradhan, P. (2012). Revitalizing irrigation systems for food security: Vision and approaches in nepal irrigation systems. *Hydro Nepal: Journal of Water, Energy and Environment, 2012*(April), 44–49. https://doi.org/10.3126/hn.v11i1.7203

Pradhan, P., & Belbase, M. (2018). Institutional reforms in irrigation sector for sustainable agriculture water management including water users associations in Nepal. *Hydro Nepal: Journal of Water, Energy and Environment, 23*(23), 58–70. https://doi.org/10.3126/hn.v23i0.20827

Rosegrant, M. W., & Svendsen, M. (1993, February). Asian food production in the 1990s: Irrigation investment and management policy. *Food Policy, 18*(1), 13–32. https://doi.org/10.1016/0305-750X(93)90094-R

Sagardoy, J. A., Bottrall, A., & Uittenbogaard, G. O. (1986). Organization, operation and maintenance of irrigation schemes- FAO irrigation and drainage paper 40.

Shrestha, S. (2009). Agriculture and natural resources sector in Nepal. Asian Development Bank, Independent Evaluation Department. https://www.oecd.org/countries/nepal/47146419.pdf

Sijapati, S., & Paudel, T. (2010). Participatory irrigation management: Lessons to learn from FMIS. National Irrigation Seminar - Challenges in Irrigation Development and Management, Lalitpur, Nepal, (pp. 118–125). http://www.dwri.gov.np/public/uploads/file/1538388756.pdf

Yoder, R. (1994). Locally managed irrigation systems: Essential tasks and implications for assistance, management transfer and turnover programs. International Irrigation Management Institute. https://publications.iwmni.org/pdf/11888.pdf

Irrigation assistance service. http://www.fao.org/3/ X5647E/x5647e0b.htm#7

Sampath, R. K. (1992). Issues in irrigation pricing in developing countries. *World Development, 20*(7), 967–992. https://doi.org/10.1016/0305-750X(92)90124-E

Schoengold, K., & Zilberman, D. (2004, September). Water and development: The importance of irrigation in developing countries. Presentation, Berkeley. [Online]. http://are.berkeley.edu/courses/ARE253/2004/handouts/Bretton_Woods.pdf

© 2020 The Author(s). This open access article is distributed under a Creative Commons Attribution (CC-BY) 4.0 license.

You are free to:
Share — copy and redistribute the material in any medium or format.
Adapt — remix, transform, and build upon the material for any purpose, even commercially.

The licensor cannot revoke these freedoms as long as you follow the license terms.

Under the following terms:
Attribution — You must give appropriate credit, provide a link to the license, and indicate if changes were made.
No additional restrictions
You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits.

*Cogent Food & Agriculture* (ISSN: 2331-1932) is published by Cogent OA, part of Taylor & Francis Group.

Publishing with Cogent OA ensures:
- Immediate, universal access to your article on publication
- High visibility and discoverability via the Cogent OA website as well as Taylor & Francis Online
- Download and citation statistics for your article
- Rapid online publication
- Input from, and dialog with, expert editors and editorial boards
- Retention of full copyright of your article
- Guaranteed legacy preservation of your article
- Discounts and waivers for authors in developing regions

Submit your manuscript to a Cogent OA journal at www.CogentOA.com