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Irrigation Project Efficiency Analysis Using Multi Criteria Decision Making Tools

Background and objective

Agriculture is an important part of Nepal's economy and social fabric, contributing an estimated 27% country's GDP in 2017 and providing employment to more than 70% of the labor force. Nepal has 2.64 million hectares (Ha) of arable land (or 18% of its total land area), of which two-thirds (i.e., 1.77 million Ha) is potentially irrigable. Irrigation infrastructure has been developed to provide irrigation to 1.332 million Ha, with around 0.972 million Ha serviced by surface water and the rest by groundwater sources. However, available water is limited, thus, optimizing its use is essential. Multi-criteria decision making (MCDM) is used in circumstances when the decision maker must choose between several usually conflicting objectives, such as optimizing (i.e., finding a good compromise among alternatives) use of water.

A large number of small to large sized irrigation projects are in operation, however, their efficiency is a key concern. A scientific approach for selection of irrigation projects for maintenance is required to mobilize limited resources. Multi Criteria Decision Making (MCDM) approach is suggested for such purpose.

Materials and Methods

Five irrigation projects (Manushmara irrigation system-phase 1, Sarlahi; Kamala Hardinath irrigation system, Danusha; Narayani irrigation system, Birgunj; Rajapur irrigation project, Bardiya; and Kiran nala lift irrigation system, Banke), as shown in Figure 1a, were selected. Nine most important common parameters (conveyance efficiency, application efficiency, soil type, average infiltration rate, initial soil moisture, final soil moisture, crop intensity, evapotranspiration and command area) of the project were identified.

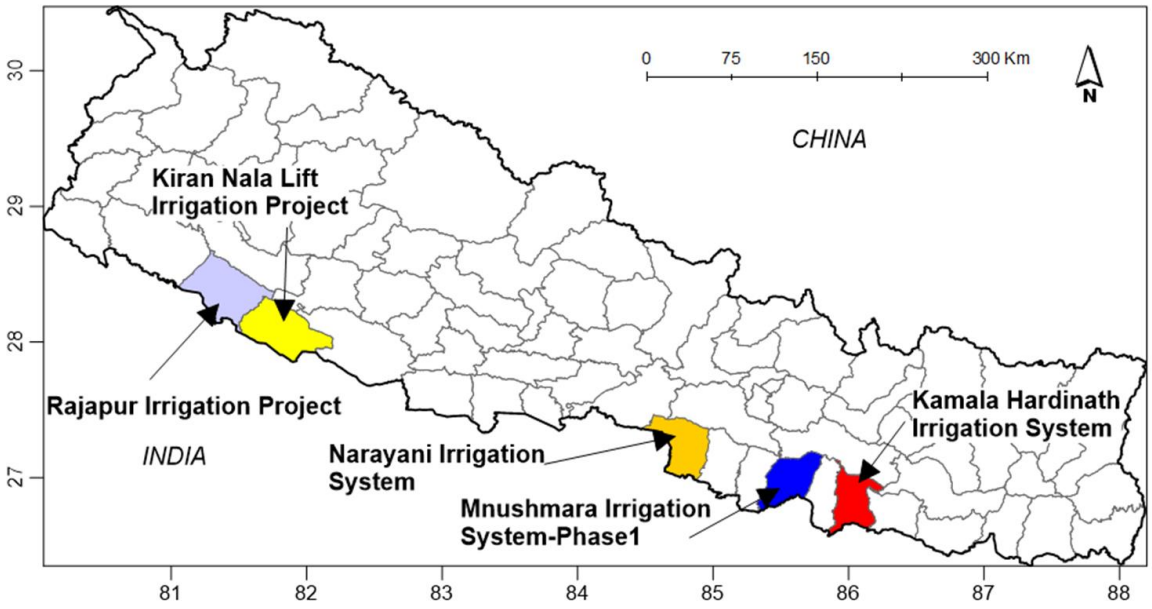

Figure 1: Location of Irrigation projects

Five irrigation projects (Manushmara irrigation system-phase 1, Sarlahi; Kamala Hardinath irrigation system, Danusha; Narayani irrigation system, Birgunj; Rajapur irrigation project, Bardiya; and Kiran nala lift irrigation system, Banke), as shown in Figure 1, were selected. Nine most important common parameters (conveyance efficiency, application efficiency, soil type, average infiltration rate, initial soil moisture, final soil moisture, crop intensity, evapotranspiration and command area) of the project were identified. Questionnaire survey was conducted to identify the relation of each parameter and prioritize the all parameters according to the weightage obtain by the questionnaire survey. Relation of the parameters were identified by Analytical Hierarchy Process (AHP); one of the type of MCDM techniques. Comparison and normalization matrix were formulated, after identify the relation of the parameters. The relative weight of particular parameter is calculated and weight is assigned according to the relative importance of the criteria included for analysis. Prioritization of project is done based on relative weightage of parameters.

Results

The identified parameters were evaluated with MCDM technique using AHP method. The weightage value of each parameters is obtained 1-9 from the questionnaire survey. The pairwise comparison matrix and normalization matrix are developed with nine parameters based on the value obtained from questionnaire survey. Based on the weightage value; among the nine parameters, conveyance efficiency is ranked as first parameter having weightage value 0.30 and command area is ranked as last parameter having weightage value 0.02. Based on the weightage value of each parameters, Kiran Nala Lift irrigation project, Banke is prioritize as the first with a score of 69.92% and Rajapur irrigation project, Bardiya as the last with a score of 51.21%.

Table 1: Prioritization of project based on weightage value

Projects	Weightage value	Manushmara	Kamala	Narayani	Rajapur	Kiran Nala lift
Conveyance Efficiency	0.30	7.00	7.00	5.00	5.00	7.00
Application Efficiency	0.21	5.00	7.00	5.00	7.00	7.00
Soil Type	0.15	7.00	5.00	9.00	3.00	7.00
Average Infiltration Rate	0.11	9.00	7.00	9.00	5.00	9.00
Final Soil Moisture	0.08	7.00	5.00	5.00	5.00	7.00
Initial Soil Moisture	0.06	5.00	5.00	3.00	5.00	5.00
Crop Intensity	0.04	7.00	5.00	5.00	5.00	7.00
Evapotranspiration	0.02	5.00	5.00	5.00	5.00	5.00
Command Area	0.02	3.00	5.00	9.00	5.00	3.00
Total		6.56	6.26	6.01	5.12	6.99
Prioritization Percentage		65.62	62.57	60.08	51.21	69.92

Conclusions

MCDM technique is implemented in agriculture sector to select the best irrigation project on the basis of prioritization percentage. This approach avoids the risk of investing in less beneficial projects for maintenance. The AHP has emerged as a powerful tool that is applicable to all fields of decision making to choose the best overall alternatives based on selection criteria. In this study, AHP method one of the type of MCDM technique, is used to determine the relative weightage value of each parameter.

FOR FURTHER INFORMATION:
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