INTRODUCTION OF AN INTELLIGENT PRE-ANALYSIS METHOD FOR IRRIGATION NETWORKS STUDIES

PRESENTATION D'UNE METHODE INTELLIGENTE DE PRE-ANALYSE POUR ETUDES DES RESEAUX D'IRRIGATION

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ABSTRACT

One of the essential activities to increase water productivity is improving current performance of irrigation networks by making monitoring, evaluation, performance assessment and Operation and Maintenance (O&M) activities better. The main idea behind this research is using a fuzzy clustering methods namely Gustafson-Kessel (GK) clustering algorithms for extracting homogenous areas with similar physical attributes out of the irrigation conveyance network. The case study of this research is Ghazvin irrigation network (GIN) in Iran comprising 12 secondary canals, which are divided into 162 canal reaches with constant capacity. Five physical attributes of canal reaches namely: length, capacity, number of intakes, number of conveyance structures and the covered irrigated area, are applied for spatial clustering. Clustering validity indices indicate that optimum number of clusters is 9 for the clustering algorithm. The 93 canal reaches with membership values (MVs) more than 40% are ranked in 3 classes. MV ranking helps managers to take decision about canal reaches by different ranges of uncertainty. These 93 canal reaches are used to create Ghazvin irrigation network regionalization map in which every cluster is recognized by a specific color and represent a physically homogenous region. Clustering is a feasible approach and is useful in pre-analysis in studies such as: performance evaluation, rehabilitation, modernization and water productivity planning of irrigation networks. Clustering gives useful hints to decision makers for prioritizing existed facilities, budget, workmen, and machinery resources for managing O&M activities.

Key words: *Fuzzy clustering, Irrigation network, Regionalization.*

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RESUME ET CONCLUSIONS

Comme la population continue d'augmenter dans les pays en développement et dans le monde, il y a une demande croissante de sécurité, de sources d'eau fiables pour répondre aux besoins de la population en expansion. Il est nécessaire de maintenir l'approvisionnement en eau adéquat pour produire assez de nourriture, tout en maximisant la productivité de l'eau. L'une des activités essentielles pour accroître la productivité de l'eau est l'amélioration des performances actuelles des réseaux d'irrigation et leur entretien. La plupart de ces activités sont expérimentées. La performance des réseaux est améliorée, compte tenu des paramètres qui varient dans le temps et dans l'espace.

Cette recherche à pour but d'aider dans les méthodes de classification pour retenir les zones homogènes ayant les mêmes caractéristiques physiques hors du réseau d'adduction d'irrigation. L'étude de cas de cette recherche est le réseau d'irrigation de Ghazvin (GIN) en Iran. Cette étude concerne 12 canaux secondaires de la GIN qui sont divisées en 162 canaux. Cinq caractéristiques physiques du canal à savoir: longueur, capacité, nombre de prises, nombre de structures de transport et de zones irriguées, sont appliquées aux grappes spatiales. L'une des méthodes de classification GK algorithmes de classification, est utilisée pour classer l'ensemble des données. Clustering la validité des indices de sorte que le nombre optimal de clusters est de 9. Bien que les résultats de clustering sont vérifiés avec les indices clustering de validité, les résultats confirment que l'ensemble des caractéristiques physiques sont apportées en matière de regroupement de l'ensemble des données et il n'ya pas seulement un ou deux traits dominants en matière du processus de regroupement. Les valeurs d'appartenance (VM) de plus de 40% sont classés en 3 catégories. Classement VM aide les gestionnaires à prendre une décision au sujet du canal atteint par différentes gammes d'incertitude. Ces 93 tronçons du canal sont utilisés pour créer la carte du réseau d'irrigation de Ghazvin.

L'approche Clustering est possible qui pourrait être utilisée comme étude préalable pour l'évaluation des performances, la réhabilitation, la modernisation et la planification de productivité de l'eau des réseaux d'irrigation.

Mots clés: *Clustering imprécis, réseau d'irrigation, régionalisation.*

1. INTRODUCTION

An analysis by FAO of 93 developing countries indicates that within 32 years period from 1998 to 2030, the agriculture production should be increased by 81% in irrigation systems. Therefore, major portion of the additional food production should come from irrigated land, three-quarters of which are located in developing countries (Playán & Mateos, 2004). Many irrigation schemes in developing countries suffer from poor management, both in its technical and social dimensions.

Irrigation networks performance can be improved, provided that the variant spatial and temporal factors are considered. One of the concerns of the irrigation managers is to cope with spatial diversity and temporal variability of parameters that strongly affect the operation and maintenance (O&M) activities (Sarwara et al., 2001). The spatial diversity is created by different reasons such as: physical differences between canals and structures in different areas of irrigation networks; operators with different knowledge and experiences; various type of management, etc. Unfortunately, no quantitative approaches have been introduced to assert how O&M activities should be oriented with respect to spatial and temporal parameters. Regionalization of irrigation networks is one of the approaches, which could be used to facilitate activities such as evaluation of irrigation network, modernization, rehabilitation and especially for O&M activities.

Fuzzy clustering technique was applied on temporal data in specific period of time for Goulburn and Shi-jin irrigation networks in Australia and China, respectively, as a managerial tool for clustering of temporal data by Malano and Gao (1992). Clustering technique could be used for spatial data to distinguish similar areas and to facilitate the management of the network. The main idea behind this research is using Gustafson-Kessel (GK) clustering for extracting homogenous areas with similar physical attributes out of the irrigation conveyance network. Clustering technique enables the managers to limit the spatial boundaries of decisions making from large scale, irrigated area, to limited homogenous regions.

2. METHODS

The Gustafson-Kessel (GK) algorithm

The process of grouping a set of objects into classes with similar attributes is called clustering (Han & Kamber 2006). The main potential of clustering is to detect the underlying structure in data set. In this paper one of the applicable fuzzy clustering algorithms named Gustafson-Kessel (GK) are used because of its wide and successful applications in several fields. The objective function of the GK algorithm is defined by Equation 1 (Babuska et al 2002):

$$J(X;U,V,A) = \sum_{i=1}^{c} \sum_{k=1}^{N} (\mu_{i,k})^m D_{i,kA_i}^2 \qquad (1)$$

Where is the dataset; is the partition matrix; is cluster centers matrix; and is an adaptive distance norm. Gustafson and Kessel employed this adaptive distance norm in order to detect clusters of different geometrical shapes through a data set (Gustafson & Kessel, 1979).

Fuzzy clustering validity indices

One of the important issues in using clustering methods is choosing an optimal number of clusters (Weatherill & Burton, 2008). In this paper four cluster validity indices named SC (Partition Index), CE (Classification Entropy), S (Separation Index), and XB (Xie and Beni) are applied for finding optimal number of clusters (Bezdek, 1981; Bensaid et al, 1996; Xie & Beni, 1991))

3. RESULTS AND DISCUSSION

According to applied fuzzy clustering indices, the optimal number of clusters is 9 clusters. The results show that 37 reaches have the membership values (MV) more than 70 per cent,

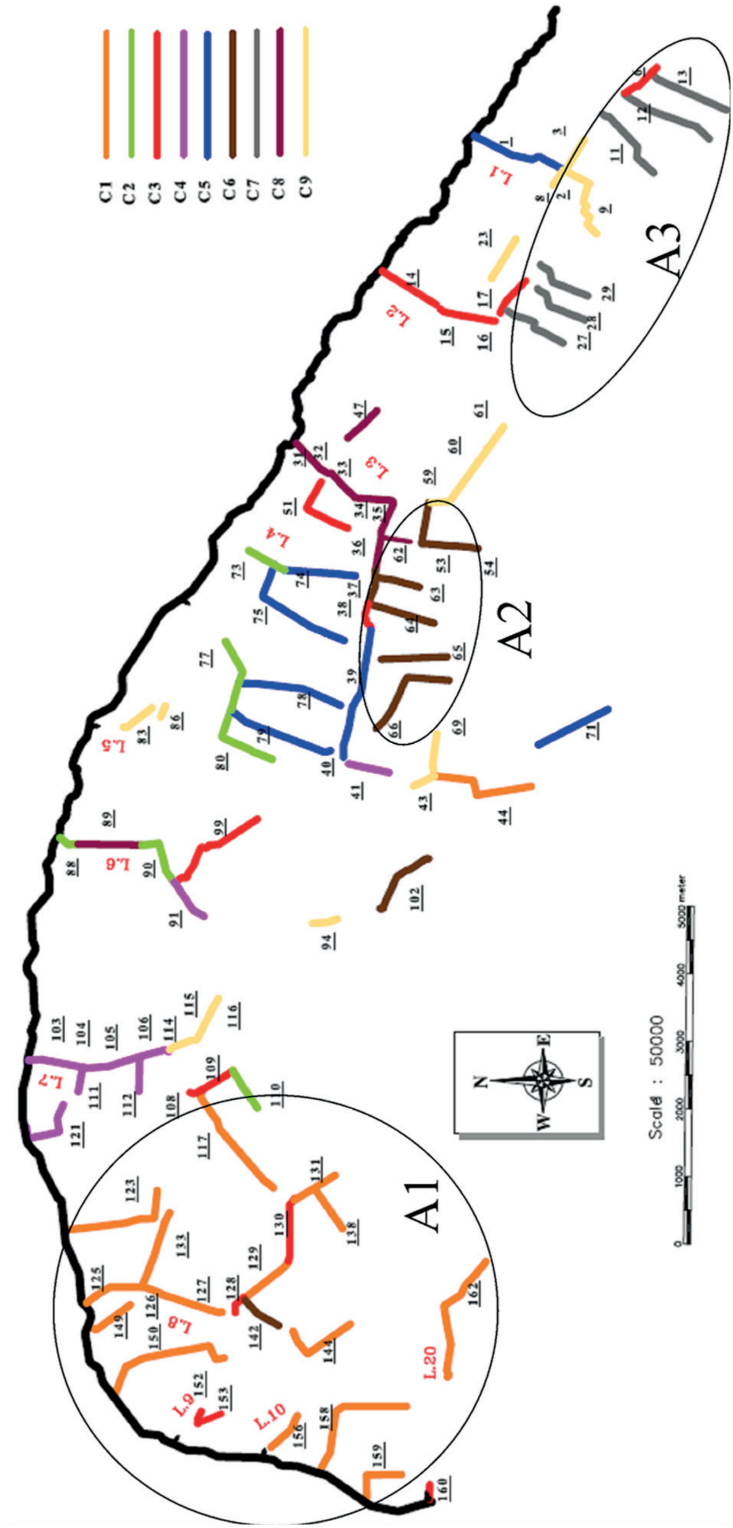

Fig. 1. The Ghazvin irrigation network regionalization map using fuzzy GK method (Plan de régionalisation du réseau d'irrigation de Ghazvin en utilisant la méthode floue GK)

36 reaches have MV between 50 to 70 per cent and 20 reaches have MV in the range of 40 to 50 per cent . The rest of the reaches have MV less than 40 per cent. Therefore these 93 reaches which have membership values more than 40 percent are used to create the Ghazvin canal network regionalization map presented in Figure 1. This Ranking of membership values allows managers to take decision about canal reaches by different ranges of certainty. The results indicate that the canal reaches are spread among all clusters. The canal reaches in the same cluster have similar physical attributes, so it provides the capability to make same decision for these objects. For the canal reaches with membership degrees lower than 40 percent, knowledge and experiences of the managers, authorities and operators in accompany with clustering results could be utilized to make managerial decisions.

When several similar reaches are situated close together, the numbers of O&M inspections and subsequently the operation and maintenance expenses will be decreased. This desire state is happened for 3 clusters, which are marked with A1 to A3 in Figure 1.

4. CONCLUSIONS

Many records are collected in regular inspections and annual surveys in irrigation districts. In many cases, these statistics just use in forms of charts and tables in reports. Usually, comparing these statics give hints to make decisions for O&M activities. However, the key point is that, comparing data for extended system like irrigation networks without applying powerful tools is beyond the human ability. Consequently, important decisions are often made based not on the information but rather on a decision maker's intuition, simply because the decision maker does not have the tools to extract the valuable knowledge embedded in the data. Thus, using assured and capable approaches, like data mining approaches, that can apply wide variety of data are indispensible for regionalization of irrigation networks.

Each of the created clusters is representative of a physical homogenous region of canals with similar physical attributes, which could help managers to prioritize the existed facilities for managing the O&M activities.

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