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Critical analysis of rural waste management weaknesses

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ABSTRACT

BACKGROUND AND OBJECTIVES: Establishing a good sound waste management system for a community requires a comprehensive knowledge of the current status and issues involved in present waste management system. This research was conducted to identify and prioritize waste management weaknesses in Saravan village of Guilan province, Iran.

METHODS: Data were gathered through a descriptive-analytical approach using a purposive sampling and researcher-made questionnaire method. Waste management weaknesses were prioritized by Analytic Hierarchy Process (AHP), Fuzzy Analytic Hierarchy Process (FAHP), and Analytic Network Process (ANP).

FINDINGS: The most important weakness of rural waste management in the study area was waste management structure, equipment, and infrastructures weakness (index C) with relative importance values of 38.1% in AHP, 37.3% in FAHP, and 38.2% in ANP approaches. The village inhabitants' weakness (index B) with relative importance values of 16.5% in AHP, 17.2% in FAHP, and 1.4% in ANP had the lowest priority among studied weaknesses. Workforce weakness (index A), and educational and cultural weakness (index D) were the second and third important weaknesses, respectively. The most important sub-indices weakness of these weakness indices were non-compliance of Rural Municipality Manager (RMM) with waste management standards, rules, and regulations; Waste disposal by the village inhabitants at the nearest site; failure to establish a solid waste fix station in the village; and lack of training and awareness of villagers about waste management.

CONCLUSION: In order to establish a successful waste management system in rural areas, it is recommended to develop a comprehensive strategy that involves aspects such as; establishing proper waste management infrastructures, employment of skilled staff, and conducting training plans and motivational programs for staff and inhabitants.

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INTRODUCTION

Environmental and population health are the pre-requisites for sustainable development. There is an undeniable relationship between man and the environment (Van der Zwiep, 1994). In today's world, environmental crises such as global warming, habitat and natural resource destruction, pollutions rise, population growth, etc. cannot be overlooked, as each of these crises somehow affects human life (Kaiser *et al*., 1999). Waste management is an important issue worldwide especially for its importance in global environmental issues (Michael-Agwuoke, 2017). Daily waste production in Iran is reported to be 48,000 tons where 10,000 tons of which is rural waste, with a per capita daily waste production of 450 g in the country's villages (OMVMC, 2018). Since the beginning of human life, waste production has been an indispensable part of man's life in various household waste, agricultural, medical, sanitary, and industrial sectors. Hence, the production of these diverse materials in various forms has led to many environmental problems. Over the years, such materials have been discharged into recipient lands and waters with maximum neglect and disregard of engineering and environmental principles, which in turn causes water, soil, and air pollution and thereby endangering the health of human and other living organisms. The quantity and quality of waste produced at different locations are highly heterogeneous and are affected by environmental conditions, season, geographical location, as well as economic, social, and cultural factors, and other factors (Russell, 1988). Wastes are typically solid substances that are created by the activity of living organisms to survive due to environmental, industrial, agricultural, mineral and urban plans and issues. Waste is referred to as all unnecessary and economically unusable materials produced by human activities that are intentionally or accidentally released into the environment (Kamara, 2006). Wastes generated in rural areas can be classified into two large groups of household wastes and agricultural wastes. The former is generally the waste generated by common household activities (Pakpour *et al*., 2014). According to the definition by the European Union, agricultural wastes are those produced from various agricultural operations, including harvesting wastes, pesticide residues entering water, air or soil, crop residues in the farms, etc. (Nagendran, 2011). Waste Management is defined as a series of coherent and systematic regulations for controlling the generation to dispose of wastes in accordance with the principles of public health, economics, engineering, conservation, aesthetics, and other environmental considerations (Sujauddin *et al*., 2008). Wastes are directly associated with climate change. Most scientists believe that climate change is a serious threat to society as it has a great impact on human health, including increasing Cerebellar strokes, respiratory and cardiovascular problems (Mohan *et al*., 2006). Different wastes inevitably result from the widespread use of chemicals, and industrial and agricultural products in everyday life. Global experience has shown that improper waste management by inadequate disposal or inappropriate conversion of wastes into less risky materials, may become source of many potential hazards and threats (Tchobanoglous and Frank, 2002). In the past waste management was not considered as a problem due to the low population density, and lack of food product diversity and available lands for waste disposal. Nowadays, however, with rapid population growth, changing patterns of household consumption, changes in the quantity and quality of wastes, high costs, and insufficient land for waste disposal, it is necessary to pay more attention to waste management, especially in rural environments (Mohan *et al*., 2006). Changes of the pattern of consumption and lifestyle of rural households have led to generation of a significant quantity of perishable and unperishable leftover materials and increased production of wastes (Demirbas, 2011). More emphasis is now placed on the crucial role and also the urgent need for more attention to waste management in the rural area. With population growth, lifestyle development in villages and subsequent changes in consumption pattern, which increases waste generation that subsequently creates problems for today's societies. In addition to human and animal health problems, it also causes ecological adversity and disrupts the economic resources of rural societies (Sharholy *et al*., 2008). Today, the environmental hazards resulting from improper waste management are one of the major problems in Iran, and this problem is more pronounced in rural areas than in the cities. Considering the importance of the rural community and the challenges facing this community in its development process, understanding

the characteristics of rural development planning and addressing all aspects of it is essential. Therefore, protection of the rural environment cannot be abandoned, rather, it is necessary to pay special attention to their waste management in national plans (Saffari, 2013). This matter is more important in villages with rich environmental and natural resources, such as those in Guilan province. Although these days more attentions are paid to the issues of rural environmental pollution and aesthetic features in most villages of Iran. However, the problems relating to improper waste management such as water and soil pollution, and landscapes ugliness of villages, are not still well-known or are less considered among villagers. As a result, rural waste management is not yet perceived as a necessity by the Iranian rural people. Waste management plays an important role in public and individual health and the environment. In order to plan for a proper waste management system in a region, it is primarily required to understand issues such as the current conditions of waste generation and management, existing problems, and weaknesses and strengths of the current waste management systems. Analytic Hierarchy Process (AHP) is a multi-indices decision support method which is used by decision makers when faced with a problem involving multiple objectives and indices (Al-Hawari *et al*., 2011). Literature review shows that Analytic Hierarchy Process (AHP) method has been successfully used in studies focusing on the evaluation of different waste management related options (Chen *et al*., 2014; Babalola, 2015; Sahil, 2017; Gusmerotti *et al*., 2019). Analytic Network Process (ANP) is a generalized form of AHP. It overcomes the limitations of AHP and provides the ability to handle the dependencies and interactions across the elements at various levels (Zhang *et a*l., 2015). Applications of ANP have been reported for analysis of waste management (Khan and Faisal, 2008; Bottero *et al*., 2011; Aung *et al*., 2019). Fuzzy Analytical Hierarchy Process (FAHP) is a combination of the traditional AHP and fuzzy theory which can be applied for vague decisions and minimize uncertainties (Wang *et al*., 2012; Istianto and Sugiantoro, 2018). FAHP has been used for decision making and analysis in the fields of waste management (Che, 2010; Ho, 2011; Kuznichenko *et al*., 2018; Khoshand *et al*., 2019; Ocampo, 2019). So far, many studies have been conducted on the conditions of waste generation and management in various locations (Beigl *et al*., 2008; Saeed *et al*., 2009; Thi *et al*., 2015; Mian *et al*., 2017; Omran *et al*., 2018; Bourtsalas *et al*., 2019). However, reviewing the literature did not show any research being conducted on the weaknesses of waste management. Information acquisition on the current status and waste-related problems in a region can help in providing solutions for improving regional waste management so that local municipalities can achieve an acceptable level of waste management. Therefore, the present research seeks to identify waste management weaknesses in villages. Saravan village (near Rasht city, Guilan province) has been chosen for a case study. Inadequate and improper management of wastes in northern Iran has caused serious public health and environmental problems in these regions. Therefore, in order to find appropriate solutions, it is necessary to analyze the existing weaknesses of waste management. The AHP, ANP and FAHP decision support approaches were comparatively applied in this study for investigating and ranking waste management weaknesses. The current study has been carried out in Saravan village of Rasht city, Guilan province of Iran from July to September, 2019.

MATERIALS AND METHODS

This is an applied research and is a methodologically qualitative study. Field information was gathered by a descriptive-analytic approach. The statistical sample of this research included 15 technicians, and scientific and executive experts in the field of rural waste management, whom were interviewed in 2018. The research instrument was a researcher-made questionnaire containing paired comparisons of the three indices. The main indices (n = 4), first-level sub-indices (n = 7), and second-level sub-indices (n= 53) had six, four, and 176 paired comparisons, respectively. The questionnaire was validated by authorized experts in Guilan waste management industry who worked in different public organizations, and University of Guilan. Thirty experts were selected as study samples by purposive sampling technique. Face-to-face interviews were used for accomplishing pairwise comparisons of weaknesses. In order to determine the importance and compare the weight of each weakness, the experts' answers to pairwise comparisons were ranked using AHP, FAHP, and ANP approaches. In this

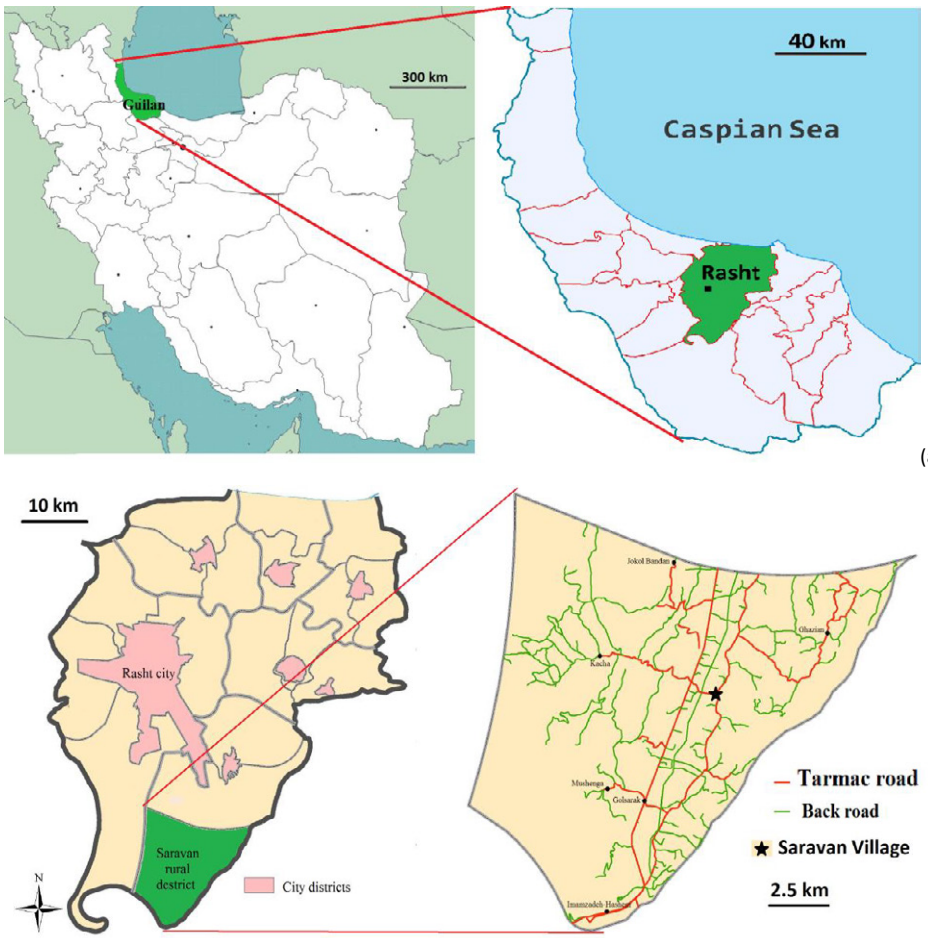
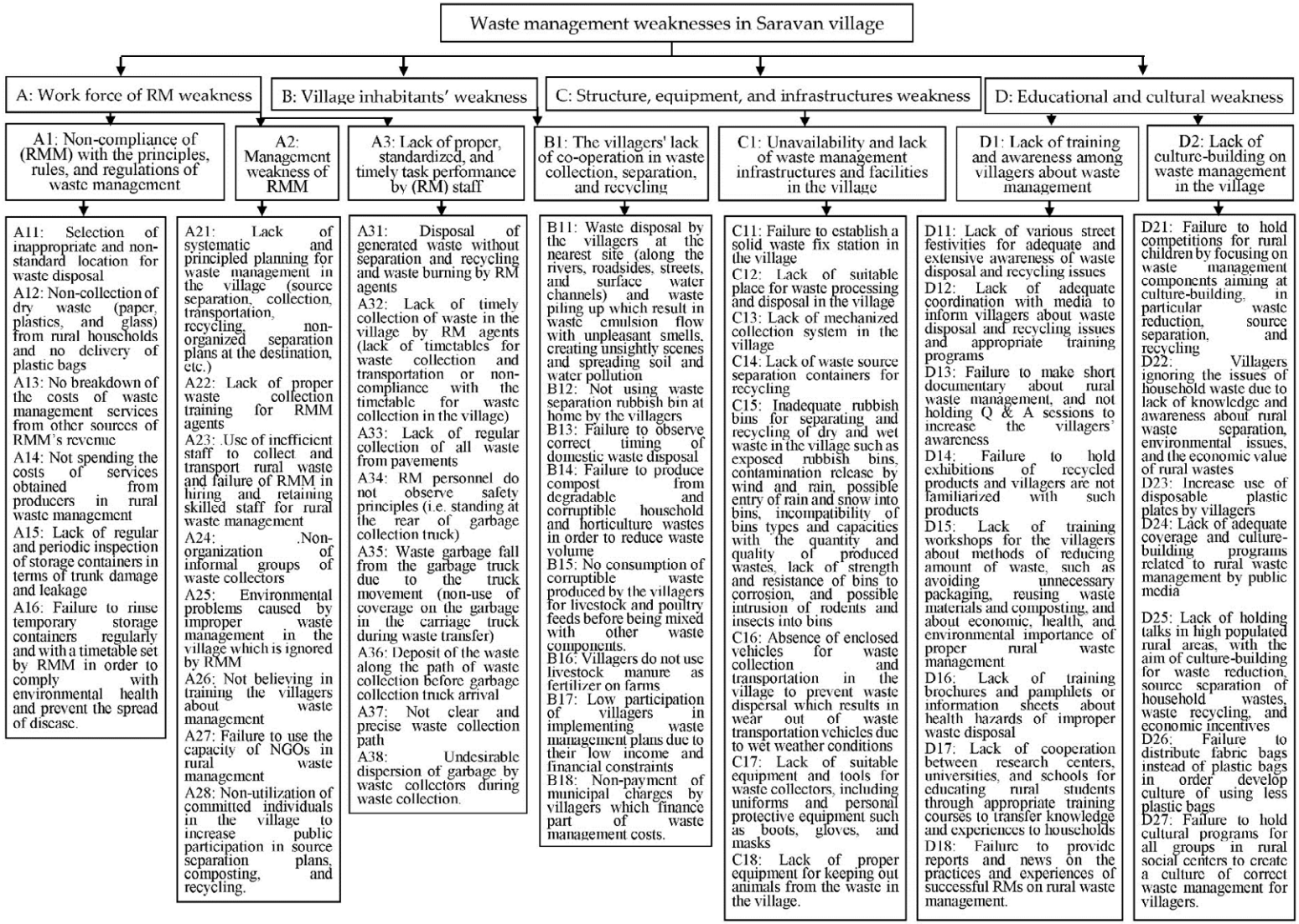


Fig. 1 Study area: a) Rasht County of Guilan Province in northern Iran, b) Saravan village in Saravan rural district of Rasht county

study, information was obtained from Saravan village located in Rasht district, Guilan province. The Saravan village is one of the seven villages of Saravan rural district. The Saravan rural district which is limited to Lakan and Sangar rural districts to the west and north, respectively, and Rudbar city to the south and southeast, has seven villages, including Ghazian, Saravan, Jokol Bandan, Kacha, Golsarak, Mushenga, and Imamzadeh Hashem (Fig. 1). This rural district has an area of 98.69 km^2 and is located between plain and mountains. The population of this area was 14837 in 1996, which decreased to 13989 in 2006, but the number of households increased by 572 families during this period (GPMPO, 2006). In 2011, the district had 14,041 inhabitants and 4,233 families (GPMPO, 2011). The population of Saravan district has decreased again to 12586 (4233 families) from which 5542 (1837 families) lived in Saravan village (GPMPO, 2016). Field surveys, expert interviews, and literature review showed that waste management in Saravan village has four main indices, including A- workforce of rural municipality (RM) weakness, B- village inhabitants' weakness, C- structure, equipment, and infrastructures weakness, and D- educational and cultural weakness.

The first index (A) was divided into three first-level sub-indices A1, A2 and A3. A1: non-compliance of rural municipality manager (RMM) with the principles, rules, and regulations of waste management (with six second-level sub-indices

Fig. 2: Hierarchical decision tree



A11-A16). A2: management weakness of RMM (with eight second-level sub-indices A21-A28). A3: lack of proper, standardized, and timely task performance by rural municipality (RM) staff (with eight second-level sub-indices A31-A38). The second main index (B) had one sub-index, B1: the villagers' lack of co-operation in waste collection, separation, and recycling (with eight second-level sub-indices B11-B18). The third main index (C) had one sub-index, C1: unavailability and lack of waste management infrastructures and facilities in the village (with eight second-level sub-indices C11-C18). The fourth main index included two first-level sub-indices, namely, D1: lack of training and awareness among villagers about waste management (with eight second-level sub-indices D11-D18), and D2: lack of culture-building on waste management in the village (with seven second-level sub-indices D21-D27). Accordingly, the hierarchical tree of this research is presented in Fig. 2.

RESULTS AND DISCUSSION

The responses of 15 waste management experts with the consistency rate of below 0.1 were compared to determine the relative weights at different levels. At the first level, four main weakness indices were compared, including workforce (A), villagers (B), waste management structure, equipment, and infrastructure (C), and education and culture (D). The inconsistency rates in AHP, FAHP, and ANP were 0.01%, 0.03%, and 0.01%, respectively. AHP results showed that the main index C had the highest priority with a relative importance of 38.1%. The second, third, and fourth ranks were attributed to A (24.6%), D (20.8%), and B (16.5%), respectively, based on the relative importance values in AHP. Application of FAHP and ANP approaches also generally yielded similar results. Considering the obtained relative importance values in AHP, FAHP, and ANP approaches, the priorities were the same in all approaches (Fig. 3). Results showed that the weakness of waste management structure, equipment, and infrastructures (C) had the highest priority among the first-level indices with relative importance values of 38.1% in AHP, 37.3% in FAHP, and 38.2% in ANP approaches. Meanwhile, the villagers' weakness (B) with relative importance values of 16.5% in AHP, 17.2% in FAHP, and 16.4% in ANP had the lowest priority among the first-level indices. Inadequate waste management infrastructure causes a number of health impacts, affecting schools, hospitals, and public squares, especially in the poorest areas (da Paz *et al.*, 2020).

A comparison was made among three second-level sub-indices of A, the inconsistency rates were 0.02%, 0.05%, and 0.01% in AHP, FAHP, and ANP, respectively. AHP results showed that the sub-index of A1 (non-compliance of RMM with waste management standards, rules, and regulations) had the highest priority with a relative importance of 48.1%. The second and third ranks belonged to A2 (29.4%) and A3 (22.6%), respectively, based on the

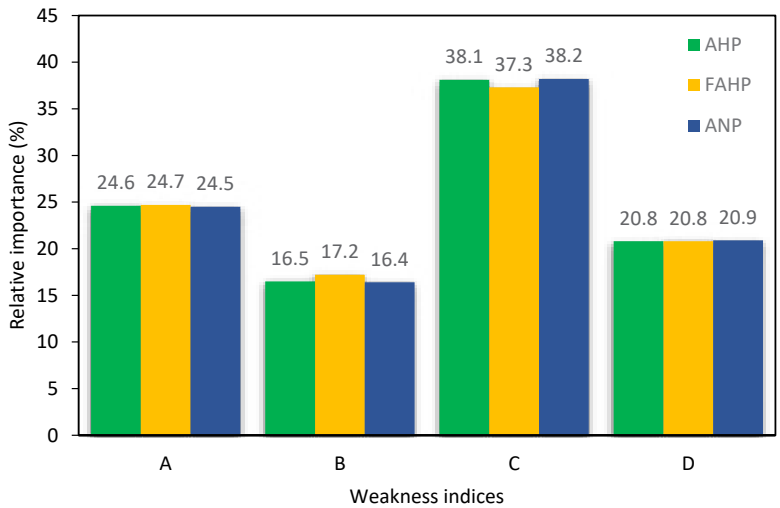


Fig. 3: Comparison of relative importance (weights) of first-level weakness indices using AHP, FAHP, and ANP approaches

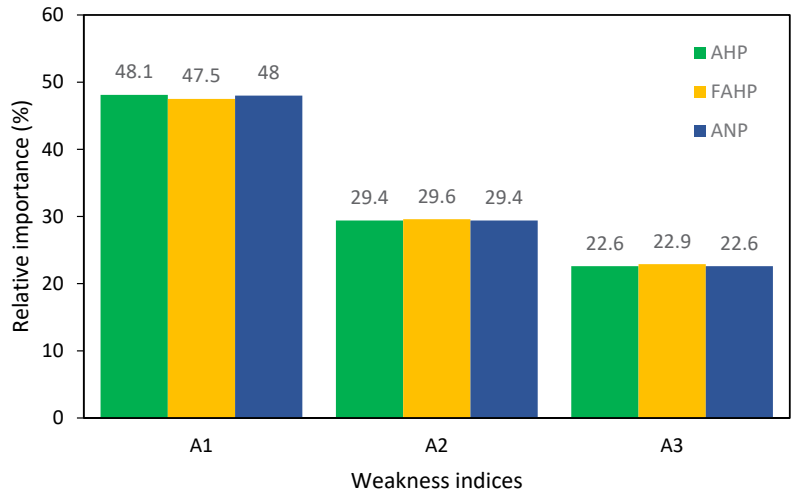


Fig. 4: Comparison of relative importance (weights) of second-level weakness indices of A using AHP, FAHP, and ANP approaches

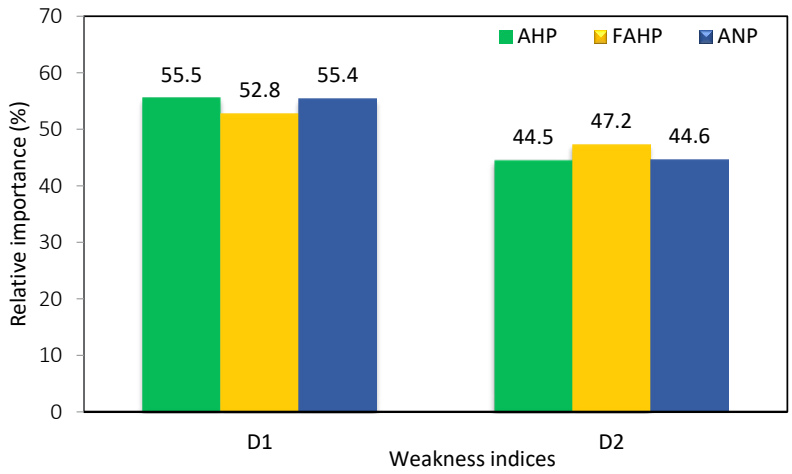


Fig. 5: Comparison of relative importance (weights) of second-level weakness indices of D using AHP, FAHP, and ANP approaches

relative importance values in AHP. With regard to the relative importance values obtained in AHP, FAHP, and ANP approaches, the priorities were the same in all three approaches (Fig. 4).

A comparison was also made between two sub-indices of D. The inconsistency rates were 0.00%, 0.01%, and 0.00% in AHP, FAHP, and ANP, respectively. AHP results revealed that D1 sub-index had the highest priority among the sub-indices of D, with a relative importance of 55.5%. D2 was ranked second with a relative importance of 44.5%. Also, similar priorities were obtained given the relative importance values resulted by FAHP, and ANP approaches (Fig. 5).

The results of this study are consistent with those of (Yoada *et al*., 2014), which concluded that public educations and training workshops are constructive measures toward proper rural waste management. The results showed that the lack of training and awareness of villagers about waste management (D1) had the highest priority among second-level indices, with relative importance values of 55.5% in AHP, 52.8% in FAHP, and 55.4% in ANP. The lack of proper, standard, and timely task performance by RM staff (A3) had the lowest priority among second-level indices, with relative importance values of 22.6% in AHP, 22.9% in FAHP, and 22.6% in ANP. At the third

Table 1: Prioritization of weaknesses and relative importance values of the sub-indices of the A1 index based on AHP, FAHP, and ANP

Priority	Second-level sub-indices	Symbol	AHP	FAHP	ANP
			Relative importance (%)	Relative importance (%)	Relative importance (%)
1	Selection of inappropriate and non-standard location for waste disposal	A11	24.3	24.2	24.7
2	Non-collection of dry waste (paper, plastics, and glass) from rural households and no delivery of plastic bags	A16	20.3	20.2	20.3
3	No breakdown of the costs of waste management services from other sources of RMM's revenue	A12	16.5	16.4	16.5
4	Not spending the costs of services obtained from producers in rural waste management	A13	14.3	14.4	14.3
5	Lack of regular and periodic inspection of storage containers in terms of trunk damage and leakage	A14	13.7	13.8	13.4
6	Failure to rinse temporary storage containers regularly and with a timetable set by RMM in order to comply with environmental health and prevent the spread of disease	A15	10.9	11	10.8
AHP inconsistency rate = 0.00 , FAHP inconsistency rate = 0.01, ANP inconsistency rate = 0.00					

Table 2: Prioritization of weaknesses and relative importance values of the sub-indices of the A2 index based on AHP, FAHP, and ANP

Priority	Second-level sub-indices	Symbol	AHP	FAHP	ANP
			Relative importance (%)	Relative importance (%)	Relative importance (%)
1	Lack of systematic and principled planning for waste management in the village (source separation, collection, transportation, recycling, non-organized separation plans at the destination, etc.)	A21	14.5	14.4	14.5
2	Lack of proper waste collection training for RMM agents	A22	13.7	13.6	13.7
3	Use of inefficient staff to collect and transport rural waste and failure of RMM in hiring and retaining skilled staff for rural waste management	A24	13.1	13.1	13.1
4	Non-organization of informal groups of waste collectors	A23	12.7	12.6	12.7
5	Environmental problems caused by improper waste management in the village which is ignored by RMM	A26	12.2	12.2	12.2
6	Not believing in training the villagers about waste management	A25	12.1	12.1	12.1
7	Failure to use the capacity of NGOs in rural waste management	A27	11.1	11.3	11.1
8	Non-utilization of committed individuals in the village to increase public participation in source separation plans, composting, and recycling	A28	10.6	10.7	10.6
AHP inconsistency rate = 0.00, FAHP inconsistency rate = 0.01, ANP inconsistency rate = 0.00					

level, six sub-indices of A1 sub-level were compared using different approaches. AHP results showed that the second sub-index A11 with a relative importance of 24.3%, and A15 with a relative importance of 10.9% had the highest and lowest priorities, respectively. The application of FAHP and ANP approaches also yielded similar results in priorities (Table 1).

Eight sub-indices of A2 index were compared and the AHP results showed that the second-level sub-indices A21 and A28 with relative importance values of 14.5% and 10.5% had the highest and the lowest priorities, respectively. Considering the relative importance values obtained in AHP, FAHP and ANP approaches, the priorities were the same among all approaches (Table 2).

Also, eight sub-indices from the A3 index were

Table 3: Prioritization of weaknesses and relative importance values of the sub-indices of the A3 index based on AHP, FAHP, and ANP

Priority			Second-level sub-indices	Symbol	AHP	FAHP	ANP
AHP	FAHP	ANP			Relative importance (%)	Relative importance (%)	Relative importance (%)
1	1	1	Disposal of generated waste without separation and recycling and waste burning by RM agents	A33	16.1	15.9	16
2	2	3	Lack of timely collection of waste in the village by RM agents (lack of timetables for waste collection and transportation or non-compliance with the timetable for waste collection in the village)	A35	15.1	14.8	15
3	3	2	Lack of regular collection of all waste from pavements	A32	14.3	14	14.4
4	5	4	RM personnel do not observe safety principles (i.e. standing at the rear of garbage collection truck)	A37	12.3	12.4	12.5
5	4	5	Waste garbage fall from the garbage truck due to the truck movement (non-use of coverage on the garbage in the carriage truck during waste transfer)	A38	12.1	12.2	12
6	6	6	Deposit of the waste along the path of waste collection before garbage collection truck arrival	A34	10.6	10.7	10.7
7	7	7	Not clear and precise waste collection path	A36	10.4	10.5	10.4
8	8	8	Undesirable dispersion of garbage by waste collectors during waste collection	A31	9.1	9.5	9

AHP inconsistency rate = 0.00, FAHP inconsistency rate = 0.02, ANP inconsistency rate = 0.00

evaluated and the results of AHP, FAHP, and ANP showed that the second-level sub-index A33 had the highest priority with relative importance values of 16.1% in AHP, 15.9% in FAHP, and 16% in ANP. The A31 index with relative importance values of 9.1% in AHP, 9.4% in FAHP, and 9% in ANP had the lowest priority (Table 3).

At the third level, eight sub-indices were compared from indices B1. The results of AHP, FAHP, and ANP indicated that the second-level sub-index B11 had the highest priority with relative importance values of 18.1% in AHP, 17.7% in FAHP, and 17.7% in ANP. The second-level sub-index B18 had the lowest priority with relative importance values of 7.4% in AHP, 7.7% in FAHP, and 6.7% in ANP (Table 4). Eight sub-indices were compared from the C1 index. AHP results showed that the second-level sub-indices C13 and C18 with relative importance values of 14.9% and 9.3% had the highest and the lowest priorities, respectively. The application of FAHP and ANP approaches also yielded similar priorities (Table 5). Results from the evaluation of eight sub-indices of D1 are presented in Table 6. AHP results showed that the second-level sub-indices D17 and D18 with relative importance values of 15.2% and 10.1% had the highest and the lowest priorities, respectively. The application of FAHP and ANP approaches also yielded similar results. The results of the present study are in line with that of Apostol and Mihai (2012). They found that awareness and holding workshops could attract the participation of villagers in proper waste management. The results of the present research also corresponds to those of Wang *et al*., (2014), Barr *et al*., (2001), Bayard and Jolly (2007), and Frick *et al*., (2004), who emphasized the impact of knowledge on the environmental-related behaviors of the community. Therefore, it seems necessary to develop suitable programs to increase the knowledge and awareness of villagers about rural waste management. This is because of the fact that the knowledge and awareness of people is an important and influential factor in waste management behaviors which facilitate program implementation and ensuring its success to a large extent (Sujauddin *et al*., 2008; Purcell and Magette, 2010; Maddox *et al*., 2011; Bortoleto *et al*., 2012). The final evaluation was done on seven sub-indices of D2. AHP results showed that the second-level sub-indices D23 and D26 with relative importance values of 16.9% and 11.7% had the highest and the lowest

Table 4: Prioritization of weaknesses and relative importance values of the sub-indices of the B1 index based on AHP, FAHP, and ANP

Priority			Second-level sub-indices	Symbol	AHP	FAHP	ANP
AHP	FAHP	ANP			Relative importance (%)	Relative importance (%)	Relative importance (%)
1	1	1	Waste disposal by the villagers at the nearest site (along the rivers, roadsides, streets, and surface water channels) and waste piling up which result in waste emulsion flow with unpleasant smells, creating unsightly scenes and spreading soil and water pollution	B11	18.1	17.7	17.7
2	3	2	Not using waste separation rubbish bin at home by the villagers	B12	14.1	14.1	16.6
3	2	3	Failure to observe correct timing of domestic waste disposal	B13	14.1	13.9	13.9
4	4	4	Failure to produce compost from degradable and corruptible household and horticulture wastes in order to reduce waste volume	B14	13.8	13.7	13.6
5	5	5	No consumption of corruptible waste produced by the villagers for livestock and poultry feeds before being mixed with other waste components.	B16	11.9	12	11.6
6	6	6	Villagers do not use livestock manure as fertilizer on farms	B15	10.4	10.6	10
7	7	7	low participation of villagers in implementing waste management plans due to their low income and financial constraints	B17	10.2	10.3	9.9
8	8	8	Non-payment of municipal charges by villagers which finance part of waste management costs	B18	7.4	7.7	6.7
AHP inconsistency rate = 0.01, FAHP inconsistency rate = 0.02, ANP inconsistency rate = 0.02							

Table 5: Prioritization of weaknesses and relative importance values of the sub-indices of the C1 index based on AHP, FAHP, and ANP

Priority	Second-level sub-indices	Symbol	AHP	FAHP	ANP
			Relative importance (%)	Relative importance (%)	Relative importance (%)
1	Failure to establish a solid waste fix station in the village	C13	14.9	14.9	14.9
2	Lack of suitable place for waste processing and disposal in the village	C12	14.2	14.1	14.2
3	Lack of mechanized collection system in the village	C11	13.7	13.6	13.4
4	lack of waste source separation containers for recycling	C14	13	13	12.9
5	Inadequate rubbish bins for separating and recycling of dry and wet waste in the village such as exposed rubbish bins, contamination release by wind and rain, possible entry of rain and snow into bins, incompatibility of bins types and capacities with the quantity and quality of produced wastes, lack of strength and resistance of bins to corrosion, and possible intrusion of rodents and insects into bins	C15	11.8	11.8	11.9
6	Absence of enclosed vehicles for waste collection and transportation in the village to prevent waste dispersal which results in wear out of waste transportation vehicles due to wet weather conditions	C16	11.6	11.8	11.7
7	Lack of suitable equipment and tools for waste collectors, Including uniforms and personal protective equipment such as boots, gloves, and masks	C17	11.4	11.4	11.5
8	Lack of proper equipment for keeping out animals from the waste in the village	C18	9.4	9.4	9.5
AHP inconsistency rate = 0.00, FAHP inconsistency rate = 0.01, ANP inconsistency rate = 0.00					

priorities, respectively. The application of FAHP and ANP approaches also yielded similar results with the same priorities (Table 7). Studies by Åberg (2000) and Zhu *et al.*, (2007) revealed that participation required sufficient motivation for the general public. Therefore, it is better for the community to benefit

Table 6: Prioritization of weaknesses and relative importance values of the sub-indices of the D1 index based on AHP, FAHP, and ANP

Priority	Second-level sub-indices	Symbol	AHP	FAHP	ANP
			Relative importance (%)	Relative importance (%)	Relative importance (%)
1	Lack of various street festivities for adequate and extensive awareness of waste disposal and recycling issues	D17	15.2	15.2	15.1
2	Lack of adequate coordination with media to inform villagers about waste disposal and recycling issues and appropriate training programs	D16	14.1	13.9	14.2
3	Failure to make short documentary about rural waste management, and not holding Q & A sessions to increase the villagers awareness	D14	13.4	13.4	13.4
4	Failure to hold exhibitions of recycled products and villagers are not familiarized with such products	D12	13.3	13.3	13.3
5	Lack of training workshops for the villagers about methods of reducing amount of waste, such as avoiding unnecessary packaging, reusing waste materials and composting, and about economic, health, and environmental importance of proper rural waste management	D11	12.8	12.6	12.8
6	Lack of training brochures and pamphlets or information sheets about health hazards of improper waste disposal	D13	10.6	10.9	10.6
7	Lack of cooperation between research centers, universities, and schools for educating rural students through appropriate training courses to transfer knowledge and experiences to households	D15	10.5	10.5	10.5
8	Failure to provide reports and news on the practices and experiences of successful RMs on rural waste management	D18	10.1	10.2	10.1

AHP inconsistency rate = 0.01, FAHP inconsistency rate = 0.02. ANP inconsistency rate = 0.00

Table 7: Prioritization of weaknesses and relative importance values of the sub-indices of the D2 index based on AHP, FAHP, and ANP

Priority	Second-level sub-indices	Symbol	AHP	FAHP	ANP
			Relative importance (%)	Relative importance (%)	Relative importance (%)
1	Failure to hold competitions for rural children by focusing on waste management components aiming at culture-building, in particular waste reduction, source separation, and recycling	D23	16.9	16.7	16.9
2	Villagers ignoring the issues of household waste due to lack of knowledge and awareness about rural waste separation, environmental issues, and the economic value of rural wastes	D24	16.4	16.4	16.4
3	Increase use of disposable plastic plates by villagers	D21	14.5	14.7	14.5
4	Lack of adequate coverage and culture-building programs related to rural waste management by public media	D25	14.4	14.4	14.4
5	Lack of holding talks in high populated rural areas, with the aim of culture-building for waste reduction, source separation of household wastes, waste recycling, and economic incentives	D27	13.6	13.4	13.7
6	Failure to distribute fabric bags instead of plastic bags in order develop culture of using less plastic bags	D22	12.4	12.5	12.4
7	Failure to hold cultural programs for all groups in rural social centers to create a culture of correct waste management for villagers	D26	11.7	11.9	11.7

AHP inconsistency rate = 0.01, FAHP inconsistency rate = 0.02, ANP inconsistency rate = 0.01

from the advantages of waste reduction and waste management at the source separation point, and it can be beneficial to provide discounted waste costs, baggage endowment, and prizes. Investigations conducted in Iran and other developed, developing, and underdeveloped countries, such as China, India, Guatemala (Ye and Qin, 2008; Tian *et al*., 2012), revealed that various indices including: significant effects of rural and urban waste management on the environmental pollution and problems, changing public opinion of villagers through public media, awareness of the society about the environmental pollution of the wastes and their management, strengthening waste management system to protect the natural environment, the importance of source separation plans, and recycling due to its low cost and high revenue are the most important factors in waste management. Finally, the results showed that the weakness of inappropriate and non-standard site selection for waste disposal (A11) with relative importance values of 24.3% in AHP, 24.2% in FAHP, and 24.7% in ANP had the highest priority among the third-level indices. The lowest priority among the third-level indices belonged to the weakness indices B18, which was; waste disposal by the villagers at the nearest site (along the rivers, roadsides, streets, and surface water canals) and waste piling up (flow of latex with unpleasant smells creating unsightly views and increasing soil and water pollution) with importance values of 4.7% in AHP, 7.7% in FAHP, and 6.7% in ANP.

CONCLUSION

Proper rural waste management is one of the most important components of rural sustainable development, which requires the establishment of necessary infrastructures, including cultural and social background, facilities and equipment, and financial provisions. The growing trend of rural waste generation and its role in environmental protection in developing countries requires urgent and serious attention. The results from the ranking of weaknesses in rural waste management in Saravan village by AHP, FAHP, and ANP approaches demonstrated that the most important weakness of rural waste management was waste management structure, equipment, and infrastructures weakness with relative importance values of 38.1% in AHP, 37.3% in FAHP, and 38.2% in ANP approaches. The village inhabitants' weakness had the lowest priority among studied weaknesses with relative importance values of 16.5% in AHP, 17.2% in FAHP, and 1.4% in ANP. The second and third important weaknesses were workforce weakness, and educational and cultural weakness, respectively. In order to implement the findings of this research in an area such as Saravan village, a comprehensive plan with sufficient budgets and correct managements should be considered. This strategic plan should include aspects such as providing waste treatment infrastructures, employment of skilled staff in the field of waste management and specific training of current staff, and conducting on-site or virtual training programs along with providing incentives for villagers and private waste management companies.

AUTHOR CONTRIBUTIONS

Z. Omidi Saravani performed the literature review, questionnaire initial preparation, face-to-face interviews, and prepared the manuscript initial text. M. Kavoosi Kalashami performed experimental design, questionnaire edition, analyzed and interpreted the data, and manuscript technical check. A. Bakhshipour helped in the literature review and questionnaire edition, analyzed the data, prepared the manuscript, and performed manuscript edition. I. Bagheri helped in the experimental design, and manuscript preparation and edition. C. Psomopoulos helped in experimental design and manuscript edition.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

ABBREVIATIONS

AHP	Analytic Hierarchy Process
FAHP	Fuzzy Analytical Hierarchy Process

ANP	Analytic Network Process
RM	Rural Municipality
RMM	Rural Municipality Manager

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