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ORIGINAL RESEARCH

An intelligent decision support system to prevent and control of dengue

Daphne Lopez[1] · Gunasekaran Manogaran[2] · R. Varatharajan[3] · Kaja M. Abbas[4]

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Abstract

Prevention and control of dengue fever are considered as a complex problem in day-to-day life. Noticeable changes in the human population growth, life style, and climate would cause more dengue outbreak in all over the world. The Government of India has developed a number of prevention and control strategies to protect individuals from dengue fever. Though, the strategies provided by the government are not identified based on people, space and time. In order to overcome this issue, the proposed approach presents various alternatives such as vaccination, disease surveillance, vector control, proper sanitation and increased accessed to safe drinking water, strengthening public health activities, awareness creation, and improving nutrition foods for women and child. The proposed alternatives are selected based on people, space and time criteria's such as low temperature and heavy rain, high mean temperature and high humidity, water accumulation and rainfall resources and facilities, social culture variable and social demographic variable. The selection of alternatives based on multiple criteria's is considered as a complex problem in decision-making framework. In general, decision makers and administrators are often used linguistic terms to give their opinions. This paper uses fuzzy logic based VIKOR (VIsekriterijumska optimizacija i KOmpromisno Resenje) method to analyze the linguistic terms collected from the decision makers and rank the best alternatives based on multiple criteria's.

Keywords Fuzzy · VIKOR · Dengue · Multi criteria decision making · Dengue prevention · Dengue control

1 Introduction

Nowadays, government and healthcare professionals are trying to control the outbreak of dengue using many prevention and control strategies (Manogaran et al. 2017a, c; Manogaran and Lopez 2017a). Though, selecting the best dengue prevention and control strategy very much depends on the people, space and time. Medical providers and health care administrators are trying to reduce the operational and maintenance cost for prevention and control of dengue fever (Varatharajan et al. 2017a, b, c). In general, many complex procedures and difficulties are involved in the control strategies (Manogaran and Lopez 2018; Thota et al. 2018). Nowadays, the expenditure and demand for healthcare are increasing rapidly. Professionals and administrators from the healthcare and other industries are jointly conducting various healthcare delivery procedures with the aim to enable efficient disease control strategies using the properties and funds that are available (Manogaran et al. 2017d; Lopez and Sekaran 2016). These considerations are used to develop a decision making model based on multiple criteria's and alternatives (Cromwell et al. 2015). The intention of the multi criteria decision making (MCDM) models is to make an effective decision at various stages of an organization such as strategic, tactical and operational. In every complex decision making problem, there could be a best possible solution, and it becomes challenging task to identify such alternative. In general, strategic decisions are determined by the administrators or top level management to develop the survival and health of the organization. In addition, the following levels are involved in the strategic decisions; it includes ambiguity, possible synergies among various

✉ Gunasekaran Manogaran
gunavit@gmail.com

1 School of Information Technology and Engineering, VIT University, Vellore, India

2 University of California, Davis, USA

3 Sri Ramanujar Engineering College, Chennai, India

4 Department of Infectious Disease Epidemiology, London School of Hygiene and Tropical Medicine, London, UK

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alternatives and overall outcome (Manogaran and Lopez 2016, 2017b). Once the strategic decisions made, then the organization has to decide tactical and operational planning. Strategic, tactical and operational planning is grouped as taxonomy in healthcare (Fig. 1) (Manogaran et al. 2018; Kumar et al. 2017; Lopez and Manogaran 2017). Disease prevention and control strategies comprise of various managerial functions such as facility planning, arrangement and decision making (Manogaran et al. 2017b; Lopez and Sekaran 2016; Varatharajan et al. 2017d). The above mentioned criteria's are used in the decision making model to make the decision for improving the organization. Thus, multi criteria decision analysis (MCDA) is employed in various environments (Tromp and Baltussen 2012; Ghandour et al. 2015; Dehe and Bamford 2015).

1.1 Strategic planning in healthcare

Strategic planning is a long-term plan to achieve the overall goal and objective of the organization (Frishammar 2003). In general, strategic planning consists of various administrative and organizational procedure to get the desired output (Varkey and Bennet 2010). Strategic planning in healthcare includes various factors such as designing overall plan, identifying the goal and getting approval from the manager. Strategic planning is also called as a long-term plan to achieve the desired goal. For example, identifying the overall resource needs (hospitals, medical providers, drugs, and vehicles) and dimensioning the required resources (variety and specification of various resources) are some of the strategic plans in healthcare (Hulshof et al. 2012).

1.2 Tactical planning in healthcare

Tactical planning refers to the overall steps that need to be followed to achieve the desired goal. The following questions are some of the examples of tactical planning in any organization i.e. where, what, which, how, who and when (Manogaran and Lopez 2017a). Tactical planning is followed in healthcare with two steps, step 1: identifying and classifying the individuals based on the disease and its severity, and defining various required resources. Step 2: collecting and installing the resources (hospitals, medical providers, drugs, and vehicles) that are identified in the strategic planning, and scheduling the workload, assigning the task to all workers and scheduling the over time. Tactical planning is also named as a blue print of operational planning. Tactical planning in the healthcare industry includes staff shift scheduling and overtime scheduling in the surgical block.

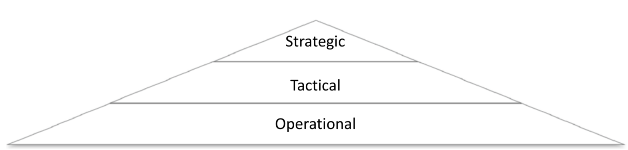

Fig. 1 Taxonomy in healthcare

1.3 Operational planning in healthcare

Operational planning refers to the short-term goal of the organization. The primary purpose of the operational plan is to make a decision to get desired healthcare delivery. Operational planning is also used to execute the steps that are identified in the tactical planning. In other words, blueprints are implemented at each resource level and individual patient level in the operational planning to get desired output (Hulshof et al. 2012). In this paper, operational plan is done with the help of fuzzy VIKOR multi criteria decision making (FMCDM). The proposed system provides various alternatives to prevent and control dengue fever. The alternatives are selected based on people, space and time criteria's such as low temperature and heavy rain, high mean temperature and high humidity, water accumulation and rainfall resources and facilities, social culture variable and social demographic variable. The above mentioned criteria's are used to identify the best alternative from the list of alternatives such as vaccination, disease surveillance, vector control, proper sanitation and increased accessed to safe drinking water, strengthening public health activities, awareness creation, and improving nutrition foods for women and child.

1.4 Statistics of dengue in India

Dengue fever is originally caused from *Aedes aegypti* and *Aedes albopictus* mosquitoes. *Aedes aegypti* mosquitoes are always choose to breed in manmade products such as water tank, tyres, pitchers, discarded containers, cement tanks, desert coolers and junk materials. Those places generally water stagnates for number of days so it breeds easily. Aedes aegypti is a day biting mosquito and most often prefers to breed in dark areas such as inside the houses and store rooms (Manogaran and Lopez 2017b; Lopez et al. 2017; Gandhi et al. 2018). While Aedes albopictus mosquitoes most often prefer to breed in natural habitats such as garden, inside grass, tree gaps and agricultural estate. Nowadays the number of dengue cases has greater than before due to improper water storage methods, lack of awareness and rapid urbanization, hence, this root causes leads to increase the mosquito breeding sites. Dengue cases are not uniformly distributed throughout the year, generally it peaks after monsoon. However, in the southern states a number of cases are constant for all months, especially; in Gujarat the transmission is permanent. The major symptoms of dengue include fever, headache, rash, joint pains, muscle, nausea and vomiting (Rawal et al. 2017).

Till decade there is no exact vaccine or anti biotic are identified to prevent and control of dengue infection. There is a possible to minimize the mortality by early detection and noticeable symptoms. Government of India has developed various guidelines, prevention and control strategies that are circulated to every state in India. In addition, Indian Committee of Secretaries (CoS) has generated the midterm plan on May 2011 for preventing and controlling of dengue that are shared among various states on India. Mid term plan is consisted of various guidelines to prevent and control of dengue. Midterm plan is also named as 'Octalogue' and it includes nine major components as depicted in the Table 1.

1.5 Dengue epidemiology

Figure 2 illustrates the global burden of dengue in 2013, with 15.95 DALYs per 100,000 population (95% UI 10.15–27.61) (Institute for Health Metrics and Evaluation 2016). Similar to the confidence interval, the 95% uncertainty interval (UI) corresponds to the estimation related modeling uncertainties in the Global Burden of Disease (GBD) study (Murray et al. 2015), which includes uncertainties in data and estimates from other sources. DALYs combine the morbidity metric of years of life lost due to disability (YLD) and mortality metric of years of life lost due to premature mortality (YLL); that is, DALY = YLD + YLL.

Table 1 Midterm plan for dengue surveillance (NVBDCP 2018)

S. no.	Components	Description
1	Surveillance	Surveillance is an activity to collect, analyze and generate reports from huge volume of data that are collected from various sources. The results, guidelines and prevention strategies generated from the surveillance system are used to prevent and control of various diseases
2	Case management	Case management is used to provide quality of care, laboratory diagnosis, desired healthcare delivery, resource management and clinical management. Case management is also used to enable efficient patient care services through various functions it include scheduling and planning, service monitoring, awareness creation, patient education service and patient monitoring
3	Vector management	*Aedes aegypti* and *Aedes albopictus* are the types of mosquito and it is considered as main vector of chikungunya and dengue fever in India. In order to control *Aedes aegypti* and *Aedes albopictus* mosquito's, effective vector control scheme has to be developed based on the knowledge of the vector and its biology. Vector management is performed by following ways: environmental source management, water storage management and drainage maintenance, personal protection by protective clothing, chemical control and waste disposal management
4	Outbreak response	Fast and emergency actions are needed to control and prevent dengue and chikungunya. In order to control the various diseases, individuals at each level should contribute their work. There are two types of outbreak responses are followed: the first one is an early diagnosis of diseases and provide control strategies based on disease severity to prevent a number of deaths. The second one is to provide emergency vector control guidelines to control transmission of diseases. In addition, the following steps are also followed in outbreak response: creating guidelines and shared using medias, verification of outbreak with current and previous records, and perform lab related test such as blood sample collection, entomological survey and specimen analysis
5	Capacity building	In order to share and implement the guidelines to protect and prevent from dengue requires trained professionals. It is required to conduct workshops, seminars and regional meetings to strengthen the individuals who are involving in the disease prevention group. In addition, training, hands-on sessions and simulation exercises should be given to the medical force and skilled workers that would help to provide appropriate services to the patients. Operational research should be performed at each region it includes analyzing space and time transmission of dengue, disease burden, and mapping various vectors that are involved in space and time disease transmission
6	Behavior change communication	Social mobilization and awareness creation are the major functions to control the dengue outbreak. In addition, social mobilization is used to involve individuals from not only householders, villagers but also political leaders, VIPs and government officers
7	Inter-sectoral coordination	In order to share the prevention and control strategies to the people, there is a need to collaborate every health and non-health sector individuals. This collaboration is used to enable resource sharing and policy adjustments between various individuals who are working in the health and non-health sectors
8	Monitoring and supervision	In order to control the outbreak of dengue, there is need to provide a strict surveillance or monitoring system. Continues monitoring of dengue transmission also monitors the entomological survey, money and other resources to achieve the desired goal. Supervision is another task to control the dengue fever. Reports generated from various locations, feedback collection, location visit, and review analysis with current and previous disease cases are the major functions of supervision

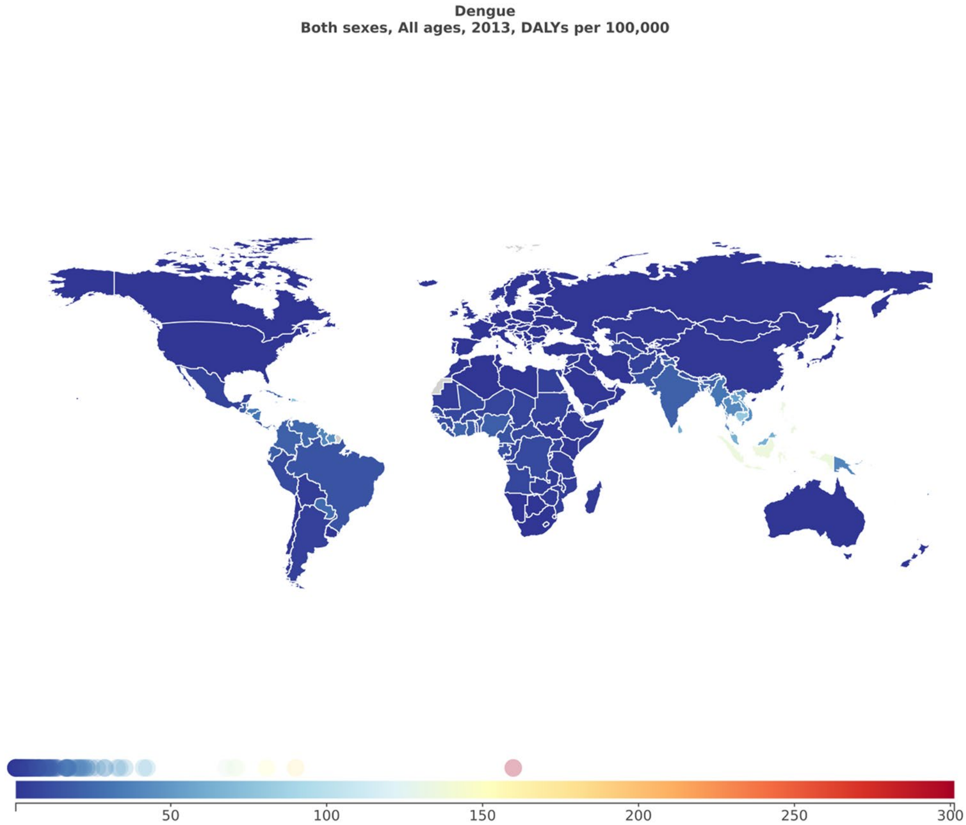

Fig. 2 Global burden of dengue in 2013. Global burden of dengue in 2013 was 15.95 DALYs per 100,000 population (95% UI 10.15–27.61)

Figure 3 illustrates the burden of dengue in India from 1990 to 2013, with 11.1 DALYs per 100,000 population (95% UI 7.54–18.96) in 1990 increasing to 20.73 DALYs per 100,000 population (95% UI 11.28–40.24) in 2013.

1.6 Prevention and control of dengue

The increasing burden of dengue in India necessitates improvement in prevention and control programs. Dengvaxia is a dengue vaccine that is licensed for use in three countries, including Mexico, Philippines and Brazil, it is not currently licensed for use in India (WHO 2016). The prevention and control programs for dengue in India are awareness creation; improved nutrition for women and children; improved water, sanitation and hygiene; strengthening public health activities; surveillance; (potential) vaccination; and vector control. The different interventions have variances in epidemiological effectiveness, access and cost, and opinions of experts and decision makers provide one viable option for public health decision making under uncertainty. Since there will be variances in the prioritization of interventions among the experts, we propose a fuzzy logic based VIKOR method to make objective decisions based on subjective opinions of the experts and decision makers.

1.7 Public health significance

This study address the significant public health problem of making an objective decision based on subjective decisions of experts and decision makers on prevention and control of dengue in India.

2 Materials and methods

2.1 Statistics of dengue in India

In general, malaria and typhoid fevers are considered as emerging diseases in India. Nowadays, chikungunya, dengue and leptospiral infections are also joined into the re-emerging disease group. This emerging and re-emerging diseases impact more in India and other countries. Nowadays, emerging diseases such as malaria and typhoid fevers, chikungunya, dengue and leptospiral infections are considered as a major issue in public health. This paper studies the impact and statistics of dengue cases in India and proposes a framework to prevent and control of dengue. Dengue fever is caused by genus Flavivirus and Aedes. Aegypti is a type of mosquito that originally transmits the genus Flavivirus to the individuals (Martina et al. 2009; Carey et al. 1966; Sarkar

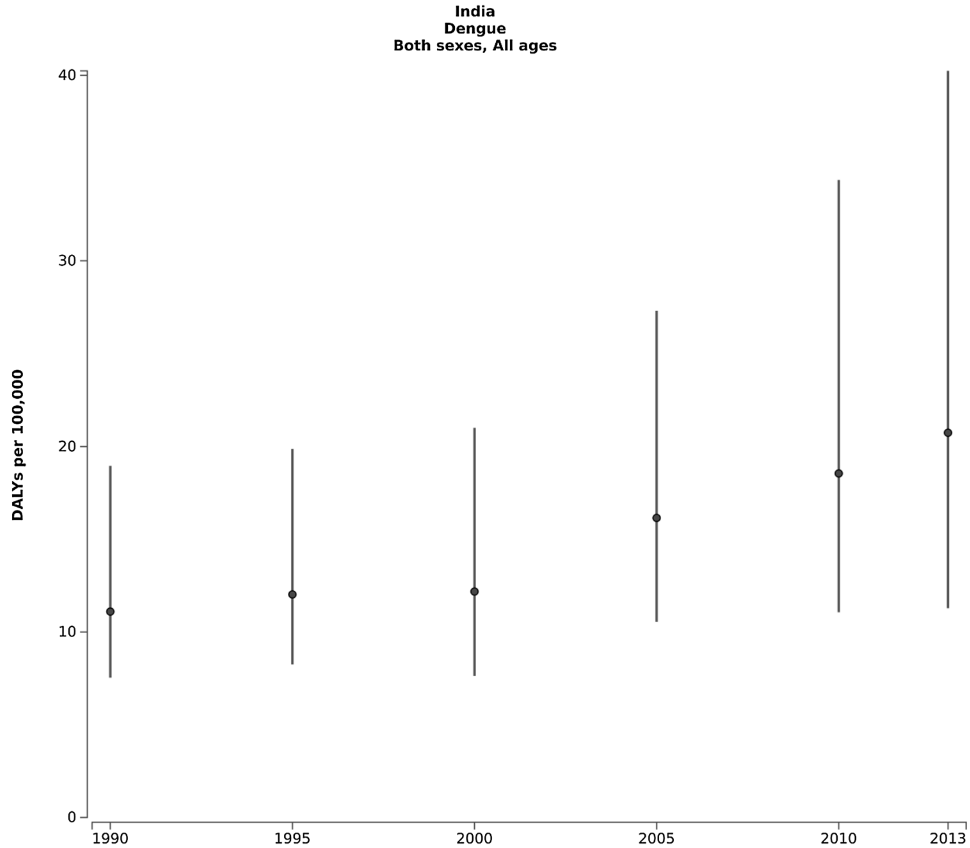

Fig. 3 Burden of dengue in India from 1990 to 2013. Burden of dengue in India from 1990 to 2013, with 11.1 DALYs per 100,000 population (95% UI 7.54–18.96) in 1990 increasing to 20.73 DALYs per 100,000 population (95% UI 11.28–40.24) in 2013

et al. 1964). People who are affected by dengue at the severe stage then the following symptoms would happen such as circulatory failure, shock, coma and death (Bhattacharjee et al. 1993; Padbidri et al. 1996). The incidence of dengue is reported first in Chennai during 1780 thereafter it emerged all over the India. Since the past few decades, there is a massive increase in a number of dengue cases, outbreaks have been reported from different states of the India (Parida et al. 2002; Broor et al. 1997). World Health Organization (WHO) estimates the annual incidence of dengue infection is around 50 million (Dar et al. 1999; WHO 2016; Gupta et al. 2005).

A recent report from Indian health officials states that above 1,102,205 cases and 562 deaths have reported in the year 2014. When comparing malaria cases, the number of dengue fever cases doubled from last year, while malaria cases in India have reported less number of cases compared to the year 2014. A recent report from Indian health officials states that in the year of 2015 nearly 84,391 dengue cases have been reported, while in 2014 the number of dengue cases was 40,571. The following states and union territories (UT) have experienced a number of dengue cases compared to other states of India. It include Delhi (15,531 cases), Punjab (12,628 cases) and Haryana (8021 cases) (Herriman 2016). Delhi is one of the cities in India, last year (2014) 158 cases reported, while in 2015 the number of dengue cases has increased above 12,000 cases; this is the highest number of dengue cases ever in Delhi, India since 1996 (Nath 2015). In addition to that, September 2015 alone the number of dengue cases has crossed 6775 cases, and this is the highest number of reported cases since 2010 (India 2016). In the recent decade, 2010 was considered the deadliest year so far, with 4375 cases. The worst dengue outbreak in Delhi was in 1996 with 10,252 cases and 423 deaths. In addition to that, Punjab also affected more by Dengue with 13,731 cases and 18 deaths reported in 2015, earlier 4117 cases and 25 deaths was the highest in Delhi during 2013. This year (2015) alone 6822, 8066 cases reported in West Bengal and Haryana respectively. Tamil Nadu is also affected more by Dengue with a total of 128 cases and five deaths reported in 1998, while in 2003, 2005 and 2015 it increased to 1600 cases and 12 deaths, 1150 cases and eight deaths, 3841 cases and six deaths respectively (Victor et al. 2007). Though compare to all other states in India, Tamil Nadu was not much affected by dengue; it is observed that in 2012 the huge number of death is reported in Tamil Nadu with 66 cases (NVBDCP 2016). Because, In 2012 Tamil Nadu alone 12,826 cases reported, this was the huge record of Tamil Nadu still now. The main reasons for dengue outbreak include climate change, huge population, global warming, air and water pollution, land change, lack of awareness among people and rapid urbanization.

In order to control the outbreak of dengue, Government of India has provided various prevention and control strategies to the public to prevent and control of dengue. In addition to that, this paper provides seven preventive strategies such as vaccination, disease surveillance, vector control, proper sanitation and increased accessed to safe drinking water, strengthening public health activities, awareness creation and improving nutrition foods for women and child. Multiple prevention strategies are analyzed in a comparative way with the help of various criteria's such as low temperature and heavy rain, high mean temperature and high humidity, water accumulation rainfall, resources and facilities, social culture variables and social demographic variable. In order to solve uncertainty in decision making process and to select the best alternative to prevent and control of dengue, this paper uses fuzzy logic based VIKOR method.

3 Related work

Multi criteria decision making (MCDM) is used to solve various decision making problems in complex environments. Qualitative and quantitative evaluation criteria utilized in the MCDM model to find the compromise solution to address any issues. Nowadays, decision making plays a vital role in public health and human life (Bellman and Zadeh 1970; Phuong and Kreinovich 2001). For example, new emerging diseases such as Ebola and Zika are considered as major issues in human health. In addition, reemerging diseases such as malaria, dengue and chikungunya are also considered as a significant problem in all over the world. In recent years, many researchers use MCDM models to prevent and control of emerging and reemerging diseases (De et al. 2001; Massad et al. 1999). In order to select the best alternative, the following MCDM models have been used in many environments it include such as grey system theory (GST), analytic goal programming (GP), network process (ANP), multi-attribute value theory (MAVT), analytic hierarchy process (AHP) and data envelopment analysis (DEA). Saaty has originally developed AHP model to solve composite decision making problems. In general, AHP often used to formulate a decision in contractor prequalification (Al-Harbi 2001). ANP works as similar to AHP, but the difference is AHP always form a hierarchy with an end whereas ANP often forms a network (Lu et al. 2007). DEA is often used to monitor various functions of an organization. For example, DEA is used recently to schedule and monitor the bridge maintenance services (Ozbek et al. 2010). Technique for order of preference by similarity to ideal solution (TOPSIS) is used to make a better decision based on the geometric distance between the events (Şimşek et al. 2013). In addition, grey system theory (GST) is also considered as an effective solution, and it is developed based on the differential equations to evaluate decisions. Recently, hybrid decision making model is developed based on the above mentioned MCDM models (Jato-Espino et al. 2014). Opricovic has initially developed VIKOR (VIsekriterijumska optimizacija iKOmpromisno Resenje) MCDM method to identify compromise solution from various contradictory criteria's (Opricovic and Tzeng 2007). VIKOR method determines the individual regret values and compromises solution to achieve better decision (Wang et al. 2009). Nowadays, there is a need to develop a decision making model that process and solve uncertainty, especially in biology and medicine. In general, disease diagnosis and epidemiological analysis have a high level of uncertainty and ambiguity (Broekhuizen et al. 2015). For example, various diseases may have a different impact on different people. In addition, due to the degree of immunization every individual may feel different symptoms for the same disease. This variation would degrade the performance of disease diagnosis based on symptoms (Lopez and Gunasekaran 2015; Lopez et al. 2014). In order to solve the above issues fuzzy logic based VIKOR method is used in this paper to solve imprecision and uncertainty problems in decision making.

4 Preliminaries

4.1 Fuzzy set theory

4.1.1 Fuzzy sets

A fuzzy set is a set of objects and membership function between 0 and 1. Zadeh (1965) has introduced fuzzy set theory to focuses real time fuzzy phenomenon problems such as vague, inaccurate and unspecific (Zadeh 1965). Fuzzy set theory is used to process subjective and imprecise judgments. Assume that X be the $\tilde{A}(x)$ universe of discourse, $X_i (i = 1, 2, \dots, n)$, a fuzzy set is denoted by a membership function $\mu_{\tilde{A}}(x)$ (Zadeh 1975).

4.1.2 Fuzzy numbers

Fuzzy numbers is used to represent the linguistic variables, let a triangular fuzzy number $\widetilde{tr}$ can be denoted as

$$\widetilde{tr} = (tr_1, tr_2, tr_3) \tag{1}$$

and its membership function $\mu_{\widetilde{tr}}(x)$ (as shown in Fig. 4) can be defined as (Liu et al. 2014):

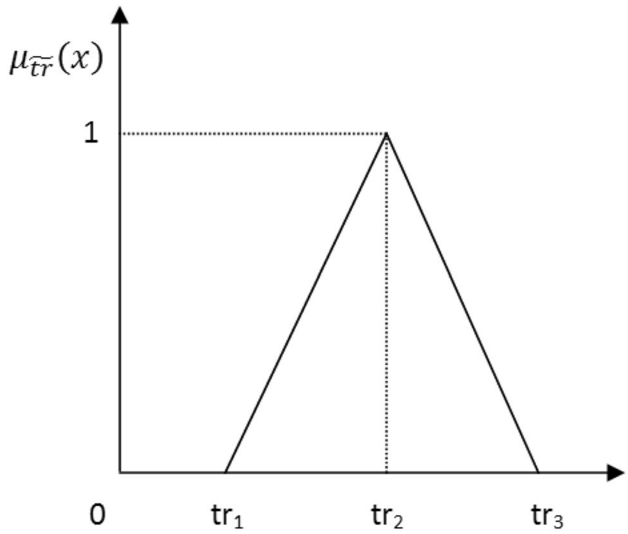

Fig. 4 Triangular fuzzy number

$$\mu_{\widetilde{tr}}(x) = \begin{cases} 0, & x < tr_1, \\ \frac{x-tr_1}{tr_2-tr_1}, & tr_1 \le x \le tr_2, \\ \frac{tr_3-x}{tr_3-tr_2}, & tr_2 \le x \le tr_3, \\ 0, & x > tr_3, \end{cases} \quad (2)$$

This paper focuses on various alternatives to prevent and control of dengue based on various criteria's. The decisions for each alternative are collected based on the following fuzzy linguistic variables. Triangular fuzzy number of x is $\mu_{\widetilde{tr}}(x)$, where, $tr_1 \le tr_2 \le tr_3$.

tr_1 = least possible rate.
tr_2 = more promising rate.
tr_3 = highest possible rate.

Let x_i and y_i are two positive triangular fuzzy numbersx_i $(i = 1, 2, 3)$, y_i $(i = 1, 2, 3)$ and a positive real number p, the arithmetical operations can be defined as follows:

$$\tilde{x} \oplus \tilde{y} = [x_1 + y_1, x_2 + y_2, x_3 + y_3], \quad (3)$$

$$\tilde{x} \ominus \tilde{y} = [x_1 - y_3, x_2 - y_2, x_3 - y_1], \quad (4)$$

$$\tilde{x} \otimes \tilde{y} = [x_1 y_1, x_2 y_2, x_3 y_3], \quad (5)$$

The operations of ∨ (max) and ∧ (min) are defined as follows:

$$\tilde{x} \vee \tilde{y} = [x_1 \vee y_1, x_2 \vee y_2, x_3 \vee y_3], \quad (6)$$

$$\tilde{x} \wedge \tilde{y} = [x_1 \wedge y_1, x_2 \wedge y_2, x_3 \wedge y_3], \quad (7)$$

Scalar operations are defined as follows:

$$r \oplus \tilde{x} = [r + x_1, r + x_2, r + x_3] \quad (8)$$

$$r \ominus \tilde{x} = [r - x_1, r - x_2, r - x_3], \quad (9)$$

$$r \otimes \tilde{x} = [r x_1, r x_2, r x_3]. \quad (10)$$

The Euclidean distance between two triangular fuzzy numbersx_i $(i = 1, 2, 3)$, y_i $(i = 1, 2, 3)$ is defined as follows (Chen et al. 2008):

$$D(X_i, Y_i) = \sqrt{\frac{1}{6}[(x_1 - y_1)^2 + 4(x_2 - y_2)^2 + (x_3 - y_3)^2]} \quad (11)$$

The distance between the two triangular fuzzy numbers x_i $(i = 1, 2, 3)$, $y_i (i = 1, 2, 3)$ by vertex method is defined as follows (Chen 2000):

$$D(X_i, Y_i) = \sqrt{\frac{1}{3}[(x_1 - y_1)^2 + (x_2 - y_2)^2 + (x_3 - y_3)^2]}. \quad (12)$$

4.1.3 Linguistic variables

Linguistic terms such as low, medium and high are used to represent the linguistic variables. In general, linguistic variables are used to describe the imprecise or complex expressions. This paper uses fuzzy linguistic terms to rate criteria's and rank the various prevention techniques of dengue.

5 Fuzzy VIKOR method

VIKOR MCDM method is combined with fuzzy logic to solve various complex and ambiguity problem in decision making system. In general, VIKOR method identifies two solutions such as best and compromise solution to rate the alternatives in MCDM process.

Fuzzy logic based VIKOR method consists of following steps to rank the alternatives (Fig. 5):

Step 1: Identify the objective of the multi criteria decision making system.

Step 2: List the p alternative methods called $A = \{A_1, A_2, \ldots, A_P\}$.

Step 3: List the q selection criteria called $C = \{C_1, C_2, \ldots, C_q\}$.

Step 4: List the various r members called $DM = \{DM_1, DM_2, \ldots, DM_r\}$ in the decision making process to identify the appropriate alternative from p alternative with respect to each q criteria.

Step 5: Define the appropriate linguistic terms, fuzzy membership function $\mu_{\tilde{t}}(x)$ and triangular fuzzy number $\tilde{t} = (t_1, t_2, t_3)$:

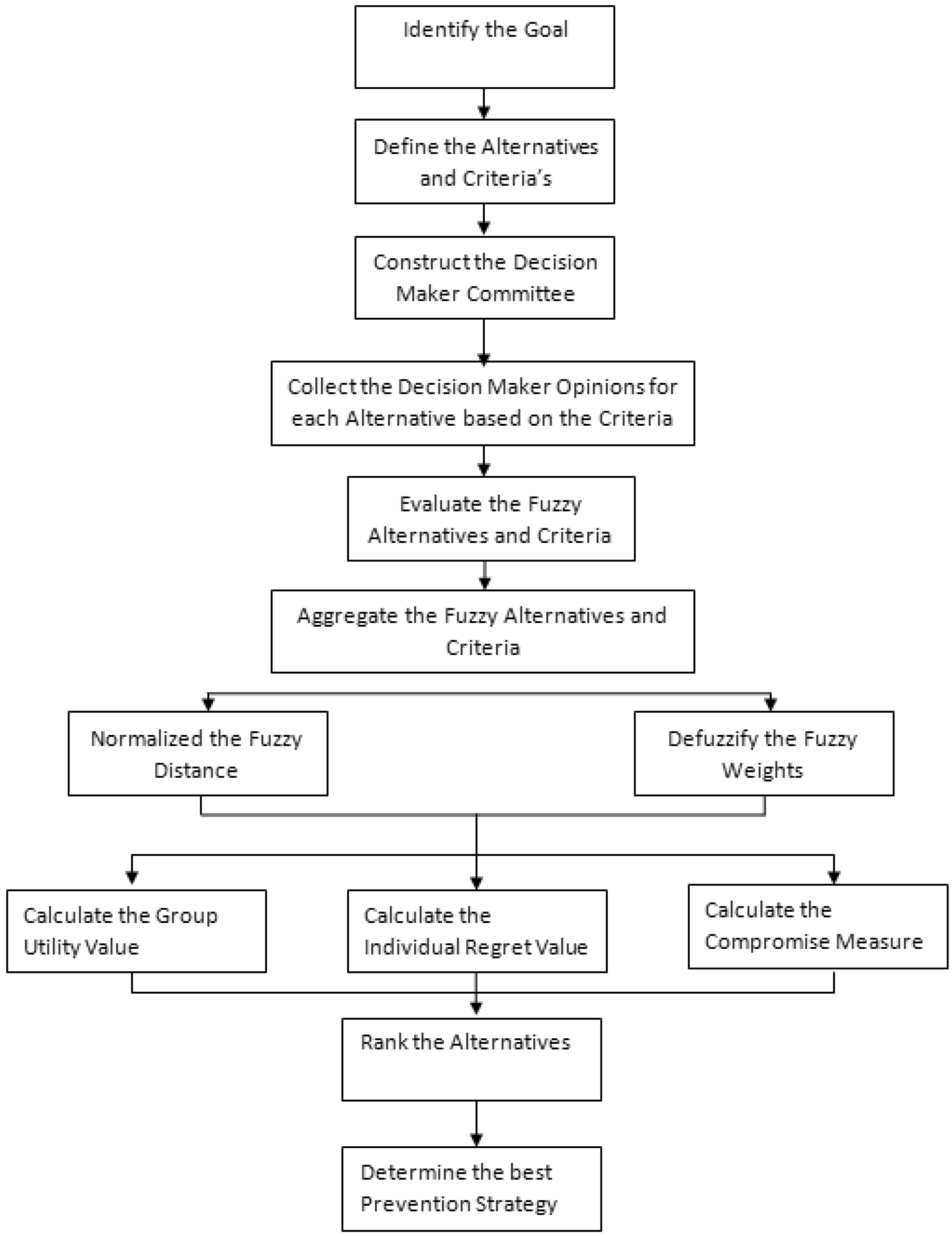

Fig. 5 Representation of the fuzzy VIKOR

$$\mu_{\tilde{l}} = \begin{cases} 0, & x < t1, \\ \frac{x-t1}{t2-t1}, & t1 \le x \le t2, \\ \frac{t3-x}{t3-t2}, & t2 \le x \le t3, \\ 0, & x > t3, \end{cases} \tag{13}$$

Step 6: Define the fuzzy criteria weights and collect the ratings for each alternative with respect to each criteria.

Step 7: Calculate the fuzzy decision matrix based on aggregated ratings of fuzzy alternatives and aggregated fuzzy weights of each criteria, let a set of fuzzy ratings of alternatives A_i $(i = 1, \quad 2, \dots, p)$ and criteria C_j $(j = 1, \quad 2, \dots, q)$, called $X = \{x_{ij}, i = 1, 2, \dots, p, j = 1, 2, \dots, q\}$.

Compute the normalized decision makers' fuzzy assessment of alternatives $\tilde{x}_{ij}^k = (\tilde{x}_{ij1}^k, \tilde{x}_{ij2}^k, \tilde{x}_{ij3}^k)$ and aggregated fuzzy weights of criteria $\tilde{w}_{ij}^k = (\tilde{x}_{ij1}^k, \tilde{x}_{ij2}^k, \tilde{x}_{ij3}^k)$:

$$\tilde{x}_{ij} = \sum_{l=1}^{q} \vartheta_1 \tilde{x}_{ijl} \tag{14}$$

$$\tilde{w}_j = \sum_{l=1}^{q} \vartheta_1 \tilde{w}_{jl}, \tag{15}$$

where $\vartheta_1 \in [0,1]$ represents the weights given to the lth decision maker member, and $\sum_{l=1}^{q} \vartheta_l = 1$,

The decision matrix $\tilde{D}$for prevention and control of dengue problem is defined as:

$$\tilde{D} = \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \dots & \tilde{x}_{1q} \\ \tilde{x}_{21} & \tilde{x}_{22} & & \tilde{x}_{2q} \\ \vdots & \vdots & \dots & \vdots \\ \tilde{x}_{p1} & \tilde{x}_{p2} & \cdots & \tilde{x}_{pq} \end{bmatrix}, \quad \tilde{w} = (\tilde{w}_1, \tilde{w}_2, \dots, \tilde{w}_q)^T \tag{16}$$

Step 8: Calculate the fuzzy best $\tilde{f}_j^* \ (i = 1,2,\dots,p)$and fuzzy worst $\tilde{f}_j \ (j = 1,2,\dots,q)$ values from the aggregated fuzzy decision matrix $\tilde{x}_{ij}^k = (\tilde{x}_{ij1}^k, \tilde{x}_{ij2}^k, \tilde{x}_{ij3}^k)$:

$$\tilde{f}_j^* = \begin{Bmatrix} \max_i \tilde{x}_{ij}, & \text{for benefit criteria} \\ \min_i \tilde{x}_{ij}, & \text{for cost criteria} \end{Bmatrix} \tag{17}$$

$$\tilde{f}_j^- = \begin{Bmatrix} \min_i \tilde{x}_{ij}, & \text{for benefit criteria} \\ \max_i \tilde{x}_{ij}, & \text{for cost criteria} \end{Bmatrix} \tag{18}$$

Step 9: Compute the average fuzzy distance values $\tilde{d}_{ij}$, $(i = 1,2,\dots,p, \ j = 1,2,\dots,q)$ from the aggregated fuzzy decision matrix $\tilde{x}_{ij}^k = (\tilde{x}_{ij1}^k, \tilde{x}_{ij2}^k, \tilde{x}_{ij3}^k)$:

$$\tilde{d}_{ij} = \frac{d(\tilde{f}_j^*, \tilde{x}_{ij})}{d(\tilde{f}_j^*, \tilde{f}_j^-)}. \tag{19}$$

The Euclidean distance $D(X_i, Y_i)$ between any triangular fuzzy membership functions $A_i = (X_1, X_2, X_3)$ and $Y_i = (Y_1, Y_2, Y_3)$ is calculated as follows:

$$D(X_i, Y_i) = \sqrt{\frac{1}{6}[(x_1 - y_1)^2 + 4(x_2 - y_2)^2 + (x_3 - y_3)^2]}. \tag{20}$$

Step 10: Fuzzy weights are defuzzified as $\tilde{w}_j$ based on graded mean integration based method:

$$\tilde{w}_j = \frac{\tilde{w}_j + 4 \times \tilde{w}_j + \tilde{w}_j}{6}, \quad j = 1,2,\dots,q. \tag{21}$$

Step 11: Identify the group utility values S_i and individual regret values R_i, $i = 1,2,\dots,p$, by the following equation:

$$S_i = \sum_{j=1}^{n} \frac{\tilde{w}_j \cdot \tilde{d}_{ij}}{\sum_{j=1}^{n} \tilde{w}_j} \tag{22}$$

$$R_i = \max_j \left(\frac{\tilde{w}_j \cdot \tilde{d}_{ij}}{\sum_{j=1}^{n} \tilde{w}_j} \right). \tag{23}$$

Step 12: The compromise measure Q_i, $i = 1,2,\dots,p$, can be defined as:

$$Q_i = \vartheta \frac{S_i - S^*}{S^- - S^*} + (1 - \vartheta) \frac{R_i - R^*}{R^- - R^*}, \tag{24}$$

where $S^* = min_i S_i$, $R^* = min_i R_i$, $S^- = max_i S_i$, $R^- = max_i R_i$.

Let ϑ and $(1 - \vartheta)$ are the weights for $S_i \ (i = 1,2,\dots,p)$ and $R_i \ (i = 1,2,\dots,p)$ value respectively.

Let $\vartheta = 0.5$ and $(1 - \vartheta) = 0.5$.

Step 13: List the various dengue prevention alternatives $A_i \ (i = 1,2,\dots,p)$ by sorting $S_i \ (i = 1,2,\dots,p)$, $R_i \ (i = 1,2,\dots,p)$ and $Q_i \ (i = 1,2,\dots,p)$ in the decreasing order.

Step 14: Calculate the compromise measure if and only if the following two conditions are satisfied otherwise go to Step 15.

Condition 1:

$$Q(A^{(2)}) - Q(A^{(1)}) \geq \frac{1}{p - 1} \tag{25}$$

Condition 2:

$(A^{(1)})$ Must be the first rank by S_i and R_i.

Step 15: If Condition 1 is not satisfied then the compromise measure can be calculated as follows:

$$Q(A^{(N)}) - Q(A^{(1)}) < \frac{1}{p - 1}. \tag{26}$$

Else if Condition 2 is not satisfied then the compromise measures are alternatives $(A^{(1)})$ and $(A^{(2)})$.

6 Case study: assessment of prevention alternative selection process

Step 1: The goal of this study is to select the best alternative to prevent and control of dengue based on various criteria's.

Step 2: Table 2 depicts the various alternatives to prevent and control of dengue.

Step 3: Six criteria's (Table 3) is considered to select an efficient alternative method to prevent and control of dengue.

Step 4: Different decision makers are identified to select the best prevention alternative from seven based on the above six criteria. In this study five decision makers were selected and it is depicted in Table 4, classification diagram of this paper is shown in Fig. 6.

Step 5: Appropriate linguistic variables for each alternatives (as shown in Fig. 7) and criteria weights (as shown in Fig. 8)

Table 2 Prevention Alternatives

Notation	Alternatives	Description
A_1	Vaccination	Vaccination should be given to the age group of 1.5–15 years Dengue vaccination should be given in 3-dose series in the month of January, June and December (Dengue Fever Vaccine Program 2016)
A_2	Disease surveillance	Early detection of various diseases using active and passive surveillance Strengthening the medical services and improve the response time Collect, analyze and generate reports from clinical records (National Programmes under NRHM 2016)
A_3	Vector control	Water storage management and drainage maintenance Encourage to use protective clothes and long lasting insecticidal nets (LLINs) Encourage to use indoor residual spraying (IRS) in hot spot regions Environmental source reduction, identifying various techniques for waste management
A_4	Proper sanitation and increased accessed to safe drinking water	Provide proper sanitation facilities Provide clean drinking water Proper maintenance of tubewell Clean the water tank and water storage blocks regularly
A_5	Strengthening public health activities	Having safe food and water, as well as air quality Encourage to do physical exercise and yoga
A_6	Awareness creation	Establish more public activities to know more about dengue outbreak Use of electronic media and social networks such as Twitter, Facebook and YouTube to create awareness among dengue
A_7	Improving nutrition foods for women and child	Providing nutritional food for child and women Improving food safety, especially for child nutrition products, by improving as international standards Implementing new food safety law, and creating awareness of food safety issues through schools, colleges, women's groups and the social media

Table 3 Various criteria's

Notation	Criteria	Description
C_1	Low temperature and heavy rain	Most of the study states that low temperature and heavy rain are negatively correlated with the number of dengue cases (Yang et al. 2009; Fouque et al. 2006; Tran et al. 2004)
C_2	High mean temperature and high humidity	Many research outcomes indicate that high mean temperature and high humidity are positively correlated with the number of dengue cases (Ehelepola et al. 2015)
C_3	Water accumulation and and rainfall	Maintenance process involve in lakes and rivers Maintenance process involve in water tank during winter season
C_4	Resources and facilities	Infrastructure: lab, hospitals and bed Transport: ambulance and other vehicles Skilled personnel: doctor and nurse Unskilled personnel: compounder and wiper Working cost: cost for the building, medical equipments, drugs, staff commitment and other costs for various purpose Communication and maintenance cost: survey collection about individuals health history, lifestyle, vaccination history, social behaviors, and preparing schedule for vaccination and medical test
C_5	Social culture variable	Considering dressing habits and lifestyle, for example, improper clothing may increase probability of getting dengue Considering daily travel plan, if the person travel more are likely to get infection
C_6	Social demographic variable	Considering social habits and lifestyle, for example, people who are working in the drainage cleaning block are likely to get dengue (Neiderud 2015) People who are working in urban places where the hygienic level is very low are more likely to get infection

are identified. The linguistic variables are depicted in Tables 5 and 6 respectively.

Step 6: Get the fuzzy logic based values for all the alternative with each criteria (Table 7) and linguistic weights for each

Table 4 Decision makers

Notation	Decision makers
DM_1	Medical officer from women and child development
DM_2	Regional officer from health and family welfare
DM_3	Head officer from housing and urban poverty alleviation
DM_4	Director from ministry of health and family welfare
DM_5	Chief officer from ministry of social justice and empowerment

criteria (Table 8).

Step 7: Aggregated fuzzy logic based alternatives $\tilde{x}_{ij}$ are calculated, and the results are shown in Table 9. In addition, Aggregated fuzzy logic based weights $\tilde{w}_j$ are calculated, and the results are depicted in Table 9. The following equations are used to calculate the values $\tilde{x}_{ij}$ and $\tilde{w}_j$ respectively.

$$\tilde{x}_{ij} = \sum_{l=1}^{q} \vartheta_1 \tilde{x}_{ijl} \quad (27)$$

$$\tilde{w}_j = \sum_{l=1}^{q} \vartheta_1 \tilde{w}_{jl} \quad (28)$$

Step 8: Fuzzy best $\tilde{f}_j^*$ $(j = 1, 2, \ldots, q)$ and fuzzy worst $\tilde{f}_j^-$ $(j = 1, 2, \ldots, q)$ values are calculated based on the following equations $\tilde{f}_j^*$ and $\tilde{f}_j^-$ respectively.

$$\tilde{f}_j^* = \left\{ \begin{array}{ll} \max\limits_i \tilde{x}_{ij}, & \text{for benefit criteria} \\ \min\limits_i \tilde{x}_{ij}, & \text{for cost criteria} \end{array} \right\}$$

$$\tilde{f}_j^- = \left\{ \begin{array}{ll} \min\limits_i \tilde{x}_{ij}, & \text{for benefit criteria} \\ \max\limits_i \tilde{x}_{ij}, & \text{for cost criteria} \end{array} \right\}$$

$\tilde{f}_1^* = (0, 0.4, 1.8)$, $\tilde{f}_2^* = (0, 0.4, 1.8)$, $\tilde{f}_3^* = (0.2, 1, 2.6)$, $\tilde{f}_4^* = (0, 1, 3)$, $\tilde{f}_5^* = (0.2, 0.6, 1.8)$, $\tilde{f}_6^* = (0, 0, 1)$.

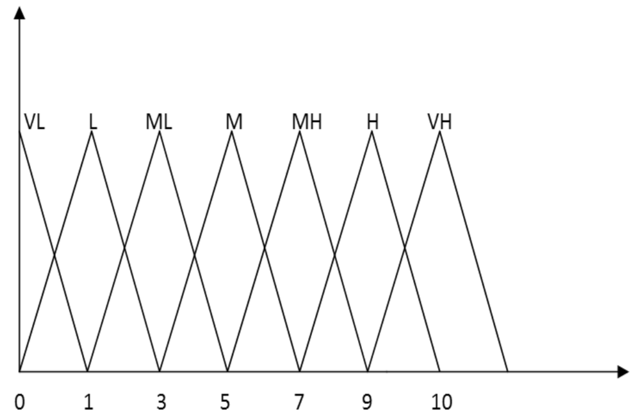

Fig. 7 Fuzzy sets for alternative

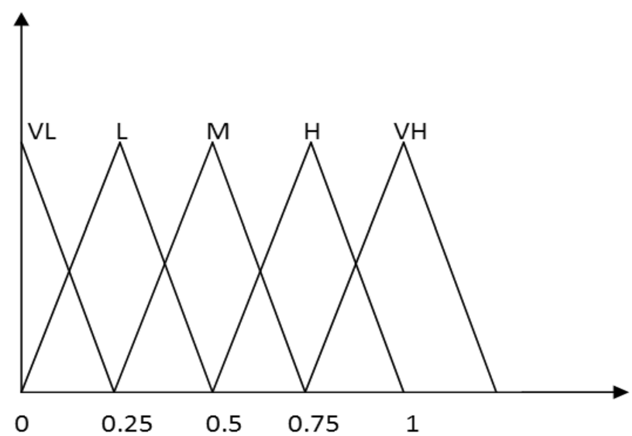

Fig. 8 Fuzzy sets for criteria weights

Table 5 Fuzzy linguistic variables for rating the criteria weights

Linguistic variable	Fuzzy membership function
Very low (VL)	(0, 0, 0.25)
Low (L)	(0, 0.25, 0.5)
Medium (M)	(0.25, 0.5, 0.75)
High (H)	(0.5, 0.75, 1)
Very high (VH)	(0.75, 1, 1)

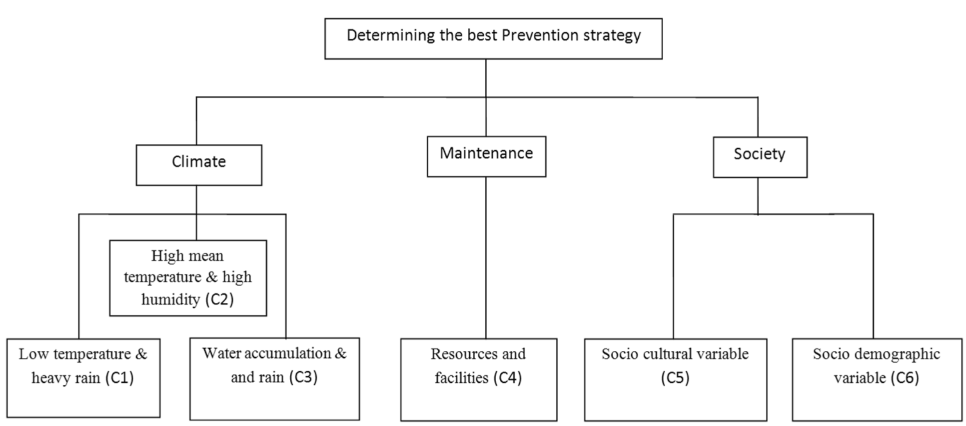

Fig. 6 Hierarchical structure of the problem

Table 6 Fuzzy linguistic variables for rating the alternatives

Linguistic variable	Fuzzy numbers
Very low (VL)	(0, 0, 1)
Low (L)	(0, 1, 3)
Medium low (ML)	(1, 3, 5)
Medium (M)	(3, 5, 7)
Medium high (MH)	(5, 7, 9)
High (H)	(7, 9, 10)
Very high (VH)	(9, 10, 10)

$\tilde{f}_1 = (8.2, 9.6, 10)$, $\tilde{f}_2 = (8.2, 9.4, 9.8)$, $\tilde{f}_3 = (7.8, 9.2, 9.8)$, $\tilde{f}_4 = (7.8, 9.2, 9.8)$, $\tilde{f}_5 = (6.2, 8, 9.4)$, $\tilde{f}_6 = (27.8, 9.2, 9.8)$.

Step 9: Aggregated fuzzy logic based alternatives $\tilde{x}_{ij}$ are converted in to normalized fuzzy logic based distance $\tilde{d}_{ij}$ $(i = 1, 2, \ldots, p; j = 1, 2, \ldots, q)$ based on the following equations and the results are depicted in Table 10.

$$\tilde{d}_{ij} = \frac{d(\tilde{f}_j^*, \tilde{x}_{ij})}{d(\tilde{f}_j^*, \tilde{f}_j)} \tag{29}$$

Table 7 Decision makers' opinion in linguistic forms

Decision makers	Alternatives	Criteria's					
		C_1	C_2	C_3	C_4	C_5	C_6
DM_1	A_1	MH	H	H	VH	MH	MH
	A_2	H	MH	MH	H	H	MH
	A_3	VH	VH	VH	M	MH	H
	A_4	H	MH	M	H	MH	H
	A_5	VL	VL	ML	M	M	ML
	A_6	VL	VL	L	L	ML	VL
	A_7	M	ML	M	ML	MH	L
DM_2	A_1	M	MH	MH	H	H	H
	A_2	M	MH	M	H	MH	MH
	A_3	H	VH	H	MH	H	VH
	A_4	MH	M	H	MH	M	MH
	A_5	VL	L	VL	ML	ML	VL
	A_6	VL	VL	L	L	VL	VL
	A_7	ML	ML	M	MH	M	L
DM_3	A_1	ML	H	VH	VH	MH	VH
	A_2	MH	MH	MH	H	MH	M
	A_3	H	VH	VH	MH	VH	VH
	A_4	MH	ML	MH	M	M	MH
	A_5	ML	VL	ML	L	VL	ML
	A_6	L	ML	ML	L	VL	VL
	A_7	ML	M	ML	MH	MH	M
DM_4	A_1	H	VH	H	VH	H	H
	A_2	MH	MH	M	H	MH	M
	A_3	VH	VH	MH	H	MH	VH
	A_4	MH	H	M	M	MH	ML
	A_5	VL	VL	L	ML	VL	L
	A_6	VL	L	VL	L	VL	VL
	A_7	ML	ML	M	ML	M	M
DM_5	A_1	MH	VH	H	H	MH	MH
	A_2	M	H	H	MH	M	M
	A_3	VH	MH	VH	VH	MH	MH
	A_4	MH	M	M	MH	MH	M
	A_5	V`L	L	ML	ML	L	VL
	A_6	L	VL	VL	L	VL	VL
	A_7	ML	M	ML	ML	ML	ML

Table 8 Fuzzy rating of criteria weights

Decision makers	Criteria's					
	C_1	C_2	C_3	C_4	C_5	C_6
DM_1	H	M	VH	M	L	H
DM_2	VH	H	M	M	M	M
DM_3	VH	H	M	L	L	H
DM_4	H	H	H	M	M	L
DM_5	H	M	H	H	M	M

Table 9 Aggregated fuzzy logic based alternatives and fuzzy ratings of criteria weights

A_n	Criteria's					
	C_1	C_2	C_3	C_4	C_5	C_6
A_1	(4.2, 6.2, 8)	(7, 8.8, 9.8)	(7, 8.8, 9.8)	(7.8, 9.2, 9.8)	(5.8, 7.8, 9.4)	(6.6, 8.4, 9.6)
A_2	(4.6, 6.6, 8.4)	(5.4, 7.4, 9.2)	(4.6, 6.6, 8.4)	(6.6, 8.6, 9.8)	(5, 7, 8.8)	(3.8, 5.8, 7.8)
A_3	(8.2, 9.6, 10)	(8.2, 9.4, 9.8)	(7.8, 9.2, 9.8)	(5.8, 7.6, 9)	(6.2, 8, 9.4)	(7.8, 9.2, 9.8)
A_4	(5.4, 7.4, 9.2)	(3.8, 5.8, 7.6)	(4.2, 6.2, 8)	(4.6, 6.6, 8.4)	(4.2, 6.2, 8.2)	(4.2, 6.2, 8)
A_5	(0.2, 0.6, 1.8)	(0.0.4, 1.8)	(0.6, 2, 3.8)	(1.2, 3, 5)	(0.8, 1.8, 3.4)	(0.4, 1.4, 3)
A_6	(0, 0.4, 1.8)	(0.2, 0.8, 2.2)	(0.2, 1, 2.6)	(0, 1, 3)	(0.2, 0.6, 1.8)	(0, 0, 1)
A_7	(1.4, 3.4, 5.4)	(1.8, 3.8, 5.8)	(2.2, 4.2, 6.2)	(2.2, 4.6, 6.8)	(3.4, 5.4, 7.4)	(1.4, 3, 5)
W	(0.6, 0.85, 1)	(0.4, 0.65, 0.9)	(0.45, 0.8, 0.9)	(0.25, 0.5, 0.75)	(0.15, 0.4, 0.65)	(0.3, 0.55, 0.8)

Table 10 Normalized fuzzy logic based distance values $\tilde{d}_{ij}$ for all alternatives$A = \{A_1, A_2, \ldots, A_P\}$ for each criteria $C = \{C_1, C_2, \ldots, C_q\}$ and crisp values of fuzzy weights $\tilde{w}_j$

Alternatives	Criteria's					
	C_1	C_2	C_3	C_4	C_5	C_6
A_1	0.6348	0.9318	0.9497	1	0.9735	0.8232
A_2	0.6796	0.7841	0.6865	0.9236	0.8683	0.6398
A_3	1	1	1	0.8053	1	1
A_4	0.7692	0.6015	0.4769	0.3661	0.7636	0.6798
A_5	0.1825	0	0.1216	0.2387	0.1665	0.1586
A_6	0	0.0386	0	0	0	0
A_7	0.3287	0.3792	0.3911	0.4407	0.6539	0.3363
W	0.8333	0.6666	0.7583	0.5	0.4	0.55

Table 11 The values of S, R and Q for all alternatives

Criteria	Alternatives						
	A_1	A_2	A_3	A_4	A_5	A_6	A_7
S	0.8663	0.7470	0.9737	0.6109	0.1395	0.0141	0.3972
R	0.1941	0.1527	0.2247	0.1728	0.0409	0.0141	0.0799
Q	0.8713	0.7108	1	0.6876	0.1289	0	0.3558

The Euclidean distance$D(X_i, Y_i)$ between any triangular fuzzy membership functions$A_i = (X_1, X_2, X_3)$ and $Y_i = (Y_1, Y_2, Y_3)$ are calculated based on the following equation:

$$D(X_i, Y_i) = \sqrt{\frac{1}{6}[(x_1 - y_1)^2 + 4(x_2 - y_2)^2 + (x_3 - y_3)^2]} \tag{30}$$

Step 10: Defuzzification of fuzzy weights $\tilde{w}_j$ are calculated with help of graded mean integration method. The deffuzzified crisp values $\tilde{w}_j$ for each fuzzy weight are computed based on the following equation and the results are shown in the last row of Table 10.

$$\tilde{w}_j = \frac{\tilde{w}_j + 4 \times \tilde{w}_j + \tilde{w}_j}{6}, \quad j = 1, 2, \ldots, q \tag{31}$$

Step 11: Group utility values $S_i\,(i = 1, 2, \ldots, p)$ are computed based on the following equation:

$$S_i = \sum_{j=1}^{n} \frac{\tilde{w}_j.\tilde{d}_{ij}}{\sum_{j=1}^{n} \tilde{w}_j} \tag{32}$$

Individual regret values $R_i\,(i = 1, 2, \ldots, p)$ are computed based on the following equation:

$$R_i = \max_j \left(\frac{\tilde{w}_j \cdot \tilde{d}_{ij}}{\sum_{j=1}^{n} \tilde{w}_j} \right) \tag{33}$$

The results $S_i\,(i = 1, 2, \ldots, p)$ and $R_i\,(i = 1, 2, \ldots, p)$ are shown in Table 11.

Step 12: Compromise measure $Q_i\,(i = 1, 2, \ldots, p)$ values are calculated based on the following equation and the results are shown in last row of Table 11.

$$Q_i = \vartheta \frac{S_i - S^*}{S^- - S^*} + (1 - \vartheta) \frac{R_i - R^*}{R^- - R^*} \tag{34}$$

where $S^* = min_i S_i$, $S^- = max_i S_i$, $R^* = min_i R_i$, $R^- = max_i R_i$.

Let ϑ and $(1 - \vartheta)$ are the weights for $S_i\,(i = 1, 2, \ldots, p)$ and $R_i\,(i = 1, 2, \ldots, p)$ respectively.

Let $\vartheta = 0.5$ as threshold value and $(1 - \vartheta) = 0.5$.

Step 13: Group utility value $S_i\,(i = 1, 2, \ldots, p)$, individual regret value $R_i\,(i = 1, 2, \ldots, p)$ and compromise measure Q_i $(i = 1, 2, \ldots, p)$ are sorted in the decreasing order for all alternatives $A = \{A_1, A_2, \ldots, A_P\}$, and the results are shown in Table 12.

Step 14: The Condition 1 and Condition 2 are satisfied, hence, the compromise measure results $Q_i\,(i = 1, 2, \ldots, p)$ shows that vector control alternative A_3 is the best alternative to prevent and control of Dengue.

Condition 1:

$$Q(A^{(2)}) - Q(A^{(1)}) \geq \frac{1}{p - 1} \tag{35}$$

where $(A^{(1)})$ = ranked first by the compromise measure Q_i (maximum) $(i = 1, 2, \ldots, p)$, which is Q_5, $(A^{(2)})$ = ranked second by the compromise measure Q_i (maximum) $(i = 1, 2, \ldots, p)$, which is Q_7

$$0.8713 - 1 \geq \frac{1}{7 - 1}$$

Table 13 Ranking of alternatives

Rank	Notation	Alternatives
1	A_3	Vector control
2	A_1	Vaccination
3	A_2	Disease surveillance
4	A_4	Proper sanitation and increased accessed to safe drinking water
5	A_7	Improving nutrition foods for women and child
6	A_5	Strengthening public health activities
7	A_6	Awareness creation

$0.1287 \geq 0.1666$, Hence the condition C_1 is not satisfied.

Condition 2:

Alternative $(A^{(1)})$ must be ranked first by S_i and R_i.

$$S^{(A_3)} > S^{(A_1)} > S^{(A_2)} > S^{(A_4)} > S^{(A_7)} > S^{(A_5)} > S^{(A_6)}$$

$$R^{(A_3)} > R^{(A_1)} > R^{(A_4)} > R^{(A_2)} > R^{(A_7)} > R^{(A_5)} > R^{(A_6)}$$

Hence the condition C_2 is satisfied.

The sorted order of various prevention and control alternatives are depicted in Table 13.

Thus, the vector control based strategy A_5 is the best method to prevent and control dengue.

7 Discussion

7.1 Public health implications

This study illustrates the use of the fuzzy logic based VIKOR method for making an objective decision based on subjective decisions of experts and decision makers on prevention and control of dengue in India.

7.2 Public health decision making under uncertainty

We have presented a viable solution for public health decision making under certainty, by using the fuzzy logic based VIKOR method for prioritization of interventions for dengue are based on experts' opinions. Dynamic modeling of dengue transmission dynamics provides another option for estimating the effectiveness and cost-effectiveness of

Table 12 Values S, R and Q for all alternatives in decreasing order

Criteria	Alternatives						
	A_1	A_2	A_3	A_4	A_5	A_6	A_7
S	2	3	1	4	6	7	5
R	2	4	1	3	6	7	5
Q	2	3	1	4	6	7	5

different interventions, as done in the disease control priorities (DCP-3) project to estimate efficacy and effectiveness of interventions for leading causes of global disease burden (DCP 2016).

8 Conclusion

Professionals and administrators from the healthcare and other industries are jointly conducting various healthcare delivery procedures with the aim to enable efficient disease control strategies using the properties and funds that are available. These considerations are used to develop a decision making model (MCDM) based on multiple criteria's and alternatives. In general, disease diagnosis and epidemiological analysis have a high level of uncertainty and ambiguity. In order to overcome this issue, the proposed approach presents fuzzy logic based VIKOR method, to analyze the linguistic terms collected from the decision makers and rank the best alternatives based on multiple criteria's. This paper presents various alternatives such as vaccination, disease surveillance, vector control, proper sanitation and increased accessed to safe drinking water, strengthening public health activities, awareness creation, and improving nutrition foods for women and child. The proposed alternatives are selected based on people, space and time criteria's such as low temperature and heavy rain, high mean temperature and high humidity, water accumulation and rainfall resources and facilities, social culture variable and Social demographic variable. The limitation of this manuscript is the proposed model identifies the best alternative only on the basis of five decision makers. The future work of this paper is to develop a decision making framework on the basis of list questionnaire.

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