SENSITIVITY ANALYSIS OF VARYING PREFERENCES IN MULTICRITERIA DECISION APPROACH FOR PRIORITIZING PATROL BEAT LOCATIONS

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ABSTRACT: *The assignment of patrol police in various locations around a locality has been seen to contribute in the deterrence of crimes. However, due to the limited number of available police, it is often difficult for police administrators to decide on where they should be located so that they provide greater visibility.*
In this study, we consider six criteria, namely crime rate, distance to the police station, flow of traffic, number of open establishments, population of area a, and road length, in implementing a multicriteria dedecision-makingpproach for prioritizing patrol beat locations. Results show how changes in the preferences of police administrators affect their decisions for the prioritization among beat patrol locations considered in the study.

Keywords: Multicriteria Decision. Patrol beat. Optimal allocation. Sensitivity analysis.

1 INTRODUCTION

Part of the mandate of every police agent is to contribute to crime control. Hence, part of their functions is to apprehend criminals, prevent and detect crimes, protect and assist the general public, and maintain public order. Several policing activities prevent crime, one of which is police patrolling [1]. Society is strongly affected by crime, both due to the cost of crime, as well as the decline in the quality of life that citizens suffer as a result of the crime. Crimes clearly require a systematic approach to achieve a serious reduction, and effective police patrolling is seen to greatly contribute to addressing this problem. Furthermore, police patrol can provide many services to the community when a good location is chosen. Due to the limited number of the police force with unlimited services and a set of demand location that needs them, the police decision-maker has to properly apportion its allocation.

Various studies have been conducted in order to provide an optimal allocation of police patrols in various areas using different approaches. In [2], an n integer programming approach was used for allocating police in an urban city in the Philippines. The results of their study provide information on how many police are to be deployed to specific locations during different shifts. On the other hand, [3] used a multiobjective linear programming approach in order to come up with an optimal assignment of police in an interurban road network in Northern Israel. The results of their study provide a timetable for police assignments. In [4], maximal covering models were used in determining optimal police patrol areas. Results of their study show that the method provides substantial improvements in providing coverage among its area of responsibility as well as a reduction in police response time. Insights from the work of [5] can also be used to solve this patrol beat location problem.

The process of making patrol beat location-allocation decisions is a haphazard process for every police-decision maker. Unfortunately, police decision-makers have few resources to guide them in determining the number of officers they need and how would they allocate them. An analytical hierarchy process (AHP) approach for determining patrol beat locations around Cagayan de Oro, Philippines was introduced in [6]. In their study, they considered crime rate, distance to the police station, flow of traffic, number of open establishments, population of the area, and road length as their criteria for multi-criteria decision-making.

In this study, we provide insights on how decisions on where the patrol beat should be located are affected by the changes in the preferences of the administrators by performing sensitivity analysis in the AHP model presented in [6]. This paper is organized as follows. Section 1 presents background information on the present study. The methodology is discussed in Section 2 while results and discussion are presented in Section 3. A brief conclusion is given in Section 4.

2 METHODOLOGY

The main goal of this study is to look into how changes in the preferences of police administrators affect their decisions for prioritizing beat patrol locations using the analytical hierarchy process (AHP) as a multicriteria decision-making approach based on the criteria considered in [6]. It should be recalled that AHP considers a set of evaluation criteria and a set of alternative options among which the best decision arrives. It involves breaking down the problem into a standardized set of components, and organizing them according to a hierarchy in order to incorporate significant quantities of information and present a more comprehensive portrait of the problem. Figure 1 shows the AHP hierarchy as considered in this study, based on [6].

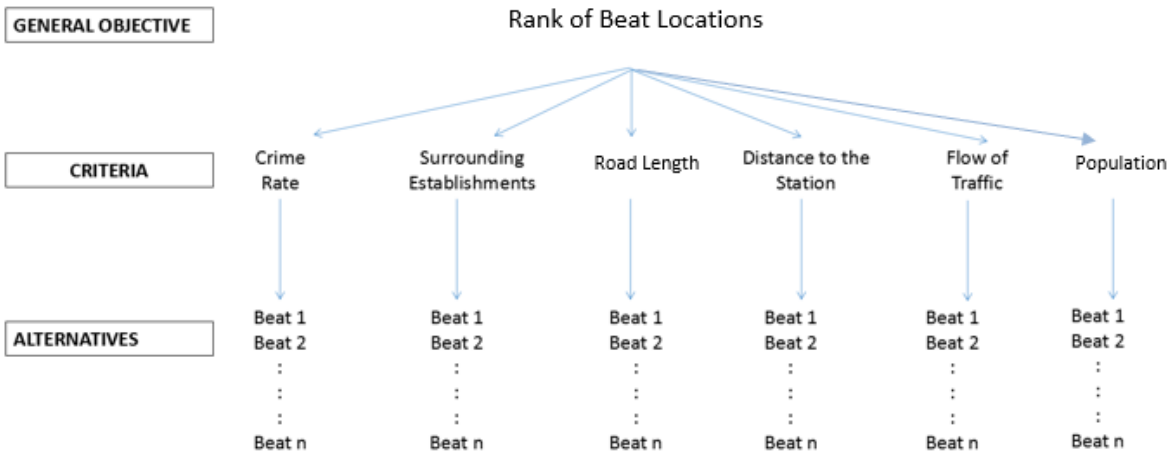


Figure 1. The hierarchy of criteria and alternatives in AHP.

As shown in the figure, the main objective of the AHP is to determine the rank of beat locations under various criteria. However, it should be noted that this current study focuses on how changes in the preferences among the six criteria affect the rankings of the best locations. The six criteria include the crime rate, distance to the station, traffic flow, the number of open establishments surrounding the area, the population of the area, and road length in the area. Table 1 shows a sample pairwise comparison for the six criteria.

Table 1. Pairwise comparison between criteria.

Criteria	*Crime Rate*	*Distance to the Police Station*	*Traffic Flow*	*Number of Open Establishments*	*Population*	*Road Length*
Crime Rate	1	9	5	3	5	7
Distance to the Police Station	1/9	1	1/4	1/9	1/7	½
Traffic flow	1/5	4	1	1/3	1/3	4
Number of Open Establishments	1/3	9	3	1	3	5
Population	1/5	7	3	1/3	1	3
Road Length	1/7	2	1/4	1/5	1/3	1

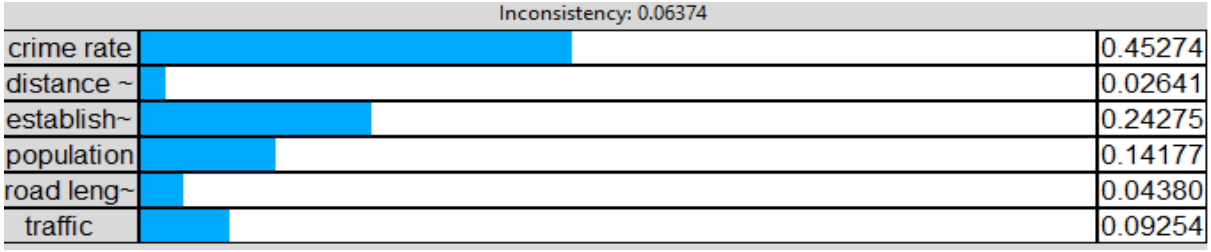


Figure 2. Relative weights between each criterion.

We then evaluate the ranks among the 4 beat patrol areas, namely beats 1 to 4. Using the preference scale in Table 2, we compare each beat patrol area for each of the 6 criteria considered in this study. Table 3 shows the direct input values of the 4 beat patrol areas under consideration as evaluated in each of the 6 criteria considered.

Table 2. AHP numerical scale for determining preference

Value	Interpretation
1	Equally preferred
3	Moderately preferred
5	Strongly preferred
7	Very strongly preferred
9	Extremely preferred
2, 4, 6, 8	Intermediate values

s.

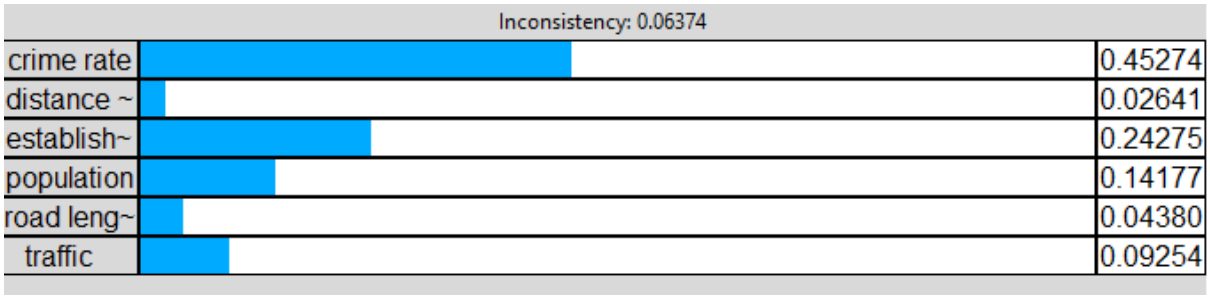
Table 3. Direct input values among beat patrols under the 6 criteria.				
Criteria	**Beat Patrol 1**	**Beat Patrol 2**	**Beat Patrol 3**	**Beat Patrol 4**
Crime Rate	5	3	3	2
Distance to the Police Station	2	3	3	5
Traffic flow	3	9	7	2
Number of Open Establishments	4	3	7	5
Population	5	4	3	3
Road Length	3	3	2	4

3 RESULTS AND DISCUSSION

We compute for the prioritization among the beat patrol areas using the six criteria using the AHP. This is implemented using *SuperDecisions*, a free educational software that implements AHP and ANP developed by Thomas Saaty and maintained by the Creative Decisions Foundation. Based on this computation, the police administrators have put more preference on Crime rate in deciding where to locate patrol beat. This means that the higher the crime rate at a beat patrol location, the greater number of patrol beats may be assigned at this location. The consistency value of 0.07092 shows that the comparison made between criteria are consistent as this is less than 0.10. This means that the rankings obtained in this study can be considered reliable. This is shown in Figure 3.

Table 4. Weights for the 6 criteria.		
Criteria	**Weight**	**Rank**
Crime rate	0.45274	1
Distance	0.02641	6
Establishment	0.24275	2
Population	0.14177	3
Road length	0.04380	5
Traffic	0.09254	4
Consistency	**0.06374**	

Figure 3. Consistency value for the criteria comparison matrix.



Overall synthesis of the AHP model results in the following ranking among beat patrol areas. Results show that given the six criteria considered in this study, beat area 1 has to be prioritized when assigning patrol beat while beat area 4 comes last.

Table 5. Ranking of beat areas using AHP.		
Beat Area	**Weight**	**Rank**
1	0.300723	1
2	0.237314	3
3	0.266506	2
4	0.195457	4

We then conduct sensitivity analysis to ascertain the effects to the ranking when police administrators change their preferences between the criteria. These are shown in the succeeding figures and discussions.

Figure 4 shows how the rankings of the beat patrol areas change at varying levels of preference for the criterion **crime**. It can be seen that when the preference level for crime is at 0.5, beat area 1 is at rank 1, followed by beat area number 3, beat 2, and finally, beat 4. It can be further seen from this figure that as we move the preference value for crime below 0.5, there are 3 more preference values in which the rankings of the 4 beat areas may vary. These are illustrated in the succeeding figures.

If the preference for the criterion crime is changed from 0.5 to 0.32, the ranking of the 4 beat patrol areas changes. The beat area is now ranked 1, followed by beat areas 1, 2 then 4. This is shown in Figure 5. Figure 6, on the other hand, shows the change in rankings of the beat areas at x=0.28. Here it can be observed that although beat area 3 remains to be in rank 1, the ranking has shifted again in beat areas 1 and 2 in which beat 2 now is at rank 2 and beat area 1 at rank 3 while beat area 4 remains on the last spot. A shift in the rankings of the best areas can further be observed when x=0.19. At this level of preference, beat areas 3 and 2 remain at rank number 1 and 2,.

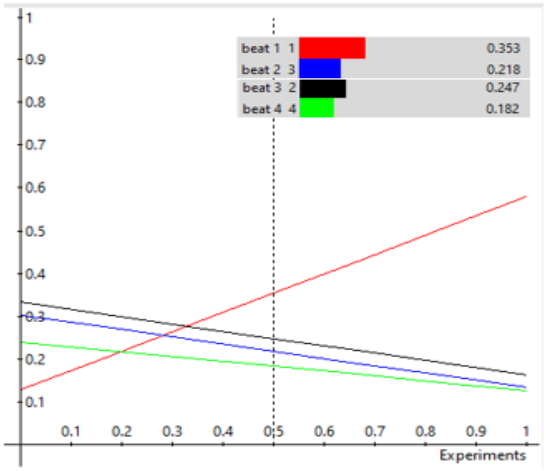


Figure 4. Sensitivity analysis for criterion CRIME (at x=0.5).

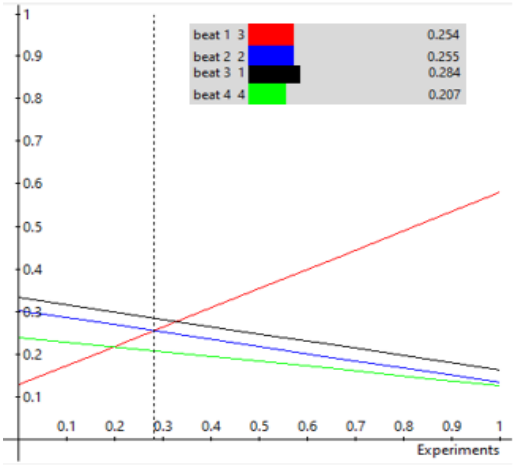


Figure 6. Sensitivity analysis for criterion CRIME (at x=0.28).

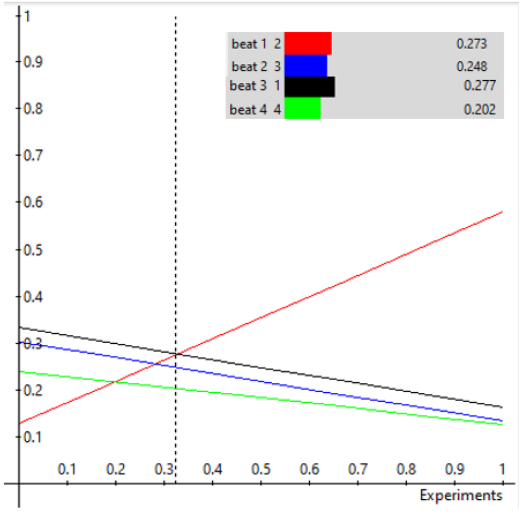


Figure 5. Sensitivity analysis for criterion CRIME (at x=0.32).

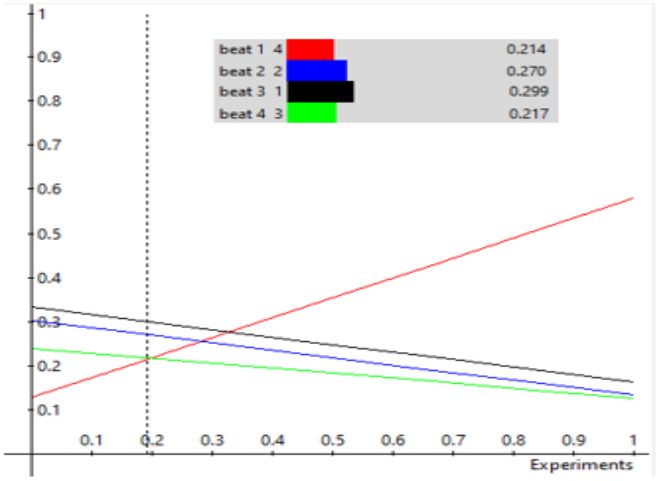


Figure 7. Sensitivity analysis for criterion CRIME (at x=0.19).

respectively. However, beat area 4 is now at rank 3 while beating area 1 moves to rank 4. This is shown in Figure 7.

CONCLUSIONS

In this study, we have demonstrated how rankings are affected by changes in the preferences of police administrators who are involved in the multicriteria decision process of identifying patrol beat locations. It can be seen from the results provided in this study that even a slight decrease or increase in the preferences among the criteria may correspond to shifts in the ranking of the patrol beat locations. These results provide insights into how these preferences affect the entire decision-making process.

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