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Heritage Tree Expert Assessment and Classification: Malaysian Perspective

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***Abstract*—**Heritage trees are natural large, individual trees with exceptionally value due to association with age or event or distinguished people. In Malaysia, there is an abundance of tropical heritage trees throughout the country. It is essential to set up a repository of heritage trees to prevent valuable trees from being cut down. In this cross domain study, a web-based online expert system namely the Heritage Tree Expert Assessment and Classification (HTEAC) is developed and deployed for public to nominate potential heritage trees. Based on the nomination, tree care experts or arborists would evaluate and verify the nominated trees as heritage trees. The expert system automatically rates the approved heritage trees according to pre-defined grades via Delphi technique. Features and usability test of the expert system are presented. Preliminary result is promising for the system to be used as a full scale public system.

***Keywords*—**Arboriculture, Delphi, expert system, heritage tree, urban forestry.

I. Introduction

HERITAGE trees are large, natural trees with extraordinary value considered irreplaceable due to age or specific event. Heritage trees are designated based on criteria such as age, scarcity, size, as well as aesthetic, botanical, ecological, and historical value [1].

In Malaysia, there are many heritage trees which are planted pre-independence. Their economic values have reached hundreds of thousands of ringgits. Hence, the need to manage trees in the urban setting has become an indispensable part of urban forestry.

The management of any resource needs to start with an inventory of that particular resource. A tree inventory system is a hands-on approach for urban forest management. Geographic information system (GIS) and global positioning system (GPS)-based tree inventory systems help local authorities such as municipalities to save cost and reduce liability.

Hence, there is a need to have the heritage trees in Malaysia to be identified and inventoried. To solve this problem, a web-based expert system (ES) is developed in this research to assist the process of identification and verification of all potential heritage trees. The basic idea behind this is that expertise is transferred from a human to a computer. The effort is part of the applied artificial intelligence domain.

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II. Problem Definition and Contribution

At present, to the best of our knowledge, there is general lack of software tools incorporating multiple expert opinions developed for the classifying heritage trees. Abatement or mitigation prescription in the past researches was based on the opinion of one expert. More expert opinion is needed in order to make the system more reliable.

Developing an expert system with a central repository accessible to various stakeholders is essential for comprehensive and effective management of heritage trees. To cater to this need, a web-based ES is developed as a universal platform accessible anytime, anywhere.

This research study is aimed at developing a comprehensive and efficient ES for urban heritage tree management. Towards this goal, the criteria and indicators for heritage trees were identified by experts. Delphi and Focus group technique were employed as the approach for gathering consensus on the identification of criteria and indicators for heritage trees. The panel members selected are experts knowledgeable about tree management, landscape architect, landscape design, tree ecology, urban forestry, and other arboricultural practices.

The remainder of this paper is organized as follows: First, review existing ESs approaches were presented. Second, the methodology in which criteria and indicators for heritage tree classification and assessment is presented.

III. Literature Review

ESs is a branch of applied artificial intelligence (AI). The basic concept behind ES is that expertise and knowledge is transferred from a human to a computer system and stored in it. Subsequently, users can consult the computer system for specific needed advice [2]. The computer can make inferences and arrive at specific conclusion. Then, like a human contestant, it may provide advices and the reason behind the advice [3]. The application of ES are proving to be critical in the process of decision support and problem solving [3].

ES methodologies can be divided into categories such as rule-based, fuzzy, knowledge-based, neural networks, object-oriented, case-based reasoning, intelligent agent methodologies etc. [2] The ES approach adopted by HTEAC is the database methodology. A database is a collection of data organized to efficiently serve many applications by centralizing the data and minimizing the redundant data [4]. A database management system allows data to be centrally stored, managed, and accessed by application programs [5].

To the best of our knowledge, our work is the first attempt to leverage on an ES for heritage tree assessment and classification.

IV. Methodology

Before the ES is developed, criteria and indicators for heritage trees need to be first formulated with the help of tree experts. In December 2013, a workshop on criteria and indicators of heritage trees was held the by Faculty of Forestry, Universiti Putra Malaysia (UPM) in collaboration with Malaysian Arborist Association (PArM). The two techniques used in formulating criteria and indicators are focus group and Delphi technique. Fig. 1 shows the process flow of the approach.

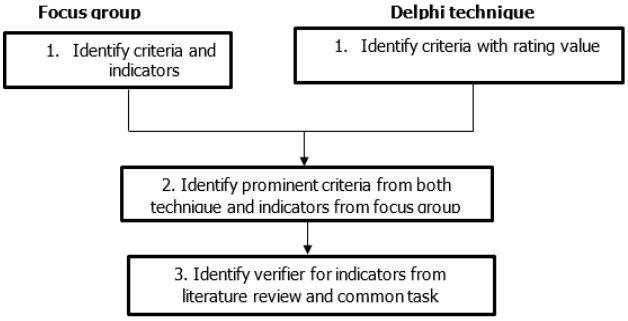


Fig. 1 Process to formulate criteria and indicators of heritage trees

Focus group was used to disseminate all possible criteria and indicators from experts which involved in urban tree management. The experts were divided into 3 categories: a) certified arborist, b) arborist practitioner (architects and landscape architects) and arborist researchers (researchers and lecturers). 46 participants were divided into 4 groups in which each group led by a facilitator and assistant. The facilitator was chosen based on his vast experience in urban tree management. Meanwhile, his assistant's task was to assist facilitator in conducting focus group. Training was conducted to ensure that facilitators and their assistants familiar with the focus group flow. In the focus group, participants were required to discuss the possible criteria and indicators in Malaysia context. The facilitators finally summarize all criteria and indicators before the focus group ends. After focus group session has ended, all participants gathered where the facilitator of each group presented their results and the leader of facilitator jot down the results. Final summary of results was discussed and voting of possible criteria and indicators was done. The focus group approach adopted is illustrated in Fig. 2. Meanwhile, Delphi technique was also employed to identify and justify the criteria. First, all possible criteria and indicators from experts were disseminated. The expert panels include arborist, local authorities, architects, landscape architects, lecturers and researchers. There were three rounds of questionnaire distributed to all participants. The participants were kept apart and unknown to each member of the expert panel to maintain independence of the process and anonymity. This procedure is to ensure that the results were truly independent and not influenced by other experts in the group.

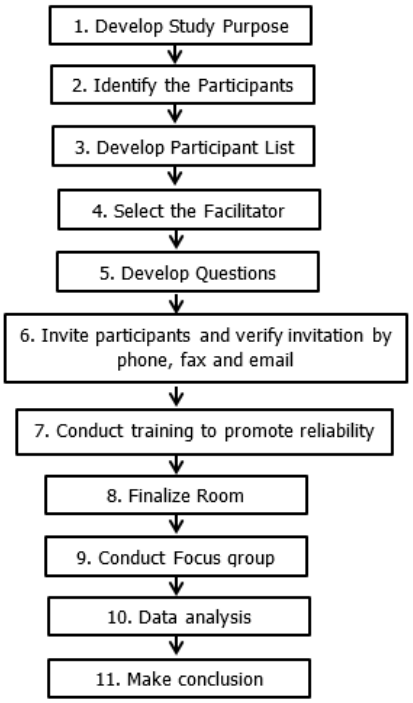


Fig. 2 Focus group process flow

In answering the questionnaire, the expert panels independently brainstorm their own ideas and choices in identifying the criteria. They set priorities and list supporting reasons. The answers were returned after the first speaker has finished his presentation. The researcher would analyze and summarize all answers, comments, responses, ideas and supporting arguments received from the respondents and based on these feedbacks, develop a new questionnaire for subsequent rounds. The new questionnaire allows the expert panels to make changes, improvement or extend further arguments in support of their earlier choices and opinions or totally a new idea within the context of overall responses from other respondents. This process was repeated for three rounds as a mean of developing consensus on the selection and prioritization of the required criteria. The participants were also requested to rate the proposed criteria based on their importance. Final criteria and indicators were selected with respect to feasibility, desirability and importance. The process is illustrated in Fig. 3.

Through the focus group and Delphi technique, experts have identified nine prominent criteria and 38 indicators for heritage tree in Malaysia. The prominent criteria identified are history/heritage value, botany value, culture and social value, uniqueness of age, uniqueness of size, aesthetic value, environmental services and ecology value, species as well as economy. The expert opinion on heritage tree criteria and indicators from Malaysia were compared to the criteria outlined in Tree Assessment for Heritage Status (TreeAH) [6]**Hata! Başvuru kaynağı bulunamadı.**. TreeAH comprises three principles, namely the special visual interest, the special scientific interest and the special cultural interest and twelve

indicators to determine heritage trees. Similarities between the expert opinion and TreeAH were deliberated and non-overlapped indicators were retained. Fig. 4 shows the process of obtaining final criteria and indicators from the two sources.

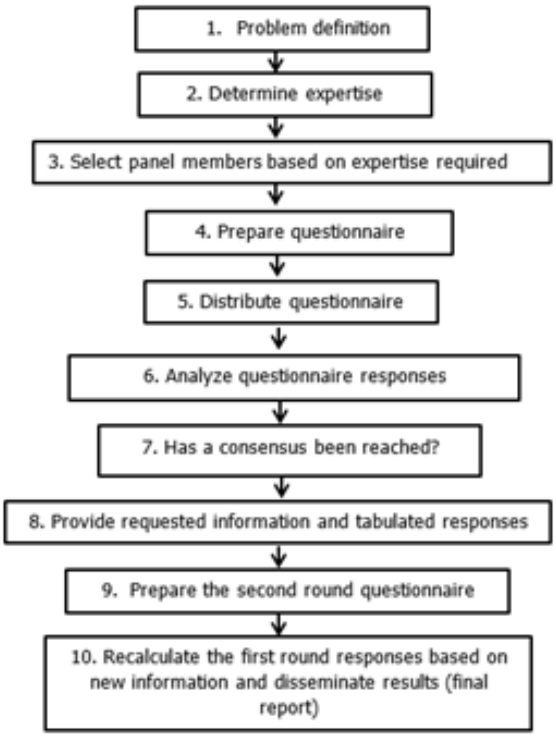


Fig. 3 Delphi technique process flow

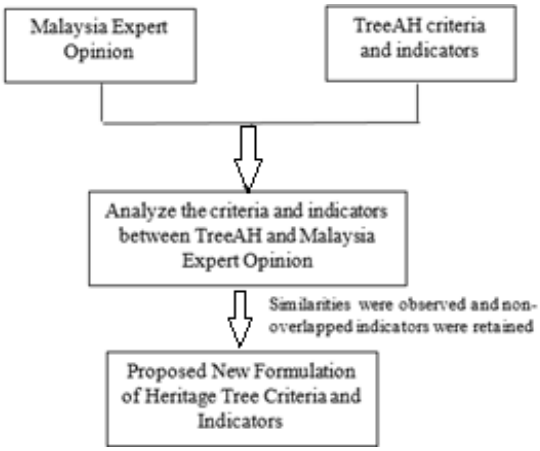


Fig.4 Process of obtaining final criteria and indicator

V. Heritage Tree Expert Assessment and Classification

With the criteria and indicators, an ES named HTEAC is designed and developed with state-of-the-art Web technologies such as CSS, HTML, Javascript and PHP together with MySQL Relational Database Management System (RDBMS). The home page of the HTEAC is shown in Fig. 5.

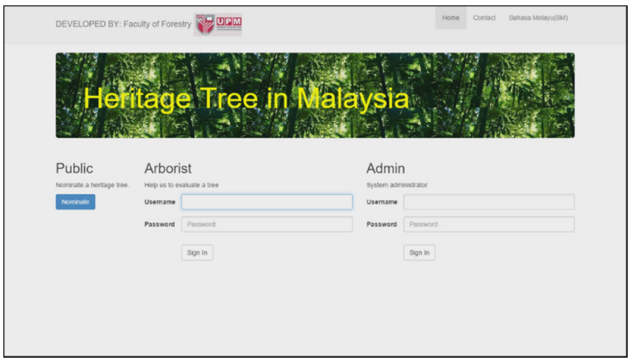


Fig. 5 HTEAC System

The main function of HTEAC is to enable public to nominate potential heritage trees as well as to assist arborist and professionals alike to determine whether the trees nominated are indeed heritage trees. The system is hosted online for easy accessibility anytime, anywhere. The knowledge component of the ES are the criteria and indicators collected from the experts during the workshop and rounds of Delphi technique.

VI. Results and Discussion

In January 2016, an accuracy assessment was carried out on heritage trees in Penang. HTEAC was used to assess the accuracy of the evaluation made by the arborist on the trees' heritage status back in 2013. The system was tested on trees located on three roads in Georgetown, Penang, namely the Jalan Macalister, Jalan Kelawei and Jalan York. A random sample of 75 trees were taken from these roads. The information of the trees was captured and entered into HTEAC by anonymous users. Screenshot of tree nomination module of HTEAC is shown in Fig. 6.

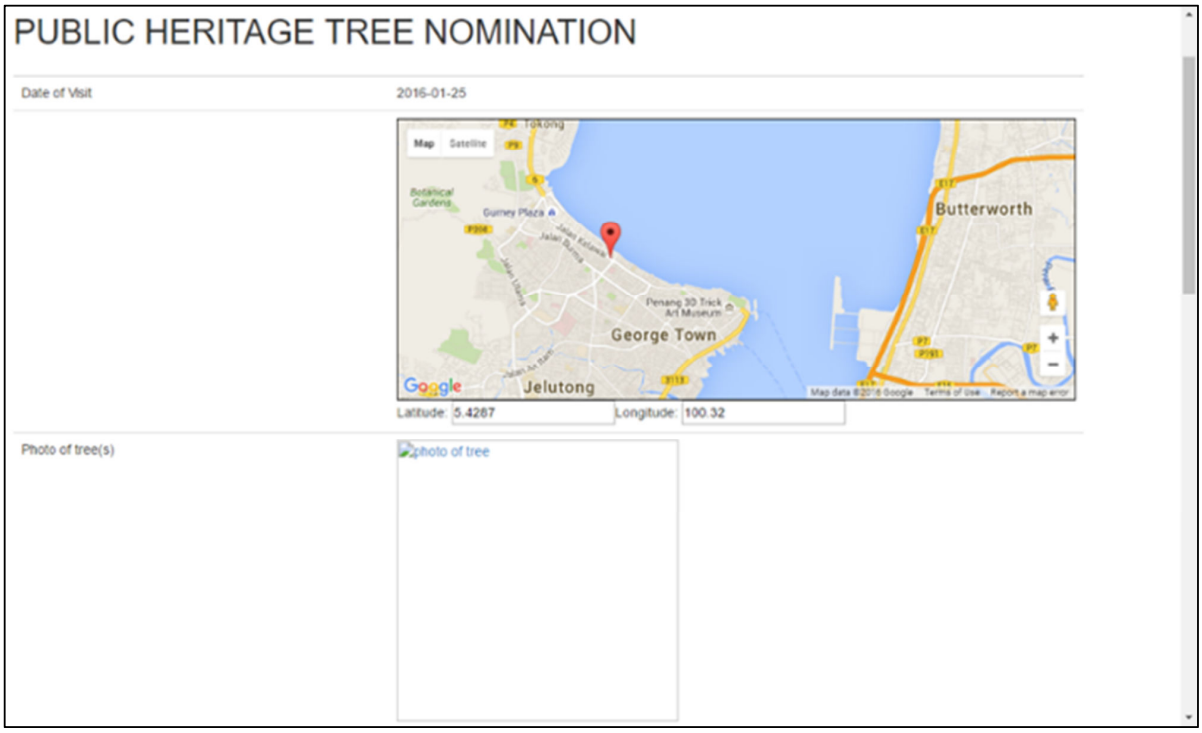


Fig. 6 (a) HTEAC tree nomination module (part 1)

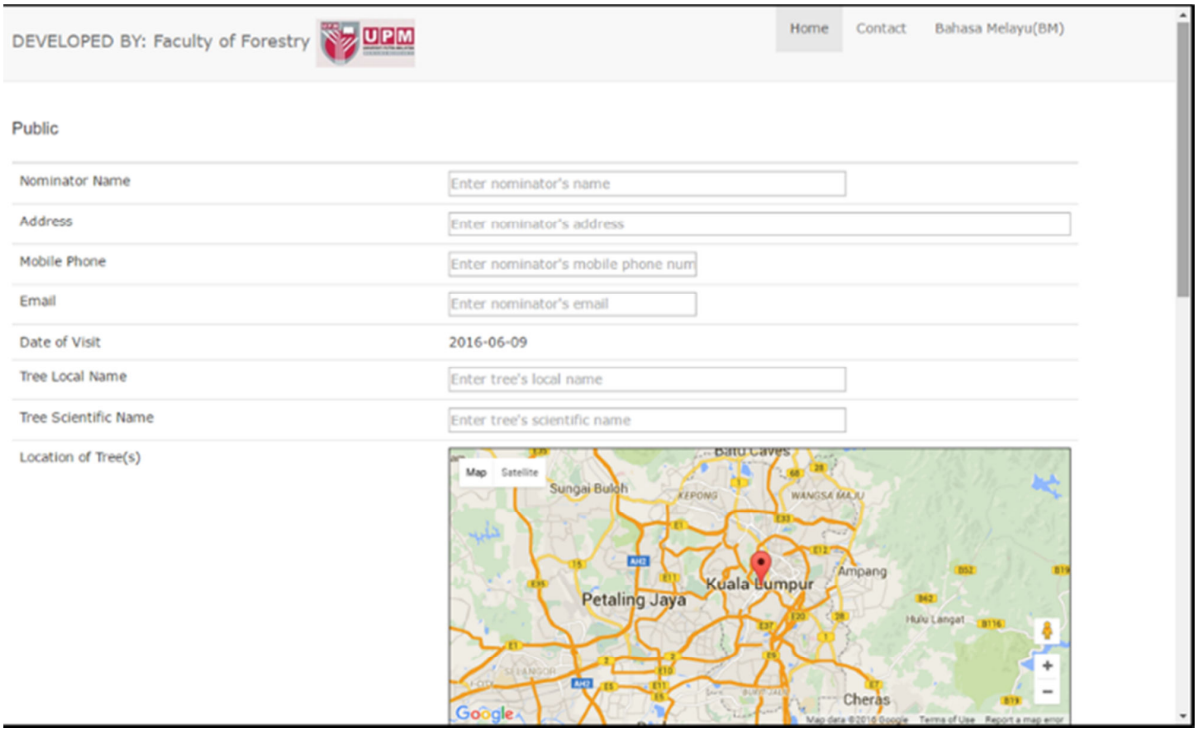


Fig. 6 (b) HTEAC tree nomination module (part 2)

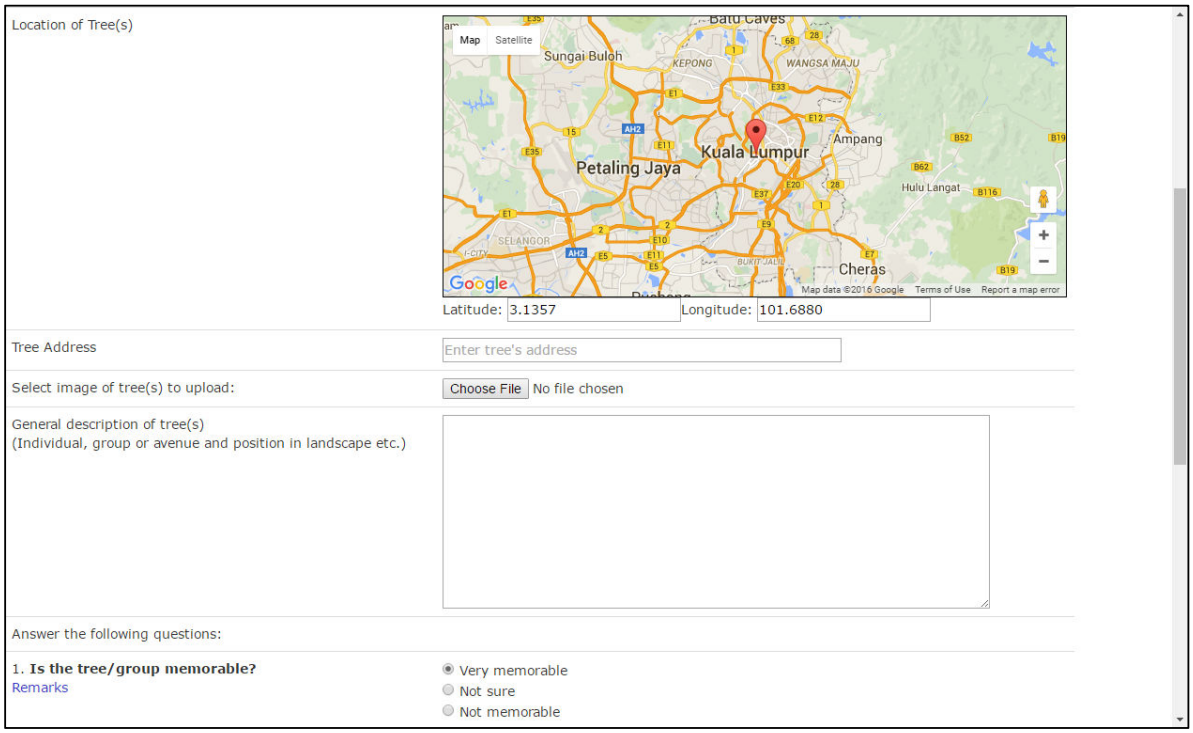


Fig. 6 (c) HTEAC tree nomination module (part 3)

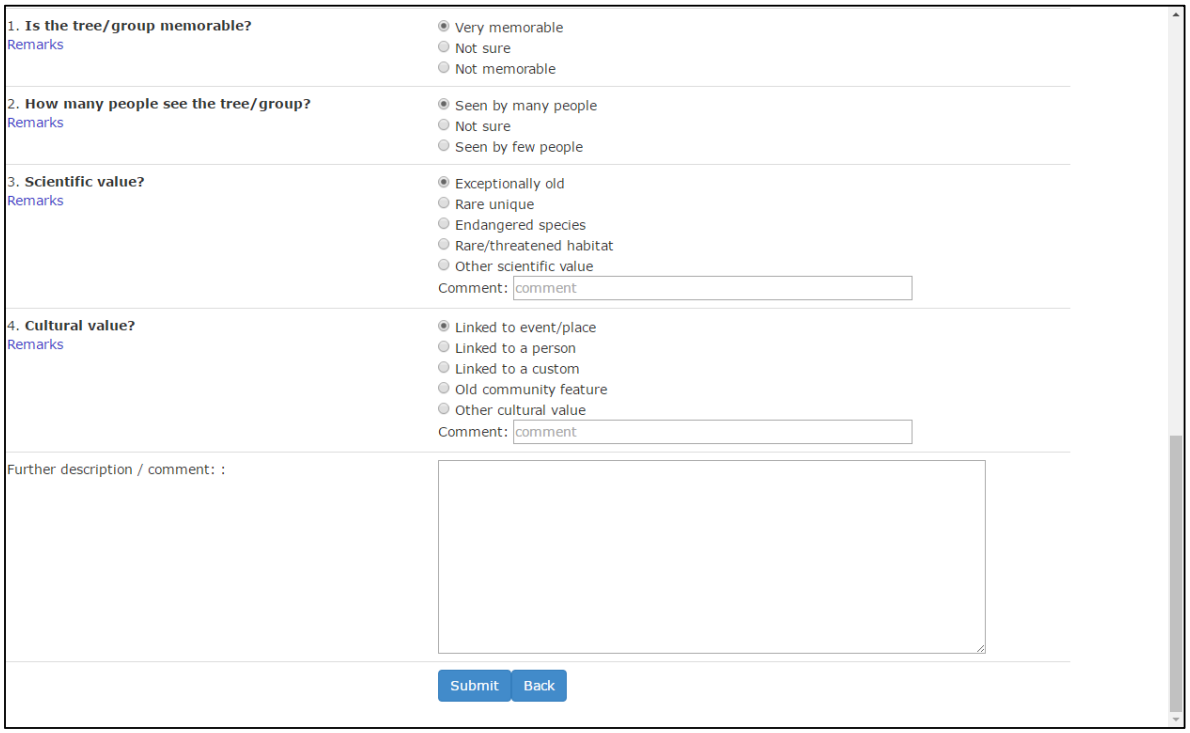
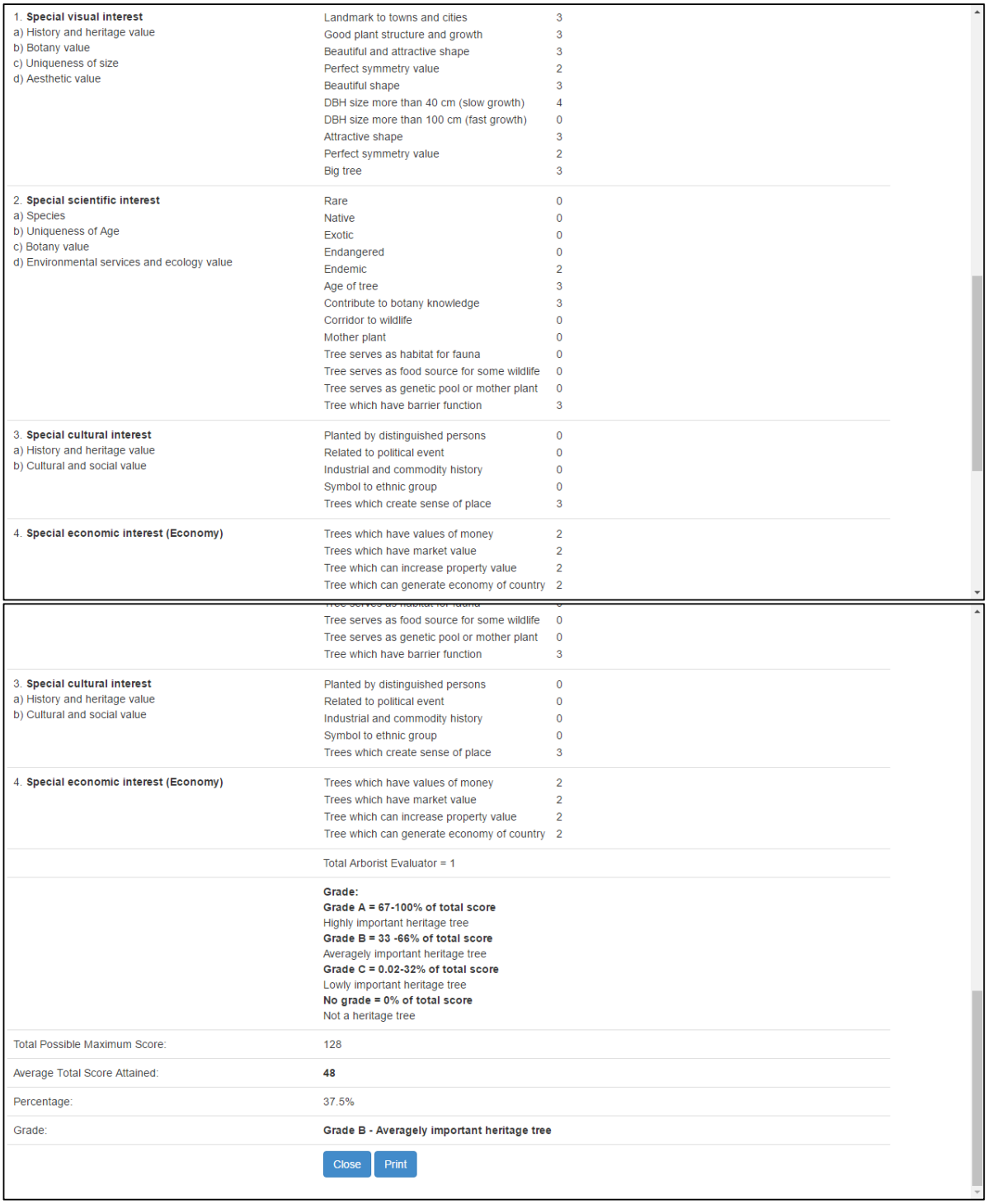


Fig. 6 (d) HTEAC tree nomination module (part 4)

The trees were rated by HTEAC according to the results as shown in Table I where Grade B indicates a moderately significant heritage tree while Grade C indicates a less significant heritage tree. At the same time, human experts were also asked to assess and identify which among those trees are heritage trees with the same information entered by

the users. It was found from the experiment that the accuracy achieved by the system is 100% with 47 trees with Grade B and 28 trees with Grade C. None of the trees were rated as highly significant heritage trees. All of the sample of trees tested was identified as heritage trees which concurs with expert opinion.



1. **Special visual interest** a) History and heritage value b) Botany value c) Uniqueness of size d) Aesthetic value	Landmark to towns and cities	3
	Good plant structure and growth	3
	Beautiful and attractive shape	3
	Perfect symmetry value	2
	Beautiful shape	3
	DBH size more than 40 cm (slow growth)	4
	DBH size more than 100 cm (fast growth)	0
	Attractive shape	3
	Perfect symmetry value	2
	Big tree	3
2. **Special scientific interest** a) Species b) Uniqueness of Age c) Botany value d) Environmental services and ecology value	Rare	0
	Native	0
	Exotic	0
	Endangered	0
	Endemic	2
	Age of tree	3
	Contribute to botany knowledge	3
	Corridor to wildlife	0
	Mother plant	0
	Tree serves as habitat for fauna	0
	Tree serves as food source for some wildlife	0
	Tree serves as genetic pool or mother plant	0
	Tree which have barrier function	3
3. **Special cultural interest** a) History and heritage value b) Cultural and social value	Planted by distinguished persons	0
	Related to political event	0
	Industrial and commodity history	0
	Symbol to ethnic group	0
	Trees which create sense of place	3
4. **Special economic interest (Economy)**	Trees which have values of money	2
	Trees which have market value	2
	Tree which can increase property value	2
	Tree which can generate economy of country	2
	Tree serves as food source for some wildlife	0
	Tree serves as genetic pool or mother plant	0
	Tree which have barrier function	3
3. **Special cultural interest** a) History and heritage value b) Cultural and social value	Planted by distinguished persons	0
	Related to political event	0
	Industrial and commodity history	0
	Symbol to ethnic group	0
	Trees which create sense of place	3
4. **Special economic interest (Economy)**	Trees which have values of money	2
	Trees which have market value	2
	Tree which can increase property value	2
	Tree which can generate economy of country	2
	Total Arborist Evaluator = 1	
	Grade: **Grade A = 67-100% of total score** Highly important heritage tree **Grade B = 33 -66% of total score** Averagely important heritage tree **Grade C = 0.02-32% of total score** Lowly important heritage tree **No grade = 0% of total score** Not a heritage tree	
Total Possible Maximum Score:	128	
Average Total Score Attained:	**48**	
Percentage:	37.5%	
Grade:	**Grade B - Averagely important heritage tree**	
	Close Print	

Fig. 7 Screen showing assessment rating result by HTEAC for a specific tree nominated

TABLE I
LIST OF SAMPLE TREES IN GEORGETOWN, PENANG TESTED USING HTEAC

Tree	Description	Grade	Tree	Description	Grade
1	JM 001	Grade C	40	JY 015	Grade C
2	JM 002	Grade C	41	JY 016	Grade C
3	JM 003	Grade B	42	JY 017	Grade B
4	JM 004	Grade B	43	JY 018	Grade B
5	JM 005	Grade C	44	JY 019	Grade B
6	JM 006	Grade C	45	JY 020	Grade B
7	JM 007	Grade B	46	JY 021	Grade B
8	JM 008	Grade B	47	JY 022	Grade B
9	JM 009	Grade C	48	JY 023	Grade B
10	JM 010	Grade B	49	JY 024	Grade B
11	JM 012	Grade B	50	JY 025	Grade C
12	JM 014	Grade B	51	JK 001	Grade C
13	JM 019	Grade B	52	JK 005	Grade C
14	JM 024	Grade B	53	JK 012	Grade C
16	JM 037	Grade B	54	JK 013	Grade B
17	JM 047	Grade B	55	JK 021	Grade B
18	JM 050	Grade C	56	JK 024	Grade C
19	JM 065	Grade B	57	JK 026	Grade C
20	JM 066	Grade B	58	JK 033	Grade C
21	JM 078	Grade C	59	JK 041	Grade B
22	JM 079	Grade C	60	JK 051	Grade B
23	JM 080	Grade C	61	JK 053	Grade B
24	JM 085	Grade C	62	JK 057	Grade B
25	JM 088	Grade B	63	JK 062	Grade C
26	JY 001	Grade B	64	JK 069	Grade B
27	JY 002	Grade B	65	JK 076	Grade B
28	JY 003	Grade B	66	JK 080	Grade C
29	JY 004	Grade B	67	JK 082	Grade C
30	JY 005	Grade B	68	JK 085	Grade C
31	JY 006	Grade B	69	JK 090	Grade C
32	JY 007	Grade B	70	JK 093	Grade C
33	JY 008	Grade B	71	JK 095	Grade C
34	JY 009	Grade B	72	JK 097	Grade B
35	JY 010	Grade B	73	JK 100	Grade B
36	JY 011	Grade C	74	JK 103	Grade C
37	JY 012	Grade B	75	JK 104	Grade B
38	JY 013	Grade B			
39	JY 014	Grade B			

Note: JM = Jalan Macalister; JY = Jalan York; Jalan JK = Jalan Kelawei;

VII. CONCLUSION

In this paper, a proof-of-concept Web-based HTEAC was presented. The system is aimed at performing the tasks of classifying and identifying heritage trees in Malaysia that were normally performed by human experts. The criteria and indicators used by the system were obtained via a rigorous process of expert feedbacks via focus group and Delphi techniques.

Moving forward, more experiments are to be carried out to enhance the accuracy and usability of the system. Preliminary result, which is promising, shows that HTEAC has the potential to one day perform the tasks of urban tree management experts to classify and identify heritage trees in Malaysia. The system may one day be adopted by government agencies and local authorities for urban forestry management.

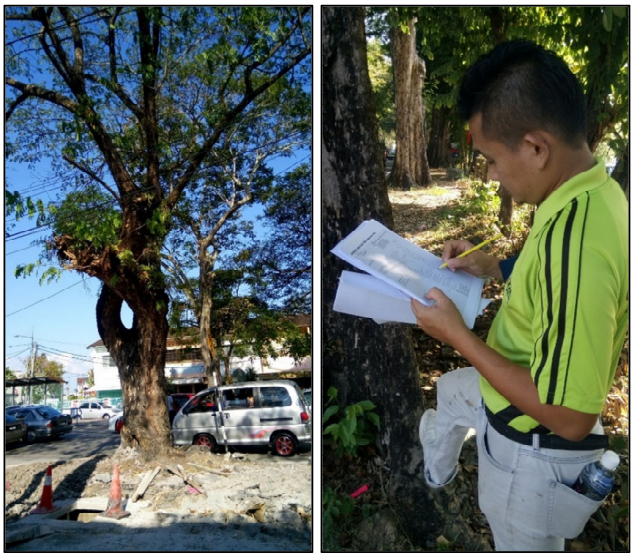


Fig. 8 Human expert nomination on the site

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