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An Evaluation on Flood Modelling Tools for Transformation of Spatial and Non-Spatial Data to 3D Geo visualization

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Abstract:
Flood is a natural disaster caused directly by excessive amount of rain water, or indirectly by the global warming. Flood information can be disseminated using visual media such as 3D flood modelling. This study uses qualitative methods to review frequently used computer tools in 3D flood modelling. Currently, the generated 3D geovisualization results produced by the 3D modelling tools are lacking in terms of their aesthetics value. The purpose of this study is to analyse and select effective 3D geovisualization tools that could be merged with multimedia tools to create better aesthetics images. This study can offer insights into creating future 3D geovisualization based on spatial and non-spatial data that are more realistic and rich with aesthetics value. The analysis was conducted using SWOT analysis in order to find out strengths, weaknesses, opportunities and threats of each tools. Result shows that some commonly used 3D geovisualization tools such as ArcGIS and FME can be combined with multimedia tools such as 3ds Max and Blender to create 3D geovisualsization for flood modelling with applied aesthetics value.

Keywords: *3D geovisualization, flood modelling, spatial data, non-spatial data, multimedia.*

I. INTRODUCTION

Climate change and global warming are possess great threats to all countries on the Earth today [1]. This problem is one of the causes of natural disasters such as floods [2]. Many scientists and researchers predict that natural disasters including severe floods will occur more frequently in future [3]. Some researchers argued that visualization media that are made using computer tools is more effective to relay information during crisis such as severe floods [4]. The 3D visual effects are often used as information media

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to convey information in the forms of messages, events, facts and ideas [5]. The 3D visual effects can be used for picture that cannot be produced using camera shooting such as 3D rendering results, 3D graphic images, and other computer generated images (CGI) [6], [7].

The purpose of this paper is to review common and frequently used computer tools in making 3D geovisualization for flood disaster modelling. The review determine the types of data, analyses the mechanisms how tools are used in transforming data into visuals, and evaluating the strengths, weaknesses, opportunities and threats of each tools. The results of literature review show that the most widely used computer tools in making flood modelling are ArcGIS, HEC-RAS, HEC-HMS, XP-SWMM, FME, and ANUGA [8]. Are commonly used spatial and non-spatial data [9], [10].

This study uses qualitative methods to explore problem of the tools used for 3D geovisualization, as well as to discover methods to change spatial and non-spatial data into 3D geovisualization [11]. The process of data collection and triangulation analysis used to examine and establish the validity of data sources by investigating various perspectives, as well as ensure the validity of the collected data, checking the reliability of the literature [12].

The literature analysis was done by searching related articles from several online databases, namely Science Direct (SD), Google Scholar, Scopus (SCP), Web of Science (WOS), and IEEE [13].

The structure in this paper consists of four parts, that is introduction, data review and tools to build 3D geovisualization for flood (the material and method), and SWOT analysis for flood tools that are used in making 3D geovisualization (result and discussion), conclusion and future research tools.

II. DATA REVIEW AND TOOLS TO BUILD 3D GEOVISUALIZATION FOR FLOOD

These literature finding covers the main discussion on spatial and non-spatial data, 3D geovisualization and the transformation of data, and tools used in making 3D geovisualization.

A. Spatial and Non-Spatial Data

Spatial data is a location information in the form of geographical coordinates for instance altitude, latitude and longitude or squares (X, Y, Z, Cartesian), abscissa coordinates, and earth dimensional projection systems [10]. Non-spatial data is a descriptive attributes such as information on condition of a location including area, zip code, population, and types of vegetation [9].

B. 3D Geovisualization

3D modelling is the best options used in delivering information on flood disasters, compared with 1D and 2D modelling. This is because the result of the 3D visualization is more satisfying to the audience [14], [15], [16]. Visualization that displays all or part of the surface of the Earth in 3 dimensions is known as 3D geovisualization [17], [18]. The 3D geovisualization is able to grab audience' attentions and make them more focused while receiving the delivered information [14],[11]. Hence, 3D geovisulization is considered as one of the most efficient technologies used in conveying information about flood disasters [19], [17].

C. Transformation Data into 3D Geovisualization

The process of data input, data reading, and turning them into a new shape that is more useful and can be further developed is an understanding from transformation data [6]. To be able transform data into 3D flood modelling, tools such as FME, ArcGIS, and Google SketchUp can be used. The result of this data transformation is shape of terrain, buildings, or other

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information, which will be exported in CAD file format, to be developed further using the Google SketchUp tools [15]. The locations mapping and processing topographic data will be transformed into 3D flood modelling using ArcGIS [20], [21]. In addition, there are several other tools such as XP-SWMM, ANUGA, HEC-RAS, and HEC-HMS could be used but only for 2D flood models [22], [23].

In another study, many 3D flood modelling was used to convey information on flood disaster, by combining ArcGIS and Google SketchUp [24], [25]. The 3D geovisualization which was made by FME tools, is able to analyse damages in buildings [19], [26].

D. Building 3D Geovisualization For Flood Modeling

HEC-HMS, HEC-RAS, FME, XP-SWMM, ANUGA, combined with ArcGIS, and Google SketchUp, is a tools that many used by researcher in doing transformation data to 3D geovisualisasi [22],[27],[28]. Geovisualization is image making technique that organizes earth surface information in the form of 2D and 3D displays. Presented images, animations, and diagrams, provides useful information on flood, situations recognition, and environmental structures at flood locations [18], [29]. These also includes the process of creating 3D geovisualization from spatial data and non-spatial data, and process them into a visual form with data processing tools as in Fig. 1 [30].

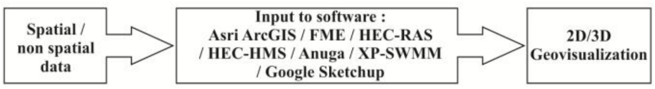

Fig. 1 The process of transforming data into geovisualization.

ArcGIS Desktop was used in management, analysis, and display of geographical information [31], [32]. This tools is very useful for communication interoperability, distributing and dividing data. It also can use classified data in spatial ETL (Extract, Transform, and Load) via all applications [32]. The process of transforming spatial and non-spatial geographic information into 2D and 3D geovisualsization using the ArcGIS tools applications, can be seen in Fig. 1 [15], [33].

The other software that can be used is FME, which can save, extract convert data input, and transform them into 3D geovisualsization that suits user needs [34],[35].

The HEC-HMS is a tools designed to simulate hydrological processes [36]. Modelling results can be used simultaneously with other tools for urban drainage, flow forecasting, reduction of flood damage, and floodplain regulations [37].

The HEC-RAS tools was used to perform 1D and 2D hydraulic calculations for completing network of natural and artificial channels [38],[19]. This tools is able to do data entry and editing, inundation mapping and animations of water propagation [39],[40].

The ANUGA used to create various modelling of hydrological disaster such as flood flows, dam damage, storm surge, and tsunami [28]. The ANUGA capable to track evolution of water depth [20].

The XP-SWMM is has the ability to visualize in 1D and 2D views so the user can picture what happens to the storm water, floodplains when a disaster occurs [7],[41],[42]. Visual display in various file formats which can be tailored for animation designing [43].

Google SketcUp tools is actually not functional for transformation of spatial and non-spatial data in the 3D geovisualization processes. This tools is used as a tool to refine the modelling results that have been made previously in ArcGIS, or FME tools. It has an ability to make modelling, provide more realistic effects that

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cannot be done using the ArcGIS and FME [44], [45], [46].

E. 3D Geovisualization for Flood Modelling

Data needed in 3D flood modelling production are (i). Spatial data about information of location such as map, attribute data, regional boundaries, location coordinates, (ii). Non-spatial data of research location such as administrative, annual rainfall, soil type land use and land units, slope, and hydrology data [47],[48]. The result of conversion in import to Google Sketchup, before developed into 2D/3D modellling [45],[46]. Flow of 3D geovisualization process for flood modelling using ArcGIS and Google SketchUp is in Fig. 2 [49].

Fig. 2 The 3D modelling flow with spatial and non-spatial data converter

(ArcGIS) and combine with Google SketchUp.

The ArcGIS is used to transform spatial and non-spatial data from flood events, before exports them into AutoCAD to be processed by Google SketchUp [48], as explained in Fig. 3 [49].

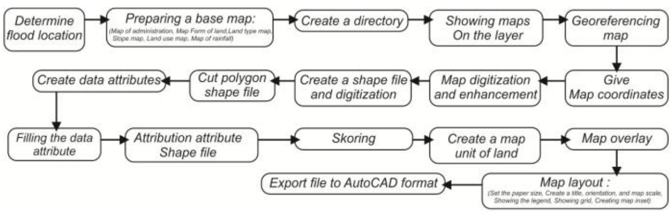

Fig. 3 The flow of data transformation into geovisualization using ArcGIS tools.

FME (Feature Manipulation Engine) processing streamlining and translating spatial data in a geometric and digital format, aims for to can be used in geographic information systems (GIS) [49], [57]. The simplified process can be seen in Fig. 4 [6].

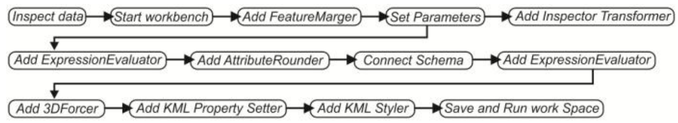

Fig. 4. The flow of data transformation into geovisualization using FME

tools.

The HEC-HMS is also used in converting spatial and non-spatial data into 3D geovisualsization for flood modelling [22],[14]. This process of flood modelling is simplified in Fig. 5 [37].

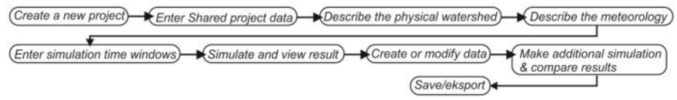

Fig. 5 The flow of data transformation into geovisualization using HEC-HMS.

The HEC-RAS tools is very accurate in making 2D flood modelling. In addition, HEC-RAS could be used together with ArcGIS to mapping and simulate flood area as in Fig. 6 [50], [51].

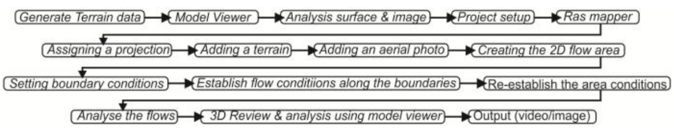

Fig. 6 The steps transforming data into govisualization through HEC-RAS tools.

The ANUGA is a system of hydrodynamic modelling that usable as simulate of floods [20]. Operates using an object-oriented python toolsming language. The ANUGA workflow of flood modelling can be referred in Fig. 7 [50].

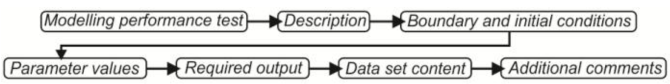

Fig. 7 The flow of data transformation into geovisualization using ANUGA tools.

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The XP-SWMM it is very accurate in making flood modelling to predict the depth, speed, and duration of the flood [7]. Data modelling process of this tools is shown in Fig. 8 [52].

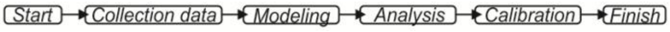

Fig. 8 The flow of data transformation into geovisualization using XP-SWMM tools.

The Google SketchUp functions as an advanced stage of the 3D geovisualization through spatial and non-spatial data [44]. To appropriate effects and materials were added,–to maximize modelling results. The modelling process using Google SketchUp can be seen in Fig.9 [50].

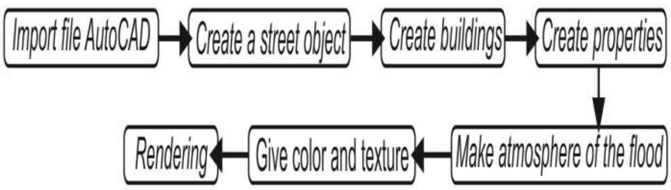

Fig. 9 The flow of data transformation into geovisualization using Google SketchUp tools.

The final result of the 3D geovisualization process can be saved as an image in JPG, PNG, and TIFF format file, as well as animation in avi, MP4, and etc. Fig. 10 shows some of the examples of 3D geovisualsization [15], [19], [53].

Fig. 10. Example of 3D geovisualization for flood.

III. SWOT ANALYSIS FOR FLOOD TOOLS TOOLS

THAT USED IN MAKING 3D GEOVISUALIZATION

This analysis is to find out which tools is the most appropriate to be used in future, by merging multimedia tools to produce better 3D geovisualsization [54].

SWOT analysis identification of the strengths (to know the advantages), weaknesses (to know the shortcoming), opportunities (to know the possibilities for further development) and threats (to find out cause of the user stop using) [55]. This section only performs analysis without comparing, because each tools has its own characteristics that complement each other. Table 1 summarizes the SWOT analysis for the reviewed tools [56].

TABLE I
SWOT ANALYSIS FOR FLOOD TOOLS TOOLS THAT USED IN MAKING 3D GEOVISUALIZATION

No	**Tools**	
1	**ArcGIS**	
	S	Simple application, easy to used. Support files: BSQ, JPEG, TIFF, BMP, GeoTIFF, avi, spatial and non-spatial data, CAD, etc. 2D and 3D visualization.
	W	Needs highly specific computer, Difficult to create a mass mapping.
	O	Allow to be developed using multimedia tools to achieve better visualization results.
	T	Cannot stand alone to achieve maximum 3D modelling.

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2	**FME**	
	S	Simple application. Support files: Point cloud via XML, raster, database, GIS, CAD, spatial and non-spatial data, etc. 2D and 3D visualization. Able to create a real time map.
	W	Need highly specific computer, Hard to use.
	O	Allow to be developed using multimedia tools to achieve better visualization results.
	T	Cannot stand alone to achieve maximum 3D modelling.
3	**HEC-HMS**	
	S	Simple application, easy to used, free tools, standard specification computer. Support files: GIS, specially toolsmed for the hydrological modelling.
	W	Only 1D and 2D visual.
	O	Allow to be developed using multimedia tools to achieve better visualization results.
	T	Cannot stand alone to achieve 3D modelling.
4	**HEC-RAS**	
	S	Simple application, easy to used, free tools, standard specific computer. Support files: GIS and CAD, Specially toolsmed for hydraulic modelling.
	W	Only 1D and 2D visual.
	O	Allow to be developed using multimedia tools to achieve better visualization results.
	T	Cannot stand alone to achieve 3D modelling.
5	**ANUGA**	
	S	Simple application, easy to used, free tools, standard spec computer. Support files:WaterRide, Mirone, SWW2DEM, and QGIS. Hydrodynamic visual modelling.
	W	Hard to used app (base data toolsing), Only 1D and 2D visual.
	O	Allow to be developed using multimedia tools to achieve better visualization results.
	T	Cannot stand alone to achieve 3D modelling.
6	**XP-SWMM**	
	S	Simple application, easy to used, free tools, standard spec computer. Support files: GIS and CAD. Hydrologic, hydraulic visual modelling.
	W	Only 1D and 2D visual.
	O	Allow to be developed using multimedia tools to achieve better visualization results.
	T	Cannot stand alone to achieve 3D modelling.
7	**Google SketchUp**	
	S	Simple application, easy to used, free tools, standard spec computer. Support files: GIS and CAD, 3ds Max, etc. 2D and 3D visualization.
	W	3D material is still less realistic.
	O	Allow to be developed using multimedia

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		tools to achieve better visualization results.
	T	Cannot process Hydrological, hydraulic modelling, spatial, and non-spatial data.

The overall result of SWOT analysis above shows:

1) *Strengths:* All tools have a simple look so they are easy to the user. A standard computer device can be used for installing HEX-HMS, HEC-RAS, Anuga, and XP-SWMM. All of the above tools are can be incorporated with ArcGIS.

2) *Weakness:* A highly specific computer is required for installation of ArcGIS, FME, and Google Sketchup. The FME and Anuga are difficult to use. In addition, only ArcGIS, FME and Google SketchUp are able to perform 3D modelling. Visual result from some tools is still less perfect.

3) *Opportunity:* Because some of the above tools provides GIS and CAD file formats, so it is possible to be developed further using multimedia tools to achieve better visual results with aesthetic value.

4) *Threat:* The above tools highly dependent on ArcGIS, FME, and collaborated with Google Sketchup. If available a new tools can stand alone in processing spatial and non-spatial data into 3D modelling, maybe user will switch into new tools.

Finally, SWOT analysis above shows that the entire data processing tools are capable of producing flood visualsization, which are accurately in the form of 1 and 2 dimensions. Most of the data processing tools cannot directly generate 3D modelling from spatial and non-spatial, except ArcGIS and FME. However 3D visualization results is still not maximal, because only able to provide with basic colours.

Study shows that Google SketchUp has a important role in creating 3D flood geovisualization, as it serves as a link between spatial and non-spatial data through conversion tools (ArcGIS, FME, HEC-RAS, HEC-HMS, XP-SWMM).

For the future 3D flood visualizations, a file need to exported from Google SketchUp to multimedia tools such as Blender, 3ds Max, or others. This method is expected to increase aesthetic value like perfection of material, lighting, and animation.

IV. CONCLUSION AND FUTURE RESEARCH

The 3D geovisualization is one of the best ways to convey information about flood. Many academics have used ArcGIS tools, FME, HEC-HMS, HEC-RAS, ANUGA, and Xp-SWMM combined with Google SketchUp to make 3D flood modelling.

The result of SWOT analysis shows that most of the tools above cannot stand alone to produce 3D modelling based on spatial and non-spatial data, but dependent on ArcGIS, FME and Google SketchUp to create good 3D geovisualization.

Geovisualization-making tools are recommended to be further developed with multimedia tools such as Blender, 3ds Max, Cinema 4D, or others, to generate aesthetic 3D geovisualization of flood models based on accurate data.

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