

## Conference Paper

# Spatio-Temporal Visualization of Peatlands Changes

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## Abstract

Increased deforestation and draining of peatlands with the started of the drainage occurs quickly makes the availability of peatlands as carbon storage is even more alarming. The presence of peat land conversion greatly affect the hydrological balance of the ecosystem. The conversion of peatland have the massive effect with the increase of drainage constructions for land cultivation needs. This makes the neighborhood unity peat hydrology (KHG) which is wet into dry so prone to burning and experiencing land subsidence. Information of peatland degradation is presented in the spatio - temporal visualization using Space Time Cube (STC). The usability in order to determine the extent of the spatio - temporal visualization can be used by users to obtaining information peatland degradation in terms of effectiveness, efficiency and satisfaction for users. Drainage density built on KHG getting bigger every year with the index of medium density classification. Increasing the number of long-drainage occurs at 119.4934 km per year from 2000 to 2008 and 148.6954 km per year from 2008 to 2012. Based on observations in 12 years has increased the number of distribution Hotspot significantly in February. In May and September the spread of hotspots increased by the average number of hotspots at 15 points per month. The drainage development's and distribution of hotspot has dominant occurs at the HTI in the KHG Peatland degradation is presented in Visualization spatio-temporal, which visualization is very effective, fairly efficient, and give satisfaction to the users in displaying information peatland degradation in time series.

**Keywords:** Visualization, Spatio--Temporal, Degradation, Peatlands, Space Time Cube, Usability.

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## 1. Introduction

Indonesia is the largest country in Southeast Asia. Tropical peatlands are spread in Southeast Asia, especially in Indonesia and Malaysia with an area of nearly 247 778 km<sup>2</sup> and stored carbon about 68.5 giga tons [1]. Based on this known that Indonesia has the largest peat land among other tropical countries. Tropical peatlands spread in the several islands in Indonesia, in Sumatra, Kalimantan and Papua. Availability of peat quite concerning, peatlands converted for the needs of oil palm plantations, farms and

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smallholder plantations such as rubber, and other agricultural areas is also increasing rapidly [2]. Besides conversion, peat land availability is reduced because of increased deforestation and draining of peatlands with the start of the drainage that occurs very rapidly [3].

The 3D model is a system that displays geographic conditions in three dimensions with high system, projection, and datum, and with particular reference height field [4]. Efficient method used to obtain the 3D model data such as DTM and DSM with a relatively wide area coverage is LIDAR (Light Detection and Ranging) and the use of imagery RADAR. Measurement and geospatial analysis of several different data acquisition provides 3D models approach peatlands in generating information events on the surface of peat. Surface peatlands can be decreased (subsidence), this is caused by increased land conversion and drainage. In general, excessive subsidence of peat make peatlands can not return to its original state. Peatland surface dynamics by looking at temporal aspects of geospatial data have direct relevance to the changes that occur on the surface of peat. Data geospatial-temporal regions of a same object can be realized in the visualization that provides an understanding of the phenomenon of change of an object at a certain time period.

Research related to the use of 3D models that estimate carbon stocks in peat. Improve given in the estimation of carbon stock using SRTM data, in situ measurements of the thickness of the peat and GIS modeling techniques in the application of 3D models [5]. Other research in the form of high-resolution digital soil mapping using the proposed method for data mining and digital soil mapping. This study soil profile information by using LiDAR DEM data, geological variables, the data landuse and soil thickness map [6]. Other relevant research is the use of Space-Time-Cube to visualize changes in the cliffs of the data Terrestrial Laser Scanning. This study managed to visualize the condition of the cliff to look at temporal aspects of geospatial data with time series 2010-2013, preliminary data in the form of point cloud to build surface modeled voxel. Voxel model is used to visualize the form of STC using GRASS GIS software [7]. Other relevant research is a discussion about the evaluation of usability visualization space-time cube. This study discusses the quality of the data view in accordance with the expected trajectory and quantitative data can be reported. The final result is a good starting point for some testing with alternative sets of data [8]. Other studies on the evaluation of the usability is the usability of visualization methods in tapping geovisualization environment. The study assessed a usability and usability conducted to evaluate the ability of each to see visualizations which aims to meet the performance and user satisfaction. The test

in this study compared the representation of different visualization in exploring social-demographic data [9].

The research raises the topic of visualization of degradation that occurs on the surface of peat use 3D modeling of geospatial data by looking at the temporal aspects of geospatial data using Space Time Cube (STC). This study represents the STC to explore the phenomenon that occurs in the form of peat land fires, construction of drainage and land cover change from time to time. This study provides information on peatland degradation caused by land conversion that makes the unity of the hydrologic peat (KHG) is no longer wet (prone to burning) and decreased (subsidence) in the changes that occur on peat soil has an influence on the surface elevation and continues on volume and carbon stocks contained. This study is expected to provide direct benefits to provide ease of decision-makers to take concrete policy related to peatland in Indonesia, the extent of geomatics and geodetic technology utilized in inventory and monitoring peatland dynamics.

## 2. Research Methods

### 2.1. Research materials and tools

These datasets below are used:

1. DTM IFSAR 2008 dataset
2. DSM X-SAR 2000 dataset
3. DTM LIDAR 2014 strips data
4. Landsat 8 year 2013 dataset
5. hotspot data years 2000 -- 2014
6. Global forest cover loss data years 2000--2014
7. Administrative data
8. RTRW data
9. HTI concession area data

## 2.2. Preparation

The beginning stage of this research is to collect all sources of reference related to the theme of research and identify data needs. In the preparation of the necessary checks on the condition of the hardware used, where the specifications of the hardware used must be able to support data processing.

## 2.3. Data collection

The data collection is an advanced process of preparation. All data that has been planned as a research needs to be collected. Data collected by the location of the research with the position is geographically located on 102° 00' 00" E -- 103° 00' 00" E and 0° 15' 36" N -- 0° 30' 00" N.

## 2.4. Data processing

### 2.4.1. Identification of subsidence peatland surfaces

Ideally observation of subsidence peat surface can be seen from the comparison of DTM data in 2008 and 2014. When examined the data collected, the DTM IFSAR data owned by BIG which is used as a secondary data can not be used. The subsidence of peatland surfaces are identified based on the observation cross section is made of strips of data LiDAR DTM in 2014. This was done in order to get a cross section data to identify the dome shape of natural forest cover has significant differences with peat dome that experienced land conversion (non-forest).

### 2.4.2. Creation DTM topographic peatlands

DTM Data peatlands, acquired in 2014 is the data recorded in the Flyway LiDAR (strips) with a width of approximately 1.2 km area in each track, the distance between lines even fly quite far is 5 km. Interpolation needs to be done to fill the gap so that the data in the form of strips DTM can be processed into data DTM full coverage. Filling the gap by interpolating the contour based on the height of the data strips using a data stream. DTM generated requiring correction LiDAR data in the form of a geoid correction to the MSL of -0.706 meters. Correction is done by using raster calculator on the QGIS application tools.

### 2.4.3. Spatio -- temporal visualization

Visualization is made to the users understand the information more effectively and efficiently about the peatland degradation. The use of ILWIS software as an open source application is expected to facilitate research in the visualization process of peatland degradation in time series. This study is required to enter some data for further analysis using ILWIS. ILWIS has the ability to display spatio-temporal data in the Space Time Cube (Schouwenburg 2013). Space time cube has 3 axes in displaying predefined objects. the x and y axes indicate the location of objects horizontally while the z axis (t) indicates time (t). The drainage data shown in the STC using Space Time Path (STP), while hotspot data using the station.

### 2.4.4. Usability test

Usability process begins with the collection and classification of usability attributes based on specific criteria or dimensions usability. Usability in spatial visualization is done to explore what information is obtained by the user from the visualization that is implemented from certain data. Indexing usability conducted by collecting attributes and classified in accordance with the usability dimensions from ISO 9241. Usability criteria determined by the features and functionality of visualization products. Attribute classification process is done subjectively by the researchers, this study involving respondents to provide an assessment of the level of importance. In the Figure 1, showing the flow of process usability conducted to determine the usefulness of spatio-temporal visualization in this study.

## 3. Result and Discussion

### 3.1. Observations subsidence peatlands

Identification subsidence of peat surface indicates degradation that occurs in peat areas of cultivation compared with natural peatlands. A natural peatland are the peatland which covered by natural forest. Observations subsidence conducted based on strips data DTM which representing peatland surface conditions at this time. The condition of the surface shape in the form of peat dome KHG observed by land cover in the form of forest and non-forest. Observations conditions KHG dome shape not only based on land cover, but also based on data from HTI concession area along the data strips DTM traversed. Land cover data used is global forest cover loss of data from the Global

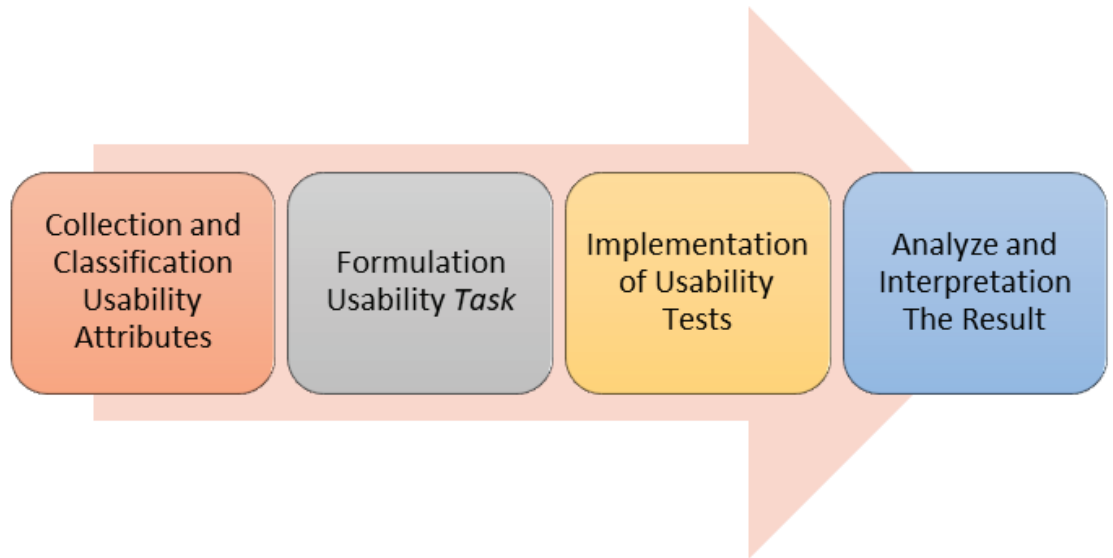


Figure 1: Usability Processing.

Forest Climate (GFC) in 2015 and Industrial Plantation Forest (HTI). The value 0 (zero) in global forest cover loss graph represents the value that identifies the area of forest cover, contrary to the value of 12 (twelve). This values is identification of land cover forest (zero) and non forest (twelve) in 2015.

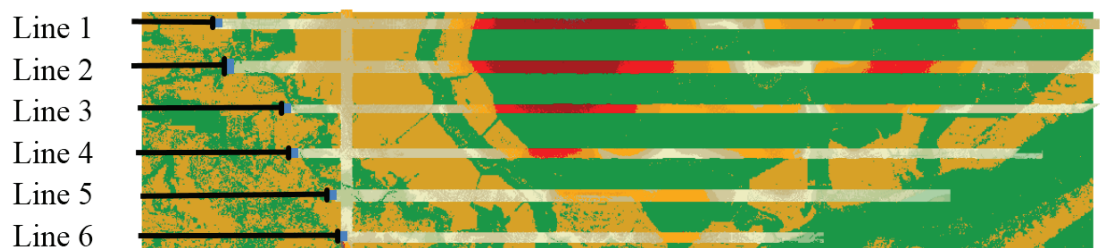
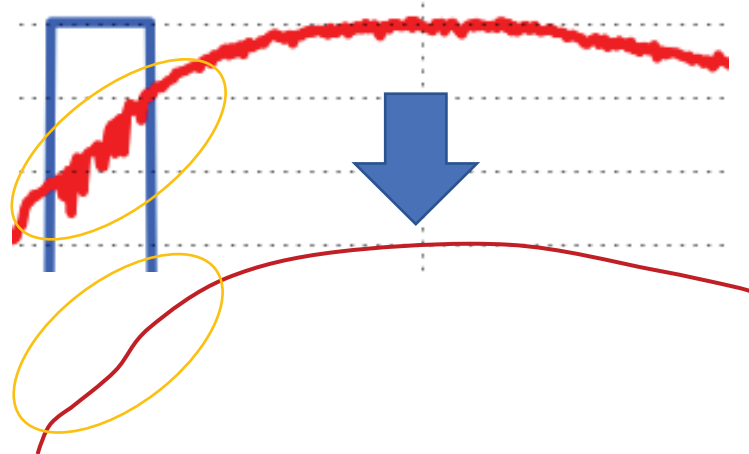


Figure 2: Numbering of Cross Section on DTM Strips.

The profile data cross section that represents state dome shape peatland peatland area of cultivation (global forest cover loss and HTI concession areas) provides an indication of the surface that had a drop elevation, which the surface has a shape more concave than the dome shape peatlands naturally. Observations entire data strips done by making 12 (twelve) cross section. Observations with the number of 12 (twelve) cross section performed by two (2) cross section in each lane strips with total of six (6) lines. Each strips have a width about 1,2 km which makes the surface conditions are distinctly different elevations on the north and south in each track. So that the cross section data observations conducted on the north and south on each lane strips DTM.

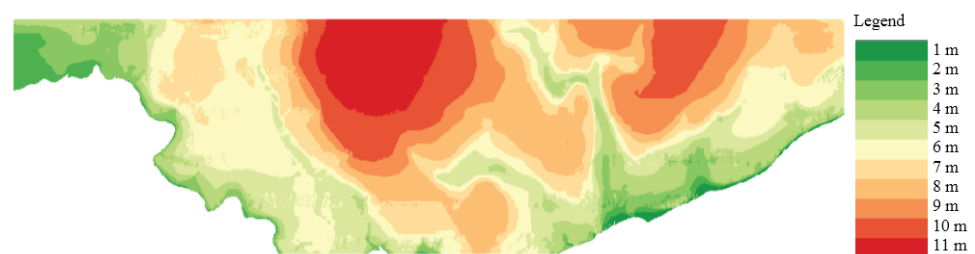
In the Figure 2 concave shape can be identified by generalizing the surface elevation graphs. Be seen clearly the differences in the shape and height of the surface of natural peatlands and peat cultivation.



**Figure 3:** Identification of the Surface Elevation Drop Peatland.

### 3.2. Results identification unit hydrology peat (KHG)

The result of the interpolation process based on data strips and contour generate data DTM full coverage. Based on data from the interpolation, hydrological unity peat in the form of a dome can be clearly identified (Figure 2). Full coverage of the resulting DTM is part of the peat ecosystem of the river KHG Bunut - Kiyap Sungai Riau Province. Based on Unity Hydrological Peat maps, known that the DTM is one ecosystem KHG. But keep observation on a large scale in some KHG as research areas.



**Figure 4:** Intepolation Result.

Delineation of peatland ecosystems carried out based on the shape of the dome that formed the contours DTM Data obtained. Peatland ecosystems in Muara Kampar area bounded by natural rivers. There are three (3) hydrological unity peat domes separated by several small rivers, where the unity of the hydrologic peat in Pelalawan district was included in the administrative borders of the two (2) sub districts, Palalawan and Teluk Meranti sub-districts.

Distribution drainage from 2000 to 2013 became increasingly crowded. Drainage or waterways is one of the water system management activities that aim to regulate and maintain the ground water level in the planting area. However, excessive drainage development has an influence on the peat drought occurred so that its hydrophilic nature does not work.

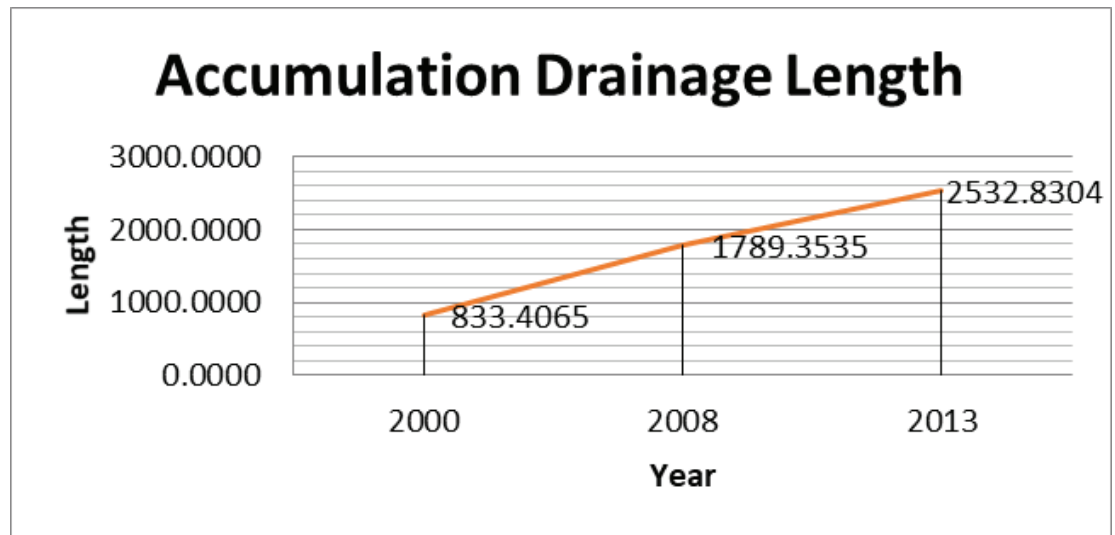


Figure 5: Graph of Drainage Construction Growth Up to 2013.

In 2008 until 2013 the addition of drainage run into considerable increase is 148.6954 km per year. The following indices drainage density in the area by the number of overall unity peat hydrology 2310.988 km<sup>2</sup>:

TABLE 1: Drainage Density Indeks.

No	Year	Drainage Length (L)	Drainage Density (Dd)
1	2000	833,406	0,361
2	2008	1789,353	0,774
3	2013	2532,830	1,096

Based on this calculation obtained drainage density in the area KHG included in the criteria of the medium. Distribution hotspot on observations of the study area has the sizeable amount. Observations spread of hotspots by the time the incident needs to be done to understand the relationship of events by year and month (Figure 5). The Highest number of hotspots occurred in February, while the lowest in December. Sufficient number of hotspots increased in February and declined until in April and May. While based on the accumulation of observations per year hotspot was found that in 2005, 2009, 2013, and 2014 hotspots that appear exceeded the average amount that occur annually.



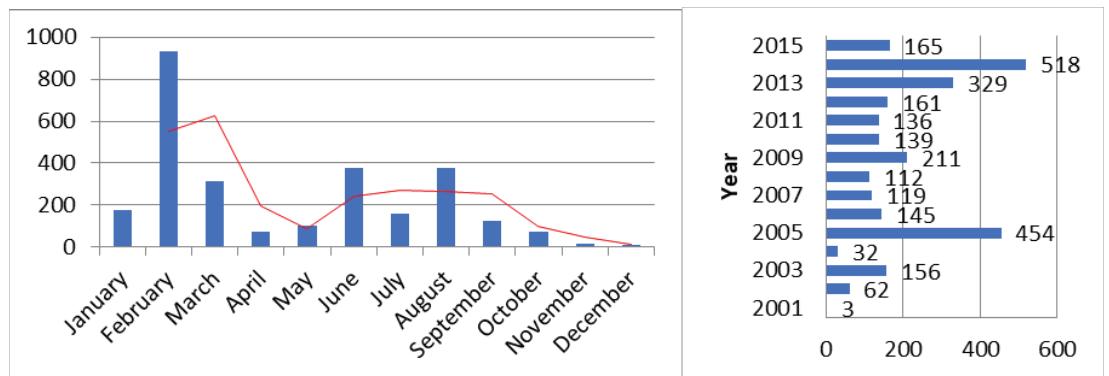


Figure 6: Graph of Number Hotspot Monthly and Yearly 2001-2015.

The dry season in Indonesia average starting in April / May. In the month after May an increasing number of hotspots with a steady amount each month throughout the months of June, July, and August. The incidence of burn agriculture in some areas often coincide with the start of El Niño events.

Distribution dominant hotspot within the scope of HTI concession area. the appearance of hotspots in the use of plantation land is synonymous with the burning is done for the opening of new land or rejuvenation. Similarly, construction of drainage at KHG not done evenly throughout the KHG, but focused on the HTI concession areas. Drainage density increased from 2000, 2008 and 2013 concentrated on HTI concession area. HTI issuance of location permit would not be separated from the RTRW which is owned by every region in Indonesia, especially province of Riau.

TABLE 2: Appropriation comprehensive HTI Concession Area Region at KHG.

RTRW HTI Owner	Protected Area (m <sup>2</sup> )	Forestry APK (m <sup>2</sup> )	Plantation APK (m <sup>2</sup> )
CV. Alam Lestari	15768919,2125	1186088,7416	-
CV. Harapan Jaya	50499738,0547	-	-
CV. Mutiara Lestari	1940408,2382	-	14903778,8028
PT. Madukoro	98911489,5230	-	-
PT. Mitra Hutani Jaya	133785,0160	51267333,2146	16884136,7111
PT. Riau Andalan Pulp & Paper	124014332,1521	574427172,2276	19576965,7171
PT. Selaras Abadi Utama	-	72703479,4726	67171947,3677
Non HTI	981539210,3110	208495807,4398	91530448,2194
<b>Sum</b>	<b>1272807882,5076</b>	<b>908079881,0962</b>	<b>210067276,8181</b>

Based on data from table 2, protected areas in the KHG has the largest area with total area of 1272.80 km<sup>2</sup>, while the Forestry APK area of 908.07 km<sup>2</sup>. Plantation APK region has the smallest area in the amount of 210.06 km<sup>2</sup>. More than 50% of the KHG is an

area allocated as a protected area. Some were intended as APK Forestry department (38%) and a small portion of APK Plantation (9%).

### 3.3. Results visualization creation STC

Spatial-temporal data visualization is needed in understanding the phenomena that occur and can provide appropriate information is good and factual. Temporal geospatial data representing the movement of massive objects, reflecting the improved technical skills in obtaining and recording the data in accordance with the reality on the ground is collected repeatedly over a period of time [10]. The use of software ILWIS determine the temporal spatial visualization is performed. This software not only can display 3D visualization, but can display a visualization of Space Time Cube.

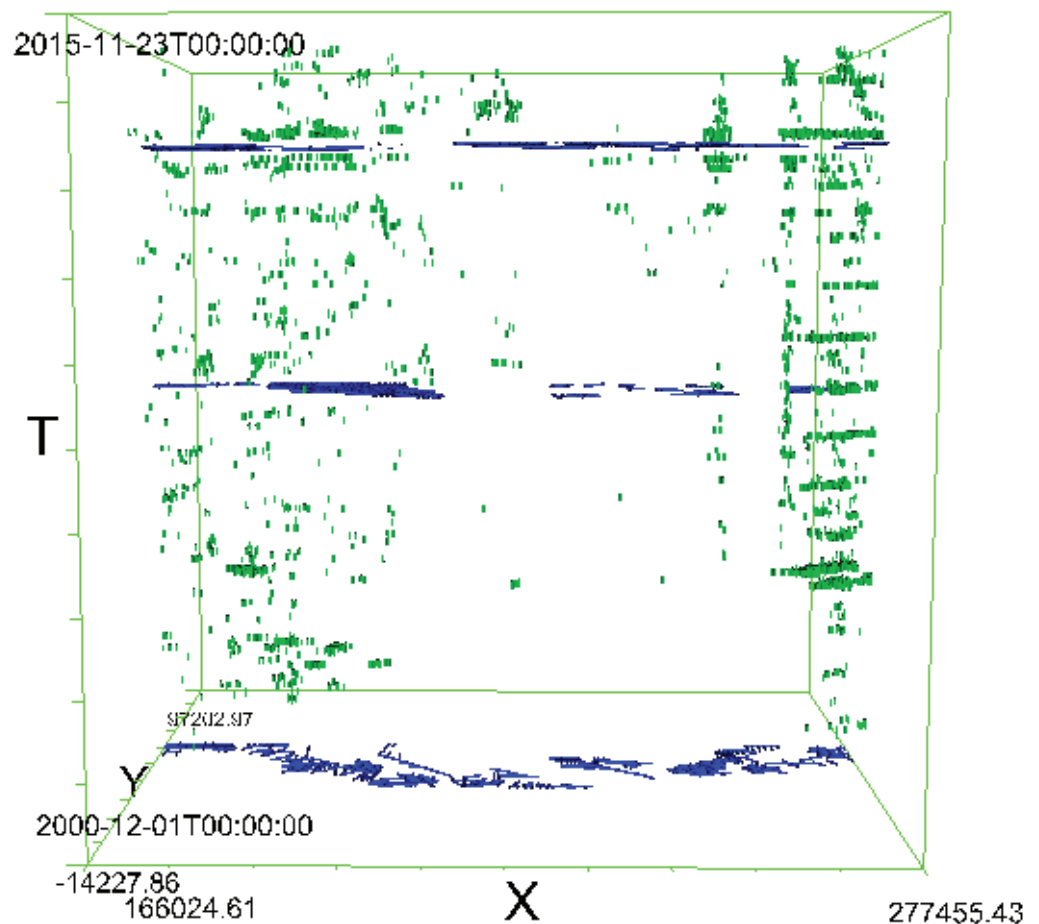


Figure 7: STC Visualization.

Space-time cube has a 3-axis displaying the predefined objects. x and y axis shows the location of the object horizontally while the axis z indicates the time (t). In Figure 6

generated, showing hotspots and drainage point spread on the area Pelalawan, Riau Province.

### 3.4. Results visualization usability

Visualization criteria in order of importance from the viewpoint of the subject, the order of priority obtained a good visualization as follows:

TABLE 3: Criteria Priority.

<b>Effectiveness</b>
1. In accordance with requirement
<b>Satisfaction</b>
2. Easy to use
3. Easy to understand
4. Not many failures in running the visualization
<b>Efficient</b>
5. Not need much time

Users in this spatio - temporal visualization test are users of geographic information systems (GIS) with the use of different levels. Most have knowledge of spatio-temporal visualization in the field of GIS. Users are given the display visualization and given eight tasks need to be completed by the user for utilizing visualization experience in obtaining the information needed. The time needed to do the task as a whole is an average of 1 hour 12 minutes with a total of 8 tasks. Based on this, each task takes 9 minutes to work on. 9 minutes of work on each task is a time duration that is not too long for the user to identify information from the spatio-temporal visualization of peatlands. In addition to assisting users in working on each stage of spatio-temporal visualization exploration, the tasks given are also an indication of the extent of the efficiency, satisfaction and effectiveness of the visualization.

Then the results of working on a given task is obtained that users pretty good at running the system and explore visualization. The information is understood directly by the user based on the observation of events on the visualization according to the purpose of each task prepared beforehand. Users can identify the incidence density of peatland degradation at certain times. In addition, users can identify degradation occurrences are spatially with the presence of the dome, the concession area of Industrial Plantation Forest (HTI), and land cover in a certain time. Overall user can identify peatland degradation are closely related to farming activity spatially peatlands.

No there is considerable difficulty fatal for users in doing the task and in exploration visualization of spatio - temporal, but there are a few things for the user dissatisfaction. Users expect other than to identify visually, users can run a particular query analysis

based on the attribute data and the accumulated amount of data in certain circumstances. Users also hope there are some indications snap when the data DTM or HTI concession area intersected by a certain time serial data.

Overall task compiled helping users work through each stage of exploration visualization of spatio - temporal experiences, especially for users who have never used visualization methods STC. Users who do not have experience in using the same applications tend to have difficulty in using any tools that have been available. User habits in using GIS on certain software provides limitations will use the new software that are not familiar to the user for reasons not familiar. The preparation of The task enables users to explore the visualization of spatio - temporal.

## 4. Conclusion, Recommendation, and References

### 4.1. Conclusion

The subsidence in the land ecosystem hydrological unity peat massively influenced by farming activities can be identified. Identification is done by observing the cross section DTM 2014 based on the area of land cover and HTI area concessions of KHG. In 2000 and 2015 the cultivation of peatlands is increasing which resulted in increasingly dense drainage on ecosystems KHG. Peatland degradation that occurs in the form of distribution of hotspots and subsidence associated with spatial policy factors that give investment opportunities concession area of plantation forests (HTI) and plantations. Visualization spatio - temporal very effective, fairly efficient, and very satisfaction to the users in displaying information of peatland degradation on time series.

### 4.2. Recommendation

1. Limitations of elevation data with different acquisition impact on the difficulty in selecting the use of the reference datum. There needs to confirm and cross-check the data used in the study with the mayor of data quality related data. Differences in data acquisition provide different resolutions, up to affect the quality of the final results of the processing of data.
2. Better identification of subsidence in units of surface strips when compared to using cross section. There are variations in the DTM will be the response of deforestation and drainage development in strips unit area compared to that observed using a cross section.

3. Analysis of subsidence would be better if to approach the average value in units of centimeters per year. Where the observation area since the construction of the drainage of peatlands to date 3D models using data on peatlands.
4. Based on this study, further research needs to be done related to peatland degradation that occurs in sub-sub KHG. Peatlands are hydrological unity with a content of 90% peat is water. If the peatland ecosystem has been damaged because of the influence of the cultivation of peatlands, should be done immediately in order to secure peatlands remain wet on sub-KHG which has passed through a drainage. Of course it is considering water balance calculations, both input and output.

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