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Estimated Land and Building Tax using Aerial Photography (Case Study: Tingkir District, Salatiga City)

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Abstract
Salatiga, a city that borders directly and is surrounded by Semarang Regency. It has an area of 56.78 km^2, with four sub-districts including, Sidorejo Regency, Argomulyo Regency, Tingkir Regency, and Sidomukti Regency, which covers 23 villages. The city of Salatiga has a fairly high population density with a proportion of more than 3300 inhabitants / km^2. In this study took place in the Central Tingkir and Tingkir Lor areas by taking several points that are considered as housing as a case study. This study aims to estimate the price of land and building tax on an object of land and building tax. The process of this research uses aerial photo processing, where aerial photographs will be processed using professional software Agisoft photoscan to become an orthophoto, digital surface models and digital terrain models to obtain building area and land area data, then digital surface models and digital terrain models are processed . with ArcGIS 10.6 software using a raster calculator to get the height of the object to be used as the height of the building. The data obtained will be used to perform land and building tax calculations. The results of this study estimate the estimated land and building tax prices of at least IDR 37,313.00 and a maximum value of IDR 3,809,763.00.

Keywords: Aerial Photograhy, Digital Surface Model, Digital Terrain Model, Orthophoto, Property Tax

1. Introduction

Salatiga, a city which directly borders and is surrounded by Semarang Regency. It has an area of 56.78 km^2, with four sub-districts including, Sidorejo District, Argomulyo District, Tingkir District, and Sidomukti District, covering 23 villages. The city of Salatiga has a fairly high population density with a proportion of more than 3300 inhabitants / km^2. (BPS Kota Salatiga, 2019)

Tingkir sub-district has always experienced an increase in population, in 2013 the total population density of Tingkir sub-district was 3955 people / km^2 to 4229 people / km^2 in 2018, so Tingkir became the district with the highest population density in the city of Salatiga. (BPS Kota Salatiga, 2019)

Increased population growth will also increase the needs of the population, especially the need for space so that the growth rate of development in the area will further develop, resulting in changes in the object and subject of the Land and Building Tax (PBB), so it is necessary to re-collect data related to changes in land and building tax. Data collection requires measurement of the area of the tax object building, in which case the tax object data collection is carried out on the building in large numbers, causing difficulties in the measurement process and requires a long time. The use of aerial photographs can be a solution to the problem of building a tax object area, also using aerial photographs can measure a large number of buildings with a relatively faster time. Aerial photographs will be corrected by reducing or removing the photo tilt effect due to the recording of the object's tilt data to produce a corrected whole photo, which can be referred to as orthophoto. The use of aerial photographs has been carried out in several research studies, such as research on mapping tsunami disasters (Rosaji *et al.,* 2015), research on communal sanitation pipelines(Suharyadi. and Nurteisa, 2016), and also researching simple photogrammetric mapping. (Anurogo *et al.,* 2017)

The purpose of this study is to estimate the price of land and building tax that will be imposed on an object of land and building tax. This research took several points in the Tingkir sub-district as a case study.

2. Literature Studies

Some of the previous studies used as a reference in this study are entitled "Making a Map of Land Value Zones to Determine Market Prices using GIS Applications" written by Galuh Fitriarestu Santoso, Andri Supriyogi, and Bandi Sasmito (2017). This study aims to determine the land value zone in Tingkir District, which is expected to be used as a reference for the Office of Revenue and Financial Management. The results were obtained based on the lowest land price survey located in the eastern Sidorejo Kidul, the highest on the Salatiga - Solo road. Based on the sale value of the lowest tax object in the area of Tingkir Lor and Kalibening, the highest is on the Semarang-Solo road. (Santoso *et al.,* 2014)

Other research entitled "Utilization of Small-Format Aerial Photos for Data Collection of Land and Building Tax Objects" written by Agung Haris Setiawan, Prijono Nugroho, and Christine Noegroho K. This study aims to utilize the use of small-format aerial photographs to be used as an alternative to collect data on land and land tax objects. building. The results obtained RMSE (Root Means Squared Error) values generated by type 1 photo images ranged between (4.04 - 10.83) meters, with an average of 8.311 meters, for type 2 images ranged between (2.08 - 10, 65) meters, with an average of 6.485 meters. The orthophoto scale is 1: 5000 and the total RMSE value received is 2.5 meters based on the British Columbia Specification TOR and Guidelines for Geomatic Digital Orthophoto. Therefore the image RMSE values 1 and 2 cannot meet the TOR. Indicates errors that cannot be solved by the mathematical model used. (Setiawan *et al.,* 2004)

The above research has a different research focus, in the first study that was approved in the making of land value zones in the research, which produces research that is an estimate of the value of land and building taxes.

Land and Building Tax (PBB)

Rural and urban land and building tax is a tax on land and/or buildings owned, controlled, and/or utilized by individuals or entities, except areas used for plantation, forestry, and mining business activities**.** (Indonesia, 2009)

Tax Object Selling Value (NJOP)

The tax object sale value, abbreviated as NJOP, is the average price obtained from a sale and purchase transaction that occurs fairly. If there is no sale and purchase transaction, NJOP is determined through a comparison of prices with other similar objects, or new acquisition value, or substitute NJOP.(Indonesia, 2009)

Land Value Zone (ZNT)

A land value zone or ZNT is a geographical zone consisting of one or more tax objects that have the same Average Indication Value (NIR) and is limited by the tax control/ownership limit in the administrative unit of the village without being bound to block boundary.(Menteri Keuangan Indonesia, 2018)

Aerial Photography

Aerial photographs are the results of aerial surveys through aerial photography in certain regions and heights. Aerial photographs have coordinated data and information that can be processed and prepared so that they can display the data contained therein and become a mosaic of photographs and then do the geometry correction process into orthophoto then DSM and DTM. (Hartini *et al.,* 2019) Processing aerial photographs in this study using Agisoft software.

Orthophoto

Represents the result of processing aerial photographs that are corrected, in which photos will display images of objects in correct orthography (Wolf, 1981). Correction is needed to eliminate the tilt effect of photos and photo objects so that they display the upright photo. Orthophoto processing using Agisoft software.

Digital Surface Model (DSM)

Is modeling the surface of the earth by describing the entire surface of the earth which contains more information related to the height of all objects such as vegetation, buildings, and others. DSM data collection can be obtained through map data, image matching, extraction of LiDAR data, and direct measurements in the field. (Martiana e*t al.*, 2017) DSM data processing in this study was obtained from aerial photo data which will be processed using Agisoft Photoscan software. DSM data processing in this study was obtained from aerial photo data which will be processed using Agisoft Photoscan software.

Digital Terrain Model (DTM)

It is a modeling of the surface of the earth that eliminates objects that are above the surface of the land and only contains information about the height of the land without being affected by vegetation, buildings, or other objects so that later a smooth surface of the earth is produced. DTM can model relief more realistically or by reality (Martiana *et al.,* 2017). DTM in this study is the result of processing from DSM data, where DSM data will be classified to distinguish between building objects, land, and vegetation, which will produce DTM data that has ground-level information.

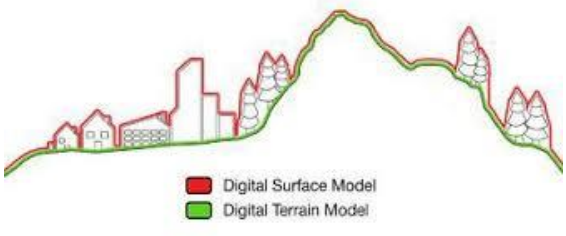

Figure 1 Ilustration of DSM and DTM

3. Method

Research Data

Data needed to carry out this research include:

1. Aerial Photo

The aerial photo data in this study is data obtained from the Salatiga regional government, through PT Mitra Geotama Indonesia. Aerial photo taking using the Flying Wing Skywalker X8 with a pre-arranged flight path. This aerial photo data will be processed into Orthophoto, DEM, DSM, and DTM using the agisoft software.

2. Tax Object Selling Value (NJOP)

This data is obtained from the sum of the sale value of land and building tax objects. To do the calculation, we need data from the land area and building area, also the price of land and buildings. With calculations as below:

The sale value of building tax objects = Building area multiplied by building price.

The sale value of land tax objects = Land area multiplied by lan price.

3. Land area

Land area is used as data to calculate the sale value of the tax object of the Earth. The use of aerial photographs can greatly assist the calculation of land area, without having to measure directly on the location of a tax object, because it has good photo resolution. But the use of aerial photographs can also have obstacles in the calculation of land area when a tax object does not have clear land area limits so that it will later affect the accuracy of the calculation.

4. Building area and Building Height

The building area is used to calculate the sale value of building tax objects. This data was obtained from calculations using orthophoto. Then for building height calculations the use of aerial photographs will later be processed using software and DSM data will be obtained, then processed again into DTM. After that the Normalized Digital Surface Model process is carried out, this process is carried out to eliminate the elevation in the DSM data using DTM so that only the land elevation data is used as the height of the building.

5. Land price

Land price to determine the sale value of the earth tax object. Land price data is obtained from the Land Value Zone (ZNT) obtained from the Ministry of Agrarian Affairs and Spatial Planning of the National Land Agency (ATRBPN).

6. Building price

The price of the building to determine Building NJOP. Building price data is obtained from field surveys

Research Tools

1	Laptop HP with specification processor AMD 10-9600P Radeon 5 and RAM 6GB
2	ArcGIS software version 10.6
3	Agisoft Photoscan Professional software
4	Microsoft Office Word2016
5	Microsoft Office Excel 2016
6	Microsoft Office Visio 2013

Table 1 Research Tools

Stages of Research

Research stages can be seen in Error! Reference source not found.

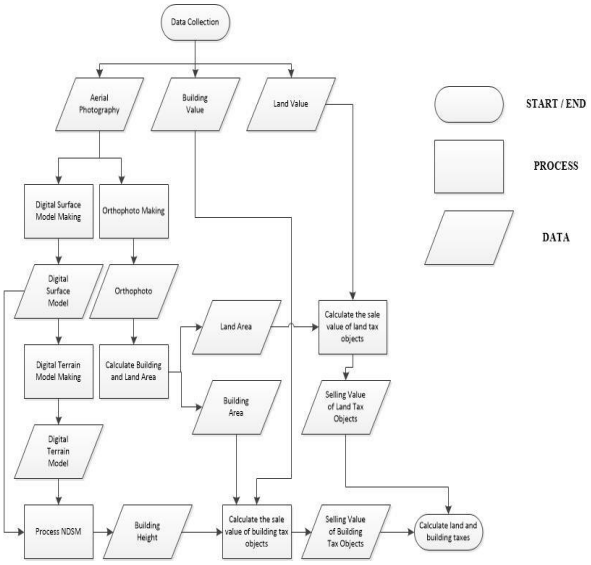

Figure 2 Stages of Research

Broadly speaking there are three processes in this study, the first process is the process of data preparation, the data prepared is secondary data in the form of aerial photographs, building values, and land values. The primary data in this study are in the form of land area, building area, and building height, where this data will be obtained after processing the data.

The second process is the data processing process. Secondary data in this process utilizes aerial photographic data. Aerial photographs will be processed and produce several maps, among others orthophoto maps, DSM, and DTM, also in the process of processing DSM and DTM maps will be reprocessed to produce building height data. Land area and building area data will be generated in this process utilizing orthophoto.

The third process is the process of calculation and presentation of results. Secondary data and primary data obtained will be processed to be calculated based on the formula for the formation of the Land and Building Tax, as well as the laws or regulations governing the Regional Regulation Salatiga City No. 02 of 2013 concerning Land and Building Taxes for Rural and Urban.(Salatiga, 2013) The presentation of the results will be in the form of land and building tax estimates.

4. Result and Discussion

Aerial Photo Processing

Aerial photographs in this study are secondary data taking locations in the Tingkir area, aerial photo data generated from aerial photography using the Flying Wing Skywalker X8, with flight paths arranged using Ardupilot software.**Figure 3** Aerial photo processing using Agisoft Photoscan software. Aerial photographs were processed into three results, namely Orthophoto, DSM, and DTM.

Figure 3 Flight Paths

Orthophoto and Digital Surface Model

The orthophoto and DSM processes are carried out simultaneously by entering aerial photographs and adjusting the coordinate system in the reference setting to match the original coordinates, the WGS 84 datum, and the Universal Transverse Mercator Zone 49 South (UTM 49 S) coordinate system. The process of orthophoto formation and DSM is also required to enter the coordinates of the Ground Control Points (GCP) which are known reference points, Independent Control Points (ICP) are also identified points but different positions on the GCP aim to measure the accuracy of GCP, These two coordinate points will help the formation of orthophoto and DSM so that each photo can be corrected geometrically well as increasing the accuracy of the orthophoto and DSM produced. Orthophoto results will be taken by exporting ortho build results to a .tif form, as well as DSM results are taken from DEM build results, because processing uses the results of aerial photographs whose photos will capture the entire elevation of objects obtained in trees, buildings, and other object elevations. The results of orthophoto **Figure 4** and DSM **Figure 5**Error! Reference source not found.

Name	East	North	Elevation	Code
GCP7	446158.9146	9185964.4400	711.2083	GCP
GCP12	446161.5118	9187156.1220	681.3633	GCP
GCP13	447449.685	9187658.424	667.427	GCP
GCP14	448371.826	9186245.599	679.336	GCP
ICP29	446297.6426	9188334.1581	644.6373	ICP
ICP30	448559.006	9187786.845	673.935	ICP
ICP31	447938.526	9187028.651	673.661	ICP
ICP37	446920.3430	9187092.2245	697.9703	ICP

Table 2 GCP and ICP

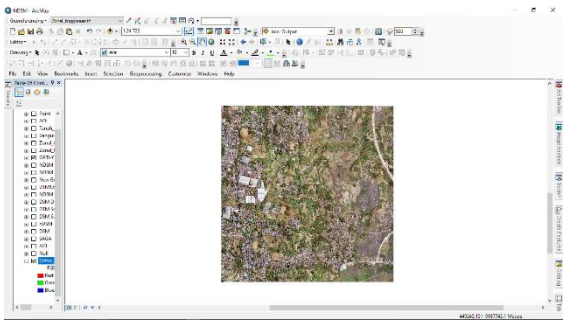

Figure 4 Orthophoto

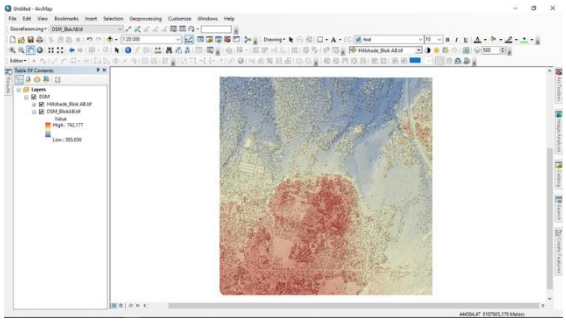

Figure 5 DSM

Digital Terrain Model

The process of making DTM is done by classifying the results of dense cloud class. This process classifies which parts are grounds and which are not based on results from orthophoto, then will be reshaped by building DEM by selecting the source data in the form of dense cloud points and only taking the grounds class. DTM result can be seen in **Figure 6**Error! Reference source not found.

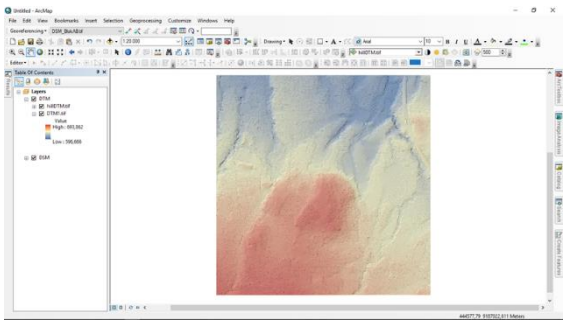

Figure 6 DTM

Digitizing Buildings and Land

In the digitization process, this study took several sample points which were assumed to be housing in the Central Tingkir and Tingkir Lor areas. The digitization process through remote sensing like this has the disadvantage of seeing the boundaries of the land to allow the extent of the digitization results to be less accurate, therefore housing was chosen as a research sample because it appeared to have clearer soil boundaries to facilitate the digitization process. Calculation of land and building area using calculate geometry tools that calculate the area of the digitization results that have been made. The extent of the soil obtained from the digitization results has a minimum area of 20 m^2 and a maximum area of 521

m^2. **Figure 8** The area of the building obtained has a minimum area of 20 m^2 and a maximum area of 494 m^2. **Figure 7**

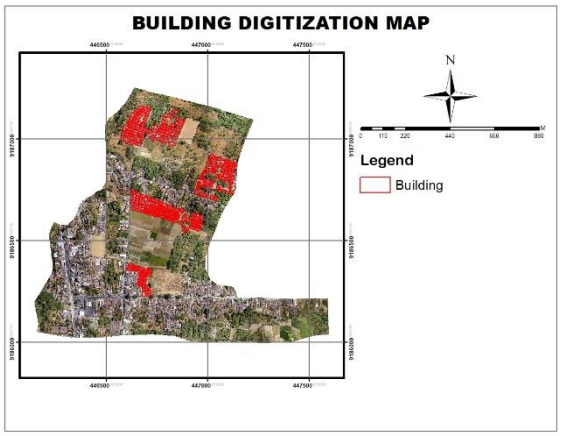

Figure 7 Digitizing Buidings

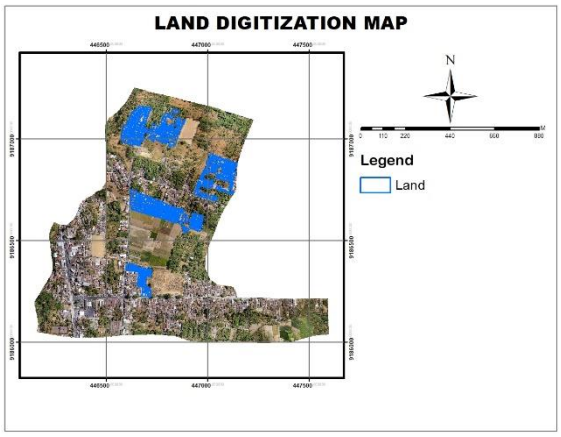

Figure 8 Digitizing Lands

Making Building Height

The height of the building in this study uses two processed maps namely DSM and DTM, this process uses ArcGIS software. The DSM map has elevations related to building objects, trees, and other objects, while the DTM map only has elevations related to land or earth elevation. The DSM map will be reduced by the DTM map using the Raster Calculator tool so that the result is only the elevation of objects above the earth's surface that will be taken as the height of the building. **Figure 9**

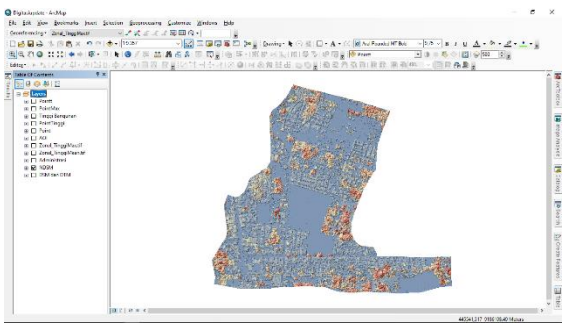

Figure 9 The result of the DSM and DTM processes

Elevation results from the processing of DSM and DTM are data that will be used as building height, to retrieve building height data begins by changing the digitized building polygons to point form using tools features to point. **Figure 10** The elevation data is then inputted into a point form using the Extract Values data tool which will later be used as the height of the building, after which the building height data will be combined again with the results of building digitization using a join. Building height data is calculated to be at a minimum of 2,108 meters, a maximum height of 12,400 meters where the height of buildings above 7 meters is two or more storey buildings.

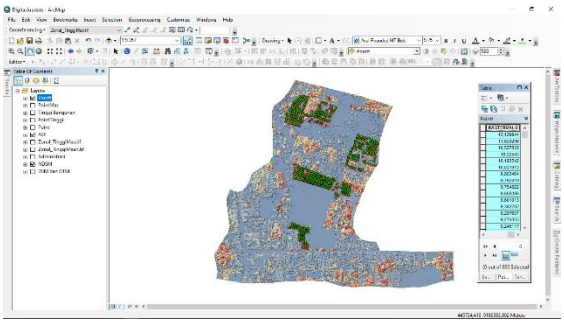

Figure 10 Build polygons to the point

Land Value Zone

The land value zone (ZNT) is based on government data from land parcels on the ATRBPN website. ZNT is used as land value, the closer the land zone to the main road the higher the value. The lowest ZNT data is valued at IDR 164,000.00 per meter, and the highest value is IDR 4,423,000.00 per meter.**Figure 11**

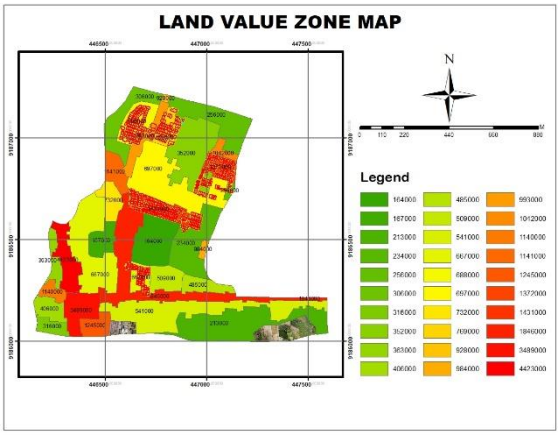

Figure 11 Land Value Zone

Calculation of Land and Building Tax (PBB)

The calculation of land and building tax in the Salatiga City area is fundamental to the Salatiga City Government Regulation No.02 of 2013 concerning Land and Building Taxes in Rural and Urban Areas, which regulates the nominal value of the sale of non-taxable tax objects (NJOPTKP) worth IDR 10,000,000.00 (ten million rupiahs). Land and Building Tax rates are set :

A. For tax objects with NJOP up to IDR 1,000,000,000.00 (one billion rupiahs) in the amount of 0.1% (zero points one percent)

B. For tax objects with NJOP over IDR 1,000,000,000.00 (one billion rupiahs) in the amount of 0.1% (zero points one percent)

Land and Building Tax calculation formula :

The sale value of building tax objects (NJOP Land) = Land area multiplied by land price

The sale value of land tax objects (NJOP Building) = Building area multiplied by building price

Tax Object Selling Value (NJOP) = NJOP Land plus NJOP Building

Taxable Sales Value (NJKP) = NJOP minus NJOPTKP

PBB = Land and Building Tax rates (0.1% or 0.2%) mutilplied by NJKP

The results of land and building tax calculations are performed using the ArcGIS application, the results obtained from the estimated land and building tax prices are with a minimum price of IDR 37,313.00 up to a maximum price of IDR 3,809,763.00

5. Conclusions and Recommendations

Conclusion

1. Land and building tax estimates in this study use the Central Tingkir and Tingkir Lor areas and take the point assumed to be housing to become a case study area. The building that is taken has a land area of at least 20 m^2 and a maximum of 521 m^2, and a building area of at least 20 m^2 and a maximum of 494 m^2.

2. In this study, the building height was calculated by reducing the elevation of the DTM and DSM. The height of the building will be the basis for determining the level of the building that will affect the area of the building. Building height data obtained has a minimum value of 2,108 meters and a maximum of 12,400 meters. Buildings that have the same height or more than 7 meters are buildings with two floors or more.

3. The land value zone (ZNT) is used as the land value to calculate the NJOP of land, the ZNT obtained has a minimum value of IDR 164,000.00 per meter and a maximum of IDR 4,423,000.00 per meter. The value of buildings in this study uses the average value of housing construction, especially in residential buildings with a value of IDR 2,000,000.00 per meter.

4. The estimated land and building tax results obtained have a minimum value of IDR 37,313.00 which is a small building located in ZNT with a value

of IDR 352,000.00 per meter, while the maximum value obtained is IDR 3,809,763.00 which is the building located on ZNT with a value of IDR 1,814,000.00 per meter.

Recommendation

It is better to use aerial photography on a smaller area or specifically at a location that will be used as a case study so that it can be seen more clearly on the ground and the altitude can be measured more accurately, also reducing the number of buildings that will be sampled as case studies.

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Number	Picture	Land Area (m2)	Building Area (m2)	Land Value (Rp)	Building Value (Rp)	PBB (Rp)
1		266,42	227,46	688000	2000000	628209
2		279,67	197,90	769000	2000000	600869
3		206,28	168,12	697000	2000000	806255
4		151,61	151,61	667000	2000000	697551
5		382,50	341,88	1431000	2000000	3809763

Figure 12 Sample table of results for Estimating Land and Building Taxes

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