B. Making class for each map

The first step was processing all of the maps to be spatial data that had certain classification.

1. Contour Map

We generated classes of slope from processing the contour map. Angle and length of slope are a very important topographic factor for landslide possibility. Therefore, the greater is angle slope, the higher is rate of prone landslide so that this factor gets the highest value for scoring. 5 Classes of slope can be seen on Table I.

TABLE I
SLOPE CLASSES

No	*Class (%)*	*Slope Form*	*Score*
1	0 - 8	flat	1
2	8 - 15	slope slightly	2
3	15 - 25	a bit sheer	3
4	25 - 45	sheer	4
5	> 45	very sheer	5

Source: Nicholas and Edmunson (1975)

2. Geology Map

Geology factor determined by rock structure and mineral composition can make landslide disaster related to the sensitivity of erosion. In other word, the level of danger is depending on rock types. Based on the size of rock granule, rock that has soft granule is more dangerous for slope instability than compact rock [3]. Scoring for rock types can be seen on table II.

TABLE II
SCORING FOR ROCK TYPES

No	*Rock Types*	*Score*
1	Alluvial	1
2	Vulkanik-1	2
3	Sedimen-1	3
4	Sedimen-2 and Vulkanik-2	4

3. Land Cover Map

Land cover is a material physic covering earth surface [4]. It includes of vegetation such as grass and tree, asphalt, and unused area. There are two main methods to know land cover area which are field surveying and remote sensing. The main literature used to classify score of each land cover type is from Lestari's research [2] which her research is competing researches from [5], [6] and [7]. Score of land cover types are divided to 5 classes that can be seen on table III.

TABLE III
SCORING FOR CLASSES OF LAND COVER

No	*Land cover types*	*Score*
1	Dense vegetation (forest) and body water	1
2	Variety plantation (underbrush)	2
3	Plantation and irrigation area	3
4	Industrial and residential area	4
5	Unused land	5

4. Rainfall Data

There are two types that can make landslide disaster, heavy rain about 70 – 100 mm/daily and common rain that is always happened continuously at hours and days [5]. Rainfall factor belongs to increasing rate of rainfall (greater on water pore's pressure, water containing in land soil, higher rate of clay, strains reducing, saturated water in layer soil), water seepage entering crack soil and water inundation. It can cause slope movement because there is an influence from rainfall. In other word, If the area has heavy rainfall, the rate of slope movement will be high either [3]. Determining of classification on rainfall condition can be seen on table IV.

TABLE IV
SCORING FOR RAINFALL INTENSITY

No	*Rainfall intensity (mm/year)*	*Parameter*	*Score*
1	2000 – 2500	average / humid	1
2	2500 – 3000	wet	2
3	> 3000	very wet	3

C. Scoring

Scoring cumulative used an algorithm from Directorate of Volcanic and Disaster Mitigation [3]. Rainfall is the greatest scoring (30%) that can cause landslide disaster while geology condition is the second scoring (20%). Furthermore, both land cover and slope have 15% scoring. The equation of landslide hazard scoring refers to (1).

$$\text{Cumulative score} = (30\% \times \text{rainfall}) + (20\% \times \text{rock types}) + (15\% \times \text{land cover}) + (15\% \times \text{slope}) \tag{1}$$

Based on the result of cumulative score, potential landslide areas have 3 clusters, which are:

1. Bit prone ($\leq 2{,}5$)
2. Average prone ($\geq 2{,}6 - \leq 3{,}6$)
3. Very prone ($\geq 3{,}7$)

D. Spatial Analysis (Union method)

Furthermore, the results of scoring prone landslide areas were going to be union each other as spatial analysis in GIS. According to theory in Guide Book of ArcGIS, Union method creates a new coverage by overlaying two polygon coverages or more. The Output Coverage contains the combined polygons and attributes of both coverages. The feature attribute table for the Output Coverage contains items from both the input and Union Coverage attribute tables. Items are merged into the output polygon feature class using the old internal number of each polygon.

E. Spatial Analysis (Overlay Method)

The final step was the results of DInSAR processing which has slope movement information but they still have many decorellation area were going to be overlaid by potential landslide map in order to find slope movement map in exact potential landslide areas. Hopefully, the results of DInSAR can be more efficient that the value of slope movement showed real deformation in landslide areas not because of decorellation error, limitation of covering area due to Line of Sight (LoS), and characteristics of land cover which are urban area or non-urban area.

III. Results and Discussion

1. Slope Value

Besides of geologic condition, one parameter that is very important causing landslide is slope value. The more slope is steep, the more prone landslide will be happened. However, we also have to consider land condition and rock structure in steep area.

Source data that was used to make slope value are contour map with interval 12.5 m extracted by Digital Elevation Model (DEM) SRTM 30 m. Moreover, classification was divided to 5 classes [8].

a. Flat area (0-8% slope value) with 22341.295 ha area (65.92% of all area) located in northern Semarang.
b. Slightly slope (8-15% slope value) with 4649.626 ha area (13.72% of all area) located in southern Semarang.
c. Bit steep area (15-25% slope value) with 3719.779 ha area (10.97% of all area) located in sub district of Ngaliyan, Gajah Mungkur, Candisari, Tembalang, Banyumanik and Gunung Pati.
d. Average steep area (25-45% slope value) with 2370.663 ha area (6.99% of all area) located in Gajah Mungkur, Banyu Manik, Tembalang and Candisari region.
e. Very steep area (>45% slope value) with 812.037 ha area (2.40% of all area) located in Gajah Mungkur, Banyu Manik and Gunung Pati region.

TABLE V
Slope Value in Semarang City

No	*Class*	*Area (ha)*	*Percentage (%)*
1	0 - 8 %	22341,295	65,92
2	8 - 15 %	4649,626	13,72
3	15 - 25 %	3719,779	10,97
4	25 - 45 %	2370,633	6,99
5	> 45 %	812,037	2,40

While processing slope value classification, system was automatic making Triangulated Irregular Network (TIN) (Figure 2) which is used as structure digital data to represent earth surface. Triangulation points were only connecting contour lines that were available in the areas.

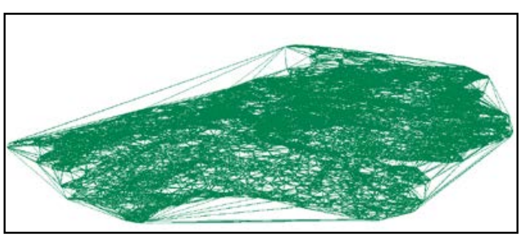

Fig. 2 Triangulated Irregular Network

2. Geology Condition

Based on geology map Province of Central Java, Semarang rock types are alluvial, volcanic rock, formation, andesitic, and sedimentation. Sediment and volcanic were formed by corrosion of clay stone, lime clay stone, and lime stone that has impermeable liquid characteristic so that while in saturated water condition, water can be function as gliding field and it could be a landslide disaster [3].

According to table VI, research areas were divided to 4 classes rock types which were alluvial with 13480.203 ha area, sediment with 20107.469 ha area, volcanic with 2634.237 ha area and sub-volcanic with 16.284 ha area. Most sediment and volcanic rock types were located in 8% - 46 % slope value region. Thus, it very influenced to landslide hazards.

TABLE VI
Rock Types in Semarang City

No	*Rock types*	*Area (ha)*
1	Alluvial	13480.203
2	Sediment	20107.469
3	Volcanic	2634.237
4	Sub-Volcanic	16.284

3. Land Cover

There are 5 classification land cover in Semarang city. The scoring method was taken by Lestari's research [3]. Actually, there are 14 classification land cover in Semarang city yet we were general the 14 classes to be 5 classes to make easier for scoring calculation.

According to table VIII, the biggest land cover was variety plantation (underbrush) areas with 15698.659 ha. The second one was industrial and residential region with 10525.942 ha area. In addition, there was still unused land in Semarang city with 7762.211 ha area.

TABLE VII
Land Cover in Semarang City

No	*Land cover*	*Area (ha)*
1	Dense vegetation (forest) and body water	8,736
2	Variety plantation (underbrush)	15698,659
3	Plantation and irrigation area	4564,385
4	Industrial and residential area	10525,942
5	Unused land	7762,211

4. Rainfall Data

Rainfall is one of the weather factors that have a big role to landslide hazards. Infiltration of rain water in layer soil will saturate the soil and soften materials forming slope so that it can be a trigger for landslide disasters. In other words, rainfall which has high intensity will give a dangerous surface movement [3].

Research data are divided to 2 main area, there are an area which annually rainfall 2000-2500 mm/year with 5033,163 ha (13.47% of all area) and 2500-3000 mm/year with 32319,336 ha (86.53% of all area). The biggest annually rainfall is about

2500-3000 mm/year. It meant area project having relative high number of annually rainfall. Based on five station BMKG on Semarang, negatively founding AR about 3000 mm/year at 2007-2008 cause of limited data for rainfall years on each station thus interpolation that had used IDW method did not classify rainfall level data accurately.

TABLE VIII
CLASSIFICATION OF RAINFALL IN SEMARANG CITY

No	*Rainfall classes (mm/year)*	*Area (ha)*	*Percentage (%)*
1	2000 - 2500	5033.163	13.47
2	2500 - 3000	32319.336	86.53
3	> 3000	0	0

IV. SLOPE MOVEMENT AND POTENTIAL LANDSLIDE AREAS

The number of slope movement will be affective if we combine two layers which are both potential landslide map and slope movement map on 8th June 2007 – 26th July 2008 that is showed on figure 5. Sub district of Gajah Mungkur, Candisari, Tembalang dan Banyumanik were the most dominant detection areas for slope movement whereas Kecamatan Gajah Mungkur, Candisari dan Banyumanik show ± 2 cm/year while Sub district of Tembalang dan Southern Banyumanik had ± 4-6 cm/year. The biggest number of slope movement was found on Region of Jabungan, Banyumanik and Mangunharjo, with the value of slope movement was ± 6 cm/year with 3.185 ha area. For a whole data, average of slope movement value in Semarang city was 2,621 cm/year with1255.42 ha area.

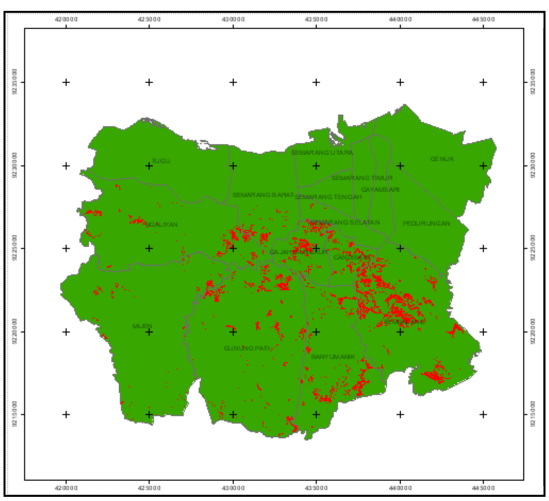

Fig. 3 Prone landslide areas map

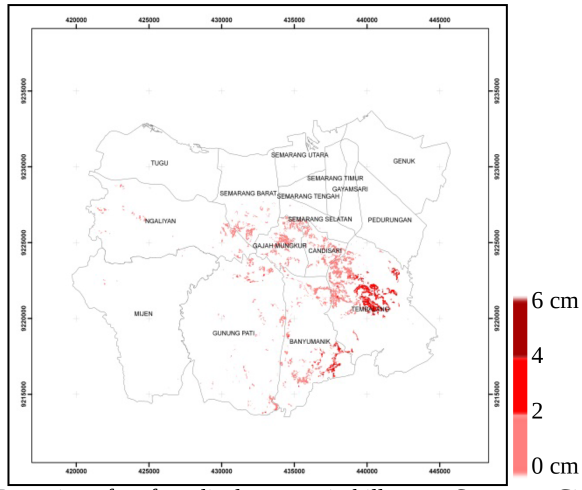

Fig. 4 Detecting of surface displacement in hilly area, Semarang City

V. LOOK DIRECTION OF SELECTED SAR IMAGES

Figure 5 shows slope aspects in Semarang city, database made from contour map which the source was from DEM SRTM 30 M. For the information, character slope that lead to east and west had more chance for detection slope movement due to ascending and descending orbit. However, character slope that lead to north, south and other side can still detection slope movement while LOS and incident angle still could be reflected to radar clearly. Therefore, the value of surface displacement is depending on geometry slope.

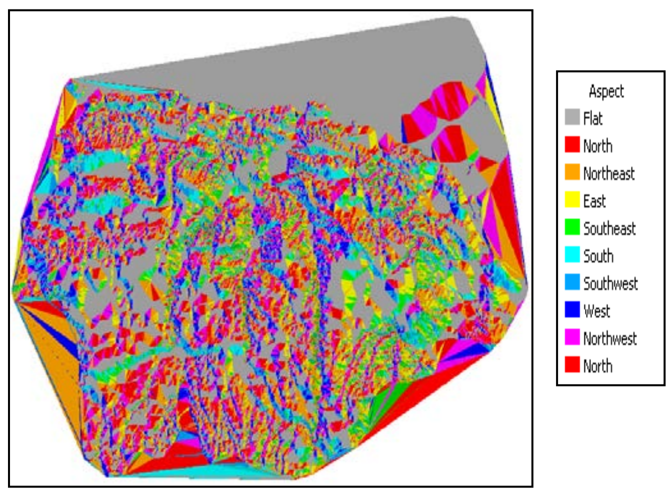

Fig. 5 Direction of slope aspects in Semarang City

This study used SAR data with ascending orbit that automatically it leaded to east in order that slope facing west direction as well as facing to LOS radar had a big chance to detect slope movement. On figure 8, Grey colour was the area that had the biggest shadow effect because facing off radar LOS while Green colour was area which had a big chance for detection slope movement.

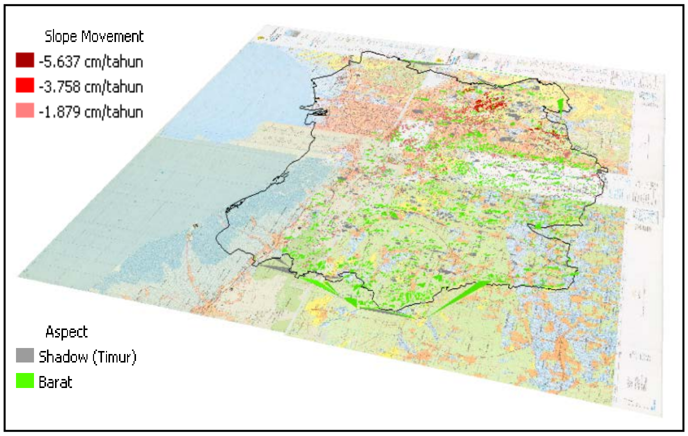

Fig. 6 Surface displacement and Look Direction of SAR

VI. Conclusion

The value of slope movement in Semarang City with 8-45% slope value was about 1-6 cm/year. Sub district of Gajah Mungkur, Candisari, Tembalang dan Banyumanik are places whose the slope movement had dominant detection. Sub district of Gajah Mungkur, Candisari and Banyumanik showed the value about 1 cm/year while Kecamatan Tembalang dan south Banyumanik had the biggest value which was about 4-6 cm/ year. The exact locations where had the biggest number surface displacement was 6 cm/year with 3.185 ha area located on Jabungan, Banyumanik, Mangunharjo and Tembalang Region. Generally, the total area that occurred slope movement was 1255.42 ha with average displacement value 2.621 cm/year. On this project, we hope GIS method will improve DlnSAR value. However, we realize this method has some errors and lack of limited data for 4 parameters that actually are important to determine analysis for scoring poltential landslide areas.

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