

# UTILIZATION LANDSAT TO KNOW EFFECT OF DROUGHT AGAINST TOBACCO PLANTING PATTERN TERRITORY BOJONEGORO USING MOTION FLOW WEIR

Dyan Agni Mayatirtana<sup>1</sup>, Sobirin<sup>2</sup>

<sup>1</sup> Magister Program of Geography, Indonesia University, Build H, FMIPA UI, New Collage, Depok, 16421

<sup>2</sup>Lecturer Program of Geography, Indonesia University, Build H, FMIPA UI, New Collage, Depok, 16421

dyanagnimaya05@gmail.com, sobirin\_62@yahoo.com

**Abstract.** Water is a key resource in support of human life, both for the fulfillment of their daily needs as well as a supporter of human activity. Bojonegoro with an area of 230 706 ha is the region with the condition of difference rainfall is quite clear, during the dry season and the rainy season. Genesis El-Nino became one of the factors of drought which can be categorized into a meteorological drought that resulted in inadequate water availability and to overcome the limitations of water resources, the government is building a dam to drain water Gerak Bojonegoro Solo River to the paddy fields. The purpose of this study was to determine the level of the drought that occurred from rainfall for 30 years using SPI (Standardized Precipitation Index) in the year of El Nino (1991, 1997, 2002, 2009 and 2015) were also reviewed drought conditions of the analysis of Landsat imagery and associated with the availability of water weir Gerak Bojonegoro on cropping patterns tobacco. Then obtained the drought conditions in the year of El Nino are more likely to show increased and the average peaked in September according to the supervised analysis of Landsat images. While the cultivation of tobacco in optimizing in 2002 and 2009 with drought conditions, farmers still optimizing through shifting planting along streams and rivers. Whereas in 2015 in the time of drought is very high, the availability of water is reduced to make farmers more likely to pay attention to the time of planting to reduce water availability constraints or prefer emptied while the existing land (fallow).

**Keywords:** Drought, SPI, Landsat, Water Supply, Tobacco Planting Pattern

## 1. Introduction

Water is a key resource in support of human life, both for the fulfillment of their daily needs as well as a supporter of human activity. Agriculture is a sector that need water the most, especially rice cultivation, about 66% of the water needs of humans.

Bojonegoro with an area of 230 706 ha, an area that has several featured in the sectors of mining, plantation and agriculture. Rice area in the region of about 77,000 hectares or 32.58% of the total area. So it can produce rice production reached 1 million tons, of which half of the rice production of rice needs of East Java province. Additionally, Bojonegoro has featured other commodities namely tobacco economically has contributed significantly to revenue. The type of tobacco grown in Bojonegoro include several types such as Virginia and Java Tobacco, Virginia Tobacco is the kind of top quality tobacco in the world and seeded Bojonegoro with sales value reached Rp27.000 / kg (beritabojonegoro.com.2015).

According to climate conditions, Bojonegoro is the region with the condition of difference rainfall is quite clear, during the dry season and the rainy season. Genesis El-Nino was one factor drought in

Indonesia have an impact also in Bojonegoro, so that the area is experiencing a drought that caused droughts, which are categorized as drought meteorological, that kind of drought associated with the level of rainfall is below normal in one season (Bakorsurtanal 2007).

From the influence of El Nino and water availability Farmers prefer to plant rice and tobacco compared to crops, so it is not uncommon rice plants grown in excess of the planned area. Therefore the government building weirs Gerak Bojonegoro to optimize the Bengawan Solo River water to paddy fields to determine the effect on cropping patterns tobacco.

The purpose of this study was to determine the level of the drought that occurred from rainfall for 30 years using SPI (Standardized Precipitation Index) in the year of El Nino (1991, 1997, 2002, 2009 and 2015) associated with the availability of water weir Gerak Bojonegoro against tobacco cropping patterns.

## 2. Methods

The study was conducted in 5 sub-districts in Bojonegoro the District Bojonegoro, Dander, Kalitidu, Ngasem and Trucuk using Landsat time series when the occurrence of El Nino over the image to see the distribution pattern and cropping tobacco, in addition to using images evidenced from data obtained with way down directly into the field. The approach used in this study is the spatial approach. Aspect in this case, agricultural seen based on the physical condition of the area that affect rainfall and cropping patterns. Variables that used in this research are a meteorological drought, land conditions and physical conditions of the region. The data used is secondary data that is processed by several methods.

### 2.1 Method of SPI (Standardized Precipitation Index)

According to Hayes et al (1999) the determinations of the criteria of drought do with rainfall data processing for 30 years (1986-2015). The data is then calculated by the method of Standardized Precipitation Index (SPI) to determine the meteorological drought index is happening with SPI drought index.

SPI calculate the current El Nino years (1991,1997,2002,2009 and 2015) of rainfall data in 12 rain stations in the area where the research. SPI uses software processing methods scopic with a choice of time of 1 month to determine the meteorological drought in 7 classifications SPI. The drought classification based on SPI values are presented in Table 1.

**Tabel 1.** Classification scale SPI value

Value	Classification
$\geq 2,00$	Very Wet
1,50 ~ 1,99	Wet
1,00 ~ 1,49	Somewhat Wet
0,99 ~ -0,99	Normal
-1,00 ~ -1,49	Kind Dry
50 ~ -1,99	Dry
$\leq -2,00$	Very Dry

Source: Mc Kee, 1993 (processed by BMKG)

### 2.2 Landcover classification

To obtain the landcover in the form fields, open land forests, tobacco fields, fields and water bodies in the study site using Landsat imagery processing in 2002, 2009 and 2015 with a supervised classification and maximum likelihood using ArcGIS 10.3 software. Condition of ArcGIS software is tailored to the availability of water of weir Motion Bojonegoro. The combination of bands in the Landsat 5 image processing using Landsat bands 5,4,2 whereas on 8 using 7,5,4 band combination to display the true colors (near true color) so it is easy to classify the distribution of rice fields by making the grade as a signature class the pixel values are used in determining the classification.

### 2.3 Account the amount of water provided

Water Solo River which is taken through the building making (intake) at the Weirs Gerak Bojonegoro. In this case the need for irrigation water is the volume of water required to meet the needs of evapotranspiration, water loss, water requirements for crops by taking into account the amount of water provided by nature through the rain and the contribution of groundwater. Count of rainfall there, found differences in water conditions based on the availability of irrigation canals running it. Whether it's at the study site conditions are always getting the water or up until  $\geq 3$  months tidak get water at all.

## 3. Result

### 3.1 Rainfall monthly at the El Nino

The influence of El Nino on the rainfall in the region of Sumatra and Java are generally seen in the months of east monsoon season (June-September) until October and November. Based on the monthly rainfall that occurred in the study site, in normal years entered the rainy season from November to April, and entered the dry season in May until October. But among the sites began to decrease in intensity of rainfall which mostly took place in June to October, while in the dry season will be more significant at 1 year compared to normal conditions, such as rainfall data were compared with the ONI could be shown as table 2.

**Table 2.** Average Monthly Rainfall Compared With INI value in the year of El Nino

Tahun	1991		1997		2002		2009		2015	
	CH	ONI	CH	ONI	CH	ONI	CH	ONI	CH	ONI
Jan	292	0.4	131	-0.5	261	-0.2	280	-0.8	41	0.5
Feb	222	0.3	164	-0.4	167	-0.1	241	-0.7	52	0.4
Mar	285	0.2	116	-0.2	137	0.1	239	-0.4	76	0.5
Apr	182	0.2	138	0.1	140	0.2	153	-0.1	66	0.7
Mei	103	0.4	132	0.6	127	0.4	190	0.2	49	0.9
Jun	38	0.3	24	1.0	57	0.7	36	0.7	24	1.0
Jul	53	0.3	45	1.4	116	0.8	101	0.5	12	1.2
Ags	31	0.7	31	1.7	55	0.9	43	0.6	3	1.5
Sep	33	0.7	37	2.0	52	1.0	30	0.7	0	1.8
Okt	60	0.8	46	2.2	41	1.2	43	1.0	16	2.1
Nov	154	1.2	73	2.3	108	1.3	136	1.2	54	2.2
Des	237	1.4	147	2.3	115	1.1	146	1.3	188	2.3

Source: Data processing, 2016

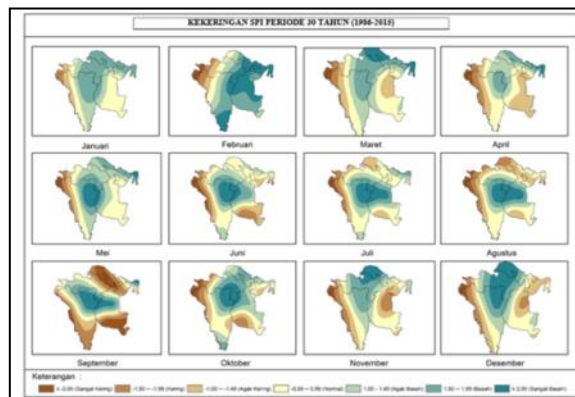
Table 2 in the five years experience El Nino rainfall conditions exist and comparison of the value of ONI then inversely which it was concluded that the lower the average rainfall then the value of ONI will be higher, so that when El Nino occurs, the bulk rain there will be less intensity.

When an El Nino with a strong type in 2015 the highest rainfall in the range of  $< 200$  mm, while the 1997 is also a strong El Nino highest rainfall  $\geq 150$  mm. It was different in 1991 being the year of El Nino with a weak type where the average rainfall is highest reaches  $\geq 290$  mm. So that the condition is still classified by el nino conditions with a weak type, as they go in dry conditions with the wet type that still have high rainfall intensity compared to the years comparator.

### 3.2 Drought conditions average SPI 30 years

From several years of El Nino and rainfall conditions exist then the drought becomes a condition deviations are temporary and vary with the dry season, the Standardized Precipitation Index (SPI) to an index that is used to determine the deviation of rainfall against the normal, within a period long (monthly, bimonthly, quarterly, and so on).

Processing of rainfall for 30 years (1986-2015) using SPI (Standardized Precipitation Index) showed that  $< -2.00$  is very dry while the criterion values  $> 2.00$  is a drought index type is very wet. Generally drought that occurred during the 30 years (1986-2015) is described as follows on the map below.



**Figure 1.** Map Average Monthly Rainfall Year 1986-2015.

See record drought in 30 years due to El Nino, it can be concluded based on the rainfall that occurred during the last 30 years, and pay attention to the development of atmospheric dynamics throughout 1986-2015 in February occurred fairly high rainfall in almost 90% of the study sites. But for the other months also continued to receive rainfall average intensity condition is quite high, so that despite the El Nino strong but on average, the drought that occurred in SPI during the 30 years of relatively diverse, with the type of drought that occurred from type is very wet to very dry.

### 3.3 Planting pattern and planting time

Comprehensive tobacco plants in the study site every year occur dynamically. This situation is influenced by seasonality that occurs because of the condition of the land that is highly dependent on water conditions. Based on the data in the Agriculture and Plantation Bojonegoro in the district as research areas described in the condition of the land suitable for cropping tobacco because it gets a stream of the weir Gerak Bojonegoro. In general, the cropping pattern is applied to 5 districts, an area of research there are two types, namely: rice-palawija-bera and rice-tobacco. The conditions to cropping patterns can be done at the study site in terms of physical condition can be described in table 3.4, and 5.

**Table 3.** Planting Pattern 2002

POLA	N	D	J	F	M	A	M	J	J	A	S	O
1	PADI											
					PALAWIJA							
									PADI			
POLA	N	D	J	F	M	A	M	J	J	A	S	O
2	PADI											
					TEBKAU							
									PALAWIJA			

**Table 4.** Planting Pattern 2009

POLA	N	D	J	F	M	A	M	J	J	A	S	O
1	PADI											
					BERA							
					PALAWIJA							
POLA	N	D	J	F	M	A	M	J	J	A	S	O
2	PALAWIJA/PADI											
					BERA							
									TEBKAU			

**Table 5.** Planting Pattern 2015

POLA	N	D	J	F	M	A	M	J	J	A	S	O
1	PADI											
					PADI							
					PALAWIJA							
POLA	N	D	J	F	M	A	M	J	J	A	S	O
2	PALAWIJA				TEBKAU						BERA	

From the table above cropping pattern, it can be concluded that tobacco cropping patterns shift and change because it is influenced by several factor, both physical conditions of land and water become a primary source of tobacco cropping patterns. In general cropping tobacco research sites in one year can be planted 2-3 times the cropping pattern, but in 2015 became the year of El Nino high part of the land is selected for in berakan (emptied). It is intended to reduce production costs and prevent failures in the harvest due to physical factors such as season and inadequate water availability.

Some types of tobacco farmers cultivated in Bojonegoro are aspen Java tobacco, Virginia and Java chopped tobacco. Tobacco plants need water in the amount and timing to be controlled satisfactorily, by setting a good drainage system. However, despite the tobacco plant needs water is very vulnerable to high rainfall. Thus tobacco plants have when the time of harvest in the dry season the water takes a little bit so that the yield and quality of the results can be maintained for the irrigation schemes should be optimized as possible.

### 3.4 Changes in landuse tobacco

Of the availability of existing water and optimization that can be developed on the use of land for agriculture and plantations, the conditions are suitable in the implementation of land use through the results in classification image using 5,4,2 band combination of land use maps can be made as follows.

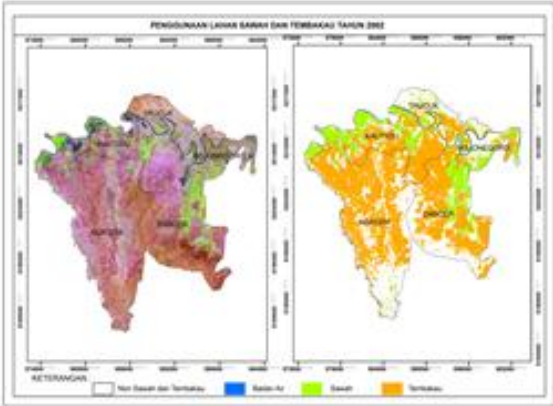


Figure 2. Map of Landuse 2002

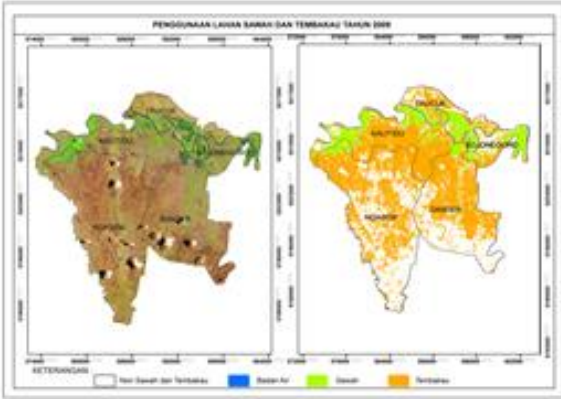


Figure 3. Map of Landuse 2009

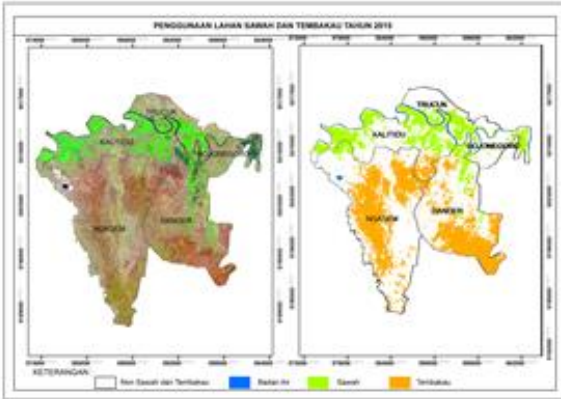
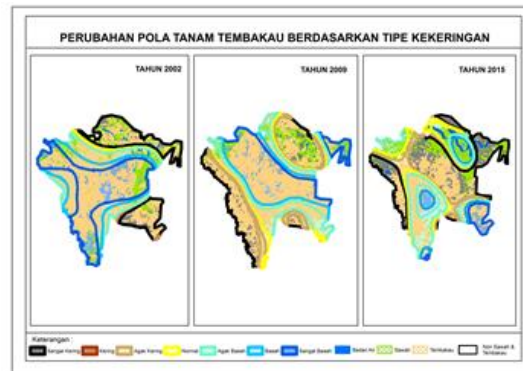


Figure 4. Map of Landuse 2015



**Figure 5.**Map of Tobacco Planting Pattern Changes Dryness by Type

Of land use changes that occurred in 2002, 2009 and 2015 may be said that the tobacco hectares for change. For the 2002 paddy field and tobacco is still seen to spread in almost all regions. However, for the year 2009 changes in tobacco fields look more dominating than the rice fields. While cropping tobacco in 2015 was more focused, which is located after the area planted with rice. Because the flow of water from the fields will drain the water to the surrounding lands were classified as dry as a result of El Nino and drought to the region with high enough. More farmers choose to left or left blank, as in the map 5. Changes in cropping patterns are influenced by the type of tobacco dryness of the criteria very wet to very dry show if in 2002 being the year of El Nino weak type of cropping patterns in the study site fairly evenly almost each section districts. While in the year 2009 that was classified as moderate El Nino year type, indicated that the vast tobacco fields dominate. For 2015, which became a strong El Nino years. This condition is also quite an impact on tobacco planting. Additionally in 2015 the agricultural land area decreased due to changes in land use that is made of agricultural land as a settlement.

### 3.5 Irrigation water availability

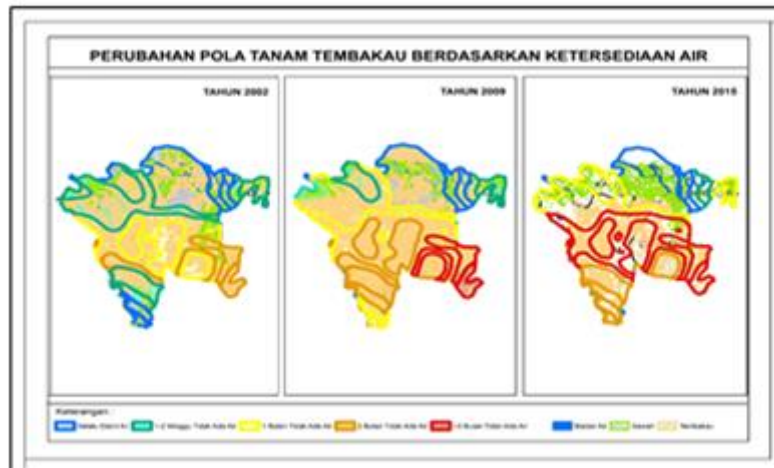
The availability of water in a given location can be a determining factor in a crop, it is because of the availability of adequate water becoming an important part affecting the availability of a plant, especially the type of crop is cultivated is the type of crop water requirements are relatively large. So the availability of adequate water becomes an important consideration in plant cultivation activities.

But the availability of water into effect if the condition of the area affected by drought which is long enough as the current El Nino occurs, in addition to the dry season becomes longer than normal dry conditions occurred during the El Nino impact on the situation of higher levels of drought. This directly into factors influence the availability of adequate water because of the intensity of rainfall is also declining. So that the discharge of the amount and intensity of rainfall as the determinant of the availability of water, and the results of plotting the location of irrigation sert interviews with farmers around so he found a picture of water availability in accordance with the conditions such as the following maps:



**Figure 6.** Map of Irrigation Water Supply 2002, 2009, and 2015

Under the conditions of the existing water supply, from the calculation of rainfall and water discharge in 2002, the tobacco cropping pattern in accordance with the availability of water as a key factor for growth in plants it can be seen spreading on figure7 below:



**Figure 7.** Map Changes in Tobacco Planting Pattern Based Water 2002, 2009, and 2015

From the figure 7 cropping tobacco in 2002, 2009 and 2015 experienced a considerable change. The availability of water in cropping patterns become the main indicator of a plant. For the study site with tobacco as a crop that is optimized indicates that the existing availability of water has mixed conditions starting with areas that always have water to areas that until  $\geq 3$  months do not get water. So that in 2002 almost all regions with diverse conditions of water availability can be optimized as tobacco planting area. Whereas in 2009 the extreme conditions of water availability is  $\geq 3$  months of no water in this region began to decrease tobacco plants. Because in addition to drought quite high when coupled with the availability of water is minimal, the tobacco difficult optimized. While in the year 2015 into a year long drought, it also affects the availability of water in there.

#### 4. Conclusion

Drought conditions that occurred in Bojonegoro especially at the study site, showing the spatial distribution pattern of meteorological drought, where the intensity of rainfall is a key determinant of drought levels for 30 years. While the pattern of inter-temporal dynamics month showed that in September became the month with the highest drought conditions and patterns of drought on the El Nino years of 1997 and 2015 showed a higher rate than the drought in 1991, 2002 and 2009. For the availability of adequate water supply from irrigation networks starting from the main channel to the end to be a sign that water availability is quite good. However, the cropping pattern changed when entering the El Nino year which decreased water water availability due to drought that hit high on the specific number of years so that the conditions that occurred in 2002 when the availability of adequate water almost the entire area can be planted with rice and tobacco. While in the year 2009 when the relatively higher drought and low water availability further optimize the tobacco farmers. But in 2015 that became one of the year El Nino strong with drought conditions is very high and dry seasons are longer, and the area with the availability of adequate water only found along the river course, it is in these conditions some areas are more likely to be a vacant land (fallow).

#### References

- Bakorsurtanal PB 2007 Penanggulangan Bencana Berbasis Masyarakat *Jakarta ISBN 978-979-24-1370-6*
- Cahyono 1998 *Tembakau, Budidaya Analisis Usaha Tani*(Yogyakarta: Kanisius)
- Danoedoro P 2012 *Pengantar Penginderaan Jauh Digital*(Yogyakarta : ANDI)
- Dinas Pertanian, Perkebunan, dan Kehutanan Kabupaten Bojonegoro 2001 *Laporan Data Sensus Pertanian Kabupaten*



- Bojonegoro Provinsi Jawa Timur* (Bojonegoro: Pemerintah Kabupaten Bojonegoro Provinsi Jawa Timur)
- Djaenudin D, Maerwn H, Subagyo H, Mulyani A and Suharta N 2003 *Kriteria Kesesuaian Lahan untuk Komoditas Pertanian*. (Bogor: Pusat Penelitian Tanah dan Pengembangan)
- Agroklimat. Badan Penelitian dan Pengembangan Pertanian. Departemen Pertanian Bogor.
- Gusti Rusmayadi G 2002. *Klimatologi Pertanian*. Jurusan Budidaya Pertanian Fakultas Pertanian. Universitas Lambung Mangkurat. Banjarbaru.
- Hansen E 2009 *Penalized Maximum Likelihood Estimasi Of A Stochastic Multivariate Regression Model* 2010 Elsevier B.V. All rights reserved
- Indrawan S 2006 *Analisis Ketersediaan Air Tanah dan Kekeringan dalam Diklat Teknis Klimatologi dan Kualitas Udara* (Jakarta: Badan Meteorologi dan Geofisika)

**Table 4.** Planting Pattern 2009

POLA	N	D	J	F	M	A	M	J	J	A	S	O
1	PADI											
					BERA							
					PALAWIJA							
POLA	N	D	J	F	M	A	M	J	J	A	S	O
2	PALAWIJA/PADI											
					BERA							
									TEBKAU			

**Table 5.** Planting Pattern 2015

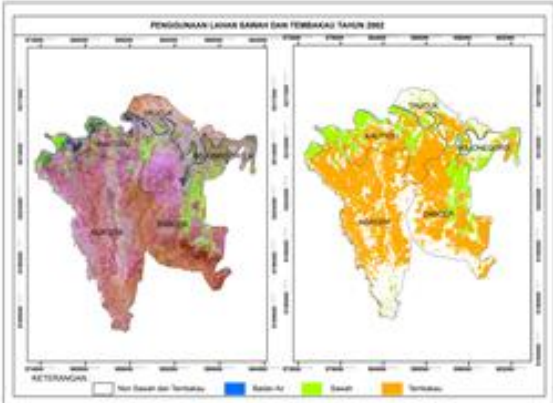
POLA	N	D	J	F	M	A	M	J	J	A	S	O
1	PADI											
					PADI							
					PALAWIJA							
POLA	N	D	J	F	M	A	M	J	J	A	S	O
2	PALAWIJA				TEBKAU						BERA	

From the table above cropping pattern, it can be concluded that tobacco cropping patterns shift and change because it is influenced by several factor, both physical conditions of land and water become a primary source of tobacco cropping patterns. In general cropping tobacco research sites in one year can be planted 2-3 times the cropping pattern, but in 2015 became the year of El Nino high part of the land is selected for in berakan (emptied). It is intended to reduce production costs and prevent failures in the harvest due to physical factors such as season and inadequate water availability.

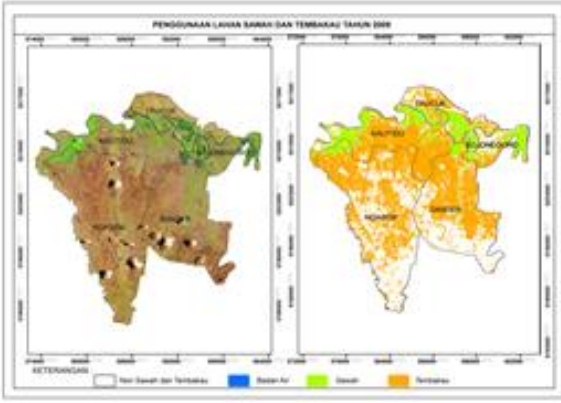
Some types of tobacco farmers cultivated in Bojonegoro are aspen Java tobacco, Virginia and Java chopped tobacco. Tobacco plants need water in the amount and timing to be controlled satisfactorily, by setting a good drainage system. However, despite the tobacco plant needs water is very vulnerable to high rainfall. Thus tobacco plants have when the time of harvest in the dry season the water takes a little bit so that the yield and quality of the results can be maintained for the irrigation schemes should be optimized as possible.

### 3.4 Changes in landuse tobacco

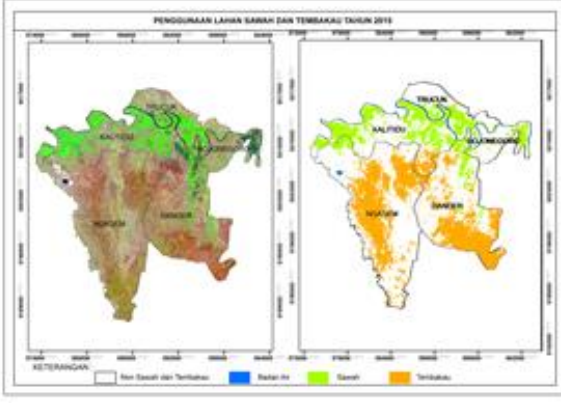
Of the availability of existing water and optimization that can be developed on the use of land for agriculture and plantations, the conditions are suitable in the implementation of land use through the results in classification image using 5,4,2 band combination of land use maps can be made as follows.



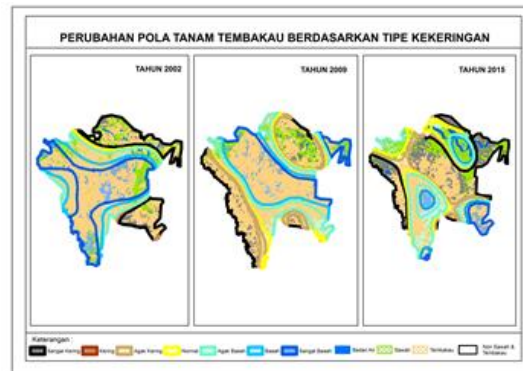
**Figure 2.** Map of Landuse 2002



**Figure 3.** Map of Landuse 2009



**Figure 4.** Map of Landuse 2015



**Figure 5.**Map of Tobacco Planting Pattern Changes Dryness by Type

Of land use changes that occurred in 2002, 2009 and 2015 may be said that the tobacco hectares for change. For the 2002 paddy field and tobacco is still seen to spread in almost all regions. However, for the year 2009 changes in tobacco fields look more dominating than the rice fields. While cropping tobacco in 2015 was more focused, which is located after the area planted with rice. Because the flow of water from the fields will drain the water to the surrounding lands were classified as dry as a result of El Nino and drought to the region with high enough. More farmers choose to left or left blank, as in the map 5. Changes in cropping patterns are influenced by the type of tobacco dryness of the criteria very wet to very dry show if in 2002 being the year of El Nino weak type of cropping patterns in the study site fairly evenly almost each section districts. While in the year 2009 that was classified as moderate El Nino year type, indicated that the vast tobacco fields dominate. For 2015, which became a strong El Nino years. This condition is also quite an impact on tobacco planting. Additionally in 2015 the agricultural land area decreased due to changes in land use that is made of agricultural land as a settlement.

### 3.5 Irrigation water availability

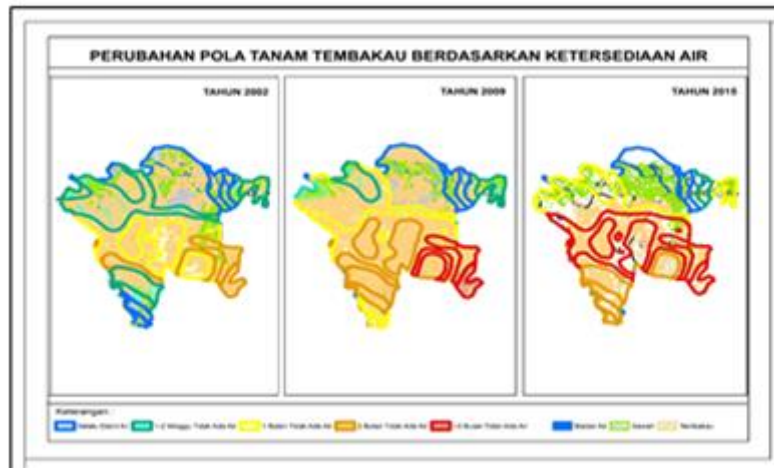
The availability of water in a given location can be a determining factor in a crop, it is because of the availability of adequate water becoming an important part affecting the availability of a plant, especially the type of crop is cultivated is the type of crop water requirements are relatively large. So the availability of adequate water becomes an important consideration in plant cultivation activities.

But the availability of water into effect if the condition of the area affected by drought which is long enough as the current El Nino occurs, in addition to the dry season becomes longer than normal dry conditions occurred during the El Nino impact on the situation of higher levels of drought. This directly into factors influence the availability of adequate water because of the intensity of rainfall is also declining. So that the discharge of the amount and intensity of rainfall as the determinant of the availability of water, and the results of plotting the location of irrigation sert interviews with farmers around so he found a picture of water availability in accordance with the conditions such as the following maps:



**Figure 6.** Map of Irrigation Water Supply 2002, 2009, and 2015

Under the conditions of the existing water supply, from the calculation of rainfall and water discharge in 2002, the tobacco cropping pattern in accordance with the availability of water as a key factor for growth in plants it can be seen spreading on figure7 below:



**Figure 7.** Map Changes in Tobacco Planting Pattern Based Water 2002, 2009, and 2015

From the figure 7 cropping tobacco in 2002, 2009 and 2015 experienced a considerable change. The availability of water in cropping patterns become the main indicator of a plant. For the study site with tobacco as a crop that is optimized indicates that the existing availability of water has mixed conditions starting with areas that always have water to areas that until  $\geq 3$  months do not get water. So that in 2002 almost all regions with diverse conditions of water availability can be optimized as tobacco planting area. Whereas in 2009 the extreme conditions of water availability is  $\geq 3$  months of no water in this region began to decrease tobacco plants. Because in addition to drought quite high when coupled with the availability of water is minimal, the tobacco difficult optimized. While in the year 2015 into a year long drought, it also affects the availability of water in there.

#### 4. Conclusion

Drought conditions that occurred in Bojonegoro especially at the study site, showing the spatial distribution pattern of meteorological drought, where the intensity of rainfall is a key determinant of drought levels for 30 years. While the pattern of inter-temporal dynamics month showed that in September became the month with the highest drought conditions and patterns of drought on the El Nino years of 1997 and 2015 showed a higher rate than the drought in 1991, 2002 and 2009. For the availability of adequate water supply from irrigation networks starting from the main channel to the end to be a sign that water availability is quite good. However, the cropping pattern changed when entering the El Nino year which decreased water water availability due to drought that hit high on the specific number of years so that the conditions that occurred in 2002 when the availability of adequate water almost the entire area can be planted with rice and tobacco. While in the year 2009 when the relatively higher drought and low water availability further optimize the tobacco farmers. But in 2015 that became one of the year El Nino strong with drought conditions is very high and dry seasons are longer, and the area with the availability of adequate water only found along the river course, it is in these conditions some areas are more likely to be a vacant land (fallow).

#### References

- Bakorsurtanal PB 2007 Penanggulangan Bencana Berbasis Masyarakat *Jakarta ISBN 978-979-24-1370-6*
- Cahyono 1998 *Tembakau, Budidaya Analisis Usaha Tani*(Yogyakarta: Kanisius)
- Danoedoro P 2012 *Pengantar Penginderaan Jauh Digital*(Yogyakarta : ANDI)
- Dinas Pertanian, Perkebunan, dan Kehutanan Kabupaten Bojonegoro 2001 *Laporan Data Sensus Pertanian Kabupaten*

- Bojonegoro Provinsi Jawa Timur* (Bojonegoro: Pemerintah Kabupaten Bojonegoro Provinsi Jawa Timur)
- Djaenudin D, Maerwn H, Subagyo H, Mulyani A and Suharta N 2003 *Kriteria Kesesuaian Lahan untuk Komoditas Pertanian*. (Bogor: Pusat Penelitian Tanah dan Pengembangan)
- Agroklimat. Badan Penelitian dan Pengembangan Pertanian. Departemen Pertanian Bogor.
- Gusti Rusmayadi G 2002. *Klimatologi Pertanian*. Jurusan Budidaya Pertanian Fakultas Pertanian. Universitas Lambung Mangkurat. Banjarbaru.
- Hansen E 2009 *Penalized Maximum Likelihood Estimation Of A Stochastic Multivariate Regression Model* 2010 Elsevier B.V. All rights reserved
- Indrawan S 2006 *Analisis Ketersediaan Air Tanah dan Kekeringan dalam Diklat Teknis Klimatologi dan Kualitas Udara* (Jakarta: Badan Meteorologi dan Geofisika)