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| RESEARCH ARTICLE

Impact of Extreme Climate on Orage Farming Surjan System in Botola

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| ABSTRACT
The determining factor for the success of agricultural cultivation in tidal swampland is water availability, which fluctuates throughout the plant's growth. The availability of water for oranges has a significant role in the final production of the product. In Indonesia, there are three types of rain patterns with variations in the growing season related to water availability: the rainy season between October and March and the dry season between April and September. Climate extremes such as drought (El-Niño) and wetness (La-Niña) fluctuate dynamically, impact shifts at the beginning and end of the growing season, and hurt citrus crop productivity. Therefore, an analysis of rice planting time in tidal swampland in Barito Kuala under extreme climatic events was carried out. The research was conducted in September – December 2020 with the survey method. The data was dug in-depth on the research respondents: citrus farmers, fruit traders, and related agencies. The number of samples was 90 people (45 male farmers and 45 female farmers). Two different villages were surveyed in each sub-district according to the type of tidal land, namely Marabahan sub-district (SP1 village and SP2 village), type A, Mandastana (Karang Indah village and Karang Bunga village) type B, and Cerbon sub-district. (Village of Simpang Nungki and Sungai Kambat) Type C. Planting time in tidal land begins after the amount of rainwater is sufficient to dissolve the iron content in the water. The probability of an El-Niño occurrence with an intensity of 1, 2, 3, and 4 years has the highest frequency of occurrence—respectively 3, 3, 5, and 3 times with probability around 16.7% to 27.8%. Meanwhile, La-Nia with an intensity of once a year with the highest frequency eight times with a 40.0% chance. La-Nia events coexist with El-Nio 15 times, and generally, El-Nio precedes La-Nia by about 44%. The cropping pattern in tidal swampland shows high resistance to climate change. Namely, the planting time has not changed much for decades under different climatic conditions.

| KEYWORDS

El-Nio, extreme climate, citrus, La-Niña, tidal land

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1. Introduction

Climate change is projected to significantly impact yields, pest and disease outbreaks, and changes in land suitability for citrus plantations. Oranges are ideally grown in areas of moderate temperature, usually located 0 - 400 m above sea level. Under climate change, the best citrus growing areas will be shifted to the higher ground. Climate change will also impact pest and disease outbreaks, growth, and development of citrus plantations. This study focuses on the impact of climate change on (i) Shifting citrus growing areas, (ii) Growth and development of citrus plantations, and (iii) Major citrus pest or disease outbreaks.

Using tidal swampland for agriculture is not easy because several things influence it. One factor determining the success of agricultural cultivation in tidal swampland is planting time. Planting food crops, especially rice, has a significant role in producing agricultural products. Even though it is only about ten days (*dasarian*), the shift in planting time can reduce yields by up to 40% (Irianto, 2000).

The dynamics of climate change, such as uncertain periods of drought (El Nino years) and or wetness (La Nina years), have an impact on shifting the beginning and end of the growing season and hurt crop productivity, especially for food crops as a system farming other than the main crop. Orange.

Based on differences in topography, tidal swampland is divided into several types of water overflow: (1) overflow type A, which island that is injured by large and small tides, (2) overflow type B, which is only land that is injured by large tides, (3) Type C overflow, which island that is not inundated with high tides, but the water level is shallow, and (4) Type of overflow D, which island that is not inundated with high tides and the water level is deep (BBSDLP, 2006).

Cultivation of Siamese oranges in swamps can be done with a stretch system (paddy field), but generally with system *support* (mound) or gradual *surjan* (*system dressing*). Gradually, farmers make supports in their paddy fields. This system bend is recommended only for swamps with mineral or peat soil types but also begins to propagate into peatlands of various thicknesses from shallow to medium. The shape of the support is generally rectangular, with a height of 60-75 cm and a side width of between 2-3 meters. Spacing between plants in rows 4-6 meters. The distance between rows is 10 - 14 meters depending on the area of land and the operational capability of the tractor in processing the soil for rice plants if the choice of land arrangement with a *surjan* system is channel drainage on one side with a width of 1.0depth of meters and a0.6 meters for easy drainage of water out and also equipped with a*dam overflow system*.

El-Niño events position Indonesia and the Australian continent as low-pressure centers and during La-Nia as high-pressure centers. According to the Malaysian Meteorological Service (1998), Indonesia experienced powerful impacts from these phenomena, the 1983 fires with an average SOI of -8.3 and the 1997 El-Nino with an average SOI of -11.0. This incident is an apparent relationship with the rain that occurred in Indonesia.

Climatic anomalies such as El Nino and/or La Nina more often with shorter repeat times. El Nino or La Nina in the last fifty years (1950-2000) often happens within five years and has increased the frequency in the last ten years. Therefore, this study aims to analyze the relationship between the development of swampland with the *Surjan* system and climate change, namely various efforts adaptation and mitigation in dealing with climate change.

2. Method

2.1. *Time and Place*

The research location was determined purposively, namely in the center of Siamese citrus development according to the type of tidal swampland, namely Barito Kuala Regency, South Kalimantan Province. Tidal type C in Marabahan sub-district (SP1 and SP2), type B in Mandastana sub-district (Karang Bunga and Karang Indah villages) and type A in Cerbon sub-district (Simpang Nungki village and Sungai Kambat).

2.2 Types and Sources of The Data

the research was carried out using survey methods, FGDs, interviews, and direct observations in the field. The data was dug in-depth (in-depth interviews) of the research respondents, namely: citrus farmers, fruit traders, and related agencies (Department of Food Crops and Horticulture of Barito Kuala Regency, Department of Agriculture of Food Crops and Horticulture of South Kalimantan Province, and BPP Cerbon District Barito Kuala Regency). The data collected was then analyzed descriptively.

2.2.1 Rain Watch Station

Rainfall data period of 1972 s / d in 2019 from BPS District Batola (https://baritokualakab.bps.go.id/publication.html)

2.2.2 Phase SOI

SOI data were drawing dynamics ocean accessible from DATA SOI(HTTP:// www .bom.gov.au/climate/current/soi2.shtml) in the same period (1978 – 1999).

2.2.3 Citrus Production Data Citrus

production was obtained from the Department of Agriculture, Food Crops, and Horticulture 2015 – 2019.

2.3 Methods of Analysis

The relationship between the SOI phase and the diversity of the beginning of the rainy season and the length of the rainy season was analyzed by tabulating monthly rainfall data for 26 years to determine the average start of the rainy season. Then the start of the season is rainy on average concerning the SOI data, which corresponds to the start of the rainy season. El-Nino and La-Nina's year of occurrence is determined based on the number of occurrences of SOI with a significant value (greater than +5 or less than -5). If the SOI of more than +5 lasts for at least six months, then the year concerned is declared an El-Nino year, whereas if the SOI is between -5 and +5, then it is declared an average year ((http://www.bom.gov.au /climate/current/soi2.shtml)).

Then the relationship between the beginning of the rainy season and the length of the rainy season with SOI was analyzed by linear regression, namely:

$$\tilde{Y} = \alpha + \beta X_i$$

with $\tilde{Y}\tilde{Y}$ = dependent variable (start of rainy season and length of rainy season), X = independent variable (SOI), = intercept, and = slope.

El-Nino and La-Nina events were analyzed with a cumulative frequency distribution to obtain the following probabilities:

$$f = \left({}^{m}/_{(n+1)} \right)$$

with f = frequency distribution, m = 1st to nth data, n = total data on the

2.3.1 Impact of Extreme Climate on the Citrus Farming System, Surjan System in Batola

The relationship between ocean dynamics and rainfall diversity and agricultural production was analyzed with the following analytical steps: 1) Monthly rainfall data for a minimum observation period of 20 years to see the relationship between the SOI phase and the diversity of the beginning of the rainy season, the length of the rainy season, and 2) Long-term district citrus production data.

2.3.2. Yield of Citrus Plants

The impact of climate variability on citrus growth and development was assessed using a qualitative approach to correlate between characters' physiological plant and climatic conditions. The impact on the results was calculated using regression analysis. The results were obtained from the average results per tidal category (A, B, and C). The weight for the mean of the results is $1/\sigma^2$, where^2 is the variance of the results. Mean future yields are also estimated using the same equations as climate projections. The assumption is that the correlation between yield and climate variables remains the same for now and in the future (excluding technological developments in citrus cultivation).

2.3.3 Farming Business Systems

Information about farming is obtained from FGDs and interviews. It can be used as material for analysis to formulate forms of intervention in counselling or other programs that can increase farmers' capacity to deal with extraordinary events that can affect their livelihoods.

2.3.3.1 Information collected

1) Information on extreme climate change based on farmers' perceptions in the last 10-15 years, for example, long dry season, excessive rains, hurricanes
2) Climatic and socio-economic factors affecting tree productivity and local farming systems
3) Types of trees and farming systems that are important to their livelihoods and the most widely or commonly found at the site of an example of the study area
4) Calendar farm system during normal conditions and if their extreme change from extreme events
5) public perception of the response of trees to climate change and pests and disease, both in saplings and productive trees.
6) Criteria farmers use to select trees and farming systems applied in their gardens. These factors can be used to identify the level of farmers' capacity to cope with the impact of an extraordinary event and to identify the types of farming systems or suitable trees to be developed at the local site
7) facilities and capacity that have and have not been owned by farmers and the surrounding environment to overcome the impact of extraordinary events.

2.3.3.2 Respondents

FGD participants came from several villages or specific to one village, depending on the scope of the study to be carried out. Participants were separated into male and female discussion groups. Each discussion group consists of about 8-10 people. Participants in the discussion are farmers who understand the farming system and tree resilience to climate change in the study area. Leaders of farmer groups, independent extension farmers, collector farmers, traditional leaders, youth, village officials, and communities whose main livelihood is the agricultural sector are ideal participants.

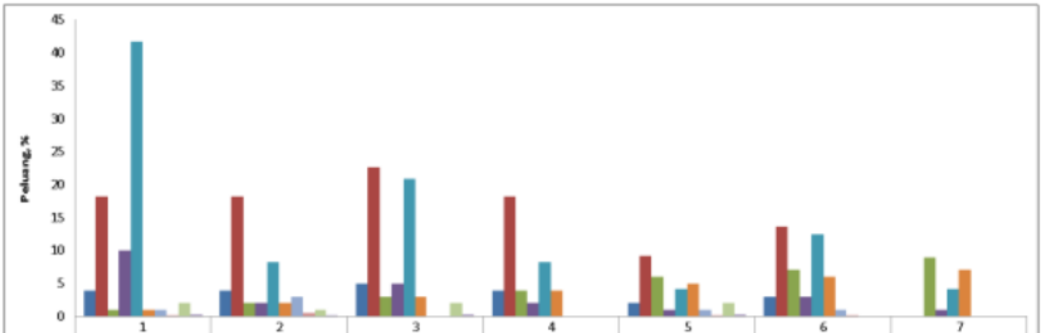
2.3.4 Tools and materials

The tools and materials used in the group discussions are: a) 20-30 sheets of A1 flipchart paper, b) Permanent markers, c) Colorful markers for drawing maps of the study area, d) Paper tape or *double-sided tape, e)* paper *Metaplanand f)* Table of discussion material.

3. Results and Discussion

3.1. Odds of El-Nio and La-Niña

El-Nino events with an intensity of 1, 2, 3, and 4 years have the highest frequency of occurrences of 4, 4, 5, and 4 times with a probability of about 18.2% to 22.7%. La-Nina with intensity once a year with the highest frequency ten times with 41.7% chance. La-Nia events coexist with El-Nio 13 times, and generally, El-Nio precedes La-Nia by about 50% every two years.



	1	2	3	4	5	6	7
El-Nino	4	4	5	4	2	3	0
	18,2	18,2	22,7	18,2	9,1	13,6	0,0
	1	2	3	4	6	7	9
La Nina	10	2	5	2	1	3	1
	41,7	8,3	20,8	8,3	4,2	12,5	4,2
El/La	1	2	3	4	5	6	7
	1	3	0	0	1	1	0
	17%	50%	0%	0%	17%	17%	0%
La/El	2	1	2	0	2	0	0
	29%	14%	29%	0%	29%	0%	0%

Figure 1. The probability of El Nio and La Nia occurrences from 1950 – 2019. Note: processed from http://ggweather.com/enso/oni.htm, 2020.

The probability analysis above shows that the El Niño and La Nia phenomena strongly influence the climate in Barito Kuala. Ashok el (2007) stated that Indonesia is located between two oceans (India and the Pacific) and two continents (Asia and Australia). Because of this position, Indonesia has dynamic and complex climate variability. The climate variability likely to occur in Indonesia is La Nia and La Nia *Modoki*. La Nia refers to the ENSO event that SST cooling occurs only in the central and eastern equatorial Pacific while La Nia *Modoki* SST cooling occurs in the central equatorial Pacific and SST warming in the eastern and western equatorial Pacific. Then according to Boer *et al*. (2007), Indonesia's rainfall anomaly has the most substantial relationship with the SST anomaly in the Nino 3.4 region (170˚-120˚W, 5˚N-5LS). It turns out that Nino 3.4 has a stronger correlation with rainfall in Indonesia.

Reduced rainfall and prolonged drought are direct impacts that can trigger other problems in the agricultural sector, such as crop failure and weakening food security. Air significantly affects the quality of the fruit; the fruit that blooms before the rainy season (October-November) those that ripen in August or September are sweeter in taste when compared to fruits that flower before the dry season (in May -June) or fruit interrupt. The long drought is a sign that the next year's citrus plantations will bear fruit. The probability of this occurrence will repeat once every two years with a percentage of 50%. It is suspected that this spurred flowering orange. Citrus flowering is induced through low-temperature stress or groundwater deficit stress.

Many attribute the onset of flowering to a prolonged rest period often associated with cold, sub-tropical winter, or water stress conditions in the tropics (Mendel, 1969; Reuther and Rios-Castano, 1969; Reuther, 1973). At the outset, Monselise (1947) suggested that cessation of root growth due to low temperature, water pressure, weak rootstock, and limited roots was necessary for flower induction. The hypothesis was then extended to show that citrus buds are continuously induced to flower, but the presence of endogenous root-generated gibberellins keeps such events from recurring in control (Goldschmidt and Monselise, 1972). Conditions conducive to inhibiting root growth, thereby, will reduce levels of gibbere llins, which, if not distributed to shoots, lead to suppressed flowering shoots (Monselise, 1978; 1985). There is no single hypothesis that can explain the problem of irregular flowering. The flowering pattern was also found in oranges cultivated on dry land (Rusmayadi, 2000).

3.2. *Determination of the Beginning of the Rainy Season in Batola*

The diversity of the beginning of the rainy season (MH) and the length of the rainy season in Batola is arranged as shown in the image below. The average rainy season starts in October and ends in May, with a rainy season of 9 months.

Table 1. Determination of the Beginning and Length of the Rainy Season in Batola

TAHUN	Bulan										
	SEP	OKT	NOP	DES	JAN	FEB	MAR	APR	MEI	JUN	JUL
1972		26	202	227	203	442	202	292	179	50	30
1973	271	77	253	420	268	345	394	515	205	72	66
1974	131	330	172	165	110	320	197	166	194	53	146
1975	202	294		136	348	302	516	257	140	81	149
1976	46	309	422	386	229	298	336	143	84	15	100
1977	23	13	266	373	141	214	398	227	141	48	40
1978	98	380	91	483	424	243	269	73	159	158	178
1990	26	168	114	409	355	205	159	80	142	32	62
1991	61	62	351	413	411	289	254	272	142	97	2
1992	100	102	241	225	229	393	274	202	215	49	76
1993	12	115	187	158	226	208	218	177	141	78	55
1994	7	37	204	429	289	244	259	235	68	105	28
1995	162	83	353	272	315	292	371	177	146	156	152
2002	60,75	73,88	282,75	339	334,88	268,63	372,76	207,88	57	182,14	12,57
2006	187,2	227,5	309,5	250,6	222,28	358,14	292,27	252,04	209,12	177,41	129,53
2007	27,75	101,28	303,52	442,57	261,4	361,35	476,74	432,82	162,05	203,47	173,81
2008	54,3	134,3	448,9	483,4	247,7	214,7	553,1	257	101	153,8	162,8
2011	111,5	227,2	234,4	191,8	358,5	274,3	304	531,7	138,6	144	237,9
2012	14	149,7	454,2	494,5	135	243,9	309,1	213,8	132,4	77,7	23,7
2013	27,2	91,6	205,8	543,8	232,5	507	265,5	213,8	309,9	136,5	104,3
2014	12,5	34,1	162,3	344	142	234,6	470	245,5	239,4	119,4	2
2015	0	46,4	128,9	243,2	615,1	449,5	190,6	298,6	105,1	97,5	4,8
2016	203,6	200,2	259,2	263	167,7	265,5	321,7	374,7	145,3	91,3	103,7
2017	49,8	124,8	258,7	335,1	241,3	210,9	418,8	120,2	244,3	147,7	70,6
2018	117,9	39	356,2	342,8	298,8	254,4	325,1	264,3	101,9	133,7	122
2019	59	93,8	154,2	189,8	372	212,9	213,2	243,3	139,9	195,4	7,5

3.3. Relationship between Rainfall and SOI in Batola

The relationship between SOI in October and the beginning and length of the rainy season (MH) is shown in the figure below, with the regression equation for SOI, and early MH is = -0.0507x + 9.5181

And the coefficient of determination, R^2 = 0.1883. Meanwhile, the SOI with the length of MH is = 0.0932x + 9.3267

And the coefficient of determination, R^2 = 0.2338. are the initial, and the old MH and x are SOI, respectively.

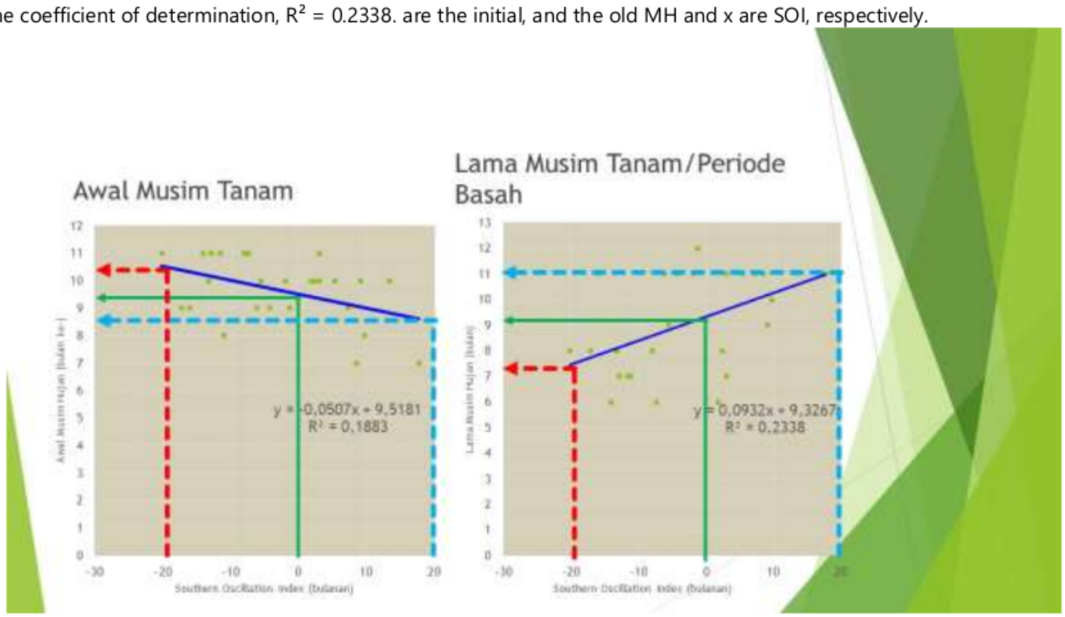


Figure 2. Relationship between SOI and early MH (left) and duration of MH (right)MH

3.4 Prediction of Early Probability and Length of entry Based on Soi October Phase in Batola

Suppose the SOI phase is in the La-Nina category (> +5, for example, at +20). In that case, the initial chance of MH will advance to August/September, and the relative length of MH will be longer for ten months compared to the normal phase (0) or the El-Nino category phase (<-5, for example, at -20), then the initial probability of MH will be pushed back to October/November with a length of MH for 7.5 months (Figure 2).

3.5 Surjan System Model and Patterns Adaptive to Climate Change

Interviews with farmers in their 50s show that the cropping pattern in Batola shows that the *Surjan* system model has survived for more than decades with a relatively unchanged pattern, as shown in the figure below.

This system is actually a local knowledge (local knowledge) of farming communities in swamps to meet their needs. Farmers organize their land into two parts: the raised part (mound) and the excavated part (tabuh). Due to the formation of a paddy field system and a dry field system in this system, farmers can optimize the space and time of tami farming with a variety of tolerant commodities and cropping patterns. Commodities in the mounds are generally citrus and other horticultural crops, while those that are taboo are planted with a combination of local (Siamese) rice with superior rice.

In its development, the surjan system has adapted to its environment, including adapting to environmental conditions due to climate change. The surjan system not only adapts to drought and flooding but also adapts to the risk of soil acidity, attack by plant pest organisms (OPT), and crop failure due to other biotic and abiotic stresses. In addition, the surjan system also considers aspects of economic benefits by choosing a cropping pattern for commodities that are not only suitable for swampland but also have high economic value.

Figure 3. *Surjan* Model and Adaptive Cropping Patterns to Climate Change

4. Conclusion

Surjan systems in swamps are adaptive and mitigated to climate change. Adaptive with technological components in the bund and tabukan is the anticipation of farmers against the risk of drought and flooding.

The *surjan* system is mitigated because the components technological in the oxidative ridge are in a flooded condition so that they become reductive.

The cropping pattern in the swamp tidal indicates the level of high resilience to climate change, namely the cropping pattern has not changed much over the decades on the climatic conditions fluctuate.

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