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PREFACE

On behalf of the University of Mataram it is a pleasure and a great honor for me to welcome you to Lombok Island and to this international seminar on economic, culture and environment. Unram is one of the state universities in Indonesia which was founded in 1964. At the beginning of its establishment, it was only Law Faculty followed by Economic Faculty few years later. Now, Unram has eight faculties, i.e. law, economic, agriculture, animal husbandry, engineering, medical, and science faculties with about 1000 more lecturers and 450 supporting staffs and 17 000 students. Last month, October 2010, we celebrated our 48th anniversary. 48 years old if we make an analogy as the age of a human being is certainly a mature age. We realize that Unram is as it is now, because of supports from both government and stakeholders. To respond to this, Unram will continue to improve its maturity in all aspects. For instance, in recent years, our university has significantly improved the competency and qualification of its staff. This can be seen from the increase in number of our staff who gained their Ph.D from both domestic and overseas universities, including the increase in number of the professors. This is relevant as an approach to indicate progress. Now, we try to work even harder to reach our goal to be one of the World Class Universities. Because, we have huge potentials that need to be tackled professionally.

We have wide range of dry land area in both Sumbawa and Lombok island. In terms of facilities, we have standard laboratories to conduct collaborative research. So far, we have joint research with Nagoya University, Jichi Medical School in Japan, Arizona State University in United States, La Trobe University in Australia, Utrecht University in The Netherlands, SOAS in England. We expect to have more joint research in the future as this global world requires. This is also imperative that we need more colleagues to collaborate with in handling related issues for the betterment of the future life.

However, let us see what is going on in our region where malls, supermarkets, housing complex are built on very productive lands which sometimes are not based on comprehensive environmental studies. We expect that not in a very long time Unram would show its existence and scientific contribution on this global trend. This seminar is one of the efforts to show the world that we exist and ready to work together hand in hand to face the world's common concern. There is an urgent need of saving our planet from an even detrimental destruction. One of them is climate and environmental change, another is economic and cultural change.

In terms of economics, the discourse among Asean countries to unify their currency system is an interesting issue to be addressed proportionally. This seminar is expected to contribute some principle ideas and strategies on how Asean should tackle their internal problems to reach harmonious cooperation among its members. In relation to culture, there is a massive change in this global world. We are expected to refer to our local wisdoms as a filter of values which are destructive. Those issues are addressed proportionally in this seminar. Therefore, I expect that we gather in this place to contribute our best to tackle relevant issues based on our own discipline.

Last but not least, we need to give a special appreciation to the committee of this seminar because of their efforts this important event could be realized. Having said that, please excuse any inconvenience that we may cause. Finally, have a great seminar and please enjoy your stay in Lombok. Wassalamu'alaikum Wr Wb .Thank you

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PREFACE

Inventing Scientific Value of Local Wisdom: A Lesson from Warige Sasak in Lombok, Indonesia

by

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It has been very long time, indigenous *Sasak* tribe in Lombok refers to local wisdom called *warige* as a` seasonal climate forecasting. This model was well known by traditional farmers in southern Lombok. In modern day, local wisdom is being ignored because of scientific approaches in climate forecasting. A descriptive research was carried out by interviewing local people who are still practicing *warige* and literature review was also conducted. Research was implemented in two stages. First of all, study on how does *warige work* in 2005 to 2007 and the second stage was a study on mechanism of physical interaction in *warige* system in 2008 to 2009. The purpose of the first study was to explore basic principals of *warige*. The purpose of the second research was to study mechanisms which possibly make *warige* able to predict seasonal rainfall. It was found from the first study that *warige* model considers position of sun and moon relative to earth latitude. It means that *warige* has a scientific consideration. The most critical step in *warige* is determination of *tumbuk* which is a period when sun is on overhead at midday. Phase of the moon at the time of *tumbuk* is attributed to characteristic of rainfall in the next rainy season. If *tumbuk* occurs at date 6th of a local calendar means that the next season will be more rain (wet), at date 16th means normal rainfall, whereas it will be dry season if *tumbuk* occurs at 26th. Result of the second study revealed that position of sun above the Indian Ocean at the date 20th of the month 10th of *Sasak* calendar (third week of February) has significant effect on rainfall pattern at the end of rainy season. Traditionally, it is coincides to *nyale* event (sea worm catching time) in southern beaches of Lombok. This event is believed to have correlation with rainfall pattern. It can be concluded that *warige* model has included effect of global factors, mainly interaction of gravitational force of sun, moon and earth to the ocean. It makes *warige* as a unique model in which scientific concepts were integrated.

Keywords: *warige, climate forecasting, tumbuk, nyale and local wisdom*

INTRODUCTION

Warige is a model of traditional climate forecasting. This model is an example of local wisdom belong to *Sasak* tribe in Lombok, Indonesia. As an indigenous knowledge, *warige* is no longer practiced in modern society of Sasak. It is only referred by traditional communities in Southern Lombok, particularly at villages of dry land agriculture areas. Mahrup *et al.*, (2007) found that *warige* model has a scientific basic of which global factors, such as position of sun and moon relative to earth latitude are considered. There is no modern climate forecasting which includes effect of the moon on predicting climate variability. However, in *warige* system, moon phase and its position are essentially considered. It makes the *warige* as a unique model and scientifically accepted.

Literatures were carefully traced to get scientific arguments. How both sun and moon could possibly affect rainfall pattern ? Tjasyono (2007) explained that sun is the only main source of heat energy on earth. Intensity of heat energy received on earth surface varies

according to earth latitude. Equatorial zone receives high intensity of heat energy. This zone extends from 23.5° North to 23.5° South latitude. Lombok island is geographically located at 116°15' 11"-116°24' 5" E and 8° 5' 11" – 8° 9' 33"). Borders of the tropical zone at northern hemisphere is called *tropic cancer* laid on Indian continent and southern border in southern hemisphere is called *tropic capricorn* laid across Australian continent (Baker-Finch, et al., 1973:20-21; Anonym, 1984:1048-1051). The intensity of sun energy successively decreases as the latitude increase, either toward northern or southern latitude. Revolution of earth on its orbit results in variation of light intensity. Keppler revealed that earth revolves on an elliptical path or orbit with sun as a center (Serway, 1990:362), It takes 365¼ days for earth to complete one period of revolution. While revolution, earth rotates on its axis with a period of 24 hours, three minutes 56 seconds in *solar day* or 23 hours, 56 minutes, and four seconds in *sidereal day* (Anonym, 1986:4). At the time of sun is at equator, position of *equinoxes* all places on earth get similar day hour of 12 hours (Baker-Finch, et al., 1973).

At the time of sun is on tropic *cancer* (22nd June), northern hemisphere receives higher sunlight intensity then southern hemisphere. On the other hand at the time of sun is on tropic *Capricorn* (22nd December), it will be high sun rays intensity received on southern hemisphere. Difference in the sunlight intensity received between northern and southern hemisphere results in climate variation between both sides. Rainy season, of course coincides with the sun is on each side (Baker-Finch, et al., 1973:20-21).

It was hard to believe that moon has significant effect on rain pattern. There is no modern models of climate forecasting which includes effect of the moon. Sir Isaac Newton discovered law of gravitation in the 1600's. The law explained that the sun and the moon exert a pull (force) on the earth called gravitation. The force (*F*) is proportional to the mass (*m*) of the bodies and inversely proportional to the square of the distance (*r*). The law is formulated as *follows* $F = G.\ m_1 \times m_2 / r^2$ (Serway, 1990:364-368).

The moon's gravity pulls the water nearest the moon slightly away from the solid part of the earth. At the same time , the moon pulls the solid earth slightly away from the water on the opposite side of the earth. In this way, the moon's gravity produce two bulges on the sea. These bulges are position of high tides. Tides follow the moon in its apparent motion and move around the earth under gravitational force of the moon. When the sun and the moon are pulling at the same line, as they do at full moon and new moon. The forces pull simultaneously at the time of near new and full moon, high spring tides result. When sun and moon pull at right angles, as when the moon is in its first and last quarters, low neap tides occur. The neap tide does not rise as high as usual. Tides also take place in atmosphere. It is similar to those in the sea. It is caused by moon's gravitation as well. At earth's surface, the tides are called *lunar winds*. The lunar winds blow at speed of about 0.08 km/hour. They blow eastward in the morning and westward in the evening. High and low tides in atmosphere come twice daily. There also are high stages that are equivalent to the sea spring's tide (Anonym, 1986; World Book, 1999).

Thus, there is one full moon and one new moon every month. The interval between one full moon and the next is approximately 29½ days. There are two motion taking place, namely: (1) rotation of the earth on its axis and (2) the revolution of the moon around the earth. The moon moves about 12° around the earth each day. Between successive risings of the moon , the earth makes a complete rotation days (Anonym, 1986; World Book, 1999).

There are two datum used in *warige* model, namely *tumbuk* and *nyale* event. *Tumbuk* is time where sun is on over head at midday in Lombok. It occurs on October 15th which indicates the month 6th in Sasak calendar. The phase of the moon at the time of *tumbuk* is associated to characteristic of rainfall for next season. If *tumbuk* occurs at date 6th of a local calendar means that the next season will be more rain (wet), at date 16th means normal rainfall, whereas it will be dry season if *tumbuk* occurs at 26th. Nyale event is traditionally celebrated by local people in southern beaches on the date 20th of month tenth in *Sasak* calendar. It is the time where sea

worm, *nyale* (*Echeria veridis*) is harvested in southern beaches, Indian Ocean. Result of the second study revealed that position of the sun above the Indian Ocean at the date of *nyale* catching time (in third week of February) has significant effect on rainfall pattern at the end of rainy season. Scientifically, this event has correlation with effect of the sun onto evaporation rate, atmospheric pressure, sea surface temperature and biological activities in Indian Ocean.

Objectives

The purpose of the researches were to explore basic principals of *warige* and to study mechanisms which possibly make *warige* able to predict seasonal rainfall.

Hypothesis

There are scientific mechanisms and value which enable *warige* model to be used as a climate forecasting.

METHOD

A descriptive research was carried out by interviewing local people who are still practicing *warig*. Literature review was also conducted. Research was implemented in two stages. First stage, study on how does *warige work, implemented* in 2005 to 2007 and the second stage was a study on mechanisms of physical interaction in *warige* system, conducted in 2008 to 2009. The first study was conducted by: (1) interviewing local resources or people who are knowledgeable in *warige*, (2) conducting a literature review, and (3) learning from existing ancient scripts written on woods or palm leave. Computer simulation using Planet Watch 2nd version was used to determine ephemeral data, namely position of sun, and moon relative to the earth latitude. The time of *tumbuk, i.e.* the sun is on over head (at right angle) on middy in Lombok (8.5° – 8.9°S) was directly observed on October 15th. Phase of the moon at the time of *tumbuk* was also observed at night. Local practices in observing the sun *tumbuk* and moon phase were demonstrated by local people who are still practicing *warige*. All procedures have been documented.

The date of *nyale* harvesting in southern beaches was determined using calculation of local calendar. It occurs on date 19th or 20th of month tenth. It coincides with February. Position of the sun at the date of *nyale* was determined using Planet Watch version 2nd. The position of sun is classified into two, namely: the sun is still at south of Java trench (>11° S) or it has been at north of the Java trench (< 11° S. Java trench is located at 10° - 11° S. The trench extends from east, commenced from south beaches of Sumbawa island, Lombok, Bali, Java and ended to west beaches of Sumatera.

RESULTS AND DISCUSSIONS

Observation of Sun's Position

The most critical stage in *warige* system is the determination of *tumbuk* and moon phase which is coincidence at the time of *tumbuk*. Position of sun *tumbuk* is observed by standing at midday. It is conducted in the month sixth of Sasak calendar or in October.

The way of local people observe the sun's revolution is illustrated in Figure 1.

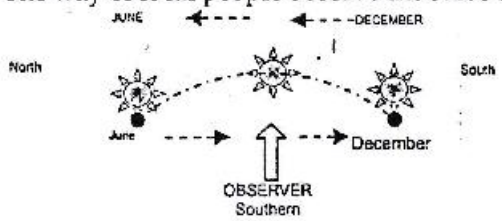

Figure 1. Illustration of Sun Revolution in Southern Hemisphere

Observation is directed to a point where the sun is raising in the morning. Local people use natural things or some things stand on fixed place, such as hill, a big tree to indicate the end point of sun move to northward or southward. Observers are always at the same place whenever they do observation. *Tumbuk* occurs when the sun is exactly on over head at midday; there is no shadow at either sides. Figure 2 shows how to observe *tumbuk* in traditional practice.

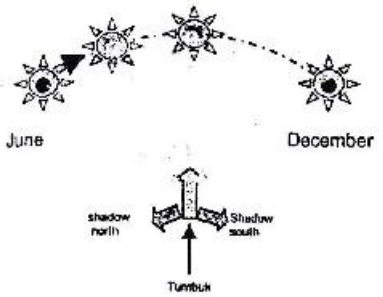

Figure 2. Traditional Practice in Observing *Tumbuk*

At period of *tumbuk* the sun rays make a right angle in Lombok. The sun goes southward and give its heat energy onto Indian Ocean. It results in increasing evaporation rate in the ocean, increasing sea surface temperature and relative humidity of atmosphere. Snellius Law explains that incoming radiation which is on right angle onto a flat plane (earth surface) produces the highest intensity (Serway, 1990). Energy of sun reaches the earth surface is constant of about 1,367 watt/m^2, or 3.67x 10^{21} call per per day with *albido* of about 30%. Temporal and spatial variation of the energy from the sun on earth surface depends on position of the earth on its orbit (Tjasyono, 2007). Scientific illustration of earth revolution is described in Figure 3.

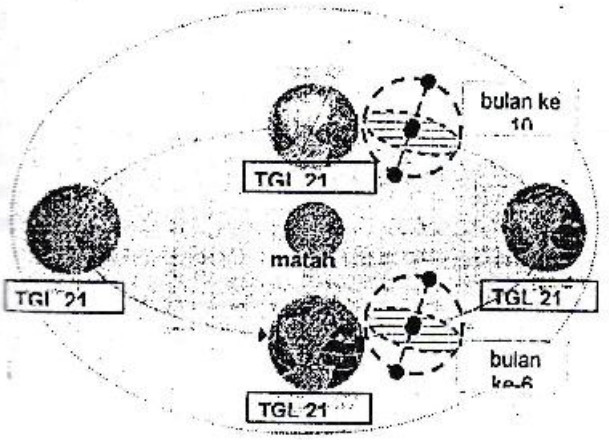

Figure 3. Position of the Earth on its Orbit during Revolution

It is clear from Figure 3 that the earth revolves around the sun once a year, and rotate daily on its axis which inclines at 66.5° to orbital plane. The sun is on right angle in Lombok (at 8.5° S) on October 15th every year. In term of climate is concern, there are four positions of earth, namely: summer *solstice* on June 21st, Autumn equinox on September 21st, Winter solstice on December 21st, and Spring equinox on March 21st. Similarly, *warige* system name *tumbuk* at the time when the earth at that position on October 15th when the sun makes a right angle in Lombok. It calls *ombek nyale* when the earth is on that position at about mid February. It coincides with *nyale* harvesting time.

On its journey revolves the sun, the earth find its closest distance, called *perihelion*. It is about 147 x 10^6 km away from the sun on 3rd January. While on 4th July, the earth is on longest distance, called *aphelion*. The earth is 152,007 x 10^6 km away from the sun (Linacre and Hobbs, 1982:15; Anonim,1986:4-7). Period of revolution is 365¼ days in three successive years and it is 366 days for the year forth. Radius of the orbit is 1.49x10^{11}m (Prendergast and Hammond, 1979:166-171).

Phase and Position of moon

Warige considers moon as a main parameter controlling variation in rainfall or climate variability. Local people put attention on new moon. They put a mark (a pin) on special wood to indicate the day one of the incoming month. They move the mark or a pin every days till the end of the month. Anonym (1986) gave a scientific illustration of moon's position relative to the earth and the sun on particular dates (Figure 4)

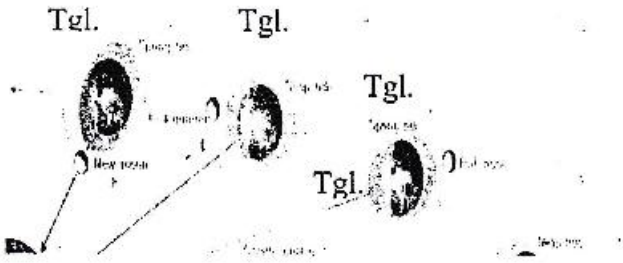

Figure 4. Position of the Moon Relative to the Earth and the Sun

Figure 4 shows position of moon relative to the earth and the sun. There are four position which have significan effect on ocean (Anonym, 1986), namely: (1) the earth, the moon, and the sun is in one stright line. It takes place on two condition. First on the date 1st when new moon appears. The moon lies in between the earth and the sun. Second on date 15th, full moon. Here, earth lies between the sun and the moon. While sun earth and moon are on one stright line, the biggest gravitational force from the sun and moon exert onto the earth (Anonim, 1986:4). The forces pull the liquid part (water) on earth. It causes high tide or *spring tide* on sea or water body in land which are nearest to the moon's position. (2) the moon, the earth and sun make right angles. It causes small tide, *neap tide*. This takes place in twice a month, i.e on first quarter (date 8th) and on last quarter (date 23rd) (Anonim, 1986:4-5; Serway, 1990:364-365; Anonim, 1999).

Warige incorporates the effect of graviattional force from the moon and the sun in a very simple model described in Figure 5.

Figure 5. Warige Medel for Climate Forecasting

Moon of date 6th and 26th represents first and last quarter respectively. Moon of date 16th represents full moon. This model is realy simplification of a very complex interaction between the sun, the moon and earth. Computer simulation was conducted to prove the model. The result shows that in 50 years, *tumbuk* does not always occur exactely on those three dates.

It could be close by, but the effect is similar to the date in which it closes to. If *tumbuk* occurs at date 6th of a local calendar means that the next season will be more rain (wet season), at date 16th means normal rainfall, whereas it will be dry season if *tumbuk* occurs at 26th. Modern system also classifies climate characteristics into three categories, e.g. It is named *La Nina* for wet season, Normal, and *El-Nino* for dry season (less rain).

How *warige* could explain the relation between phase of the moon and rain pattern ? The relationship is not direct, but indirect relation. Results of computer simulation conducted in the second study shows that *tumbuk* at 26th of lunar date is followed by higher freqwency of full moon or new moon and the sun are on a stright line to the earth in southern latitude (southern hemisphere) during a period of rainy seasons. High tides or spring tides frequintely occur in southern sea, e.g. southern part of Indian ocean. This high tides could cause turbulance which mixes hot water on upper layers or surface layers and cold water at bottom layers. Consequently, sea surface temperature decreases and low evaporation rate. Linacre and Hobbs (1977:102-103) explained that ocean has a mixed layer where temperature is verticaly constant up to 50 m depth, and temperature decrease as it goes down. For example, average surface temperature of Indian ocean is about 22°, it sharply decreases in the depth more then 200 m. On the other hand, if tumbuk on 6th, the moon, sun and earth on a stright line frequently occur in nothern latitude. It means that high tides or spring tides take place more frequent in nothern pars. At the same time, southern seas is in calm condition during a period of rainy season. In such condition, surface sea temperature is kept high, then evaporation rate is high as well. Tumbuk on 16th is followed by condition in which the sun, the moon and the earth are on one line with similar frequency for either side.

Phase of the moon

Phase of the moon indicates a portion of the moon's surface which reflects the sun light and it is visible from the earth. Phase of the moon consists of four phases (Anonim,1999), namely: (1) *new moon phase*, (2) *first qurter* at date 8th, (3) *full moon* and (4) *last qurteur* a date 23rd. Moon is named according to its appearance. It is called bulan sabit, *crescent*, at date 5th for less than half appears. Development of the moon from creasent to half moon is called *waxing* (date 8th) Moon appears bigger than half, but less than full moon is called *gibbous* (date 11th). Change of moon from full moon to new moon is called *waning*. Full moon is on the date 15th. Last quarter is on the date 23rd, and old moon is on the 30th . Detail of moon phase is illustrated in Figure 5 which was copied from Anonym (1986:15-16).

Figure 5. Development of Moon Phase

Datum *Nyale* as an Indicator of Rain Pattern

Harvesting *nyale*, sea worm (*Echercia veridis*) is traditional celebration conducted by local community in southern beaches. It is to celebrate the princes of *Mandalike* (who threw her self into sea for peacefull and humanitarian reason. It is a very famous folk story (folklor) of Sasak tribe in Lombok. *Nyale* is usually harvested in southern beaches (Indian ocean) on 19th or 20th of month tenth in Sasak caledar (third week of February). While in Pacific ocean, e.g. communities in Samoan Islands (14° 0′ S, 171° 0′ W), the similar sea worms are harvested in November 20th every year. Here, sea worms appear two months after the sun passes equator on September 21st. The sun locates at 19.6° S on 20th of November.

It seems that the story of Princes *Mandalike* is a personification of sea worm living in corral reefs under Indian ocean. Anciester of Sasak tribe was aware that how importent is the *nyale* (sea worm) as a natulal resource for the best nutrition. A great attention to the time of nyale's day has been put by local people from generation to generation. However, there had

been no explanation untill Mahrup *et al.*,(2007) published their research on the matter. A scientific lesson could be drawn from the *nyale* event. It can be stated that *nyale* with its unique characteristic was used in *warige* system as one of the most important biological indicator for climate variabilities.

Local community believes that if there is no heavy rain on the date of *nyale*, they will get a little *nyale* on beaches. Heavy rain, *ombek nyale* in local name will be followed by huge amount of sea worms floating on the beaches. Linacer and Hobbs (1977:146-156) reported that scientific approches are developed for climate forecasting. In early time, climate forecasting is commonly stated in folklors. Nowadays, scientific approaches have been developed. In term of nyale ivent in Lombok, two observations i.e. event on February 26th, 2008 and February 14th, 2009 were documented as in Figure 6.

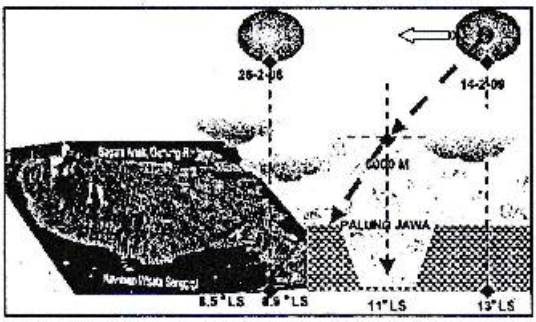

Figure 6. Position of the sun on February 26th, 2008 and February 12th 2009 Relative to Java Trench in Indian Ocean

It is clear from Figure 6 that the sun was at 8.9° S on *nyale* event, 26th February 2008 and It was at 13° S on 14th February 2009. The both events were on 20th of the month tenth of local calendar. As border of those position is Java trench located at 11° S The Java trench is 7,450 m depth (Anonim, 1986:16). The trench is about 230 km to the south from southern beaches in Lombok. Deep water body could play a significant role in heat energy budget and food chain in oceanic ecosystem. It could also affect hydrological cycle and caracteristic of atmosphere above Indian ocean. A huge heat energy could be conserved in the deep trench and it is released into atmosphere along with water favour. Lenacre dan Hobbs (1977:96-77), reported that Indian ocean get heat energy as much as 113 W/m², and average sea surface temperature is 22.2°C. Average evaporation rate is 1320 mm per year and raifall is about 1170 mm per annum. Heat energy captured on surface is transferer downward through *convection* process. It forms a temperature gradient in the trench, e.g. 22.2°C on the surface dan 1.9 °C in 3000 m depth (Lenacre dan Hobbs, 1977:46-47 dan Dejong, *et al.*,1990:100-105).

There is no doubt that position of the sun relative to the trench brings about significant effect on rainfall pattern in regions nearby the trench. Serway (1990:1072-1093), O'Dwyer (1981:502-503) and Dejong, *et* al. (1990:100-105) explained that refraction in water is determined by an angle of incoming light. The incoming light in water is refracted (pass through) into deeper layers. If the incoming light makes a small angle againt normal line i.e. the sun is on right angle to the water surface, then sun light will penetrate further down into deeper layers. In water the light intensity will attenuate depending on water properties. It is one possible mechanism by which *warige* could be developed as a scientific tool for climate forecasting. *Warige* is no longer mitos, but scientific values will come as we learn more from the local wisdom.

Rainfall pattern in retaltion to position of the sun relative to Java trench at the date of nyale ivent is presented in Figure 7.

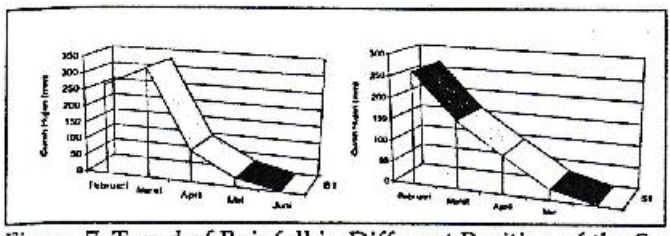

Figure 7. Trend of Rainfall in Different Position of the Sun Relative to Java Trench: Data in 2008 (left hand) and Data 2009 (right hand)

As can be seen from Figure 7 that rainfall intensity was very high in February and March 2008 when the sun had passed the trench at the date of *nyale* (26th February 2008). The sun was at 8.9° S when nyale ivent., The rainfall intensity sharply decresed from March to April. In February 14th, 2009 when the sun was at 13° S during *nyale* ivent, rainnfall intensity in February and March were lower than previous year. Rainfall intensity smootly decreased from March to April and so on till June. Variation of rainfall in this region is a local fenomena which is affected by local factors as well. This fact supports the reason why the *warige* is being practiced by local people for hundreds of years.

CONCLUSION

1 *Warige* model was developed under scientific mechanisms in which interaction between the sun, the moon and the earth were considered

2 Effect of local factors e.g. heat energy balance in Indian ocean was integrated in warige system which enable it to predict varaibility of rainfall in the region.

3 *Warige* refers to two distinguished periods in determining climate variability, namely: *tumbuk* is to indicate rain pattern during rainy season, and *nyale* ivent to predict rain pattern at the end of rainy season.

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