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Ethnoastronomy-The Baduy agricultural calendar and prediction of environmental perturbations

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Abstract. *Iskandar J, Iskandar BS 2016. Ethnoastronomy-The Baduy agricultural calendar and prediction of environmental perturbations. Biodiversitas 17: 694-703.* In the past, the village farmers of Java and other islands owned extensive the traditional ecological knowledge (TEK) on climate or *pranata mangsa*. It had culturally practiced as guidance to various agricultural activities, such as planting rice which is considered and fixed with dynamic climate conditions. Nowadays, however, the *pranata mangsa* has eroded and neglected by the majority irrigated rice (*sawah*) farmers. Unlike the *sawah* farmers, the Baduy people have culturally maintained the *pranata mangsa* (called by Baduy as *pananggalan*) for annual practicing the swidden farming (*ngahuma*). This paper discusses the way in which cultural practices of Baduy swidden farming based on traditional calendar. Method used in this study qualitative which is based on ethnoecology or ethnoastronomy approach. The result of study shows that the Baduy rice farming cycle is fixed annually with reference to an agricultural calendar. It has slightly affected by the various environmental perturbations, because the Baduy people have developed some strategies, such as by organizing the traditional calendar and applying the traditional agroforestry that productions can be used for both subsistence and commercial purposes.

Keywords: Baduy, ethnoastronomy, environmental perturbations, traditional calendar, swidden farming

INTRODUCTION

A farm system is a very complex that is generally influenced by biophysical factors and socio-economic and cultural factors, including the rural society's value, knowledge, skills, and technologies (Rambo and Sajise 1984; Lovelace 1984; Beets 1990; Reijntjes et al. 1992). In the past, the traditional rice farming system of West Java and Banten was managed by local knowledge (*corpus*) and cosmos/belief and local institution (cf. Mustapa 1996; Toledo 2000). For example, both the swidden farmers (*petani ladang*) and the wet-rice farmers (*petani sawah*) had plentiful local knowledge on climate because their farming systems are annually influenced by the various climate conditions. As a result, it has widely been recognized that farmers in cross-cultural in different areas of Indonesia had traditionally applied an agricultural calendar which is called *pranoto mongso* or *pranata mangsa* (van den Bosch 1980; Daldjoeni 1984; Arsana et al. 2003; Hidayat 2011; Wiramihardja 2013; Retnowati et al. 2014; Ammarell and Tsing 2015). The *pranata mangsa* system is not less complex with the calendar of ancient Egypt, China, Maya, and Burma (Sindhunata 2011). In the *pranata mangsa* system has a complex and close interaction between cosmography and bioclimatology which is as a fundamental farmer live society (Daldjoeni 1984; Hidayat 2011). On the basis of environmental or ecological history, *pranata mangsa* has been recognized as the traditional ecological knowledge (TEK) which is inherited by the oral through inter generations for a long ago. The *pranata mangsa* as a TEK has some characteristics, such as inherited by oral, teaching through doing, holistic, subjective and experiential based on trial and error in the agricultural system, based on intensive interrelationship between farmers and their local environment (cf. Ellen and Harris 2000; Silitoe 2002).

Before introduction of the green revolution, before earlier 1970s, rice farmers in Java and Bali had traditionally managed planting rice with the same time in simultaneity. They had used water in efficient, and management of pest based on the traditional ecological knowledge (TEK), such as implementing the *pranata mangsa* and cosmos or belief (cf. Gelpke 1986; Lansing 1991). However, by introduction of the green revolution, the *sawah* cultivation system had dramatically changed. The green revolution had affected both positive and negative aspects.

The main positive or benefit of the green revolution has been increase in rice farming productivity in macro level. Some negative aspects, however, have also occurred. For example, the new rice cultivation system is more dependent on subsidies from outside. In addition, ecologically damage such as pest outbreaks, loss of local genetic diversity of rice, and environmental pollution have also occurred (cf. Fox 1991; Lansing 1991). Indeed, the traditional ecological knowledge of the *pranata mangsa* has seriously eroded.

Unlike the rice farmers, the Baduy people who reside in South Banten, have traditionally maintained the traditional

calendar (*pananggalan* or *pranata mangsa*) and embedded with cosmos to manage their swidden farming in sustainable system despite various environmental perturbations, such as long drought and an abnormal high rainfall have frequently occurred and affected the Baduy swidden farming system.

This paper discusses the way in which cultural practices of Baduy swidden farming based on traditional calendar and tended to able to adapt to the environmental perturbations, particularly anomaly climate caused of the global warning.

MATERIALS AND METHODS

Study sites

The Baduy area was recognized as the communal land (*Tanah Ulayat*) decided by the local regulation of District of Lebak No. 32 year of 2001, with has size 5.136,58 hectares. Geographically Baduy village is located at $6^0$27'27''-6^0 30' South and longitude $106^0$3'9"-106^0 4' 5" East. On the basis of the culture, the Baduy area can be divided into two main groups, i.e. Inner Baduy (*Baduy Jero, Baduy Dalam*) and Outer Baduy (*Baduy Luar, Baduy Panamping*). Inner Baduy consist of 3 permanent hamlets, Cikeusik, Cikartawarna, and Cibeo, while the Outer Baduy composes of 59 hamlets, such as Kampung Kaduketug Gede, Kaduketug I, Kadukaso, Cipondok, Cihulu, Marengo, Gajeboh, Cibalingbing, Cigula, Kadujangkung, and Karahkal located in the north of Inner Baduy. The hamlets are scattered along valleys near the Ciujung river and its tributaries, or near other water resources, at altitude of between 170 m and 410 m asl. In addition, initially there are Dangka area (*Kawasan Dangka*) consists of 7 areas, namely Cihandam, Kamancing, and Kompol located in the Muslim enclave and lead by the informal leader representative (*Jaro Dangka*). Today, however, several *Dangka* areas, such as Cihandam and Kamancing have been taken over by the Muslim community and the *Jaro Dangka* have been moved to Kaduketug. However, an interim of the government administrative, the Baduy area is legalized as a village (*desa*) of Kanekes, sub-district (*kecamatan*) of Leuwidamar, district (*kabupaten*) of Lebak, province (*provins*i) of Banten, Indonesia (Figure 1).

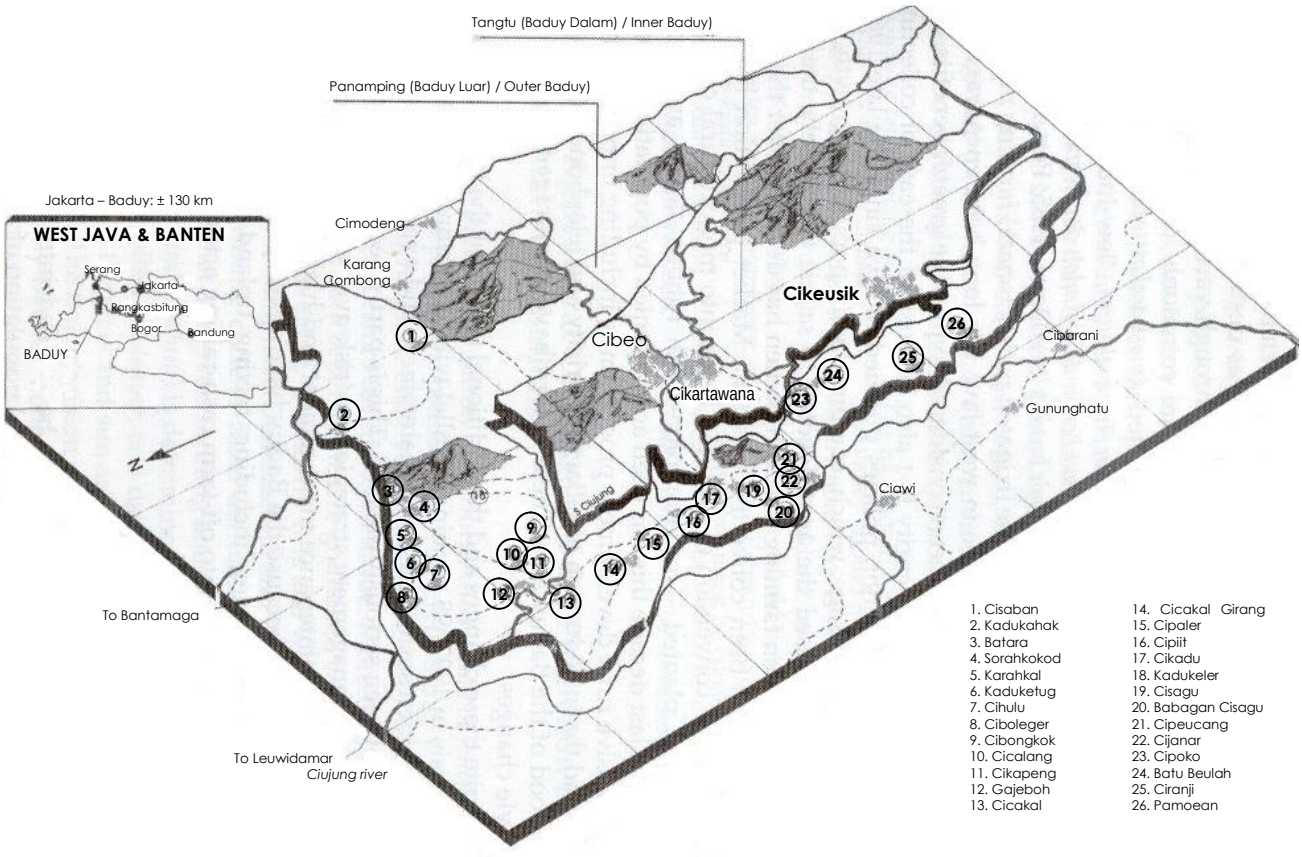

Figure 1. Study site Baduy area of Kanekes village, Leuwidamar sub-district, Lebak district, Banten province (adapted from Rangkuti 1988)

In 2010, population of Baduy was recorded 11,172 people, representing 2,948 households consisting of Inner Baduy 1,170 people (10.48 %) and Outer Baduy 10,002 people (89.52 %). While in 2015, the total population of Baduy increased to 11,620 people representing 3,395 households. Swidden cultivation is the main source of Baduy subsistence. However, Baduy women are also involved in making traditional woven cloth (*kain tenun*). Some Baduy men also involved in making traditional bags from bark cloth; *koja* and *jarog* which are produced for personal use, as well as being sold to visitors or to small shops (*warung*) in their village or in the neighboring area. Trade in non-rice crops, such as durian (*Durio zibethinus* Murr), petai (*Parkia speciosa* Hassk), banana (*Musa paradisiaca* L), and brown sugar of aren (*Arenga pinnata* (Wurmb) Merr) is also important for some Baduy people.

Procedure

This study was applied qualitative method and used of the ethnoecology and ethnobiology approach (cf. Newing et al. 2011; Iskandar 2012; Albuquerque et al. 2014). To collect some primary data, the observation, participant observation and deep interview with competent informants were applied. Observation was conducted to observe conditions of human settlements, swidden fields, and forests. Participant observation was applied by involving the researchers in some swidden farming activities of informants, including cutting shrubs and trees (*nyacar* and *nuar*), planting rice (*ngaseuk*), weeding (*ngored*), harvesting rice (*panen pare*) and various traditional rituals. The first author had completely involved in almost every stage of swidden farming due to intensively conducted the field research for master thesis program in 1984/1985 (Iskandar 1991) and in 1994/1995 for the dissertation program (Iskandar 1998). In addition, between 2000 and 2015 we took every possible opportunity to visit Baduy village to accompany students to conduct the field research in this area. While, deep interview was applied with some competent informants which was purposively selected and heterogeneity or categorization are considered. Some informants were mainly selected, mainly village formal leader (*jaro pamarentah*), village secretary (*carik desa*), hamlet informal leaders (*kokoklot lembur*) of Outer Baduy, *Jaro Tanggungan Dua Belas* of Outer Baduy, informal leader staff of Inner Baduy (*Jaro Tangtu*), several old farmers of Inner and Outer Baduy. In deed, in terms of the study on ethnoastronomy, we undertaken deeply interviewed with local experts on the traditional calendar, including informal leader staff and old farmers, and some time we participated in observing the position of *bentang kidang* (the belt of Orion) on the horizon at dawn, and observed and identified of the biological indicators for predicting the annual seasonal changes of the traditional Baduy calendar, including various flowering plants and soil spider.

Data analysis

Analysis data involved cross-checking, summarizing and synthesizing from different sources, including observation, participant observation, semi structure or deep interview, and secondary data, and built up a narrative accounts as a descriptive analysis which is focused on the annual Baduy swidden system management which is based on the traditional calendar (*pranata mangsa* or *pananggalan*) (cf. Iskandar 2012; Newing et al. 2011).While various species of plants that are culturally used as indicator for predicting the annual season changes of the traditional Baduy calendar were identified in the Herbarium Bogoriense, Indonesian Institute of Sciences (LIPI), Cibinong, Bogor, West Java, Indonesia.

RESULT AND DISCUSSION

The swidden cultivation as an obligation of Baduy

Since the early nineteenth century various names have been given by outsiders to the traditional Sundanese minority who live in the area of 'Desa Kanekes': *urang Baduy* (Baduy people), *urang Rawayan* (Rawayan people), *urang Kanekes* (Kanekes people), and *urang Parahiang* (Parahiang people). Although the name 'Baduy' is now established among outsiders, it is strongly rejected by Baduy themselves. They prefer to call themselves *urang Kanekes* (Danasasmita and Djatisunda 1986, Iskandar 1998). According to some scholars (e.g. Ekadjati 1985; Iskandar 1998; Wessing and Barendreght 2005) there are three main theories concerning their origin. The first is that they are descendant of people who managed to escape from the Hindu kingdom of Pajajaran, near present day Bogor, before Islamic forces from the Sultanate of Banten destroyed it AD 1579. The second is that they are descendant of Hindu people who originally lived in Banten but who fled to present day Kanekes from Islamic forces of Sultanate Banten. The third theory, based on old Sundanese text, is that Baduy are descendants of an ascetic group living in sacred parts of the forest in pre-Islamic times. Such places and people were usually called *mandala* areas and *mandala* communities.

On the basis of the culture, unlike the Sundanese ordinary, in their daily lives, the Baduy have tried to keep their original culture as pure as possible based on their ancestry (*karuhun*), particularly in the practicing of swidden farming (*ngahuma* or *berladang*). They would like to live in harmony with their environment, the forest. So Baduy life is regulated by many prohibitions, such as planting rice in wet-rice-fields (*sawah*), using chemical fertilizers, pesticides, selling swidden rice, rearranging buffalo and sheep, growing monoculture commercial crops, such as rubber, teak, and clove; digging wells, and poisoning wild animals and fish (Iskandar 1998; Ichwandi and Shinohara 2007). Baduy life is regulated many prohibitions related to their concept of sacred place. It is central to their belief that they maintain a simple way of life (*hidup sederhana*), faitfull to their ancestry regulated by asceticism (*tapa*); in contrast to the hectic life of the modern world (*ngaramekeun negara*). They prefer honesty (*bener*) to cleverness (*pinterteu bener*), honoring the various obligations they have to their ancestors.

Culturally, Baduy respect six main obligations in their daily lives: (i) *ngersakeun Sasasaka Pusaka Buana* (they should keep the holly place of *Sasaka Buana*); (ii)

ngersakeun Sasaka Domas (they should keep the holly place of *Sasaka Domas*); (iii) *ngasuh ratu ngajayak menak* (they should take care of King or Sultanate or President and noble families in the present time); (iv) *ngabaratakeun nusa telu-puluh-telu,bagawan sawidak lima, pancer salwe nagara* (they should ascetic rituals for thirty tree hamlets, sixty five sub-rivers, and twenty five country centers); (v) *kalanjakan kapundayan* (they should hunt animals and catch fish for *kawalu*; and (vi) *ngukus kawalu muja ngalaksa* (they should burn incense in conducting ascetic, to perform ritual of *kawalu* and *ngalaksa*) (Danasmita and Djatusunda 1986; Iskandar 1998; Wessing and Barendreget 2005).

On the basis of these duties, for Baduy, swidden cultivation is necessary part of the annual obligation to perform *kawalu* and *ngalaksa*. In other words, rituals such as *kawalu* and *ngalaksa* firmly unite of swidden cultivation with their religion, *Sunda Wiwitan*. Each year swidden rice (*pare huma*) must be offered to the ancestor (*karuhun*) for life to continue. Swidden cultivation is necessary, therefore, for the effective practice of Baduy religion; it is not simply a matter of subsistence economics. Moreover, practicing swidden cultivation is a religious, even when it appears to be economically irrational. Although Baduy traditional farming had been opposed and given negative stereotype by the government since the Dutch (cf. Kools 1935; Dove 1985; Li 2000), nowadays, it has still widely practiced due to considered by Baduy as their religion obligation.

Six types of swiddens (*huma*) recognized in Baduy: (i) *huma serang*, swidden belonging to enter community, both Inner and Outer Baduy, consist of *huma serang* of Cibeo, Cikartawarna, and Cikeusik, located in the southern hamlet area of Inner Baduy (and never overlapping with plot types, considered very sacred); (ii) *huma puun*, swiddens belonging to and managed by families of the religious leaders (*puun*), consists of *huma puun* of Cibeo, Cikartawarna, and Cikeusik obtained through inheriting from their ancestral, located in special place in the southernmost part of each Inner Baduy hamlet; (iii) *huma girang seurat*, swiddens belonging to and managed by families of the informal leader who assist the *puun* (*girang seurat*), located in a special place attached to the *huma serang*; (iv) *huma jarodangka* or *huma tauladan*, consists of 7 *huma tauladan*, swidden belonging to and managed by informal leader staff or assistants of *puun*, called *jaro dangka* living in *dangka* area. These are considered less sacred than *huma serang*, and used as a model swidden in Outer Baduy. Some activities, particularly planting rice, involve cooperative ritual; (v) *huma tangtu*, swiddens belonging to each household of Inner Baduy, mostly in the north of each Inner Baduy hamlet. Obtained through ancestral felling mature forest; and (vi) *huma panamping*, swiddens belonging to Outer Baduy households, obtained on loan and through inheritance, rent share-cropping or exchange for labor from neighboring non-Baduy. On the basis of annual cultivation practice, the Baduy swidden types, i.e. *huma serang*, *huma puun*, and *huma masyarakat* are always sequentially cultivated, which is culturally based on specific traditional calendar of Baduy (*pananggalan Baduy* or *pranata mangsa*).

Traditional calendar and working activities of the swidden farming system

For the Baduy, the annual obligation to perform the rituals of *kawalu* and *ngalaksa* is an integral part of the practice of swidden farming, which thus unites agricultural and religion. *Kawalu* derives from *walu* meaning *bali*, *balik*, *kabali* or *kembali* (comeback). The ritual is undertaken after harvesting rice of *huma serang* that is considered very sacred. The rice has been carried back from the swidden plot to the hamlet and placed in the rice barn (*leuit*). At that time, rice is considered to have 'comeback' to the rice barn after staying with her husband on earth (*bumi=pertiwi* or swidden plot). Because based on Baduy culture, it is believed that in sowing rice, the rice goddess, *Nyi Pohaci* (*Dewi Sri* in Javanese) becomes engaged (*direremokeun*) to the earth, *pertiwi* (Danasasmita and Djatisunda 1986; Iskandar 1998). According to Baduy beliefs, the fast must be conducted during *kawalu* to fulfill an obligation and continue the ritual work of their ancestors. The *kawalu* ritual is considered very important and must offer the cooked of new rice harvested from the *huma serang* to their ancestors and can determine the beginning of the first day of the new years (*tindak tahun* or *tunggul tahun*). In other words, although various methods, such as environmental indicators, including the appearance and disappearance of certain stars, and appearance of certain flowering plants and animals are used to determine *tindak tahun*, the most important factor determine *tindak tahun* is the harvesting time of the *huma serang*, as three months before *tindak taun*, the ritual *kawalu* must be performed. Therefore, if there is a delay in harvesting rice from the *huma serang*, the *kawalu*, *ngalaksa*, and *seba* ritual will also be delayed, as will the next *tindak tahun* (Iskandar 1998; Iskandar 2007).Because the *kawalu* can be considered very important in determining the Baduy calendar, therefore, the names of Baduy month are now rather confusing, particularly compared to the original names of the Javanese calendar (*pranata mangsa*). For example, the first month of the Baduy Calendar on *Sapar* or *Kapat* instead of *Kasa* of the traditional Javanese calendar, while *Kasa* of Baduy calendar is known as the first *Kawalu* or *huma serang* harvesting time. The completed Baduy calendar can be seen in Table 1.

On the basis of Baduy calendar, one year is divided into 12 months which each month always constant consists of 30 days instead of between 23 and 43 days of Javanese calendars (cf. van den Bosch 1980; Ammarell 2005; Ammarell and Tsing 2015). Various methods such as *kolenyer* and environmental indicators, namely position of stars, fruiting certain kind of plant and animal are culturally used to determine *tindak tahun*, and the final decision is usually made by the traditional leader (*puun*) of Cibeo. The *kolenyer* is traditionally used to calculate *naptu* which is made by wood of 6 cm x 25 cm. The various symbols written in the both front and back of *kolenyer*, such cross line, empty, one dot and four dots. These symbols have special meaning namely, cross line, empty, one dote, and four dotes means *pati* (unlucky), *neutral*, *milik leutik* (little luck), and *milik gede* (much luck), respectively. In the front of *kolenyer* written symbols are used to locate auspicious

times for engaging in special works. For example, on Sunday *isuk-isuk* (5.00-9.00), *tengah naek* (9.00-12.00), *tangange* (12.00-13.00), *lingsir* (13.00-14.00) and *burit* (14.00-16.00) is considered as unlucky, little luck, much luck, neutral, and much luck, respectively. Therefore, if, for example, someone wants to hunt animals or to press for payment of a debt on Sunday, the auspices time must be chosen in the afternoon; during *tangange* and *burit* because these times are considered to be more auspicious. While, various symbols in the back are used to locate auspicious direction. For example, direction of arrival on a Sunday should be to the west, east and south, while direction of departure must be to the north east.

Arranging the annual calendar is usually done by expert, *dukun*. Today, however, there remain few *dukun* who are recognized as experts who can assist the *puun*. Environmental indicators, *kikandayan tani*, are used to decide the beginning of the farming year. Both *bentang kidang* (the belt of Orion) and *bentang kartika* (the Pleiades) are usually observed on the horizon at dawn. Particularly, the Baduy people regulate various phases of the swidden farming cycles with reference to the position, appear and disappear of *kidang* (Kools 1935; Iskandar 1998, 2007). This was described by informants as follow:

Tanggal kidang turun kujang	When *kidang* first appears, a chopping knife should be used
Kidang ngarangsang kudu ngahuru	When *kidang* appears in a position similar to that of the sun at 8.00-10.00 a.m., vegetation should be burned
Kidang nyuhun atawa condong ka barat kudu ngaseuk	When *kidang* appear overhead or sideways to the west, rice should be planted
Kidang marem turun kungkang, ulah melak pare	When *kidang* disappears, insect pests will appear, and rice planting should stop

On the basis of various position of *kidang*, it can be integrated with various phases of the annual swidden farming cycle. Normally *kidang* is observed appearing on the east horizon at dawn corresponds to *Sapar* or *Kapat* (April-May) of the Baduy calendar. At this month the vegetation must be cut for preparing the swidden (*ladang* or *huma*) plot, particularly for the *huma serang* (Table 2). The *kidang* position is observed in a position similar to that of the sun at 8.00-10.00 above Eastern horizon at dawn corresponds to *Kanem* (June-July) and burning vegetation of the *huma serang*. The next month, the *kidang* position is observed overhead (zenith) or sideways, usually corresponds to *Kapitu* (July-August), considered to commence to planting rice of the *huma serang*, the burning vegetation (*ngaduruk*) of *huma puun*, and the cutting shrubs (*nyacar*) of *huma masyarakat*. While the *kidang* has could not be seen or disappeared on west horizon at dawn corresponds to *Hapit Kayu* (December-January), rice planting should stop. It is considered to be inappropriate to plant rice, because the soil is too 'hot' and insect pests (*kungkang*) come to *buana tengah*. According to Baduy cosmology, the world can be divided into three parts: *buana tengah* (the presence world), *buana handap* (the world where the human body is buried after death), and *buana luhur* (the hereafter). Other environmental indicators, such as flowering certain plants and animal behaviors are also used as indicator to commence to undertake certain phase of the swidden farming cycle. For example, based on information of the informants, besides traditional calculations used *Kolenyer*, observing the belt of Orion (*kidang*), the times when plant flower and fruit can also be used as indicators to determine certain month of the Baduy calendar. For example, *kanyere* (*Bridelia monoica* (Lour.) Merr), *jampang kidang* (*Centotheca lappacea* (L.) Desv.) and *jampang kerti* (*Centotheca* sp.), the flowering and fruiting of which is usually synchronizes with the appearance *bintang kidang* on Eastern horizon or the dry season. In addition, *lancah kidang* (the soil spider) indicates the time when people should start planting rice. The *lancah kidang* usually make its nest on grasses growing in swidden fields. If her web has a hole in the middle, and she stays most of time on the edge of the nest, rice planting in the swidden should start.

Table 1. Comparison of the Baduy calendar and Javanese *pranata mangsa*

Baduy calendar*)				Javanese calendar**)		
Month	**Month name**	**Duration in days**	**Corresponds to**	**Mangsa**	**Duration in days**	**First day civil calendar**
1	Sapar or Kapat	30	April-May	Kasa (1st)	41	21 or 22 June
2	Kalima	30	May-June	Karo or Kalih (2nd)	23	1 or 2 August
3	Kanem	30	June-July	Katelu or Katiga (3rd)	24	24 or 25 August
4	Kapitu	30	July-August	Kapat or Kasakawan (4th)	25	17 or 18 Sept.
5	Kadalapan	30	August-September	Kalima or Gangsal (5th)	27	12 or 13 October
6	Kasalapan	30	September-October	Kanem (6th)	43	8 or 9 November
7	Kasapuluh	30	October-November	Kapitu (7th)	43	21 or 22 December
8	Hapit lemah	30	November-December	Kawolu (8th)	26 or 27	2 or 3 February
9	Hapit kayu	30	December-January	Kasanga (9th)	25	ult.Feb. or March
10	Kasa	30	January-February	Kasepuluh or Kasadasa (10th)	24	25 or 26 March
11	Karo	30	February-March	Desta (11th)	23	18 or 19 April
12	Katiga	30	March-April	Sada (12th)	41	11 or 12 May

Note: *) The field research (Iskandar 1991, 1998, 2007). **) Adapted from van den Bosch (1980); Ammarell (2005); Ammarell and Tsing (2015)

About five months after sowing, or in *Kasa* (January-February), *huma serang* rice matures and is ready to be harvested. Moreover, the new rice must be offered to their ancestors in the ritual of the first *kawalu* (*kawalu kahiji* or *kawalu tembey*).Thus, to conduct the first *kawalu ritual* (*kawalu kahiji*) in Inner Baduy, the new rice harvested in *huma serang* must be used. In addition, the new rice of *huma serang* can be used to conduct other rituals, namely *ngalaksa* in *Katiga* (March-April) and *seba* in *Sapar* (April-May). Because the rituals of *kawalu*, *ngalaksa* and *seba* must use new rice of *huma serang*. Therefore, if there is a delay in harvesting rice from *huma serang*, the *kawalu*, *ngalaksa* and *seba* will also delayed, as will the *next tindak tahun*, as happened in the farming years of 1994/95 and 1997/98 due to long drought. In normal circumstances, *huma serang* rice must be harvested during *Kasa* (January-February) (Table 2). However, because in 1994 there had been a drought, the *huma serang* rice was harvested during *Katiga* (March-April). Consequently, the first *kawalu* was performed during *Katiga* (March-April) instead of *Kasa* (January-February), the second *kawalu* during *Sapar* (April-May) instead of *Karo* (February-March) and the third *kawalu* during Kalima (May-June) instead of *Katiga* (March-April). In addition, *tindak tahun* was fixed for *Kanem* (June-July) instead of *Sapar* (April-May). Therefore, for re-adjustment with the dynamic of climate conditions, particularly rainfall conditions, in every month and in each year this calendar by a ritual specialist (namely *puun Cikeusik*), who resynchronizes the calendar with the rotation of the *bentang kidang* and with the flowering and fruiting season of particular species (Iskandar 1998, 2007). To determine the beginning of annual new year is determined by the harvesting of *huma serang*, the various position of *bentang kidang*, the flowering and fruiting particular plant species, animal behavior (soil spider), and auspicious day (*hari bagus*), and is used standard that the total number of day in each year 360 days instead of 364/365 (Table 2).In other words, the total number of day in the Baduy's calendar is 360 instead of 364/365 days of BC calendar (*masehi*) or Muslim calendar (*hijrah*). It is caused of between 4 and 5 days are usually excluded in the traditional calendar Baduy due to *puun* perceptions considered as not appropriate. Therefore, the *puun* is an important role in setting a date for the new year of the Baduy's calendar and can determine to the success and failure of practicing swidden farming. For example, it is commonly expressed by informants as; " one of main tasks of informal leader (*puun*) is to calculate time of the traditional calendar for the benefit of all of the Baduy community (*tugas puun ngitung waktu ngeja bulan kalender keur sarerea Urang Baduy*)".

On the basis of the Baduy calendar (Table 2) it can be seen the Baduy informal leaders (*puun*) and his staff organize their swidden agriculture activities, including various rituals which are appropriately adapted to seasonal monsoon cycle of the Baduy for centuries. For example, cutting vegetation of the *huma serang*, *huma puun* and *huma masyarakat* is normally undertaken in *Sapar* (April-May), *Kalima* (May-June) and *Kanem* (June-July) during the low rainfall or dry season. This time is considered appropriate time to cut vegetation and is properly burned dry biomasses to produce ash of composing nutrients for growing rice and other crops. Planting rice of the *huma serang*, *huma puun*, and *huma masyarakat* is undertaken on *Kapitu* (July-August), *Kadalapan* (August-September), and *Kasalapan* (September-October), respectively that is considered as suitable time for planting rice due to starting rainy season or increasing rainfall. While the harvesting rice of *huma serang*, *huma puun*, and *huma masyarakat* is done on *Kasa* (January-February), *Karo* (February-March), and *Katiga* (March-April), respectively in correspond to decrease rainfall or starting the dry season that is considered as right time to dry new harvested rice. Given this example, it can be inferred that Baduy people aware that are surrounded by seasonal rhythms including climatologically changes, such as rainfall, humidity, and winds that are closely related with phenological changes in flora, fauna, position of stars and sun; as a result, they must variably adapted to the climate changes manifested in agricultural calendar. Baduy believe that if they depart from the traditional seasonal pattern of their calendar (*pananggalan* or called *pranata mangsa* in non-Baduy), their work will fail either totally or partly (cf. van den Bosch 1980; Daldjoeni 1984; Brossius et al. 1986; Ammarell 2005; Hidayat 2011; Ammarell and Tsing 2015).

Environmental perturbations

In the past, the village farmers of Java, Bali, Borneo, Sulawesi, and other parts of Indonesia, traditionally cultivated rice based on local knowledge, belief or cosmos, and local institution (cf. Wessing 1978; van den Bosch 1980; Gelpke 1986; Adimihardja 1992; Mustapa 1996; Wisnubroto 1999; Lahajir 2001; Arsana et al. 2003; Ammarell 2005; Sani and Nuhaedar 2007; Iskandar and Iskandar 2011; Ammarell and Tsing 2015). One of the set traditional knowledge (TK) or traditional ecological knowledge (TEK) is the agricultural calendar or *pranata mangsa*. Unlike Western knowledge, the TEK is recognized as" a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living being (including humans) with one another and with environment" (cf. Berkes 1999, Alexander et al. 2011). Thus, unlike the scientific Western knowledge, the TEK has some characteristics, namely holistic, subjective, communicated by oral, teaching through doing and inherited by oral, and its value for environmental conservation and sustainable use and analysis and monitoring of long-term ecological changes (cf. Ellen and Harris 2000; Silitoe 2002; Maffi 2004).

On the basis of the ecological history, the *pranata mangsa* system has been an important role in contributing to achieve to the success and glory of the old Mataram Kingdom, Pajang, and Mataram Muslim or Mataram Sultanate. The *pranata mangsa* was intensively applied by the kingdom family members to practice of farming, trading, traveling, and running the royal government (Sindhunata 2011). Similarly, before introduction of the green revolution, before earlier 1970s, farmers in Java and Bali had traditionally managed planting rice with the same

time in simultaneity. They had used water in efficient, and management of pest based on the traditional ecological knowledge (TEK), such as implementing the *pranata mangsa* and cosmos or belief (cf. van den Bosch 1980; Gelpke 1986; Lansing 1991).Four seasons are traditionally recognized by the Sundanese people, namely wet season (*usum ngijih*), dry season (*usum katiga* or *usum halodo*), transition season from dry wet season to dry season (*usum dangdangrat*), and transition season from dry season to wet season (*usum mamareng*). To adapt with local environment, particularly the rain fall conditions, the wet-rice field (*sawah*) had been traditionally cultivated by farmers twice in each year. The main rice cultivation which is called *nyawah gede* (literally 'big rice cultivation' or 'main rice cultivation') or *ngawuluku* (literally 'plowing land') during the wet season, while the second cultivation or re-cultivation, called *nyawah leutik* (literally little rice cultivation), *morekat* (re-rice cultivation) or *malik jarami* (flip straws), had been carried out in the dry season. The astronomical indicators, the belt of Orion (*bentang kidang* or *bentang wuluku*) and the Pleiades (*bentang kerti*, *bentang ranggeuy*, *kartika* or *gumarang*) are the most important factor determination planting time of the wet-rice cultivation (cf. Wiramihardja 2013). In the recent past, before the impact of rice intensification, farmers had often been able to use efficient water availability. For example, after harvesting rice in the main season, if the water supply is still plentiful, before re-planting rice in the second rice planting, the wet-rice field had been reared various fishes, such as *ikan mas* or common carp (*Cyprinus carpio* L), tilapia or nila (*Osteochilus hasselti* Valenciennes) and *mujair* (*Oreochromis mossambicus* Peters) for only between 3 and 4 months. In addition, the rearing fishes had been mixed with rice crops (*sistem mina padi*) in the early planting season of rice cultivation only for about 3 months. By practicing of *mina padi* system had provided some ecological and socio-economic benefits, such as pest controlling, creating soil fertility, and providing fish production. Conversely, if the lack of water supply, after the rice harvesting, the wet-rice filed had been cultivated by non-rice crops (*palawija*), including corn (*Zea mays* L), cucumber (*Cucumis sativus* L), sweet potato (*Ipomoea batatas* (L) L) and peanuts (*Arachis hypogaea* L) (cf. Iskandar 2007). As a result, the requirement for water was low compared with that needed for the continuous and intensive planting of rice alone. Moreover, pests could usually be contained more easily as their population tended to decrease after the rice harvest with the dramatic reduction in their food supply and destruction of their habitat, as rice was replaced with other crops.

Table 2. Baduy agricultural calendar and associated with various works in swidden farming and ritual activities

Months	**Rainfall**	***Huma serang**)**	***Huma puun* **)**	***Huma masyarakat* ***)**	**Rituals**
Sapar (April-May)	200-250 mm	Cutting shrubs (*nyacar*)	Fallowed	Fallowed	*Seba*
Kalima (May-June)	100-150 mm	Felling trees (*nuar*)	Cutting shrubs (*nyacar*)	Fallowed	*Puun ziarah* to sacred place, and *hajatan;* circumcision (*sunatan*); wedding (*kawinan*)
Kanem (June-July)	100-150 mm	Burning vegetation(*ngaduruk*)	Felling trees (*nuar*)	Fallowed	Wedding (*kawinan*)
Kapitu (July-August)	100-150 mm	Reburning (*ngahuru*) and planting rice (*ngaseuk*) in *huma serang*	Burning vegetation (*ngaduruk*)	Cutting shrubs (*nyacar*)	*Ngaseuk humaserang;* circumcision (*sunatan*); wedding (*kawinan*)
Kadalapan (August-September)	120-160 mm	First weeding (*ngored munggaran*)	Reburning vegetation (*ngahuru*) and planting rice (*ngaseuk*)	Felling trees (*nuar*), burning	*Narawas* and *Nukuh* of *huma masyarakat*
Kasalapan (September-October)	200-250 mm	Second weeding (*ngored ngarambas*)	First weeding (*ngored munggaran*)	Reburning, and planting rice	*Ngaseuk* of *huma masyarakat*
Kasapuluh (October-November)	250-350 mm		Second weeding (*ngored ngarambas*)	First weeding (*ngored munggaran*)	*Ngirab sawan* of *huma masyarakat*
Hapit lemah (November-Desember)	350-400 mm			Second weeding (*ngored ngarambas*)	*Ngirab sawan* of *huma masyarakat*
Hapit Kayu (December-January)	350-450 mm				
Kasa (January-February)		Harvesting (*panen*) *huma serang*			*Kawalu kahiji*
Karo (February-March)			Harvesting (*panen*) *huma puun*		*Kawalu tengah*
Katiga (March-April)				Harvesting (*panen*) *huma masyarakat*	*Kawalu tutug* and *ngalaksa*

Note: *) *Huma serang*-three of communal sacred swiddens located in Cibeo, Cikartawarna and Cikeusik of Inner Baduy. **) *Hum puun*-three of swiddens owned by Baduy informal leader located in Cibeo, Cikartawarna and Cikeusik of Inner Baduy. ***) *Huma masyarakat*-swiddens of ordinary Baduy household (*huma masyarakat*) of Inner and Outer Baduy.

However, by introduction of the green revolution in early 1970's consists of the application of a package of inputs through had top down and homogenous the five endeavors of rice intensification programs (*panca usaha tani*), i.e. introduction of the new high-yielding rice varieties (HYVs), such as IR-8, IR-5, IR-22 and IR-24 mainly produced by the International Rice Research Institute (IRRI) in Los Banos, the Philippines; using synthesis inorganic fertilizer produced by factories; using intensive pesticides; improvement cultivation practice; and development and improvement of irrigation systems—the sawah cultivation system had dramatically changed (Iskandar 2001; 2014). The green revolution had affected both positive and negative aspects. The main positive or benefit of the green revolution has been increase in rice farming productivity in macro level. Some negative aspects, however, have also occurred. For example, the new rice cultivation system is more dependent on subsidies from outside. In addition, ecologically damage such as pest outbreaks, loss of local genetic diversity of rice, and environmental pollution have also occurred. The homogenous rice crop varieties planted continuously rice-rice-rice in the same fields three times in one year, and not simultaneous plant and harvest rice have become vulnerable to diseases and insect destruction, particularly the brown plant hopper (*wereng coklat*, *Nilaparvata lugens* Stal) and water deficit in the dry season (cf. Fox 1991; Lansing 1991; Bardini 1994). Indeed, the traditional ecological knowledge of the *pranata mangsa* has seriously eroded. As a result, at the present time the anomaly climate due to global warming has frequently occurred and its impact has been globally felt (cf. Rosenzweig et al. 2000; Orlove et al. 2002; Nabegu 2009; Alexander et al. 2011; Boillet et al. 2011), the rice farmers in different areas of Indonesia have become vulnerable to fail rice harvesting (*puso*).For example, in 1997 a drought was reported as due to the El Niño and about 426, 000 hectares of wet-rice field (*sawah*) in Indonesia was disturbed (PEACE 2007). In more recently, in 2012 it was reported 2,345 hectares of sawah in West Java were not harvested (*puso*) (Saturi 2012). In general, the rice crops due to long drought are more serius than the high rainfall and flood (cf. Surmaini and Susanti 2009). However, there are indications that the sawah affected by flood in the previous season are most likely explosion of brown planthoppers (Boer 2010). Therefore, with increasingly frequent climate anomaly and exploitation of pests can disturb rice production and food insecurity (Syaukat 2011). In addition, the farmers have tended to powerless against increasing unpredictable climate anomaly among others caused by the erosion or loss of the traditional ecological knowledge (TEK) of the *pranata mangsa*. Whereas in the past farmers used very carefully observed natural phenomena and able to predict and to a certain extent able to predict perturbations, such as climate anomaly. In other words, by application of *pranata mangsa*, farmers had obtained benefit because they had encouraged recognized the natural character of each place (cf. Sriyanto 2009). Therefore, on the basis of the experiences in last decade, climate anomaly events such as long drought caused of El Niño and flood due to La Niña, have caused fail rice harvesting and have a high more risk for the future (cf. Bardini 1994; Sani and Nuhaedar 2007; Naylor et al. 2007; Keil et al. 2009; Surmaini and Susanti 2009; Boer 2010; Kusnanto 2011; Syaukat 2011; Solichah 2014) because of various factors, including the framers have lost of the traditional ecology knowledge (TEK) of *pranata mangsa* to predict and to adapt with dynamic climate changes.

Unlike sawah, the swidden farming traditionally practiced by the Baduy had only slightly affected by the drought as well as pest in the last decades. Because they have tried to adapt to climate changes by application of the traditional calendar (*pananggalan* or *pranata mangsa*), synchronously rice plant and rice harvest, burning of field before planting rice, fallow land, implementation of the traditional agroforestry systems, and development of diversification of off-farm jobs (cf. Rambo 1984; Altieri and Liebman 1986; Altieri 1993; Iskandar 2007; Turner 2012; Iskandar and Iskandar 2015). Although swidden rice (*pare huma*) did not harvest well due to drought, non-rice crops, such as fruit, vegetables and industrial crops farmed in the traditional agroforestry of swidden fallow (*reuma*) and in hamlet forests (*dukuh lembur* or *leuweung lembur*), were not seriously affected. Perennial fruit trees even tended to increase their yields in the year following the dry periods, because of the sunshine to which they were exposed at a critical period (Iskandar 2007).

On the basis of ecological history, unlike the wet-rice farmers, the Baduy have rejected the green revolution. They have managed the swidden system by applying organic farming and LEISA (Low External Inputs and Sustainable Agriculture) that modern inputs, such as chemical fertilizers, pesticide and modern rice varieties are prohibited to apply (cf. Reijntjes et al 1992). However, Baduy have not avoided with the environmental changes, such as weather and climate, but they have culturally adapted with these natural changes, namely by harmonizing the traditional calendar, *Pananggalan*. Thus, the Baduy's calendar is associated with the swidden cycle (cf. Iskandar 2007; Ellen 2016). It is arranged based on carefully observed natural phenomena changes of various indicators, such as the annual cycle of appearance and disappearance of the configuration the belt of Orion (*bentang kidang*), the flowering time of certain kind of plants, and animal behavior. The Baduy traditional calendar has also closely related to human welfare due to may influence to successful and fail of practicing swidden agriculture and moreover impact on abundance or scarcity of food, and to maintain the harmonization between human with the environment, and social harmony, some ritual performances are integrated in the traditional calendar. Therefore, the Baduy calendar has been very complex, integrated traditional ecological knowledge of atmospheric parameters, biological phenomena, and socio-cultural factors of local people (cf. Daldjoeni 1984; Ammarell 2005; Hidayat 2011). In other words, the swidden agricultural cycle and the ritual life integrated in the traditional ecological knowledge (TEK) of Baduy's calendar has been an important role in management local ecology to adapt with environmental disturbances, such as

climate changes. Therefore, due to climate change is a global phenomenon and its impacts have been felt globally and the studies have widely been undertaken globally across culture (Rosenzweig et al. 2000; Orlove 2002; Nabegu 2009; Kristoko et al. 2012; Boillet and Berkes 2013; Aryal and Choudury 2015), adaptation strategies must be specific to given location and needed of the local community participants (cf. Crate and Nuttall 2009; Boiessere et al. 2013). Indeed, collaboration between TEK of the local community and the Western scientists knowledge has been an important role in the context of development programs, such as to adaptation of agriculture on climate changes (cf. Warren et al. 1995; Silitoe 2002; Carlson and Maffi 2004). In general, the Baduy swidden farming has slightly affected by the various environmental perturbations, such as drought and flood disaster because the Baduy people have developed some strategies, including organizing a flexible traditional calendar, applying agroforestry traditional, and developing diversification of off-farm jobs (cf. Ichwandi and Shinohara 2007; Iskandar 2007). In conclusion, it can be said that with regard to development process, we further suggest that, rather than ignoring or attempting to replace or overcome the complex traditional ecological knowledge (TEK) systems which are embedded by cosmos or belief, it may be more useful to consider how these systems of ideas can be usefully incorporated into process of development and modernization to strengthen the sustainable agriculture in Indonesia.

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