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Review: The impact of social and economic change on domesticated plant diversity with special reference to wet rice field and home-garden farming of West Java, Indonesia

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Abstract. *Iskandar J, Iskandar BS, Partasasmita R. 2018. Review: The impact of social and economic change on domesticated plant diversity with special reference to wet rice field and home-garden farming of West Java, Indonesia. Biodiversitas 19: 565-577.* The Impact of social and economic change on genetic diversity of domesticated plants with special reference to wet rice field and home-garden farming of West Java. Various farming systems have played an important role as sources of genetic diversity in plants. A large number of cultivated varieties have been commonly selected, maintained, and distributed by farmers and cultural practices and ecological factors have been involved. These factors, such as soil, climate, pests, and culinary, magical and ritual uses, have influenced farmers in their selection of plants in farming systems. Nowadays, however, the number of plant varieties in various farming systems of Java has dramatically declined. This article attempts to discuss the impact of social and economic change on the genetic diversity of agricultural plants of the wet rice field and home-garden farming, particularly based on data from West Java.

Keywords: Diversity, domesticated plant, home-garden, social and economic change, wet rice field, West Java

INTRODUCTION

There are various farming systems in different regions in Indonesia. For example, in West Java as other parts of Java, six main types of farming systems have been commonly distinguished: low-land wet rice or wet-rice field (*sawah*), home-garden (*pekarangan*), garden (*kebun*), mixed-garden (*kebun campuran* or *talun*), dryland (*tegalan*), and swidden field (*ladang* or *huma)* (Pelzer 1948; Soemarwoto and Soemarwoto 1984; Soemarwoto 1985; Iskandar and Abdoellah 1988; Iskandar and Iskandar 2011, 2016a). Each type of farming system has played an important role as source of genetic diversity. This is due to the variety of indigenous plants which have been domesticated and selected. Simultaneously, due to social and economic change, new varieties have also been extensively introduced. The introduction of plant species may be local and spontaneous or as part of centralized government initiative. For example, some local plant varieties in home-garden in West Java have been mainly replaced spontaneously by new varieties due to social and economic changes, such as upgrading of standard of living, introduction of cash crops, availability of new substitute products, change of food habits, and ritual and ceremonial practices (cf. Michon and Mary 1990; Iskandar and Iskandar 2001; 2016a; Hadikusumah 2003; Kubota et al. 2003; Abdoellah et al. 2006; Wiersum 2006; Kehlenbeck 2007**;** Suryana and Iskandar 2014).

Unlike home-garden, local rice varieties in the wet rice field (*sawah*) in West Java have dramatically decreased due to the green revolution in the late 1960s, which involved the introduction of New High Yielding Varieties (NHYV) of rice from the Philippines intended to increase yield (cf. Iskandar and Abdoellah 1988; Fox 1991; Lansing 1991; Lansing and Cramer 1995; Whitten et al. 1999; Iskandar 2001; Hardiyoko and Saryoto 2005; Soemartono 2005; Warsiti 2009; Sastrapradja 2010; Sastrpradja and Widjaja 2010; Iskandar and Iskandar 2011; Iskandar et al. 2011; Iskandar 2014; Permana 2015). The variety of causal factors influencing the genetic diversity of plants in two types of farming, the *sawah* and home-garden will be discussed in this article.

TRADITIONAL RICE, THE SAWAH

In many parts of Indonesia, most cultivated land is used for growing low-land wet rice (cf. Pelzer 1948; Gertz 1963; Puspita et al. 2005; Sastrapradja and Widjaja 2010; Iskandar and Iskandar 2011; Nugroho et al. 2017). Wet rice farming is a common practice in this region as not only does it provide food income but also social status. For example, in West Java, farmers who have paddy fields

(*sawah*) have been considered rich farmers (*orang kaya*), with a higher status than those farmers who have other cultivated lands, such as dryland (*lahan kering*) (cf. Soemarwoto and Soemarwoto 1984; Igarashi 1985; Soemarwoto 1985). Therefore, most of the time, labor, and farmer income has been in association with wet rice framing. In other words, socio-economic and cultural factors have been deeply involved in rice cultivation.

Rice is important both in terms of providing calories and social status in Java or Indonesia in general (cf. Soemarwoto and Soemarwoto 1984; Igarashi 1985; Fox 1991; Persoon 1992; Widjaja et al. 2014). According to Suhardi et al. (2002), actually, in addition to rice, the nutrition of manioc and corn are relatively high (Table 1). However, although corn and cassava in terms of carbohydrate content are high, unlike rice, both manioc and corn in terms of social status are inferior in Java region. The cultivation of both corn and cassava is not culturally significant for farmers in Java compared to that of rice (Falcon et al. 1984; Mustapa 1996; Iskandar 1998). This is in contrast to Latin American countries where manioc (*Manihot esculenta* Crantz) and maize (*Zea mays* L.) are culturally regarded as superior (Boster 1984; Ellen and Soselisa 2012).

As a status symbol in Java, rice is considered superior. For example, farmers in Indonesia who consume rice as a staple food are considered to be of a higher social class (*orang kaya*). On the contrary, people who do not consume rice, but who eat manioc, maize, taro, or sago as a staple food are considered poor people (*orang miskin*) (cf. Persoon 1992; Soemarwoto and Soemarwoto 1984; Lassa 2009; Iskandar 2012).

Worldwide, there are two main species of cultivated rice: *Oryza sativa* and *Oryza glaberrima*. Initially, *O. sativa* came from tropic and subtropic Asia, while *O. glaberrima* came from West Africa and is only grown in Africa (Chang 1984; Widjaja et al. 2014). Moreover, *Oryza sativa* may be divided into two sub-species namely *Oryza sativa* sbsp. *japonica* and *Oryza sativa* sbsp. *indica*. Sub-species *indica* is grown in South China, Southeast Asia, and South Asia to produce 70% of rice in the world, while sub-species *japonica* is grown in East Asia. One estimate of the number of traditional cultivars (landraces) of rice in Indonesia gives a figure of more than 8,000 (Bernsten et al 1982; Brush 1986). The rice landraces in Indonesia consist of 68% of *indica* and 32% of tropical *japonica* (Widjaja et al. 2014).

Subsistence farmers have been recognized as having a substantial knowledge of rice varieties and planting patterns. This is not surprising as traditional farmers have long managed indigenous rice varieties in their local environments, such as *sawah tadah hujan, sawah irrigasi, sawah surjan*, and *sawah pasang surut*, including swidden field (*ladang* or *huma*) (cf. Hardjono 1987; Iskandar 1998; Puspita et al. 2005; Sastrapradja 2010; Widjaja 2014). In the past, local rice varieties have commonly classified based on various criteria, mainly culinary and other features, such as seed hair, seed color. For example, based on field research in Rancakalong, Sumedang, West Java, it has been recorded 22 local rice varieties (land races) that are predominant in rice field (Table 2). Of those varieties based on the folk classification, can be divided into several categories, namely based on grain phenotypes (*ranggeuyan/tidak mudah rontok* and *segon/mudah rontok*), hulled rice color (*warna beras/beas*), glutinous (*ketan*) and non-glutinous (*non-ketan*), and mature period (*umur panen*) (Warsiti 2009).

On the basis of Sundanese culture, the local rice varieties can be divided into three types: *pare bahun* (ancient), *pare biasa* (regular), and *pare ketan* (glutinous). *Pare buhun* (*buhun* rice), commonly called *pare ageung* (lit. big rice) or *pare asal* (lit.original) is regarded as the most sacred (Warsiti 1991; Soemarwoto 2007). Meanwhile, based on culinary properties, local varieties of rice can be divided into two major groups: glutinous (*padi ketan*) and non-glutinous rice (*padi biasa*). In culinary terms, glutinous rice has been recognized as being of higher quality to non-glutinous rice. This rice is usually consumed only on special occasions, at ceremonial and ritual meals (*selamatan* or *hajatan*) (Prawirasuganda 1964; Warsiti 1991; Soemarwoto 2007). Most often this rice is eaten as plain cooked rice, but is sometimes mixed with coconut scrapings or beans, or is made into various traditional cakes, such as *tapai ketan*, sweet cake made from slightly fermented glutinous rice.

On the whole, traditionally in the past glutinous rice varieties were not marketed. Farmers believe that glutinous rice was the older brother of non-glutinous rice. As a result, it was also forbidden for any other varieties when they were stored in a rice barn (*lumbung padi*) (cf. Iskandar and Ellen 1999). This rice was usually placed in a separate of the rice shed.

Unlike glutinous rice, non-glutinous rice varieties are usually consumed as a daily staple food and some surplus can also be sold, except for Baduy community the swidden rice is traditionally prohibited to sell. With regard to culinary concerns, non-glutinous rice can be divided into several types, such as not too sticky, white or red color (*padi putih bear* or *padi merah bear*) and rather sticky white or red rice color (*padi putih liket* or *padi merah* or *pulen*).

Table 1. Comparison of nutrition of rice, corn flour, and cassava flour of 100 g

Nutrition content	Milled rice	Yellow corn flour	Manioc flour
Calories (Cal)	360.00	335.00	363.00
Protein (g)	6.80	9.20	1.10
Fat (g)	0.70	3.90	0.50
Carbohydrate (g)	78.90	73.70	88.20
Calcium (mg)	6.00	10.00	84.00
Phosphor (mg)	140.00	256.00	125.00
Iron (mg)	0.80	2.40	1.00
Vitamin A (International Standard)	0.00	510.00	0.00
Vitamin B-1	0.12	0.38	0.04
Vitamin C (mg)	0.00	0.00	0.00
Water (g)	13.00	12.00	9.10
Part of edible (%)	100.00	100.00	100.00

Table 2. Rancakalong landraces recorded up to 2009 (listed alphabetically, italics indicate and a present landrace after green revolution (adapted from Warsiti 1990)

Landrace	R/S**	Hulled rice color	G/NG***	Mature period (*umur panen*) (months)
Angsana	R	Whitish (W)	NG	5-6
B1	S	Pure whitish (PW)	NG	4-5
Bengawan	S	Pure whitish (PW)	NG	4-5
Campaka*	R	Whitish (W)	NG	5-6
Cere haur*	S	Whitish (W)	NG	4-5
Cere melati*	R	Whitish (W)	NG	4-5
Cere uit	R	Whitish (W)	NG	4-5
Cere ulil*	R	Whitish (W)	NG	4-5
Cikur	R	Whitish (W)	G	5-6
Gajah belang*	R	Whitish (W)	NG	4-5
Gembang	S	Pure whitish (PW)	NG	4-5
Gobod*	R	Whitish (W)	NG	4-5
Gombal	R	Whitish (W)	NG	4-5
Gombol	R	Pure whitish (PW)	NG	5-6
Gudril*	R	Pure whitish (PW)	NG	4-5
Hawara baru*	R	Whitish (W)	NG	4-5
Hawara belang*	R	Whitish (W)	NG	4-5
Hawara beureum*	R	Reddish (R)	NG	4-5
Hawara biasa*	R	Whitish (W)	NG	4-5
Hawara bulu*	R	Whitish (W)	NG	4-5
Hawara gadog*	R	Reddish (R)	NG	4-5
Hawara geulis	R	Pure whitish (PW)	NG	4-5
Hawara jambu*	R	Whitish (W)	NG	4-5
Hawara Kalapa*	R	Whitish (W)	NG	4-5
Hawara kapas*	R	Whitish (W)	NG	4-5
Hawara lembang sari*	R	Whitish (W)	NG	4-5
Hawara peuteuy*	R	Whitish (W)	NG	4-5
Hawara rebon*	R	Reddish (R)	NG	4-5
Hawara tamiang*	R	Whitish (W)	NG	4-5
Hideung	R	Black (B)	G	5-6
Janga wiring*	R	Whitish (W)	G	5-6
Jembar*	R	Pure whitish (PW)	NG	4-5
Kalapa*	R	Whitish (W)	G	5-6
Kopo*	R	Whitish (W)	NG	4-5
Kowal*	R	Whitish (W)	NG	5-6
Leuir molog	R	Whitish (W)	NG	5-6
Leuir peuteuy	R	Whitish (W)	NG	5-6
Lokcan*	R	Whitish (W)	NG	4-5
Mataram	R	Reddish (R)	NG	5-6
Mesir	R	Whitish (W)	NG	4-5
Nyonya*	R	Pure whitish (PW)	NG	5-6
Ocet*	R	Whitish (W)	NG	5-6
Omas	S	Pure whitish (PW)	NG	4-5
Perak (ketan perak)	R	Whitish (W)	G	5-6
Racik	R	Pure whitish (PW)	NG	5-6
Randakaya	R	Whitish (W)	G	5-6
Rante emas*	R	Whitish	NG	5-6
Rayot	R	Reddish (R)	NG	5-6
Sari kuning	R	Whitish (W)	G	5-6
Segon beureum	S	Reddish (R)	NG	4-5
Segon perak*	S	Whitish (W)	NG	4-5
Segon salak	S	Pure whitish (PW)	NG	4-5
Segsreg*	R	Pure whitish (PW)	NG	5-6
Sinta	S	Pure whitish (PW)	NG	4-5
Sirtu*	S	Whitish (W)	NG	5-6
Sogol*	R	Whiteish (W)	NG	5-6
Torondol	S	Pure whitish (PW)	NG	4-5
Tulak bala*	R	Blackish (B)	NG	5-6
Waluh*	R	Whitish (W)	G	5-6
Warsih	R	Whitish (W)	G	5-6

Note: *: Locally disappeared after green revolution program in the beginning of 1970s. R/S**: Grain phenotype (*ranggeuyan* (R)/ *Segon* (S). G/NG***: Glutinous (G)/Non-glutinous (NG)

Non-glutinous rice in terms of hair seed can be divided into hairy (*padi bulu*) and non-hairy seed (*padi gundul*). Based on seed color glutinous rice can be divided into two types, black (*beras ketan hitam*) and white glutinous rice (*beras ketan putih*). while non-glutinous rice varieties are also distinguished into two types, white (*padi putih*) and red seed (*padi merah*) or *cere merah*. In addition, the seed/grain of rice (*siki pare*) can be divided into several types based on size, length, and shape. On the basis of size it can be recognized as *gede* or *ageung* (big), *sedengan* (slightly smaller), *leutik* or *alit* (small); based on length, it can be acknowledged namely; *manjang* (long), *sedengan* (slightly shorter) and pondok (sort); while based on shape, it can be detected into 4 types, namely *buleud* (roundish), *lonyod* (oval), *gendut* (thick), and *gepeng* (flat).

According to Fox (1991), *padi bulu* and *padi gundul* are varieties of *javanica* which has the following characteristics: relatively long maturation, sturdy, wide-leaved with long panicles, large and bold grain and low photoperiod sensitivity. In contrast, *padi cere* a variety of *indica* has the following characteristics: narrow leaves, shortened culms and panicles, and slender grains and is often photoperiod sensitive. Agronomically, *javanica* varieties are more likely to grow on volcanic soil and indica varieties on other soil formations (Fox 1991). While *japonica* of Indonesia has characteristics, such as big panicle, big leaves, strong root system, and little unproductive tillers (Purseglove 1985; Widjaja et al. 2014).

Similarly, rice varieties in Chiang Mai of Northern Thailand are also locally classified by local farmers according to color, shape and size of the grain and panicle branching and size (Rerkasem and Rerkasem 1984; Kundstadter 1978). Based on these criteria, 42 rice varieties from 55-grain samples have been identified by framers. Therefore, rice may be identified in various ways based on color: white, red and black, fragrance non fragrance, length of grain; sort and long (Kundstadter 1978). However, with regard to more general classifications, two groups of rice varieties, glutinous and non-glutinous rice, have been popular in Northern Thailand. Glutinous rice (*khao niow*) is commonly consumed daily and non-glutinous rice (*khao jaow*) is often sold.

On the basis of emphirical evidences, it is believed that the most progenitors of rice crop diversity are not laboratory, based on scientists or storage facility managers, but subsistence farmers living in communities with high level of inter-household seed exchange and intra-household seed storage (cf. Widjaja and Jessup 1986; Damus 1992, 1993; Soedjito 1996; Iskandar 1998; Iskandar and Ellen 1999; Oakley 2003; Setyawati 1999, 2003; Pfeiffer et al. 2006; Soemarwoto 2007; Hendra et al. 2009; Warsiti 2009; Rohaeni and Hastini 2015; Permana 2015; Nurhasanah and Sunaryo 2015; Kelana et al. 2016). In other words, the cross-cultural traditional farmers of in many regions which have the traditional ecological knowledge embedded with their culture are those who have an important role in conserving various local rice varieties (rice landraces).

Traditional rice selection and maintenance

Indigenous rice varieties have long been selected and maintained by traditional farmers (cf. Widjaja and Jessup 1986; Damus 1992, 1993;Soedjito 1996; Iskandar 1998; Iskandar and Ellen 1999; Oakley 2003; Setyawati 1999, 2003; Pfeiffer et al. 2006; Soemarwoto 2007). In the past, selection and preservation of indigenous varieties were continually made in the seasonal routine, during planting and storing new rice (Iskandar and Iskandar 2011).

The cycle of planting wet-rice in many areas of West Java is commonly determined by the rainfall pattern. As an example, in the past farmers in West Java grew rice twice a year; in the dry and wet seasons. Growing rice during the wet season was called main cultivation (*musim tanam utama*), while during the dry season is considered as "*musim tanam morekat*" (Sundanese).

Wet rice fields were usually planted with various indigenous rice varieties, both glutinous and non-glutinous. The rice varieties were planted in separate fields based on different local environments. Before planting, farmers usually select various rice seed to be grown. Seed selection is based primarily on the quality of each rice variety from their previous crops, if possible from the same plot (*petak*) of *sawah*. Rice seeds were prepared as early as possible after harvesting new crops. Exchange and borrowing seed among farmers, relatives or neighbors were common. Women played an important role in selection of traditional rice seed. This was due to farmer's veneration for the goddess of rice, *Nyai Pohaci* or *Nyi Pohaci* (Sundanese) or *Dewi Sri* (Javanese) (Wessing 1978; Iskandar and Iskandar 2011). In respect for the rice goddess, the rice is usually treated as a woman carefully maintained.

Seed selection was usually done in West Java at the beginning of harvest just before rice crops were harvested. Firstly, some high-quality rice seeds that were still in the rice stalk (called *Ibu Padi*) were selected. These stalks were ceremonially cut before harvesting takes place. For example, before *ibu padi* was harvested, farmers would make a *sanggar*, a structure consisting of a basket supported by one or several sticks, and covered by a fancy cloth. Inside the basket are *nasi tumpeng* (cone form shaped cooked rice, mixed with coconut milk and turmeric), chicken eggs, fish, betel leaves trimmings, flowers, seven kinds of fruit salad and brown sugar with banana and coconut milk, a comb, cosmetic powder, a mirror, and various traditional cloth. Near *sanggar*, yellow and white flags were tied on an upwardly curving bamboo (cf. Prawirasuganda 1964; Mustapa 1996; Partasasmita et al. 2017).

In the morning before beginning the rice harvest, *kemenyan* (incense) was burned in *sanggar* areas and a prayer for blessings was raised. Some rice stalks which had been selected as *ibu padi* near *sanggar* were cut after asking permission from the rice goddess. The small knife (*etem*-Sundanese or *ani-ani*-Javanese) which was used to cut rice stalk was perfumed. All stalks complete with seeds and leaves were tied and wrapped in a traditional white perfumed cloth. These rice stalks were hung in the *sanggar*. Upon completion of these ceremonies, *ibu padi* was brought to the farm house (*saung*), while other goods used in the ceremony were brought to the farmer's homes. *Rujak* (fruit salad) was given to everyone who attended the ceremony. In addition, at that time, for about three days, nasi *tumpeng* was commonly provided by landowners to serve the harvesters. Quality, as well as quantity of meals given, can be used as indicators of the status of the landowners.

After finishing the ceremony, the non-*ibu padi* was started to be harvested, involving groups of women using small knives. The knife was held in the right hand between the third and fourth fingers when cutting the paddy stalk. Each paddy stalk cut was then transferred to the left hand until the left hand was full. Bunches of stalk were grouped and laid in rice field dikes. Finally, some bunches of stalk were tied in bundles by men using a bamboo string (*pocong*). After finishing the harvest, all paddy bundles were brought to farmer's houses. The *ibu padi* was brought first. Before being brought to the houses of farmers, *ibu padi* was ornamented using a good cloth and women's belt, mirror, comb, traditional perfume, and flower put in a basket. Non-*ibu padi* were also brought. Everyone who carried rice walked in a line. Near to the *ibu padi* was bamboo a bamboo rice stretcher called *rengkong* upon which, when bound, padi was hung, making a pleasant sound when the rice bundles were shaken (Figure 1). In addition, traditional musical instrument, such as *angklung* (traditional music instrument made of bamboo performed by men), and *gondang* (wooden mortar with wooden pounders done by women) were played (Figures 2 and 3).

After arriving in the settlements all the rice was collected in a certain place. Before rice was put in the rice barn, a special ceremony of burning *kemenyan* (incense) was performed. The *ibu padi* was put in a special place in the rice barn in and will not be allowed to be used for consumption and become a source of seed for the next planting (Mustapa 1996).

Rice for daily consumption and seeds was taken from rice barn by women. Rice seeds were carefully taken from the rice barn by women. Rice seeds were carefully taken from the straw by rubbing. Good quality seeds were selected by using a winnowing tray. Moreover, seeds were soaked for two or three days to bring forth the bud. In this process, bad seed can be selected. For example, some good quality seeds will sink, while bad seeds will float in water. Moreover, the sprouted seed was brought into nursery. These sprouted seeds were separately sown by women in different nursery block fields according to different varieties.

Before seeds were sown, *kemenyan* (incense) was burned at the sluice and banana shoot or *hanjuang* bush [*Cordyline fruticosa* (L) A.Chev] planted on the bank of the channel (*hulu wotan*). Fruit salad consisting of fruits, egg, and cooked rice were placed nearby (Iskandar et al. 2011).

Regularly, every two or three days farmers visited their nursery to inspect the water level and sometimes a little water added or withdrawn. The seedlings were ready to be transplanted after 40 days. Moreover, the seedlings were cut off to stimulate rapid growth after transplanting. These bundles of seedlings were carried by men to plots of rice

fields (Figure 4). Different varieties of seeds were transplanted by women into separate rice fields (Figure 5). Some extra rice seedlings were also planted to be used to replace those shoots destroyed by pests and diseases. Where there were insufficient rice seedlings, these could be borrowed from relatives or neighbors.

The rice was ready to be harvested about five or six months after transplanting, indicated by yellowing of all the grains and stalks. Finally, farmers make preparations for the harvest, such as making the *sanggar* mentioned earlier, and superior seed such as *ibu padi* was selected to be planted for the next season. The harvesting of rice is traditionally undertaken by women (Figure 6).

In short, rice seed varieties were carefully selected and maintained by farmers in each planting season without which quality would be lost. Thus, rice was available to fulfill farmer's needs to plant it on the long-term basis. Traditionally, planting rice is strongly based on the local knowledge embedded with local culture of farmers. The local knowledge was obtained by trails and errors in a long process of interaction between farmers and their environments (cf. Hunn 1993; Warren et al. 1995; Cotton 1996; Berkes 1999; Ellen and Harris 2000).

TRADITIONAL HOME-GARDEN PLANT VARIETIES

Home-garden may be defined as " a piece of land with a definite boundary surround a homestead, being cultivated with a diverse mixture of perennial and annual plant species, arranged in a multilayered vertical structure, often in combination with raising livestock, and managed mainly by household members for subsistence production (Karyono 1981; Soemarwoto and Soemarwoto 1984; Christanty et al. 1986; Fernandes and Nair 1986; Hoogerbrugge and Fresco 1993; Kumar and Nair 2004; Kehlenbeck 2007; Iskandar and Iskandar 2011). Home-gardens in West Java vary in size from a few meters to over 3,000 $m^{3,}$ with an average of 500 m^2, and from less than 1,000 m^2 to 2 or ha and average of 0.25 ha on other islands (Christanty 1990). Personal preference and altitudes, socioeconomic status, and culture are the main determinant factors for home-garden appearance, structure, and function. While there are many variations in home-garden design and pattern, the basic features, however, remain the same. A home garden usually consists of a bare space (*buruan*) and cultivated space (*bagian ditanami*), with the latter, the garden, either in front as a front yard or behind as backyard or surrounding the house. Gardens in rural areas are typically multilayered, comprising plants between < 1m high and > 10 m high; while those in urban areas, although sharing similar feature, often show a lower configuration in vertical structure compared with rural home-gardens since they are dominated by non-wood ornamental plants as aesthetic functions (Karyono 1981; Iskandar 1985; Christanty 1990; Iskandar and Iskandar 2016b).

One characteristic of home gardens is the high diversity of plant species with different flowering, fruiting, and cropping seasons (Kayono 1981; Michon and Mary 1990; Kubota et al. 2003; Kehlenbeck 2007; Suryana and Iskandar 2014). For example, in Citarum catchment area of West Java, home gardens usually contained 19-24 species, with a Shannon-Wiener diversity index of 2.79-2.99. The inventory of plants for the whole area, based on 351 gardens, yielded a list of 602 species, consist of ornamentals, fruits, vegetables, medicinal, spices, food crops, industrial, weeds, and miscellaneous (Karyono 1981). As a result, the vegetation structure of home-garden is very complex and is similar to the forest vegetation structure (Figures 7 and 8).

On the basis of ecological history, the distinctive characteristics of the Javanese home-garden have been recognized since a long time. For example, Raffles in "the History of Java", published in 1817, mentioned that in Java " in the first establishment or formation of village on new ground, the intended settlers take care to provide themselves with sufficient garden ground their huts for stock and to supply the ordinary wants of their families (Stoler 1978). Pelzer (1948) also mentioned that home-gardens in Java were commonly planted with a large variety of crops, ranging from fruit trees to plants which supplement the diet and add flavor to daily rice meal. In addition, according to Reijntjes et al. (1992), village agroforests, including home-garden have existed in Java since at least the 10th century, which provide a wide range of products with a high food value (e.g. fruits, vegetable, meat, eggs) and other products, such as firewood, timber and medicines.

Plants grown in home-gardens vary from one region to another, depending on both physical and socio-economic factors (Pelzer 1948; Karyono 1981; Christanty et al. 1986). For example, various factors have been recognized as a determinant for plant genetic diversity, such as soil, climate, elevation, and taste of the farmers. In addition, whether people live in *sawah* and non-*sawah* areas, educational background, household income, and distance from cities are recognized as eminence factors that can influence vegetation structures and functions of home-garden (Karyono 1981). Starchy food crops as a supplementary staple food are more often in non-*sawah* areas due to shortfalls in rice production. Moreover, high diversity of starchy plants and fruits are dominant in villages far from larger cities due to supplementary source of foods and income. Conversely, flowers are important for aesthetic reasons and are commonly dominant in villages closer to the larger cities (Soemarwoto 1985) (Figure 8). Plant varieties are also affected by cultural factors. For example, vegetables are more dominant in Sundanese home-gardens as there is a cultural reference for fresh vegetables (*lalab*) mixed with chili sauce (*sambal*) (Surawiria 2006).

Figure 1. After harvesting rice, *rengkong* is performed accompanied by many people who will attend a ritual to put the rice in a rice barn

Figure 2. The traditional music, '*angklung'* is performed by several individual men

Figure 3. The traditional music '*gondang*' is performed by women

Figure 4. Seedling bundles are carried by a man

Figure 5. Different rice varieties are planted by a woman

Figure 6. Rice varieties harvesting are traditionally undertaken by a woman

Figure 8. Various plants are planted in home-garden

Figure 9. Home-garden of Sundanese is equiped with a fish pond to raise fishes

Figure 10. The urban home-gardens are predominantly planted by the flowering plants as an esthetic function

A rich diversity of plants in home-gardens provides ecological, socio-economic, and cultural benefits (Verenooij 1988; Christanty 1990; Karyono 1990; Marten 1990; Kehlenbeck 2007; Hadikusumah 2010; Wiryono et al. 2016; Iskandar et al. 2016; Iskandar and Iskandar 2016b). Ecological benefits include resistance to pests, maintenance of genetic diversity, habitat of beneficial fauna (pollinator insects and birds), maintenance of micro-climate, production of oxygen (O_2), potential for mitigating global climate change through CO_2 sequestration, and the conservation of soil fertility. Socio-economic functions can be divided into two main functions mainly subsistence and commercial. Subsistence functions, for example, various plants can be harvested for providing various nutrients of additional staple food (starchy crops as source of calories), vegetables, spices; medicinal plants; ornamentals; building materials and firewood; handicrafts; fodders; industrial plants; ceremonial and rituals; and commercial functions,

based on some production surpluses can be sold to obtain cash income of the household. While social cultural functions, namely bare space of the front of house is an important place for socializing, pleasure, and performing traditional rituals, and drying various crops seeds, such as rice, corn, and coffee.

Generally, each cultigen fulfills many needs. For example, the manioc the root is eaten as an additional staple food, and young leaves as vegetables; papaya provides a fruit, and young leaves are eaten as vegetables; banana (fruits, and leaves used for wrapping). The coconut palm provides the greatest variety of food and materials. Mature coconut milk can be used for cooking oil, young coconut milk for drinking mixed with sugar and syrup, dry stems and midribs for fire woods, fresh leaves for decorations and banners in a wedding ceremony sign in front of house entrance, young leaves for making *ketupat* (rice cake boiled in a rhombus-shaped packet of plaited coconut leaves), palm leaves for a broom, and the tree is used for building materials and firewood.

Due to a rich diversity of plants with different maturation, various home-garden products can be harvested throughout the year. These products are mainly used to fulfill daily needs of home consumption, but some surpluses, such as fruits, can be sold to obtain additional income. In addition, home-garden plants can provide important source of carbohydrate, protein, and vitamins. Osche and Terra (Pelzer 1948), and Iskandar and Abdoellah (1988) pointed out that caloric return of the home-garden proved to be slightly higher per hectare than those of sawah. Moreover, one of the great advantages of garden culture over field culture is that there is always something ready to harvest from the former and therefore something to sell when money for daily household needs become scarce. According to Stoler (1978), home-gardens may provide more than 20% of household income, and more than 40% of household caloric requirements.

Some home-garden plants are also commonly used as traditional medicines, such as young guava leaves (diarrhea), starfruits (hypertension) and lime (cough) (Suryana et al. 2014). Moreover, some plants have played an important role in magical, ritual and ceremonial functions. For example, it has been widely believed by villagers that yellow bambu (*bambu kuning*) can be used as protection from black magic (*tolak balak*). Therefore, this plant is commonly planted in the front of houses, meanwhile, hanjuang bush (*Cordyline fruticosa* (L) A.Chev) is widely used for the rice planting ceremony before rice seeds are sown in the nursery, as mentioned earlier.

Since plant varieties of home-gardens provide many functions, the home-gardens in West Java or Indonesia in general have been widely called *lumbung hidup* (source of food), *warung hidup* (additional income), and *apotek hidup* (source of traditional medicines). Therefore, home-garden provides safeguard against the scarcities imposed by crop failure, drought, rural poverty.

Subsistence farmers have been recognized as having their own deep indigenous knowledge in classifying home-garden plants. In terms of naming and folk taxonomic system, a variety of crops, such as a banana, mango, *rambutan*, citrus, coconut palm, pepper, and manioc have been classified according to various criteria, namely morphology, fragrance, and original distribution. For example, varieties of banana fruits are traditionally classified based on morphology, texture, color, and culinary according to folk classification of farmers of Sukajaya, Sumedang, West Java (Table 3).

Another example, let us look at varieties of mango or *mangga* (*Mangifera* spp) which are commonly found in West Javanese home-gardens; *mangga aromanis* (a fruit fragrant), *mangga golek* (a long shaped fruit), *mangga Indramayu* (an endemic in Indramayu district, West Java), *mangga limus* also called *kaweni* (an own fibre fruit meat), *mangga cengkir* (a small and sweet fruit), *mangga simanalagi* (a rather large and seed fruit), and *mangga rujak* (an immature fruit suitable for making *rujak* or fruit salad).

In short, plant varieties in home-gardens have played an important role in providing various functions: ecological, socio-economic and cultural.

PLANT SELECTION AND CONSERVATION IN HOME-GARDENS

Unlike wet rice fields (*sawah*), homegradens are planted with a very rich plant diversity, both annual and perennial. Therefore, different plant varieties which need different light requirements are carefully arranged. Plant varieties may be divided into several groups, such as, shade tolerant, semi-shade tolerant, and shade intolerant (Pelzer 1948; Christanty et al. 1978). Based on the interview, direct observation and experimental studies in homgardens of West Java (Christanty et al. 1978), it has been revealed that farmers have a broad knowledge regarding the light requirement of plants and plant them in gardens in accordance with these requirements. For example, taro (*Colocasia* spp.) may be more tolerant to shade, and therefore, is planted in the shade of trees. Betel vine (*Piper betel* L.), however, may be planted in either open or shaded places, depending on the desire of the owners. For example, if the owner wants to obtain betel which has dark green wide leaves suitable for medicinal uses, but not delicious for betel chewing, this plant can be grown in shaded under trees. On the other hand, if this crop is needed for betel chewing producing leaves which are yellowish leaves and sweetie tasting it is grown in open areas.

Generally, the cultigens of home-gardens can be distinguished by height into several plant canopy layers (Pelzer 1948; Karyono 1981; Iskandar and Iskandar 2016b). The ground layers consist of starchy foods (sweet potatoes, taro), vegetables, flowers, and medicinal plant. The middle layers contain various perennial plants, such as fruit. The upper layers consist of tall perennial plants, such as fruits, building materials and firewood. Coconut trees which provide various foods and materials are commonly found in the upper layer (Figure 7).

Table 3. Banana are traditionally classified by farmers of Sukajaya village, Sumedang, West Java (Hehakaya 2010)

Banana varieties	Fruit					Leave			
	Skin color	Culinary	Texture	Seed	Fruit flesh color	Morphology	Color	Flexible	Midrib base color
Ambon lumut	Green black spot	Sweet, fragrant	Soft rather hard	No seeds	White	Medium length	Green	Not flexible	Green
Ambon bodas	Yellow	Rather tasteless	Soft	No seeds	White	Medium length	Green	Not flexible	Green
Ambon jepang	Yellow	Sweet, fragrant	Soft	No seeds	White	Medium length	Green	Not flexible	Green
Ampeang	Yellow	Sweet	Rather hard	No seeds	Yellowish	Medium length	Green	Not flexible	Reddish
Apu	Yellow	Rather sour	Hard	No seeds	Yellowish	Rather round	Green	Rather flexible	Green
Astrali	Green yellowish	Sweet	Hard	No seeds	White	Big and long	Green	Not flexible	Green
Baduyut	Yellow	Sweet	Soft	No seeds	White	Small	Green	Not flexible	Reddish
Bodas	Yellow	Rather sour	Hard	No seeds	White	Small	Green	Not flexible	Reddish
Bogo	Yellow	Sweet	Soft	No seeds	White	Small	Green	Not flexible	Reddish
Emas	Bright yellow	Sweet	Soft	No seeds	Yellow	Small little bit long	Green	Not flexible	Black spot
Galeuh	Green	Sweet	Soft	No seeds	White	Angled	Green	Flexible	Green
Gebray/Tanduk	Yellow	Sweet	Hard	No seeds	Yellow	Big and long	Green	Slight flexible	Green
Geulis	Yellow	Sweet	Hard	No seeds	Green	Medium long	Green	Not flexible	Reddish
Hoe	Yellow	Sweet	Soft	No seeds	White	Medium long	Green	Not flexible	Whitish
Kole	Dark green	'*Sepet*"	Hard	Seeds	White	Small	Dark green and black dark	Flexible	Reddish
Kapas	Green whitish	Rather '*sepet*'	Rather hard	No seeds	White	Oval	Green	Flexible	Green
Longing	Green	Sweet	Soft	No seeds	White	Small	Green	Not flexible	Green
Manggala	Green	Sweet	Soft	Seeds	White	Angled	Green	Flexible	Green
Manggala wulung	Green	Sweet	Soft	Seeds	White	Angled	Green dark	Flexible	Black bluish
Muli	Yellow	Sweet	Soft	No seeds	Yellow	Rather small	Green dark	Not flexible	Green
Nangka	Yellow	Sweet, fragrant	Hard	No seeds	Yellow	Long	Green	Not flexible	Green
Oli	Yellow	Sweet	Chewy	No seeds	Yellow	Medium	Green	Not flexible	Yellowish
Raja bulu	Yellow	Sweet, fragrant	Soft	No seeds	Yellow	Oval	Green	Not flexible	Green
Raja cere	Yellow black spots	Sweet, fragrant	Soft	No seeds	Yellow	Oval	Green	Not flexible	White
Roid	Yellow	Sweet	Soft	Seeds	Yellow	Small	Green	Not flexible	Green
Sewu	Yellow greenish	Sweet	Soft	No seeds	Yellow	Rounded	Green	Not flexible	Reddish
Siem	Yellow	Sweet	Slimy	No seeds	Yellow	Angled	Green	Not flexible	Green
Siman	Yellow	Sweet slight sour	Soft	Not seeds	Yellow	Small	Green	Not flexible	Green
Susu	Yellow	Sweet	Soft	Not seeds	Yellow	Bulging	Green	Not flexible	Green
Usuk	Green yellowish	Sour	Hard	Not seeds	White	Big, long	Green	Not flexible	Green

Unlike *sawah* fields, plants in home-gardens can be planted throughout the year by each family member; father, mother, and their children. Bean seeds are stored differently from rice seeds in bottles for protection from insect attack. Roots (manioc) and tubers (yams, taro) are put in shaded places or moist places near fish ponds and bathing places. These seeds may be obtained from various sources, by collecting, grafting, breeding, propagating, or vegetating. Grafting and breeding from various existing plants is generally considered a good way of selecting good quality, particularly fruits. Seed exchanges among relative and neighbor are common. Only some commercial seeds are commonly bought from markets, such as citrus, clove, and import fruits. Currently, a variety of fruit seeds, such as guava and papaya, have been imported from Thailand, popularly called among farmers, '*jambu Bangkok'* and '*papaya Bangkok'*, respectively.

To sum up, plant varieties in home-garden have been selected and maintained by farmers and fulfill many purposes, socio-economic and cultural, and is the outcome of experience accumulated over a long time. Seeds are provided by farmers themselves, the only small number is brought from markets.

CHANGE IN THE GENETIC DIVERSITY OF PLANTS

In the past, rice of West Java were culturally selected by farmers for various reasons, such as culinary or suitability to ecological conditions (Soemarwoto 2007; Warsiti 2009; Permana 2015). For example, some non-glutinous rice varieties are recognized to be culinary superior to their fragrance and stickiness. Based on farmers perceptions, when cooked these varieties are delicious, even served only with a simple menu without a variety of side dishes. Moreover, this cooked rice can be served for lunch and do not need to be recooked first. Therefore, they represent a saving in terms of labor, time and firewood.

Glutinous varieties are also famous for high quality and commonly planted through preference. These varieties are preferred for pulverizing in making certain traditional cakes. These cakes are served with special ritual or ceremonial feasts, such as weeding and celebrating the end the Islamic fasting period (*Idul Fitri*).

Certain rice varieties have also been selected by farmers because they are resistant to drought, sustain soil fertility, and are photoperiod sensitive. Therefore, in each planting season, different rice varieties are cultivated by farmers in different plots, block or locations. Although many local rice varieties are superior in quality, these varieties are often inferior in yield. In order to fulfill rapid increases in rice demand a consequence of rapid population increases in Indonesia, some major rice-growing areas, such West Java have developed new rice varieties. In Java, for example, the historical introduction of new varieties began in 1905 with establishment of rice breeding programs in Bogor to develop improved varieties (Fox 1991). Since 1914 improved varieties have been planted. Added to this, there have been rapid and significant changes in rice cultivar in and Java and West Java, in the late 1960s with the introduction of modern high-yielding varieties from the Rice Research Institute (IRRI) released in 1967 (Iskandar 2001). Moreover, in 1971, Indonesia introduced high-yielding varieties, Pelita 1-2 from its own program. The spread of these varieties was rapid. By year 1971/72 *sawah* areas were planted by traditional and non-traditional (improved and modern) varieties, 45% and 55%, respectively. Eight years later in 1979/1980, *sawah* areas were planted by traditional and non-traditional varieties, 31% and 67%, respectively (Fox 1991). Traditional varieties are partly replaced by modern varieties, particularly in the low land *sawah* due to technology of the green revolution: irrigation development, inorganic fertilizer, pesticides, and cultivation improvement (Iskandar 2001). In other higher elevation areas, however, where new technology is not appropriate, traditional varieties have not been affected.

The green revolution has increased rice yields. For example, in 1968 average rice yield in Java and outer Java was 2.58 $t.ha^{-1}$ and 2.15 $t.ha^{-1}$ respectively with total production of *gabah* in Indonesia 15,353 tons. In 1989, this production in Java and Outer Java has become 4.98 $t.ha^{-1}$ and 3.52 $t.ha^{-1}$, respectively, with total production of *gabah* in Indonesia 44,723,000 tons (Fox 1991). Production increase, however, came with massive loss of genetic diversity, which had been a response to local socio-economic and cultural requirements over many areas. For example, on the basis of study ethnobotany in several villages of West Java, revealed that some local rice varieties loss due to farmers introduced the high-yielding varieties (Table 4).

Table 4. Loss of local rice diversity in several villages of West Java and Banten caused by introduction of Green Revolution program

Location (Farming System)	Local rice varieties		Source
	Before the green revolution	After the green revolution	
Majalaya, Bandung, West Java (*sawah*)	88	Less than 10	Parikesit et al. (1997)
Rancakalong, Sumedang, West Java (*sawah*)	60	20	Warsiti (2009)
Naga, Tasikmalaya (*sawah*)	24	9	Permana (2015)
Kasepuhan, Sukabumi, West Java (*sawah* and *huma*)	146	78	Soemarwoto (2007)
Baduy, Kanekes village, Banten (*Huma*)	?	89	Iskandar and Ellen (1999)

By introducing new technologies, rice seeds are mainly from the Department of Agricultural shops (*kios pertanian*) instead of being prepared locally at home, by women who carefully select seeds from the previous crop. Although new rice varieties are superior in production, in many cases such seeds are inferior. The degeneration of these seed varieties usually occurs within three years (Hardjono 1987). Therefore, the stability of farmers in maintaining seed is low. Another problem is that intensive rice cultivation and genetic uniformly carries with it a high risk of disease and pest outbreaks. It has been widely reported that new high yielding varieties in Indonesia, have been seriously attacked by the brown planthopper (*Nilarvata lugens* Stal). About 43 year after firstly reported the brown planthopper serious attack the rice as in 1970s, until now it has not been totally eradicated due to many factors, such as loss of natural enemies due to intensive use of pesticides and the pest become resistant due to the use of inappropriate pesticide doses (cf. Fox 1991; 2016; Baehaki 2012; Sogawa 2015; Tauruslina et al. 2015; Winarto 2016). In addition, it has caused other factors, such as home organization of planting rice, and irregular and uncooperative rice cropping pattern, and continues intensive rice cultivation without intermittent with other non-rice cultivation.

Through rice intensification, some varieties of non-rice staple foods in Indonesia have also been disturbed. A shift from non-rice staples to rice was apparent in many parts of the country (Soemarwoto 1991; Persoon 1992; Lasa 2009; Soselisa and Ellen 2013). For example, the Madurese and Timorese, whose main staple food was once maize, have changed to rice, while in Maluku, Papua and other places more people now than formerly are eating rice (Soemarwoto 1991). Moreover, due to increased popularly of rice, manioc production has also been reduced. The production of this crop has declined and is less popular in food supply (Dixon 1978). As a result, some cassava manioc varieties are no longer maintained by farmers.

Unlike rice varieties, home-garden plant varieties have mainly changed spontaneously with less interference by the government. Plant varieties have been continuously selected by farmers, such as eliminating or replacing unwanted crops and emphasizing others. The selection of plant varieties has been determined by various factors, such as culinary preferences. Lots of fruit have been eliminated or disappeared due to taste. Therefore, some wild and semi-cultivated fruits, such as banana, rambutan, mango, and papaya have been replaced because people do not like them, which has lessened demanded both home consumption and in the markets.

Some indigenous plant varieties have also been replaced due to introduction of cash crops, such as clove, citrus, strawberry, and vegetables. As a result, the structure of home-garden has been simplified (Hadikusumah 2003). As a result, the positive functions of home-gardens, such as maintaining soil fertility and preventing soil erosion, have disappeared. Moreover, the home-gardens which are dominated by only a particular cash crop are more monoculture, and sustainability of this system is more difficult in the long term due to pest problems and fluctuation in market places. For example, in many parts of West Java, ecological history in the 1970s, almost all citrus trees of Garut variety (*jeruk Garut*) in home-gardens collapsed due to attack of Citrus Virus Vein Ploen Degeneration (CVVPD). In addition, due to over production of certain cash crops, such as clove in many provinces and citrus, particularly in Kalimantan, many farmers in these areas in the 1990s have high significantly financial losses. The Government has been trying to help by establishing the BPPC (*Badan Penyangga Pemasaran Cengkeh* = Committee of Buffer Stock and Markering of Clove) to maintain an appropriate price for clove by direct buying of this crop from farmers, but this did not success.

On the basis of these examples, it can be observed that farmers have deep knowledge of subsistence systems to encounter problems in changing to new systems, i.e., the introduction of new cash crops without enough knowledge and skill both to cultivate and market them. Changes in food habits, rituals and ceremonies have also influenced the choice of plant varieties in the home-garden. For example, in the past, the chewing of betel leaf (*sirih*), the areca nut (*pinang*), tobacco (*tembakau*), and gambir was common to all classes in Java (Raffles 1965). This custom was important for the social affability produced by sharing a quid with friends (Rooney 1993). It has been noted that some fruits varieties, such as green coconut is commonly used symbolically in rituals for West Javanese as well as Javanese women who are seven months pregnant (Raffles 1965; Prawirasuganda 1964; Piper 1989). This ritual was given to relations and friends, at which yellow rice invariably forms a part of the entertainment. Afterwards, the pregnant women must wash her body with the milk of green coconut, on the shell of which has previously been carved two standards of beauty for their expected offspring intended to engrave on the imagination of the mother, impressions which may extend to the lineaments of her infant (Raffles 1965).

Nowadays, betel chewing, and ceremonies and rituals associated with pregnancy are rare or have disappeared altogether. For example, betel chewing has not been popular due to changes in consumption patterns, such as the introduction of cigarettes (Reid 1985). Moreover, the traditional trade in betel leaf and areca nut by vendors in markets has also disappeared. Therefore, there is less incentive to plant *pinang* trees in the home-gardens in many areas of West Java. Similarly, some plants which are used in the ceremonies, such as green coconut are no longer required socially. Added to this a lot of medicinal plants have been replaced by farmers due to the introduction of modern medicine whose product can be easily purchased in the markets. Similarly, some varieties of banana, such as *pisang biji* or *pisang klutuk*, which are commonly produced only for the leaves used in food packing, have been rapidly substituted by plastic or paper.

To sum up, genetic diversity in wet rice field (*sawah*) and home-garden farming has been determined by cultural and ecological factors. In *sawah* farming, farmers prefer to plant different local rice varieties for many reasons, such as

ecological suitability and social and cultural needs: culinary, ritual and ceremonial. Similarly, home-garden have been planted with plant varieties intended to fulfill various daily needs and adjusted to local environments. High diversity of plants in home-gardens has provided some benefits, such as low inputs, less dependence on markets and more resistance to pests. Nowadays, however, genetic diversity of plants in these farming systems has dramatically fallen, mainly due to social and economic change, such as population growth, market economic penetration, and introduction of new agricultural technologies. Since plant genetic diversity in wet rice and home-garden environments has been maintained by cultural practices, by replacing local plant varieties, certain varieties will disappear as well as the indigenous knowledge and cultural practices which accompany them.

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