Potential impacts of swidden rice transitions on nutrient intake in Kapuas Hulu, West Kalimantan,Indonesia

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1 Introduction

Swidden systems (shifting cultivation farming systems practiced in upland Southeast Asia) are rapidly declining in extent, driven by various forces including demographic changes, land tenure transitions, and the expansion of cash crop agriculture (Padoch et al. 2007; Schmidt-Vogt et al. 2009; Dressler et al. 2016). The transition from swidden farming systems to sedentary agriculture is often seen as a positive force for stimulating rural development (Padoch et al. 2007; Dressler et al. 2018), however, swidden systems also have many advantages over sedentary agriculture which are often overlooked. Among the advantages of traditional swidden systems are more flexible labour demands allowing for the pursuit of off-farm income (Dove 1993). Off-farm labour, combined with a more diverse range of foods produced on swidden farms, can serve as a hedge against risk of commodity price fluctuations (Sulistyawati et al. 2005) which can adversely affect food security and nutrition (Potter 2011). Swiddens farms also offer a diverse range of ecosystem services – including soil-erosion control, carbon storage and biodiversity – that significantly outcompete alternative land uses (Labrière et al. 2015a, 2015b).

Agricultural systems based upon swidden may also have positive effects upon dietary quality. Links have been shown between land classes associated with swidden farming and agroforestry systems, and increased consumption of micronutrient rich foods (Ickowitz et al. 2016; Broegaard et al. 2017). These links may be the result of greater availability of these foods groups, due to planted crop diversity or non- or semi-cultivated foods like legumes and fruit trees which proliferate in fallows, or such links may derive from livelihoods associated with landscapes which include swidden.

The transition away from swiddens may have mixed effects upon diets. On the one hand, households may have greater access to cash income (via cash crop farming or off-farm work) as well as greater access to market foods via improved infrastructure. On the other hand, the loss of swidden livelihoods and swidden landscapes may reduce access and consumption of nutritious food groups. Few studies have explored the dietary trade-offs associated with this transition.

1.1 Dietary transitions in Kapuas Hulu, Indonesia

This study builds on an existing study of diets in Kapuas Hulu Regency, West Kalimantan, Indonesia, in a context of rapid agrarian and landscape change driven by oil palm expansion into previously remote forested communities. The study explored the dietary consequences of a transition from traditional swidden livelihoods to oil palm-based livelihoods, based upon detailed dietary data collected using rigorous 24-hour dietary recall methodology with over 520 mothers across 37 villages (Purwestri et al. 2019). The study found that mothers and children in traditional swidden households consumed more healthy foods like fruits and vegetables – especially nutritionally important green-leafy vegetables – but fewer eggs and less dairy than those in non-swidden households.

As well as changes in dietary patterns, the study found that oil palm was driving changes in swidden rice production and consumption – with a general trend away from traditional varieties of rice and with increased consumption of market-sourced rice. While there was no significant difference in the quantities of rice consumed between the oil palm and swidden sites, there were significant differences in the source of rice consumed. In traditional livelihood households, 72% of rice came from own-farm production, compared with 43.3% in the oil palm site. The reduction in the proportion of rice coming from the farm in the oil palm area was compensated for by an increased share of rice coming from market sources, with 25.7% of rice originating from market sources in the traditional swidden site, compared with 55.4% in the oil palm site.

As well as changes in the patterns of rice consumption, the study revealed changes in the pattern of rice production between the traditional swidden and oil palm sites. In traditional swidden households, less than 3% of households did not grow any rice at all, whereas 18% of households surveyed did not grow any rice in the oil palm area (Rowland et al. 2022). The same study found no difference in the use of herbicides (households using at least some herbicide on their rice fields), but found significantly more rice farming households using fertilizers and pesticides in the oil palm site compared with the traditional swidden site.

1.2 Nutritional impact of changing rice production and consumption

It is possible that the observed changes in rice consumption may have consequences for nutrient intake of local populations. However, without accurate Food Composition Tables (FCT) for local varieties, this impact cannot be calculated. No food composition information is available for the different types of rice that may be consumed in Kapuas Hulu. In rural areas of West Kalimantan, Indonesia, where swidden remains the predominant form of agriculture, numerous varieties of rice are grown. Typically, Indigenous Dayaks grow several varieties of rice at once, balancing risk, alongside other considerations like taste, ceremonial importance and consumption method (Van Noordwijk et al. 2008). These varieties of rice are typically processed by de-husking with homemade, hand-cranked machines, winnowed by hand, and sun dried. Little is known about the nutrient content of these varieties of rice. The Indonesian national food composition database contains a single entry for *Beras Ladang* (uncooked swidden rice) of the species Asian Rice (*Orzya sativa*) (KKRI 2018). No indication of the origin of this record is provided, and it could refer to any species of rice from any island across the Indonesian archipelago. No indication is given either as to the extent of processing, in the form of winnowing, de-husking or polishing.

While no data on the nutrient content of local varieties is available, there are, however, reasons to believe that rice produced in traditional systems is nutritionally superior to rice grown in other production systems – especially the highly-processed and polished white rice available in markets (Pfeiffer et al. 2006; Rahman et al. 2006). One reason is that market-sourced rice often consists of varieties selectively bred for high yields and other characteristics, often at the expense of nutritional quality (Yu and Tian 2018). Additionally, locally grown rice in traditional systems is often less processed than market-sourced rice, which is generally highly polished for commercial appeal; this lower level of processing keeps nutritionally important layers of the rice intact. Another potentially contributing factor is the conditions in which rice is grown. Soil quality and the application of chemical inputs is known to affect the nutritional quality of grains consumed (Mandal et al. 2000; Cakmak and Kutman 2018; Huang et al. 2020; Muleya et al. 2021). A meta-analysis of transitions from swidden to competing land uses found consistently large, significant reductions in Soil Organic Content (SOC), Above Ground Biomass (ABG) and Cation Exchange Capacity (CEC) (Dressler et al. 2017). Such changes may impact the availability of nutrients in the soil, the uptake of these nutrients by grains, and thus the subsequent nutritional composition of foods.

2 Study aims

2.1 Theoretical premise

This study is premised on three observations. The first observation is that the nutrient content of rice varies greatly according to variety, growing conditions, postharvesting processing and cooking method. The second observation is that, as rice makes a up a large share of the total caloric intake for many populations in West Kalimantan, Indonesia, small differences in the nutrient content of rice could result in substantial differences to overall nutrient intake – and potentially to differences in nutrient adequacy and the prevalence of micronutrient deficiencies. The third observation is that landscape change, forest loss and agrarian change, driven by oil palm expansion in Kapuas Hulu, are resulting in changes to the way that rice is produced and consumed. As such, we postulate that oil palm may be driving changes in nutrition, via changes in staple food consumption.

The idea that oil palm and agrarian change may drive changes in nutrition, via changes in staple food nutrient content, is novel. Most pathways linking oil palm and nutrition focus on pathways driven by changes in overall diets. Existing studies ascribe observed changes in diets and nutrition to forces like market access and household income (Euler et al. 2015; Sibhatu 2019; Chrisendo et al. 2020) or loss of access/use of wild foods, and changes in the food environment (Purwestri et al. 2019). If our hypothesis is proven correct, however, changes in nutrition could occur even without significant changes in diets, if the source of staple foods changes significantly. If our hypothesis is proven correct, the implications are significant. It would suggest that analyses of the nutritional implications of land-use change cannot be based upon dietary intake data alone – unless detailed food composition data is available for local varieties of staple foods and local production systems. As such, it would also reduce the certainty of findings based upon the analysis of dietary data, and suggest the need for anthropometric analysis of nutritional status. It would also underline the importance of indigenous varieties and landraces of rice, and highlight the importance of agricultural biodiversity in the food system for nutrition.

2.2 Objectives

The purpose of this study was to determine if and what nutritional differences there may be between different varieties of rice consumed in Kapuas Hulu, and the implications for nutritional consequences of local agrarian change. The study aimed to:

1. characterize the varieties of rice grown, consumed and sold in Kapuas Hulu;
2. identify changes in rice production and consumption being driven by land-use change dynamics;
3. identify candidate varieties of rice that could be sampled for further vitamin and mineral analysis.

2.3 Methodology

Our study design aimed to compare the differences between rice produced in traditional agricultural systems and rice originating from market sources in Kapuas Hulu Regency, West Kalimantan, Indonesia. The study is an extension of a project funded by the Drivers of Food Choice Competitive Grants Program[1] which compared diets in oil palm areas of Kapuas Hulu with diets in villages with more traditional swidden-based livelihoods (Purwestri et al. 2019). As this previous study had collected extensive dietary and nutritional data over multiple seasons, we chose to revisit the same areas to analyse

1 https://driversoffoodchoice.org/

Table 1. Characteristics of the Drivers of Food Choice (DFC) study sites

Characteristics	Traditional swidden	Oil palm
Ethnicity	Indigenous Dayaks	Indigenous Dayaks
Livelihoods	Predominantly swidden	Predominantly oil palm

rice consumption. This would allow findings of the nutritional analysis of rice to be incorporated into the dietary data for population modelling. The general characteristics of the study sites are shown in Table 1.

The purpose of this study was to inform the sampling strategy for the nutritional analysis of rice varieties. As such, we aimed to rapidly identify the rice varieties of interest, as well as characterize local rice production systems and market rice dynamics. As our study focused on the real world nutritional implications of agrarian change, we did not aim to produce an exhaustive list of rice varieties, but rather focus on those commonly consumed in local diets. We did not, therefore, focus on underused species, despite their potential for improving nutrition. Information pertaining to rice production and consumption in Kapuas Hulu was obtained by combining desk-based research with primary qualitative research. A review of existing information and data was conducted using official statistics, documents, published articles and grey literature as well as local media reports.

Two subdistricts where traditional swidden rice is cultivated, and two subdistricts where rice cultivation practices had been modified by oil palm-driven agrarian change, were selected based upon existing data from the Drivers of Food Choice project as well as information provided by key informants in the regency capital, Putussibau. Study locations were also constrained by widespread flooding of the region during the study period. As such, we selected the subdistricts of Kalis and Batang Lupar for the swidden sites and the subdistricts Putussibau Selatan and Empanang for the oil palm areas.

In each subdistrict, focus group discussions were carried out with farmers. Focus groups were centred around discussions of farming practices, starting from land clearing and planting up until harvest, as well as rice consumption. We also conducted key informant interviews with knowledgeable respondents on an opportunistic basis. Both interviews and focus groups were conducted using a semi-structured questionnaire that focused on farming activities. Interviews with government officials were conducted with regency government offices in the regency capital, Putussibau. Officials interviewed worked at the Department of Agriculture and the Logistics Bureau (Bulog). Interviews focused on trends and types of rice production, rice consumption, local rice varieties and the market dynamics of rice.

Primary qualitative fieldwork was conducted in November 2021. We obtained data from a wide range of knowledgeable informants in different parts of Kapuas Hulu Regency. A total of 16 in-depth interviews and two focus group discussions were conducted. Ten interviews were conducted with farmers, and six interviews were conducted with local government officials. Of the two focus groups, one was conducted in the oil palm area and one was conducted in the traditional swidden area. Interviews were recorded and notes taken. Transcripts were analysed by thematic coding of transcripts in Microsoft Excel.

3 Background: Rice production

Over half of the world's population consumes rice as a staple food (Muthayya et al. 2014.) Most rice is consumed in Asia, where it is vital for food security. Among the 520 million people living in poverty in Asia, rice provides up to 50% of calorie intake (Muthayya et al. 2014). Rice is also an essential source of micronutrients. Globally, 3.8% of dietary folate comes from rice consumption, ranking it as the fifth most important source of dietary folate (Smith and Myers 2019). The importance of nutrient dense rice in global diets is likely to increase as a result of the effects of climate change, as increased atmospheric carbon dioxide concentrations are likely to reduce levels of protein, iron, zinc and B vitamins (Maclean et al. 2013).

There is a great diversity of rice species and varieties, each with a different nutrient profile. Most rice consumed by humans belongs to one of two species: *Oryza sativa* and *Oryza glaberrima*. The former, *O. sativa,* is the most widely-consumed species and is the dominant species grown in Asia, Europe and the Americas. There are tens of thousands of different varieties of Oryza species, which can be grouped into four complexes and 11 genomic groups (Maclean et al. 2013). Globally, there are over 40,000 varieties of *O. sativa* alone, which can be grouped broadly into the rice types Japonica, Javanica (or tropical Japonica) and Indica.

3.1 Rice production in Indonesia

Indonesia is the third largest producer of rice in the world (Maclean et al. 2013), producing over 75.4 million metric tons of rice across a total rice area of 8.1 million ha (Rumanti et al. 2018). Over 55% of this land area consists of lowland irrigated rice, while 28% is lowland rainfed rice and 13% is upland dry rice (ibid). Rice is grown by over three quarters of farmers in the country. Most are subsistence farmers with an average farm size of less than one hectare; the majority of farmers have between 0.1 and 0.5 ha of rice area (Maclean et al. 2013).

Indonesian agricultural policy has long been guided by a desire to achieve national self-sufficiency in rice (Timmer 2004; Neilson and Wright 2017). As a result, the rice producing sector has received considerable investment over many decades (Warr and Yusuf 2014; Davidson 2018). Over the last 40 years, the average rice yield in Indonesia has more than doubled from 2.4 metric tons per hectare in 1972 to 5.1 metric tons per hectare in 2020 (IRRI 2020). Total production has grown significantly due to increases in yields, but also due to agricultural expansion of rice, often into areas that were previously forested (Goldstein 2016; Byerlee et al. 2017). Improvements in rice yields can be attributed to the release and adoption of high-yielding varieties, in combination with state investment in irrigation and subsidies for chemical inputs. In recent years, despite periodic outbreaks of pest attacks and unfavourable weather conditions, yields have continued to grow around 1–3% per year (FAO 2018).

Alongside government incentives to 'modernize' rice production, the adoption of a narrow range of high-yielding varieties has dramatically improved rice yields; however, it has also led to a loss of indigenous rice varieties and landraces, and the loss of traditional rice production systems (Potter 2001; Pfeiffer et al. 2006; Pasolon et al. 2016). Such changes introduce risk into the food system, reducing diversity and thus resilience. The genetic uniformity of rice has been blamed for millions of metric tons of rice yields lost during mass outbreaks of tungrovirus in Indonesia in 1973 (Thrupp 2000) for example, following the widespread adoption of so-called 'high-yielding varieties'. Genetic diversity in the food system is vital to adapt to the challenges of climate change (Mercer and Perales 2010; Heisey and Day-Rubenstein 2015; Lopes et al. 2015). While rice yields have been growing consistently in Indonesia, climate change threatens this progress, as farmers face increased frequency and severity of floods, droughts and salination of soils (Amien et al. 1996; Rondhi et al. 2019). Some estimates suggest that rice yields could decrease between 4% and 16.5% by 2080, due to a combination of temperature rises and loss of productive farmland in coastal areas due to sea level rises (Sleet 2020).

3.1.1 Upland dry rice production in Indonesia

There are three main types of rice production in Indonesia: irrigated paddy, rainfed lowland rice, and upland rice. Irrigated paddy makes up the overwhelming majority of rice production in Indonesia; production is dominated by both irrigated and rainfed lowland rice (which use the same varieties but with different irrigation systems), concentrated on the islands of Java, Sumatra and Sulawesi. Together these three islands contribute around 90% of Indonesian rice production and 80% of the area cultivated by rice (USDA 2016).

Upland dry rice contributes a small fraction of Indonesia's total rice area and total rice production, estimated at around 1.2 million hectares (Saito et al. 2018). Despite this, Indonesia has a wide range of upland rice varieties, many of which are undocumented in the scientific literature (Pfeiffer et al. 2006; Pasolon et al. 2016; Utami et al. 2019). Dry upland rice has not seen the level of research and investment that wet rice production has. Between 1981 and 1985, research institutes produced five times as many varieties and strains of wet rice than dry rice (Ismachin and Sobrizal 2006; Panuju et al. 2013). One reason for this is policymakers' pervasive view that dry rice cultivation is "wasteful" and "unproductive" (Okushima 1999). Unlike irrigated paddy, most upland dry rice is harvested only once a year, leading to lower yields per hectare. Policymakers view irrigation as a means to increase the intensification of rice production, allowing farmers to harvest multiple times per year (Agus et al. 2019; Erythrina et al. 2021).

While irrigation results in higher yields of rice, it also results in higher labour demands for rice production. As such, it may preclude combined livelihood strategies, consisting of rice production in conjunction with other income- and food-generating activities (Dove 1981; Sulistyawati et al. 2005; Merang et al. 2020).

3.1.2 Indigenous rice varieties in Indonesia

Indonesia's vast biodiversity is home to an astounding number of plants of potential importance to food security and nutrition. Included in this are a total of 1968 taxa of Crop Wild Relatives (CRWs) – 29% of which are endemic nationally and 44% endemic regionally – which serve as a vital source of genetic diversity for plant breeding and crop and agronomic improvement programmes (Rahman et al. 2019). Alongside CRWs are ancestral varieties and landraces, primarily cultivated by Indigenous Peoples.

There are many indigenous varieties of rice in Indonesia which have been planted locally in a hereditary fashion, but which have not been formally analysed, classified or studied (Utami et al. 2019). In Indonesia, lowland irrigated rice is dominated by hybrid crop lines, while upland dry rice is dominated by ancestral landraces (Pfeiffer et al. 2006). While no comprehensive list of indigenous rice varieties in Indonesia exists, local case studies suggest that single locations can contain tens and even hundreds of landraces. For example, one upland Sundanese area of West Java was found to have 146 different ancestral landraces (Budi 1997).

Indigenous heirloom rice varieties are highly specialized for particular environments and soil conditions. Such landraces often have properties and characteristics either selected against or lost in hybrid varieties, but which nevertheless provide useful adaptations. For example, long time to maturity, considered a disadvantage in modern varieties, allows farmers to carefully time the intercropping with other subsistence crops in such a way that reduces competition between plants and reduces the likelihood of having to harvest multiple crops (Pfeiffer et al. 2006), and allows for more precise timing of harvesting which can be adjusted in accordance with labour availability (Soemarwoto 2007).

Indigenous rice varieties go hand-in-hand with traditional ecological knowledge and farming practices. Communities maintain a collective seed-bank of ancestral varieties through continual preservation and exchange of seeds. Anthropological studies have shown how sophisticated decision making processes govern the judicial selection of varieties, allowing farmers to manage risk by diversifying species and selectively planting varieties based upon changing year-on-year conditions (Pfeiffer et al. 2006; Soemarwoto 2007; Iskandar and Iskandar 2017; Iskandar et al. 2018). Indeed, the ability of traditional varieties grown in traditional cropping systems to produce consistent yields, regardless of climatic conditions or environmental changes, can mean that in the long term they can outcompete so-called 'high-yield' varieties that are more vulnerable to crop failure due to pests, drought or inability to purchase chemical inputs (Pfeiffer et al. 2006).

3.2 Rice production in Kapuas Hulu, West Kalimantan

Total rice production in West Kalimantan is a fraction of that in the highest-producing provinces located in Java, Sumatra and Sulawesi. In 2018, the area of rice harvested in West Kalimantan was 214,877 hectares, producing 662,041 metric tons of rice (BPS 2018, 2021). Rice production in Kapuas Hulu is a small proportion of the rice produced in West Kalimantan, producing only around 25,000 metric tons of rice (Figure 1). Rice production in Kapuas Hulu, consists primarily of dry-rice production. Almost all (>99%) dryland paddy cultivation in West Kalimantan consists of non-hybrid varieties, with most households (>83%) using local seed varieties (BPS 2017). Dryland rice cultivation in West Kalimantan is relatively traditional, with few cultivating households using mechanized machinery or chemical fertilizers. One survey of rice farmers found that just 8% of households farming dry rice used chemical fertilizers, and fewer than 1% used mechanized production methods (BPS 2017). Households cultivating dryland rice reported high rates of pest attacks – often significantly reducing yields by more than 25%.

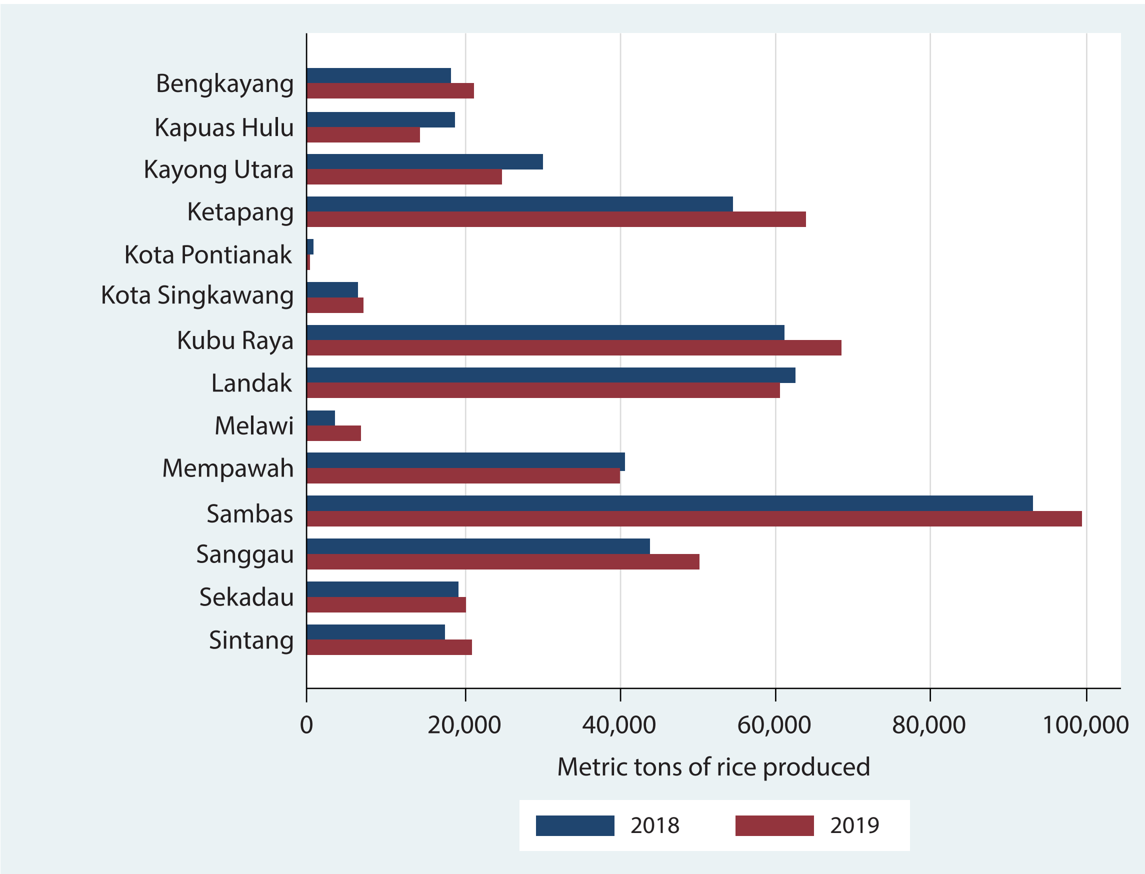

Figure 1. Rice production in different regencies of West Kalimantan

The dominant form of dry rice cultivation traditionally in Kalimantan is swidden cultivation, a form of rotational, long-fallow, slash-and-burn production system. In Kalimantan, official policies have attempted to persuade dry rice farmers to switch to wet rice production systems. The continued use of dry rice farming systems in Kalimantan is often attributed to lack of knowledge, or lack of technological capacity. In fact, several authors have shown that dry rice cultivators possess knowledge and experience with wet rice cultivation, but continue to cultivate dry rice for other reasons, like protection from flooding and drought, taste, perceived nutrition, and suitability for less fertile upland soils (Okushima 1999).

Multiple studies suggest that swidden is adaptive, both for the ecological context and for the livelihoods of its practitioners (Dove 1983; Pfeiffer et al. 2006; Hendra et al. 2009; Merang et al. 2020). One advantage of swidden is its flexibility and suitability as part of a diverse portfolio livelihood. Though less productive than irrigated systems in terms of yields per hectare, upland rice can (under certain conditions) be more productive in terms of yield per labour time (Dove 1985; Raintree and Warner 1986; Sulistyawati et al. 2005; Nakano 2014). Additionally, when combined with long fallow periods, in which there is natural forest regeneration, the use of costly chemical inputs can be avoided (Saito et al. 2018). Thus, while irrigated systems may produce more rice, swidden rice cultivation may be a relatively low-cost, low-labour way of producing the majority of a household's rice requirements, while freeing up time for other activities that produce food or income. Such portfolio livelihoods – consisting of swidden cultivation combined with alternative sources of food and income – may be more resilient than more profitable, but more specialized livelihood approaches, acting as a 'buffer' against price fluctuations in cash crops and other sources of income (Sulistyawati et al. 2005). However, while swidden requires less labour than more intensive rice production systems, it requires several short periods of the year with high labour input. As such, it may be less compatible with livelihoods that require consistent year-round time commitment, like waged labour (Maharani et al. 2019; Rowland et al. 2022).

3.2.1 Decline of swidden in Kapuas Hulu

The transition from swidden to agriculture to permanent agriculture is a trend seen throughout Southeast Asia (Padoch et al. 2007). Swidden systems in Kalimantan have continually adapted to changing social and economic circumstances. Historical changes in swidden patterns have also been observed; like changes from "pioneer swiddens", associated with nomadic livelihoods, to "rotational swiddens", associated with permanent settlements (Potter 2011); or the adoption of rainfed wet rice systems of *sawah* cultivation in response to population pressure and land scarcity (Padoch et al. 1998). Swidden systems have also been altered by the arrival of economic opportunities like logging, and price fluctuations in cash crops like rubber and pepper (Colfer 1991; Wadley and Mertz 2005; Colfer 2008; Purwanto 2018).

In Kapuas Hulu, where swidden has been the dominant form of agriculture for centuries, its decline is being rapidly accelerated by the expansion of oil palm (Leonald and Rowland 2016; Hasudungan 2018; Maharani et al. 2019; Anandi et al. 2020; Rowland et al. 2022). Transitions may be sudden or gradual, and involve a year-on-year shortening of fallow periods, reduction in plot sizes, and increases in the use of agricultural inputs (Padoch and Peluso 1996; Cramb et al. 2009; Maharani et al. 2019; Rowland et al. 2022).

4 Background: Rice and nutrient content

Multiple factors influence the nutrient content of rice. In this section we briefly outline some of the factors which may result in nutritional differences between locally produced indigenous dry rice varieties and market-sourced rice grown from high-yielding varieties in irrigated paddy fields. We posit that locally produced rice varieties may be nutritionally different to rice available from the market system, based upon the following suppositions: (1) locally produced rice has not been as intensively selectively bred, and therefore may be genetically superior in terms of nutrient content; (2) rice grown in long-fallow systems may be nutritionally superior, due to the absorption of nutrients from the soil; (3) locally produced rice is likely to be less processed, and thus may contain nutritionally dense parts of the grain that are absent in highly processed market rice.

4.1 Genetics and nutrient content

A rice's genotype is an important factor affecting its nutrient content. Table 2 shows the range of micronutrient content for different varieties of rice from around the world. Although nutrient content has been analysed for only a small fraction of total rice varieties, existing data suggests significant variation between varieties when it comes to nutrient content. For example, varieties of rice with the highest zinc content have over seven times the concentration of zinc than varieties with the lowest content. Likewise, the difference in concentration between the highest and lowest varieties are a factor of 9 for iron, 44 for niacin (vitamin B3) and 66 for calcium (Kennedy et al. 2002).

Analysis of rice varieties found in Indonesia has also shown a wide range of nutrient content caused by genotypic variation. For example, multiple studies have shown, in controlled experimental conditions, the effect of genotype on micronutrients like zinc and iron (Barokah et al. 2018). One study of 180 genotypes in Indonesia found some cultivars to have twice the density of iron and zinc than others (Rohaeni and Susanto 2021).

Table 2. Range of micronutrients across different varieties of rice

Nutrient	No. varieties analysed	Content (g/100g of rice)	
		Highest	Lowest
Amylose	1,182	76	1
Protein	1,339	14.58	5.55
Iron	95	6.35	0.7
Zinc	57	5.89	0.79
Calcium	57	65	1
Thiamine	79	1.74	0.117
Riboflavin	80	0.448	0.011
Niacin	30	9.22	1.97

Source: Kennedy et al. 2002

4.1.1 Indigenous rice varieties

As variations in the nutrient content of rice can be attributed to genotype differences, this provides a rich basis for bioengineering via selective plant breeding or transgenic approaches. Capitalizing on genetic variation in micronutrient content, plant breeding programmes have succeeded in producing high-yielding varieties enriched with improved micronutrient profiles for iron and zinc (Barokah et al. 2018). However, the enormous success of high-yielding hybrid varieties, and the efficiencies of monoculture production during the green revolution, have driven a huge decline in the diversity of rice varieties that are grown globally. For example, the green revolution in India has led to decline in the number of rice varieties, from over 110,000 in the 1970s to over 6,000 varieties today (Rathna et al. 2019). Despite this decline, indigenous varieties continue to be widely used and provide a reserve of genetic diversity for future plant breeding. Many of these indigenous varieties are themselves nutritionally richer than high-yielding varieties, the latter having often been optimized for yields rather than nutrient content. Likewise, many traditional rice varieties exhibit properties which may make them resistant to the effects of climate change and biodiversity loss (Muralikrishnan et al. 2021). Traditional varieties, farmed under traditional rice farming systems, also require less intensive use of inputs and resources like fertilizers, pesticides and water (Dass and Dhar 2014; Kota et al. 2019).

4.2 Soils and nutrient content

Soil type has been shown to affect the nutrient content of cereals significantly. Mineral elements in soil are absorbed by rice roots, ending up in the grain which is consumed by humans. Along with minerals in soils, minerals in fertilizers applied to fields can change the nutritional profile of foods (Cakmak and Kutman 2018). Judicious changes in soil mineral content – by improved soil management, organic and inorganic fertilizer use, as well as specially-designed fortified fertilizers – could make substantial contributions to reducing the burden of micronutrient deficiencies (Lowe et al. 2020; Joy et al. 2021; Manzeke-Kangara et al. 2021; Muleya et al. 2021). For example, application of zinc supplements to soil and organic fertilizer have been shown to increase the zinc content of rice by up to 27% (Cakmak and Kutman 2018).

Given the importance of soil type and fertilizers in determining the nutrient content of grains, differences in production systems which create differences in soils are also likely to have an impact on the nutrient content of the grains consumed. No studies to date have investigated the nutritional impacts of different farming methods and systems on nutrient content. However, given the impact of farming systems like using long-fallow regeneration cycles (such as swidden) and/or minimum/no-till production systems, and the use of natural fertilizers (e.g., manure/leaf mulch) on soil nutrient content, it is possible that nutritional differences could be observed between diverse farming systems.

4.3 Post-harvest processing and nutrient content

Rice harvesting methods can have significant effects upon the nutrient content of rice consumed. For example, during harvesting, the timing of harvesting can significantly impact upon protein content (Nakano et al. 2008), while the method of storing grains by staking can result in loss of nutrients like lysine due to a heat build-up from anaerobic respiration (Eggum et al. 1984). Post-harvest processing, the process of drying, and subsequent storing, also greatly affect the nutritional properties of rice. The protein, lysine and vitamin content of rice all decline with increased time spent exposed to light and heat (Juliano 1985). Once the chaff is removed from the rice grain it becomes brown rice. Further milling of the rice removes bran and endosperm to create white rice. Polishing of rice occurs through successive abrasion by friction polishers depending on the level of polishing required (Rahman et al. 2019). Each stage further reduces the nutrient content of the rice. Milling and polishing of rice can result in losses of around 67% of vitamin B3, 80% of vitamin B1, 90% of vitamin B6, 50% of manganese and phosphorus, 60% of iron, and all dietary fibre (Rabbani and Ali 2009; Rathna et al. 2019).

Post-harvest processing varies significantly by location and tradition. However, as a general rule, the commercially produced rice which is prevalent in market-based food systems tends to be more processed than locally produced rice, due to consumer preference for more highly polished rice[2]. Additionally, rice available in market-based systems is often processed on an industrial scale, using industrial equipment which is highly effective at removing the nutritious layers of rice. In contrast, rice consumed locally is often processed using a combination of hand-winnowing and hand-powered mechanical de-huskers, and thus is more likely to retain some of the nutritious bran layers.

4.4 Rice and nutrition in Indonesia

4.4.1 Nutrient content of Indonesian rice

Food Composition Tables (FCT) for Indonesia contain several entries for rice (Utami et al. 2019). However, only three varieties are specifically named – Pelita, Menir and Rojolele. The food composition tables contain one entry for '*ladang*' rice – assumed to be upland dry rice. This record does not have a source, and could refer to any dry rice variety grown on many of the Indonesian islands where dry rice is cultivated. Locating the original entry for this rice is challenging, but it appears to have been added without documenting the original rice origin.

The nutrient content of rice within the Indonesian Food Composition Tables is shown below for cooked (Table 3) and uncooked (Table 4) rice. The tables show significant variation in nutrient content. For example, zinc content differs between the highest and lowest entries by a factor of three, while the entry with the highest thiamine (B1) content has over twice the content as the variety with the lowest content.

Table 3. Nutrient content of cooked rice according to Indonesian Food Composition Tables

Nutrient	Units	Cooked rice	Par-boiled rice	Cooked red rice
Air (Water)	g	56.7	10.0	64.0
Energi (Energy)	Kal	180	353	149
Protein (Protein)	g	3.0	6.8	2.8
Lemak (Fat)	g	0.3	0.6	0.4
Karbohidrat (CHO)	g	39.8	80.0	32.5
Serat (Fibre)	g	0.2	0.5	0.3
Abu (ASH)	g	0.2	2.5	0.3
Kalsium (Ca)	mg	25	5	6
Fosfor (P)	mg	27	142	63
Besi (Fe)	mg	0.4	0.8	0.8

continued on next page

2 While the nutrient contents of brown rice are higher than those of white rice, this does not automatically translate into improved nutrition; the bioavailability of nutrients is also an important consideration. Studies in rats have shown that protein absorption is similar in both white and brown rice – due to the higher fibre and phytate content of brown rice, which reduces digestibility and absorption (Rahman et al. 2019). However, population-level studies have shown that substituting white rice for brown rice may have a range of benefits for health outcomes such as diabetes (Zhang et al. 2010; Pletsch and Hamaker 2018).

Table 3. Continued

Nutrient	Units	Cooked rice	Par-boiled rice	Cooked red rice
Natrium (Na)	mg	1	2	5
Kalium (K)	mg	38.0	46.0	91.4
Tembaga (Cu)	mg	0.10	0.28	0.20
Seng (Zn)	mg	0.6	1.0	0.9
Retinol (Vit. A)		0	0	0
Beta-Karoten (Carotenes)	mcg	0	0	0
Karoten Total (Re)	mcg			0
Thiamin (Vit. B1)	mg	0.05	0.22	0.06
Riboflavin (Vit. B2)	mg	0.10	0.11	0.00
Niasin (Niacin)	mg	2.6	3.4	1.6
Vitamin C (Vit. C)	mg	0	0	0

Table 4. Nutrient composition of raw rice according to Indonesian Food Composition Tables

Nutrient	Units	Raw milled rice	Raw black rice	Raw Ladang rice	Raw Pelita rice	Raw Menir rice	Raw Rojolele rice
Air (Water)	g		12.9	9.8		12.0	12.0
Energi (Energy)	Kal	357	351	376	369	362	357
Protein (Protein)	g	8.4	8.0	7.5	9.5	7.7	8.4
Lemak (Fat)	g	1.7	1.3	3.8	1.4	4.4	1.7
Karbohidrat (CHO)	g	77.1	76.9	78.0	77.1	73.0	77.1
Serat (Fibre)	g	0.2	20.1	5.9	0.4	0.2	0.2
Abu (ASH)	g	0.8	0.9	0.9	0.6	0.2	0.8
Kalsium (Ca)	mg	147	6	20	68	22	147
Fosfor (P)	mg	81	198	110	171	272	81
Besi (Fe)	mg	1.8	0.1	0.8	1.4	3.7	1.8
Natrium (Na)	mg	27	15	10	34	90	34
Kalium (K)	mg	71.0	105.0	70.0	0.0	201.0	112.9
Tembaga (Cu)	mg	0.10	0.10	0.10	0.00	0.10	0.14
Seng (Zn)	mg	0.5	1.6	1.4	0.0	0.5	0.1
Retinol (Vit. A)		0	0	0	0	0	
Beta-Karoten (Carotenes)	mcg	0	0	0	0	0	0
Karoten Total (Re)	mcg	0	0		0		80
Thiamin (Vit. B1)	mg	0.20	0.21	0.20	0.26	0.55	0.20
Riboflavin (Vit. B2)	mg	0.08	0.06	0.20	0.00	0.00	0.02
Niasin (Niacin)	mg	2.6	0.0	5.1	0.0	1.9	1.5
Vitamin C (Vit. C)	mg	0	0	0	0	0	0

4.4.2 Rice consumption in Indonesian diets

The nutritional implications of rice varieties' differing nutrient contents depends on the quantities and types of rice consumed. Indonesians are among the most extensive rice consumers globally (Sleet 2020). Based on the Indonesian Socio-economic Survey (Susenas), per capita rice consumption was recorded above 95 kg from 2013 to 2018 (Badan Ketahanan Pangan, Kementerian Pertanian 2019). In the province of West Kalimantan, rice consumption per capita was reported at approximately 256 g of rice per person per day in 2018. This is almost twice the reference quantity modelled in Sabah (Malaysian Borneo) by Hashmi and Tianlin (2016). Thus, rice's potential contribution to the recommended dietary allowance (RDA) for various mineral elements, is substantial. As such, variations between the types of rice (white rice versus brown rice), as well as the varieties of rice, could have major implications for nutrient intake.

4.4.3 Implications for nutrient intake

When rice is consumed in large quantities, even trace amounts of nutrients can have significant effects contributing to dietary adequacy. For example, based upon a 128 g per day intake of rice, indigenous varieties of rice in Sabah were found to contribute up to 75% of the RDA for iron (compared to 37% for white polished rice), and 43% of the RDA for copper (see Table 5) (Hashmi and Tianlin 2016). While rice's contribution towards the RDA for many minerals was significant from a nutritional and public health perspective, the impact of this contribution depends on a population's intake of these minerals from other sources. A 29% contribution to the RDA for zinc may have significant nutritional effects in a population that is otherwise deficient in zinc, but a higher contribution from a mineral that the population is not deficient in, may have little to no effect upon health.

Table 5. Contribution of indigenous rice to nutrient adequacy in Sabah (Malaysian Borneo) based upon 128 g per day intake

Mineral	Brown rice (%)	Polished white rice (%)
Na	3.84	3.32
K	10.68	9.47
Mg	19.46	8.19
Zn	28.88	25.86
Cu	42.75	42.75
Mn	30.21	29.95
Fe	75.72	37.72
Cr	10.66	9.22

Source: Hasmi and Tianlin 2016

5 Cultivation, consumption and trade of rice in Kapuas Hulu

This section brings together findings from the literature review presented above with the results of the qualitative fieldwork, and interviews with farmers and policymakers in Kapuas Hulu. We first present a characterization of the swidden systems practiced by the farmers in our study. We then compare rice cultivation among these farmers with rice cultivation practices among farmers who previously had similar livelihoods, but who have subsequently adopted oil palm-based livelihoods (in the form of participation in oil palm plasma schemes).

5.1 Swidden practices in Kapuas Hulu

"*I don't sell the rice, we always eat the rice from our field.*" (IDI F-4)
"*The important thing is we eat rice first and never leave our stomachs empty.*" (IDI F-1)
"*We mostly consume our own rice from our field and if there's rice left, I will sell it.*" (IDI F-2)

The majority of households in our study villages practiced a form of traditional swidden agriculture. Rice fields (*ladang*) were primary opened by slashing old fallow land which had regenerated naturally from surrounding forest. Most farmers surveyed had 1–2 *ladang* and 0.5 to 2 hectares for rice farming. Farmers mostly had *ladang* close to roads, but some also had *ladang* close to the forest. To reach the *ladang*s close to the roads, most of the farmers used motorcycles, taking around 3–10 minutes. However, a small proportion of farmers also maintained more traditional *ladang* on forested slopes further away from the village. During focus group discussions, farmers estimated that a single household could produce about 15–30 sacks of grain (375–750 kg), roughly 60% of which was edible rice after processing. Farmers estimated that 20 sacks of rice was a sufficient amount to feed a family for one year – leaving a deficit in poor harvest years, to be supplemented with purchased rice, and a surplus in good years which could be sold locally.

"*We move from one* ladang *to another around every 3–4 years*..." (IDI F3-JWN)

"*The farmers move to fields that have been previously cleared, because the land there is already fertile. So, they rotate or move to field that they have used before*..." (IDI GO3-JNTG)

Figure 2 shows the general trajectory of a swidden cycle in Kapuas Hulu. *Ladang* may be used once or several times before rotating, depending upon soil quality and fertility. The reuse of *ladang* varies considerably by village, as does the total time that fields are left fallow before they are returned to. Respondents in our study reported moving to another *ladang* after three or four years of successive replanting. In most cases, moving to a new *ladang* involved reopening an old *ladang* that had been left to regenerate naturally. Most of the *ladang* are located in lowland areas, and all of the *ladang* are rainfed rice fields.

For most households, the year is structured around the swidden calendar, as are most traditional and customary events and festivals. Swidden cultivation consists of a cycle of land clearing, followed by planting, and a period of maintenance before harvesting. Figure 3 depicts the typical calender among the study respondents. Typically, rice is planted around August–September and harvested between February–March. The swidden cycle can change each year, however, depending on weather conditions. Heavy rains and floods can delay planting, while lack of rain can delay land clearing by burning, due to the risk of fires spreading. In 2021, the year of this study, planting was delayed due to heavy rains and floods, leading to an estimated harvest time of April–May.

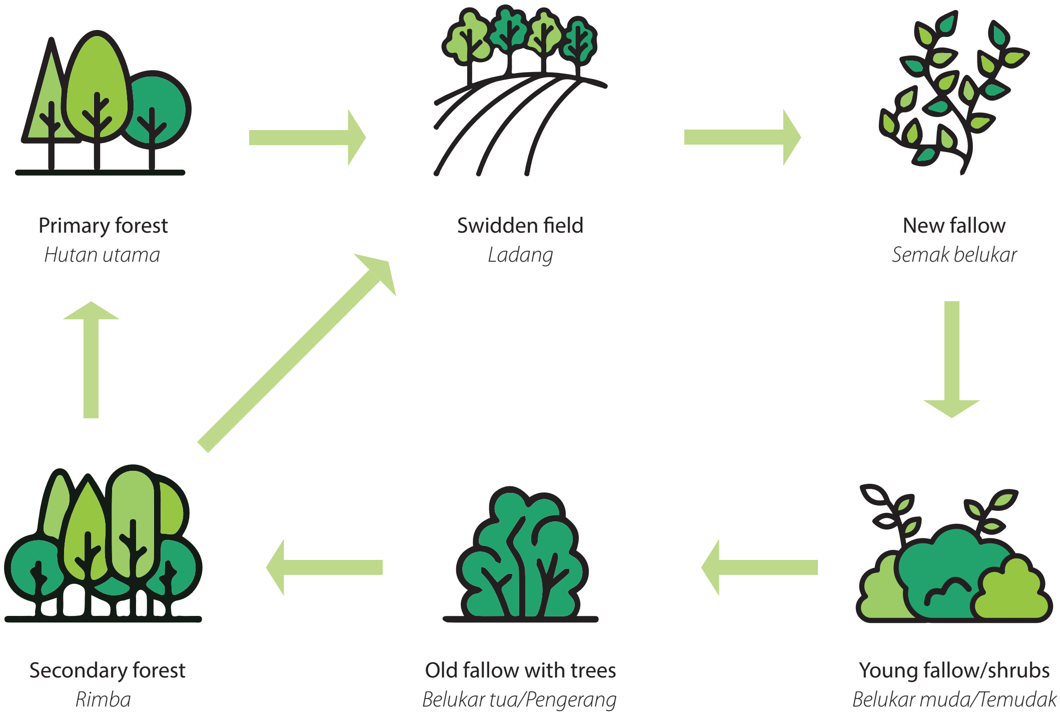

Figure 2. Typical swidden cycle in Kapuas Hulu

	January	February	March	April	May	June	July	August	September	October	November	December
Land clearing					■	■	■					
Burning							■	■				
Planting								■	■			
Weeding	■									■	■	■
Harvesting		■	■	■								

Figure 3. Typical swidden calendar in Kapuas Hulu

Respondents in our study primarily prepared and maintained the land themselves as a household unit. A few households paid other people to assist with land preparation. For the majority of farmers, harvesting was primarily carried out using a traditional form of reciprocal labour exchange – locally referred to as *gotong royong* – whereby households group together to help harvest each other's land. A small minority of farmers either harvested their land independently as a household unit, or used hired labour. The standard rate for one day of casual agricultural labour was IDR 60,000–80,000.

Rice seeds are primarily obtained by retaining seeds from the previous year's harvest. Additionally, there exists a degree of intra-village trade in seeds of different varieties – primarily in the form of seed swapping. This has created a communal seed bank of varieties and strains at the local level, from which farmers can select seeds. Respondents considered the most important factors in selecting seed varieties to be seed availability, followed by climatic conditions and soil type. A frequently cited practice was that of planting multiple varieties of seeds within the same field. This strategy was said to reduce the risk of crop failure due to pest attack, as well as improve taste. Some varieties were also more commercially desirable and – although households were predominantly subsistence farmers producing only enough for household needs – if there was a particularly good harvest, excess could be sold in the nearest town.

Land clearing is done by slash-and-burn, with larger trees felled before burning. Clearing land before burning helps prevent the spread of fire to the surrounding forest, as does the clearing of firebreaks around the edges and the timing of fires to coincide with the beginning of the rainy season. Land burning was said to largely obviate the need for fertilizers, by enriching the soil. While fertilizer use was low, pesticides were used on an as-needed basis. Pests were considered the main challenge for rice cultivation; frequent rotation of fields was said to reduce the risk of pests.

5.2 Post-harvest rice processing

Harvesting of rice is conducted using traditional hand tools (*'ani-ani')* usually in reciprocal labour exchange arrangements, although hiring of waged labour also occurs. Following the harvesting of rice, grains are threshed by foot (folding, rolling and stepping). Winnowing is done by hand using a traditional tool (*'tampi'*) – a ratan mat with a raised rim used to throw rice up and catch it again. Following winnowing, grains can be stored in stacks or milled by machine. The rice milling and threshing machines being used come in a wide variety of forms, from homemade hand-powered constructions made of wood, through to machines run by an attached petrol generator. These rice milling machines were not owned by all farmers, but could be rented from neighbouring farmers for IDR 700 per kg. Our study failed to find a 'typical' level of processing. Farmers reported processing rice at various levels – measured by the number of times grain was passed through milling machines. We found that the number of times grain was passed through a milling machine ranged from 1–3, with most farmers passing rice through the machine 2 or 3 times. However, the wide variety of both commercial and handmade machines makes processing levels difficult to determine. Only a small minority of farmers consumed unmilled brown rice – although this was more common for coloured varieties or rice (red or black rice) and brown rice.

5.3 Cooking and consumption

"*Mixing rice is done so that the flavours mix with each other and complement one another*." (IDI F4-STE)

Multiple informants reported mixing rice for consumption. The mixing of rice was a strategy to both diversify risk at the farm level, but also to balance between the taste and productivity of different varieties. Different combinations of varieties were said to be complementary together. Rice was cooked either in rice cookers or by using traditional methods, with wood fires or a gas stove. In the latter method, rice was measured, washed 2–3 times, then heated in cold water without a lid for around 15 minutes until boiling. The heat was then lowered and a lid placed on the pot for another 2–3 minutes. When cooking in a rice cooker, rice was washed twice before cooking.

5.4 Comparison of rice production in traditional and oil palm villages

Table 6 shows a general comparison of rice production practices in the traditional and oil palm villages in Kapuas Hulu. In contrast with the traditional livelihood area, obtaining land for rice cultivation in the oil palm area was said to be difficult. Respondents in Empanang cited competition for land with oil palm plantations as a reason why land was difficult to obtain. The majority of rice farmers in the oil palm area also worked full-time jobs in oil palm, leaving limited time for rice cultivation.

"People who work in oil palm companies work Monday to Thursday, from 7:30 am to 2:30 pm. After they finish working in the palm oil company, they continue farming for about one hour." (IDI GO4-ANT)
"We farm in the afternoon after we finish our work in the oil palm company." (FGD F2-AYN)

Table 6. Comparison of rice production in traditional and oil palm villages

	Traditional villages	Oil palm villages
Livelihood strategies	Subsistence swidden rice farming, rubber farming and NTFP collection	Oil palm labour and subsistence rice farming
Land availability	Widely available. Existing inherited fallows and land available for opening new fields	Limited availability of suitable rice farms
Land tenure	Customary land tenure	Mix of customary and legal titles
Swidden cycles	2 to 4-year cycle, rotational	
Field size and number	1–2 fields, 0.5–2 ha. Typically, around 1 ha of rice planted	1–2 fields, 0.5–2 ha. Typically, around 1 ha of rice planted.
Field characteristics and location	Mostly in lowland areas liable to rainwater flooding; some on forested slopes further from the village; some forested slopes also accessible by motorcycle via unpaved paths	Mostly in lowland areas liable to rainwater flooding; accessible by motorcycle
Use of chemical inputs	Self-reported high-levels of fertilizer and herbicides; pesticides used as needed; reports of escalating need for chemical input use over time	Self-reported minimal use of fertilizer and herbicides; pesticides used as needed
Labour arrangements	*Gotong royong* (reciprocal labour exchange between local families)	*Gotong royong* is less common; farmers farm their own land with assistance provided by paid workers as needed
Rice yields	Sufficient to feed one family for 10–12 months to one year	Sufficient to feed one family for around 6 months
Rice varieties grown	Traditional ancestral varieties	Traditional ancestral varieties
Post-harvest processing	Threshing and winnowing by hand; milling and polishing using variety of powered and hand-powered machines; milling 2 to 3 times before consumption	Threshing and winnowing by hand; milling and polishing using variety of powered and hand-powered machines; milling 2 to 3 times before consumption

Source: Focus group discussions

The main difference between the traditional and oil palm site was in the quantity of rice produced by the average farmer. In the traditional site, most farmers aimed to produce enough rice for a whole year, typically achieving at least 10 months' worth of rice. In contrast, farmers in the oil palm site produced only enough rice for 6 months' worth of consumption, and thus relied on purchasing market-sourced rice for the rest of the year. Some differences were found in rice cultivation between the traditional and oil palm sites. In the oil palm site, limited land availability resulted in less frequent rotation of land in the swidden cycle. Rice fields were also slightly smaller in the oil palm site – reflecting both increased land scarcity as well as the labour demands of oil palm work. Other differences found were less frequent use of traditional reciprocal labour exchange arrangements in the oil palm site, with waged labour more likely to be employed during planting and harvest.

Interestingly, we found fewer differences between sites than we expected in terms of the nature of cultivation practices. For example, farmers in both sites used ancestral rice varieties and had not adopted hybrid varieties. Likewise, farmers in both sites operated their swiddens in similar locations – mainly in lowland areas accessible by motorcycle. The latter finding may be an artifact of the logistical constraints on fieldwork, caused by serious flooding during the fieldwork period; selection bias may have been introduced, as only villages in relatively accessible parts of subdistricts with traditional livelihoods were visited, since more remote villages were not accessible due to impassable roads. A transition from forested upland slopes, towards lowland fields near to roads, is well documented in the region (Maharani et al. 2019; Rowland et al. 2022). As such, there is a wide range of practices in different villages, with those closest to main towns and other sources of waged employment more likely to have already transitioned.

Some differences between sites were difficult to assess. For example, in both sites farmers claimed to use minimal chemical inputs, using pesticides when needed, but generally using very little fertilizer or herbicides. However, self-reported fertilizer use is subjective and relative, and without a quantitative survey of pesticide use it is difficult to determine whether differences exist. Likewise, the extent of post-harvest processing of rice is difficult to determine, as farmers used a mix of different hand-powered and petrol-powered machines, and milled rice to different extents.

5.5 Comparisons with other studies

This study finds some similarities and some differences with other studies of rice production in Kapuas Hulu. Table 7 shows a comparison between findings in this study with two recent studies of swidden transitions in Kapuas Hulu (Maharani et al. 2019; Rowland et al. 2022). Each study used different methods and surveyed different types of oil palm and non-oil palm villages[3].

The comparison between studies shows the diversity of swidden practices and the importance of local context. For example, all three studies identified shorter fallow lengths and fields rotated less frequently in oil palm sites, compared with traditional livelihood sites. However, in this study, focus group respondents attributed this to a general scarcity of suitable land for rice cultivation (as well as the cost of this land in the emerging land market) while in Rowland et al. (2022), respondents stated there was no scarcity of suitable land for rice cultivation, and fallows were rotated less frequently mainly to save on the labour required for land clearing.

To some extent, the difference between studies may reflect the choice of study villages. Both Maharani et al. (2019) and Rowland et al. (2022) suggest a general trend towards the relocation of swidden away from upland slopes to areas near roads and villages. Our study found that this had already occurred in the traditional livelihood villages, and that therefore there was little difference between the traditional livelihood and oil palm sites. This difference may merely reflect a difference in sampling. Due to widespread flooding in the region during the fieldwork period, it was only possible to access those traditional villages whose roads were in better condition. As such, these villages are perhaps further along the transition from upland shifting cultivation towards sedentary rice production. This finding serves to emphasize that swidden transitions are occurring even in the absence of oil palm cultivation, and that oil palm may merely be accelerating pre-existing swidden transitions.

Another difference between studies was the use of chemical inputs. In this study, focus group respondents reported minimal use of chemical inputs in both traditional livelihood and oil palm sites, whereas the other two studies report increased use in oil palm sites, compared with traditional livelihood sites. One important factor which may affect chemical use is the access to chemicals on oil

3 In Maharani et al. (2019), oil palm villages consisted half of villages where livelihoods were dependent on oil palm alongside swidden, and half of more traditional swiddening villages (but where men were often absent engaged in migratory labour on oil palm plantations elsewhere). Comparisons were made between pre- and post-oil palm conditions, as well as between oil palm and more traditional swiddening villages. In Rowland et al. (2022) comparisons were made between 13 oil palm and 13 non-oil palm villages. While a few men in households in non-oil palm villages were engaged in migratory oil palm labour, most households were predominantly engaged in traditional swidden cultivation alongside rubber and non-timber forest product (NTFP) collection. Sampling in this study was based upon similar subdistricts where oil palm was either prevalent or not prevalent. Fieldwork was constrained by heavy flooding. As such, villages where research was carried out are likely to be the most accessible within those subdistricts.

palm plantations (whether given to farmers or subsidized by companies, or taken from surplus supplies by workers), as well as local prices, and knowledge and experience of using chemical inputs. Many households also use natural inputs – including organic fertilizer and naturally-derived pesticides – using local ecological knowledge.

Table 7. Comparison of this study with two recent studies on swidden transitions in Kapuas Hulu, West Kalimantan

	Maharini et al. 2019	Rowland et al. 2022	This study
Field location	• Field location differences between TL and OP sites • OP fields nearer to roads; TL fields on upland slopes	• Field location differences between TL and OP sites • OP fields nearer to roads; TL fields on upland slopes	• Field sites in TL and OP sites similar; both close to roads • Both sites have abandoned ancestral use of forested slopes
Field size	NA	No significant difference in rice field area[1]	1–2 fields of between 0.5 and 2 ha (both OP and TL); qualitative data suggests trend towards smaller farm sizes in OP
Land tenure and availability	Transition from public to private tenure	• Customary land tenure in TL sites; mix of customary and formal legal titles in OP sites • Access to swidden land not limited in either TL or OP sites • Market for formal titled land in OP sites	Customary land tenure in TL sites; mix of customary and formal legal titles in OP sites
Rotation frequency	More common in OP to use the same plot consecutively for 4 to 5 years	• Fields are rotated more frequently in TL sites (approx. every 1 to 2 years) • Farmers in OP sites report rotating less frequently to save labour	• 2 to 4-year cycle in TL sites • 3 to 4-year cycle in OP sites
Fallow length	• Shorter fallow length in OP than in TL sites • Reduced clearing of old fallows (>10 years) for planting rice; increased use of newer fallows (2-5 years); plots reused more times consecutively before shifting	Shorter fallow length in OP than in TL sites	Shorter fallow length in OP than in TL sites
Pests, weeds and soil fertility	Shorter fallows lead to more pests and weeds	• Shorter fallows lead to more pests and weeds • Respondents report more rapidly declining soil fertility in OP sites compared with TL sites	Soil fertility said to decline over time in OP site when reusing plots (despite increased use of chemical inputs)

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1 Note that rice fields may contain crops other than rice. Area of rice cultivation was not measured.

Table 7. Continued

	Maharini et al. 2019	Rowland et al. 2022	This study
Use of chemical inputs	• 80% of respondents (across both sites) report using herbicides, pesticides or both in swidden • But frequency, intensity and dependency on chemical inputs higher in OP site	• No significant difference for % of farming households using fertilizers, but significantly more households using herbicides and pesticides in OP than TL sites • Some fertilizers acquired for free from oil palm labour • Mixture of natural and chemical fertilizers used	• Minimal use of fertilizers and herbicides in both OP and TL sites • Pesticides used on as-needed basis in both OP and TL sites
Land clearing	• Easier in OP than TL sites due to smaller trees • More frequent use of hired labour in OP sites replacing traditional *gotong royong*	• Easier in OP than TL sites due to smaller trees • Herbicides used to poison large trees in place of chopping • More frequent use of hired labour in OP sites replacing traditional *go-tong royong*	

Note: TL = traditional livelihood sites; OP = oil palm sites; *gotong royong* = reciprocal labour exchange between families

6 Market-sourced rice in Kapuas Hulu

"Rice from fields has more nutritional value and tastes better. For rice that is sold, the nutritional value has decreased because rice in the market uses pesticide and it is not natural." (IDI F4-STE)

6.1 Types of market rice

Rice markets in Kapuas Hulu consist of both locally produced rice as well as rice produced from outside of the regency. Table 8 shows some commonly available rice varieties in Kapuas Hulu markets, as well as their origin and typical price. Locally produced rice carries a price premium as it is highly desirable due to taste, aroma, and trust that it has been grown with minimal chemical inputs. Supply of locally produced rice is also limited, as few farmers in Kapuas Hulu grow a surplus. Some local varieties of rice can be more than twice as expensive as market rice sourced from outside the regency. As a result, locally produced rice varieties sold in the market, like Raja Uncak and Calon, are considered premium rice, eaten only by those in higher socioeconomic brackets. Market-sourced rice, mainly imported from Pontianak and Sintang and sold in mini-markets, consists of generic brands available in many parts of Indonesia.

Table 8. Common varieties of rice available in Kapuas Hulu markets

Variety	Origin	Subsidized	Price/kg (in IDR)
Beras Kita	Non-local, imported		9,500
BPNT (Beras untuk Pangan Non Tunai)	Central Kalimantan	Yes	12,500
Lumba-Lumba 07	Non-local, imported		10,500
Madu Kuala	Non-local, imported		13,000
Raja Uncak	Kapuas Hulu		24,000
TJ	Non-local, imported		12,000

6.2 Subsidized rice

Kapuas Hulu Regency is primarily made up of subsistence farmers, so rarely produces a surplus of rice and often produces a deficit (Windha 2012; iNewsKalbar 2021). As such, many residents depend on subsidized rice from government programmes. Historically, subsidized rice has been distributed via the *Raskin* ('*Beras untuk Rakyat Miskin*' or 'Rice for the Poor') programme, which despite facing logistical and budgetary challenges, was viewed as an essential source of subsidized rice for many poorer residents (Windha 2012). In 2016 alone, Kapuas Hulu required 213,840 kg of *Raskin* rice, with the amount required varying greatly by subdistrict, ranging from 2,850 kg in Empanang to 9,050 kg in Selimbau (Kupas Merdeka 2016). *Raskin* rice was coordinated centrally via the state logistics agency (Bulog)[4]. *Raskin* rice consisted of a variety of types sourced from a number of locations – all of them outside of Kapuas Hulu – including Java and Sulawesi, as well as internationally from countries like Vietnam (Kupas Merdeka 2016).

4 A major instrument of both food security and agricultural policy is the state logistics agency Bulog (Badan Urusan Logistik). Bulog operates a 'buffer stock' scheme, which stabilizes rice availability and prices by purchasing rice during years with high yields, and selling rice during yields with lower yields. Historically Bulog managed the distribution of subsidized rice under the *Raskin* scheme, a role it still plays – albeit with greater private sector competition – in the replacement *Raskin BPNT.*

Since 2017, *Raskin* (also known as *Beras Sejahtera* or *Rastra*) has been replaced with a non-cash food assistance programme (*Bantuan Pangan Non Tunai*, BPNT). BPNT is managed by the Ministry of Social Affairs under Presidential Regulation No. 63/2017. The programme targets households (*Keluarga Penerima Manfaat*, KPM) classified as the poorest 25% of households in a region (Ilman 2020) and transfers funds to a recipient's electronic payment card (KKS) (KESEMOS n.d.). This payment card can then be redeemed at selected stores in exchange for rice and eggs. While managed by the Ministry of Social Affairs, the majority of rice (up to 70%) is supplied to the programme by Bulog, reminiscent of the *Raskin* scheme (Ilman 2020).

In Kapuas Hulu, BPNT has faced similar challenges to *Raskin*, with logistical constraints, slow or missing disbursements of funds from banks, and poor targeting of households in need (Pontianak Post 2021a, 2021b), reflecting challenges experienced in many other parts of Indonesia (Ilman 2020; Vedy and Juwono 2020). Informants from the Bureau of Logistics in Kapuas Hulu stated that premium BPNT rice is sourced from local rice varieties in Sambas (the neighbouring regency to Kapuas Hulu). While many policymakers have stated a desire to acquire locally produced rice for public distribution, a lack of local production has meant that most of the rice is acquired from outside the regency (iNewsKalbar 2021).

6.3 Participation in rice markets by farmers in field sites

For most farmers interviewed, in both sites, the consumption of market rice only occurs when rice from own production is insufficient. In the oil palm sites however, consumption of market rice is more common than in the traditional sites, as farmers grow around six months' worth of rice a year rather than the 10–12 months' worth of rice produced in traditional sites. Some respondents attributed this to the lack of available land for planting rice. In general, respondents preferred the taste of self-produced rice and had greater trust that the rice was not contaminated by pesticides and fertilizers or adulterated with other contaminants. Local varieties of rice available on the market are also more desirable than rice imported from outside the regency. Some local varieties grown in Kapuas Hulu are also highly desirable in Malaysian Borneo (David and Kartinaty 2019). Raja Uncak – a local variety available in markets and said to be especially flavoursome – fetches an especially high price premium, as demand is high in both the domestic and international markets (Kusnadi 2018).

Despite the desirability of locally produced rice, this price premium means that if any surplus is available at all, locally-grown rice is not sold locally in the village, but rather sold in nearby towns. Thus, a local domestic market for locally produced rice does not exist. Rather than buying surplus rice from other farmers, households buy rice imported from outside of the regency, purchased directly from mini-markets in nearby towns. Some households also have access to subsidized rice via participation in government programmes.

7 Rice varieties of Kapuas Hulu

"*Raja Uncak is the most delicious rice. If you eat this rice with salt, it's already tasty. If you eat this rice, you definitely want to have more. If you have more too often, the rice will run out quickly.*" (IDI F7-JWN)

"*If Calon rice is cooked, the aroma is fragrant and it can be smelled by neighbours across the street.*"(IDI F2-PLN)

A range of different varieties of rice exist across Kalimantan, not all of which have been formally described and documented (Subekti 2014). Table 9 shows a variety of commonly grown rice varieties in Kapuas Hulu. Some local varieties are indigenous to Kapuas Hulu and six varieties (Bale, Balik, Paya Tembakau, Raja Uncak, Sanik, Tutung Adong) are legally recognized as indigenous varieties by the Center for Crop Variety Protection and Agricultural Licensing Secretariat General (PVTPP) of the Ministry of Agriculture.

Table 9. Local varieties of rice grown in Kapuas Hulu, West Kalimantan

Variety	Colour	Rainfed/dryland	Indigenous	IP	Consumed	Sold	Origin
Aseuwe	White				BL		
Badak	White				E		
Bale	White	Rainfed paddy	Yes	Yes			Palau Manak, EH
Balik	White		Yes	Yes		BL*	
C-4	Red		Yes				
Calon	White				BL*		
Jarah	White				BL		
Kelempapak	White				E	E*	
Kucai	White	Rainfed	Yes	Yes			Rantau Prapat, EH
Malaya	Brown				K		
Maranau	White	Dryland	Yes	?			Banau Martinus, EH
Martinus	White				BL		
Ogkok	White				K*	K	
Paya Nymuk	White				BL		
Paya Tembakau	White	Rainfed	Yes	Yes	PS*		Melapi, PS
Raja Uncak	White		Yes	Yes	PS*	PS*	
Ruguk	White	Dryland	Yes	?			Melapi, PS
Sanik	Black		Yes	Yes	PS		
Siam	White				BL		
Subis	White	Rainfed	Yes	?			Rantau Prapat, EH
Tangit	White				E*		
Tempunak	White				K		
Tutung Adong	White		Yes	Yes			Banau Martinus, EH
Uwe	White	Dryland	Yes	?			

Indigenous status refers to whether the variety originates from Kapuas Hulu Regency. IP (Intellectual Property), indicates whether indigenous status is recognized by the PVPP. Codes for subdistricts: K = Kalis, BL = Batang Lupar, PS = Putussibau Selatan, E = Empanang, EH = Embaloh Hulu. An * after the abbreviation indicates that this is the most commonly consumed or sold variety in the subdistrict.

Our study suggests that the majority of rice production in Kapuas Hulu consists of local varieties. Respondents noted large differences between rice varieties in terms of taste, however, respondents vary in their consumption strategies. Some respondents prefer to sell the best tasting varieties, as their market prices are higher than those of less desirable varieties, which are consumed at home; others prefer to consume the better tasting rice. Mixing rice in order to balance economic efficiency and taste is a common practice.

7.1 Locally produced rice

- Raja Uncak is an indigenous rice variety that was patented as an indigenous variety of Kapuas Hulu in 2018 (Kusnadi 2018). It produces a grain that is longer, fluffier and more aromatic than other varieties, and is considered a premium rice. Its desirability is such that it is exported to Malaysian Borneo where there is demand for high quality rice (Hatta and Dadan 2021).
- Calon is also considered a quality rice but is less desirable (and expensive) than Raja Uncak. Calon is cultivated predominantly in the subdistrict of Batang Lupar.
- Ongkok is an indigenous variety of white rice that is widely grown in the subdistrict of Kalis, Kapuas Hulu Regency.
- Sanik Merah is an indigenous variety of red rice grown in Putussibau Selatan.
- Sanik Hitam is a short grain variety of black rice that is widely cultivated in Putussibau Selatan.

7.2 Market-sourced rice

- Beras 07 rice is one of the most popular brands of rice available on the market in Kapuas Hulu due to its affordable price.
- Beras Kita Medium is another widely-consumed type of market rice.
- Beras BPNT is subsidized rice, available through the government BPNT programme for people of low socioeconomic status. The exact variety of rice is unknown, as it comes from the Bulog warehouse. Informants from Bulog stated that much of the BPNT rice is grown in the neighbouring regency of Sambas, West Kalimantan.

8 Rice sampling

Based upon the preliminary research outlined above, we selected a range of rice varieties for nutrient content analysis in the laboratory. To compare potential effects of changing rice cultivation in Kapuas Hulu, we selected both widely consumed indigenous varieties as well as rice varieties available within the local market-based food system. We selected four varieties of indigenous rice for nutritional analysis: Raja Uncak, Ongkok, Calon and Brown Malaya. The most commonly grown and consumed rice variety in each of the three subdistricts was selected for analysis to best approximate the nutritional profile of locally consumed rice. A less commonly consumed local variety of red rice (Sanik Merah) and black rice (Sanik Hitam) were also selected for their potential nutritional properties.

9 Conclusion

Landscape change is interconnected with multiple cultural, economic, social, demographic and agrarian transitions (Rasmussen et al. 2017; Sunderland et al. 2017). Our study suggests that oil palm-driven land-use change is driving changes in rice cultivation and rice purchasing practices. As a result, people in oil palm adopting areas are consuming different varieties of rice than they traditionally would, for more of the year. We propose that, given the variation in nutritional content between rice varieties, and given the large quantities of rice consumed by local people, these changes may have an impact upon nutrient intake of local populations. The basis for deriving this hypothesis described in the report can be summarized as the following:

Past research by the Drivers of Food Choice (DFC) project has shown that oil palm adopting households consumed much greater proportions of their rice from market sources than households carrying out traditional swidden livelihoods. Our qualitative investigation here confirms this, and further adds that oil palm adopting households rely almost entirely on market rice for a large proportion of the year.

Our qualitative investigation revealed great diversity in local rice varieties, which are still planted and widely consumed. Little is known about the nutrient content of these varieties, but variation in nutrient content in indigenous and non-indigenous varieties is significant. Studies conducted in neighbouring Sabah suggest that the mineral content of indigenous rice varieties could have significant contributions towards recommended daily allowances of nutrients, at rice consumption levels considerably lower than in Kapuas Hulu.

This report explored the types of rice available in the market system. It shows that the market-sourced rice that oil palm farmers consume in greater quantities comes from outside the regency. It is also more processed than locally produced rice, and may therefore be nutritionally inferior to indigenous rice.

The preservation of indigenous varieties and landraces is essential for maintaining the genetic diversity of food crops. Indigenous varieties are not only an essential bank of useful adaptive genes, but also a bulwark against genetic uniformity in food crops which poses an existential threat to the food system, increasing the risk of mass pest epidemics and increasing vulnerability to the effects of climate change. It is also likely that these varieties have superior nutrient content compared to commercial-imported varieties, and therefore are better for local health and nutrition.

References

Agus F, Andrade JF, Rattalino Edreira JI, Deng N, Purwantomo DKG, Agustiani N, Aristya VE, et al. 2019. Yield gaps in intensive rice-maize cropping sequences in the humid tropics of Indonesia. *Field Crops Research* 237(May):12–22.

Amien I, Rejekiningrum P, Pramudia A, Susanti E. 1996. Effects of interannual climate variability and climate change on rice yield in Java, Indonesia. *Water Air and Soil Pollution* 92(1–2):29–39.

Anandi AM, Yuliani EL, Moeliono M, Laumonier Y, Narulita S. 2020. Kapuas Hulu: A background analysis to implementing integrated landscape approaches in Indonesia. *In* Reed J, Ros-Tonen MAF, Sunderland T. eds. *Operationalizing Integrated Landscape Approaches in the tropics.* Bogor, Indonesia: CIFOR, pp. 166–204.

BPS (Badan Pusat Statistik Provinsi Kalimantan Barat). 2021. *Statistik Daerah Kabupaten Kapuas Hulu 2021.* Kapuas Hulu Regional Statistics 2021.

BPS. 2018. *Produksi Padi Menurut Provinsi (Ton), 1993–2015.* BPS. https://www.bps.go.id/dynamictable/2015/09/09/865/produksi-padi-menurut-provinsi-ton-1993-2015.html.

BPS. 2017. *Hasil Survei Struktur Ongkos Usaha Tanaman Padi 2017 (SOUT2017-SPD) Provinsi Kalimantan Barat*.ISBN 978-602-438-180-6. BPS.

Barokah U, Susanto U, Swamy M, Djoar DW, Parjanto. 2018. High-zinc rice as a breakthrough for high nutritional rice breeding program. *IOP Conference Series Earth and Environmental Science* 129(1)012004.

Broegaard RB, Rasmussen LV, Dawson N, Mertz O, Vongvisouk T, Grogan K. 2017. Wild food collection and nutrition under commercial agriculture expansion in agriculture-forest landscapes. *Forest Policy and Economics.* https://doi.org/10.1016/j.forpol.2016.12.012.

Budi S. 1997. *Variasi Jenis Padi.* Thesis. Bandung, Indonesia: Padjajaran University.

Byerlee D, Falcon W, Naylor R. 2017. *The Tropical Oil Crop Revolution.* Oxford University Press.

Cakmak I and Kutman UB. 2018. Agronomic biofortification of cereals with zinc: A review. *European Journal of Soil Science* 69(1):172–180.

Chrisendo D, Krishna VV, Siregar H, Qaim M. 2020. Land-use change, nutrition, and gender roles in Indonesian farm households. *Forest Policy and Economics* 118(September):102245.

Colfer C. 2008. *The Longhouse of the Tarsier: Changing Landscapes, Gender and Well Being in Borneo.* Borneo Research Council.

Colfer C. 1991. Indigenous rice production and the subtleties of culture change: An example from Borneo. *Agriculture and Human Values* 8(1–2):67–84.

Cramb RA, Colfer C, Dressler W, Laungaramsri P, Trang Le Q, Mulyoutami E, Peluso N, Wadley RL. 2009. Swidden transformations and rural livelihoods in Southeast Asia. *Human Ecology* 37(3):323–346.

Dass A and Dhar S. 2014. Irrigation management for improving productivity nutrient uptake and water-use efficiency in system of rice intensification: A review. *Annals of Agricultural Research* 35(2). https://www.academia.edu/download/77168749/18705.pdf.

David JH and Kartinaty T. 2019. Karakteristik mutu beras di berbagai penggilingan pada sentra padi di Kalimantan Barat. *Journal TABARO Agriculture Science* 3(1):276–286.

Davidson JS. 2018. Then and now: Campaigns to achieve rice self-sufficiency in Indonesia. *Bijdragen Tot de Taal-, Land- En Volkenkunde / Journal of the Humanities and Social Sciences of Southeast Asia* 174(2–3):188–215.

Dove MR. 1993. Smallholder rubber and swidden agriculture in Borneo: A sustainable adaptation to the ecology and economy of the tropical forest. *Economic Botany.* http://www.springerlink.com/index/Y712557716217257.pdf.

Dove MR. 1985. Swidden agriculture in Indonesia. The subsistence strategies of the Kalimantan Kantu. New Babylon. *Studies in the Social Sciences* 43.

Dove MR. 1981. Household composition and intensity of labour: A case study of the Kantu' of West Kalimantan. *Bulletin of Indonesian Economic Studies.* https:// doi.org/10.1080/000749181123313 34069.

Dove MR. 1983. Theories of swidden agriculture, and the political economy of ignorance. *Agroforestry Systems*. https://doi.org/10.1007/BF00596351.

Dressler WH, Smith W, Montefrio MJF. 2018. Ungovernable? The vital natures of swidden assemblages in an upland frontier. *Journal of Rural Studies* 61(July):343–354.

Dressler WH, Wilson D, Clendenning J, Cramb R, Keenan R, Mahanty S, Bruun TB, Mertz O, Lasco RD. 2017. The impact of swidden decline on livelihoods and ecosystem services in Southeast Asia: A review of the evidence from 1990 to 2015. *Ambio* 46(3):291–310.

Eggum BO, Juliano BO, Villareal CP, Perez CM. 1984. Effect of treatment on composition and protein and energy utilization of rice and mung bean by rats. *Plant Foods for Human Nutrition* 34(4):261–272.

Erythrina E, Anshori A, Bora CY, Dewi DO, Lestari MS, Mustaha MA, Ramija KE, et al. 2021. Assessing opportunities to increase yield and profit in rainfed lowland rice systems in Indonesia. *Agronomy* 11(4):777.

Euler M, Krishna V, Schwarze S, Siregar H, Qaim M. 2015. Oil palm adoption, household welfare and nutrition among smallholder farmers in Indonesia. *World Development* 219–235.

FAO (Food and Agriculture Organization of the United Nations). 2018. *Rice Market Monitor*. FAO. https://www.fao.org/3/I9243EN/i9243en.pdf.

Goldstein J. 2016. *Carbon bomb: Indonesia's failed Mega Rice Project.* Arcadia. https://arcadia.ub.uni-muenchen.de/arcadia/article/view/100.

Hashmi MI and Tianlin JS. 2016. Minerals contents of some indigenous rice varieties of Sabah Malaysia. I *International Journal of Agriculture, Forestry and Plantation* 2:31–234.

Hasudungan A. 2018. *Political ecology of palm oil development in the Kapuas Hulu District of West Kalimantan.* https://ses.library.usyd.edu.au/handle/2123/18976.

Hatta M, Azri H, Dadan P. 2021. Utilization ameliorant for improvement productivity of 'Raja Uncak' local rice in Kapuas Hulu Regency West Kalimantan. *E3S Web of Conferences* 306: 01024.

Heisey P and Day-Rubenstein K. 2015. *Using crop genetic resources to help agriculture adapt to climate change: Economics and policy.* USDA-ERS Economic Information. https://doi.org/10.2139/ssrn.2709190.

Hendra M, Guhardja E, Setiadi D, Baroto Walujo E, Purwanto Y. 2009. Cultivation practices and knowledge of local rice varieties among Benuaq farmers in Muara Lawa District West Kutai, East Kalimantan-Indonesia. *Biodiversitas: Journal of Biological Diversity* 10(2). https://doi.org/10.13057/biodiv/d100208.

Huang S, Wang P, Yamaji N, Feng Ma J. 2020. Plant nutrition for human nutrition: Hints from rice research and future perspectives. *Molecular Plant* 13(6):825–835.

IRRI (International Rice Research Institute). 2020. *Indonesia and IRRI*. http://books.irri.org/Indonesia_IRRI_brochure.pdf.

Ickowitz A, Rowland D, Powell B, Salim MA, Sunderland T. 2016. Forests, trees, and micronutrient-rich food consumption in Indonesia. *PloS One* 11(5):1–15.

Ilman AS. 2020. *Effects of high food prices on non-cash food subsidies (BPNT) in Indonesia: Case study in East Nusa Tenggara.* Policy Paper No. 26. Center for Indonesian Policy Studies. https://repository.cips-indonesia.org/media/300890-effects-of-high-food-prices-on-non-cash-96273002.pdf.

iNewsKalbar. 2021. *Duh, Kapuas Hulu Kekurangan 30.000 Ton Beras Setiap Tahun.* 20 June 2021. https://kalbar.inews.id/berita/duh-kapuas-hulu-kekurangan-30000-ton-beras-setiap-tahun

Iskandar BS, Iskandar J, Partasasmita R. 2018. Strategy of the outer Baduy community of South Banten (Indonesia) to sustain their swidden farming traditions by temporary migration to non-Baduy areas. *Biodiversitas: Journal of Biological Diversity* 19(2):453–464.

Iskandar J and Iskandar BS. 2017. Kearifan ekologi orang Baduy dalam konservasi padi dengan 'sistem leuit'. *Jurnal Biodjati* 2(1):38–51.

Ismachin M and Sobrizal. 2006. *A significant contribution of mutation techniques to rice breeding in Indonesia*. https://www.osti.gov/etdeweb/biblio/20880304.

Joy EJM, Kalimbira AA, Sturgess J, Banda L, Chiutsi-Phiri G, Manase H, Gondwe J, et al. 2021. Biofortified maize improves selenium status of women and children in a rural community in Malawi: Results of the addressing hidden hunger with agronomy randomized controlled trial. *Frontiers in Nutrition*. https://doi.org/10.3389/fnut.2021.788096.

Juliano BO. 1985. Factors affecting nutritional properties of rice protein. *Transactions National Academy of Science and Technology* 7:205–216.

KESEMOS. n.d. *Bantuan Pangan Non Tunai (BPNT), Non-Cash Food Assistance (BPNT).* Accessed 28 December 2021. https://pusdatin.kemensos.go.id/en/bantuan-pangan-non-tunai-bpnt.

KKRI (Kementerian Kesehatan Republik Indonesia). 2018. *Indonesian Food Composition Data - Home*. https://www.panganku.org/en-EN/view.

Kennedy G, Burlingame B, Nguyen N. 2002. Nutrient impact assessment of rice in major rice consuming countries. *Korea & World Affairs* 165(23.3):12–15.

Kota S, Senguttvelu P, Rao DS, Mandal BN, Yadav AS. 2019. Evaluation of aromatic short grain rices under direct-seeding for yield and yield components. *International Journal of Current Microbiology and Applied Sciences*. https://www.researchgate.net/profile/Arunasri-Perugu/publication/331346781_Evaluation_of_Aromatic_Short_Grain_Rices_Oryza_sativa_L_Under_Direct_Seeding_for_Yield_and_Yield_Components/links/5c752a53299bf1268d25ef1a/Evaluation-of-Aromatic-Short-Grain-Rices-Oryza-sativa-L-Under-Direct-Seeding-for-Yield-and-Yield-Components.pdf.

Kupas Merdeka. 2016. *Bulog Siapkan Pasokan Beras Untuk Kabupaten Kapuas Hulu.* 25 April 2016. https://www.kupasmerdeka.com/2016/04/bulog-siapkan-pasokan-beras-untuk-kabupaten-kapuas-hulu/.

Kusnadi. 2018. *Kapuas Hulu Sudah Patenkan Beras Raja Uncak.* 17 May 2018. https://infopublik.id/read/269462/kapuas-hulu-sudah-patenkan-beras-raja-uncak.html.

Labrière N, Laumonier Y, Locatelli B, Vieilledent G, Comptour M. 2015a. Ecosystem services and biodiversity in a rapidly transforming landscape in northern Borneo. *PloS One* 10(10):1–18.

Labrière N, Locatelli B, Laumonier Y, Freycon V and Bernoux M. 2015b. Soil erosion in the humid tropics: A systematic quantitative review. *Agriculture, Ecosystems & Environment* 203(May):127–139.

Leonald L and Rowland D. 2016. Drivers and effects of agrarian change in Kapuas Hulu Regency, West Kalimantan, Indonesia. *In* Deakin E, Kshatriya M, Sunderland T. eds. *Agrarian Change in Tropical Landscapes.* Bogor, Indonesia: CIFOR, pp. 91–138.

Lopes MS, El-Basyoni I, Baenziger PS, Singh S, Royo C, Ozbek K, Aktas H, et al. 2015. Exploiting genetic diversity from landraces in wheat breeding for adaptation to climate change. *Journal of Experimental Botany* 66(12):3477–3486.

Lowe NM, Zaman M, Hall Moran V, Ohly H, Sinclair J, Fatima S, Broadley MR, et al. 2020. Biofortification of wheat with zinc for eliminating deficiency in Pakistan: Study protocol for a cluster-randomised, double-blind, controlled effectiveness study (BIZIFED2). *BMJ Open* 10(11): e039231.

Maclean J, Hardy B and Hettel G. 2013. *Rice Almanac, 4th Edition: Source Book for One of the Most Important Economic Activities on Earth*. IRRI.

Maharani CD, Moeliono M, Wong GY, Brockhaus M, Carmenta R, Kallio M. 2019. Development and equity: A gendered inquiry in a swidden landscape. *Forest Policy and Economics* 101(October 2018):120–128.

Mandal B, Hazra GC, Mandal LN. 2000. Soil management influences on zinc desorption for rice and maize nutrition. *Soil Science Society of America* 64(5):1699–1705.

Manzeke-Kangara MG, Joy EJM, Mtambanengwe F, Chopera P, Watts MJ, Broadley MR, Mapfumo P. 2021. Good soil management can reduce dietary zinc deficiency in Zimbabwe. *CABI Agriculture and Bioscience* 2(1). https://doi.org/10.1186/s43170-021-00057-4.

Merang OP, Lahjie AM, Yusuf S, Ruslim Y. 2020. Productivity of three varieties of local upland rice on swidden agriculture field in Setulang Village, North Kalimantan, Indonesia. *Biodiversitas: Journal of Biological Diversity* 21(1). https://doi.org/10.13057/biodiv/d210108Mercer KL and Perales HR. 2010. Evolutionary response of landraces to climate change in centers of crop diversity. *Evolutionary Applications* 3(5–6):480–493.

Muleya M, Young SD, Reina SV, Ligowe IS. 2021. Selenium speciation and bioaccessibility in se-fertilised crops of dietary importance in Malawi. *Journal of Foodservice.* https://www.sciencedirect.com/science/article/pii/S0889157521000417.

Muralikrishnan L, Padaria RN, Dass A, Choudhary AK, Kakade B, Shokralla S, Zin El-Abedin TK, Almutairi KF, Elansary HO. 2021. Elucidating traditional rice varieties for consilient biotic and abiotic stress management under changing climate with landscape-level rice biodiversity. *Land* 10(10):1058.

Muthayya S, Sugimoto JD, Montgomery S, Maberly GF. 2014. An overview of global rice production, supply, trade, and consumption. *Annals of the New York Academy of Sciences* 1324 (September):7–14.

Nakano H, Morita S, Hattori I, Sato K. 2008. Effects of planting time and cultivar on dry matter yield and estimated total digestible nutrient content of forage rice in southwestern Japan. *Field Crops Research* 105(1):116–123.

Nakano K. 2014. An essay on the Boserupian model with particular emphasis on labour input and productivity in upland rice swiddens in Southeast Asia. *Tropics* 23(1):1–14.

Neilson J and Wright J. 2017. The state and food security discourses of Indonesia: Feeding the Bangsa. *Geographical Research* 55(2):131–143.

Okushima M. 1999. Wet rice cultivation and the Kayanic Peoples of East Kalimantan: Some possible factors explaining their preference for dry rice cultivation (1). Research Notes. *Borneo Research Bulletin* 74+.

Padoch C and Peluso NL. 1996. *Borneo in Transition: People, Forests, Conservation, and Development.* Oxford University Press, USA.

Padoch, Christine, Emily Harwell, Susanto A. 1998. Swidden, sawah, and in-between: agricultural transformation in Borneo. Human Ecology 26(1): 3-20.

Padoch C, Coffey K, Mertz O, Leisz SJ, Fox J, Wadley RL. 2007. The demise of swidden in Southeast Asia? Local realities and regional ambiguities. *Geografisk Tidsskrift - Danish Journal of Geography* 107(1):29–41.

Panuju DR, Mizuno K, Trisasongko BH. 2013. The dynamics of rice production in Indonesia 1961–2009. *Journal of the Saudi Society of Agricultural Sciences* 12(1):27–37.

Pasolon YB, Borromeu MDR, Muhidin. 2016. Diversity and agronomic features of indigenous upland rice in Southeast Sulawesi, Indonesia. *Advances in Environmental Biology* 10 (June):49.

Pfeiffer JM, Dun S, Mulawarman B, Rice KJ. 2006. Biocultural diversity in traditional rice-based agroecosystems: Indigenous research and conservation of Mavo (*Oryza Sativa* L.) upland rice landraces of eastern Indonesia. *Environment, Development and Sustainability* 8(4):609–625.

Pletsch EA and Hamaker BR. 2018. Brown rice compared to white rice slows gastric emptying in humans. *European Journal of Clinical Nutrition* 72(3):367–373.

Pontianak Post. 2021a. *Data Bansos Banyak Tidak Valid.* 29 November 2021. https://pontianakpost.co.id/data-bansos-banyak-tidak-valid/.

Pontianak Post. 2021b. *Sebelas Ribu Warga Kalbar Belum Terima Dana Bansos.* 5 November 2021. https://pontianakpost.co.id/sebelas-ribu-warga-kalbar-belum-terima-dana-bansos/.

Potter L. 2001. Agricultural intensification in Indonesia: Outside pressures and indigenous strategies. *Asia Pacific Viewpoint* 42(2–3):305–324.

Potter L. 2011. Swidden, oil palm, and food security in West Kalimantan. *Kasarinlan: Philippine Journal of Third World Studies* 26:252–263.

Purwanto SA. 2018. Back to the river: Changing livelihood strategies in Kapuas Hulu West Kalimantan. *Forests, Trees and Livelihoods*. https://doi.org/10.1080/14728028.2018.1446849.

Purwestri RC, Powell B, Rowland D, Wirawan NN, Waliyo E, Lamanepa M, Habibie Y, Ickowitz A, et al. 2019. *From growing food to growing cash: Understanding the drivers of food choice in the context of rapid agrarian change in Indonesia.* CIFOR Infobrief No. 263. Bogor, Indonesia: CIFOR. https://www.cifor.org/knowledge/publication/7360/.

Rabbani GH and Ali M. 2009. Rice bran: A nutrient-dense mill-waste for human nutrition. *The ORION Medical Journal* 32(3):694–701.

Rahman S, Sharma MP, Sahai S. 2006. Nutritional and medicinal values of some indigenous rice varieties. *Indian Journal of Traditional Knowledge.* http://nopr.niscair.res.in/handle/123456789/6939.

Rahman W, Brehm JM, Maxted N. 2019. Setting conservation priorities for the wild relatives of food crops in Indonesia. *Genetic Resources and Crop Evolution* 66(4):809–824.

Raintree JB and Warner K. 1986. Agroforestry pathways for the intensification of shifting cultivation. *Agroforestry Systems* 4(1):39–54.

Rasmussen L, Watkins C, Agrawal A. 2017. Forest contributions to livelihoods in changing agriculture-forest landscapes. *Forest Policy and Economics* 84:1–8.
Rathna PTS, Nelson A, Ravichandran K, Antony U. 2019. Nutritional and functional properties of coloured rice varieties of South India: A review. *Journal of Ethnic Foods* 6(1):11.
Rohaeni WR and Susanto U. 2021. Fe and Zn content of various genetic background of released rice varieties in Indonesia. *IOP Conference Series Earth and Environmental Science* 752(1):012057.
Rondhi M, Khasan AF, Mori Y, Kondo T. 2019. Assessing the role of the perceived impact of climate change on national adaptation policy: The case of rice farming in Indonesia. *Land* 8(5):81.
Rowland D, Zanello G, Waliyo E, Ickowitz A. 2022. Oil palm and gendered time use: A mixed-methods case study from West Kalimantan, Indonesia. *Forest Policy and Economics* 137 (April):102682.
Rumanti, Indrastuti A, Hairmansis A, Nugraha Y, Nafisah, Susanto U, Wardana P, Subandiono RE, et al. 2018. Development of tolerant rice varieties for stress-prone ecosystems in the coastal deltas of Indonesia. *Field Crops Research* 223(June):75–82.
Saito K, Asai H, Zhao D, Laborte AG, Grenier C. 2018. Progress in varietal improvement for increasing upland rice productivity in the tropics. *Plant Production Science* 21(3):145–158.
Schmidt-Vogt D, Leisz SJ, Mertz O, Heinimann A, Thiha T, Messerli P, Epprecht M, et al. 2009. An assessment of trends in the extent of swidden in Southeast Asia. *Human Ecology* 37(3):269–280.
Sibhatu KT. 2019. Oil palm boom and farm household diets in the tropics. *Frontiers in Sustainable Food Systems* 3(September):75.
Sleet P. 2020. *The state of Indonesian food security and nutrition.* Strategic analysis paper. Future Directions International. https://www.futuredirections.org.au/wp-content/uploads/2020/02/The-State-of-Indonesian-Food-Security-and-Nutrition.pdf.
Smith MR and Myers SS. 2019. Global health implications of nutrient changes in rice under high atmospheric carbon dioxide. *GeoHealth* 3(7):190–200.
Soemarwoto R. 2007. Kasepuhan rice landrace diversity, risk management, and agricultural modernization. *Modern Crises and Traditional Strategies: Local Ecological Knowledge in Island Southeast Asia* 6:84–111.
Subekti A. 2014. *Karakteristik dan pola kekerabatan plasma nutfah padi beras merah di Kalimantan Barat.* http://repository.pertanian.go.id/bitstream/handle/123456789/11973/Karakteristik2015.pdf?sequence=1.
Sulistyawati E, Noble IR, Roderick ML. 2005. A simulation model to study land use strategies in swidden agriculture systems. *Agricultural Systems* 85(3):271–288.
Sunderland T, Abdoulaye R, Ahammad R, Asaha S, Baudron F, Deakin E, Duriaux J-Y, et al. 2017. A methodological approach for assessing cross-site landscape change: Understanding socio-ecological systems. *Forest Policy and Economics* 84 (November):83–91.
Thrupp LA. 2000. Linking agricultural biodiversity and food security: The valuable role of agrobiodiversity for sustainable agriculture. *International Affairs* 76(2):265–281.
Timmer P. 2004. *Food security in Indonesia: Current challenges and the long-run outlook.* Working Paper No. 48. Center For Global Development.
USDA (United States Department of Agriculture). 2016. *Indonesia: Rice Production Prospects Reduced by El Nino.* USDA Foreign Agricultural Service. 9 March 2016. https://ipad.fas.usda.gov/highlights/2016/03/Indonesia/Index.htm.
Utami R, Rusmana F, Susiyanti SRE, Sjaifuddin. 2019. *Physical properties of Indonesian local rice varieties.* https://doi.org/10.1088/1755-1315/383/1/012026.
Van Noordwijk M, Mulyoutami E, Sakuntaladewi N, Agus F. 2008. *Swiddens in transition: Shifted perceptions on shifting cultivators in Indonesia.*
Vedy NK and Juwono V. 2020. *Analysis of the implementation of non-cash food assistance (BPNT) program for reducing poverty in sub-district Panjang, Bandar Lampung 2018.* https://doi.org/10.4108/eai.30-10-2019.2299419.
Wadley RL and Mertz O. 2005. Pepper in a time of crisis: Smallholder buffering strategies in Sarawak, Malaysia and West Kalimantan, Indonesia. *Agricultural Systems* 85(3):289–305.
Warr P and Yusuf AA. 2014. Fertilizer subsidies and food self-sufficiency in Indonesia. *Agricultural Economics* 45(5):571–588.

Windha. 2012. Implementasi Program Beras Miskin (Raskin) di desa Sejiram Kecamatan Seberuang Kabupaten Kapuas Hulu. *Jurnal Governance* 1(1). http://jurmafis.untan.ac.id/index.php/governance/article/view/42.

Yu S and Tian L. 2018. Breeding major cereal grains through the lens of nutrition sensitivity. *Molecular Plant* 11(1):23–30.

Zhang G, Malik VS, Pan A, Kumar S, Holmes MD, Spiegelman D, Lin X, Hu FB. 2010. Substituting brown rice for white rice to lower diabetes risk: A focus-group study in Chinese adults. *Journal of the American Dietetic Association* 110(8):1216–1221.

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CIFOR-ICRAF Working Papers **contain preliminary or advanced research results on important tropical forest issues that need to be published in a timely manner to inform and promote discussion. This content has been internally reviewed but has not undergone external peer review.**

Traditional swidden rice cultivation in Kapuas Hulu consists of long-fallow cycles practiced on forested slopes. As oil palm development accelerates swidden transitions, these traditional practices are increasingly replaced by modified swidden systems which incorporate shorter fallows, and less forest regeneration.

This report documents changes in rice cultivation practices and the types and varieties of rice cultivated among smallholder farmers. Using a mix of primary and secondary data, this report highlights the great diversity of local varieties of rice still cultivated — many of which are indigenous to the region. However, as oil palm adopting households alter their cultivation practices, locally produced rice appears to comprise a smaller proportion of rice consumption and a smaller share of rice available in the market food system.

The nutritional consequences of these transitions are as yet unknown. Existing Food Composition Tables (FCT) for rice consist of only a few varieties and comparisons between locally produced and market origin rice are not available. However, many indigenous rice varieties have been shown to be nutritionally superior to higher-yielding alternatives commonly found in market systems. Given the significant quantities of rice being consumed, even small differences in nutrient content may have effects on nutrient intake and nutritional adequacy.

This report recommends investigation of the nutritional effects of changes in swidden rice transitions. An urgent priority is the nutritional analysis of indigenous rice varieties to be included in local and national FCTs. Such improved tables can then be used to model nutritional effects at the population level of changes in swidden rice cultivation and local food systems, and provide agricultural and health program planners with actionable recommendations to improve the health and nutrition of local populations.

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