UNDERSTANDING THE POTENTIAL OF MUNG BEAN VALUE-CHAINS IN THE LAO PDR

Chitpasong KOUSONSAVATH, NUOL

Isabelle VAGNERON, CIRAD

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1. INTRODUCTION

The mung bean market study was organized in four provinces of the Lao PDR: Vientiane capital, and Vientiane, Xayabouly and Xiengkhuang provinces. The main focus of the study in Vientiane Capital was to understand the demand, supply and consumption of mung beans in the capital. The study also aimed to assess whether the mung beans grown in Vientiane, Xayabouly and Xiengkhuang provinces were available in Vientiane capital or not, and if not, where the mung bean used in the capital came from. For Vientiane, Xayabouly and Xiengkhuang provinces the study focused on the farmers and on the main intermediaries involved in the mung value-chain.

Figure 1 – Study sites

Xayabouly province is located in the northern part of Laos, around 300Km away from Vientiane capital with a relatively good road condition to the city center of the province. The most important agriculture of the Xayabouly are feed corn, job's tears and cassava. The Borten, Kenthao and Paklay districts are the three main production areas of these crops. In 2017, more than 39,00ha allocated for feed corn and the total production of 206,000T. The job's tear is the second largest production crops with the total area of 27,807ha and total production of 81,800T and the third most important crop is cassava with 24,172ha of production area and 877,333T of production (PAFO stat, 2017). The province shares border Loei province of Thailand, and in the Lao side is Kenthao district at the Heuang River checking point of the province. This checking point is the main exportation market for feed corn and cassava, however some of feed corn is also export to Vietnam. Xayabouly is also well known for red bean, pea nut and sesame production and some of mung bean selling in Vientiane capital is coming from Xayabouly.

Xiengkhuang province is located to the northern region of Laos, but under the classification of the government, Xiengkhuang is located in the central region of the country. Xiengkhuang province is well known for several agriculture products, such as: livestock, especially cattle, maize and some other products like silk and pine tree. In 2017, Xiengkhuang has more than 150,000cattle and 57,000buffalo and the livestock is mainly export to China and Vietnam. Maize is another important crop for Xiengkhuang with 21,000ha and the total production of 107,970T in 2017, silk product and pine tree are also classified under the strategic crops that the provincial governor is targeted to promote. There are some production of soybean, mung

bean and peanut but not very significant compare to other provincial strategic crops (Agricultural Statistics Yearbook 2017).

Vientiane province is around an hour drive from Vientiane capital, the province is also well known for livestock production, especially cattle and buffalo, the well-known livestock production group is also form and located in this province. In 2017, the province has more than 177,000 heads of cattle and 61,000 buffalo, which is more than the total number of cattle and buffalo in Xiengkhuang. The province is also producing sweet corn and feed corn for the food processing and animal feed factory and the total production of maize in 2017 is 59,000T and total production area of 9,595ha. There are some other important crops grown in this province also, for example starchy roots (taro) production in 2017 has more than 131,000T, cassava has more than 118,000T and Job's tears 61,000T. The vegetable production is also very important for Vientiane province, in the same period of time Vientiane province produced more than 112,000T of vegetable, the biggest vegetable producer in the central region (Agricultural Statistics Yearbook 2017). There are mung bean production in Thoulakom district but the production is very limited.

Vientiane capital agricultural production is mainly vegetable crops. For example, leafy vegetable production in the central region, Vientiane capital comes as the third largest vegetable production after Vientiane province and Savannakhet province. There are some livestock production also in Vientiane capital mainly in Pakngume, Xaythany and Sangthong districts. And in 2017, there are around 84,000heads and 15,000heads of buffalo (Agricultural Statistics Yearbook 2017). Vientiane capital in the center of agricultural production trade with some big wholesale markets are operating close to the city center. These agricultural products are coming from across the country, from the northern region, southern region and importing from neighboring country. The most important place for mung bean production is in Sangthong district and Pakngume district and the mung bean production is mainly sell in the markets in Vientiane capital and supply as raw material to bean sprout processing factory.

1.1. Study Objectives

The mung bean market study was organized in four provinces of the Lao PDR: Vientiane capital, and Vientiane, Xayabouly and Xiengkhuang provinces. The main focus of the study in Vientiane Capital was to understand the demand, supply and consumption of mung beans in the capital. The study also aimed to assess whether the mung beans grown in Vientiane, Xayabouly and Xiengkhuang provinces were available in Vientiane capital or not, and if not, where the mung bean used in the capital came from. For Vientiane, Xayabouly and Xiengkhuang provinces the study focused on the farmers and on the main intermediaries involved in the mung value-chain.

The general objective of the study was to analyze the mung bean (vigna radiata) value-chain in the Lao PDR. The idea was to identify market opportunities that may be both available for and accessible to smallholder mung bean farmers. Beyond the case of mung beans, the objective was to develop a more general method of analyzing value-chains for Neglected and Underutilized Species (NUS).

Specific objectives of the study included understanding:

- the reasons behind the limited use of mung beans relative to their economic potential;
- the conditions for a successful commercialization of mung beans;
- potential market-led opportunities for smallholder mung bean producers;
- The strategies that may be developed to help smallholders and their communities take advantage of these opportunities.

1.2. Methodology

A snow-balling method was adopted for this survey. A preliminary market study was conducted in Vientiane Capital to understand the current supply, demand and utilization of mung bean. This involved interviewing restaurant owners (focus on well-known and relatively large noodle shops). The research team also conducted interviews with those in charge of trading dry mung beans and bean sprouts on wholesale and retail markets in Vientiane. In Vientiane, Xayabouly and Xiengkhuang provinces, interviews were conducted with individual farmers, traders, collectors, exporters as well as with local authorities

Primary data collection was based on semi-structured interviews. Participants to be interviewed were purposefully selected, provided their business activities formed part of the mung bean value chain in regions of interest to the project. The research does not aim to be considered as statistically representative, but rather aims to identify themes which represent opportunities and challenges for smallholder farmers.

Reverse value chain analysis was used to understand the operation of the mung bean value-chain. The surveys started at end-markets in Vientiane and in Xieng Khouang (i.e., retail markets, restaurants, noodle factories) and proceeded upstream towards mung bean producers based in producing areas supplying these cities as shown in Map 1 –*e.g.*, Vientiane Capital, Vientiane Province, Xayabouly, Xieng Khouang.

The mung bean market survey was conducted in Vientiane Capital as Vientiane Capital has the highest concentration of retailers, wholesalers and consumers in the country. The main objective was to find out where mung beans came from and what kind of products mung beans were used for. The interviews with retailers, wholesalers and restaurants in Vientiane were organized in several main markets of Vientiane Capital. The market study was divided into two different levels of trade (wholesale and retail). Interviews were carried out in four

retail markets: Huakhua, Nonsavang, Khuadin and Phonetong markets. The main wholesale markets included in the survey were the *i.e.* Lao-Aussie market, Nonhai and Nonkhor markets. Observations were also made at premium supermarkets and convenient stores. Finally, restaurants (especially noodle shops) were included as soups are commonly served with sprouted mung beans and herbs.

In Vientiane Capital and in Xieng Khouang province the surveys started at the main retail markets, selected large restaurants selling traditional soups and with noodle processors. The surveys then moved up the value-chain towards the stakeholders involved in supplying the retailers/restaurants/processors initially interviewed with sprouted or dried mung beans.

Interview guidelines focused on the following topics (for different categories of stakeholders):

- end-users: volumes, prices, quality standards, seasonality, frequency of purchases, main buyers and location of buyers, etc.
- traders/middlemen: volumes, prices, quality standards, location of purchase, main distribution channels, etc.
- farmers: farmers profile such as: production area, variety of mung bean, production system, production calendar, main trading system and traders, etc.

Table 1 – Sample size

Stakeholder	VC		VP		XY	XK		Total
	Bean	Sprout	Bean	Sprout	Bean	Bean	Sprout	
Retailers	12	12	-	-	-	1	1	26
Restaurant	-	5	-	-	-	-	3	8
Wholesaler (trader)	-		-	-	1	-	-	1
Processor		2	-	1	-		4	7
Collector/trader	3	-	2	-	2	-	-	**7**
Producer	30		8	-	14	0	-	52
Soy bean producer	-	-	-	-	-	22	-	22
Red bean producer	-	-	-	-	-	6	-	6
Total	**45**	**19**	**10**	**1**	**17**	**28**	**9**	**129**

Note: VC= Vientiane capital, VP= Vientiane province, XY= Xayabouly, XK= Xiengkhuang

In Xiengkhuang, the survey team started the survey by discussing with the provincial agriculture and forestry office and the EFICAS project coordinator to understand the production and trade system of mung bean. However, after the discussion, especially with the project coordinator, the mung bean has not been promoted by the project, only red bean or rice bean and soy bean are promoted. Thus, this is left with the research team to find out about the source of mung bean from the bean sprout producer.

1.3. Definitions and concepts: what are we talking about?

1.3.1. Mung beans

Mung bean (*Vigna Radiata* L. Wilczek) is a fast-growing, warm-season legume. It is an annual crop, cultivated mostly in rotation with cereals (rice, wheat). This highly branched plant can reach about 60-76 cm tall and produces approximately 7.5 cm long pods containing about a dozen small green or gold-colored seeds. It reaches maturity very quickly under tropical and sub-tropical conditions. Mung bean is deep rooted and its leaves are trifoliate like other legumes. The pale yellow flowers are borne in clusters of 12-15 near the top of the plant (Sharasia *et al.,* 2017). Mung bean is commonly known in Asia as the green gram[1]. Seed color is usually a dark olive green or yellow, but some cultivars produce brown or black seed (Rubatzky and Yamaguchi, 1997).

In terms of uses, the mung bean plant offers a wide range of possibilities:

- the beans can be *dried and stored* for use at a later date –dried mung beans enter the composition of sweets such as sticky rice cakes or may be used to make noodles, although cassava and rice noodles may be cheaper;
- the beans can be *germinated* and eaten raw as sprouts (e.g., in Southeast Asian noodle soups);
- the beans can be *split and cooked* with spices (as in dahl);
- the *whole plant* can be used as fodder. Current mung bean prices make this possibility quite theoretical as cheaper sources of animal feed exist.
- mung bean *by-products* (bran, hull, straw) can also be used for animal feed.

Furthermore, as a good source of dietary protein and contains vitamin A, amino-acids, iron, calcium, zinc and folate, mung bean can be promoted in rural areas to achieve nutritional security (Table 2).

Table 2– Nutrient content of mung bean in various forms

Nutrient	Raw	Mashed/ flour	Noodles	Sprouts	Dry
Kilocalories	306.0	361.5	381.0	61.0	116.0
Protein (g)	20.3	24.5	0.3	6.6	7.7
Vitamin A (RE)	5.0	6.0	0.0	1.0	2.0
Vitamin C (mg)	0.0	0.0	0.0	8.0	0.0
Iron (mg)	6.6	6.4	0.5	1.1	2.5
Zinc (mg)	3.4	3.7	0.1	0.6	1.3
Folate (µg)	549.0	499.5	0.0	86.0	208.0
Amino acids (g)	10.2	12.0	0.1	3.1	3.9
Lysine (g)	1.6	1.9	0.0	0.5	0.6

Source: Huijie (2003).

[1] Other popular names include golden gram, moong, and chop suey bean.

This is a crucial feature for the Lao PDR, a country with one of the highest rates of chronic malnutrition in Southeast Asia[2].

Last but not least, planting mung bean improves soil properties and provides additional nitrogen to subsequent crops. According to Weinberger (2003), rice yields following a mung bean intercrop can increase by up to 8% through the nitrogen fixed by mung bean in the soil and due to reduced pest and disease pressure.

1.3.2. Neglected and underutilized species

Neglected and Underutilized Species (NUS) are species that are locally very useful and globally under-utilized. This definition excluded recently introduced species and/or species that are locally inappropriate.

Mung beans have been domesticated in India since very ancient times (Fuller and Havrey, 2006) and were subsequently introduced to Peninsular Thailand by the Indian community (Castillo *et al*, 2016). They are very much consumed and produced in South Asia (Bangladesh, India, Myanmar), but are much less utilized in Southeast Asia, especially in the Lao PDR despite the variety of benefits they may generate for farmers and consumers in general (cf. above).

The main reasons for the absence of operational market for NUSs (in our case mung beans) may include: high transaction costs; low level of domestic consumption; poor knowledge of local populations regarding how to grow and use the crop; existence of competing crops that are more rewarding and/or easier to grow, lack of information about potential markets, poor market connections, etc.

Comparison with neighboring countries were dynamic markets exist can be interesting to understand how these markets operate and what makes them efficient.

Positive (biodiversity, cultural aspects, and ecosystem services) or negative externalities may be associated with NUSs that could either be remunerated or sanctioned.

2. OVERVIEW OF MUNG BEAN PRODUCTION AND TRADE IN SOUTHEAST ASIA

2.1. Mung bean production

Mung bean is one of the most important indigenous legume crops in South and Southeast Asia, where 90% of global production currently occurs (LIFT, 2006). The annual mung bean production area currently reached over six million hectares worldwide in the Mid 2000s

[2] Approximately 44% of children under the age of five years (CU5s) suffer from chronic malnutrition and stunting in the Lao PDR (GOL, 2015).

(Ebert, 2014). India alone accounted for 65% of world acreage (3.7 million hectares) and 54% of world production (1.57 million tons) in the early 2000s (Sharma *et al*., 2011).

Mung bean production in Asia dropped in the 1960s because of the Green Revolution, which focused mainly on rice-wheat cropping systems to the detriment of pulses and coarse cereals, which were relegated to marginal lands (Chadha, 2010). Mung bean production also declined due to the spread of various diseases –*e.g*., powdery mildew, cercospora leaf spot, mung bean yellow mosaic virus. The intensive and continuous cultivation of cereals led to an increase in nutrient uptake, to a rapid decline in the organic matter content of soils, as well as to water-related problems (lower level of water tables, excessive use of irrigation causing salinity). The addition of mung bean to the cereal cropping system was subsequently investigated as a way to fix nitrogen in the soil, save irrigation water and maintain soil fertility and texture, and increase farm incomes. This meant developing short-duration mung bean varieties.

The AVRDC has been working with nine countries in Asia (Bangladesh, Myanmar, Nepal, Pakistan, Sri Lanka, Bhutan, China, India and Thailand) to develop mung bean varieties with a short maturity duration, high yields and resistant to disease. Table 3 below illustrates the differences in production areas before and after the introduction of new mung bean varieties. Over 3 million hectares of mung beans grew in these nine countries, representing 25% of the mung bean produced in the world in year 2000 (Counting on beans, 2010, pg 2).

As shown in Table 3 below, Myanmar and China had the largest growing areas in the late 1990s and early 2000s. Mung bean production in Myanmar jumped from 43,000 hectares of mung beans in 1980 to 1,000,000 hectares in 1998.

Table 3 – Estimated area (ha) under mung bean in different Asian countries

Name of country	Production Area (ha) before intervention* (year)		Production Area (ha) after intervention* (year)	
Bangladesh	15,000	(1985)	70,000	(2006)
China	547,000	(1984)	776,000	(2000)
India	284,500	(1980)	550,000	(2008)
Myanmar	43,000	(1980/81)	1,000,000	(1998/99)
Pakistan	100,000	(1985)	200,000	(1995)
Sri Lanka	14,000	(1980)	33,200	(1995)
Thailand	308,000	(1984)	335,000	(1995)

Note: intervention of AVRDC in research on identifying mung bean variety

Source: reconstruct from the “Counting on beans: mung bean improvement in Asia” (2010)

2.1.1. Cambodia

The Cambodian government promotes the cultivation of subsidiary crops such as mung beans. Over the period 2013-2017, the average mung bean harvested area was around 52,000 hectares and production was around 50,400 MT (average yield over the period was 1.2 tons per hectare) as shown in Table 4 below. Cultivated and harvested mung bean areas slightly

yet constantly declining from 54,000 hectares to In 2017, mung bean harvested areas and production further declined (MAFF, 2018).

Table 4 – Mung bean cultivated areas, harvested areas, (Ha) and yield (tons/Ha) in Cambodia

	Cultivated Area (ha)	Harvested Area (ha)	Yield (tons/ha)	Production (tons)
2013	54,312	53,282	1.27	67,561
2014	53,294	52,858	1.15	60,652
2015	57,172	53,962	1.10	59,220
2016	50,417	49,404	1.29	64,137
2017	45,352	45,340	1.18	53,597

Source: BDLink (2016), MAFF (2018).

Main production areas in season 2017/2018 were Preah Vihear, Siem Reap, Mondul Kiri, Kampot, Battambang, Khampong Chhnang, Prey Vang (MAFF, 2018).

2.1.2. Myanmar

Beans and pulses in Myanmar are generally grown after the main rice crop in the delta region and as a monsoon crop in the central plain and Shan State. About 70% of all pulses are grown during the winter. Black gram, green gram and pigeon peas account for 70-75% of total bean and pulse production. Mung bean is grown during the winter (starting October), and in the rainy season (starting August).Winter crop is harvested in February to April and monsoon crop is harvested from August to January. Production areas are Kachin, Kayin, Kayar, Sagaing, Pegu (East and West), Megue, Mandalay, Mon, Shan (North), Yangon and Irriwady.

Myanmar bean and pulse production in MY2016/17 increased in response to attractive domestic prices. However, Myanmar's pulse production is expected to decrease in MY 2017/18 as farmers shift to other crops such as dry season paddy, corn, soybean, green gram and sesame. This switch is due to Indian import restrictions towards Myanmar exports.

Mung bean yields in Myanmar are quite low due to a variety of factors –e.g., it is often grown in marginal lands, lack of seed of improved varieties, pests and diseases and poor crop management practices, heat and drought stress. Yields for beans and pulses per unit area are expected to decrease by 13 % in 2017/18 (Gain, 2018).

2.1.3. Thailand

Mung bean is a very important legume crop for Thailand (Sirinives), where it is perceived as a healthy food and is commonly used by Thai people for religious ceremonies. Thailand used to be one of the world's top mung bean producers and exporters. Thai farmer still prefer to grow mung bean after their rice, corn and cotton production. Thai farmer perceived mung bean as a cash crop with shorten maturity and treated as a green manure. The major problem

of mung bean production in Thailand is diseases (e.g., powdery mildew, cercospara leaf spot and mung bean yellow mosaic virus). Over 90% of dry beans produced in Thailand are mung beans (Cramb, 2015).

Mung bean production in Thailand increased by 22% between 1980 and 2000 (Lambrides and Godwin, 2006).

In Thailand, mung bean production is expected to be increase as farmers prefer growing mung beans rather than off-season rice. Increasing mung bean farm-gate prices and expected water shortages for off-season rice production make mung beans more attractive to farmers. Farmgate prices of mung beans in Thailand more than doubled between 2004 and 2014, from 15 Baht/kg (around 3,750 LAK/kg) in 2004 to almost 35 Baht/kg (8,750 LAK/kg) (GAIN, 2014).

Although Thailand has more than 275,000 ha devoted for mung bean production, but Thailand imports mung bean from other major mung bean production countries especially Myanmar. Myanmar accounted for 90% of total mung bean imports. In 2013-14, Thailand imported 27,912 metric tons of mung bean from Myanmar, while exportation of mung bean is predicted to continue declining due to the domestic demand by the food processing industries.

2.1.4. Vietnam

Mung bean is a commonly grown legume crop in Vietnam. It is primarily used as food in the domestic market as a variety of traditional dishes use mung beans –*e.g.*, mung beans cooked with glutinous rice, sweet mung bean soup, mung bean sprouts, mung bean cake. Processed mung bean products include flour, vermicelli, and sprouts. Vietnamese farmers use the by-products of mung bean processing (hull, sludge) as animal feed, and the stem and leaves are as green manure. Mung bean is commonly cultivated in the Delta Region, Midland to Highland from the North to the South. Mung bean can be planted throughout the year. Vietnam planted about 50,000 ha and the average yield is about 590 kg/ha (Le Thanh Hiep, 2000). The yield is higher in the South than in the North and in some Mekong Delta areas the yield is as high as 1,000 kg/ha. Low yield can be explained by poor soils, lack of irrigation or inputs, poor seed quality, low investment and poor information.

2.1.5. China

Mung bean production represents some 19% of China’s total legume production. In China, although mung bean is one of the major pulses cultivated and consumed, production has largely fluctuated over the years. China's mung bean production dropped by 50% in 2014, due to poor weather conditions and less available land for planting. The decline in the production of pulses in China can also be explained by the fact that other competitive and more value crops like maize, wheat and cotton cultivation are being promoted.

According to Huijie (2003), China was a major mung bean producer in the 1950s. In 1957, 1.64 million hectares of land were devoted for mung bean and mung bean production reached around 800,000 metric tons. Mung bean yields were then relatively low (488 kg/ha) because of a low use of inputs. In the 1960s and 1970s, mung bean production in China declined because the government paid more attention to other grains such as rice and soybean. However, in the 1980s the decline in mung bean production stopped. Improvement in high yielding varieties and production practices led to a dramatic change in mung bean production. In 1986, mung bean yields increased to 914 k g/ha and to 1,154 kg/ha in 2000. In 2000, mung bean production area reached 772,000 hectares and mung bean production was 891,000 metric tons. Since then, mung bean production stabilized and has become an important export crop. China's top-three mung bean producing provinces in 2000 were Jilin, Henan, Inner Mongolia, and Shannxi.

Li *et al* (2016) identify three main cropping patterns in China:

- in Southern China (middle and lower Yangtze River regions), mung bean is summer-sown in early June and harvested mid to late August. The main cropping patterns associate mung beans other crops such as: wheat, maize, cotton and sweet potato;
- in spring-sown areas of Northern China (one crop per year), sowing is done late April to early May and harvested September. The main rotation cropping system is mung bean–millet–sorghum (maize). Mung bean is also intercropped with millet, maize, or sorghum;
- in summer-sown areas in Northern China (two crops a year), sowing is done June and harvested early September, and mung bean is intercropped with wheat.

2.2. Mung bean trade

The overall value of mung beans trade was 2 Bn USD in 2016 (COMTRADE). India is not only the main producer of mung beans, it is also world's largest importer of mung beans. To cover its domestic consumption, India has taken several measures to ban the export of pulses and pulse products from 2007 onwards. Another big exporter of mung beans is Australia,

2.2.1. Myanmar

Myanmar exports beans and pulses to India, Thailand, Bangladesh and China. According to government sources, black gram, mung beans, and pigeon peas accounted for 80-90% of total exports in MY2016/17 (GAIN, 2018). Myanmar exported 0.62 million metric tons of beans and pulses in the first six months of 2018/19, which was 35% down from the same period of 2017 (*ibidem*). This may be explained by Indian import restrictions (Box 1), and the subsequent decrease in production acreage in Myanmar.

Box 1 – Indian bans on imports of beans and pulses

India is the largest producer and importer of pulses. The Government of India (GoI) regularly imposes stringent restrictions or complete bans on the imports of pulses to protect domestic farmers against competing supplies, or falling prices –*e.g.* in the case of bumper harvests. With inadequate marketing and storage infrastructure and insufficient financial resources to undertake price support operations, import restrictions are a handy instrument to regulate markets (GAIN, 2018). Restrictions and bans are lifted when domestic production cannot cover the country's needs, for example due to poor weather conditions. Such measures have as strong impact on prices and create instability on the markets.

In 2016, a severe drought in India spurred Myanmar bean and pulse exports in response to high prices. In August 2017, when India's weather returned to normal and pulse production increased, the GoI established strict import quotas for black gram, green gram and pigeon peas. Only imports through government-to-government contracts were allowed, at very low prices. This excluded Myanmar, which had no system in place for government trade of pulses. These measures affected both domestic and export prices for Myanmar beans and pulses. In response to India's import restriction on beans and pulses, the Government of Myanmar suspended bean and pulse imports in September 2017, and asked farmers to reduce growing areas and to shift to other crops –*e.g.*, seed corn, soybeans, green gram, dry season rice, and sesame– starting from the 2018 dry season. In May 2018, GoI announced another import quota for mung bean, valid until August 2018.

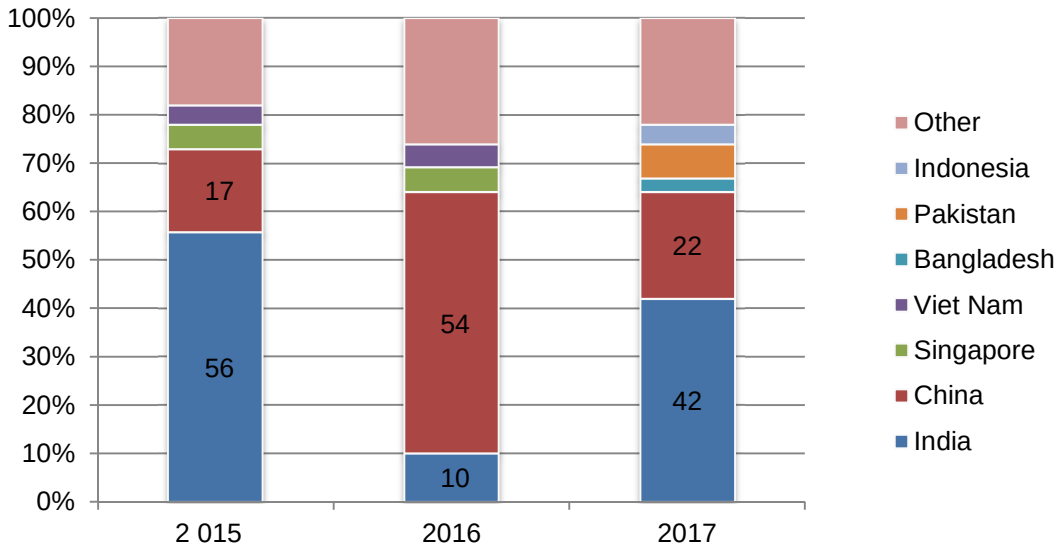
Source GAIN, 2018.

India is Myanmar's main export market for mung beans. Only a small amount of mung bean is exported as raw material for the sprouted seed production in Europe where quality and food safety requirements are stringent[3] but the returns for growers and traders are high (especially for quality sprouted bean production). About 90% of total mung bean production is exported.

The destination of Myanmar mung bean exports presented in Figure 2 below shows the importance of the Indian and Chinese markets, but also the great instability brought by Indian import restrictions.

[3] For imports into the EU market the mung beans should be GAP certified and fully traceable. EU importers also require clean, sorted and graded and disease-free seeds with good sprouting qualities.

Figure 2 – Destination of Myanmar mung bean exports (% of total exports)



Note: Figures show exports as reported by Myanmar of commodity code HS 071331 "Vegetables, leguminous; beans of the species *Vigna Mungo* (l.) Hepper or *Vigna radiata* (l.) Wilczek shelled, whether or not skinned or split, dried"

Source COMTRADE.

2.2.2. China

Chinese know the health benefits of mung bean and hence products made of it are sold at the higher or premium price. Organoleptic characteristics and price make the dry peas as close substitute. As a result, Chinese imports of dry peas are related to mung beans production and prices as they can be used as replacement in some of the food preparations.

In 2014, China imported mung bean from three main countries, namely Myanmar, Australia and Thailand but the volume imported has been declining from 30,334 MT in 2011/12 to 13,297 MT in 2013/14 (Table 5). During the same period, China exported mung beans to several countries such as: Vietnam, Japan, United States, Philippines and South Korea. Mung bean exports however have been declining from 131,281 MT in 2011/12 to 105,894 MT in mid-2013/14 (Table 5).

Table 5 – China's mung bean Imports and Exports

Mung bean Imports				Mung bean Exports			
Country (MT)	MY 2011/12	MY 2012/13	MY 2013/14	Country (MT)	MY 2011/12	MY 2012/13	MY 2013/14
Myanmar	19,910	12,356	12,155	Japan	58,248	45,322	46,172
Australia	6,078	0	540	Vietnam	25,943	22,548	25,416
Thailand	4,242	1,319	352	United States	10,219	9,719	9,094
Others	105	421	250	Philippines	5,764	7,174	4,724
Total	30,334	14,096	13,297	South Korea	2,721	5,167	3,914
				Others	28,386	40,097	16,568
				Total	131,281	130,028	105,894

Source: (GAIN (2014)

Over 80% of China's total production of dry grains from pulses is consumed within China. While China exported less than 150,000 MT of pulses per year between 1961 and 1985, exports of beans to Europe and other countries have increased strongly since the mid-1980s. China exports large volumes of faba beans, adzuki beans, and mung beans to Japan, the Republic of Korea, and Europe (Li *et al.*, 2016). For example, about 80% of bean sprouts sold in Japan are made from mung beans, which Japan mostly imports from China. To meet domestic demand, China has been making up for its shortfall with imports from Myanmar (Tahoue, 2015).

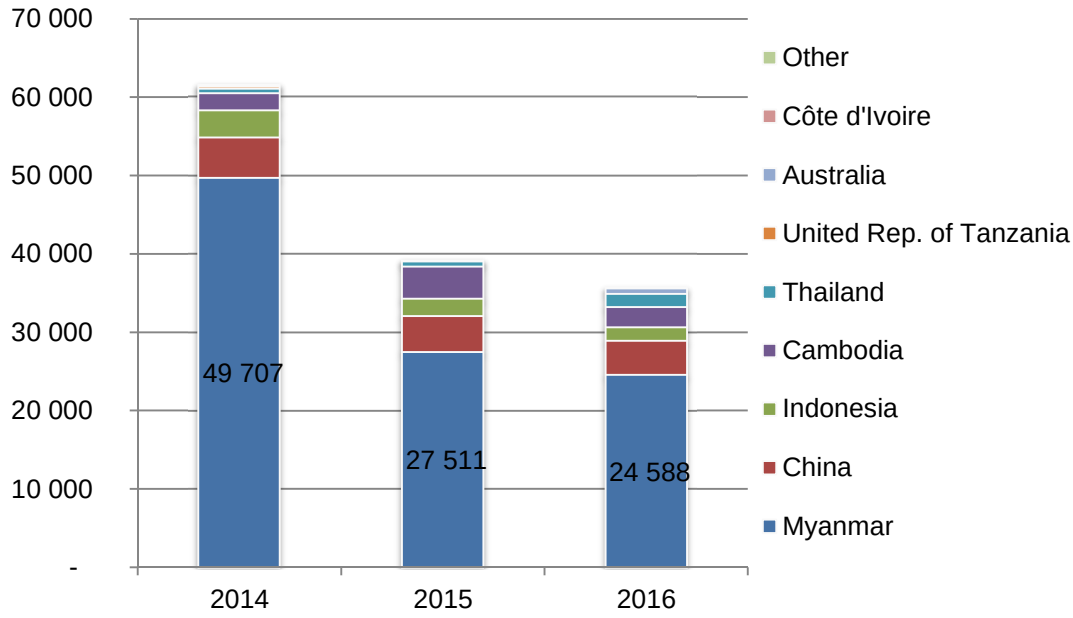
2.2.3. Vietnam

Figure 3 below shows that Vietnam imported over 61,000 MT of mung beans in 2014, 39,000 MT in 2015 and almost 36,000 MT in 2016 (Comtrade). Most of the mung bean imported by Vietnam came from Myanmar (between 81% in 2014, 70% in 2015 and 69% in 2016) and China (8% in 2014, 12% in 2015 and 2016). Without improved varieties and because mung beans rarely comply with export standards[4], there is very little export.

[4] Export grades request 94% purity for Grade I (89% for Grade II) and 14.5% moisture content. The acceptable level of defects for Grades I and II are 4% and 8%, respectively.

Figure 3 – Vietnam imports of mung beans (2014-2016)

Unit: Metric tons

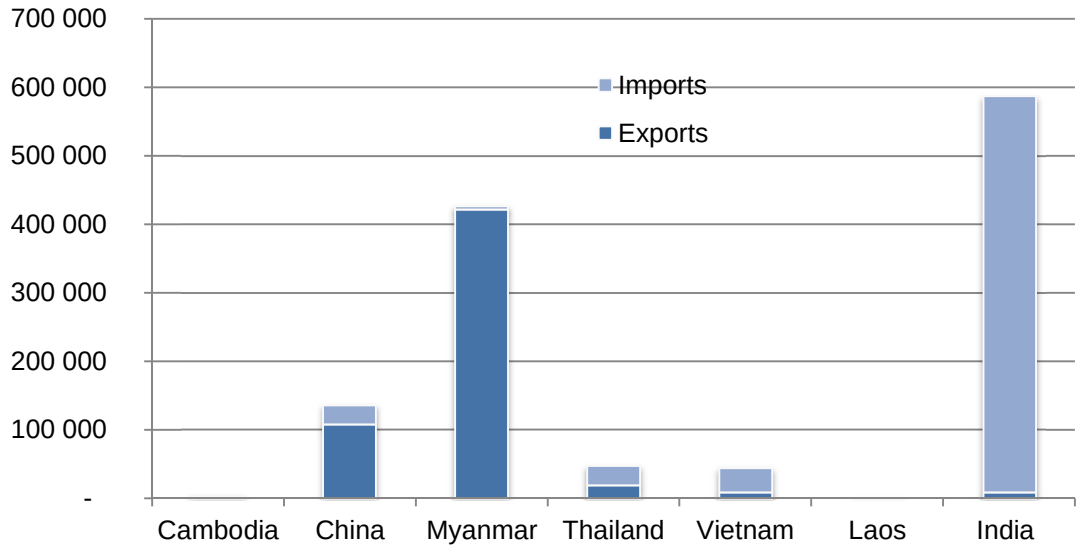


Source: COMTRADE statistics.

2.2.4. *Mung bean imports and exports in Southeast Asia*

Figure x offers a glimpse at the situation of regional mung bean trade in Southeast Asia in 2016. Figure shows the importance of India, as a main importer of mung beans, and Myanmar as a main supplier. Figure most likely underestimates trade flows as COMTRADE only takes into account official trade flows.

Figure 4 – Southeast Asian mung bean trade (2016)



Source: COMTRADE statistics.

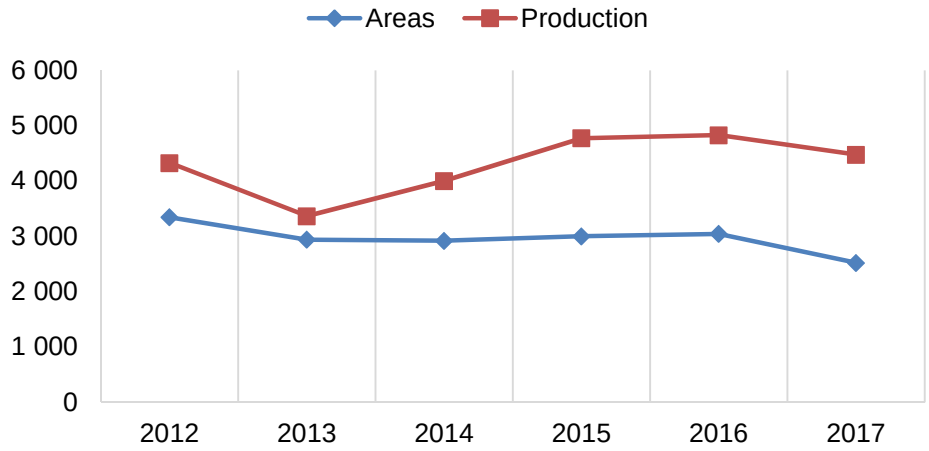
3. MUNG BEAN PRODUCTION IN LAO PDR

3.1. Mung bean production in the Lao PDR

Mung beans are produced in many different provinces of the Lao PDR –e.g., Vientiane Capital, Vientiane, Luang Prabang, Xayabouly, Xiengkhuang and Champasack provinces.

Figure 5 below shows the evolution of mung bean production areas and volumes between 2012 and 2017. The total surface devoted to mung bean production in the Lao PDR has always been quite small –less than 3,000 hectares on average between 2012 and 2017. Over the same period, mung bean production was around 4,300 tons per year on average. Both mung bean planted areas and mung bean production declined between 2012 and 2013. After 2013, mung bean production areas stagnated or declined (2,500 hectares in 2017), while mung bean production increased until 2015 before reaching a plateau and declining again in 2017. Over the period, yields have increased from 1.3 M per hectare in 2012 to nearly 1.8 MT per hectare in 2017.

Figure 5 – Mung bean production areas and production in the Lao PDR



Source: Agricultural Statistics Yearbook 2017, Department of Planning and Finance, Ministry of Agriculture and Forestry.

If we take a look at mung bean production across the country (Table 6 below), we can observe that mung bean production is scattered across the country, and that production is higher in the Central part of Lao PDR than in the Northern or the Southern parts of the country. In the North, Luang Prabang and Xayabouly provinces represent a large proportion of the production area and volumes produced. In the Central part of the country, mung bean production was more concentrated in Vientiane Capital. In the South, Champasack was the leading province in terms of production area and production.

Table 6 – Area, production and productivity of mung bean in the Lao PDR

Province	Area (ha)			Productivity (T/ha)			Production (T)		
	2015	2016	2017	2015	2016	2017	2015	2016	2017
North	**810**	**975**	**675**	**1.41**	**1.77**	**2.00**	**1,145**	**1,725**	**1,350**
Phongsaly	235	230	70	1.81	2.04	3.07	425	470	215
Luangnamtha	40	40	35	1.88	2.13	2.14	75	85	75
Oudomxay	-	-	-	-	-	-	-	-	-
Borkeo	-	-	-	-	-	-	-	-	-
Luang Prabang	355	395	260	1.21	1.70	2.15	430	670	560
Huaphan	-	-	-	-	-	-	-	-	-
Xayabouly	180	310	310	1.19	1.61	1.61	215	500	500
Central	**855**	**755**	**1,090**	**1.76**	**1.33**	**2.02**	**1,505**	**1,005**	**2,200**
Viantiane Capital	425	260	275	2.45	1.25	2.04	1,040	325	560
Xiengkhuang	30	105	45	1.17	2.14	1.11	35	225	50
Vientiane Province	355	355	360	1.01	1.01	2.00	360	360	720
Bolikhamxay	35	25	50	1.43	3.00	3.00	50	75	150
Khamouane	-	-	360	-	-	2.00	-	-	720
Savannakhet	-	-	-	-	-	-	-	-	-
Xaysomboun	10	10	-	2.00	2.00	-	20	20	-
South	**1,335**	**1,315**	**755**	**1.59**	**1.60**	**1.23**	**2,125**	**2,100**	**925**
Salavan	-	-	-	-	-	-	-	-	-
Xekong	25	5	5	1.20	2.00	1.00	30	10	5
Champasack	1,295	1,295	725	1.60	1.60	1.20	2,070	2,070	870
Attapue	15	15	25	1.67	1.33	2.00	25	20	50
Total	**3,000**	**3,045**	**2,520**	**1.59**	**1.59**	**1.78**	**4,775**	**4,830**	**4,475**

Source: Agricultural Statistics Yearbook 2017, Department of Planning and Finance, Ministry of Agriculture and Forestry.

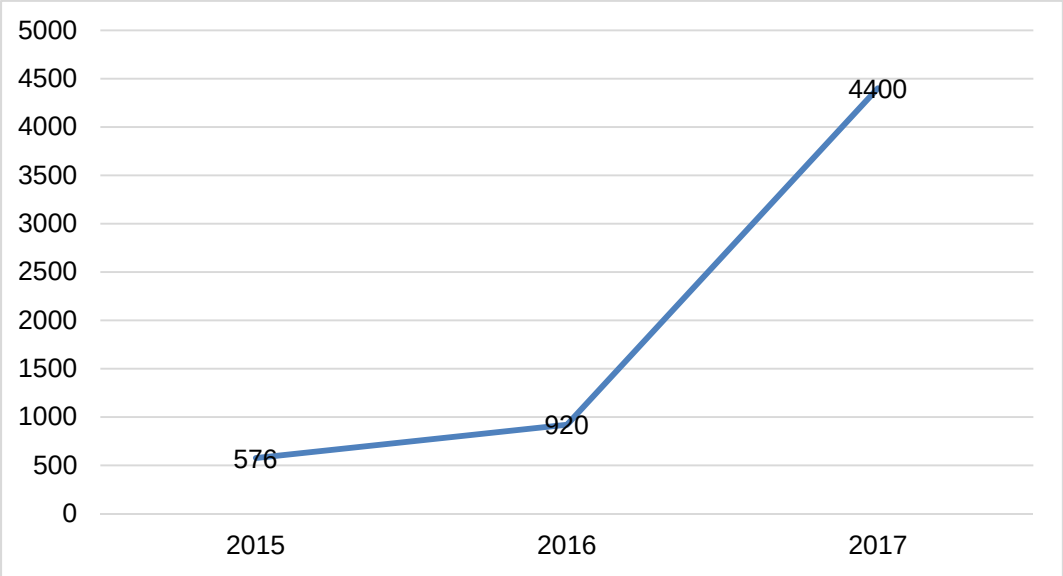
There are two major mung bean production areas in Vientiane Capital: Sangthong and Pakngum districts. Production is more concentrated in Pakton, Kokphuerng, Nasanghin, Done Sangkong and Hinlup villages, Sangthong district. Mung beans are also channeled to Vientiane markets from nearby locations in Vientiane province (Jum and Jeng villages, Thoulakhom district). Mung bean production has been practiced for over 20 years in Vientiane Capital. However, it is difficult to know which variety is grown as no particular variety of mung bean is promoted and farmers use the seeds of the previous crop.

In Xayabouly province the main mung bean growing areas are located in Boten and Kenthao districts. In Xayabouly, mung beans were introduced through the EFICAS project as an option to improve the fertility of soil that after continuous maize production in the area. The project did not only introduce mung beans, but also red beans and black beans as options for farmers.

3.2. Mung bean imports and exports

Some of the mung bean sold in Vientiane were also imported from neighboring countries (Thailand, Vietnam). The Lao PDR also imported mung beans from Vietnam in the past years, as shown in Figure 6 below. The statistics show a sharp increase in the volume of mung bean imports, from 576 kg in 2015 to 920 kg in 2016 and to more than 4,400 kg in 2017.

Figure 6 – Mung bean imports from Vietnam



Source: Crop Statistics Year Book 2015, 2016 and 2017, Planting and Cooperation Division, Department of Agriculture, MAF

Discussions with local authorities reveal that there are no statistical records about mung bean exports from the Lao PDR. The reason for this is that exporters officially declare their exports of key products that are traded in large quantities (e.g., maize, cassava and red beans). For paperwork, mung bean exports are bundled together with these other products. Indeed, it would be too costly to make separate documents for mung bean exports as only a few ton are exported (PAFO, Xayabouly province).

4. MUNG BEAN QUALITY

4.1. Types of mung beans sold in Vientiane Capital

In Vientiane Capital, mung beans were either sold dried (milled, un-milled, split or whole) or sprouted.

4.1.1. Dried beans

The mung bean sold in Vientiane came from Thailand, Vietnam and the Lao PDR. The imported beans came in two different forms: 1/ un-milled mung beans and 2/ milled mung beans. Domestic mung beans came from Sangthong and Pakngum districts in Vientiane capital, Thoulakhom district in Vientiane province, and Xayabouly province.

below (next page) summarizes the characteristics of the main mung bean products that are available in various outlets in Vientiane Capital.

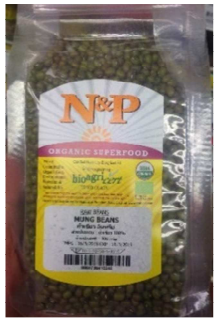
4.1.2. Sprouted mung beans

According to the interview with mung bean collector at the village level, almost 80% of the mung beans were used to produce bean sprouts. Bean sprouts have several uses, but are mainly served along with noodle soups. The use of bean sprouts was higher in Vientiane Capital than in Xiengkhuang, Xayabouly and Vientiane provinces. This may be due to the traditional eating habits of urban consumers lacking time and space to cook.

Most of the mung bean used to make bean sprouts were imported from Vietnam and Thailand. Mung beans were imported by Vietnamese traders and sold by Vietnamese wholesalers in Phonesavanh agricultural product market (Suan Phou Kham). It was quite difficult to discuss with mung bean wholesalers because they spoke very little Lao and were not willing to speak. Two types of mung beans were sold in the markets: milled and un-milled mung beans. The two main brands for un-milled mung beans sell at the market were Hao Ji and AAA+ mung. These two brands were very popular with bean sprout producers.

Photo 1 – Imported Vietnamese and Thai mung bean sold in Xiengkhuang

Table 7– Mung bean products sold in Vientiane Capital

Company	Outlet	Product characteristics	Photos
Thanya Farm Company Ltd. (Thailand) *Brand name: Rai Thip*	▪ Premium supermarkets, ▪ Convenient stores, ▪ Wet markets. Retail price: 20,000 LAK/kg	▪ Cleaned and graded beans. ▪ Milled and un-milled, split and whole, ▪ Standardized packaging with all the details about the company.	Photo 2 --Thai conventional mung bean 
Natural and Premium Food Company Limited (Thailand) *Brand name: N&P*	▪ Sold only at the premium supermarket (Rimping) in Vientiane capital. Retail price: 67,000 LAK/kg	▪ Organic certified whole beans as organic beans.	Photo 3 – Thai organic mung bean 
Hang nong san Viet dich thuc (Vietnam) *Brand name: Choice*	▪ Korean supermarkets Retail price: 49,000 LAK/kg	▪ Unmilled beans ▪ Well packed with a label, but the label is not translated in Laotian	Photo 4 – Premium Vietnamese mung bean 

Company	Outlet	Product characteristics	Photos
Mung beans sold in bulk (Vietnam) *Brand name: -*	▪ Vietnamese retailers in Laos repack the product into smaller packages (0.5-1kg/bag) Retail price: 10,000 LAK/kg	▪ Milled beans sold in large quantities. ▪ No label.	Photo 5 – Vietnamese mung beans sold at the wet market 
SKVP ບໍລິສັດ ສຸນີ ເກ້ອມະນີອັນ ພົມດວງສີ (Lao PDR) *Brand name:* This company is a wholesaler and a processor.	▪ Premium supermarket (Rimping), ▪ Vientiane organic market, Phonthan minimarket. ▪ Wet market. Retail price: 67,000 LAK/kg	▪ Un-milled mung beans from Champasack province	Photo 6 – Lao mung beans sold at convenience stores 
AgroAsie[5] (Australia) *Brand name: Sangthong Organic*	▪ AgroAsie shop ▪ Convenience stores ▪ Premium supermarket (Rimping) Retail price: 80,000 LAK/kg	Un-milled, organic certified beans Hiigh quality standards and quality control system.	Photo 7 – Organic Lao mung beans sold at convenience stores and premium supermarkets 

[5] This foreign-owned company created in 2010 aims to create employment for poor farmers from Sangthong district (poor district of Vientiane capital).

4.2. Mung bean quality

It is very important for producers to manage mung bean quality properly and therefore to plan production carefully, as the first decision that is likely to determine bean quality is the planting period. Indeed, farmers must make sure that they grow their mung bean early enough for the harvesting period to take place before the rainy season, otherwise the rain will destroy the bean, it will be difficult for the farmer to control the beans' moisture content and mold may develop on grow on the beans and damage them.

However, discussions with collectors and farmers revealed other quality-related problems as the collectors received low quality beans because the farmers harvested the mung beans too early when the beans were not yet mature. This problem had an impact on the germination of the seeds, which was a major concern for bean sprout producers. Bean sprout producers were able to check by visual inspection whether the mung beans met their quality requirements or not.

Photo 8 below shows a very good example of the difference in terms of quality between Vietnamese and Lao mung beans. The left hand side of the picture shows Vietnamese mung beans taken from a bag of imported mung beans. The right hand side shows mung beans produced by Lao producers. If we take a close look, we see that the Vietnamese mung bean has a better overall quality, the size of the bean is the same and there are no black seeds. Conversely, Lao mung beans have almost 50% of black seeds that will not germinate and cannot be used by bean sprout producers. So the interest of bean sprout producer in purchasing Lao mung bean is limited.

Photo 8 – Quality differences between Vietnamese imported and Lao mung bean

The quality of mung bean depends on the mung bean utilization. 80% of the mung beans are used for bean sprout production (according to the discussion with collectors) and the

remaining is sold as dried beans for cooking. Thus, if the Lao bean quality is very low, it is very hard to compete with imported mung beans that clearly have a better quality.

The *quality of bean sprout* is also an issue for the end-users of bean sprouts (noodle soup restaurants). The most common issues raised were:

- *short shelf life*: the bean sprouts can be kept only one day then become black quickly. Vietnamese bean sprouts were said to have a longer shelf life (2-3 days) and could thus keep their white color longer;
- *size*: the size of the bean sprouts is highly variable (sometimes long, sometimes big and sometimes small). Maintaining a constant size is a highly demanded quality attribute for mung bean sprouts, so how can we managing the size of the bean sprout?
- *roots of sprouts*: some roots remain attached to the sprouts and the end-users need to spend time and labor to take the roots out.

Based on the issues raised by the restaurants, it is important for the sprout producers to control the processing procedure to ensure that the quality of their sprouts meet the demand *e.g.*, sprouts with a longer shelf life, big and even size, and no roots attached to the sprout.

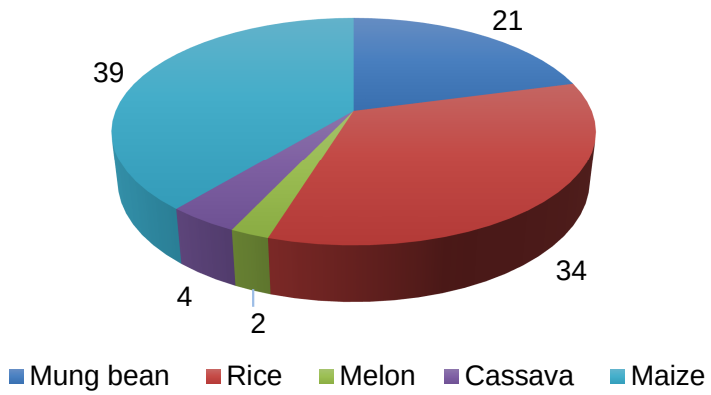
Improving sprout quality also means addressing food safety issues. Indeed, one sprout producer mentioned two bean sprout production systems: 1/ a natural production system where no chemicals substances are involved in the production of bean sprouts (in this system, the sprouts are small, thin and soft); 2/ another system involving the utilization of chemical substances to make the sprouts white, help them grow quicker and keep them longer (so-called “triple 9”). In this system, further investigations are needed to check whether the chemicals used in bean sprout production can cause any harm to the health of the consumers in the short or long term.

5. MUNG BEAN VALUE-CHAIN STAKEHOLDERS

5.1. Mung bean producers

Mung bean producers are smallholder farmers that grow mung bean for an extra household income. No specialized commercial mung bean producer was identified during the field survey. Producers grew mung bean in a traditional way and the average holding area for mung bean was 0.8 hectares per household. Mung bean farmers were mainly rice farmers and produced mung bean as an additional household cash income earning crop. These farmers grew various crops, including: rice, maize, mung bean, sticky corn, sesame, eggplant, French bean, black bean and melon. Mung beans were therefore part of a production and income strategy developed by the farmers aimed at using their land productively.

Figure 7 – Average land sharing of mung bean and other crops



5.1.1. Mung bean production and costs

The mung bean production usually started after the farmer finished maize production, which usually (September or October). Farmers cut all the grass with a weeding machine (some used chemical to kill the weed). Farmer then planted the beans without further preparation of the plots. As the beans grow and cover the land, other grass cannot grow. Due to good soil conditions, no fertilizers were applied. In January and February, the beans are ready to be harvested. The farmers use sickles to harvest the fruit of the bean that already dried and are still attached to the tree.

After harvesting the beans the farmers continue sun-drying the beans until they are completely dry. They then thrash the beans, either with a hand tractor to run over the dry beans and crack the bean shells or with a wooden stick to smash and crack the bean shells. Because the threshing procedure takes a long time and requires labor, some farmers used a rice threshing machine to save time, but this damaged to the beans and made it difficult to sell them as dried beans or to a bean sprout processor. Mung bean yields were around 811 kg/ha.

Table 8 – Production calendar

Activities	Month					
	9	10	11	12	1	2
Soil preparation						
Planting						
Caring						
Harvesting						
Threshing						

Source: Authors' survey.

The mung bean production system is not very complicated and does not require a lot of investment. The table below indicates the major cost for mung bean production per hectare.

The main input for mung bean production was seeds, and most of farmers kept their seeds for many generations and seldom bought seeds. Seeds were sold 10,000 LAK/kg. According to the field survey, mung bean production in Sangthong district was the most market-oriented, compared to other provinces. In Sangthong, some farmers applied fertilizers to improve quality and herbicides and pesticides due to the lack of labor for weeding and pest control.

5.1.2. Mung bean marketing

Mung bean trade is totally free: farmers are free to choose who to sell their beans to, and this decision is mainly based on the price. Based on the data collected from 52 mung bean farmers, there were no contract arrangements between the collectors and the producers, and the producers did not receive any support from their buyer.

There were two transportation systems: 1/ the collector contacted the producer, asked for the beans and then came and collected the beans at the producer's house. In this arrangement the collector collected the beans by motorbike from different households and gathered all beans in one place, then took a truck to collect all the beans. 2/ the producer will come to the collector's to sell the bean directly to the collector. The first transportation system is usually use when there is a great demand for mung bean, and the second arrangement happened when the demand for mung bean was low.

Similar payment systems prevailed between the producer and collector in all of the studied provinces (XY, VTE, and VP). Whether the collector came to collect the mung bean from producer or the producer delivered the mung beans to the collector's house, the beans were always paid cash upon the delivery of the beans.

5.1.3. Problems and challenges

Labor is very important for mung bean production. Labor shortages lead farmers to adopt poor practices when weeding, harvesting and threshing the beans[6]:

- some farmers used chemical substances to save labor when weeding their plots;
- some farmers threshed their beans using a machine. The beans were broken in the process and the collectors refused to buy the beans or offered a lower purchasing price for the beans.

Planning of production is also an issue. Indeed, if growth is delayed, the mung beans may face the fog and lead to mold problem. When grown during rainy season, production is high but bean quality is very low due to high moisture content.

5.2. MUNG BEAN INTERMEDIARIES

5.2.1. Collectors

Village collectors are based in the villages or come from nearby villages. These collectors have been involved in trade for over seven years. Besides mung beans they also collect other seasonal products such as sesame, black beans, French beans, peanuts and tamarind.

Collectors act as middlemen between the producers and the mung bean wholesalers, traders and bean sprout producers. The role of the collectors is to collect the beans from the producers and to deliver them to the wholesalers and bean sprout producers. They also play an important role in quality management.

Collectors may improve the quality of the mung beans:

- by refusing to buy beans from producers if the beans are poorly handled. This means if the beans are harvested prematurely (the seed are relatively small) or if they are broken. These problems are very important, especially for the collectors who supply the beans to the bean sprout producers. Indeed, if the bean is not mature or if the bean is broken, the germination rate will be very low, and the bean sprout production is low. Although the collectors disseminate information about quality to the producers for them to improve the quality of their beans, the quality of the beans remains low. Furthermore, it is sometimes very difficult for the collectors to refuse to buy the beans, especially when the demand is very high;
- by getting directly involved in the quality management. After the collector collect all the bean the collector will dry them if the bean is not properly dry, then the collector will use the fan or the wooden plate (Kadong) to get rid of the empty seed. After that

[6] This is also the case in Cambodia, where farmers are reported to harvest mung bean with a combined harvester, leading to low yield and poor bean quality, resulting in around 15% reduction in sales revenues (Vernooy, 2015).

the bean will be pack in the 12 kg bag before transporting to the wholesalers and bean sprout producers.

The motorbike and the 3T Hyundai truck are the mean of transportation for collector to transport the bean from the producer and also to transport the bean from the producer to the wholesalers and bean sprout producer.

5.2.2. Processors

Characteristics of the processor: the processor in this case will be divided into two different processor namely: bean processor and bean sprout processor.

- *dried bean processor:* The bean processor here is referring to the dried bean processor. The Mung bean processor receiving mung bean from collector and then they will grad, packaging and distributing to the retailers.
- *bean sprout processor*: the bean sprout is mainly household processor, however they are very different in their quantity of supply. For example: some of them supply bean sprout to the market only 5kg and some of them supply 1,000kg of bean sprout per day depending on the market demand. The biggest bean sprout market is in Vientiane capital with the demand of 10-20T/year. This is due to the size of the population and number of restaurants in Vientiane capital is more concentrated in Vientiane capital rather than the market in provinces. One interesting observation is also related to the eating habit of customers in Vientiane capital and other provinces. For example: in Xiengkhuang, bean sprout use in the dishes or even the noodle is very little which make them using only 250gram of bean sprout per day whereas in Vientiane the demand in more than 10kg/day.

In the provinces, where market demand was relatively small, the bean sprout processor, wholesaler and retailer were the same person. These processors had a very clear idea on how much they produced each day.

5.2.3. Bean sprout producers

Box 1 – Bean sprout production in five steps

1. Soak the mung bean for up to 8 hours;
2. Place the soaked beans in a black bucket with holes at the bottom to drain the water when watering the beans;
3. Cover the bean bucket with: 1) a green and very clean bag with holes to drain the water; 2) a thick bag that can protect the beans from the sunlight. If the first bag is not very clean, the sprouts will rot.
4. Keep the beans for three nights to allow them to grow;
5. When the beans are ready, wash the bean, remove the bean husk and keep only the white bean sprout.

Photo 9 – Equipment used for sprout production at the household production level

5.2.4. Wholesalers

There are two types of wholesalers: *mung bean wholesalers* selling mung beans to bean sprout processors. In Vientiane Capital, these wholesalers also collected mung beans from producers and delivered them to the bean sprout processors and to mung bean retailers in the market. In Xiengkhuang, wholesalers were based in the market in Peak and Kham districts and were mostly Vietnamese. Bean sprout producers came to purchase mung beans from wholesalers at the market once every two months (25 kg/bag). The transportation cost of mung beans was born by the bean sprout processors. *Bean sprout wholesalers* are intermediaries between the bean sprout processor and the retailers. They operate from wholesaler markets in Vientiane capital, Thongkunkham, Khuadin and Nonkhor market. These wholesalers receive bean sprouts from processor and sell at the wholesale market where the retailers come to buy the bean sprouts. The clients of bean sprout wholesalers are not only retailers, but also include restaurants (noodle shop) and consumers who occasionally come and buy bean sprouts at the wholesale market. Some bean sprout wholesalers acts as intermediaries to supply bean sprouts to large noodle soup restaurants such as Pho Zap and Pho Vientiane. This form of arrangement is based on trust and long term business relationships (over ten years) and the quantity demanded is quite large (36-40 kg/day). However, for smaller noodle shops, the owner of the restaurant simply goes and purchases the bean sprouts at the wholesale market.

In other provinces, where the consumption of bean sprouts is not very high, the bean sprout processors also act as wholesalers. The wholesalers bring the bean sprouts to the early morning market and sell them directly to restaurants and consumers. The payment made for the wholesaler and retailers or restaurant is cash up front.

5.2.5. Retailers

There were also two main types of mung bean retailers: dried mung bean retailers and bean sprout retailers. *Mung bean retailers* were intermediaries who received mung bean from a collector and sell in retailed markets in Vientiane. They were based in markets like Khuadin, Nonsavang, Phonrtong and Huakhua. There are two forms of dried bean sold by retailers, the peeled and unpeeled dried mung bean, and the dried mung bean sold is not only limited to mung bean in Laos but retailers are also sell imported dried mung bean. The price, dryness, color and cleanliness are main selection criteria that the retailers used when purchasing dried bean from traders. The transportation cost for delivering dried bean to the destined markets is born by the traders and the dried bean trader will receive payment immediately after the dried bean is delivered.

The dried mung bean retailers are also refer to those convenient stores and high-end super market and organic markets. These retailers mostly sell the imported dried bean from Thailand and Vietnam both the peeled and unpeeled dried mung bean. In the case of the high-end retailer like supermarket, the mung bean sold are classify into different standards, the first one is conventional mung bean like Raithip brand and the second one is imported organic dried mung bean from Thailand, Vietnam and few Lao grown organic mung bean. These bean are selling at the very high price.

Bean sprout retailers bought the bean sprouts either from the bean sprout processors or from the wholesalers. As mentioned earlier, small bean sprout processors are also responsible for wholesaling at the wholesale market, so the retailers come and collect bean sprouts from the processors and sell the sprouts on the retail market. Retailers also purchased bean sprouts from bean sprout wholesaler at the wholesale market, and the payment is made up front.

5.2.6. Importers

Mung bean importers import mung beans and distribute them to wholesalers at the market. Mung beans may be imported in two different quantities: 50 kg bags and 25 kg bags (the most frequently used are 25 kg bags). Mung bean importers also deliver mung beans to sprout producers. According to the field survey, a Vietnamese wholesaler mentioned Lao importers who imported mung beans and distributed them at the market. Although the bean sprout processors told us that they used Vietnamese mung beans, the brand name and the bag of mung beans (as shown earlier) were written in Chinese, so it is unclear whether Vietnam imported the mung bean from China and exported them to Laos. The Vietnamese mung bean traders identified in the study were not very keen to speak to us about this, and some of them did not speak Lao to us at all, which made the process of gathering information more difficult.

5.2.7. Exporter

The mung bean exporter was a Vietnamese trader who was difficult to meet as he could only be found in Xayabouli (harvesting season). This exporter mainly collected beans, red beans and peanut. Mung bean trade was only a small component of his business. Again, the exporter mentioned that he only submitted export documents for major crop and just added mung bean as an additional crop (small volumes). As discussed with the biggest trader in Kenthao, who has been trading with this exporter for four years, the volume of exported mung beans in 2017 was very low (only 1 MT of mung bean exported).

This Vietnamese trader comes and collects the main products from the Lao trader and if there are mung beans he takes them too. These products will be export through the international check point in Khammuane province. The current system trade between the Vietnamese trader and Lao trader is that the Lao trader will collect product based on the demand of Vietnamese trader and the Vietnamese trader will bring in truck to collect product back to the country. There is no proper written trader agreement between the two parties, which is very risky for the Lao trader. The Lao trader is now facing a major problem as he did not get paid as promised. This problem is very significant and could lead to the failure of this system.

5.3. GOVERNMENT ACTORS

In the study sites, mung bean is not a major trading crop compared to maize and cassava. There are no proper exportation arrangements for mung bean, and mung bean export volumes can hardly be identified in the exportation sheets of the Provincial and District Agriculture and Forestry Offices. Mung bean is exported to Vietnam when there is mung bean available during the maize harvesting and export season. According to the discussion with one of the key maize traders in Kenthao district (Xayabouly province), only one ton of mung bean was exported in 2017 to Vietnam, together with maize through the border check point in Khammuane province. With very limited volumes of mung beans it is not worthwhile for traders to undergo the same documentation process as for other strategic trading crops.

Unlike maize and cassava, where provincial and district authorities monitor trade thoroughly, mung bean has no proper trade agreement signed between trade partners (with specific quality and quantity requested). Exporters ask whether there are some mung bean available when they come to purchase maize, and if so they purchase the quantity available. No export documentation is prepared for mung bean separately, as mung beans basically go under the maize exportation procedure.

6. ANALYZING THE VALUE-CHAIN

6.1. Value distribution within the mung bean value chain

6.1.1. Producers

The average cost of mung bean production was constructed from the 52 farmer interviews. Table 9 shows that the main mung bean production costs for farmers were: fixed costs (30%), this cost mainly for the depreciation cost of equipment such as hand tractor and weeding machine, threshing costs (37%) and labor (18%). The farmers paid on average 1,000 LAK/kg to the owner of the threshing machine in order to save time and labor. The average annual profit for mung bean farmers was 1,684,300 LAK.

Table 9 – Annual income, costs and margins of mung bean farmers

	LAK/ha	USD/ha	*LAK/kg*	*%*
Total income	**3, 892,800**	**458**	**4,800**	
Cash expenditures	**1, 552,250**	**183**	**1,913**	
Seeds	106,250	13	131	4.8
4.8Land tax	75,000	9	92.4	3.3
Pesticides	20,000	2	24.6	0.9
Herbicide	100,000	12	123.3	4.5
Fuel	40,000	5	49.3	1.8
Labor	400,000	47	493.2	18.1
Threshing costs	811,000	95	1,000	36.7
Fixed costs	656,250	77	809	29.5
Total cost	**2, 208,500**	**260**	**2,723**	***100***
Profit	**1, 684,300**	**198**	**2,077**	

Source: Authors' survey.

6.1.2. Collectors

Table 10 below was constructed based on the interview of one village collector, who did not only collect mung bean but also other products grown in the village. Table 10 shows an estimation of the annual income of a mung bean collector. Among the costs occurred in the process of collecting and selling mung beans, the cost of purchasing the product was the most significant cost, which accounted for 92% of the total costs. Due to the purchasing process and because the amount purchasing was not very large (10-20 tons per year), labor was not a big issue for the collector. Thus, the average annual profit for the collector was around 35 Mn LAK (Table 10).

Table 10 – Annual income, costs and margins of mung bean collectors

	LAK/Year	USD/Year	LAK/kg	%
Mung bean sales	135,777,500	15,974	6,788	
Total income	**135,777,500**	**15,974**	**6,788**	
Mung bean purchases	91,630,000	10,780	4,582	*91.62*
Bags	1,666,000	196	83.3	*1.66*
Transportation	1,200,000	141	60	*1.19*
Fixed costs	5,543,000	652	277	*5.53*
Total costs	**100,039,000**	**11,769**	**5,001**	***100***
Profit	**35,738,500**	**4,205**	**1,787**	

Source: Authors' survey.

6.1.3. Bean processors

The mung bean processor (producing bean sprouts) is the key actor in the chain because mung beans are currently mainly used for the production of bean sprouts. Table 11 shows that the main cost for mung bean processors was the cost of purchasing the mung beans, (similarly to collector) as the bean sprout production process does not require many inputs (mung beans and some equipment). Bean sprout processors require a specific quality (no broken or premature seeds) but have a limited purchasing capacity. The highest price that the processor in Vientiane capital could pay was 12,000 LAK/kg. In Xiengkhuang, the purchasing price could be as high as 20,000 LAK/kg but the annual processing capacity and market were also very different.

Table 11– Annual income, costs and margins of mung bean processor

	LAK	USD	LAK/kg	%
Bean sprout sales	112,500,000	13,235	3,750	
Total income	**112,500,000**	**13,235**	**3,750**	
Mung bean purchases	54,000,000	6,353	1,800	*70.2*
Plastic bags	6,000,000	706	200	*7.8*
Additives	75000	8.8	2.5	*0.09*
Transportation	4,800,000	565	160	*6.2*
Fixed costs	12,040,881	1,417	401	*15.6*
Total costs	**76,915,881**	**9,050**	**2,564**	***100***
Profit	**35,584,119**	**4,186**	**1,186**	

Source: Authors' survey.

6.1.4. Wholesalers

Based on discussions with mung bean processors in Vientiane capital, Xiengkhuang and Xayabouly, many mung bean processors were at the same time processors and wholesalers. The average annual income of a mung bean wholesaler was 4,477,500 LAK and the major costs are listed in Table 12 below.

Table 12 – Annual income, costs and margins of bean sprout wholesaler

	LAK	USD	LAK/kg	%
Bean sprout sales	73,000,000	8,588	4,000	
Total income	**73,000,000**	**8,588**	**4,000**	
Bean sprout purchases	68,437,500	8,051	3,750	*99.8*
Fixed costs	85,000	10	4.6	*0.12*
Total costs	**68,522,500**	**8,061**	**3,754**	***100***
Profit	**4,477,500**	**526**	**245**	

Source: Authors' survey.

6.1.5. Retailers

Table 13 (based on the interview of 26 retailers) shows the main costs borne by the bean sprout retailers. Again, the cost of purchasing bean sprouts is the main cost (87% of total costs) and the annual profit of the mung bean sprout retailer was 35 Mn LAK.

Table 13 – Annual income, costs and margins of bean sprout retailer

	LAK	USD	LAK/kg	%
Bean sprout sales	118,625,000	13,955	6,500	
Total income	**118,625,000**	**13,955**	**6,500**	
Bean sprout purchases	73,000,000	8,588	4,000	*87.7*
Bags	5,475,000	644	300	*6.5*
Rental fee	4,650,000	547	255	*5.5*
Fixed costs	43,000	5	2.3	*0.05*
Total costs	**83,168,000**	**9,784**	**4,557**	***100***
Profit	**35,457,000**	**4,171**	**1,942**	

Source: Authors' survey.

For the dried mung bean retailers the major cost was also the cost of purchasing the beans and the annual income of these retailers reached 1.3 Mn LAK (Table 14 below). The margin per kilogram of sprouted and dried mung beans was quite similar: 1,942 LAK/kg for bean sprouts and 1,940 LAK/kg for dried mung beans. The volume trade is the main difference, which makes such a big different in terms of the profit.

Table 14 – Annual income, costs and margins of dried bean retailer

	LAK	USD	LAK/kg	%
Dried bean sales	10,080,000	1,185	14,000	
Total income	**10,080,000**	**1,185**	**14,000**	
Dried bean purchases	8,640,000	1,016	12,000	*99.5*
Fixed costs	43,000	5	60	*0.5*
Total costs	**8,683,000**	**1,021**	**12,059**	***100***
Profit	**1,397,000**	**164**	**1,941**	

Source: Authors' survey.

6.2. Margin distribution in mung bean value chain

Table 15 shows the distribution of total profits and costs among the stakeholders (up to retailer of bean sprout) in the value chain. This table shows a fairly even distribution of profits among farmers, collector and wholesalers/processors and retailers. Farmers had the highest share of profit (29%), followed by retailers (27%), collectors at (25%) and wholesalers/processors (20%).

Table 15 – Distribution of profit per kg of mung bean sprouts

	Farmers	Collectors	Wholesalers/ Processors	Retailers
Total costs	2,723	5,000	6,318	4,557
Total output	4,800	6,788	7,750	6,500
Profit	**2,077**	**1,787**	**1,432**	**1,940**
Share of total profit	**29%**	**25%**	**20%**	**27%**

Source: Authors' survey.

Table 16 shows the distribution of total profits and costs among the stakeholders (up to the retailer of dried mung beans) in the value chain. This table shows a fairly even distribution of profits among farmers, collector and retailers. Farmers had the highest share of profit (36%), followed by retailers (33%), collectors at (31%).

Table 16 – Distribution of profit per kg of dried mung bean

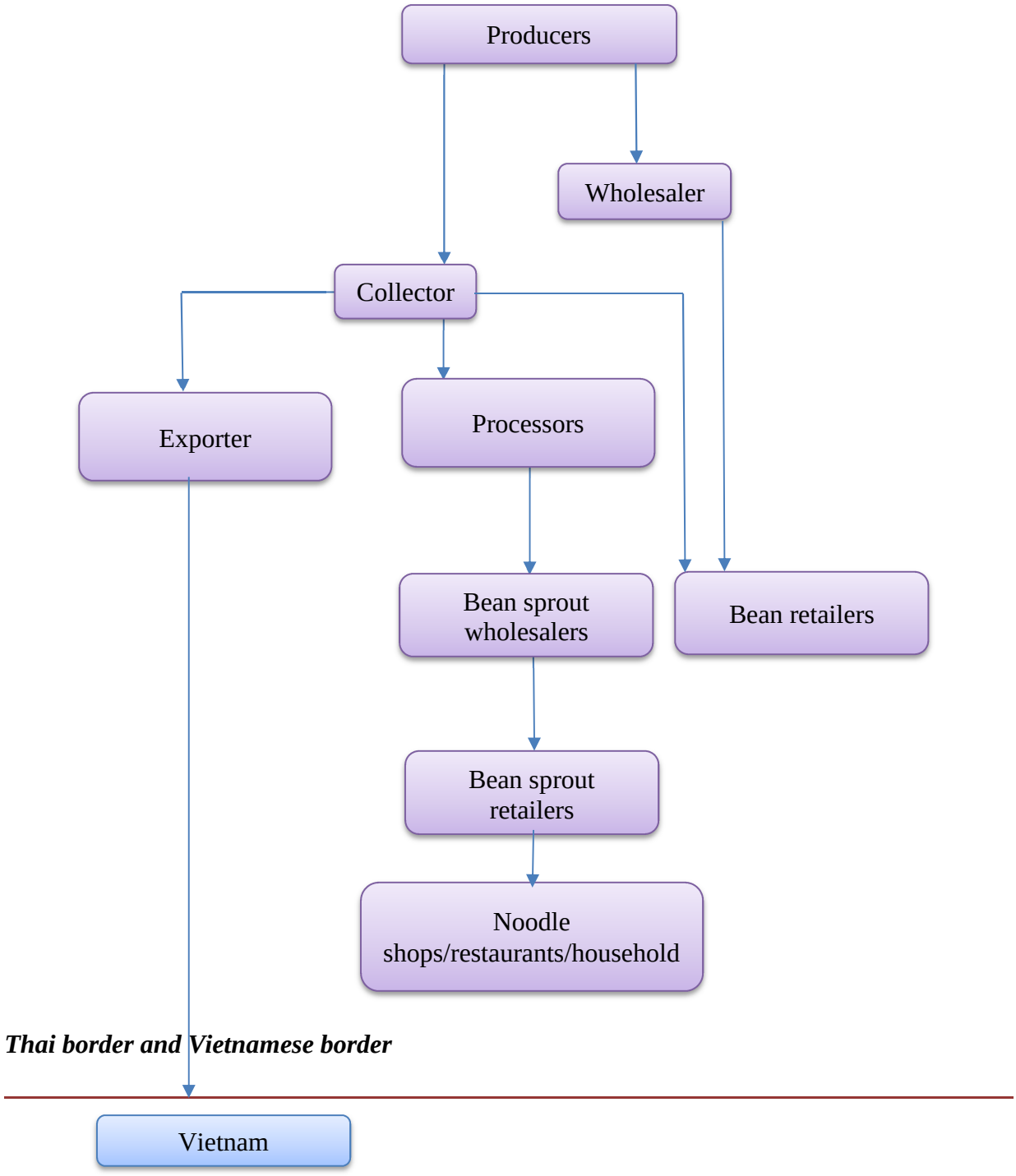
	Farmers	Collectors	Retailers
Total costs	2,723	5,000	12,059
Total output	4,800	6,788	14,000
Profit	**2,077**	**1,787**	**1,941**
Share of total profit	**36%**	**31%**	**33%**

Source: Authors' survey.

6.4. Value-chain maps

Based on the field survey in Vientiane capital, Vientiane province, Xayabouly and Xiengkhuang, the mung bean value chains are identified as in Figure 8 bellow.

Figure 8 – Mung bean value chains in the Lao PDR



Source: Authors' survey 2018.

7. MUNG BEAN MARKETING ARRANGEMENTS

7.1. Contract arrangements

According to the farmer survey, none of the mung bean producers had a specific contractual arrangement with their buyer or collector. The supply was based on a mutual agreement; no official written contract was arranged. The producers knew the collector well as they lived in the village, and producers did not only supply mung beans to the buyer, but also other agricultural products such as French beans, peanuts and red beans.

Similarly, there were no contractual arrangements between the collectors, wholesalers and bean sprout producers. Mung bean trade occurred based on which buyer could offer the highest price.

Trust: in this case the two parties developed a strong relationship because the suppliers were very reliable. Whenever there was a problem with the supply, they informed their buyer beforehand to find a solution for supply. If the quality of the bean sprouts did not meet the requirements (spoiled, not nice) then the noodle shop could return or replace with the better sprout.

- Supply in time
- Meet the quantity demand
- Reliability

Transport arrangement: the suppliers bring the bean sprouts to the agreed dropping point and the restaurant distributes the sprouts to the other branches themselves and the transport costs is the suppler responsibility.

7.2. Mung bean prices

It is interesting to see the differences in the price of mung beans purchased by the bean sprout producers in the provinces and in Vientiane Capital. Table 16 below shows that the highest purchasing price for mung beans in Vientiane Capital was 12,000 LAK/kg whereas in other provinces, especially in Xiengkhuang the price of mung bean for bean sprout could reach 20,000 LAK/kg.

Table 16 – Wholesale price of mung beans

Product	Lowest (LAK/kg)	Highest (LAK/kg)
Imported mung beans	14,000	20,000
Lao mung beans	5,000	10,000

Source: Author's survey

According to our discussion with restaurant owners, the price of bean sprouts over the past ten years did not change significantly (only 500 LAK change), and bean sprouts are not a high-value product. The highest demand for beans among the project site is in Vientiane

capital, as the volume supply of mung bean is 10,000-20,000 kg/year, however in other provinces the volume of beans purchased for bean sprout production was around 200kg. In Xiengkhuang, the price of bean sprouts was very high and the demand was very low.

Eating habits of consumers in Vientiane capital and in the other provinces seemed quite different. The use of mung beans in Vientiane capital was quite diverse, whereas in other provinces the use of bean sprout was limited.

Table 17 – Wholesale price of bean sprouts

Product	Lowest (LAK/kg)	Highest (LAK/kg)
Bean sprouts	5,000	20,000

Source: Author's survey.

The table below illustrates the estimation of mung bean demand for dried bean and for bean sprout production. This volume of bean volume is representing annual demand that is constructed from the interview with collector, processor and retailers. So, it can be seen that, there are around 72T of mung bean is producing and being trade in domestic markets.

Table 18 – Estimation of mung bean demand for dried beans and bean sprout production

Actor	Laos (kg/year)
Processor	29,000
Retailer	10,800
Collector	33,000
Total	72,800

Source: Author's survey.

8. MAIN ISSUES IN THE MUNG BEAN VALUE CHAIN

The major issue in the mung bean value-chain study is the quality. If the Lao mung beans are to compete with imported beans, quality should be improved. The quality management is very critical at the production stage. As the discussion with collectors and bean sprout processors suggested, the quality of the beans is very low and this has an impact on the quality of the bean sprouts, which is the key utilization of mung beans in this case. It is important that the farmers take this massage from the collectors and the bean sprout producers if they want to access the value chain.

Based on the observation and discussions with mung bean farmers, it is quite a challenge for farmers to improve the quality of their mung bean productions as they only grow mung beans for extra cash, the production system is very simple (no plot management, no fertilization), and there is a lack of labor to harvest the mung beans. Threshing mung beans is not easy, and lack of time and/or labor leads the farmers to use rice threshers to crack the bean shells, which breaks the beans. With enough time and labor, farmers would use traditional methods and produce higher quality beans.

Finally, mung bean prices have been dropping since 2016, making farmers give up their mung bean production and turn to other high-value crops like peanuts. The price of mung bean used to be as high as 7,500 LAK/kg (2016) but now it is only 4,500 LAK/kg (2018). This price drop is a major concern for farmers and prevents them from taking action to improve the quality of their mung beans.

9. OTHER OPPORTUNITIES FOR LEGUME PRODUCTION

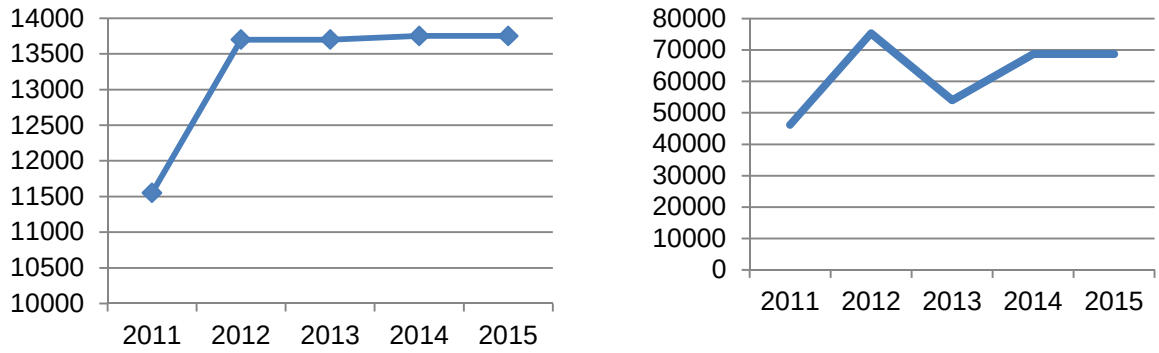
Our study focused on mung beans but also investigated the market situation of soybean and red bean. The soybean and red bean are among the soil fertility improvement crops under the Landscape Management and Conservation Agriculture Development for Eco-friendly Intensification and Climate Change Resilient Agricultural Systems in Lao PDR (EFICAS project). Xayabouly and Xiengkhuang provinces are two out of five provinces in Northern Laos where the project works. The project aims to develop innovative methods and intervention approaches to support farmers to adopt climate smart agricultural systems based on conservation agriculture. The EFICAS project introduced ranges of legume crops to the farmers to ensure the sustainable intensification of agriculture in Northern Laos.

9.1. Red beans

Red bean or rice bean is new crop, which was successfully introduced in Xayabouly province as an optional crop for soil fertility improvement and alternative crop for maize given that maize production is dropping and soil fertility is also degrading. The main objective of

promoting legume production in Xiengkhuang is to improve soil fertility of maize farmers. Commercialization production of maize in Xiengkhuang started in 2001-2002, with peak of maize price in 2006 (2,500 LAK-2,600 LAK/kg).

Figure 9 – Maize production area and production



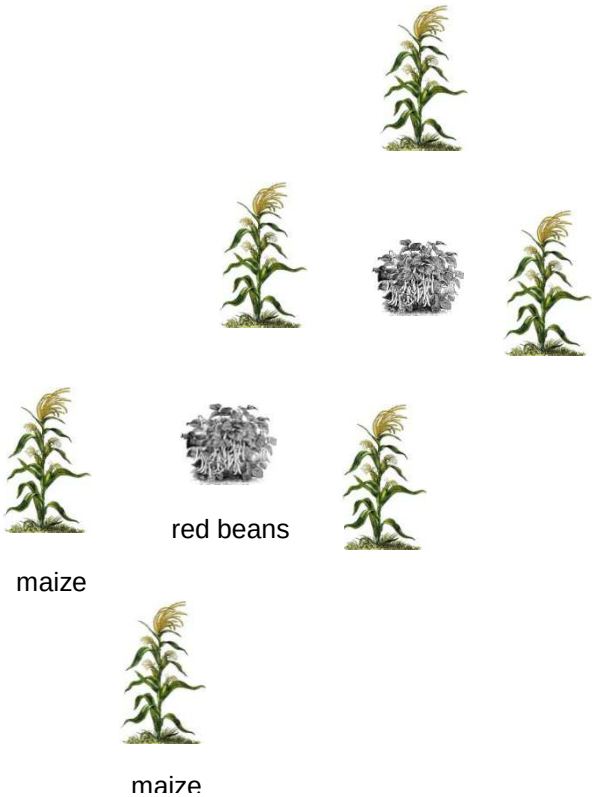
However, maize prices started to drop in 2008 and the current maize prize is 1,500 LAK/kg. Productivity also dropped due to the degradation of soil fertility. The EFICAS project aimed to introduce options to increase soil fertility as well as to earn some cash from the crop. In 2017, the project distributed red bean seeds to selected farmers in some villages –Dor village for red beans and soy beans, Sai-Nadoo village for red beans only, Leng village for red beans only. Red bean is a relatively new crop in Xiengkhuang, as maize has been recognized as a provincial strategic crop for more than 15 years. As a result, the project introduced new growing techniques for maize farmers that do not force them to give up maize.

The red bean production system is called an inter-cropping system, where red bean is introduced between maize, when the maize reaches 50 cm high (see Figure 10 below). Based on the discussion with five producers who received the red bean seeds, it can be observed that red bean was adopted well in the soil and climate conditions in Kham district. However, the productivity of red bean was unknown because it was eaten by rat and cattle. Farmers listed the following challenges encountered in producing red beans:

- *different harvesting time*s: when maize is ready to be collected the red bean is not mature yet. When maize farmers take off the fences to harvest the maize, other farmers release their animals that were confined during the rice and maize production. When the fences are taken down the red bean are eaten by the animals, so those farmers who want to adopt the new crop must invest to build fences to prevent the cattle and buffalo from eating the beans;
- *animal pests*: another important issue is pests, especially rats. The farmers interviewed had tested and grown red beans on a limited area and most of the beans were destroy by the rats. Red beans offer a good habitat for rats to stay and eat;

- *labor*: the labor for harvesting (this needs to be statistically compared with maize and other strategic crops).

Figure 10 – Inter-cropping system for red bean and maize production



Kham district is one of the key areas for maize production and exports to China and Vietnam. The district also welcomes investors from neighboring countries to be involved in maize trade in the district. One of the most important trade partners in Kham district is China.

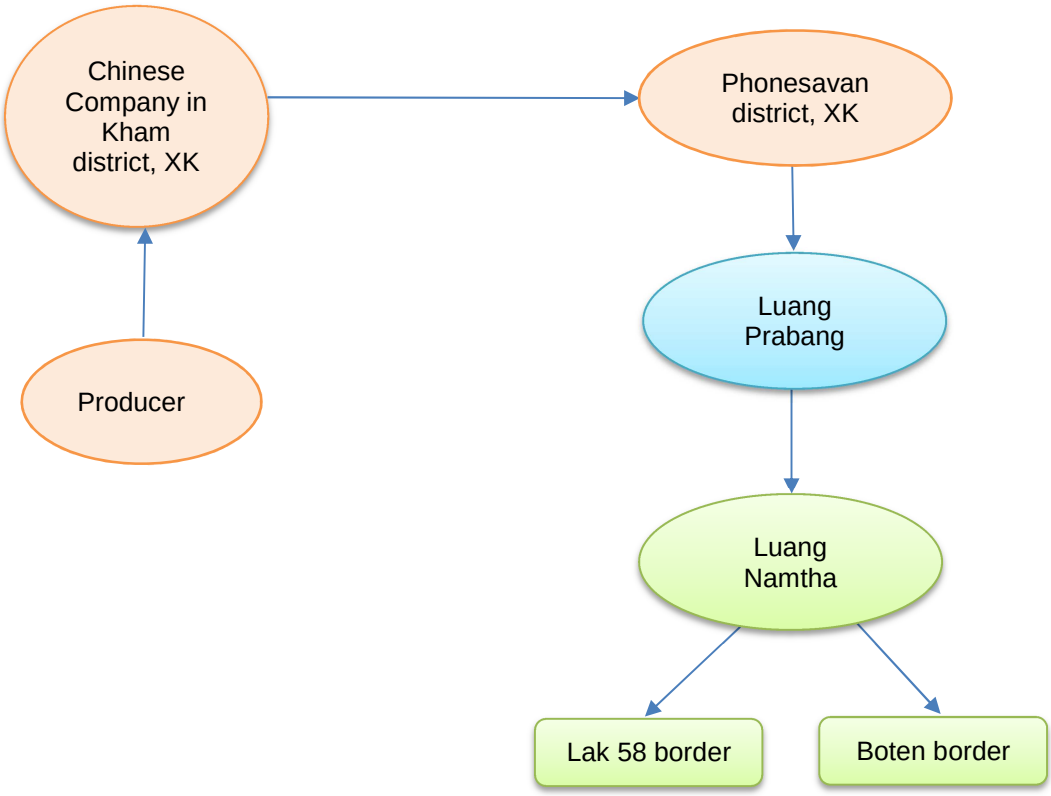
The Chinese company (Mr Ming Company) started trade in Kham district more than 20 years ago and is the biggest trader in Kham district. This company mainly trades maize, job's tear and NTFPs and has started trading red beans. The company signed a master trade contract with the provincial governor, a contract with the district governor, and will make contracts with farmers by recording the name and the quantity of red bean seeds provided. In 2018, the company saw opportunities for red bean trade and brought red bean seeds from Thailand to test in Kham district. The Chinese company gave seeds to the villagers to test in Kham and Nhong Het districts, but most villagers who received seeds are in Kham district, and in this year alone the company distributed over 6,000 kg of red bean seeds to the farmers. In December 2018 to January 2019, the red beans will be ready to be harvested and the farmer will have to return the seeds back to the company and the rest of the bean production the company will buy back. The contracted price, if the red bean is delivered to the company in Kham district is 2,800 LAK/kg but if the company has to go and buy at the farm then the

price will be lower (2,500 LAK/kg), depending on how far the farm is, as the trader has to pay for the transportation cost.

Table 19 – Major red bean seed distribution of the Chinese company

Area	Quantity of seed (kg)
Kham district (Suan mon village)	5,000
Phoukoud	500
Koun district	200
Long Jeng district, Vientiane province	200

The company plan to export red bean to China with the trade direction as they use for exporting maize, job's tear and NTFPs, the map bellow the red bean export direction of Chinese company.



There are two border crossings: trucks over 42 tons will go to Lak 58, while trucks that weigh 40 tons or below will go through Boten border to China

Lao border

China

The export procedure is a standard export procedure: the company obtains documents from the District Agriculture and Forestry Office, and then goes to the office of industry and

commerce and then the finance office to pay the export tax. The costs associated with the export are shown in bellow:

Table 20 – Major red bean seed distribution of the Chinese company

Concern government office	Document	Cost (LAK/time)
Agriculture and Forestry	Phytosanitary	
Industry and Commerce	Export document	50,000
Finance	Export tax	800,000
Border office	Export tax	1,900,000

The following market opportunities for red beans were identified:

- *market access*: according to discussions with Chinese company, there is still no connection between the Chinese company and the EFICAS project. This is interesting in terms of marketing opportunity for red bean producers in Kham district. As by the end of 2018 to the beginning of 2019, the company will evaluate and buy back the distributed red bean from villages. The EFICAS project could make contacts with this Chinese company and see if there is opportunity for project farmers to join the market. This will have a dual impact in terms of soil fertility improvement and connecting farmers to potential markets;
- *volume of demand*: currently the company is not limiting the volume that it will buy from the farmers. Again, this could be a good market opportunity for farmers.
- *production:* during the discussion with farmers, we observed that if there is a secure market for red beans, farmers are welling to adopt this new opportunity crop. One of the farmers who tested growing red bean in 2017 told us that he found that his maize production in 2018 looked better (based on his observation) compared to 2017 and he thinks that it is because of he did inter-cropping of maize and red bean last season. So farmer can take opportunity of improving soil fertility as well as taking advantageous from the available market.

9.2. SOY BEANS

Soy bean has been grow in Xienkhuang for many years by the Hmong minority. This crop is associated with the cultural practices of Hmong people who grow soybean every year in a small quantity in their garden together with other crops, such as maize. One day per year, Hmong people process the soybean to tofu, cook it as their food and eat it for that day only. That day, no animal are killed and no blood or meat is eaten. Everyone in the extended family from different parts of the country gathers in one house that has been selected and eats the soybean together.

The soybean production system is very simple: farmers grow maize first and when the maize is 50 cm high, the farmers grow soybean between the maize. Two soybean varieties are used in Kangkhea village, namely small seed and big seed varieties (Photo **10** below). The small seed varieties grow in June-July and the big seed varieties grow between June and September. The farmers decide when to grow based rainfall pattern. It is crucial that the rainy season is over when the soybean is ready to harvest, otherwise the beans will be damaged by the rain.

Photo 10 – Soybean varieties in Kangkhea village, Xieng Khuang

Small seed variety Big seed variety

Photo 11 below shows different production systems for soybean mixing with maize.

Photo 11 - Soybean garden in Kangkhea village, Kham district, Xiengkhuang

In the villages targeted by the EFICAS project, the production system is different: farmers start growing their soybean in March-April and the soybean is ready to harvest right in the rainy season. So, the rain caused major damages to the quality of soybean. The soybean could not be used or kept for growing in the next season at all. Photo 12 below was taken from a farmer who grew soybean, which was damaged by the rain.

Photo 12 – Soy bean production of the project

In terms of market opportunities for soybean, the project coordinator declared that there is an animal feed factory that has expressed its willingness to buy soybean and to use as part of animal feed production. However, the quality of the bean is very low and need pay more attention to the production, such as the production calendar and soybean production techniques can also be learnt from Kangkhea village where soybean production has been practiced for several generations.

10. CONCLUSION AND DISCUSSION

This study aimed to better understand the situation of mung bean production and marketing, and to identify market opportunities that may be available for and accessible to smallholder mung bean farmers. The study also tried to find out the reasons behind the limited use of mung beans relative to their economic potential, conditions for a successful commercialization of mung beans, potential market-led opportunities for smallholder mung bean producers and the strategies that may be developed to help smallholders and their communities take advantage of these opportunities.

The research found that mung bean production and consumption in the Lao PDR is currently very limited. Mung bean production occurs at a very small scale (the average holding area of production was 0.8 ha/household). The production system was highly traditional, with a very limited use of inputs (fertilizers, machines). There was no postharvest management and no quality control of the products although specific harvesting and postharvest handling methods have a major impact on the quality of the mung beans. The low quality of the mung beans produced in the Lao PDR was a major problem raised by both the collectors and the processors.

As 80% of the mung beans were used to produce bean sprouts, the low quality of the mung beans had a considerable impact on the quality of the bean sprouts. Quality was a key purchasing criteria for bean sprout processors. Immature and broken mung beans result in low germination rates, which is not acceptable for bean sprout processor. These quality issues

regarding mung beans have been discussed and shared with the farmers by the collectors but the farmers did not change their production practices.

The price of mung beans dropped since 2016 due to the importation of *thua kheak* (a black bean that is a little bit bigger than mung bean). This black bean is popular for bean sprout production because of high germination rates and because it has a better weight and is preferred by the consumers, especially in big cities like Vientiane Capital. The price of *thua kheak* is similar to that of mung beans (6,000 LAK/kg), so this new bean variety greatly affects the demand for mung beans[7].

Mung bean production in Xayabouly and Xiengkhuang provinces was almost impossible to identify. The provincial consumption of bean sprouts was very limited (not comparable to Vientiane capital). In these provinces, the mung beans used for bean sprout production came from Bokeo and Vietnam, which have a higher quality compared to Laotian mung beans. Bean sprout processors in the two provinces declared that if the quality of Lao mung beans improved, they would rather use Lao mung bean as the price was lower (the highest Lao mung bean price was 10,000 LAK/kg, while the price of Vietnamese mung beans was over 20,000 LAK/kg). The problem was the low volume of demand.

[7] During the market study in Vientiane Capital, the team tried to interview one of the biggest bean sprout processors, who uses a lot of *thua kheak*, but he refused the interview.

Appendix 1 – Mung bean (Vigna radiata)

Common names

Mung bean, mungbean, moong bean, golden gram, green gram, celera bean, Jerusalem pea feijão-da-china, feijão-mungo [Portuguese]; mungboon [Dutch]; Mungbohne, Jerusalembohne [German]; kacang hijau [Indonesian]; kacang ijo [Javanese]; fagiolo indiano verde, fagiolo mungo verde [Italian]; monggo, munggo [Tagalog]; Đậu xanh [Vietnamese]; **الماش بقلة** [Arabic]; 绿豆 [Chinese]; મગ [Gujarati]; **שעועית מונג**[Hebrew]; मूँग [Hindi]; ヤエナリ, リョクトウ [Japanese]; 녹두 [Korean]; ചെറുപയർ [Malayalam]; मूग [Marathi]; **ماش** [Persian]; Бобы мунг [Russian]; பாசிப் பயறு [Tamil]; పెసలు [Telugu]; ถั่วเขียว [Thai]

Species

Vigna radiata (L.) R. Wilczek [Fabaceae]

Synonyms

Phaseolus aureus Roxb., *Phaseolus radiatus* L., *Phaseolus setulosus* Dalzell, *Phaseolus sublobatus* Roxb., *Phaseolus sublobatus* var. *grandiflora* Prain, *Phaseolus trinervius* Wight & Arn., *Vigna radiata var. setulosa* (Dalzell) Ohwi & H. Ohashi, *Vigna sublobata* (Roxb.) Bairig. *et al.*

Taxonomic information

Mung bean (*Vigna radiata*) used to be known as *Phaseolus aureus* Roxb. before many *Phaseolus* species were moved to the Vigna genus (Lambrides *et al.,* 2006). In spite of its usual vernacular name of mung bean, *Vigna radiata* is a different species from *Vigna mungo*, which is usually called black gram or urd bean. Both species have a similar morphology (see Description below).

Feed categories

- Legume forages
- Legume seeds and by-products
- Plant products and by-products

Related feed(s)

- Cowpea (Vigna unguiculata) seeds
- Black gram (Vigna mungo)
- Bambara groundnut (Vigna subterranea) seeds

Description

The mung bean (Vigna radiata (L.) R. Wilczek) is a legume cultivated for its edible seeds and sprouts across Asia. There are 3 subgroups of Vigna radiata: one is cultivated (Vigna

radiata subsp. radiata), and two are wild (Vigna radiata subsp. sublobata and Vigna radiata subsp. glabra). The mung bean plant is an annual, erect or semi-erect, reaching a height of 0.15-1.25 m (FAO, 2012; Lambrides et al., 2006; Mogotsi, 2006). It is slightly hairy with a well-developed root system. Wild types tend to be prostrate while cultivated types are more erect (Lambrides et al., 2006). The stems are many-branched, sometimes twining at the tips (Mogotsi, 2006). The leaves are alternate, trifoliolate with elliptical to ovate leaflets, 5-18 cm long x 3-15 cm broad. The flowers (4-30) are papillonaceous, pale yellow or greenish in colour. The pods are long, cylindrical, hairy and pending. They contain 7 to 20 small, ellipsoid or cube-shaped seeds. The seeds are variable in colour: they are usually green, but can also be yellow, olive, brown, purplish brown or black, mottled and/or ridged. Seed colours and presence or absence of a rough layer are used to distinguish different types of mung bean (Lambrides et al., 2006; Mogotsi, 2006). Cultivated types are generally green or golden and can be shiny or dull depending on the presence of a texture layer (Lambrides et al., 2006). Golden gram, which has yellow seeds, low seed yield and pods that shatter at maturity, is often grown for forage or green manure. Green gram has bright green seeds, is more prolific and ripens more uniformly, with a lower tendency for pods to shatter. In India, two other types of mung beans exist, one with black seeds and one with brown seeds (Mogotsi, 2006). The mung bean resembles the black gram (Vigna mungo (L.)) with two main differences: the corolla of Vigna mungo is bright yellow while that of Vigna radiata is pale yellow; mung bean pods are pendulous whereas they are erect in black gram. Mung bean is slightly less hairy than black gram. Mung bean is sown on lighter soils than black gram (Göhl, 1982).

The mung bean is a major edible legume seed in Asia (India, South East-Asia and East Asia) and is also eaten in Southern Europe and in the Southern USA. The mature seeds provide an invaluable source of digestible protein for humans in places where meat is lacking or where people are mostly vegetarian (AVRDC, 2012). Mung beans are cooked fresh or dry. They can be eaten whole or made into flour, soups, porridge, snacks, bread, noodles and ice-cream. Split seeds can be transformed into dhal in the same way as black gram or lentils. Mung beans can be processed to make starch noodles (vermicelli, bean thread noodles, cellophane noodles) or soap. The sprouted seeds ("bean sprouts" in English, and incorrectly called "germes de soja" or "pousses de soja" in French) are relished raw or cooked throughout the world. The immature pods and young leaves are eaten as a vegetable (Mogotsi, 2006).Several mung bean products are useful for livestock feeding (Vaidya, 2001):

- Mung beans, raw or processed, as well as split or weathered seeds.
- By-products of mung bean processing: mung bean bran (called chuni in India), which is the by-product of dehulling for making dhal, and the by-product of the manufacture of mung bean vermicelli.
- Mung bean is sometimes grown for fodder as hay, straw or silage (Mogotsi, 2006). It is particularly valued as early forage as it outcompetes other summer growing legumes such as cowpea or velvet bean in their early stages (Lambrides et al., 2006).

The mung bean plant makes valuable green manure and can be used as a cover crop (Mogotsi, 2006).Distribution

The mung bean is thought to have originated from the Indian subcontinent where it was domesticated as early as 1500 BC. Cultivated mung beans were introduced to southern and eastern Asia, Africa, Austronesia, the Americas and the West Indies. It is now widespread throughout the Tropics and is found from sea level up to an altitude of 1850 m in the Himalayas (Lambrides et al., 2006; Mogotsi, 2006).

The mung bean is a fast-growing, warm-season legume. It reaches maturity very quickly under tropical and subtropical conditions where optimal temperatures are about 28-30°C and always above 15°C. It can be sown during summer and autumn. It does not require large amounts of water (600-1000 mm rainfall/year) and is tolerant of drought. It is sensitive to waterlogging. High moisture at maturity tends to spoil the seeds that may sprout before being harvested. The mung bean grows on a wide range of soils but prefers well-drained loams or sandy loams, with a pH ranging from 5 to 8. It is somewhat tolerant to saline soils (Mogotsi, 2006).Mung bean production is mainly (90%) situated in Asia: India is the largest producer with more than 50% of world production but consumes almost its entire production. China produces large amounts of mung beans, which represents 19% of its legume production. Thailand is the main exporter and its production increased by 22% per year between 1980 and 2000 (Lambrides et al., 2006). Though it is produced in many African countries, the mung bean is not a major crop there (Mogotsi, 2006).

Processes

Seed harvest. Mung bean crops grown for seeds are generally harvested when pods begin to darken. They are mostly hand-picked at weekly intervals. In newer varieties in which the plants mature uniformly, the whole plants are harvested and sun-dried before being threshed. Once pods have dried, the seeds are removed by beating or trampling (Mogotsi, 2006).

Forage harvest

The mung bean can be grazed six weeks after planting and two grazings are usually obtained (FAO, 2012). It can be used to make hay, when it should be cut as it begins to flower and then quickly dried for storage. It is possible to make hay without compromising seed harvest.

*Forage management.*Mung bean seed yields are about 0.4 t/ha but yields as high as 2.5 t/ha can be reached with selected varieties in Asia (AVRDC, 2012). Mung beans can be sown alone or intercropped with other crops, such as other legumes, sugarcane, maize, sorghum, fodder grasses or trees (Göhl, 1982). Intercropping can be done on a temporal basis: modern varieties ripen within 60-75 days and there is enough time to harvest another crop during the growing season. For instance, in monsoonal areas, it is possible to sow mung bean and harvest it before the monsoon season when rice is planted. It is also possible to grow mung bean on residual moisture after harvesting the rice (Mogotsi, 2006). Forage yields range from 0.64 t/ha of green matter under unfertilized conditions to about 1.8 t/ha with the addition of fertilizer (FAO, 2012)

Environmental impact

Cover crop and soil improver. The mung bean can be used as a cover crop before or after cereal crops. It makes good green manure. The mung bean is a N-fixing legume that can provide large amounts of biomass (7.16 t biomass/ha) and N to the soil (ranging from 30 to

251 kg/ha) (Hoorman et al., 2009; George et al., 1995 cited by Devendra et al., 2001; Meelu et al., 1992). Green manure should be ploughed in when the plant is in full flower (FAO, 2012).

Nutritional attributes

Seeds. Mung beans are rich in protein (20-30% DM) and starch (over 45% DM) with a low lipid content (less than 2% DM), and variable but generally low amounts of fibre (crude fibre 6.5% DM on average). The amino acid profile of mung beans is similar to that of soybean.

Mung bean by-products. The by-product of mung bean vermicelli processing contains 11-23% crude protein, 0.4-1.8% ether extract, 13-36% crude fibre, 0.30-0.68% calcium and 0.17-0.39% phosphorus depending on the mung bean material (Sitthigripong et al., 1998).

Forage. Fresh mung bean forage has a moderate (13%) to high (21% DM) protein content. Like other legume straws, mung bean straw is higher in protein (9-12%) than cereal straws.

Table 1 – Chemical composition of mung bean and its by-products (percent, DM basis)

Parameter	Seeds	Straw	*chuni*
Crude protein	19.5–29.4	8.7–11.6	19.2
Ether extract	0.2–3.7	2.3–2.4	2.2
Crude fibre	4.3–12.4	26.6–29.9	26.2
NDF	15.6	63.5	43.5
ADF	6.6–10.3	32.0–47.2	26.4
Lignin		4.8	4.3
Ash	0.9–14.0	6.1–12.1	4.8
Calcium	0.08–0.47	2.7	0.4
Phosphorus	0.36–0.62	0.2	0.3

Notes: DM (as fed) is 90.0 percent for seeds, 88.2 percent for straw and 95.3 percent for *chuni*.

ADF = acid detergent fibre; NDF = neutral detergent fibre.

Potential constraints

Antinutritional factors

Mung beans contain several antinutritional factors (trypsin inhibitors, chymotrypsin inhibitor, tannins and lectins) (Wiryawan et al., 1997). The amounts of antinutritional factors vary greatly among mung bean types and can be reduced through processing methods such as soaking, cooking or extruding (Lambrides et al., 2006; Mogotsi, 2006; Wiryawan et al., 1997). However, in some cases, these metabolites were found to have no negative effects (Creswell, 1981).

Ruminants

Seeds. Information on the use of mung beans in ruminants is limited. Mung beans are highly fermentable in the rumen and compare favourably with coconut meal, palm meal (mechanically or solvent extracted) and dried brewer's grains (Chumpawadee et al., 2005). In a comparison of several legume seeds in the Southern Great Plains of the USA, the protein and in vitro digestible DM of mung beans indicated that they could be efficient replacements for maize or cottonseed meal in livestock diets, assuming that mung bean

could generate enough grain biomass to be cost-effective. Though not as effective as soybean, the mung bean was capable of accumulating useful levels of protein and digestible dry matter under the variable growing conditions of the study (Rao et al., 2009).

Mung bean bran (chuni). Mung bean chuni was included at 50% of the concentrates offered to buffaloes fed on a rice straw diet. It met maintenance requirements without any adverse effect on nutrient utilization (Krishna et al., 2002).

Forage. Mung bean forage sustained sheep maintenance without adverse effects (Garg et al., 2004). Mung bean straw (haulms) can be used in the same way as other cereal and legume straws. In the highlands of Afghanistan, they are mixed with rice straw and wheat straw to make a bulky component in sheep and goat diets (Fitzherbert, 2007). In a comparison of sheep and goat feeding, mung bean straw was found to be palatable to both species with no deleterious effects on animal health. Reported OM digestibilities were moderate, 56 and 61% in sheep and goats respectively (Khatik et al., 2007). DM digestibility of mung bean straw (64%) fed to ewes ad libitum was similar to that of the straws of groundnut, alfalfa and cowpea and higher than that of cajan pea straw (54%). Feeding ewes with mung bean straw increased overall DM intake from 12.6 to 18.9 g/kg LW/day (McMeniman et al., 1988).

Pigs

Seeds

Growing pigs. Mung beans are rich in protein, with a high lysine content, but the raw seeds contain antinutritional factors that may limit their use in pigs (Maxwell et al., 1989). Processed seeds have a higher digestibility in growing pigs: extrusion proved to be more effective than cooking or roasting (Canizales et al., 2009). Mung beans used as a supplementary source of lysine could be included at up to 10% in the diets of growing pigs, with weight gains similar to that obtained with maize-soybean based diets (Maxwell et al., 1989). Inclusion levels were increased up to 30% with specific cultivars (Wiryawan et al., 1997). In finishing pigs, proposed inclusion levels have been lower (6 to 9%) (Maxwell et al., 1986a), though higher rates (up to 16%) were shown to have little negative effect on performance (Maxwell et al., 1989).

Sows. Gestating sows were fed up to 16% mung beans without negative effects on animal performance or litter size (Luce et al., 1988). A 19% dietary inclusion had negative effects on gestating sows, notably a lower weight gain during pregnancy and lower milk production (Maxwell et al., 1986b).

Mung bean by-products. The mung bean meal, a by-product of the vermicelli manufacturing, has been tested in pig diets with satisfactory results, due to its bulk and fibre content. It could replace up to 75% of the rice bran in pig diets, with older pigs benefiting the most. Higher inclusion rates resulted in higher intakes but were detrimental to feed conversion ratio (Sitthigripong, 1996). Amino acid supplementation failed to make diets based on this product as efficient as a maize-soybean meal based diet (Sitthigripong et al., 1998). Mung bean bran (chuni) was included at 15% level in the rations of finisher crossbred pigs (Ravi et al., 2005).

Forage. Mung bean forage has been assessed with 8 other tropical legumes as a potential alternative protein feed for pigs and ranked among the more suitable ones (Bui Huy Nhu Phuc, 2000).

Poultry

Mung bean has a higher energy value than many other legume seeds (Wiryawan et al., 1995). It is a high value resource for poultry feeds.

Broilers. High levels of mung beans have been tested in young broilers without loss of growth or feed efficiency: up to 40% mung beans in the diet gave the same performance as the maize-soybean meal based control diet. Feed efficiency was affected only when the energy level of the diet was not adjusted. There was no effect of raw mung bean on pancreas weight, and boiling mung bean did not increase performance. It can be concluded that no harmful antinutritional factors were present (Creswell, 1981).

Layers. Raw mung beans introduced at levels of 15% or 30% in the diet did not result in reduced egg production or feed efficiency. However, egg production was significantly depressed at a 45% inclusion level. Pelleting diets had no effect at the 15% or 30% inclusion rate, but had a positive effect on production at the 45% level (Robinson et al., 2001). In all cases body weight was slightly depressed by the inclusion of mung beans in the diet. The general recommendation is to use mung beans at levels up to 30% in layer diets, provided that the diet is properly balanced, especially with amino acids.

Rabbits

Little information is available in the international literature on mung bean utilization in rabbits. In a study where soybean meal was replaced by mung beans in complete feeds for growing rabbits, mung beans were introduced at up to 24% in the diet without impairing performance. The 10% reduction in growth rate observed at the 32% inclusion rate may be related to the lower protein digestibility attributed to mung beans when compared to soybean meal (73 vs. 85%) (Amber, 2000).

Fish

Asian sea bass (Lates calcarifer). Mung beans can be used as a protein source at up to 18% in the diet of Asian sea bass without affecting growth (Eusebio et al., 2000).

Nile tilapia (Oreochromis niloticus). Nile tilapia fry were fed on mung beans as a partial replacer of fish meal. Best results were obtained at 25% fish meal replacement (de Silva et al., 1989).

Crustaceans. Indian prawns (Fenneropenaeus indicus) fed a soybean meal-based diet, where mung beans replaced 9% of the protein, had a significantly lower weight gain, growth rate and survival rate than those fed the control diet (Eusebio et al., 1998).

Source: https://www.feedipedia.org/node/235

Appendix 2 – Legume marketing chains in Thai provinces close to Sayaburi (Welsh & Coudray, 2007)

Study on legume production and marketing in three Thai provinces (Loei, Nongboualamphou and Udon Thani) bordering Sayaboury province, Lao PDR.

Mung bean marketing in Thailand

There is no contract farming for mung bean production. Farmers depend on local middlemen for agricultural services (seeding and milling facilities) as well as marketing. Farmers can sell their mung beans to large middlemen directly. The traditional marketing chain for legumes quite simple:

Organization of mung bean value-chains from Xayabouli to Bangkok

Producer		Local middleman		Middleman 1		Middleman 2		Factor / exporter
Xayabouli Province	→	Xayabouli Province *Kenethao district*	→	Loei Province *Tha Li, Loei, Wangsa Phung districts*	→			Bangkok
Xayabouli Province	→	Xayabouli Province *Kenethao district*	→	Loei Province *Chiangkhan district*	→	Nong Bua Lamphu Province	→	Bangkok
Xayabouli Province	→	Xayabouli Province Vientiane Province	→	Nongkhai Province	→	Udon Thani Province	→	Bangkok

Local middlemen were generally based in the same district as the producers. They lived from agricultural production and the supply of agricultural services (rental of ploughing, seeding and milling equipment) but did not own any storage facilities.

Large middlemen often had several businesses (trade of agricultural inputs and seeds) but their activity never directly involved agricultural production. They generally operated at the provincial level. They usually owned storage facilities. Some bought beans directly from the farmers, depending on the proximity of the farms, the quality and the type of product –*e.g.*, corn and soybean were never bought directly from farmers. Large middlemen in Northern Thailand never interacted and beans were directly sold to the exporter or the processor. Large middlemen were in charge of: (re)drying, cleaning and manual grading mung beans according to their quality (yellow or black grains were removed if their proportion was too high) and size. Most middlemen bought small volumes of legumes –*e.g.*, they added a few bags of legumes to large shipments of corn. Middlemen sold mung beans to noodle and sweet factories producing for the Thai market. These factories were located in Bangkok, Nakhon Pathom and Khon Kaen provinces. Mung bean exports in 2002-2007 represent less than 10% of total production. Middlemen's profit margin ranged 0.5- 2.5 Baht/kg depending on the quality of the product and their capacity to store long enough to wait for a good price. Mung bean can be stored but have to be treated with insecticides (aluminum phosphide) every 45-60 days. A long storage period (12 months) results in a high costs (insecticides), loss of color (grains become yellow), loss of weight

(3% per year) and finally in a reduced sale price. A short storage (2-3 months) enables to limit losses while waiting for an appropriate selling price.

Mung bean quality issues

There were seven grades of beans, each one with a specific price. Grades No. 3-5 were the most traded –little or no production of No. 1-2 grains in the region and sale prices of No. 6-7 were too low to be profitable. 3-5% of yellow or black grains were tolerated by traders. If the proportion reached 10%, mung beans were sold at Grade No. 7 price. The middlemen mentioned the low quality of Lao products compared to Thai products, in terms of cleanliness, presence of dust or soil in the bags, and size of the beans.

Mung bean production

The steady decline in mung bean production in Thailand. There has been a steady decline (about 5.8% per year) in the production of mung beans in Thailand, from 256,000 tons (1994) to 178,000 tons (2003), 135,000 tons (2004) and 133,000 tons (2005). The drop in mung bean production was observed in Sukhothai (50% drop), Kamphaeng Phet (70%), Nakhon Sawan (30%) and Petchabun, Thailand's largest production area with 60,000 tons per year (15% drop), In the North-East, production fell from 14,000 tons (2001) to 5,600 tons (2005). This downward trend in mung bean production was also noticed in the provinces studied:

- Loei: mung bean production fell from 6,000 tons (mid-90s) to 2,000 tons (2002), 173 (resp. 134) tons in 2003 (resp. 2004) and 461 tons in 2005;
- Nongboualamphou: mung bean production fell from over 500 tons (2002) to 269 tons (2005);
- Udon Thani: production was stable until 2002 (800-1000 tons per year) then fell to 150-200 tons since 2003.

This downward trend is due to a lower demand as factories replaced mung bean by cheaper cassava, and to the expansion of more profitable crops for the farmers such as cassava and rubber.

Prices. Average farm gate prices in Thailand remained stable (10-12 Baht/kg) for ten years before increasing to 14.5 Baht/kg in 2004 and to 17.3 Baht/kg in 2005 in response to the decline in national mung bean production since 2003. In Loei province, farm gate prices dropped from 20 Baht/kg (1997) to 6-7 Baht/kg over the same period. As a result, farmers gradually reduced their production of mung beans and finally gave up producing mung beans. Prices picked up in 2007 (12-15 Baht/kg) following the reduction of mung bean production. Farm gate prices depended on the quality of the product, i.e.: a) the size of the grains (the price differential between grades No.3 and No.5 can reach 1 Baht/kg); b) the proportion of spoilt grains (yellow or black grains); c) the presence of soil or dust. Large price swings are a source of significant risk for farmers and for traders. Farmers can only deal with such risk by diversifying their production. Traders can make business more secure if they have the possibility to store mung beans for some months. Although middlemen said that mung bean trade could be very profitable (more than corn or soybean), they were reluctant to buy large amounts of mung bean.

Recommendations

To support legume production in the Lao PDR, need to promote suitable cropping (to maximize the weight of grains), harvest and post-harvest techniques (to export a clean product); to develop and introduce selected varieties that match the Thai market.

Appendix 3 – CONTACT OF MUNG BEAN VALUE CHAIN ACTORS

No	Name	Location	Phone number	Remark
1	Mrs Phan (ພັນ)	Nonkhor market	55702761	Sprout producer in VC
2	Mr. Shy (ສີ)	Yapha village, Sykai, Vientiane capital	99425559	A very big bean sprout producer in VC
3	Mrs. Duoang (ດ້ວງ)	Nhongthatai village	NA	Second big bean sprout producer
4	Mrs. Lai (ໃຫ)	Sumphanna village , Santhong district	22244988	Village collector
5	Mrs. Vieng (ແມ່ວຽງ)	Kokphuerng village, Santhong district	52834709	Village collector
6	Mrs. Meo (ເອື້ອຍ ແມ້ວ)	Nasanghin village, Santhong district	NA	Collector and small bean sprout producer in Nasanghin village.
7	Agro-Aussie ບໍລິສັດອິນຊີສັງທອງ	Santhong district	020 21254376	Dried bean processor
8	SKVP company: ບໍລິສັດ ສຸນີ ແກ້ວມະນີວັນ ພົມດວງສີ	Vientiane capital	55462406, 55561261, 22227011	Dried bean processor that source bean from Champasack
10	Miss Tew (ແມ ຕົ້ວ)	Kenthao district, Xayabouli	030 5759887	Sprout producer
11	Mrs Teng (ແຕ້ງ)	Khonkean village, Paklay district, Xaya	NA	Village collector
12	Mrs Kabkeo	Khonkean village, Paklay district, Xaya	NA	Village collector
13	Mr. Xaythor (ໄຊທ໋)	Kham district, Xiengkhuang province	0305732101	Chinese company coordinator for red bean production promotion and trade in Xiengkhuang Seed
14	Mr Phetsavanh	Paklay district, Xayabouli		Big maize and bean trader in Paklay district

Remark: this table aims to provide connection information among actors in the chain.

11. REFERENCES

ANDERSON-SPRECHER, A. and ZHANG LEI. 2014. China, Pulses Annual, Gain Report No. CH14061, 6 p.

DFID, 2010. Counting on Mung beans: mung bean improvement in Asia, https://assets.publishing.service.gov.uk/media/57a08b1ced915d3cfd000b38/DFID_impact_case_study_Mungbean_FINAL_1_.pdf (accessed in October 2018).

EBERT, A. 2014. "Potential of Underutilized Traditional Vegetables and Legume Crops to Contribute to Food and Nutritional Security, Income and More Sustainable Production Systems", Sustainability, (6):319-335.

GOVERNMENT OF LAOS (GOL), 2015. National Nutrition Strategy to 2025 and Plan of Action 2016-2020, Vientiane: GOL, 73 p.

MAFF, 2018. *Annual Report for agriculture and Forestry and Fisheries 2017-2018 and Direction 2018-2019*, Phnom Penh: Ministry of Agriculture Forestry and Fisheries, 113 p.

HUIJIE, Z., N.H. Li, X.Z. CHENG, and K. WEINBERGER, 2003. *The impact of mung bean research in China*. AVRDC Publication No. 03-550. Working paper No.14. Shanhua, Taiwan: AVDRC-The World Vegetable Center.

KOPONEN, J., PAIBOONVORACHAT, C. and MUNOZ, A., 2017. *The Council Study: Study on the sustainable management and development of the Mekong River, including impacts of mainstream hydropower projects*, Mekong River Commission (MRC): Vientiane, Lao PDR. 128 pp.

LE THAN HIEP, 2000. "Vietnam", in Processing and Utilization of Legumes, Report of the APO Seminar on Processing and Utilization of Legumes, Japan, 9–14 October 2000, 295 p.

LI, L., T. YANGA, R. LIU, B. REDDENC, F. MAALOUF, and X. ZONG, 2016. "Food legume production in China", *The Crop Journal*, 5(2):115-126.

MAF, 2017. Agricultural Statistics Year book 2017, Vientiane: Ministry of Agriculture and Forestry.Department of Planning and Finance.

PRASERTSRI, P. 2014. Thailand, Grain and Feed Annual, Gain Report No. TH4021.

PEIRIS, H., R. KAVEETA, S. RANGSIPAHT and R. PITAKDANTHAM, 2016. "Effects of Thailand and Sri Lanka agronomic practices on mungbean (Vigna radiata (L.) Wilczek) production in rice-based cropping system", *Agriculture and Natural Resources*, 50(4):286-290.

SWE MON AUNG, 2018. "Myanmar Beans and Pulses Update 2018", Gain Report No. BM 8021, 5 p.

TANOUE, I., 2015. "China not so full of mung beans", *Nikkei Asian Review*, https://asia.nikkei.com/Business/China-not-so-full-of-mung-beans (last accessed in October 2018).

VERNOOY R. 2015. Effective implementation of crop diversification strategies for Cambodia, Lao PDR and Vietnam: Insights from past experiences and ideas for new research. Bioversity International, Rome, Italy, 122 p.

WEINBERGER, K. Impact Analysis of Mungbean Research in South and Southeast Asia; AVRDC - The World Vegetable Center: Tainan, Taiwan, 2003.

WELSH, N. and J. COUDRAY, 2007. Study of the marketing chain of the legumes produced in the Thai provinces close to Sayaburi, Vientiane: PCADR project, 15 p.