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Efficiency Indicators of Smallholder Farming Systems in the Central Highlands of Vietnam and Northeast Cambodia

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Abstract

The agricultural sectors of the Central Highlands of Vietnam and Ratanakiri Province in northeast Cambodia are undergoing rapid transitions out of traditional, subsistence-oriented production systems and towards increased intensification and market-orientation. In addition to sharing a border, both regions share common biophysical characteristics including soil and agro-climatic conditions, yet Vietnam's agricultural sector is more intensified and benefits from improved infrastructure, more mature markets for cash crops, and steadily increasing demand for higher-value products such as meat, fish, and dairy. These regions therefore represent a gradient of alternative agricultural practices from low-intensity (as measured by input usage) systems common to Ratanakiri, to relatively intensive systems including specialty crops, e.g. pepper, aquaculture and animal systems in the Central Highlands. In both regions, smallholder agriculturists are faced with tremendous uncertainty about which alternative land use practices will result in favorable livelihood outcomes. In the Central Highlands, old, unproductive coffee trees abound, and new markets mean difficult choices about what to invest in next. In Ratanakiri, increased land pressure from the continued development of Economic Land Concessions and associated immigration has resulted in most smallholders transitioning out of swidden systems and into permanent systems of primarily cash crops. Here, we characterize several alternative crop and livestock production systems in the region in terms of their 1) economic and 2) energy efficiencies in the hope that more precise efficiency metrics will aid in the decision making process for agricultural stakeholders and policy makers in the region.

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1. Introduction

The commonalities between the Central Highlands region of Vietnam and the northeastern Cambodian province of Ratanakiri extend far beyond their shared border. Biophysically, both regions are comprised of undulating plateaus of basaltic soils bordered by the Annamite range in the north, and are characterized by a monsoonal climate with an extended dry season. Both regions were covered primarily in dense tropical forest prior to the expansion of smallholder agricultural production in the Central Highlands, and the introduction of large-scale economic land concessions in Ratanakiri (Hor et al., 2014). The ethnographic history of both regions has also followed a similar trajectory, characterized by a high concentration of ethnic minority groups for whom assimilation into the social and economic systems of their respective countries has been met with resistance. Today, agriculture remains the primary economic engine of both regions, and health and economic outcomes are generally worse relative to national indicators (Ridell, 2006; D'haeze, et al., 2005). Despite these similarities, policy changes and market reforms since the 1970s have contributed to substantial differences in the current state of the agricultural sectors of the Central Highlands and Ratanakiri.

Prior to the reunification of Vietnam in 1975, agricultural production in the Central Highlands was dominated by subsistence-oriented, shifting cultivation (McElwee, 2001). Following the development of "New Economic Zones", over a million ethnic Vietnamese (Kinh) were settled in the region from more densely populated regions (Dang et al., 2001), and eventually slash and burn (i.e. swidden) agriculture was banned outright, resulting in the rapid adoption of sedentary smallholder systems at the expense of a vast portion of the region's forested area (Salemink, 2003). The introduction of Robusta coffee, followed by the tremendous growth in its production of approximately 20% annually between 1993 and 2000, contributed to

a further influx of migrants to the region and a near doubling of the population of the two Central Highlands provinces that are the subject of this study – Dak Lak and Dak Nong – between 1990 and 2000 (D'haeze et al., 2005). Vietnam's relatively sudden and dramatic entry into the Robusta market, coupled with global trade liberalization and regulatory reforms during the 1990's, contributed to an oversupply of coffee globally and subsequent dramatic price declines (D'haeze et al., 2005). Marginal producers in the Central Highlands, especially those producing in more acidic soils, subsequently adopted a more diverse set of agricultural systems, including cash crops such as cassava and rubber, as well as more intensive, market-oriented animal systems (Frison et al., 2011).

In contrast to the Central Highlands, the transition out of swidden, substance-oriented cropping systems and into semi-permanent or permanent, market-oriented systems in Ratanakiri began only in the last 10 to 20 years (Fox et al., 2009). Today, many smallholder farmers in the region are producing cash crops such as cashew, cassava, and soybeans in permanent systems, while others are still producing rice and other crops for household consumption in swidden systems (Cambodia Census of Agriculture, 2015). Land use pressure on smallholder farmers in Ratanakiri has intensified in recent years following the introduction of the Economic Land Concession (ELC) program by the Cambodian government, in which corporations, usually foreign-owned, are awarded low-lost, long-term leases on large tracts of land in an attempt to boost economic output from natural resource extraction and agricultural production (Davis, et al., 2015). Employment opportunities associated with ELCs in the region have also contributed to increased immigration into Ratanakiri from other provinces, further constraining traditional land-use practices of ethnic minority agriculturalists in the region (Baird and Fox, 2015).

In both the Central Highlands and Ratanakiri, therefore, a combination of biophysical, political, and socio-economic variables have contributed to what is now a diverse agricultural region still largely dominated by increasingly market-oriented and intensive smallholder productions systems (Blrnholz et al. 2017). Despite the growth of more market-oriented agricultural sectors in both regions, poverty rates remain high and the collapse of coffee prices in the 1990s serves as a stark reminder of the risks associated with a homogenous agricultural sector, driving the push for more intensive agricultural systems to boost output, raise incomes, and increase food security (Blrnholz et al. 2017). At the same time, there is a concern that continued intensification, as measured by the increased use of agrochemical inputs and water, will result in negative ecological externalities such as those attributed to the intensification of coffee production in Vietnam, e.g. diminished soil fertility and loss of organic matter (Tran and Kajisa, 2006), water table depletion (Technoserve, 2013), and water body pollution attributed to agricultural runoff (Rahman and Thapa, 1999).

As is now commonplace in the agricultural policy and research domains, the tradeoffs inherent in the desire to intensify production while limiting negative ecological externalities has led to an ever increasing focus on "sustainable intensification" (SI), i.e. increasing agricultural output while minimizing the associated ecological footprint (Struik et al., 2014). While the motivations behind sustainable intensification of agriculture are rather obvious, definitions of both "sustainable" and "intensification" insofar as they relate to agriculture can vary considerably (Struik et al., 2014). Although not explicitly attempting to define SI, Keating et al. (2010) proposed the concept of "eco-efficient" agriculture, that is, increasing the quantity and quality of agricultural output while using less "land, water, nutrients, energy, labor, or capital." Similarly, Tittonel and Giller (2013) defined "ecological intensification" as increasing

agricultural output while "reducing the use and need for external inputs, and capitalizing on ecological processes that support and regulate primary productivity in agro-ecosystems." Compounding the problem of lack of consistency across SI definitions is the fact that SI conceptual frameworks generally do not include specific indicators or metrics for the objective comparison of alterative agricultural systems, or guidance on, e.g., the relative weighting of different components of sustainability (ecological, economic, cultural, etc.). Further, there can exist an implicit suggestion in SI definitions that short-term goals of agriculturalists, such as income generation, should be balanced against long-term measures of ecological health (Spiertz, 2010). Such recommendations can be unrealistic in systems managed by agriculturalists with very high discount rates, reflecting an unwillingness to forego near-term consumption in exchange for future benefits.

Common to all SI definitions is some concept, either implicit or explicit, of *efficiency*. Indeed, efficiency is the very core of any definition of SI, as any production system that produces more with less, however the "inputs" to the system are defined, is more efficient than the equivalent system generating the same output with greater quantities of inputs. Unfortunately, while the concept of efficiency is easily stated, there is no single efficiency metric capable of objectively signaling which production systems represent a more "sustainable" alternative. In order to guide more meaningful, directed, stakeholder and policy discussions around the advancement of sustainable agriculture, it is necessary to characterize various agricultural production systems using objective efficiency metrics. While objective efficiency metrics are not in and of themselves answers to questions such as, "which systems and / or practices should we promote or avoid?," they can serve as concrete, measurable indicators of various aspirational

notions of “sustainability”, and should therefore be front and center in policy discussions around agricultural development.

In view of the difficulties inherent in developing prescriptive agronomic practices around SI, we examined multiple smallholder agriculture systems in two neighboring, biophysically similar regions – Dak Lak and Dak Nong Provinces in the Central Highlands of Vietnam and Ratanakiri province, Cambodia – in which 1) there is a general desire on the part of agricultural research institutions and policy makers to increase the productivity and sustainability of local agricultural systems and 2) a range of crop and livestock systems are currently in place that reflect a gradient from more-to-less intensive in terms of labor, capital expenditures, and input usage. We conducted detailed interviews with agriculturalists in the region to gather data on all crop and livestock system inputs, outputs, and flows among crop and livestock systems managed by a given household, for the full life of the system, i.e. from initial planting to conversion to another system, or reversion to fallow or forested area. Using these data, we applied 1) price and 2) energy value-weights to the inputs and outputs to derive various measures of economic and energy efficiency.

Specifically, we examined the following research questions:

1) How do alternative crop and animal production systems in the Central Highlands of Vietnam and Ratanakiri province, Cambodia, compare in terms of their economic and energy efficiency?
2) In view of the goal inherent to SI of promoting systems that are more efficient, how do more and less intensive systems, as measured by total inputs including labor, capital expenditures and agrochemicals, compare in terms of their economic and energy efficiency? Similarly, are systems that are more integrated, as indicated by the recycling of inputs from one system

component to another (e.g. residual crop biomass or animal manure), more economically or energy efficient than others?

3) Are the energy and economic efficiency of a given system correlated? If so, is the correlation positive or negative? In general, does economic efficiency come at the expense of energy efficiency or vice versa?
4) What are the policy implications of examining agricultural systems in the region though an energy rather than an economic efficiency lens? If integrated systems are, in fact more efficient, should they be promoted? If so, what are the tradeoffs associated with their promotion?

2. Study Region and Methodology

2.1 Study Region

The study region was comprised of three provinces: 1) Dak Lak and 2) Dak Nong Provinces in the Central Highlands region of Vietnam, and 3) Ratanakiri Province in northeast Cambodia (Figure 1). The study region was selected due to the relative similarity of biophysical variables, e.g. soils, elevation, and rainfall patterns, and distinct differences in specific socioeconomic and policy variables. Both the Central Highlands of Vietnam and Ratanakiri Province, Cambodia, have tropical monsoonal climates characterized by a rainy season from approximately May to November, and a dry season from approximately December to April. Soils across the study region are also fairly similar, comprised primarily basaltic soils, as well as Ferralsols (red soils) and others, across a series of undulating plateaus between approximately 300 to 900 m altitude. Rainfall across the study region ranges from approximately 1,900 to 2,200 mm yr^{-1} with average daily temperatures of approximately 23 to 25°C. The topography of

Vietnam's central highlands and northeast Cambodia is fairly flat, with occasional rolling hills of moderate slope.

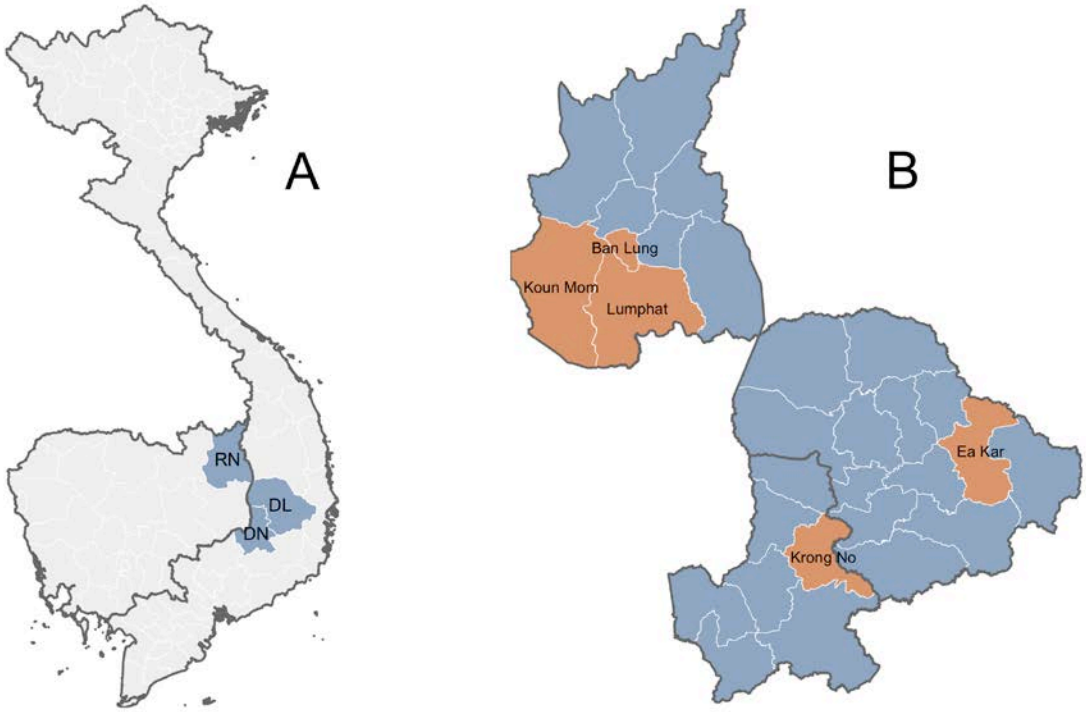

Figure 1**.** Study region locations for household surveys conducted from August to December, 2016. Household surveys were conducted in 3 provinces (A): Ratanakiri, Cambodia (RN), Dak Lak, Vietnam (DL), and Dak Nong, Vietnam (DN), and 5 districts (B): Kuon Mon, Ban Lung, and Lumphat, Ratanakiri, Cambodia, Ea Kar, Dak Lak Vietnam, and Krong No, Dak Nong, Vietnam.

Agricultural area makes up a sizable portion of overall land cover in the three provinces; as of 2015, Dak Lak and Dak Nong provinces were comprised of 48% agricultural and 40% forested, and 55% agricultural and 36% forested land, respectively (General Statistics Office of Vietnam, 2017). Forest remains a greater proportion of land cover in Ratanakiri, Cambodia relative to the Central Highlands provinces; agricultural land accounted for approximately 26% of total land area in Ratanakiri in 2011, while forest accounted for approximately 71% of total

land area (Hor et al., 2014). Agricultural production is more diverse and more intensive in the Central Highlands of Vietnam than in Ratanakiri. While in Ratanakiri, smallholder famers have only recently transitioned out of subsistence-oriented, swidden systems into commercially-oriented, permanent production systems (Hor et al., 2014), farming systems in the Central Highlands have a history of permanent, commercially-oriented coffee production dating back several decades. In addition to coffee, relatively mature markets exist for livestock, including pigs and cows, broiler and laying hens, and aquaculture products, as well as other industrial crops such as cassava. Other crops produced in the region include rice, maize, soybean, sugarcane, cashew cacao, and, more recently, pepper. Animal ownership is less common in Ratanakiri and is generally limited to household consumption. The somewhat low-diversity crop mix is comprised primarily comprised of commercial crops such as cassava, cashew, and soybeans, and rice for household consumption.

2.2 Household Surveys

We conducted a total of 32 household surveys across the three provinces in the study region between August and December 2016 (Table 1). We conducted the Vietnam surveys in 2 districts and 2 communes, and the Cambodia surveys in 4 districts (Table 1). In all survey locations, we coordinated with local government and agricultural extension agents in order to ensure that the households surveyed represented a reasonable cross-section of the agricultural practices of the region, such as a gradient of cropping and / or livestock systems, field sizes, and input use, as well as a gradient of more to less wealthy households. Specifically, we conducted interviews in 4 villages (from 4 districts) in Ratanakiri selected for their relative levels of commercialization and market orientation. Survey questions included general demographic,

ethnographic and socioeconomic variables, and focused on crop or livestock system input and output flows and activities at the plot level, including chemical and organic inputs, yields, and any integration or recycling of outputs from one system component (e.g. a plot or livestock herd) as inputs to another. The complete survey is included in Appendix 1.

Table 1. Number of households surveyed in each of the study locations in Cambodia and Vietnam

Country	Province	District	Households	Total
Vietnam	Dak Lak	Ea Tih	9	19
	Dak Nong	Krong No	10	
Cambodia	Ratanakiri	Lumphat	4	13
		Ban Lung	4	
		Kuon Mom	1	
		O Yadav	4	

For all activities, we asked respondents to recall the amounts of labor and labor types (family or hired) required to complete each task. Further, we asked respondents to recall all activities and input/output flows associated with each plot for the full history of the plot, from the establishment or purchase of the plot to present day. For all system inputs and outputs, we asked respondents to recall prices for each product for the current year and for as many seasons as they could recall. In addition to agronomic and animal husbandry activities and associated costs, we asked respondents to provide information on all capital costs associated with the establishment of each cropping system or livestock herd. All surveys were conducted in an interview format in the local language, i.e. Vietnamese or Khmer, and translated into English via an interpreter.

2.3 Systems modeled

We modelled a selection of commercially-oriented systems representing a gradient from low-to-high intensity in terms of input use and capital and operating costs, in order to compare the efficiency of agricultural practices representative of typical production systems in the region. In total, we modeled 7 distinct production systems: 5 "individual" or discreet systems in which only a single product is generated, and 2 "household-level" models in which a household managing multiple cropping and animal/aquaculture systems was characterized. Household-level models were generated by aggregating the individual production systems models. For consistency, all production systems modelled were assigned a 20-year system lifecycle. The choice of system lifecycle was based on survey respondents' characterization of the typical production lifecycle of perennial tree crops in the region, especially coffee. While in practice certain systems may ultimately have longer or shorter lifecycles, the majority of non-coffee (and to a lesser extent, cashew) cash crop and livestock systems in the region, e.g. cassava, pepper, and intensive pig systems, data was generally not available to allow for the assignment of unique lifecycle values on a per-system basis.

Wherever possible, labor type (household or hired labor) inputs were assumed to be the average reported labor, in person-days per year (PD yr^{-1}), required to complete the specific task. In a few instances, labor data were insufficient or unavailable. In such cases, specific assumptions about the required labor were made, generally based on reported labor for similar tasks, expert knowledge of the specific production system and practices, or a combination thereof. We detail specific assumptions about labor inputs which deviate from assuming average reported PD yr^{-1} required in the individual model descriptions that follow. We also assumed commercialization activities, including marketing and farm management, totaled 30 PD yr^{-1} in all

models, as data for these activities was generally unavailable. For all models, we included all system outputs including marketed products and those consumed by the household, as well as residual biomass products such as animal waste that may be recycled as an input in the same or a separate system.

2.3.1 Individual systems

The lowest intensity system modeled was a 1 ha cassava system typical of the agronomic practices in Ratanakiri, Cambodia. Cassava production in Ratanakiri is characterized by very low or no agrochemical input use, no irrigation, and low economic value. On the high end of the intensity spectrum were two animal production systems in Vietnam: pond aquaculture and meat pigs, as well as a small (0.27 ha) pepper plot. A coffee system typical of those that dominate the Central Highlands was modelled to represent a middle-intensity, "status quo" system. In all Vietnamese systems modeled, certain capital costs were consistent across models, including a well and water pump, electrical hookup, irrigation equipment including pipes and hoses, a backpack sprayer, motorbike, tarps, shovels, and gunny sacks. Additional detail on system dynamics, including inputs and outputs through time, and capital unique to that system is provided below. See Appendix 2 for the complete model for every system included in the study.

Cassava

We assumed land used for the cassava plot had previously been in forest, as was typical for many of the households surveyed. None of the households surveyed reported any fertilizer usage or irrigation in their cassava systems. We therefore assumed that the only chemical inputs into the system were a combination herbicide and hormone treatment which the majority of

cassava growing households reported using. We assumed the plot used the Green Malaya variety, having average yields of 8,500 kg ha^{-1} yr^{-1} of dried, chopped cassava in the first year. This was higher than the average reported yield (6,383 ± 3,644 kg ha^{-1} yr^{-1}, n = 20) across all surveys for all years of the system, but represents a conservative estimate of yields in year 1 after opening new land from forest. We assumed a yield decline of 133.45 kg ha^{-1} yr^{-1}, based on studies conducted on typical cassava yield declines in the region (Howler and Aye, 2014). We assumed a planting density of 10,000 stems ha^{-1} using stems saved from the previous year's harvest, as was consistently reported in all surveys. Unique capital costs for the cassava system included knives used for harvesting.

Coffee

Average reported coffee yields varied considerably (3,030 ± 788 kg ha^{-1} yr^{-1}, n = 10), reflecting the variation in tree age, soil types, agronomic practices, and varieties used by those coffee-producing households surveyed. We assumed the coffee plot was previously in coffee production but with older, less productive trees. We assumed the plot was planted with the TR4 variety of Robusta coffee; a relatively modern and higher-yielding variety released by the Western Highlands Agriculture and Forestry Science Institute (WASI) that several interviewees reported recently as a replacement for aging trees. Based on yield values reported by survey participants currently growing the TR4 variety, as well as discussions with local extension professionals and WASI staff, we assumed coffee bean yields of 500 kg ha^{-1} in year 2, 1,500 kg ha^{-1} in year 3, 2,500 kg ha^{-1} in year 4, a mature yield of 3,500 kg ha^{-1} in years 5 to 15, and a 10% yearly yield decline in years 16 to 20. We assumed the coffee system used only 15-15-15 NPK chemical fertilizer applied at a rate of 2,500 kg ha^{-1} yr^{-1}, based on the average reported chemical

fertilizer usage from the surveys (2,492 ha^{-1} yr^{-1} kg ± 1,829 kg ha^{-1} yr^{-1}, n = 10). We also assumed the use of additional chemical inputs in quantities typical of those households surveyed, including a pesticide, and an herbicide. Unique capital costs included a coffee mill and dryer, and a weed trimmer.

Pepper

We modelled a pepper plot of the average size reported from all pepper growing survey respondents: 0.27 ha ± 0.11 ha. Respondents producing pepper reported a more complex and labor and capital intensive system establishment process than the other cropping systems modeled, including the planting of "pole" trees that provide shade to growing pepper vines and allow them to climb, and vine training to allow the pepper plants to climb the pole trees in a way that allows for easier harvesting and a more manageable crop. In general, crop management practices were more varied in pepper relative to coffee and cassava and included a broader range of input combination, e.g. chemical fertilizers, compost, and animal manure. We were therefore unable to rely on average reported inputs for several key variables including fertilizer, and therefore assumed a production system that was representative of several pepper producing households surveyed. The plot as modeled included an initial application 4500 kg^{-1} ha^{-1} of animal manure and 80 kg^{-1} ha^{-1} of 15-15-15 NPK during planting, as well as an application of 2000 kg^{-1} ha^{-1} yr^{-1} of 15-15-15 NPK fertilizer and 4000 kg^{-1} ha^{-1} yr^{-1} of animal manure. We assumed a planting density of 1,111 pole trees ha^{-1}, or 300 pole trees for the 0.27 ha plot, onto which a total of 4 vines were planted and trained. We assumed a peak pepper yield of 5000 kg ha^{-1} for years 7 to 15 based on typical reported yields of several systems that had been in production for 3 or more years. We assumed a 10% yr^{-1} yield decline in years 15-20.

Aquaculture

All aquaculture systems surveyed, including those that were exclusively used for household consumption, and those primarily purposed for commercial production included a grass plot from which all or a portion of the fish feed was generated. In general, those households with commercially-oriented aquaculture systems fed their fish using a combination of grass, industrial feed, and occasionally household food scraps or other organic matter e.g. animal manure, or crop by-products such as rice husks. Commercial aquaculture systems were generally multi-trophic comprising between 4 and 6 fish species, one or more of which fed primarily on fish waste and algae, e.g. catfish, and some which fed directly on feed inputs, e.g. grass carp, common carp, and / or tilapia. Species-specific price and yield data was not available as all survey respondents reported purchasing pre-mixed quantities of fish fry comprising multiple species, and receiving payment on a per- kilogram basis for all species harvested. Our aquaculture model therefore assumes a mixed-trophic system with a pond size of 0.5 ha with a depth of 2 m (typical of those commercially-oriented aquaculture systems surveyed), and an accompanying grass plot of 0.1 ha. In general, much less data was available on commercially-oriented aquaculture systems, as only 3 households surveyed managed such systems. Our aquaculture model is therefore based on data acquired from these three households and attempts to use very conservative yield estimates. We assumed a 4-month production cycle in which 250 kg of fry are purchased and fed 100 kg day^{-1} of grass for the first two months and 100 kg day^{-1} of grass and 25 kg day^{-1} of industrial animal feed for months 3 and 4. We assumed a fish yield of 2300 kg per production cycle, implying an average feed conversion ratio across all species of 5.14. We assumed a very conservative VA06 hybrid grass yield of 100 kg ha^{-1} yr^{-1}. Additional

system inputs included an anti-viral medication and pond cleaning chemicals applied yearly, and a small amount of NPK applied to the grass plot. Unique capital costs included pond construction materials including a spillway.

Pigs

Commercially-oriented pig systems in the Central Highlands of Vietnam utilize "exotic" species which are distinct from those commonly produced for household consumption in the region. They are higher yielding, and are generally sold as whole piglets at either 1 month of age, if sold to a fattening operation, or at 4 months of age if sold for direct consumption. Here, we model a pig production system comprising an initial 5 wet sows, with the heard size reaching 11 wet sows by year 5 (the largest number of wet sows owned by any household surveyed) selling piglets at 4 months old. We assumed wet sows were impregnated via an insemination service. at an average rate of 2.5 pregnancies yr^{-1} with an average birthrate of 10 piglets $pregnancy^{-1}$ sow^{-1} based on survey data and expert interviews. We also assumed a 10% mortality rate of piglets. Based on survey data and expert interviews, we assumed an average sale weight of 50 kg $piglet^{-1}$. We assumed a feeding rate of 0.5 kg day^{-1} of industrial feed concentrate for < 1 month old piglets, 1 kg day^{-1} for piglets between 1 and 2 months old, 3 kg day^{-1} for piglets between 2 and 4 months old, and the survey average of 3.75 kg day^{-1} for wet sows. Additional inputs included multiple vaccinations for piglets and wet sows, deworming medication, and antiviral medication. Unique capital costs included the materials for the construction of the pig sty.

2.3.2 Household-level systems

In order to characterize the impacts to economic and energy efficiency of integrated agricultural practices, i.e. the use of outputs of one or more of the foregoing individual systems as an input for another, we modeled two multi-component households: 1) an integrated household in which pig dung and coffee pulp are used as the primary ingredients for compost, and 2) a non-integrated household in which no outputs are recycled. Both household-level systems included a 1.0 ha coffee plot, 0.27 ha pepper plot, an intensive meat pig operation, and an intensive pond aquaculture system, as detailed above. Such multi-component, high-intensity systems are fairly typical for higher income households in Dak Lak. In the "non-integrated" system, the individual system components were combined and redundant capital costs were removed. In the "integrated" system, 3000 kg ha^{-1} yr^{-1} of compost was applied to the coffee plot, displacing 1500 kg ha^{-1} yr^{-1} (60%) of the NPK fertilizer. We assumed all other inputs and outputs of the individual systems comprising the household models were unchanged.

2.5 Modeling methodology

We compared the performance of the systems modelled using 1) economic and 2) energy metrics. In both modeling frameworks, a matrix of the yearly inputs and outputs to each system were multiplied by a corresponding set of value-weights to derive either an economic or energy budget for the full lifecycle of the system.

2.5.1 Economic performance

For all individual systems, we used the Land Use System (LUS) modeling framework to generate multiple economic performance metrics of the crop and livestock systems analyzed

(Kragten et al., 2001). For all LUS models, we multiplied the full 20-year time series of system inputs and outputs by a per-unit estimated price for the corresponding year to calculate annual revenues and costs. Using the annual revenues and costs, we calculated the net present value (NPV) of each individual system as follows:

$$NPV = \sum_{i=0}^{n} \frac{B_t - C_t}{(1+i)^t}$$

where n is the number of years of the system, t is the current year of the system, B_t is the revenues in year t, C_t is the costs in year t, and i is the discount rate. Using the NPV calculation, we calculated returns to land (RL) on a per-hectare basis as

$$RL = \frac{NPV}{S}$$

where S is the size, in ha, of the system, and returns to family labor (RFL), as

$$RFL = \frac{NPV}{L}$$

where L is sum of all family labor, in person-days, for all years of the system.

Price Scenarios

All models assumed a retrospective price scenario using nominal prices. Therefore, the final year of each system (year 20) represents a price scenario for 2016, while the first year of each system represents a price scenario in the year 1997. The majority of input prices for 2016 were calculated based on the relevant average values collected from the household surveys. In certain instances, assumptions were made where survey averages were either unavailable or highly variable.

Chemical Fertilizer: No chemical fertilizers were used in the Cambodian cassava system. NPK was bar far the most commonly used chemical fertilizer used by those households surveyed. Historical Vietnam NPK prices for the region were not directly available. In order to approximate a time-series of NPK fertilizer prices, a linear model was built regressing historical urea prices from the years 1991-2001 (FAOSTAT, 2016) onto historical Black Sea bulk urea prices (World Bank, 2017) for the same years. Vietnam producer prices for 2002-2016 were predicted using the resulting linear model. The predicted 2014 Urea price was approximately $0.55/kg, representing a 43% premium of the average producer prices reported in the same year from household survey data collected in the same region (Hands and Minds, 2014). We therefore estimated regional urea prices for the full time series by multiplying each value by 0.57. Using the previously collected survey data, we determined that urea sold for a 5.31% premium over NPK in 2014. We therefore generated an NPK price time series by multiplying the estimated regional Urea values by 0.957.

Pesticides: Time-series for other agrochemicals were generally unavailable. We therefore estimated the pesticide input prices, included all herbicides, fungicides, and insecticides, by assuming they tracked the NPK time-series at the same margin as the average reported survey prices. For example, the average reported herbicide per-liter cost from all surveys was 18.18 times greater than the average reported per-kilogram price of NPK fertilizer. We therefore multiplied the NPK price time-series by 18.18 to generate a full herbicide price time-series.

Other inputs: Due to a lack of reliable historical data, we assumed that all other inputs prices were stable through the time-series. To generate historical prices, we converted average

reported survey values to nominal historical values by multiplying them by their corresponding consumer price indices (CPI) values for Cambodia (FRED, 2017) and Vietnam (Vietnam General Statistics Office, 2016). Inputs assumed to be stable included animal feed, all medicines and cleaning supplies, all planting materials (seeds and seedlings), and all capital expenditures. We assumed compost price was 50% of the predicted NPK price for the time series. We obtained historical Vietnamese gasoline prices for 11 years between 1995 and 2016 (World Bank, 2016). To generate a complete gasoline time-series, we performed linear interpolation to derive missing values. We assumed gasoline prices were consistent in Vietnam and Cambodia. We generated a time series of manure prices by converting values reported by Thi et al. (2004) into nominal values using the Vietnamese CPI time series.

Wages: We used rural agricultural labor values reported in real 2010 $USD for the years 1993 1998, and 2002 as a basis for an estimated time series of Vietnamese wages (Wiggins and Keats, 2014). First, we converted the real 2010 $USD for 1993, 1998, 2002 into nominal values, and fit a linear model to the nominal 1993, 1998, 2002 values and the average day labor wage rate from the household surveys for 2016. The linear model was then used to estimate a full time series of regional agricultural day wages for 1997-2016. Historical rural wages for Cambodia were unavailable. To estimate a Cambodian wage time-series, we used the average yearly increase in rural wages from all Southeast Asian countries from 2000 to 2010 of 5.3% (Wiggins and Keats, 2014). To estimate a full time series of Cambodia wage rates, we assumed a steady increase from of 5.3% from year 1 through 20 of the system, using the average reported daily wage rate from the surveys as a 2016 baseline. Family labor was valued at the market wage rate,

representing the opportunity cost of family labor applied to a household's agricultural production.

Output prices: With the exception of the aquaculture system, we used historical farmgate prices from the years 1987 to 2015 (FAOSTAT, 2016) and average reported survey prices as output price estimates for all marketed products. We assumed coffee pulp had the same price value as animal manure.

Discount rate: We based the discount rate on Interest Rates for short- and medium-term financing for private sector borrowers in Vietnam as reported by the World Bank (2016). The Lending Interest rate for Vietnam in 2014 was 8.7%. As agriculturalists typically have higher cost of capital, and therefore higher discount rates, than private sector borrowers, we assumed a discount rate of 10% for all systems modelled.

2.5.2 Energy Performance

We used the same yearly system input/output (I/O) matrix from all models, described above as a basis for generating an energy performance metric for each system. First, we multiplied the I/O matrix by a corresponding set of energy values for each input and output, in mega joules (MJ), to derive yearly energy input and output values for the lifecycle of each system (Pimentel, 1980). To derive a single, Energy Return on Investment (EROI) value, we divided the cumulative sum of energy outputs from all years by the cumulative sum of energy inputs from all years. The resulting value is representative of the amount of the energy output by the system over the full 20-year period for each unit of energy input. As an example, a system

with an EROI value of 2 would output 2 units of energy for every 1 unit of energy input by humans, including labor, agrochemical and organic inputs, animal feed, and the like. Individual energy values for all system inputs are shown in Table 2. We assumed that all capital expenditures, e.g. building materials, did not have energy values as they were generated in separate production processes that did not cross a plot or animal system boundary as molded here.

Table 2. Energy values for all inputs and outputs of the Vietnam Central Highlands and northeast Cambodia crop and livestock systems modeled.

Item	Unit	Energy Value (MJ)	Source
Inputs			
Human labor	Person-day	17.25	Pimentel and Pimentel, 2008
NPK	kg	15.75	Pimentel and Pimentel, 2008
Urea	kg	32.35	Pimentel and Pimentel, 2008
Animal manure	kg	6.71	Pimentel, 2009
Compost	kg	6.71	Assumed same energy content as manure
Lime	kg	1.32	Pimentel and Pimentel, 2008
Trichoderma	kg	0.59	Assumed energy content of mushroom
Herbicide	liter	41.87	Pimentel and Pimentel, 2008
Pesticide	liter	41.87	Pimentel and Pimentel, 2008
Gasoline	liter	32.2	Hofstrand, 2008
Electricity	kwh	10.78	Pimentel, 2009
Cassava stems	num	0.19	Pimentel and Pimentel, 2008
Animal feed (fish, pig)	kg	7.7	Pimentel and Pimentel, 2008
Pepper seedlings	num	0.19	Assumed same energy content as cassava stems
Coffee seedlings	num	0.19	Assumed same energy content as cassava stems
Grass seed	kg	87.93	Pimentel and Pimentel, 2008
Fish fry	kg	186.57	Pimentel and Pimentel, 2008
Backhoe	machine hour	161	Assumed consumption of 5 gal gasoline hr^{-1}
Weed trimmer	machine hour	161	Assumed consumption of 0.5 gal gasoline day^{-1}
Antiviral spray	liter	140.91	Pimentel and Pimentel, 2008*
Deworming medicine	liter	140.91	Assumed same energy content for all medicines
Vaccine	liter	140.91	Assumed same energy content for all medicines
Outputs			
Cassava (dried, chopped)	kg	15.9	Pimentel and Pimentel, 2008
Coffee beans	kg	16.75	Calculated based Nogaim et al., 2013
Coffee pulp	kg	6.71	Assumed same energy content as manure
Pepper berries	kg	19.05	USDA Nutrient Database, 2017
Pork	kg	9.81	Pimentel and Pimentel, 2008
Grass	kg	7.18	Pimentel and Pimentel, 2008
Fish	kg	140.91	Pimentel and Pimentel, 2008

* Energy content was assumed to be the same as “medicine” used in aquaculture systems as described by Pimentel and Pimentel, 2008.

Finally, we compared the relative energy and economic performance of all seven systems modelled – 5 individual systems and 2 household-level systems – by plotting their respective

returns to land against their EROI values. We selected returns to land as the economic metric for comparison due to the consistency in units ($USD ha^{-1}) across systems of different scale.

3. Results

3.1 Summary of household surveys

The average amount of land managed by households interviewed was greater in Ratanakiri than in the Central Highlands (Figure 2). In Ratanakiri, the average household owned 4.2 ha with an average plot size of 1.2 ha, while in the Central Highlands, the average household owned 1.9 ha with an average plot size of 0.7 ha (Figure 2). In contrast, livestock ownership was much more prevalent in the Central Highlands, with the average household managing 2.3 livestock herds compared to 1.4 herds in Ratanakiri (Figure 2).

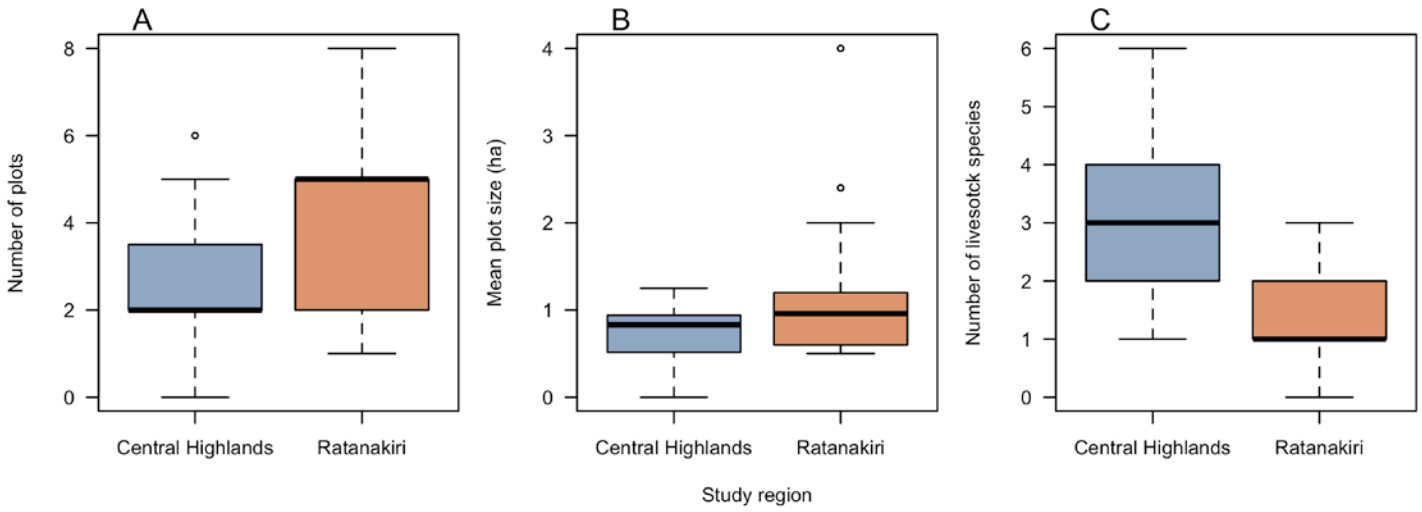

Figure 2. The number of plots (A), average plot size (B) and number of livestock species managed by households surveyed in the Central Highlands of Vietnam and Ratanakiri, Cambodia.

In general, the diversity of crops and livestock species managed by the Central Highlands households was greater than the Ratanakiri households (Figure 3). In Ratanakiri, the primary crops produced were cashew, rice, and cassava, while in the Central Highlands, the majority of households grew coffee and between 1 and 3 additional crops (Figure 3). Livestock ownership, especially market-oriented production, as well as aquaculture, was much more common in the Central Highlands than in Ratanakiri (Figure 3).

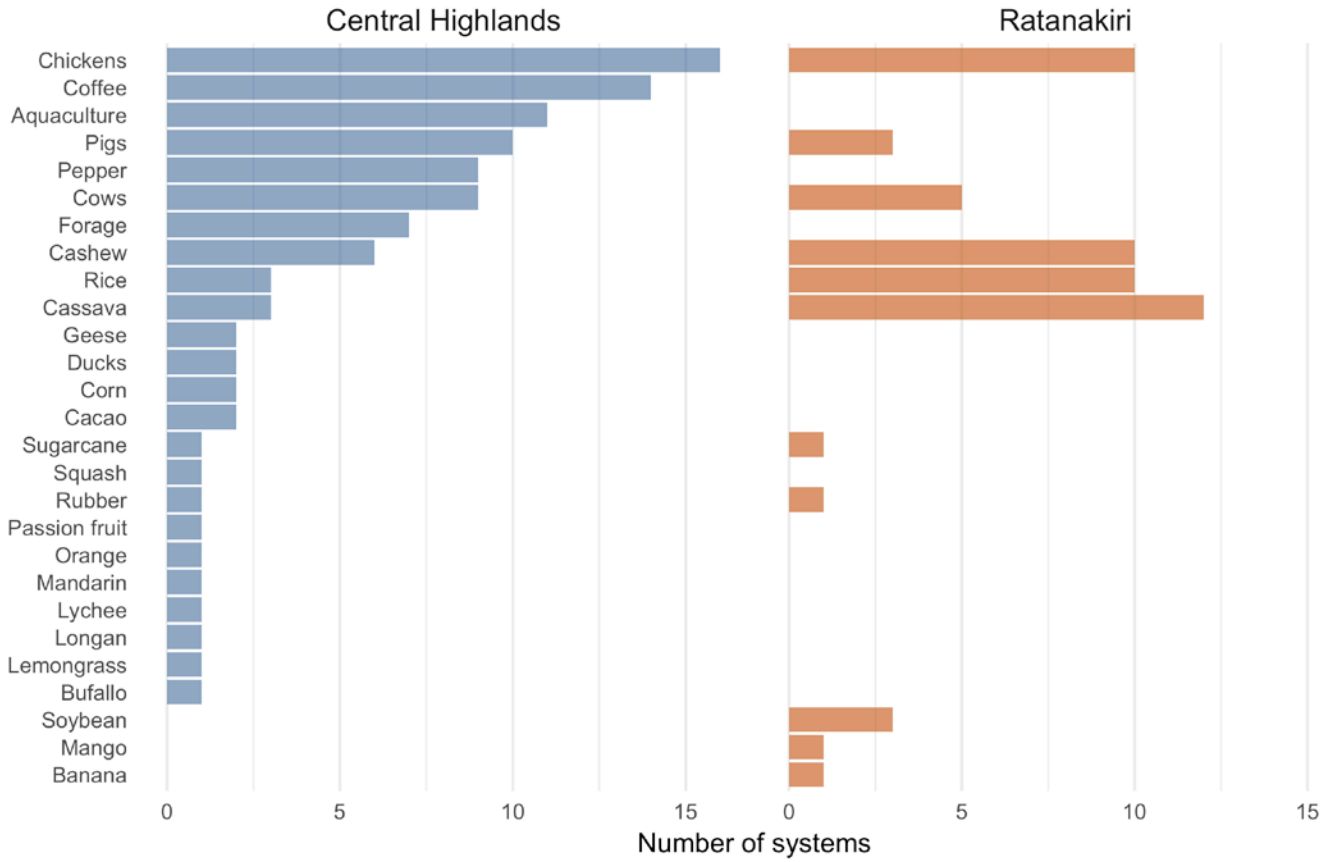

Figure 3. The number of households managing of each of the crop and livestock species reported in the household surveys in the Central Highlands of Vietnam and Ratanakiri, Cambodia.

3.2 Labor

On a per-hectare basis, aquaculture and pepper had the highest initial labor inputs associated with establishing the production systems (Figure 4, Table 3). For pepper, this is driven primarily by the establishment of the pole trees on which the pepper vines climb, and training the pepper vines in the first two years of the production system. For aquaculture, a considerable amount of labor is required in the construction of the fish ponds and associated infrastructure. Coffee and pepper labor inputs both increase after the first few years of production as the plants begin to yield, increasing the amount of harvesting and processing labor in the system. With the exception of pepper, harvest and processing labor on a per-hectare basis is similar across all systems (Table 3). Pepper harvesting was substantially more labor intensive than the other cropping systems modelled (Table 3). Pig labor increases after initially low labor inputs in response to the daily feeding, watering, and cleaning requirements associated with managing pigs (Figure 4). Operational labor requirements for cassava were very low, reflecting the lack of intensive production, in terms of irrigation, fertilizer applications, etc. (Table 4), associated with cassava production of those households surveyed. No household harvest and processing labor was required for the pig system, as the standard practice by those households surveyed was to pay a service for a driver to purchase and pickup piglets at individuals' farms.

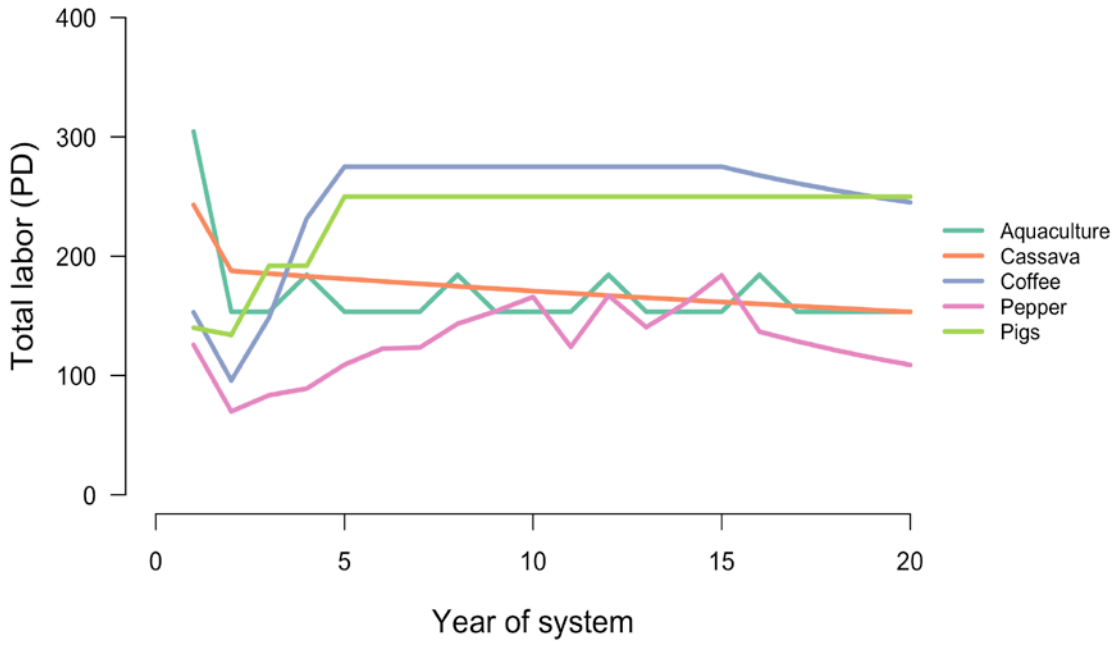

Figure 4**.** Annual labor requirements of small-scale agricultural systems in the Central Highlands of Vietnam and Northeastern Cambodia

Based on household survey data, the labor associated with making compost and managing the compost operation in the integrated household model was assumed to be 10 PD yr^{-1}, starting with the first coffee harvest in year 3 of the system. In total, the compost operation added an additional 180 PD of operational labor to the integrated household-level model, relative to the integrated model.

Table 3. Labor inputs over the full system lifecycle to crop and animal production systems in northeastern Cambodia and the Central Highlands of Vietnam

System	Category	PD	PD/ha
Cassava	Establishment	53.00	53.00
	Operations	1,554.00	1,554.00
	Harvest/processing	1,911.25	1,911.25
	Total	**3,518.25**	**3,518.25**
Coffee	Establishment	127.80	127.80
	Operations	3,667.00	3,667.00
	Harvest/processing	1,172.79	1,172.79
	Total	**4,967.59**	**4,967.59**
Pepper	Establishment	63.29	234.41
	Operations	1,136.98	4,211.04
	Harvest/processing	1,371.93	5,081.22
	Total	**2,572.20**	**9,526.67**
Aquaculture	Establishment	225.00	375.00
	Operations	2,370.00	3,950.00
	Harvest/processing	700.00	1,166.67
	Total	**3,295.00**	**5,491.67**
Pigs	Establishment	6.00	-
	Operations	4,430.32	-
	Harvest/processing	0.00	-
	Total	**4,436.32**	-

3.3 Economic performance

The NPV of the two animal systems, as well as the pepper system, were considerably higher than the coffee and cassava systems (Figure 5, Table 4). Cash flows in both the pepper and coffee systems were negative until year 3 due to a lack of yields in the first two years after planting (Figure 5). Unlike pepper, however, there were several years of negative cash flow even after the mature yields were reached due a drop in coffee prices to an average of \$0.23 kg^{-1} in years 5-10 of the system (the average coffee price over the 20-year system life was \$0.90 kg^{-1})

(Figure 5). In general, pepper prices were more stable and significantly higher (average of $3.56 kg^{-1} over the 20-year system life), resulting in positive cash flows once mature yields were realized, despite the lower absolute yield of pepper relative to coffee. The negative cash flows in the cassava system were driven by steadily declining yields through the life of the system. Cassava in Ratanakiri generated positive cash flows for only a short period of time, despite the relatively low establishment costs. Both animal systems had high and stable cash flows in the majority of years modeled, resulting in higher NPVs than both coffee and cassava (Figure 5).

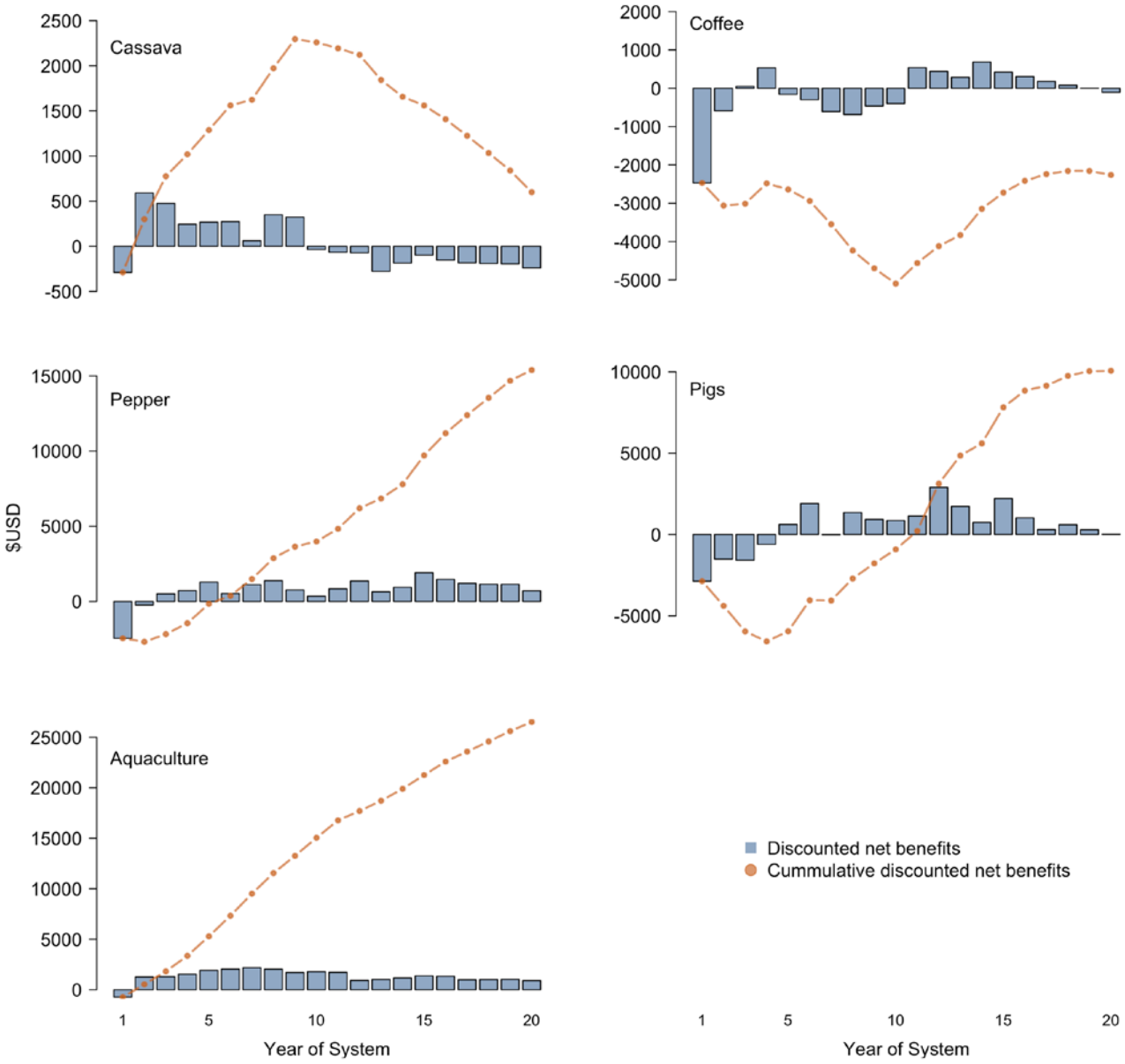

Figure 5**.** Discounted net benefits and cumulative discounted net benefits of agricultural systems modeled.

Aquaculture and pig systems benefit from the fact that they are not dependent on soil fertility to maintain yields. Whereas yields declined in the plant-based systems modeled after some period of optimal productivity, despite the continued use of chemical fertilizer, fish and pig

yields remain stable through time, resulting in ever increasing cumulative discounted cash flows throughout the system life-cycle (Figure 5).

The pig system had the highest returns to land, due to the small amount of space required for an intensive pig production system (Table 4). Pepper, aquaculture, and both household-level systems had returns to land of over \$35,000 ha^{-1}, while cassava and coffee had very low returns to land of \$543.73 ha^{-1} and \$-2,262.55 ha^{-1}, respectively (Table 4). Despite the very high returns to land, returns to family labor were lower in the pig system than in the aquaculture system, which had the highest returns to labor of all systems modeled (Table 4). Returns to family labor were similar in the pig and both household systems. Despite the higher NPV and returns to land, returns to family labor in the integrated household were lower than the non-integrated household due to the labor required for the compost operation (Table 4). Only the pepper and aquaculture systems had greater returns to family labor than the average market rate over the lifecycle of the system as modeled (Table 4). Returns to family labor were nearly double the average market wage rate in the aquaculture system, reflecting the relatively low labor requirements associated with the system relative to the other systems modeled (Table 4). Returns to family labor in the pig, integrated household, and non-integrated household were similar, with returns to family labor of approximately half that of the market wage rate (Table 4).

Table 4. Economic performance of 5 individual and 2 household-level agricultural production systems in northeastern Cambodia and the Central Highlands of Vietnam.

System	Location	System size (ha)	NPV ($USD)	Returns to land ($USD/ha)	Returns to family labor ($USD/PD)	Returns to family labor / market wage rate
Cassava	Cambodia	1.00	543.73	543.73	0.21	0.07
Coffee	Vietnam	1.00	-2,262.55	-2,262.55	-0.68	-0.17
Pepper	Vietnam	0.27	15,386.51	56,987.07	5.98	1.46
Aquaculture	Vietnam	0.60	26,564.92	44,274.86	8.01	1.96
Pigs	Vietnam	0.10	10,065.37	100,653.66	2.16	0.53
Integrated household	Vietnam	1.97	72,530.98	36,817.76	2.35	0.57
Non-integrated household	Vietnam	1.97	69,527.96	35,293.38	2.54	0.62

3.4 Energy inputs and outputs

Aquaculture was the most intensive system modeled in terms of energy inputs and outputs (Figure 6). This is due primarily to the frequent turnover of fish stock (3 harvests per year) and large quantity of high-energy biomass output of the system. Pepper energy input and output values were very low, mainly due to the small system size, and low biomass yields relative to other systems modeled (Figure 6). The energy inputs to the cassava system were very low (114.4 GJ), reflecting the low input usage and relatively few management activities associated with managing the crop (Figure 6).

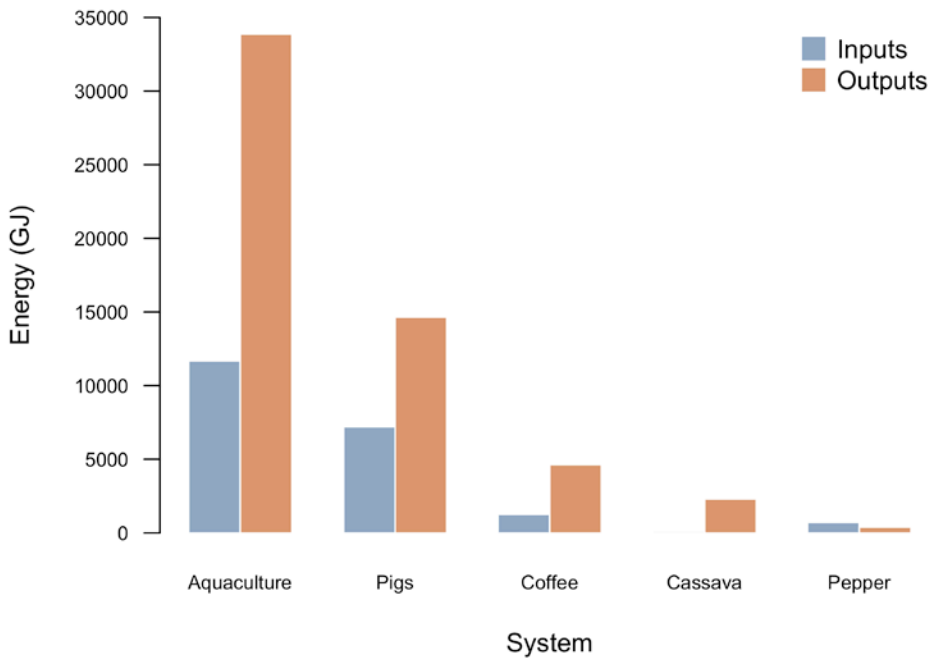

Figure 6**.** Cumulative energy inputs and outputs over the full lifecycle (20 years) of agricultural systems in northeastern Cambodia and the Central Highlands of Vietnam.

3.5 Returns to land and energy efficiency

With the exception of Cassava, all systems modeled had similar EROI values ranging between approximately 0.5 and 3.5 (Figure 7). The overall energy efficiency of a system was not positively correlated with a system's economic efficiency (Figure 7). The most energy intensive systems in terms of total inputs required over their system life, pigs and aquaculture, had high returns to land, but relatively low EROI values of 2.03 and 2.90, respectively (Figure 7). Cassava had the second lowest returns to land and was the most energy efficient (EROI of 20.10) of the systems modeled (Figure 7). The integrated household was slightly less energy efficient than the non-integrated household (EROI of 2.49 and 2.57, respectively), while having slightly higher

returns to land than the non-integrated system ($368 and $353, respectively). In general, energy efficiency appeared to be negatively correlated with returns to land (Figure 7).

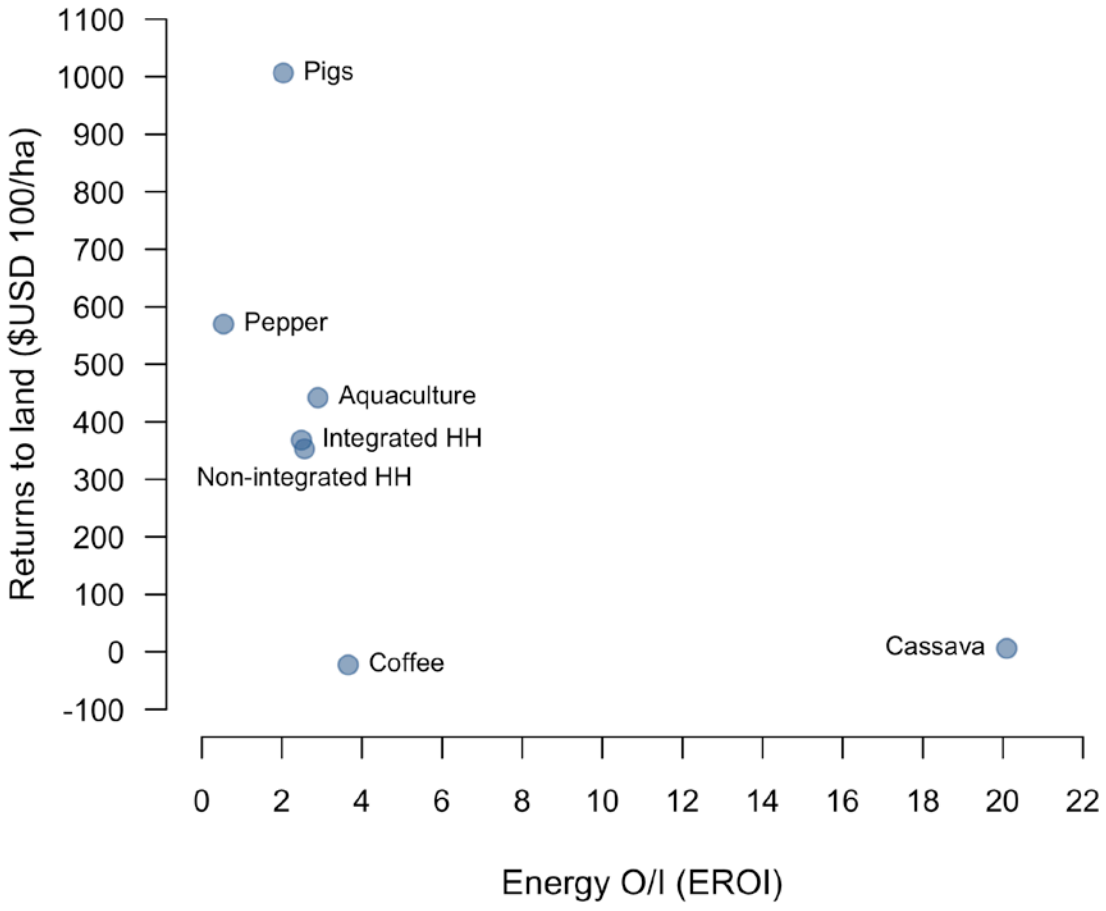

Figure 7. Average annual returns to land and energy output/input ratio of smallholder agricultural systems in the Central Highlands of Vietnam and Northeastern Cambodia.

4. Discussion

Central to the concept of the "sustainable intensification" (SI) of agriculture is the idea that *more* can (and should) be produced with *less* (Struik et al., 2014). Our results underline the importance of bolstering SI and similar concepts, e.g. "eco-efficiency", through the development of precise definitions of not only what is meant *more* and *less*, but specifically how *more*

(outputs) and *less* (inputs) are measured. When comparing the relative sustainability, as indicated by some measure of the system's ecological efficiency (i.e. to what extent does it rely on external, chemical inputs, and / or what are the environmental externalities of that system), it is reasonable to view the production system through a mass-balance, or energy efficiency lens as we have done here. All other variables held constant, if a system produces the same output with fewer external inputs than an otherwise identical system, the energy efficiency of that system will be greater. However, as we have demonstrated here, the energy efficiency of an agricultural system is not necessarily a good predictor the economic performance of that same system.

Here, we define inputs and outputs to the production system modelled as all labor, chemical and organic inputs, and capital expenditures. When we applied energy value-weights to these inputs and outputs, the cassava system emerged as the clear winner as measured by EROI. When the cassava system is measured by economic efficiency, only the coffee system performed worse in terms of NPV, returns to land, and returns to labor. This stark contrast between energy and economic performance highlights the different conclusions that may be drawn when measuring a system's efficiency using different sets of value weights applied to input and output quantities. Our results indicate that, with the exception of cassava, there were no major differences in EROI, despite having vastly different economic performance. This was true not only for the individual systems modeled, but for the household-level models as well. In the integrated household model, the reductions in energy inputs realized from supplanting a substantial portion of NPK inputs with household-produced compost was more than canceled out by the increased human labor required to make and manage the compost system. It is also worth noting that the production of such a sizable quantity of compost may depend on having a rather intensive animal operation from which to gather manure. When viewed as a whole, therefore, our

results suggest that efforts to increase the adoption of intensive, high-value crop and livestock production systems may have result in better livelihood outcomes, e.g. from increased incomes, than efforts focused on increasing the level of system integration among household production systems.

While the differences among systems in terms of their economic performance are clear, our findings do, in fact, indicate that some level of integration may have positive economic outcomes. Specifically, the aquaculture system, in which a significant portion of the food produced for the fish is generated on-farm, is an integrated system that also performed very well in all measures of economic performance. These findings are in-line with previous research suggesting that agriculturalists in the Central Highlands region have benefited from increased incomes when diversifying away from coffee production and into animal fattening operations in which beef cows are fed primarily using household-grown fodder (Stür et al., 2013). In fact, the grass generated by the 0.1 ha plot in our aquaculture model, despite a pessimistic yield scenario, produced more than enough fodder to meet the input requirements of the fish ponds, suggesting that the same system may have been capable of supporting additional livestock, resulting in even greater economic output.

It is also worth noting that the systems modeled do not necessarily represent likely outcomes for all producers managing the crops and livestock systems discussed here. In all cases, we attempted to model an average case using historical price series across the relevant region. This fails to capture nuances in performance that are to be expected from producers in high-, or low-suitability regions, or alternative future price scenarios. For example, NPV of the coffee system as modeled becomes \$905.88 if a \$0.50 kg^{-1} price floor is assumed, and \$4,637.43 if a \$0.75 kg^{-1} is assumed, neither of which are particularly unlikely given that the price drops seen

in the 90s were primarily a response to very specific macroeconomic and policy environments. Similarly, the economic high-performers, i.e. pigs, pepper, and aquaculture, are modeled using historical price scenarios reflecting a setting in which far fewer farmers in the Central Highlands region were producing those products. It is not unreasonable to expect prices of those commodities to fall as more producers enter into these higher-value markets.

Finally, it should be stated that the efficiency metrics explored here are not in and of themselves indicators of sustainability. While we believe that the economic metrics in particular can provide important guidance for agricultural policy discussions in the region, they do not directly measure other important indicators of sustainable farming practices. For example, various soil quality parameters, including increases in available P, K, Ca, and Mg, may be improved by increased use of organic fertilizers, such as the compost discussed here, in Central Highlands coffee systems (Long et al., 2014). Similarly, integrative practices in the regions may reduce total water usage and improve nutritional outcomes of agriculturalists in the Central Highlands and Ratanakiri (Lancombe et al., 2016). Nor do our metrics capture ancillary benefits of integrated households such as possible hedging strategies against unfavorable price environments. The metrics presented here should therefore be considered part of a broader set of analytical tools towards the development of increasingly objective and adaptive measures of concepts such as sustainable intensification.

5. Conclusions

We have shown that more intensive production practices, e.g. intensive livestock, aquaculture, and specialty crop, e.g. pepper, production may result in improved economic outcomes for smallholder agriculturalists in the Central Highlands of Vietnam and Ratanakiri

Province, Cambodia. We have also shown that there is perhaps less to be gained from viewing the same systems through the lens of energy, rather than economic efficiency. The study regions are currently undergoing dramatic and transitions towards increasing market-orientation and intensification of agricultural production, and farmers should be armed with as many decision making tools as possible when facing choices about which production systems to invest in. We have shown that low-intensity production of cassava, and the status-quo production of coffee in the Central Highlands may have lower returns to land, labor and lower NPVs than some of the less conventional, high-intensity systems modelled here. Policy discussions should therefore focus on means and associated costs of improving access to, and lowering the barriers to adoption of these higher-intensity systems.

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Appendix 1: Household Survey

Smallholder Farm Household Survey: Energy and Economic Efficiency of Alternative Land Use Practices

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General household information

Date (mm/dd/yyyy)	
Country	
Province	
District	
Sub Location	
Village	
Household ID*	
Name of household head	
Name of respondent	
Ethnicity/Gender of respondent	
Geographical location (House)	
Latitude	_____°_____M_____S
Longitude	_____°_____M_____S
Elevation [meters]	
Researcher name	Jamey Smith
Interpreter name	
Language used in interview	

*****Province, district, commune, #
e.g. DL-EK-ET-01

HH Structure

Total HH #:

Position in HH	Age	Gender	Off-farm work? (Y/N)	Education (years)	Off-farm work type and frequency

Farm Structure

Total Land Owned (sq m)		
Total Land Cultivated (sq m)		
Number of plots | Plots cultivated		
Amount of land rented (sq m) | Price		
Total Number of Crops		
Aquaculture? (Y/N) | No. of species		
Livestock? (Y/N) | No. of species		
Intercrops? (Y/N) | No. plots intercropped		
Home Garden? (Y/N)		

Notes:

Plot Structure and Utilization

Plot:		1	2	3	4	5	6	7	8	9	10
Area (sq m)											
Type of land (code)											
distance to home [m]											
ownership status (code)											
ownership by gender (code)											
Main (long rain) season	utilization										
	crop										
Short rain season	utilization										
	crop										

Type of land: 1 - not irrigated flat, 2 - not irrigated slope, 3- irrigated, 4-flooded regularly, 5-other

Ownership status: 1-owned, 2-rented, 3-shared, 4-other. **Ownership by gender:** 1-male, 2-female, 3- jointly

Utilization: 1-cropped, 2-fallow, 3-grazed, 4-not utilized by this household

Crop: (See crop code table)

Managed Trees (outside of specific plots)

Tree type (code)	no.	Utilized for					Yield*	% consumed	Price
		food	feed	timber	fuel	other			

*****Determine most relevant unit for yield depending on tree type and utilization

Notes:

Plot History and Land Preparation

HH ID:	
Plot No.:	
Area (sq m):	
Irrigated (Y/N)	Water Source:
	Dist. To Plot (m):

GPS Coordinates

Waypoint	Latitude	Longitude

System History

	Production method (Code)	If Intercrop		Years in production		If intercrop		Plans to change system?		Crop Spacing	
		Crop 1 (Code)	Crop 2 (Code)	Crop 1 (Code)	Crop 2 (Code)	Switch to MC? (Y/N)	When? (year of lifecycle)	When? (years from now)	To What?	Crop 1 (Code)	Crop 2 (Code)
Long Season											
Short Season											

Production method: 1-monocrop, 2-intercrop, 3-rotation, 4-fallow

System Establishment (pre-planting)

Season (1-long, 2-short)	Crop (code)	Activity (code)	Performed by (code)	No. of labor type	Person-days	If HL		Months active	Machine/ equipment	No. Times task performed	Notes
						Hrs.	$/hr.				

Activity: 1-Land clearing, 2-tilling, 3-Seed bed prep, 4-prepairing drainage 5-Irrigation set-up, 6-other
Performed by: UF-unpaid family labor, UL-unpaid other labor, HL-Hired Labor

Crop Management

HH ID:
Plot No.:
Area (sq m):

All crop management activities specific to current plot

Activity: 1-Irrigation, 2-Planting/sowing, 3-Nursery preparation, 4-Fertilizer application, 5-Pesticide application, 6-Fungicide application, 7-Manure application, 8-Weeding, 9-Other

Performed by: UF-unpaid family labor, UL-unpaid other labor, HL-Hired Labor

See 'Code' sheet for other activity and crop codes

Management

Season (1-long, 2-short)	Crop (code)	Activity (code)	Months	Performed By (code)*	No. Times activity performed	Person-days/time	Person-days Total	If HL			Input type (code)	Input quantity	Input cost
								Hrs.	$/hr.				

*

Unique row per labor-type and activity

Harvest/storage/processing

Season (1-long, 2-short)	Crop (code)	Activity (code)	Months	Performed By (code)*	No. Times activity performed	Person-days/time	Person-days Total	If HL			Equipment	Service (Y/N)	Cost
								Hrs.	$/hr.				

Crop Products and Marketing

HH ID:
Plot No.:
Area (sq m):

All crop products specific to current plot

Product: 1-Grain, 2-Fruit, 3-leaves, 4-Seed, 5-Cob, 6-Whole plant, 7-all above-ground biomass

Buyer: 1-Sold at local market, 2-Trader/middle-men, 3-Co-op, 5-Broker, 6-Processor, 7-Wholesaler, 8-Retailer, 9-Other

See 'Code' sheet for other activity and crop codes

Crop Products		Production	Sales				Household food consumption	Livestock feeding		Kept as seed	Other (stored, gifts, donations, fuel, etc)
Crop (code)	Product (code)	Total	Quantity	Price/kg	Total value	Buyer (code)	quantity	quant	Species	quantity	quantity

Marketing/sales activities **Prices**

Crop (code)	Product (code)	Marketing activity	Distance travelled	Time spent on activity		Current price (expected)	2015 price	2014 price	2013 price	2012 price	2011 price	Notes

Crop Residues

HH ID:
Plot No.:
Area (sq m):

All crop products specific to current plot

Residue: 1-Straw, 2-Stover, 3-Leaves, 4-Stalks, 5-Vines, 6-Whole plant, 7-Other

Buyer: 1-Sold at local market, 2-Trader/middle-men, 3-Co-op, 5-Broker, 6-Processor, 7-Wholesaler, 8-Retailer, 9-Other

Activity (labor): 1-Harvesting/gathering, 2-Bringing to animals/stall, 3-burning, 4-other

See 'Code' sheet for 'crop' and other codes

Residues

		Left in field			Sale			Feed				Livestock	Fuel	Other
Crop (code)	Residue (code)	mulch, [%]	grazing/ gathered by others, [%]	burnt, [%]	share [%]	Price	main buyer (code)	stall-feeding, [%]		own grazing, [%]		bedding, share [%]	share [%]	share [%]
								Species	%	Species	%			

Labor – Residues

Crop (code)	Residue Activity		Performed by (code)		Person-days (total)	Months	If HL		Cost HL
	Activity	No. Times	Labor type	No. People			No.	$/hr	

Notes:

Livestock Management and Sales

Species	
Breed*	
Total No. Animals	

*If specific breed is unknown, note specifics e.g. 'local', 'improved', etc.

Notes on breeding females:

List no., size, and purpose* of male/female animals in each age group

Age class	Males		Females		Purpose*	Purchase		
	No	Wt. range (kg)	No.	Wt. range (kg)		When	Weight (kg)	Cost

* e.g. meat, breeding, milking, etc.

Livestock mgmt. (feeding schedule below)

Activity	Location		Freq.	Performed by (labor)			If HL				Input	Quantity or freq.	Cost
	On/off (if on, plot #)	Distance		Type	No.	Time req.	No.	Cost	Time req.				

Livestock feeding

Age group	Feeding schedule			Feed cost (VND)	Labor		
	Feed type*	Amount	Freq.		Type	No.	Time req.

***If from on-farm, note plot#**

Sales

Time kept on farm	Age at sale	Weight at sale	Price (specify unit)	Sold to	Notes:

Dung Utilization

List dung utilization by species and age group

Species	Age group	Total dung production (kg) – note frequency	Dung utilization								
			Use 1			Use 2			Use 3		
			Use	Amount (kg)	Value	Use	Amount (kg)	Value	Use	Amount (kg)	Value

Labor associated with dung management

Species	Activity	Freq.	Performed by (labor)			If HL				Input	Quantity or freq.	Cost
			Type	No.	Time req.	No.	Cost	Time req.				

Notes on sales or other dung-related activities:

Aquaculture

Pond size (sq m)		
Total No. fish (estimate)		
List fish species	**Species**	**No**

Notes on pond establishment, etc.:

Fish purchase

Species	No	Wt. range (kg)	When purchased	Cost (VND)	Purchased from.	Distance travelled

Fish management

Activity	Location		Freq.	Performed by (labor)			If HL				Input	Quantity or freq.	Cost
	On/off (if on, plot #)	Distance		Type	No.	Time req.	No.	Cost	Time req.				

Fish feeding

Species	Feeding schedule			Feed cost	Labor		
	Feed type*	Amount	Freq.		Type	No.	Time req.

***If from on-farm, note plot#**

Sales

Time kept on farm	Age at sale	Weight at sale	Price (specify unit)	Sold to	Notes:

INPUT SUPPLIER AND VARIETY INFO

Input	Variety/type	Used in which plots	Purchased from?	Price

EQUIPMENT/MACHINE INFO

Machine/ Equipment	Description	Used in which plots	Purchased from?	Price

Appendix 2: Land Use System Models

Appendix 2.1: Cassava monocrop, Ratanakiri, Cambodia

CONTEXT AND POLICY SETTING FOR LUS ANALYSIS		
System	**Location**	**System length (years)**
Cassava monocrop	Ratanakiri, Cambodia	20

Macroeconomic Context	Item	Units	Value	Notes
	Inflation rate	%	0.0504	

Conversions	Item	Units	Value	Notes
	KHR to USD		0.000250	May-17
	MJ to kcal		238.845800	
	kcal to MJ		0.004187	

Policy Setting	Item	Units	Value	Notes
	Discount Rate		0.1	

Agroecosystem Setting	Item	Units	Value	Notes
	Plot size	ha	1	
	Annual	months	Jan-dec	

Production System	Item	Units	Value	Notes
	Irrigation	type	none	
	Spatial Scale of LUS Operation/Evaluation	hectares	1	
	Timeframe of LUS Operation/Evaluation	years	7	
	Previous land use		Forest	
	Stem spacing	meters	1	~10,000 stems per hectare
	Plot distance to home	meters	5000	
	Stems/ha	Stem	10000	

Variety & expected yield	Item	Units	Value	Notes
	Green Malay, Year 1	kilos/ha	8,500.00	
	Yearly yield decline after year 1	kilos/ha	133.45	Howler, 2014

Socioeconomic Context	Item	Units	Value	Notes
	Land tenure		Owned	
	Household structure			
	Limits on capital		for small farmers	
	Market access		good	
	Contracts		none	
	Technology availability		low	
	Size of operational holding	hectares	3	
	Other (market) institutional factors?			
	Other (non-market) institutional factors?			

Labor	Item	Units	Value	Notes
	Kilometers to-from-plot/year	meters	500	Assumes 100 meter distance, visiting plot 100 days/year
	Motorbike fuel effeciency	kilometers/liter	36	Assumes 100 mpg fuel efficiency
	Opportunity cost of HH labor, 2016	USD/PD	5	Based on daily farm labor wage rates gathered during HH interviews
	Average wage increase/year	%	5.3	Wiggens and Keats, 2014

Input prices (2016)	Item	Units	Value	Notes
	Stems	USD/Stem	0.05	From household survey data
	Herbicide/hormone	USD/liter	11.25	From household survey data
	Gasoline	USD/liter	4.725	Assume same prices as Vietnam

Capital costs (2016)	Item	Units	Value	Notes
	Motorbike	USD/motorbike	1,000.00	From household survey data
	Tarps	USD/tarp	3.21	From household survey data
	Shovel	USD/shovel	5.00	From household survey data
	Knife	USD/knife	1.00	From household survey data

Energy values	Item	Units	Value	Notes
Inputs	Human Labor	MJ/PD	17.25	Pimentel and Pimentel, 2008
	Stems	MJ/stem	0.19	Pimentel and Pimentel, 2008
	Gasoline	MJ/liter	32.20	Hofstrand, 2008
	Herbicide/hormone	MJ/liter	41.87	Pimentel, 2009
Outputs	Cassava	MJ/kg	15.90	Pimentel and Pimentel, 2008

NPK (assume 15-15-15)	Nutrient	Units	Value	Notes
	N	MJ/kg	70.764487	Conversions based on values from Pimentel (2008)
	P	MJ/kg	16.861049	
	K	MJ/kg	17.384424	
	NPK	MJ/kg	15.751494	

Cassava monocrop: Ratanakiri, Cambodi

Inputs/Outputs (I/O), by Year	Unit	Year 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
System Establishment																						
Activities																						
Land Preparation																						
Land clearing																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD/ha	35.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	35.00
Wood removal																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD/ha	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.00
Crop Management																						0.00
Activities																						
Planting																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD/ha	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	300.00
Weeding																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD/ha	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	600.00
Herbicide/Hormone application																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD/ha	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	45.00
Inputs																						
Stems	num	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	200,000.00
Herbicide/hormone	liters	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	100.00
Gasoline (motorbike)	liters	18.92	18.92	18.92	18.92	18.92	18.92	18.92	18.92	18.92	18.92	18.92	18.92	18.92	18.92	18.92	18.92	18.92	18.92	18.92	18.92	378.34
Harvest and Processing																						
Activities																						
Harvest																						
Hired labor	PD/ha	50.00	49.00	48.02	47.06	46.12	45.20	44.29	43.41	42.54	41.69	40.85	40.04	39.24	38.45	37.68	36.93	36.19	35.47	34.76	34.06	830.98
Family labor	PD/ha	50.00	49.00	48.02	47.06	46.12	45.20	44.29	43.41	42.54	41.69	40.85	40.04	39.24	38.45	37.68	36.93	36.19	35.47	34.76	34.06	830.98
Cutting																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD/ha	10.00	9.80	9.60	9.41	9.22	9.04	8.86	8.68	8.51	8.34	8.17	8.01	7.85	7.69	7.54	7.39	7.24	7.09	6.95	6.81	166.20
Drying																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD/ha	5.00	4.90	4.80	4.71	4.61	4.52	4.43	4.34	4.25	4.17	4.09	4.00	3.92	3.85	3.77	3.69	3.62	3.55	3.48	3.41	83.10
Commercialization																						
Activities																						
Marketing																						
Family labor	PD/ha	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	200.00
Farm Management																						
Family labor	PD/ha	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	400.00
Capital costs																						
Management																						
Knives	num	5.00									5.00											10.00
Motorbike	num	1.00																				1.00
Shovels	num	4.00									4.00											8.00
Harvest & Processing																						
Tarps	num	4.00																				4.00
Yields																						0.00
Cassava (dried, chopped)	kg/ha	8,500.00	8,366.55	8,233.10	8,099.65	7,966.20	7,832.75	7,699.30	7,565.85	7,432.40	7,298.95	7,165.50	7,032.05	6,898.60	6,765.15	6,631.70	6,498.25	6,364.80	6,231.35	6,097.90	5,964.45	144,644.50
Total Labor																						
Family labor	PD/ha	193.00	138.70	137.43	136.18	134.95	133.75	132.58	131.43	130.30	129.19	128.11	127.05	126.01	124.99	123.99	123.01	122.05	121.11	120.18	119.28	2,633.27
Hired Labor	PD/ha	50.00	49.00	48.02	47.06	46.12	45.20	44.29	43.41	42.54	41.69	40.85	40.04	39.24	38.45	37.68	36.93	36.19	35.47	34.76	34.06	830.98
Total Labor	PD/ha	243.00	187.70	185.45	183.24	181.07	178.95	176.87	174.83	172.84	170.88	168.96	167.08	165.24	163.44	161.67	159.94	158.24	156.57	154.94	153.34	3,464.25
Total Labor (system life)	PD/ha	3,464.25																				
Total family labor (system life)	PD/ha	2,633.27																				

Cassava monocrop: Ratanakiri, Cambodia		Year																		
Inputs/Outputs (I/O), by Year	**Unit**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
System Establishment																					
Activities																					
Land Preparation																					
Land clearing																					
Hired labor	USD/PD	1.78	1.88	1.98	2.09	2.21	2.33	2.46	2.60	2.75	2.90	3.06	3.23	3.42	3.61	3.81	4.02	4.25	4.48	4.74	5.00
Family labor	USD/PD	1.78	1.88	1.98	2.09	2.21	2.33	2.46	2.60	2.75	2.90	3.06	3.23	3.42	3.61	3.81	4.02	4.25	4.48	4.74	5.00
Wood removal																					
Hired labor	USD/PD	1.78	1.88	1.98	2.09	2.21	2.33	2.46	2.60	2.75	2.90	3.06	3.23	3.42	3.61	3.81	4.02	4.25	4.48	4.74	5.00
Family labor	USD/PD	1.78	1.88	1.98	2.09	2.21	2.33	2.46	2.60	2.75	2.90	3.06	3.23	3.42	3.61	3.81	4.02	4.25	4.48	4.74	5.00
Crop Management																					
Activities																					
Planting																					
Hired labor	USD/PD	1.78	1.88	1.98	2.09	2.21	2.33	2.46	2.60	2.75	2.90	3.06	3.23	3.42	3.61	3.81	4.02	4.25	4.48	4.74	5.00
Family labor	USD/PD	1.78	1.88	1.98	2.09	2.21	2.33	2.46	2.60	2.75	2.90	3.06	3.23	3.42	3.61	3.81	4.02	4.25	4.48	4.74	5.00
Weeding																					
Hired labor	USD/PD	1.78	1.88	1.98	2.09	2.21	2.33	2.46	2.60	2.75	2.90	3.06	3.23	3.42	3.61	3.81	4.02	4.25	4.48	4.74	5.00
Family labor	USD/PD	1.78	1.88	1.98	2.09	2.21	2.33	2.46	2.60	2.75	2.90	3.06	3.23	3.42	3.61	3.81	4.02	4.25	4.48	4.74	5.00
Herbicide/Hormone application																					
Hired labor	USD/PD	1.78	1.88	1.98	2.09	2.21	2.33	2.46	2.60	2.75	2.90	3.06	3.23	3.42	3.61	3.81	4.02	4.25	4.48	4.74	5.00
Family labor	USD/PD	1.78	1.88	1.98	2.09	2.21	2.33	2.46	2.60	2.75	2.90	3.06	3.23	3.42	3.61	3.81	4.02	4.25	4.48	4.74	5.00
Inputs																					
Stems	USD/kwh	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.08	0.08	0.09	0.09	0.09	0.10	0.10	0.11	0.12	0.12	0.13
Herbicide/hormone	USD/liter	4.94	5.59	5.56	5.52	5.50	5.71	5.73	6.03	6.54	6.81	7.76	8.74	9.20	9.49	9.96	10.21	10.68	10.80	10.90	11.25
Gasoline (motorbike)	USD/liter	0.47	0.47	0.54	0.61	0.62	0.63	0.71	0.79	0.90	1.01	0.98	0.94	1.05	1.15	1.25	1.35	1.39	1.43	1.43	1.43
Harvest and Processing																					
Activities																					
Harvest																					
Hired labor	USD/PD	1.78	1.88	1.98	2.09	2.21	2.33	2.46	2.60	2.75	2.90	3.06	3.23	3.42	3.61	3.81	4.02	4.25	4.48	4.74	5.00
Family labor	USD/PD	1.78	1.88	1.98	2.09	2.21	2.33	2.46	2.60	2.75	2.90	3.06	3.23	3.42	3.61	3.81	4.02	4.25	4.48	4.74	5.00
Cutting																					
Hired labor	USD/PD	1.78	1.88	1.98	2.09	2.21	2.33	2.46	2.60	2.75	2.90	3.06	3.23	3.42	3.61	3.81	4.02	4.25	4.48	4.74	5.00
Family labor	USD/PD	1.78	1.88	1.98	2.09	2.21	2.33	2.46	2.60	2.75	2.90	3.06	3.23	3.42	3.61	3.81	4.02	4.25	4.48	4.74	5.00
Drying																					
Hired labor	USD/PD	1.78	1.88	1.98	2.09	2.21	2.33	2.46	2.60	2.75	2.90	3.06	3.23	3.42	3.61	3.81	4.02	4.25	4.48	4.74	5.00
Family labor	USD/PD	1.78	1.88	1.98	2.09	2.21	2.33	2.46	2.60	2.75	2.90	3.06	3.23	3.42	3.61	3.81	4.02	4.25	4.48	4.74	5.00
Commercialization																					
Activities																					
Marketing																					
Family labor	USD/PD	1.78	1.88	1.98	2.09	2.21	2.33	2.46	2.60	2.75	2.90	3.06	3.23	3.42	3.61	3.81	4.02	4.25	4.48	4.74	5.00
Farm Management																					
Family labor	USD/PD	1.78	1.88	1.98	2.09	2.21	2.33	2.46	2.60	2.75	2.90	3.06	3.23	3.42	3.61	3.81	4.02	4.25	4.48	4.74	5.00
Capital costs																					
Management																					
Knives	USD/unit	0.44	0.50	0.49	0.49	0.49	0.51	0.51	0.54	0.58	0.61	0.69	0.78	0.82	0.84	0.88	0.91	0.95	0.96	0.97	1.00
Motorbike	USD/unit	439.03	497.29	494.65	490.66	489.00	507.62	509.26	536.07	581.16	605.57	690.06	776.46	817.79	843.54	884.90	907.42	949.58	959.69	968.68	1000.00
Shovels	USD/unit	2.20	2.49	2.47	2.45	2.45	2.54	2.55	2.68	2.91	3.03	3.45	3.88	4.09	4.22	4.42	4.54	4.75	4.80	4.84	5.00
Harvest & Processing																					
Tarps	USD/unit	0.00	1.60	1.59	1.57	1.57	1.63	1.63	1.72	1.86	1.94	2.21	2.49	2.62	2.71	2.84	2.91	3.05	3.08	3.11	3.21
Yields																					
Cassava (dried, chopped)	USD/kg	0.13	0.19	0.19	0.16	0.18	0.20	0.16	0.25	0.26	0.17	0.17	0.18	0.10	0.14	0.20	0.17	0.16	0.16	0.15	0.11

Cassava monocrop: Ratanakiri, Cambodia		Year																			
Inputs/Outputs (I/O), by Year	Unit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
System Establishment																					
Activities																					
Land Preparation																					
Land clearing																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Wood removal																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Crop Management																					
Activities																					
Planting																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Weeding																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Herbicide/Hormone application																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Inputs																					
Stems	MJ/kwh	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.1
Herbicide/hormone	MJ/liter	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.8
Gasoline (motorbike)	MJ/liter	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.2
Harvest and Processing																					
Activities																					
Harvest																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Cutting																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Drying																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Commercialization																					
Activities																					
Marketing																					
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Farm Management																					
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Capital costs																					
Management																					
Knives	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Motorbike	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Shovels	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Harvest & Processing																					
Tarps	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Yields																					
Cassava (dried, chopped)	MJ/kg	15.90	15.90	15.90	15.90	15.90	15.90	15.90	15.90	15.90	15.90	15.90	15.90	15.90	15.90	15.90	15.90	15.90	15.90	15.90	15.9

Cassava monocrop: Ratanakiri, Cambodia

Inputs/Outputs (I/O), by Year	Unit	Year 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
System Establishment																						
Activities																						
Land Preparation																						
Land clearing																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	62.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	62.
Wood Removal																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	31.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.
Crop Management																						
Activities																						
Planting																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	26.65	28.14	29.72	31.38	33.14	34.99	36.95	39.02	41.20	43.51	45.94	48.51	51.23	54.10	57.12	60.32	63.70	67.26	71.03	75.00	938
Weeding																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	53.30	56.28	59.43	62.76	66.27	69.98	73.90	78.04	82.40	87.01	91.88	97.03	102.46	108.19	114.25	120.64	127.39	134.52	142.05	150.00	1,877
Herbicide/Hormone application																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	4.00	4.22	4.46	4.71	4.97	5.25	5.54	5.85	6.18	6.53	6.89	7.28	7.68	8.11	8.57	9.05	9.55	10.09	10.65	11.25	140.
Inputs																						
Stems	USD$	500.00	525.20	551.67	579.47	608.68	639.36	671.58	705.43	740.98	778.33	817.56	858.76	902.04	947.50	995.26	1,045.42	1,098.11	1,153.45	1,211.59	1,272.65	16,60
Herbicide/hormone	USD$	24.70	27.97	27.82	27.60	27.51	28.55	28.65	30.15	32.69	34.06	38.82	43.68	46.00	47.45	49.78	51.04	53.41	53.98	54.49	56.25	784.
Gasoline (motorbike)	USD$	8.89	8.89	10.22	11.54	11.73	11.92	13.43	14.94	17.03	19.11	18.44	17.78	19.77	21.75	23.65	25.54	26.29	27.05	27.05	27.05	362.
Harvest and Processing																						
Activities																						
Harvest																						
Hired labor	USD$	88.84	91.93	95.14	98.45	101.88	105.43	109.11	112.91	116.84	120.91	125.13	129.49	134.00	138.67	143.50	148.50	153.68	159.03	164.57	170.31	2,50
Family labor	USD$	88.84	91.93	95.14	98.45	101.88	105.43	109.11	112.91	116.84	120.91	125.13	129.49	134.00	138.67	143.50	148.50	153.68	159.03	164.57	170.31	2,50
Cutting																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	17.77	18.39	19.03	19.69	20.38	21.09	21.82	22.58	23.37	24.18	25.03	25.90	26.80	27.73	28.70	29.70	30.74	31.81	32.91	34.06	501.
Drying																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	8.88	9.19	9.51	9.85	10.19	10.54	10.91	11.29	11.68	12.09	12.51	12.95	13.40	13.87	14.35	14.85	15.37	15.90	16.46	17.03	250
Commercialization																						
Activities																						
Marketing																						
Family labor	USD$	17.77	18.76	19.81	20.92	22.09	23.33	24.63	26.01	27.47	29.00	30.63	32.34	34.15	36.06	38.08	40.21	42.46	44.84	47.35	50.00	625
Farm Management																						
Family labor	USD$	35.53	37.52	39.62	41.84	44.18	46.66	49.27	52.02	54.94	58.01	61.26	64.68	68.30	72.13	76.16	80.43	84.93	89.68	94.70	100.00	1,251
Capital costs																						
Management																						
Knives	USD$	2.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.2
Motorbike	USD$	439.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	439
Shovels	USD$	8.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.
Harvest & Processing																						
Tarps	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Yields																						
Cassava (dried, chopped)	USD$	1,125.40	1,563.71	1,532.13	1,326.72	1,440.29	1,537.57	1,259.61	1,885.41	1,957.69	1,257.83	1,220.74	1,253.81	660.20	965.39	1,315.07	1,126.15	1,009.24	975.83	942.94	656.09	25,01
Annual Benefits																						
Total annual costs	USD$	1,419.33	918.44	961.57	1,006.66	1,052.90	1,102.53	1,154.89	1,211.15	1,271.62	1,348.80	1,399.21	1,467.88	1,539.84	1,614.24	1,692.92	1,774.20	1,859.31	1,946.65	2,037.42	2,133.91	
Total Annual revenue	USD$	1,125.40	1,563.71	1,532.13	1,326.72	1,440.29	1,537.57	1,259.61	1,885.41	1,957.69	1,257.83	1,220.74	1,253.81	660.20	965.39	1,315.07	1,126.15	1,009.24	975.83	942.94	656.09	
Annual net income	USD$	-293.93	645.27	570.56	320.06	387.39	435.04	104.71	674.26	686.07	-90.97	-178.47	-214.07	-879.64	-648.85	-377.85	-648.05	-850.06	-970.82	-1,094.48	-1,477.82	
Annual discounted net benefits	USD$	-293.93	586.61	471.54	240.47	264.59	270.13	59.11	346.00	320.06	-38.58	-68.81	-75.03	-280.28	-187.95	-99.50	-155.14	-185.00	-192.07	-196.85	-241.64	
Economic Indicators																						
Net Present Value of system	USD$	543.73																				
Returns to land	USD$/ha	543.73																				
Returns to family labor	USD$	0.21																				
Returns to family labor/market wage rate		0.07																				

Cassava monocrop: Ratanakiri, Cambodia

Inputs/Outputs (I/O), by Year	Unit	Year 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
System Establishment																						
Activities																						
Land Preparation																						
Land clearing																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Family labor	MJ	603.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**603.77**
Wood removal																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Family labor	MJ	310.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**310.51**
Crop Management																						
Activities																						
Planting																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Family labor	MJ	258.76	258.76	258.76	258.76	258.76	258.76	258.76	258.76	258.76	258.76	258.76	258.76	258.76	258.76	258.76	258.76	258.76	258.76	258.76	258.76	**1,811.30**
Weeding																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Family labor	MJ	517.51	517.51	517.51	517.51	517.51	517.51	517.51	517.51	517.51	517.51	517.51	517.51	517.51	517.51	517.51	517.51	517.51	517.51	517.51	517.51	**3,622.59**
Herbicide/Hormone application																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Family labor	MJ	38.81	38.81	38.81	38.81	38.81	38.81	38.81	38.81	38.81	38.81	38.81	38.81	38.81	38.81	38.81	38.81	38.81	38.81	38.81	38.81	**271.69**
Inputs																						
Stems	MJ	1,876.67	1,876.67	1,876.67	1,876.67	1,876.67	1,876.67	1,876.67	1,876.67	1,876.67	1,876.67	1,876.67	1,876.67	1,876.67	1,876.67	1,876.67	1,876.67	1,876.67	1,876.67	1,876.67	1,876.67	**13,136.67**
Herbicide/hormone	MJ	209.35	209.35	209.35	209.35	209.35	209.35	209.35	209.35	209.35	209.35	209.35	209.35	209.35	209.35	209.35	209.35	209.35	209.35	209.35	209.35	**1,465.45**
Gasoline (motorbike)	MJ	609.13	609.13	609.13	609.13	609.13	609.13	609.13	609.13	609.13	609.13	609.13	609.13	609.13	609.13	609.13	609.13	609.13	609.13	609.13	609.13	**4,263.93**
Harvest and Processing																						
Activities																						
Harvest																						
Hired labor	MJ	862.52	845.27	828.37	811.80	795.56	779.65	764.06	748.78	733.80	719.13	704.74	690.65	676.84	663.30	650.03	637.03	624.29	611.81	599.57	587.58	**5,687.23**
Family labor	MJ	862.52	845.27	828.37	811.80	795.56	779.65	764.06	748.78	733.80	719.13	704.74	690.65	676.84	663.30	650.03	637.03	624.29	611.81	599.57	587.58	**5,687.23**
Cutting																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Family labor	MJ	172.50	169.05	165.67	162.36	159.11	155.93	152.81	149.76	146.76	143.83	140.95	138.13	135.37	132.66	130.01	127.41	124.86	122.36	119.91	117.52	**1,137.45**
Drying																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Family labor	MJ	86.25	84.53	82.84	81.18	79.56	77.97	76.41	74.88	73.38	71.91	70.47	69.06	67.68	66.33	65.00	63.70	62.43	61.18	59.96	58.76	**568.72**
	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Commercialization																						
Activities																						
Marketing																						
Family labor	MJ	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	**1,207.53**
Farm Management																						
Family labor	MJ	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	**2,415.06**
Capital costs																						
Management																						
Knives	NA																					
Shovels	NA																					
Motorbike	NA																					
Harvest & Processing																						
Tarps	NA																					
Yields																						
Cassava (dried, chopped)	MJ	135,140.37	133,018.67	130,896.96	128,775.26	126,653.56	124,531.85	122,410.15	120,288.45	118,166.74	116,045.04	113,923.33	111,801.63	109,679.93	107,558.22	105,436.52	103,314.81	101,193.11	99,071.41	96,949.70	94,828.00	**901,426.82**
Annual Energy Balance																						
Total annual energy inputs	MJ	6,925.82	5,971.87	5,932.99	5,894.88	5,857.54	5,820.94	5,785.08	5,749.93	5,715.49	5,681.74	5,648.66	5,616.24	5,584.47	5,553.33	5,522.82	5,492.92	5,463.62	5,434.90	5,406.76	5,379.18	**42,189.13**
Total annual enery outputs	MJ	135,140.37	133,018.67	130,896.96	128,775.26	126,653.56	124,531.85	122,410.15	120,288.45	118,166.74	116,045.04	113,923.33	111,801.63	109,679.93	107,558.22	105,436.52	103,314.81	101,193.11	99,071.41	96,949.70	94,828.00	**901,426.82**
Annual net energy output	MJ	128,214.55	127,046.80	124,963.98	122,880.38	120,796.02	118,710.91	116,625.07	114,538.51	112,451.25	110,363.30	108,274.68	106,185.39	104,095.46	102,004.89	99,913.70	97,821.89	95,729.49	93,636.51	91,542.95	89,448.82	**859,237.70**
Net energy input (system life)	MJ	42,189.13																				
Net energy output (system life)	MJ	901,426.82																				
EROI		21.37																				

Appendix 2.2: Coffee monocrop, Central Highlands, Vietnam

CONTEXT AND POLICY SETTING FOR LUS ANALYSIS		
System	**Location**	**System Length (years)**
Coffee monocrop	CH, Vietnam	20

Macroeconomic Context	Item	Units	Value	Notes
	Inflation rate	%	0.1037	Mean inf. Rate 2006-2014

Conversions	Item	Units	Value	Notes
	VND to USD		0.000044	May, 2017
	MJ to kcal		238.845800	
	kcal to MJ		0.004187	

Policy Setting	Item	Units	Value	Notes
	Discount Rate		0.1	

Agroecosystem Setting	Item	Units	Value	Notes
	Plot size	ha	1	
	Perrenial	months	Jan-dec	

Production System	Item	Units	Value	Notes
	Land quality			
	Irrigation	type	well, with sprinklers	
	Spatial Scale of LUS Operation/Evaluation	hectares	1	
	Timeframe of LUS Operation/Evaluation	years	25	
	Previous land use		Coffee	Lower performing variety (not TR4)
	Tree spacing	meters	3	~1000 seedlings per hectare
	Plot distance to home	meters	5000	
	Seedlings/ha	seedlings	1000	

Variety & expected yield	Item	Units	Value	Notes
	TR4, Year 2	kilos/ha	500	From WASI
	TR4, Year 3	kilos/ha	1500	
	TR4, Year 4	kilos/ha	2500	
	TR4, Year 5+	kilos/ha	3500	

Socioeconomic Context	Item	Units	Value	Notes
	Land tenure		Owned	
	Household structure			
	Limits on capital		for small farmers	
	Market access		good	
	Contracts		none	
	Technology availability		high	
	Size of operational holding	hectares	3	
	Other (market) institutional factors?			
	Other (non-market) institutional factors?			

Labor	Item	Units	Value	Notes
	Service fee - excavator	USD/mh	11.73	From household survey data
	Kilometers to-from-plot/year	kilometers	500	Assumes 100 meter distance, visiting plot 100 days/year
	Motorbike fuel efficiency	kilometers/liter	36	Assumes 100 mpg fuel efficiency
	Opportunity cost of HH labor	USD/PD	8.8	Based on average daily farm labor wage rates gathered during HH interviews

Input prices (2016)	Item	Units	Value	Notes
	Cow dung	USD/kg	0.00252	Thi et al., 2004
	Herbicide	USD/liter	8	From household survey data
	Pesticide	USD/liter	24	From household survey data
	Seedlings	USD/seedling	0.176	
	Gasoline	USD/liter	0.8316	From www.globalpetrolprices.com/Vietnam/gasoline_prices/
	Electricity (2016)	USD/kwh	0.051524	Average price per KWH in 2016: https://vebs.com.vn
	NPK	USD/kg	0.44	Average NPK prices from HH interviews
	NPK-to-Herbicide		18.18	
	NPK-to-Pesticide		54.55	

Capital costs (2016)	Item	Units	Value	Notes
	Electric pump	USD/pump	1,760.00	From household survey data
	Electrical hookup	USD/hookup	1,760.00	From household survey data
	Well installation	USD/meter	12.32	From household survey data
	Sprinklers	USD/sprinkler	37.40	From household survey data
	Pipes & Hoses	USD/all	308.00	From household survey data
	Weed trimmer	USD/trimmer	88.00	From household survey data
	Gunny sacks	USD/sack	0.88	From household survey data
	Motorbike	USD/motorbike	504.51	From household survey data
	Tarps	USD/tarp	0.56	From household survey data
	Shovel	USD/shovel	5.00	From household survey data
	Coffee mill	USD/mill	220.00	From household survey data
	Coffee dryer	USD/dryer	132.00	From household survey data
	Backpack sprayer	USD/sprayer	264.00	From household survey data

Energy values	Item	Units	Value	Notes
Inputs	Human Labor	MJ/PD	17.25	Pimentel and Pimentel, 2008
	Seedlings	MJ/seedling	0.19	Assume same energy content as cassava stems
	NPK	MJ/kg	15.75	See NPK, below
	Herbicide	MJ/liter	41.87	Pimentel, 2009
	Pesticide	MJ/liter	41.87	Pimentel, 2009
	Machine (backhoe)	MJ/hr	161.00	Assumes 5 galons gasoline per hour
	Weed trimmer	MJ/day	161.00	Assumes 0.5 gallons gasoline per hour
	Cow dung	MJ/kg	6.71	Pimentel, 2009
	Gasoline	MJ/liter	32.20	Hofstrand, 2008
	Electricity	MJ/kwh	10.78	Pimentel, 2009
Outputs	Coffee beans	MJ/kg	16.75	Calculated based on composition of coffee beans
	Coffee pulp	MJ/kg	6.71	Assume the same as animal manure

NPK (assume 15-15-15)	Nutrient	Units	Value	Notes
	N	MJ/kg	70.764487	Conversions based on values from Pimentel, 2009
	P	MJ/kg	16.861049	
	K	MJ/kg	17.384424	
	NPK	MJ/kg	15.751494	

Coffee Monocrop: Central Highlands, Vietnam

Inputs/Outputs (I/O), by Year	Unit	Years 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
System Establishment																						
Activities																						
Land Preparation																						
Land clearing																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD/ha	40.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.0
Digging holes	Machine hrs/ha	34.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	34.4
Irrigation setup																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD/ha	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.0
Planting																						
Planting																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD/ha	20.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.0
Manure application																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD/ha	12.00	1.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.2
NPK application																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD/ha	12.00	1.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.2
Inputs																						
Cow dung	kg/ha	2,500.00	250.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2,750.
NPK	kg/ha	500.00	50.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	550.0
Seedlings	seedlings/ha	1,000.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,100.0
Crop Management																						
Activities																						
Irrigation																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD/ha	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	360.0
Fertilize application																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD/ha	0.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	228.0
Pesticide applications																						
Hired labor	PD/ha	0.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	76.0
Family labor	PD/ha	0.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	38.0
Herbicide application																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD/ha	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	126.0
Bud trimming																						
Hired labor	PD/ha	0.00	0.00	30.00	30.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	1,830.
Family labor	PD/ha	0.00	0.00	0.00	30.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	670.0
Pruning																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD/ha	0.00	0.00	10.00	15.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	345.0
Weeding																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD/ha	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	288.0
Inputs																						
Electricity (irrigation)	kwh	1,333.00	1,333.00	1,333.00	1,333.00	1,333.00	1,333.00	1,333.00	1,333.00	1,333.00	1,333.00	1,333.00	1,333.00	1,333.00	1,333.00	1,333.00	1,333.00	1,333.00	1,333.00	1,333.00	1,333.00	38,664.
NPK	kg/ha	0.00	2,500.00	2,500.00	2,500.00	2,500.00	2,500.00	2,500.00	2,500.00	2,500.00	2,500.00	2,500.00	2,500.00	2,500.00	2,500.00	2,500.00	2,500.00	2,500.00	2,500.00	2,500.00	2,500.00	47,500.
Pesticide	liters/ha	0.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	152.0
Herbicide	liters/ha	0.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	76.0
Gasoline (motorbike)	liters	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	277.7
Gasoline (weed trimmer)	liters	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	1,000.
Harvest and Processing																						
Activities																						
Harvest																						
Hired labor	PD/ha	0.00	3.90	15.00	22.50	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	27.00	24.30	21.87	19.68	17.71	492.9
Family labor	PD/ha	0.00	3.25	12.50	18.75	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	22.50	20.25	18.23	16.40	14.76	410.8
Pulping																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD/ha	0.00	1.04	4.00	6.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	7.20	6.48	5.83	5.25	4.72	131.5
Drying																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD/ha	0.00	1.30	5.00	7.50	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	9.00	8.10	7.29	6.56	5.90	164.0
Inputs																						
Gasoline (mill)	liters	0.00	5.20	20.00	30.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	36.00	32.40	29.16	26.24	23.62	642.4
Commercialization																						
Activities																						
Marketing																						
Family labor	PD/ha	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	288.0
Farm Management																						
Family labor	PD/ha	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	400.0
Capital costs																						
Irrigation																						
Electric pump	each	1.00																				1.0
Electrical hookup	each	1.00																				1.0
Well	meters	108.00																				108.0
Sprinkler	each	2.00																				2.0
Pipes & Hoses	each	1.00														1.00						2.0
Management																						
Backpack sprayer	each	1.00									1.00											2.0
Weed trimmer	each	1.00									1.00											2.0
Motorbike	each	1.00																				1.0
Gunny sacks	each	50.00				50.00					50.00					50.00					50.00	250.0
Tarps	each	5.00		5.00					5.00					5.00					5.00			25.0
Shovels	each	4.00	3.00								2.00									2.00		11.0
Harvest & Processing																						
Mill	each	1.00																				
Dryer	each	1.00																				
Yields																						
Coffee cherries	kg/ha	0.00	0.00	6,750.00	15,750.00	19,370.09	10,027.01	16,223.88	17,181.83	12,245.77	15,123.02	15,000.08	18,191.70	13,268.22	18,170.93	13,723.61	12,351.25	11,116.13	10,004.52	9,004.06	8,103.66	241,665.
Coffee beans	kg/ha	0.00	0.00	1,500.00	3,500.00	4,304.46	2,228.23	3,605.31	3,818.18	2,721.28	3,360.67	3,333.35	4,042.60	2,948.49	4,037.98	3,049.69	2,744.72	2,470.25	2,223.23	2,000.90	1,800.81	53,690.
Pulp	kg/ha	0.00	0.00	5,250.00	12,250.00	15,065.62	7,798.79	12,618.57	13,363.64	9,524.49	11,762.35	11,666.73	14,149.10	10,319.73	14,132.95	10,673.92	9,606.53	8,645.88	7,781.29	7,003.16	6,302.84	187,915.
Total Labor																						
Family labor	PD/ha	153.00	87.99	109.50	155.25	181.00	181.00	181.00	181.00	181.00	181.00	181.00	181.00	181.00	181.00	181.00	176.70	172.83	169.35	166.21	163.39	3,345.
Hired Labor	PD/ha	0.00	7.90	39.00	76.50	94.00	94.00	94.00	94.00	94.00	94.00	94.00	94.00	94.00	94.00	94.00	91.00	88.30	85.87	83.68	81.71	1,587.
Total Labor	PD/ha	153.00	95.89	148.50	231.75	275.00	275.00	275.00	275.00	275.00	275.00	275.00	275.00	275.00	275.00	275.00	267.70	261.13	255.22	249.90	245.11	4,933.
Total Labor (system life)	PD/ha	4,933.19																				
Total family labor (system life)	PD/ha	3,345.22																				

Coffee Monocrop: Central Highlands, Vietnam																					
Inputs/Outputs (I/O), by Year	Unit	Years 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
System Establishment																					
Activities																					
Land Preparation																					
Land clearing																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Digging holes	USD/machine hr	3.44	3.69	3.84	3.77	3.76	3.90	4.03	4.34	4.70	5.05	5.46	6.73	7.20	7.84	9.30	10.15	10.82	11.26	11.36	11.73
Irrigation setup																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Planting																					
Planting																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Manure application																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
NPK application																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Inputs																					
Cowdung	USD/kg	0.0025	0.0025	0.0028	0.0031	0.0034	0.0037	0.0041	0.0046	0.0050	0.0055	0.0061	0.0068	0.0075	0.0082	0.0091	0.0100	0.0111	0.0122	0.0135	0.0149
NPK	USD/kg	0.18	0.16	0.13	0.19	0.18	0.18	0.25	0.27	0.32	0.32	0.42	0.63	0.35	0.40	0.55	0.53	0.45	0.48	0.38	0.44
Seedlings	USD/seedling	0.18	0.1760	0.1943	0.2144	0.2366	0.2612	0.2883	0.3182	0.3511	0.3876	0.4278	0.4721	0.5211	0.5751	0.6347	0.7006	0.7732	0.8534	0.9419	1.0396
Crop Management																					
Activities																					
Irrigation																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Fertilizer application																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Pesticide application																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Herbicide application																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Bud trimming																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Pruning																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Weeding																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Inputs																					
Electricity (irrigation)	USD/kwh	0.0151	0.0162	0.0169	0.0166	0.0165	0.0171	0.0177	0.0191	0.0206	0.0222	0.0240	0.0296	0.0316	0.0344	0.0409	0.0446	0.0475	0.0495	0.0499	0.0515
NPK	USD/kg	0.18	0.16	0.13	0.19	0.18	0.18	0.25	0.27	0.32	0.32	0.42	0.63	0.35	0.40	0.55	0.53	0.45	0.48	0.38	0.44
Pesticide	USD/litre	9.67	8.38	6.97	10.31	9.83	9.72	12.43	14.69	17.37	17.61	22.92	34.18	19.25	21.69	29.78	28.82	24.81	23.34	20.68	24.00
Herbicide	USD/litre	3.22	2.86	2.32	3.44	3.28	3.24	4.15	4.90	5.79	5.87	7.64	11.39	6.42	7.22	9.93	9.61	8.27	7.78	6.89	8.00
Gasoline (motorbike)	USD/litre	0.35	0.35	0.37	0.38	0.36	0.34	0.41	0.48	0.58	0.67	0.74	0.80	0.84	0.88	1.02	1.15	1.10	1.04	0.94	0.88
Gasoline (weed trimmer)	USD/litre	0.35	0.35	0.37	0.38	0.36	0.34	0.41	0.48	0.58	0.67	0.74	0.80	0.84	0.88	1.02	1.15	1.10	1.04	0.94	0.88
Harvest and Processing																					
Activities																					
Harvest																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Pulping																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Drying																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Inputs																					
Gasoline (mill)	liter	0.35	0.35	0.37	0.38	0.36	0.34	0.41	0.48	0.58	0.67	0.74	0.80	0.84	0.88	1.02	1.15	1.10	1.04	0.94	0.88
Commercialization																					
Activities																					
Marketing																					
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Farm Management																					
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Capital costs																					
Irrigation																					
Electric pump	USD/unit	515.78	553.26	576.03	566.18	563.74	585.34	604.18	651.06	704.98	757.05	819.91	1,009.44	1,080.66	1,176.42	1,396.14	1,523.11	1,623.52	1,689.86	1,704.70	1,760.00
Electrical hookup	USD/unit	515.78	553.26	576.03	566.18	563.74	585.34	604.18	651.06	704.98	757.05	819.91	1,009.44	1,080.66	1,176.42	1,396.14	1,523.11	1,623.52	1,689.86	1,704.70	1,760.00
Well	USD/meter	3.61	3.87	4.03	3.96	3.95	4.10	4.23	4.56	4.93	5.30	5.74	7.07	7.56	8.23	9.77	10.66	11.36	11.83	11.93	12.32
Sprinkler	USD/unit	10.96	11.76	12.24	12.03	11.98	12.44	12.84	13.84	14.98	16.09	17.42	21.45	22.96	25.00	29.67	32.37	34.50	35.91	36.22	37.40
Pipes & Hoses	USD/unit	90.26	96.82	100.81	99.08	98.65	102.43	105.73	113.94	123.37	132.48	143.48	176.65	189.11	205.87	244.33	266.54	284.12	295.72	298.32	308.00
Management																					
Backpack sprayer	USD/unit	77.37	82.99	86.41	84.98	84.56	87.80	90.63	97.66	105.75	113.56	122.99	151.42	162.10	176.46	209.42	228.47	243.53	253.48	255.71	264.00
Weed trimmer	USD/unit	25.79	27.66	28.80	28.31	28.19	29.27	30.21	32.55	35.25	37.85	41.00	50.47	54.03	58.82	69.81	76.16	81.18	84.49	85.24	88.00
Motorbike	USD/unit	147.85	158.59	165.12	162.30	161.60	167.79	173.19	186.63	202.08	217.01	235.03	289.36	309.77	337.22	400.21	436.60	465.39	484.40	488.66	504.51
Gunny sacks	USD/unit	0.26	0.28	0.29	0.28	0.28	0.29	0.30	0.33	0.35	0.38	0.41	0.50	0.54	337.22	0.70	0.76	0.81	0.84	0.85	0.88
Tarp	USD/unit	0.17	0.18	0.18	0.18	0.18	0.29	0.19	0.21	0.23	0.24	0.26	0.32	0.35	0.38	0.45	0.49	0.52	0.54	0.55	0.56
Shovels	USD/unit	1.47	1.57	1.64	1.61	1.60	1.66	1.72	1.85	2.00	2.15	2.33	2.87	3.07	3.34	3.97	4.33	4.61	4.80	4.84	5.00
Harvest & Processing																					
Mill	USD/unit	64.47	69.16	72.00	70.77	70.47	73.17	75.52	81.38	88.12	94.63	102.49	126.18	135.08	147.05	174.52	190.39	202.94	211.23	213.09	220.00
Dryer	USD/unit	38.68	41.49	43.20	42.46	42.28	43.90	45.31	48.83	52.87	56.78	61.49	75.71	81.05	88.23	104.71	114.23	121.76	126.74	127.85	132.00
Yields																					
Coffee cherries	USD/kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coffee beans	USD/kg	0.74	0.66	0.48	0.50	0.22	0.17	0.12	0.10	0.37	0.40	1.17	1.10	1.15	1.25	1.70	1.67	1.60	1.57	1.50	1.53
Pulp	USD/kg	0.0025	0.0025	0.0028	0.0031	0.0034	0.0037	0.0041	0.0046	0.0050	0.0055	0.0061	0.0068	0.0075	0.0082	0.0091	0.0100	0.0111	0.0122	0.0135	0.0149

Coffee Monocrop: Central Highlands, Vietnam

Inputs/Outputs (I/O), by Year	Unit	Years 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
System Establishment																					
Activities																					
Land Preparation																					
Land clearing																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Digging holes	MJ/Machine hr	161.00	161.00	161.00	161.00	161.00	161.00	161.00	161.00	161.00	161.00	161.00	161.00	161.00	161.00	161.00	161.00	161.00	161.00	161.00	161.0
Irrigation setup																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Planting																					
Planting																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Manure application																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
NPK application																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Inputs																					
Coverlamp	MJ/kg	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.7
NPK	MJ/kg	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.7
Seedlings	MJ/seedling	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.1
Crop Management																					
Activities																					
Irrigation																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Fertilizer application																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Pesticide application																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Herbicide application																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Bud trimming																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Pruning																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Weeding																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Inputs																					
Electricity (irrigation)	MJ/kwh	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.7
NPK	MJ/kg	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.7
Pesticide	MJ/liter	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.8
Herbicide	MJ/liter	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.8
Gasoline (motorbike)	MJ/liter	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.2
Gasoline (weed trimmer)	MJ/liter	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.2
Harvest and Processing																					
Activities																					
Harvest																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Pulping																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Drying																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Inputs																					
Gasoline (mill)	MJ/liter	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.2
Commercialization																					
Activities																					
Marketing																					
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Farm Management																					
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.2
Capital costs																					
Irrigation																					
Electric pump	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Electrical hookup	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Well	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Sprinkler	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Pipes & Hoses	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Management																					
Backpack sprayer	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Weed trimmer	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Motorbike	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Gunny sacks	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Tarps	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Shovels	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Harvest & Processing																					
Mill	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Dryer	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Yields																					
Coffee cherries	MJ/kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Coffee beans	MJ/kg	21.13	21.13	21.13	21.13	21.13	21.13	21.13	21.13	21.13	21.13	21.13	21.13	21.13	21.13	21.13	21.13	21.13	21.13	21.13	21.1
Pulp	MJ/kg	18.63	18.63	18.63	18.63	18.63	18.63	18.63	18.63	18.63	18.63	18.63	18.63	18.63	18.63	18.63	18.63	18.63	18.63	18.63	18.6

Coffee Monocrop: Central Highlands, Vietnam

Inputs/Outputs (I/O), by Year	Unit	Years 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
System Establishment																						
Activities																						
Land Preparation																						
Land clearing																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	33.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.0
Digging holes	USD$	118.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	118.9
Irrigation setup																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	4.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.2
Planting																						
Planting																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	16.85	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.8
Manure application																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	10.11	1.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.3
NPK application																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	10.11	1.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.3
Inputs																						
Coverbag	USD$	6.30	0.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.9
NPK	USD$	88.61	7.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	96.4
Seedbag	USD$	176.00	17.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	193.
Crop Management																						
Activities																						
Irrigation																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	15.16	18.00	27.68	33.94	40.19	19.26	52.71	58.97	65.22	71.48	77.74	84.00	90.25	96.51	102.77	109.03	115.28	121.54	127.80	134.44	1,472
Fertilizer application																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	0.00	12.00	18.45	22.62	26.80	12.84	35.14	39.31	43.48	47.65	51.83	56.00	60.17	64.34	68.51	72.68	76.86	81.03	85.20	96.96	971.
Pesticide application																						
Hired labor	USD$	0.00	4.00	6.15	7.54	8.93	4.28	11.71	13.10	14.49	15.88	17.28	18.67	20.06	21.45	22.84	24.23	25.62	27.01	28.40	32.32	323.
Family labor	USD$	0.00	2.00	3.08	3.77	4.47	2.14	5.86	6.55	7.25	7.94	8.64	9.33	10.03	10.72	11.42	12.11	12.81	13.50	14.20	16.16	161.
Herbicide application																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	5.05	6.00	9.23	11.31	13.40	6.42	17.57	19.66	21.74	23.83	25.91	28.00	30.09	32.17	34.26	36.34	38.43	40.51	42.60	48.48	498.
Soil tunneling																						
Hired labor	USD$	0.00	0.00	30.75	94.27	133.98	64.20	175.69	196.55	217.41	238.27	259.13	279.99	300.85	321.70	342.56	363.42	384.28	405.14	426.00	484.80	4,718
Family labor	USD$	0.00	0.00	0.00	56.56	80.32	42.10	117.13	131.04	144.94	158.85	172.75	186.66	200.56	214.47	228.38	242.28	256.19	270.09	284.00	323.20	3,179.
Pruning																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	0.00	0.00	15.38	28.28	44.66	21.40	58.56	65.52	72.47	79.42	86.38	93.33	100.28	107.23	114.19	121.14	128.09	135.05	142.00	161.60	1,579
Weeding																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	8.42	10.00	15.38	18.86	22.33	10.70	29.28	32.76	36.24	39.71	43.19	46.66	50.14	53.62	57.09	60.57	64.05	67.52	71.00	80.80	815.
Inputs																						
Electricity (irrigation)	USD$	23.15	24.83	25.85	25.41	25.30	26.27	27.11	29.22	31.64	33.98	36.80	45.30	48.50	52.10	62.66	68.36	72.86	75.84	76.50	79.99	891.
NPK	USD$	0.00	393.34	319.41	472.40	491.45	445.39	520.74	675.18	786.29	807.30	1,050.00	1,306.77	882.31	992.14	1,364.75	1,230.96	1,137.20	1,089.88	948.02	1,100.00	16,296.
Pernicide	USD$	0.00	68.66	55.75	82.46	78.79	77.74	99.62	117.50	138.99	140.91	183.40	278.47	154.00	173.17	238.21	230.57	198.49	186.74	165.47	192.00	2,855.
Herbicide	USD$	0.00	11.44	9.29	13.74	13.13	12.96	16.60	19.58	23.16	23.49	30.57	45.58	25.67	28.86	39.70	38.43	33.08	31.12	27.58	32.00	475.
Gasoline (motorbike)	USD$	4.79	4.86	5.07	5.28	5.00	4.72	5.49	6.67	7.99	9.31	10.21	11.11	11.67	12.22	14.10	13.97	15.21	14.44	12.99	11.53	185.
Gasoline (weed trimmer)	USD$	17.25	17.50	18.25	19.00	18.00	17.00	20.50	24.00	28.75	33.50	36.75	40.00	42.00	44.00	50.75	57.50	54.75	52.00	46.75	41.50	679.
Harvest and Processing																						
Activities																						
Harvest																						
Hired labor	USD$	0.00	3.50	23.06	42.42	66.99	32.10	87.85	98.28	108.71	119.13	129.56	139.99	150.42	160.85	171.28	163.54	155.63	147.67	139.75	143.13	2,889
Family labor	USD$	0.00	3.75	19.22	33.33	55.82	26.75	73.21	81.90	90.59	99.28	107.97	116.66	125.35	134.04	142.74	136.28	129.69	123.06	116.46	119.28	1,736
Pulping																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	0.00	1.04	6.15	11.31	17.86	8.56	23.43	26.21	28.99	31.77	34.55	37.33	40.11	42.89	45.68	43.61	41.55	39.38	37.27	38.17	555.
Drying																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	0.00	1.30	7.69	14.14	22.33	10.70	29.28	32.76	36.24	39.71	43.19	46.66	50.14	53.62	57.09	54.51	51.88	49.22	46.58	47.71	694.
Inputs																						
Gasoline (mill)	USD$	0.00	1.82	7.30	11.40	14.40	13.60	16.40	19.20	23.00	26.80	29.40	32.00	33.60	35.20	40.60	41.40	35.48	30.33	24.54	19.60	456.
Commercialization																						
Activities																						
Marketing																						
Family labor	USD$	8.42	10.00	15.38	18.86	22.33	10.70	29.28	32.76	36.24	39.71	43.19	46.66	50.14	53.62	57.09	60.57	64.05	67.52	71.00	80.80	815.
Farm Management																						0.0
Family labor	USD$	16.85	20.00	30.76	37.71	44.66	21.40	58.56	65.52	72.47	79.42	86.38	93.33	100.28	107.23	114.19	121.14	128.09	135.05	142.00	161.60	1,630
Capital costs																						
Irrigation																						
Electric pump	USD$	515.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	515.
Electrical hookup	USD$	515.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	515.
Well	USD$	389.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	389.
Sprinkler	USD$	21.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.9
Pipes & Hoses	USD$	90.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	244.33	0.00	0.00	0.00	0.00	0.00	334.
Management																						
Backpack sprayer	USD$	77.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	191.
Weed trimmer	USD$	25.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	37.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	63.6
Motorbike	USD$	147.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	147.
Granny sacks	USD$	12.49	0.00	0.00	0.00	14.09	0.00	0.00	0.00	0.00	18.93	0.00	0.00	0.00	0.00	34.50	0.00	0.00	0.00	0.00	44.00	124.
Tarps	USD$	0.83	0.00	0.92	0.00	0.00	0.00	0.00	1.04	0.00	0.00	0.00	0.00	1.73	0.00	0.00	0.00	0.00	2.71	0.00	0.00	7.5
Shovels	USD$	5.86	4.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.69	0.00	24.5
Harvest & Processing																						
Mill	USD$	64.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	64.
Dryer	USD$	38.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	38.
Yields																						
Coffee cherries	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Coffee bean	USD$	0.00	0.00	714.99	1,735.30	950.43	381.03	430.83	397.09	1,008.34	1,334.86	3,888.02	4,460.20	3,402.27	5,064.04	5,169.23	4,574.63	3,941.53	3,500.25	2,998.15	2,755.24	46,781
Pulp	USD$	0.00	0.00	14.00	37.61	51.05	29.16	52.08	60.88	47.89	63.27	71.45	95.64	76.99	116.38	97.01	90.36	95.72	93.08	94.45	93.82	1,291.
Annual Benefits																						
Total annual costs	USD$	2,470.64	649.15	670.19	1,066.61	1,234.21	891.93	1,561.94	1,791.26	2,046.29	2,341.98	2,565.49	3,297.50	2,578.35	2,812.87	3,660.08	3,394.64	3,219.52	3,186.37	3,085.78	3,300.07	46,801
Total Annual revenue	USD$	0.00	0.00	729.59	1,772.91	1,001.47	410.19	482.92	457.97	1,051.22	1,400.13	3,959.48	4,555.85	3,479.26	5,180.41	5,266.24	4,670.99	4,087.25	3,595.33	3,092.60	2,849.06	47,992
Annual net income	USD$	-2,470.64	-649.15	59.40	706.30	-232.74	-481.74	-1,079.03	-1,333.29	-995.07	-941.85	1,393.99	1,258.34	900.91	2,367.54	1,606.16	1,276.35	867.73	408.95	6.82	-451.01	1,967
Annual discounted net benefits	USD$	-2,470.64	-590.14	49.09	530.65	-158.96	-299.12	-609.08	-684.19	-464.21	-399.44	537.44	441.04	287.06	685.79	422.95	305.55	177.96	80.91	1.23	-106.45	-2,262
Economic Indicators																						
Net Present Value of $ per ha		9,282.55																				
Return to Land (USD$/ha		2,262.55																				
Return to Family Labor ($/pd		-0.68																				
Return to Family Labor/Market Wage Rate		0.17																				

Coffee Monocrop: Central Highlands, Vietnam

Inputs/Outputs (I/O), by Year	Unit	Year 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
System Establishment																					
Activities																					
Land Preparation																					
Land clearing																					
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	690.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Digging holes	MJ	5,538.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Irrigation setup																					
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	86.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Planting																					
Planting																					
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	345.01	34.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Manure application																					
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	207.01	20.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
NPK application																					
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	207.01	20.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Inputs																					
Coverbag	MJ	16,765.48	1,676.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
NPK	MJ	7,875.75	787.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Seedlings	MJ	190.00	19.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Crop Management																					
Activities																					
Irrigation																					
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.
Fertilizer application																					
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	0.00	207.01	207.01	207.01	207.01	207.01	207.01	207.01	207.01	207.01	207.01	207.01	207.01	207.01	207.01	207.01	207.01	207.01	207.01	207.
Pesticide application																					
Hired labor	MJ	0.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.0
Family labor	MJ	0.00	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.5
Herbicide application																					
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	103.50	103.50	103.50	103.50	103.50	103.50	103.50	103.50	103.50	103.50	103.50	103.50	103.50	103.50	103.50	103.50	103.50	103.50	103.50	103.
Bud trimming																					
Hired labor	MJ	0.00	0.00	345.01	862.52	1,035.03	1,035.03	1,035.03	1,035.03	1,035.03	1,035.03	1,035.03	1,035.03	1,035.03	1,035.03	1,035.03	1,035.03	1,035.03	1,035.03	1,035.03	1,035.
Family labor	MJ	0.00	0.00	0.00	517.51	690.02	690.02	690.02	690.02	690.02	690.02	690.02	690.02	690.02	690.02	690.02	690.02	690.02	690.02	690.02	690.0
Pruning																					
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	0.00	0.00	172.50	258.76	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.0
Weeding																					
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.
Inputs																					
Electricity (irrigation)	MJ	16,532.89	16,532.89	16,532.89	16,532.89	16,532.89	16,532.89	16,532.89	16,532.89	16,532.89	16,532.89	16,532.89	16,532.89	16,532.89	16,532.89	16,532.89	16,532.89	16,532.89	16,532.89	16,532.89	16,532.
NPK	MJ	0.00	39,378.74	39,378.74	39,378.74	39,378.74	39,378.74	39,378.74	39,378.74	39,378.74	39,378.74	39,378.74	39,378.74	39,378.74	39,378.74	39,378.74	39,378.74	39,378.74	39,378.74	39,378.74	39,378
Pesticide	MJ	0.00	334.96	334.96	334.96	334.96	334.96	334.96	334.96	334.96	334.96	334.96	334.96	334.96	334.96	334.96	334.96	334.96	334.96	334.96	334.9
Herbicide	MJ	0.00	167.48	167.48	167.48	167.48	167.48	167.48	167.48	167.48	167.48	167.48	167.48	167.48	167.48	167.48	167.48	167.48	167.48	167.48	167.
Gasoline (motorbike)	MJ	447.22	447.22	447.22	447.22	447.22	447.22	447.22	447.22	447.22	447.22	447.22	447.22	447.22	447.22	447.22	447.22	447.22	447.22	447.22	447.
Gasoline (weed trimmer)	MJ	1,610.00	1,610.00	1,610.00	1,610.00	1,610.00	1,610.00	1,610.00	1,610.00	1,610.00	1,610.00	1,610.00	1,610.00	1,610.00	1,610.00	1,610.00	1,610.00	1,610.00	1,610.00	1,610.00	1,610.
Harvest and Processing																					
Activities																					
Harvest																					
Hired labor	MJ	0.00	67.28	258.76	388.13	517.51	517.51	517.51	517.51	517.51	517.51	517.51	517.51	517.51	517.51	517.51	465.76	419.19	377.27	339.54	305.
Family labor	MJ	0.00	56.06	215.63	323.45	431.26	431.26	431.26	431.26	431.26	431.26	431.26	431.26	431.26	431.26	431.26	388.13	349.32	314.39	282.95	254.
Pulping																					
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	0.00	17.94	69.00	103.50	138.00	138.00	138.00	138.00	138.00	138.00	138.00	138.00	138.00	138.00	138.00	124.20	111.78	100.60	90.54	81.
Drying																					
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	0.00	22.43	86.25	129.38	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	155.25	139.73	125.76	113.18	101.
Inputs																					
Gasoline (mill)	MJ	0.00	167.44	644.00	966.00	1,288.00	1,288.00	1,288.00	1,288.00	1,288.00	1,288.00	1,288.00	1,288.00	1,288.00	1,288.00	1,288.00	1,159.20	1,043.28	938.95	845.06	760.
	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Commercialization																					
Activities																					
Marketing																					
Family labor	MJ	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.
Farm Management																					
Family labor	MJ	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.
Capital costs																					
Irrigation																					
Electric pump	NA																				
Electrical hookup	NA																				
Well	NA																				
Sprinkler	NA																				
Pipes & Hoses	NA																				
Management																					
Backpack sprayer	NA																				
Weed trimmer	NA																				
Motorbike	NA																				
Canopy nets	NA																				
Tarps	NA																				
Shovels																					
Harvest & Processing																					
Mill	NA																				
Dryer	NA																				
Yields																					
Coffee cherries	NA																				
Coffee beans	MJ	0.00	0.00	31,095.00	73,955.00	90,953.32	47,082.41	76,180.12	80,678.22	57,500.72	71,010.98	70,433.72	85,420.16	62,301.69	85,322.61	64,440.00	57,996.00	52,196.40	46,976.76	42,279.08	38,051
Pulp	MJ	0.00	0.00	97,825.00	228,258.33	280,722.79	145,317.44	235,126.06	249,009.21	177,473.02	219,171.77	217,390.09	263,644.95	192,290.97	263,343.89	198,890.76	179,001.68	161,101.52	144,991.36	130,492.23	117,443
Annual Energy Balance																					
Total annual energy input	MJ	51,399.06	62,776.00	61,676.98	63,435.08	64,503.16	64,503.16	64,503.16	64,503.16	64,503.16	64,503.16	64,503.16	64,503.16	64,503.16	64,503.16	64,503.16	64,248.43	64,019.18	63,812.85	63,627.15	63,460
Total annual energy outputs	MJ	0.00	0.00	159,120.00	302,213.33	371,676.11	192,399.85	311,306.18	329,687.43	234,973.74	290,182.75	287,823.81	349,065.11	254,592.66	348,666.50	263,330.76	236,997.68	213,097.91	191,968.12	172,771.31	155,494
Annual net energy output	MJ	-51,399.06	-62,776.00	67,843.02	238,778.25	307,172.95	127,896.69	246,803.02	265,184.27	170,470.58	225,679.59	223,320.65	284,561.95	190,089.50	284,163.34	198,827.60	172,749.25	149,078.74	128,155.27	109,144.16	92,034
Net energy input (system total)	MJ	1,268,189.50																			
Net energy output (system total)	MJ	4,635,267.43																			
EROI		3.66																			

Appendix 2.3: Pepper monocrop, Central Highlands, Vietnam

CONTEXT AND POLICY SETTING FOR LUS ANALYSIS		
System	**Location**	**System length (years)**
Pepper monocrop	CH, Vietnam	20

Macroeconomic Context	Item	Units	Value	Notes
	Inflation rate	%	0.1037	(Mean inf. Rate 2006-2014)

Conversions	Item	Units	Value	Notes
	VND to USD		0.000044	May-17
	MJ to kcal		238.845800	
	kcal to MJ		0.004187	

Policy Setting	Item	Units	Value	Notes
	Discount Rate		0.1	

Agroecosystem Setting	Item	Units	Value	Notes
	Plot size	ha	1	
	Perrenial	months	Jan-dec	

Production System	Item	Units	Value	Notes
	Land quality			
	Irrigation	type		Using drip tape - standard practice in pepper growing households surveyed
	Spatial Scale of LUS Operation/Evaluation	hectares	0.27	
	Timeframe of LUS Operation/Evaluation	years	20	
	Previous land use		Pepper	
	Plot size	m2	2700	Based on spacing needed for 300 poles
	Number of poles	num	300	
	Pole spacing	meters	3	~1000 seedlings per hectare
	Pole type	type	trees	Others households used concrete or wooden poles, but trees were most common
	Plot distance to home	meters	5000	
	Pruning			3 total pruning events in first year based on GAP from International Pepper Community
	Seedlings/ha	vines	2000	2 pepper seedlings per pole

Variety & expected yield	Item	Units	Value	Notes
	Year 1	kilos/ha	0	Variety from WASI; specific variety unknown. Peak yields in year 7
	Year 2	kilos/ha	0	
	Year 3	kilos/ha	400	
	Year 4	kilos/ha	500	
	Year 5	kilos/ha	800	
	Year 6	kilos/ha	1000	
	Year 7-15	kilos/ha	1350	Assuming 5000 kg/ha yield, based on survey data
	Year 10-20	kilos/ha	see notes	Assume 10% decline in productivity per year after year 15

Socioeconomic Context	Item	Units	Value	Notes
	Land tenure		Owned	
	Household structure			
	Limits on capital		for small farmers	
	Market access		good	
	Contracts		none	
	Technology availability		high	
	Size of operational holding	hectares	3	

Labor	Item	Units	Value	Notes
	Kilometers to-from-plot/year	kilometers	500	Assumes 100 meter distance, visiting plot 100 days/year
	Motorbike fuel efficiency	kilometers/liter	36	Assumes 100 mpg fuel efficiency
	Opportunity cost of HH labor	USD/PD	8.8	Based on daily farm labor wage rates gathered during HH interviews

Input prices (2016)	Item	Units	Value	Notes
	Cow dung	USD/kg	0.00252	Thi et al., 2004
	Herbicide	USD/liter	8	Average costs from HH surveys
	Pesticide	USD/liter	24	Average costs from HH surveys
	Seedlings	USD/seedling	0.572	Average costs from HH surveys
	Gasoline	USD/liter	0.8316	From www.globalpetrolprices.com/Vietnam/gasoline_prices/
	Electricity (2016)	USD/kwh	0.051524	Average price per KWH in 2016: https://vebs.com.vn
	NPK	USD/kg	0.44	Average NPK prices from HH intervies
	NPK-to-Herbicide		18.18	
	NPK-to-Pesticide		54.55	

Capital costs (2016)	Item	Units	Value	Notes
	Electric pump	USD/pump	1,760.00	From household survey data
	Electrical hookup	USD/hookup	1,760.00	From household survey data
	Well installation	USD/meter	12.32	From household survey data
	Sprinklers	USD/sprinkler	37.40	From household survey data
	Pipes & Hoses	USD/all	308.00	From household survey data
	Weed trimmer	USD/trimmer	88.00	From household survey data
	Gunny sacks	USD/sack	0.88	From household survey data
	Motorbike	USD/motorbike	504.51	From household survey data
	Tarps	USD/tarp	0.56	From household survey data
	Shovel	USD/shovel	5.00	From household survey data
	Pole Trees	USD/tree	2.20	From household survey data
	Backpack sprayer	USD/sprayer	264.00	From household survey data

Energy values	Item	Units	Value	Notes
Inputs	Human Labor	MJ/PD	17.25	Pimentel and Pimentel, 2008
	NPK	MJ/kg	15.75	See NPK, below
	Seedlings	MJ/seedling	0.19	Assume same energy content as cassava stems
	Herbicide	MJ/liter	41.87	Pimentel, 2009
	Pesticide	MJ/liter	41.87	Pimentel, 2009
	Weed trimmer	MJ/day	161.00	Assumes 0.5 gallons gasoline per hour
	Cow dung	MJ/kg	6.71	Pimentel, 2009
	Gasoline	MJ/liter	32.20	Hofstrand, 2008
	Electricity	MJ/kwh	10.78	Pimentel, 2009
Outputs	Pepper berries	MJ/kg	19.05	USDA National Nutrient Database: 455 kcal per 100g = 4550 kcal per kg

NPK (assume 15-15-15)	Nutrient	Units	Value	Notes
	N	MJ/kg	70.764487	Conversions based on values from Pimentel (2009)
	P	MJ/kg	16.861049	
	K	MJ/kg	17.384424	
	NPK	MJ/kg	15.751494	

Pepper Monocrop: Central Highlands, Vietnam

Inputs/Outputs (I/O), by Year	Unit	Years 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
System Establishment																						
Activities																						
Land Preparation																						
Land clearing:																						
Hired labor	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD	5.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.6
Tilling:																						
Hired labor	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD	13.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.5
Digging holes																						
Hired labor	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD	5.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.9
Pole installation																						
Hired labor	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD	7.56	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.3
Irrigation setup																						
Hired labor	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.3
Planting																						
Planting:																						
Hired labor	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD	7.56	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.3
Vine training:																						
Hired labor	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD	10.80	1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.8
Manure application																						
Hired labor	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD	3.78	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.1
NPK application																						
Hired labor	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD	3.78	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.1
Inputs																						
Cow dung	kg	1,215.00	121.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,336.5
NPK	kg	21.60	2.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.7
Vines	mm	600.00	60.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	660.0
Crop Management																						
Activities																						
Irrigation																						
Hired labor	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD	19.44	19.44	19.44	19.44	19.44	19.44	19.44	19.44	19.44	19.44	19.44	19.44	19.44	19.44	19.44	19.44	19.44	19.44	19.44	19.44	388.8
Fertilizer application																						
Hired labor	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	124.2
Pesticide application																						
Hired labor	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	24.3
Herbicide application																						
Hired labor	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	10.8
Pruning																						
Hired labor	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.0
Vine training																						
Hired labor	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD	0.00	10.80	1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.8
Weeding																						
Hired labor	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD	20.25	20.25	20.25	20.25	20.25	20.25	20.25	20.25	20.25	20.25	20.25	20.25	20.25	20.25	20.25	20.25	20.25	20.25	20.25	20.25	405.0
Inputs																						
Electricity (irrigation)	kwh	1,652.40	1,652.40	1,652.40	1,652.40	1,652.40	1,652.40	1,652.40	1,652.40	1,652.40	1,652.40	1,652.40	1,652.40	1,652.40	1,652.40	1,652.40	1,652.40	1,652.40	1,652.40	1,652.40	1,652.40	33,048.0
NPK	kg	0.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	10,260.0
Cow dung	kg	0.00	1,080.00	1,080.00	1,080.00	1,080.00	1,080.00	1,080.00	1,080.00	1,080.00	1,080.00	1,080.00	1,080.00	1,080.00	1,080.00	1,080.00	1,080.00	1,080.00	1,080.00	1,080.00	1,080.00	20,520.0
Pesticide	liters	0.00	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	15.3
Herbicide	liters	0.00	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	25.6
Gasoline (motorbike)	liters	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	277.7
Harvest and Processing																						
Activities																						
Harvest																						
Hired labor	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	PD	0.00	0.00	26.67	33.33	53.33	66.67	67.75	87.67	98.02	110.10	68.28	111.28	84.77	104.08	128.27	81.00	72.90	65.61	59.05	53.14	1,371.5
Commercialization																						
Activities																						
Marketing																						
Family labor	PD	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	54.0
Farm Management																						
Family labor	PD	5.40	5.40	5.40	5.40	5.40	5.40	5.40	5.40	5.40	5.40	5.40	5.40	5.40	5.40	5.40	5.40	5.40	5.40	5.40	5.40	108.0
Capital costs																						
Establishment																						
Pole trees	nos	300.00	30.00																			
Irrigation																						
Electric pump	nos	1.00																				1.0
Electrical hookup	nos	1.00																				1.0
Well	meters	108.00																				108.0
Sprinkler	nos	2.00																				2.0
Pipes & Hoses	nos	1.00														1.00						2.0
Management																						
Backpack sprayer	nos	1.00									1.00											2.0
Motorbike	nos	1.00																				1.0
Gunny sacks	nos	12.00				12.00					12.00					12.00					12.00	60.0
Tarp	nos	2.00				2.00					2.00					2.00					2.00	10.0
Shovels	nos	4.00									4.00											8.0
Yields																						
Pepper berries	kg/ha	0.00	0.00	400.00	500.00	800.00	1,000.00	1,016.23	1,315.10	1,470.30	1,651.57	1,024.26	1,669.15	1,271.54	1,561.24	1,934.05	1,215.00	1,093.50	984.15	885.74	797.16	20,578.1
Total Labor																						
Family labor	PD	125.70	69.90	83.50	89.09	109.09	122.42	123.50	143.43	153.77	165.86	124.04	167.03	140.52	159.84	184.03	136.76	128.66	121.37	114.80	108.90	2,572.2
Hired Labor	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Total Labor	PD	125.70	69.90	83.50	89.09	109.09	122.42	123.50	143.43	153.77	165.86	124.04	167.03	140.52	159.84	184.03	136.76	128.66	121.37	114.80	108.90	2,572.2

Total labor (system life)	PD	2,572.20
Total family labor (system life)	PD	2,572.20

Pepper Monocrop: Central Highlands, Vietnam		Years																		
Inputs/Outputs (I/O), by Year	**Unit**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
System Establishment																					
Activities																					
Land Preparation																					
Land clearing																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Tilling:																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Digging holes																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Pole instillation																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Irrigation setup																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Planting																					
Planting:																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Vine training:																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Manure application																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
NPK application																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Inputs																					
Cow dung	USD/kg	0.0025	0.0025	0.0028	0.0031	0.0034	0.0037	0.0041	0.0046	0.0050	0.0055	0.0061	0.0068	0.0075	0.0082	0.0091	0.0100	0.0111	0.0122	0.0135	0.0149
NPK	USD/kg	0.18	0.16	0.13	0.19	0.18	0.16	0.23	0.27	0.32	0.32	0.42	0.63	0.35	0.40	0.55	0.58	0.45	0.43	0.26	0.44
Seedlings	USD/seedling	0.57	0.5720	0.6313	0.6968	0.7691	0.8488	0.9369	1.0340	1.1412	1.2596	1.3902	1.5344	1.6935	1.8691	2.0629	2.2768	2.5129	2.7735	3.0611	3.3786
Crop Management																					
Activities																					
Irrigation																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Fertilizer application																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Pesticide application																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Herbicide application																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Pruning:																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Vine training:																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Weeding:																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Inputs																					
Electricity (irrigation)	USD/kwh	0.0151	0.0162	0.0169	0.0166	0.0165	0.0171	0.0177	0.0191	0.0206	0.0222	0.0240	0.0296	0.0316	0.0344	0.0409	0.0446	0.0475	0.0495	0.0499	0.0515
NPK	USD/kg	0.18	0.16	0.13	0.19	0.18	0.16	0.23	0.27	0.32	0.32	0.42	0.63	0.35	0.40	0.55	0.58	0.45	0.43	0.26	0.44
Cow dung	USD/litre	0.0025	0.0025	0.0028	0.0031	0.0034	0.0037	0.0041	0.0046	0.0050	0.0055	0.0061	0.0068	0.0075	0.0082	0.0091	0.0100	0.0111	0.0122	0.0135	0.0149
Pesticide	USD/litre	9.67	8.58	6.97	10.31	9.85	9.72	12.45	14.69	17.37	17.61	22.92	34.18	19.25	21.65	29.78	28.82	24.81	23.34	20.68	24.00
Herbicide	USD/litre	3.22	2.86	2.32	3.44	3.28	3.24	4.15	4.90	5.79	5.87	7.64	11.39	6.42	7.22	9.93	9.61	8.27	7.78	6.89	8.00
Gaveline (mortality)	USD/litre	0.35	0.35	0.37	0.38	0.36	0.34	0.41	0.48	0.58	0.67	0.74	0.80	0.84	0.88	1.02	1.15	1.10	1.04	0.94	0.83
Harvest and Processing																					
Activities																					
Harvest																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Commercialization																					
Activities																					
Marketing																					
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Farm Management																					
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.25	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Capital costs																					
Establishment																					
Pole taxes	USD/unit	0.64	0.69	0.72	0.71	0.70	0.73	0.76	0.81	0.88	0.95	1.02	1.26	1.35	1.47	1.75	1.90	2.03	2.11	2.13	2.20
Irrigation																					
Electric pump	USD/unit	515.78	553.26	576.03	566.18	563.74	585.34	604.18	651.06	704.98	757.05	819.91	1009.44	1080.66	1176.42	1396.14	1523.11	1623.52	1689.86	1704.70	1760.00
Electrical hookup	USD/unit	515.78	553.26	576.03	566.18	563.74	585.34	604.18	651.06	704.98	757.05	819.91	1009.44	1080.66	1176.42	1396.14	1523.11	1623.52	1689.86	1704.70	1760.00
Well	USD/meter	3.61	3.87	4.03	3.96	3.95	4.10	4.23	4.56	4.93	5.30	5.74	7.07	7.56	8.23	9.77	10.66	11.36	11.83	11.93	12.32
Sprinkler	USD/unit	10.96	11.76	12.24	12.03	11.98	12.44	12.84	13.84	14.98	16.09	17.42	21.45	22.96	25.00	29.67	32.37	34.50	35.91	36.22	37.40
Pipes & Hoses	USD/unit	90.26	96.82	100.81	99.08	98.65	102.43	105.73	113.94	123.37	132.48	143.48	176.65	189.11	205.87	244.33	266.54	284.12	295.72	298.32	308.00
Management																					
Backpack sprayer	USD/unit	77.37	82.99	86.41	84.93	84.56	87.80	90.63	97.66	105.75	113.56	122.99	151.42	162.10	176.46	209.42	228.47	243.53	253.48	255.71	264.00
Microtube	USD/unit	147.85	158.59	165.12	162.30	161.60	167.79	173.19	186.63	202.08	217.01	235.03	289.36	309.77	337.22	400.21	436.60	465.39	484.40	488.66	504.51
Gunny sacks	USD/unit	0.26	0.28	0.29	0.28	0.28	0.29	0.30	0.33	0.35	0.38	0.41	0.50	0.54	0.59	0.70	0.76	0.81	0.84	0.85	0.88
Taps	USD/unit	0.17	0.18	0.18	0.18	0.18	0.19	0.19	0.21	0.23	0.24	0.26	0.32	0.35	0.38	0.45	0.49	0.52	0.54	0.55	0.56
Shovels	USD/unit	1.47	1.57	1.64	1.61	1.60	1.66	1.72	1.85	2.00	2.15	2.33	2.87	3.07	3.34	3.97	4.33	4.61	4.80	4.84	5.00
Yields																					
Pepper beans	USD/kg	1.82	2.07	2.15	2.57	2.85	1.13	2.48	2.57	1.66	1.12	2.97	3.07	2.38	2.85	4.68	6.10	6.17	7.08	8.47	7.04

Pepper Monocrop: Central Highlands, Vietnam

Inputs/Outputs (I/O), by Year	Unit	Years 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
System Establishment																					
Activities																					
Land Preparation																					
Land clearing:																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Tilling:																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Digging holes																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Pole installation																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Irrigation setup																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Planting																					
Planting																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Vine training																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Manure application																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
NPK application																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Inputs																					
Cow dung	MJ/kg	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71
NPK	MJ/kg	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75
Vines	MJ/vine	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Crop Management																					
Activities																					
Irrigation																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Fertilizer application																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Pesticide application																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Herbicide application																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Pruning:																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Vine training																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Weeding:																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Inputs																					
Electricity (irrigation)	MJ/kwh	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78
NPK	MJ/kg	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75
Cow dung	MJ/kg	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71
Pesticide	MJ/liter	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87
Herbicide	MJ/liter	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87	41.87
Gasoline (motorbike)	MJ/liter	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20
Harvest and Processing																					
Activities																					
Harvest																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Commercialization																					
Activities																					
Marketing																					
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Farm Management																					
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Capital costs																					
Establishment																					
Pole trees	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Irrigation																					
Electric pump	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrical hookup	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Well	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sprinkler	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pipes & Hoses	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Management																					
Backpack sprayer	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Motorbike	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gunny sacks	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tarps	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Shovels	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yields																					
Pepper berries	MJ/kg	19.05	19.05	19.05	19.05	19.05	19.05	19.05	19.05	19.05	19.05	19.05	19.05	19.05	19.05	19.05	19.05	19.05	19.05	19.05	19.05

Pepper Monocrop: Central Highlands, Vietnam

Inputs/Outputs (I/O), by Year	Unit	Years 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
System Establishment																						
Activities																						
Land Preparation																						
Land clearing:																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	4.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.7
Tilling:																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	11.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.3
Digging holes																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.0
Pole installation																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	6.37	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.1
Irrigation setup																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.1
Planting:																						
Planting:																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	6.37	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.1
Vine training:																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	9.10	1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.1
Manure application																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	3.18	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.5
NPK application																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	3.18	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.5
Inputs																						
Cow dung	USD$	3.06	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.3
NPK	USD$	3.83	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.1
Vines	USD$	343.20	34.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	377.
Crop Management																						
Activities																						
Irrigation																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	16.38	19.44	29.89	36.65	43.41	20.80	56.92	63.68	70.44	77.20	83.96	90.72	97.47	104.23	110.99	117.75	124.51	131.26	138.02	157.08	1,590.
Fertilizer application																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	5.23	6.21	9.55	11.71	13.87	6.64	18.18	20.34	22.50	24.66	26.82	28.98	31.14	33.30	35.46	37.61	39.77	41.93	44.09	50.18	508.
Pesticide application																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	1.02	1.22	1.87	2.29	2.71	1.30	3.56	3.98	4.40	4.82	5.25	5.67	6.09	6.51	6.94	7.36	7.78	8.20	8.63	9.82	99.
Herbicide application																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	0.45	0.54	0.83	1.02	1.21	0.58	1.58	1.77	1.96	2.14	2.33	2.52	2.71	2.90	3.08	3.27	3.46	3.65	3.83	4.36	44.1
Pruning:																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	8.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.4
Vine training:																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	0.00	10.80	1.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.4
Weeding:																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	17.06	20.25	31.14	38.18	45.22	21.67	59.30	66.34	73.38	80.42	87.46	94.50	101.54	108.58	115.61	122.65	129.69	136.73	143.77	163.62	1,657.
Inputs																						
Electricity (irrigation)	USD$	24.95	26.76	27.87	27.39	27.27	28.32	29.23	31.49	34.10	36.62	39.66	48.83	52.28	56.91	67.54	73.68	78.54	81.75	82.46	85.14	960.
NPK	USD$	0.00	84.96	68.99	102.04	97.51	96.20	123.28	145.41	172.00	174.38	226.95	338.42	190.58	214.30	294.79	285.33	245.63	231.10	204.77	257.60	3,534
Cow dung	USD$	0.00	2.72	3.00	3.32	3.66	4.04	4.46	4.92	5.43	5.99	6.61	7.30	8.06	8.89	9.82	10.83	11.96	13.20	14.57	16.08	144.
Pesticide	USD$	0.00	6.95	5.64	8.35	7.98	7.87	10.09	11.90	14.07	14.27	18.57	27.69	15.59	17.53	24.12	23.34	20.10	18.91	16.75	19.44	289.
Herbicide	USD$	0.00	3.86	3.14	4.64	4.43	4.37	5.60	6.61	7.82	7.93	10.32	15.38	8.66	9.74	13.40	12.97	11.17	10.50	9.31	10.80	160.
Gasoline (motorbike)	USD$	4.79	4.86	5.07	5.28	5.00	4.72	5.69	6.67	7.99	9.31	10.21	11.11	11.67	12.22	14.10	15.97	15.21	14.44	12.99	11.53	188.
Harvest and Processing																						
Activities																						
Harvest																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	USD$	0.00	0.00	41.00	62.84	119.09	71.33	198.38	287.21	355.18	437.24	294.90	519.27	425.04	558.06	732.34	490.62	466.90	443.02	419.34	429.40	6,351
Commercialization																						
Activities																						
Marketing																						
Family labor	USD$	2.27	2.70	4.15	5.09	6.03	2.89	7.91	8.84	9.78	10.72	11.66	12.60	13.54	14.48	15.42	16.35	17.29	18.23	19.17	21.82	220.
Farm Management																						
Family labor	USD$	4.55	5.40	8.30	10.18	12.06	5.78	15.81	17.69	19.57	21.44	23.32	25.20	27.08	28.95	30.83	32.71	34.59	36.46	38.34	43.63	441.
Capital costs																						
Establishment																						
Pole tutes	USD$	193.42	20.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	214.
Irrigation																						
Electric pump	USD$	515.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	515.
Electrical hookup	USD$	515.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	515.
Well	USD$	389.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	389.
Sprinkler	USD$	21.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.9
Pipes & Hoses	USD$	90.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	244.33	0.00	0.00	0.00	0.00	0.00	334.
Management																						
Backpack sprayer	USD$	77.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	190.
Motorbike	USD$	147.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	147.
Gunny sacks	USD$	3.09	0.00	0.00	0.00	3.38	0.00	0.00	0.00	0.00	4.54	0.00	0.00	0.00	0.00	8.38	0.00	0.00	0.00	0.00	10.56	29.
Tarp	USD$	0.33	0.00	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.49	0.00	0.00	0.00	0.00	0.90	0.00	0.00	0.00	0.00	1.13	3.3
Shovels	USD$	5.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.4
Yields																						
Pepper beans	USD$	0.00	0.00	859.85	1,282.78	2,281.84	1,131.00	2,522.64	3,373.95	2,440.55	1,850.42	3,039.58	5,122.13	3,026.77	4,447.20	8,997.44	7,416.85	6,744.71	6,972.31	7,498.54	5,612.02	74,620
Annual Benefits																						
Total annual costs	USD$	2,447.30	255.74	242.11	318.97	393.18	276.52	540.00	676.85	798.62	1,034.33	848.02	1,228.18	991.43	1,176.61	1,728.02	1,250.45	1,206.59	1,180.39	1,155.95	1,272.18	
Total Annual revenue	USD$	0.00	0.00	859.85	1,282.78	2,281.84	1,131.00	2,522.64	3,373.95	2,440.55	1,850.42	3,039.58	5,122.13	3,026.77	4,447.20	8,997.44	7,416.85	6,744.71	6,972.31	7,498.54	5,612.02	
Annual net income	USD$	-2,447.30	-255.74	617.74	963.81	1,888.66	854.48	1,982.65	2,697.10	1,641.93	816.09	2,191.56	3,893.95	2,035.33	3,270.59	7,269.42	6,166.39	5,538.12	5,792.92	6,342.59	4,339.84	
Annual discounted net benefits	USD$	-2,447.30	-232.49	510.53	724.12	1,289.98	530.57	1,119.15	1,384.04	765.97	346.10	844.94	1,364.81	648.52	947.37	1,914.26	1,476.19	1,205.26	1,144.12	1,140.77	709.60	

Economic Indicators

Net Present Value of System (0.27 ha) 5,386.51

Return to land USD$/ha	56,987.07
Return to family labor USD$/PD	5.98
Return to family labor/market wage rate	1.46

Pepper Monocrop: Central Highlands, Vietnam

Inputs /Outputs (I/O), by Year	Unit	Years 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
System Establishment																						
Activities																						
Land Preparation																						
Land clearing:																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	97.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	97.8
Tilling:																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	232.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	232.8
Digging holes																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	102.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	102.4
Pole installation																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	130.41	13.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	143.4
Irrigation setup																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	23.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.2
Planting																						
Planting:																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	130.41	13.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	143.4
Vine training:																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	186.30	18.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	204.9
Manure application																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	65.21	6.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	71.7
NPK application																						0.0
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	65.21	6.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	71.7
Inputs																						
Cow dung	MJ	8,148.02	814.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8,962.8
NPK	MJ	340.23	34.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	374.2
Vines	MJ	114.00	11.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	125.4
Crop Management																						
Activities																						
Irrigation																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	335.35	335.35	335.35	335.35	335.35	335.35	335.35	335.35	335.35	335.35	335.35	335.35	335.35	335.35	335.35	335.35	335.35	335.35	335.35	335.35	6,706.9
Fertilizer application																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	107.13	107.13	107.13	107.13	107.13	107.13	107.13	107.13	107.13	107.13	107.13	107.13	107.13	107.13	107.13	107.13	107.13	107.13	107.13	107.13	2,142.5
Pesticide application																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	20.96	20.96	20.96	20.96	20.96	20.96	20.96	20.96	20.96	20.96	20.96	20.96	20.96	20.96	20.96	20.96	20.96	20.96	20.96	20.96	419.1
Herbicide application																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	9.32	9.32	9.32	9.32	9.32	9.32	9.32	9.32	9.32	9.32	9.32	9.32	9.32	9.32	9.32	9.32	9.32	9.32	9.32	9.32	186.3
Pruning																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	172.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	172.5
Vine training:																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	0.00	186.30	18.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	204.9
Weeding:																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	349.32	349.32	349.32	349.32	349.32	349.32	349.32	349.32	349.32	349.32	349.32	349.32	349.32	349.32	349.32	349.32	349.32	349.32	349.32	349.32	6,986.4
Inputs																						
Electricity (irrigation)	MJ	17,820.58	17,820.58	17,820.58	17,820.58	17,820.58	17,820.58	17,820.58	17,820.58	17,820.58	17,820.58	17,820.58	17,820.58	17,820.58	17,820.58	17,820.58	17,820.58	17,820.58	17,820.58	17,820.58	17,820.58	356,411.
NPK	MJ	0.00	8,505.81	8,505.81	8,505.81	8,505.81	8,505.81	8,505.81	8,505.81	8,505.81	8,505.81	8,505.81	8,505.81	8,505.81	8,505.81	8,505.81	8,505.81	8,505.81	8,505.81	8,505.81	8,505.81	161,610.
Cow dung	MJ	0.00	7,242.69	7,242.69	7,242.69	7,242.69	7,242.69	7,242.69	7,242.69	7,242.69	7,242.69	7,242.69	7,242.69	7,242.69	7,242.69	7,242.69	7,242.69	7,242.69	7,242.69	7,242.69	7,242.69	137,611.
Pesticide	MJ	0.00	33.91	33.91	33.91	33.91	33.91	33.91	33.91	33.91	33.91	33.91	33.91	33.91	33.91	33.91	33.91	33.91	33.91	33.91	33.91	644.2
Herbicide	MJ	0.00	56.52	56.52	56.52	56.52	56.52	56.52	56.52	56.52	56.52	56.52	56.52	56.52	56.52	56.52	56.52	56.52	56.52	56.52	56.52	1,073.5
Gasoline (motorbike)	MJ	447.22	447.22	447.22	447.22	447.22	447.22	447.22	447.22	447.22	447.22	447.22	447.22	447.22	447.22	447.22	447.22	447.22	447.22	447.22	447.22	8,944.4
Harvest and Processing																						
Activities																						
Harvest																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Family labor	MJ	0.00	0.00	460.01	575.01	920.02	1,150.03	1,168.69	1,512.40	1,690.89	1,899.36	1,177.92	1,919.58	1,462.31	1,795.47	2,212.71	1,397.29	1,257.56	1,131.80	1,018.62	916.76	23,666.
Commercialization																						
Activities																						
Marketing																						
Family labor	MJ	46.58	46.58	46.58	46.58	46.58	46.58	46.58	46.58	46.58	46.58	46.58	46.58	46.58	46.58	46.58	46.58	46.58	46.58	46.58	46.58	931.5
Farm Management																						
Family labor	MJ	93.15	93.15	93.15	93.15	93.15	93.15	93.15	93.15	93.15	93.15	93.15	93.15	93.15	93.15	93.15	93.15	93.15	93.15	93.15	93.15	1,863.1
Capital costs																						
Establishment																						
Pole trees	NA																					
Irrigation																						
Electric pump	NA																					
Electrical hookup	NA																					
Well	NA																					
Sprinkler	NA																					
Pipes & Hoses	NA																					
Management																						
Backpack sprayer	NA																					
Motorbike	NA																					
Gunny sacks	NA																					
Tarps	NA																					
Shovels	NA																					
Yields																						
Pepper beans	MJ	0.00	0.00	7,620.34	9,525.43	15,240.68	19,050.85	19,359.98	25,053.71	28,010.42	31,463.88	19,512.94	31,798.80	24,223.87	29,743.00	36,654.80	23,146.78	20,832.10	18,748.89	16,874.00	15,186.60	392,047.
Annual Energy Balance																						
Total annual energy inputs	MJ	29,038.35	36,172.82	35,547.18	35,643.55	35,988.56	36,218.56	36,237.23	36,580.04	36,759.42	36,967.89	36,246.46	36,988.11	36,530.84	36,864.01	37,281.25	36,465.82	36,326.09	36,200.34	36,087.16	35,985.29	
Total annual energy outputs	MJ	0.00	0.00	7,620.34	9,525.43	15,240.68	19,050.85	19,359.98	25,053.71	28,010.42	31,463.88	19,512.94	31,798.80	24,223.87	29,743.00	36,654.80	23,146.78	20,832.10	18,748.89	16,874.00	15,186.60	
Annual net energy output	MJ	-29,038.35	-36,172.82	-27,926.84	-26,118.12	-20,747.88	-17,167.71	-16,877.24	-11,527.32	-8,749.00	-5,504.01	-16,733.52	-5,189.31	-12,306.97	-7,121.01	-626.45	-13,319.04	-15,493.99	-17,451.44	-19,213.15	-20,798.69	

Net energy input (system life)	MJ	720,129.87
Net energy output (system life)	MJ	392,047.09
EROI		0.54

Appendix 2.4: Pond aquaculture, Central Highlands, Vietnam

CONTEXT AND POLICY SETTING FOR LUS ANALYSIS		
System	Location	System life
Mixed-culture aquaculture	CH, Vietnam	20

Macroeconomic Context	Item	Units	Value	Notes
	Inflation rate	%	0.1037	Mean anf. Rate 2006-2014

Conversions	Item	Units	Value	Notes
	VND to USD		0.000044	May-17
	MJ to kcal		238.845800	
	kcal to MJ		0.004187	

Policy Setting	Item	Units	Value	Notes
	Discount Rate		0.1	

Agroecosystem Setting	Item	Units	Value	Notes
Grass plot	Plot size	ha	0.1	
	Perrenial	months	Jan-dec	
Pond	Pond area	ha	0.5	
	Pond depth	m	2	
	Pond volume	m3	1	
	Stocking rate	months	4	
	Stocking quantity	kg	250	Assume 250 kg fry purchased every 4 months
	Stocking density	kg/m3	250	

Production System	Item	Units	Value	Notes
	Irrigation	type	pond	
	Spatial Scale of LUS Operation/Evaluation	hectares	0.6	Pond and grass plot
	Timeframe of LUS Operation/Evaluation	years	20	
	Previous land use		maize, beans	
	Plot distance to home	meters	10	
	Seeding rate (grass plot)	kg seed/ha	10	

Variety & expected yield	Item	Units	Value	Notes
	VA06, Year 1-4	MT/ha	100	VA-06 hybrid (conservative yield estimate)
	replant year 4			

Socioeconomic Context	Item	Units	Value	Notes
	Land tenure		Owned	
	Household structure			
	Limits on capital		for small farmers	
	Market access		good	
	Contracts		none	
	Technology availability		high	
	Size of operational holding	hectares	3	
	Other (market) institutional factors?			
	Other (non-market) institutional factors?			

Labor	Item	Units	Value	Notes
	Service fee - excavator	USD/mh	11.73	From household survey data
	Kilometers to-from-plot /year	kilometers	0.1	Plot and pond at house location
	Motorbike fuel efficiency	kilometers/liter	36	Assumes 100 mpg fuel efficiency
	Opportunity cost of HH labor	USD/PD	8.8	Based on daily farm labor wage rates gathered during HH interviews

Input prices (2016)	Item	Units	Value	Notes
Pond	Fry	USD/kg	1.76	Multi-trophic mix of species, average cost = 40,000/kg (typical from all surveys)
	Grass	USD/kg	0.044	Assume a low-value feed price of 1000 VND/kg
	Industrial feed	USD/kg	0.484	Typical feed costs is 11,000/kg
	Vinnesde	USD/kg	8.8	
	Pond cleaning chemicals	USD/mnt	13.2	
Grass plot	Seed	USD/kg	6.6	10 kg/ha/yr, replant every 4 years
Other	Gasoline	USD/liter	0.8316	From www.globalpetrolprices.com/Vietnam/gasoline_prices/
	Electricity (2016)	USD/kwh	0.051524	Average price per KWH in 2016 https://vcba.com.vn
	NPK (grass plot)	USD/kg	0.44	Average NPK prices from HH interviews

Output prices (2016)	Item	Units	Value	Notes
	Fish	USD/KG	1.98	

Stocking cycle	Item	Units	Value	Notes
	Num Species	num	3	Multi-trophic mix of species, average cost = 40,000/kg (typical from all surveys)
	Harvest cycle	cycles/yr	3	Harvest 3 times /yr
	Fry stocked/cycled	kg	250	
	Fish harvested/cycle	kg	1150	

Capital costs (2016)	Item	Units	Value	Notes
Pond	Hired labor (excluding backhoe)	USD/PD	6.60	From household survey data
	Spillway	USD/unit	2,200.00	From household survey data
	Cement	USD/kg	2.20	From household survey data
	Rocks	USD/m3	2.20	From household survey data
	Steel	USD/kg	2.20	From household survey data
Other	Motorbike	USD/motorbike	504.51	From household survey data
	Tarps	USD/tarp	0.56	From household survey data
	Shovel	USD/shovel	5.00	From household survey data
	Pump (from pond)	USD/pump	7.00	From household survey data

Energy values	Item	Units	Value	Notes
Inputs	Human Labor	MJ/PD	17.25	Pimentel and Pimentel, 2008
	NPK	MJ/kg	15.75	See NPK, below
	Industrial feed	MJ/kg	7.70	Pimentel and Pimentel, 2008
	Fry	MJ/kg	186.57	Pimentel and Pimentel, 2008
	Grass	MJ/kg	7.18	Pimentel and Pimentel, 2008
	Grass seed	MJ/kg	87.93	Pimentel and Pimentel, 2008
	Vinnesde	MJ/kg	140.91	Pimentel and Pimentel, 2008
	Pond cleaning chemicals	MJ/kg	140.91	Assume same as vinnesde
	Machine (backhoe)	MJ/hr	161.00	Assumes 5 gallons gasoline per hour
	Gasoline	MJ/liter	32.20	Hofstrand, 2008
	Electricity	MJ/kwh	10.78	Pimentel, 2009
Outputs	Grass	MJ/kg	7.18	Pimentel and Pimentel, 2008
	Fish	MJ/kg	140.91	Pimentel and Pimentel, 2008

NPK (assume 15-15-15)	Nutrient	Units	Value	Notes
	N	MJ/kg	70.764487	Conversions based on values from Pimentel (2009)
	P	MJ/kg	16.861049	
	K	MJ/kg	17.384424	
	NPK	MJ/kg	15.751494	

Aquaculture: Central Highlands, Vietnam

Inputs/Outputs (I/O), by Year	Unit	Year 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
System Establishment																						
Grass plot																						
Activities																						
Land Preparation																						
Land clearing:																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD/ha	50.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.00
Digging holes																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD/ha	15.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.00
Irrigation setup																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD/ha	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00
Planting:																						
Planting																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD/ha	20.00	0.00	0.00	20.00	0.00	0.00	0.00	20.00	0.00	0.00	0.00	20.00	0.00	0.00	0.00	20.00	0.00	0.00	0.00	0.00	100.00
NPK application																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD/ha	1.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	5.00
Inputs																						
NPK	kg/ha	50.00	0.00	0.00	50.00	0.00	0.00	0.00	50.00	0.00	0.00	0.00	50.00	0.00	0.00	0.00	50.00	0.00	0.00	0.00	0.00	250.00
Seed	kg/ha	10.00	0.00	0.00	10.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	50.00
Pond																						
Activities																						
Pond Construction																						
Hired labor	PD/ha	30.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30.00
Family labor	PD/ha	20.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00
Inputs																						
Backhoe	MH/ha	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00
Crop Management																						
Activities																						
Irrigation																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD/ha	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	80.00
Fertilizer application																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD/ha	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	60.00
Weeding:																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD/ha	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	240.00
Inputs																						
Electricity (irrigation)	kwh	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	10,000.00
NPK	kg/ha	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	1,000.00
Pond Management																						
Activities																						
Stocking:																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD/ha	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	360.00
Feeding																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD/ha	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	640.00
Vimarch application																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD/ha	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	40.00
Pond cleaning:																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD/ha	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	350.00
Inputs																						
Fry	kg/ha	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	30,000.00
Grass	kg/ha	36,000.00	36,000.00	36,000.00	36,000.00	36,000.00	36,000.00	36,000.00	36,000.00	36,000.00	36,000.00	36,000.00	36,000.00	36,000.00	36,000.00	36,000.00	36,000.00	36,000.00	36,000.00	36,000.00	36,000.00	720,000.00
Industrial feed	kg/ha	4,500.00	4,500.00	4,500.00	4,500.00	4,500.00	4,500.00	4,500.00	4,500.00	4,500.00	4,500.00	4,500.00	4,500.00	4,500.00	4,500.00	4,500.00	4,500.00	4,500.00	4,500.00	4,500.00	4,500.00	90,000.00
Vimarch	litres/ha	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	80.00
Pond cleaning chemicals	litres/ha	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	120.00
Harvest and Processing																						
Grass plot																						
Activities																						
Harvest																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD/ha	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	360.00
Pond																						
Activities																						
Harvest																						
Hired labor	PD/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD/ha	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00	340.00
Commercialization																						
Activities																						
Marketing:																						
Family labor	PD/ha	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	200.00
Farm Management																						
Family labor	PD/ha	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	400.00
Capital costs																						
Irrigation																						
Electric pump	num	1.00																				1.00
Electrical hookup	num	1.00																				1.00
Pipes & Hoses	num	1.00																				1.00
Management																						
Backpack sprayer	num	1.00									1.00											2.00
Motorbike	num	1.00																				1.00
Pond																						
Spillway	num	1.00																				
Cement	kg/ha	2,000.00																				
Rocks	m3/ha	5.00																				
Steel	kg/ha	400.00																				
Yields																						
Grass	kg/ha	111,427.42	80,136.61	129,603.02	121,029.42	109,345.91	105,767.59	121,242.66	78,476.87	90,769.39	107,385.53	115,332.51	105,632.31	122,685.13	110,871.90	67,490.98	79,599.16	78,639.26	64,475.32	58,027.79	52,225.01	##########
Fish	kg/ha	7,876.90	7,626.39	7,196.26	6,843.31	7,557.86	7,566.91	7,853.84	7,573.79	7,052.33	7,309.15	7,754.10	5,779.91	5,936.33	5,999.19	6,617.10	7,991.45	6,750.33	7,228.31	7,628.38	7,480.08	143,621.90
Total Labor																						
Family labor	PD/ha	274.50	153.50	153.50	184.50	153.50	153.50	153.50	184.50	153.50	153.50	153.50	184.50	153.50	153.50	153.50	184.50	153.50	153.50	153.50	153.50	3,315.00
Hired Labor	PD/ha	30.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30.00
Total Labor	PD/ha	304.50	153.50	153.50	184.50	153.50	153.50	153.50	184.50	153.50	153.50	153.50	184.50	153.50	153.50	153.50	184.50	153.50	153.50	153.50	153.50	3,345.00
Total Labor (system life)	PD/ha	3,345.00																				
Total family labor (system life)	PD/ha	3,315.00																				
Feed conversion ratio		5.14																				

Aquaculture: Central Highlands, Vietnam		Year																		
Prices ($USD) by Year	Unit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
System Establishment																					
Grass plot																					
Activities																					
Land Preparation																					
Land clearing:																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Digging holes																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Irrigation setup																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Planting																					
Planting:																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
NPK application																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Inputs																					
NPK	USD/kg	0.18	0.16	0.13	0.19	0.18	0.18	0.23	0.27	0.32	0.32	0.42	0.63	0.35	0.40	0.55	0.53	0.45	0.43	0.38	0.44
Seed	USD/kg	1.93	2.07	2.16	2.12	2.11	2.20	2.27	2.44	2.64	2.84	3.07	3.79	4.05	4.41	5.24	5.71	6.09	6.34	6.39	6.60
Pond																					
Activities																					
Pond Construction																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Inputs																					
Backhoe	USD/MH	3.44	3.69	3.84	3.77	3.76	3.90	4.03	4.34	4.70	5.05	5.46	6.73	7.20	7.84	9.30	10.15	10.82	11.26	11.36	11.73
Crop Management																					
Activities																					
Irrigation																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Fertilizer application																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Weeding:																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Inputs																					
Electricity (irrigation)	USD/kwh	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.05	0.05
NPK	USD/kg	0.18	0.16	0.13	0.19	0.18	0.18	0.23	0.27	0.32	0.32	0.42	0.63	0.35	0.40	0.55	0.53	0.45	0.43	0.38	0.44
Pond Management																					
Activities																					
Stocking:																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Feeding:																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Virucide application																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Pond cleaning:																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Inputs																					
Fry	USD/kg	0.52	0.55	0.58	0.57	0.56	0.59	0.60	0.65	0.70	0.76	0.82	1.01	1.08	1.18	1.40	1.52	1.62	1.69	1.70	1.76
Grass	USD/kg	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04
Industrial feed	USD/kg	0.14	0.15	0.16	0.16	0.16	0.16	0.17	0.18	0.19	0.21	0.23	0.28	0.30	0.32	0.38	0.42	0.45	0.46	0.47	0.48
Virucide	USD/liter	2.58	2.77	2.88	2.83	2.82	2.93	3.02	3.26	3.52	3.79	4.10	5.05	5.40	5.88	6.98	7.62	8.12	8.45	8.52	8.80
Pond cleaning chemicals	USD/liter	3.87	4.15	4.32	4.25	4.23	4.39	4.53	4.88	5.29	5.68	6.15	7.57	8.10	8.82	10.47	11.42	12.18	12.67	12.79	13.20
Harvest and Processing																					
Grass plot																					
Activities																					
Harvest																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Pond																					
Activities																					
Harvest																					
Hired labor	USD/unit	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/unit	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Commercialization																					
Activities																					
Marketing																					
Family labor	USD/unit	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Farm Management																					
Family labor	USD/unit	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Capital costs																					
Irrigation																					
Electric pump	USD/unit	515.78	553.26	576.03	566.18	563.74	585.34	604.18	651.06	704.98	757.05	819.91	1,009.44	1,080.66	1,176.42	1,396.14	1,523.11	1,623.52	1,689.86	1,704.70	1,760.00
Electrical hookup	USD/unit	515.78	553.26	576.03	566.18	563.74	585.34	604.18	651.06	704.98	757.05	819.91	1,009.44	1,080.66	1,176.42	1,396.14	1,523.11	1,623.52	1,689.86	1,704.70	1,760.00
Pipes & Hoses	USD/unit	4.62	4.95	5.16	5.07	5.05	5.24	5.41	5.83	6.31	6.78	7.34	9.03	9.67	10.53	12.50	13.63	14.53	15.12	15.26	15.75
Management																					
Backpack sprayer	USD/unit	77.37	82.99	86.41	84.93	84.56	87.80	90.63	97.66	105.75	113.56	122.99	151.42	162.10	176.46	209.42	228.47	243.53	253.48	255.71	264.00
Microtube	USD/unit	147.85	158.59	165.12	162.30	161.60	167.79	173.19	186.63	202.08	217.01	235.03	289.36	309.77	337.22	400.21	436.60	465.39	484.40	488.66	504.51
Pond																					
Spillway	USD/unit	644.72	691.57	720.04	707.73	704.67	731.67	755.23	813.83	881.22	946.31	1,024.89	1,261.80	1,350.82	1,470.52	1,745.18	1,903.89	2,029.40	2,112.32	2,130.88	2,200.00
Cement	USD/kg	0.64	0.69	0.72	0.71	0.70	0.73	0.75	0.81	0.88	0.94	1.02	1.26	1.35	1.47	1.74	1.90	2.03	2.11	2.13	2.20
Rocks	USD/m3	0.64	0.69	0.72	0.71	0.70	0.73	0.75	0.81	0.88	0.94	1.02	1.26	1.35	1.47	1.74	1.90	2.03	2.11	2.13	2.20
Steel	USD/kg	0.64	0.69	0.72	0.71	0.70	0.73	0.75	0.81	0.88	0.94	1.02	1.26	1.35	1.47	1.74	1.90	2.03	2.11	2.13	2.20
Yields																					
Grass	USD/kg	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04
Fish	USD/kg	0.39	0.45	0.43	0.61	0.74	0.84	0.93	1.11	1.09	1.17	1.14	1.12	1.15	1.45	1.88	1.64	1.73	1.81	1.90	1.98

Aquaculture: Central Highlands, Vietnam		Year																			
Energy Inputs/Outputs (I/O), by Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
System Establishment																					
Grass plot																					
Activities																					
Land Preparation																					
Land clearing																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Digging holes																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Irrigation setup																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Planting																					
Planting																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
NPK application																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Inputs																					
NPK	MJ/kg	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75
Seed	MJ/kg	87.93	87.93	87.93	87.93	87.93	87.93	87.93	87.93	87.93	87.93	87.93	87.93	87.93	87.93	87.93	87.93	87.93	87.93	87.93	87.93
Pond																					
Activities																					
Pond Construction																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Inputs																					
Backhoe	MJ/machine hr	161.00	161.00	161.00	161.00	161.00	161.00	161.00	161.00	161.00	161.00	161.00	161.00	161.00	161.00	161.00	161.00	161.00	161.00	161.00	161.00
Crop Management																					
Activities																					
Irrigation																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Fertilizer application																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Weeding																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Inputs																					
Electricity (irrigation)	MJ/kwh	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78	10.78
NPK	MJ/kg	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75	15.75
Pond Management																					
Activities																					
Stocking																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Pesting																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Vinacle application																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Pond cleaning																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Inputs																					
Pig	MJ/kg	186.57	186.57	186.57	186.57	186.57	186.57	186.57	186.57	186.57	186.57	186.57	186.57	186.57	186.57	186.57	186.57	186.57	186.57	186.57	186.57
Grass	MJ/kg	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18
Industrial feed	MJ/kg	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70
Vinacle	MJ/liter	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91
Pond cleaning chemicals	MJ/liter	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91
Harvest and Processing																					
Grass plot																					
Activities																					
Harvest																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Pond																					
Activities																					
Harvest																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Commercialization																					
Activities																					
Marketing																					
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Farm Management																					
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Capital costs																					
Irrigation																					
Electric pump	NA																				
Electrical hookup	NA																				
Pipes & Hoses	NA																				
Management																					
Backpack sprayer	NA																				
Motorbike	NA																				
Pond																					
Spillway	NA																				
Cement	NA																				
Rocks	NA																				
Steel	NA																				
Yields																					
Grass	MJ/kg	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18
Fish	MJ/kg	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91	140.91

Aquaculture: Central Highlands, Vietnam — Year

$USD, by Year	Unit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
System Establishment																						
Grow plot																						
Activities																						
Land Preparation																						
Land clearing																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	USD$	42.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	42.12
Digging holes																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	USD$	12.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.64
Irrigation setup																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	USD$	4.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.21
Planting																						
Planting																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	USD$	16.85	0.00	0.00	37.71	0.00	0.00	0.00	65.52	0.00	0.00	0.00	93.33	0.00	0.00	0.00	121.14	0.00	0.00	0.00	0.00	334.54
NPK application																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	USD$	0.84	0.00	0.00	1.89	0.00	0.00	0.00	3.28	0.00	0.00	0.00	4.67	0.00	0.00	0.00	6.06	0.00	0.00	0.00	0.00	16.73
Inputs																						
NPK	USD$	8.86	0.00	0.00	9.45	0.00	0.00	0.00	13.46	0.00	0.00	0.00	31.34	0.00	0.00	0.00	26.42	0.00	0.00	0.00	0.00	89.53
Seed	USD$	59.34	0.00	0.00	21.23	0.00	0.00	0.00	24.41	0.00	0.00	0.00	37.85	0.00	0.00	0.00	57.12	0.00	0.00	0.00	0.00	159.96
Pond																						
Activities																						
Pond Construction																						
Hired labor	USD$	25.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.27
Family labor	USD$	16.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.85
Inputs																						
Backhoe	USD$	34.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	34.38
Crop Management																						
Activities																						
Irrigation																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	USD$	3.37	4.00	6.15	7.54	8.93	4.28	11.71	13.10	14.49	15.88	17.28	18.67	20.06	21.45	22.84	24.23	25.62	27.01	28.40	32.32	327.33
Fertilizer application																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	USD$	2.53	3.00	4.61	5.66	6.70	3.21	8.78	9.83	10.87	11.91	12.96	14.00	15.04	16.09	17.13	18.17	19.21	20.26	21.30	24.24	245.49
Weeding																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	USD$	10.11	12.00	18.45	22.62	26.80	12.84	35.14	39.31	43.48	47.65	51.83	56.00	60.17	64.34	68.51	72.68	76.86	81.03	85.20	96.96	981.98
Inputs																						
Electricity (irrigation)	USD$	7.55	8.10	8.43	8.29	8.25	8.57	8.84	9.53	10.32	11.08	12.00	14.78	15.82	17.22	20.44	22.29	23.76	24.74	24.95	25.76	290.72
NPK	USD$	8.86	7.87	6.39	9.45	9.03	8.91	11.41	13.46	15.93	16.15	21.01	31.34	17.65	19.88	27.30	26.42	22.74	21.40	18.96	22.00	336.30
Pond Management																						
Activities																						
Stocking																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	USD$	15.16	18.00	27.68	33.94	40.19	19.26	52.71	58.97	65.22	71.48	77.74	84.00	90.25	96.51	102.77	109.03	115.28	121.54	127.80	145.44	1,472.97
Feeding																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	USD$	26.96	32.00	49.21	60.33	71.45	34.24	93.70	104.83	115.95	127.08	138.20	149.33	160.45	171.58	182.70	193.82	204.95	216.07	227.20	258.56	2,618.61
Vinacide application																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	USD$	1.68	2.00	3.08	3.77	4.47	2.14	5.86	6.55	7.25	7.94	8.64	9.33	10.03	10.72	11.42	12.11	12.81	13.50	14.20	16.16	163.66
Pond cleaning																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	USD$	14.74	17.50	26.91	32.99	39.08	18.73	51.24	57.33	63.41	69.50	75.58	81.66	87.75	93.83	99.91	106.00	112.08	118.17	124.25	141.40	1,432.05
Inputs																						
Fry	USD$	773.67	829.88	864.05	849.27	845.61	878.00	906.27	976.59	1,057.47	1,135.57	1,220.87	1,314.17	1,620.98	1,764.63	2,004.22	2,284.67	2,485.28	2,534.78	2,557.05	2,640.00	29,792.04
Grass	USD$	464.20	497.93	518.43	509.56	507.37	526.80	543.76	585.96	634.48	681.34	732.52	908.50	972.59	1,058.78	1,256.53	1,370.80	1,491.17	1,520.87	1,534.23	1,584.00	17,875.22
Industrial feed	USD$	638.28	684.65	712.84	700.65	697.63	724.35	747.68	805.69	872.41	936.85	1,014.64	1,249.19	1,337.31	1,455.82	1,727.73	1,884.85	2,049.11	2,091.20	2,109.57	2,178.00	24,578.43
Vinacide	USD$	10.32	11.07	11.52	11.32	11.27	11.71	12.08	13.02	14.10	15.14	16.40	20.19	21.61	23.53	27.92	30.46	32.47	33.80	34.09	35.20	397.23
Pond cleaning chemicals	USD$	25.21	24.90	25.92	25.48	25.37	26.34	27.19	29.30	31.72	34.07	36.90	45.42	48.63	52.94	62.83	68.54	73.06	76.04	76.71	79.20	893.96
Harvest and Processing																						
Grow plot																						
Activities																						
Harvest																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	USD$	15.16	18.00	27.68	33.94	40.19	19.26	52.71	58.97	65.22	71.48	77.74	84.00	90.25	96.51	102.77	109.03	115.28	121.54	127.80	145.44	1,472.97
Pond																						
Activities																						
Harvest																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	USD$	14.32	17.00	26.14	32.05	37.96	18.19	49.78	55.69	61.60	67.51	73.42	79.33	85.24	91.15	97.06	102.97	108.88	114.79	120.70	137.36	1,391.13
Commercialization																						
Activities																						
Marketing																						
Family labor	USD$	8.42	10.00	15.38	18.85	22.33	10.70	29.28	32.76	36.24	39.71	43.19	46.66	50.14	53.62	57.09	60.57	64.05	67.52	71.00	80.80	818.31
Farm Management																						
Family labor	USD$	16.85	20.00	30.75	37.71	44.66	21.40	58.56	65.52	72.47	79.42	86.38	93.33	100.28	107.23	114.19	121.14	128.09	135.05	142.00	161.60	1,636.63
Capital costs																						
Irrigation																						
Electric pump	USD$	515.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	515.78
Electrical hookup	USD$	515.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	515.78
Pipes & Hoses	USD$	4.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.62
Management																						
Backpack sprayer	USD$	77.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	190.92
Microbite	USD$	147.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	147.85
Pond																						
Spillway	USD$	644.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	644.72
Cement	USD$	1,286.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,286.77
Rocks	USD$	3.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.22
Steel	USD$	257.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	257.35
Yields																						
Grass	USD$	1,486.80	1,108.40	1,866.40	1,713.12	1,541.06	1,489.20	1,431.32	1,277.33	1,599.76	2,032.40	2,364.06	2,665.75	3,314.51	3,260.79	2,355.68	3,030.96	2,907.69	2,723.85	2,473.00	2,297.90	43,289.58
Fish	USD$	3,061.03	3,418.09	3,113.45	4,189.34	5,613.78	6,332.06	7,333.25	8,407.99	7,703.44	8,539.22	8,858.59	6,454.48	6,800.59	8,757.42	12,484.96	13,133.44	11,661.72	13,005.67	14,462.35	14,910.57	168,091.45
Annual Benefits																						
Total annual costs	USD$	5,690.19	2,217.90	2,383.62	2,473.69	2,447.28	2,348.92	2,706.73	3,043.07	3,192.64	3,553.32	3,731.67	4,667.06	4,804.25	5,215.78	6,093.34	6,828.52	7,080.71	7,239.30	7,445.42	7,804.44	
Total Annual revenue	USD$	4,497.83	4,526.49	4,979.84	5,902.46	7,154.85	7,821.27	9,164.56	9,685.33	9,303.20	10,571.62	11,192.65	9,120.23	10,115.09	11,978.22	14,770.64	16,164.40	14,569.42	15,819.52	16,935.35	17,108.47	
Annual net income	USD$	-1,192.36	2,308.60	2,596.23	3,428.77	4,707.57	5,472.34	6,457.84	6,642.26	6,110.56	7,018.30	7,460.98	4,453.17	5,310.84	6,762.44	8,677.29	9,335.88	7,528.71	8,580.22	9,489.93	9,304.03	
Annual discounted net benefits	USD$	-1,192.36	2,098.72	2,145.64	2,576.08	3,215.33	3,397.90	3,645.28	3,408.53	2,850.62	2,976.44	2,876.53	1,560.81	1,692.20	1,958.88	2,285.00	2,234.93	1,638.47	1,677.77	1,706.85	1,521.28	
Economic Indicators																						
Net Present Value of System	USD$	26,564.92																				
Returns to land	USD$/ha	44,274.86																				
Returns to family labor	USD$/PD	8.01																				
Returns to family labor/market wage rate		1.96																				

Aquaculture: Central Highlands, Vietnam

Energy I/O, by Year	Unit	Year 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
System Establishment																						
Grass plot																						
Activities																						
Land Preparation																						
Land clearing																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	MJ	662.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	662.52
Digging holes																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	MJ	258.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	258.76
Irrigation setup																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	MJ	86.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	86.25
Planting																						
Planting																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	MJ	345.01	0.00	0.00	345.01	0.00	0.00	0.00	345.01	0.00	0.00	0.00	345.01	0.00	0.00	0.00	345.01	0.00	0.00	0.00	0.00	1,725.04
NPK application																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	MJ	17.25	0.00	0.00	17.25	0.00	0.00	0.00	17.25	0.00	0.00	0.00	17.25	0.00	0.00	0.00	17.25	0.00	0.00	0.00	0.00	86.25
Inputs																						
NPK	MJ	787.57	0.00	0.00	787.57	0.00	0.00	0.00	787.57	0.00	0.00	0.00	787.57	0.00	0.00	0.00	787.57	0.00	0.00	0.00	0.00	3,937.87
Seed	MJ	679.27	0.00	0.00	679.27	0.00	0.00	0.00	679.27	0.00	0.00	0.00	679.27	0.00	0.00	0.00	679.27	0.00	0.00	0.00	0.00	3,396.35
Pond																						
Activities																						
Pond Construction																						
Hired labor	MJ	517.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	517.51
Family labor	MJ	345.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	345.01
Inputs																						
Backhoe	MJ	1,610.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,610.00
Crop Management																						
Activities																						
Irrigation																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor		69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	1,380.04
Fertilizer application																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor		51.75	51.75	51.75	51.75	51.75	51.75	51.75	51.75	51.75	51.75	51.75	51.75	51.75	51.75	51.75	51.75	51.75	51.75	51.75	51.75	1,035.03
Weeding																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	MJ	207.01	207.01	207.01	207.01	207.01	207.01	207.01	207.01	207.01	207.01	207.01	207.01	207.01	207.01	207.01	207.01	207.01	207.01	207.01	207.01	4,140.11
Inputs																						
Electricity (irrigation)	MJ	5,392.33	5,392.33	5,392.33	5,392.33	5,392.33	5,392.33	5,392.33	5,392.33	5,392.33	5,392.33	5,392.33	5,392.33	5,392.33	5,392.33	5,392.33	5,392.33	5,392.33	5,392.33	5,392.33	5,392.33	107,846.65
NPK	MJ	787.57	787.57	787.57	787.57	787.57	787.57	787.57	787.57	787.57	787.57	787.57	787.57	787.57	787.57	787.57	787.57	787.57	787.57	787.57	787.57	15,751.49
Pond Management																						
Activities																						
Stocking																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	MJ	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	6,210.16
Feeding																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	MJ	552.01	552.01	552.01	552.01	552.01	552.01	552.01	552.01	552.01	552.01	552.01	552.01	552.01	552.01	552.01	552.01	552.01	552.01	552.01	552.01	11,040.28
Vinicide application																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	MJ	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	690.02
Pond cleaning																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	MJ	301.88	301.88	301.88	301.88	301.88	301.88	301.88	301.88	301.88	301.88	301.88	301.88	301.88	301.88	301.88	301.88	301.88	301.88	301.88	301.88	6,037.65
Inputs																						
Fry	MJ	279,859.08	279,859.08	279,859.08	279,859.08	279,859.08	279,859.08	279,859.08	279,859.08	279,859.08	279,859.08	279,859.08	279,859.08	279,859.08	279,859.08	279,859.08	279,859.08	279,859.08	279,859.08	279,859.08	279,859.08	5,597,181.60
Grass	MJ	258,616.32	258,616.32	258,616.32	258,616.32	258,616.32	258,616.32	258,616.32	258,616.32	258,616.32	258,616.32	258,616.32	258,616.32	258,616.32	258,616.32	258,616.32	258,616.32	258,616.32	258,616.32	258,616.32	258,616.32	5,172,326.38
Industrial feed	MJ	34,650.52	34,650.52	34,650.52	34,650.52	34,650.52	34,650.52	34,650.52	34,650.52	34,650.52	34,650.52	34,650.52	34,650.52	34,650.52	34,650.52	34,650.52	34,650.52	34,650.52	34,650.52	34,650.52	34,650.52	693,010.41
Vinicide	MJ	563.64	563.64	563.64	563.64	563.64	563.64	563.64	563.64	563.64	563.64	563.64	563.64	563.64	563.64	563.64	563.64	563.64	563.64	563.64	563.64	11,272.74
Pond cleaning chemicals	MJ	845.46	845.46	845.46	845.46	845.46	845.46	845.46	845.46	845.46	845.46	845.46	845.46	845.46	845.46	845.46	845.46	845.46	845.46	845.46	845.46	16,909.12
Harvest and Processing																						
Grass plot																						
Activities																						
Harvest																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	MJ	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	310.51	6,210.16
Pond																						
Activities																						
Harvest																						
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	MJ	293.26	293.26	293.26	293.26	293.26	293.26	293.26	293.26	293.26	293.26	293.26	293.26	293.26	293.26	293.26	293.26	293.26	293.26	293.26	293.26	5,865.15
Commercialization																						
Activities																						
Marketing																						
Family labor	MJ	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	3,450.09
Farm Management																						
Family labor	MJ	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	345.01	6,900.18
Capital costs																						
Irrigation																						
Electric pump	NA																					
Electrical hookup	NA																					
Pipes & Hoses	NA																					
Management																						
Backpack sprayer	NA																					
Motorbike																						
Pond																						
Spillway	NA																					
Cement	NA																					
Rocks	NA																					
Steel	NA																					
Yields																						
Grass	MJ	800,470.84	575,684.34	928,040.45	869,449.51	785,517.65	731,076.64	870,988.40	563,761.06	652,067.95	771,434.71	828,524.17	758,839.99	888,343.82	796,480.09	464,840.82	571,823.36	514,641.02	463,176.92	416,859.23	375,173.31	########
Fish	MJ	1,109,928.67	########	1,014,019.42	964,286.20	########	########	########	1,067,217.01	993,739.28	########	########	814,442.71	826,463.71	845,341.44	932,410.62	1,126,067.31	951,163.64	########	########	1,054,013.47	########
Annual Energy Balance																						
Total annual energy inputs	MJ	589,072.02	563,362.86	563,362.86	565,391.97	563,362.86	563,362.86	563,362.86	565,391.97	563,362.86	563,362.86	563,362.86	565,391.97	563,362.86	563,362.86	563,362.86	565,391.97	563,362.86	563,362.86	563,362.86	563,362.86	
Total annual enery outputs	MJ	1,910,399.72	########	########	########	########	1,797,324.11	1,977,661.18	########	########	1,801,262.42	1,921,149.14	########	1,717,827.52	1,641,821.53	1,417,251.45	########	########	1,461,712.62	########	########	
Annual net energy output	MJ	1,321,327.70	########	1,361,697.01	########	########	1,233,961.25	########	########	########	1,217,999.56	########	987,890.73	########	########	853,888.56	1,112,498.70	882,461.80	898,349.76	908,406.56	845,823.92	

Total energy input (system life)	MJ	11,681,082.64
Total energy output (system life)	MJ	#########
Energy O/I ratio (system life)	MJ	2.90

Appendix 2.5: Intensive pigs, Central Highlands, Vietnam

CONTEXT AND POLICY SETTING FOR LUS ANALYSIS		
System	**Location**	**System length (years)**
Pigs (meat)	CH, Vietnam	20

Macroeconomic Context	Item	Units	Value	Notes
	Inflation rate	%	0.1037	Mean ref. Rate 2006-2014

Conversions	Item	Units	Value	Notes
	VND to USD		0.000044	May, 2017
	MJ to heat		238.845800	
	heat to MJ		0.004187	

Policy Setting	Item	Units	Value	Notes
	Discount Rate		0.1	

Agroecosystem Setting	Item	Units	Value	Notes
	Sty size	m2	100	
	Perennial	months	Jan-dec	

Production System	Item	Units	Value	Notes
	Breeding females (initial)	BP	5	
	Pregnancies per BP/yr	Preg	2.5	Each BP - 3 preg. In 2 years
	Number of offspring/preg	piglets	10	Average from all household surveys
	Num. additional BPs	#	3	Growing herd: 3 bfs pre 2 years (learn own litters)
	Piglet mortality rate	%	0.05	Assume 5% mortality rate
	Num potential offspring (year 1)	piglets	118.75	
	Timeframe of LUS Operation/Evaluation	years	10	

Herd growth	Year	BFs	Piglets sold	Notes
	1	5	119	
	2	5	119	Assuming all piglets are sold at 4 months
	3	8	190	
	4	8	190	
	5	11	261	
	6	11	261	
	7	11	261	
	8	11	261	
	9	11	261	
	10	11	261	
	11	11	261	
	12	11	261	
	13	11	261	
	14	11	261	
	15	11	261	
	16	11	261	
	17	11	261	
	18	11	261	
	19	11	261	
	20	11	261	

Socioeconomic Context	Item	Units	Value	Notes
	Land tenure		Owned	
	Household structure			
	Limits on capital		for small farmers	
	Market access		good	
	Contracts		none	
	Technology availability		high	
	Size of operational holding			
	Other (market) sociobehavioral factors?			
	Other (non-market) institutional factors?			

Labor	Item	Units	Value	Notes
	Kilometres to- from plot/year	kilometres	0	Assumes pig sty is directly adjacent to house
	Motorbike fuel efficiency	kilometres/liter	36	Assumes 100 mpg fuel efficiency
	Cleaning and clong conceal	PD/day/pig	0.002	
	Feeding	PD/day/30 pigs	0.025	
	Watering	PD/day/30 pigs	0.025	
	Vaccination	PD/yr/30 pigs	2	
	Deworming medicine	PD/yr/30 pigs	2.5	
	Antiseal spray	PD/yr	2	
	Opportunity cost of HH labor	USD/PD	8.8	Based on daily farm labor wage rates gathered during HH interviews

Feeding	Age	kg/pig/day	kg/type/yr
	> 1 mo	0.5	1781.25
	1-2 mo	1	3562.5
	2-4 mo	3	21375
	BP	3.75	6843.75

Year	> 1 mo	1-2 mo	2-4 mo	Adult
1	1785	3570	10710	6843.75
2	1785	3570	10710	6843.75
3	2850	5700	17100	10950
4	2850	5700	17100	10950
5	3915	7830	23490	15056.25
6	3915	7830	23490	15056.25
7	3915	7830	23490	15056.25
8	3915	7830	23490	15056.25
9	3915	7830	23490	15056.25
10	3915	7830	23490	15056.25
11	3915	7830	23490	15056.25
12	3915	7830	23490	15056.25
13	3915	7830	23490	15056.25
14	3915	7830	23490	15056.25
15	3915	7830	23490	15056.25
16	3915	7830	23490	15056.25
17	3915	7830	23490	15056.25
18	3915	7830	23490	15056.25
19	3915	7830	23490	15056.25
20	3915	7830	23490	15056.25

Inputs	Item	Units	Value	Notes
	Vaccines (piglets)	cycle/piglet	1	assuming 3 types at 3 days, 3 types at 10 days, and 1 type at 15 days
	Vaccines (BPs)	num/yr	2	
	Deworming medicine (piglets)	num/piglet	1	
	Antiseal spray	100 cc/week	1	

Input prices (2016)	Item	Units	Value	Notes
	Feed concentrate (young animals)	USD/kg	0.66	<1 month old
	Feed concentrate (old animals)	USD/kg	0.44	>1 month
	Insemination fee	USD	8.8	
	Antiseal spray	USD/100 cc	0.44	
	Deworming medicine	USD/cycle/piglet	0.044	Each piglet is given 1000 VND worth of deworming medicine
	Vaccination (piglets)	USD/piglet	6.6	See model notes for details. Multiple vaccinations @ 3, 10 and 15 days
	Vaccination (BPs)	USD/BP/year	5.28	2 vaccinations per year per BP, 60,000 per time

Outputs	Item	Units	Value	Notes
	Dung (average from all animals)	kg/animal/day	1.13	average from all surveys
	Piglets	kg/animal	30	assuming 4 month old animals

Capital costs (2016)	Item	Units	Value	Notes
	Pig sty	USD	660.00	Average costs from surveys ~150,000 per m2
	Breeding females	USD	56.42	Average from all surveys
	Motorbike	USD	504.51	From household survey data
	Sprayer	USD	198.00	From household survey data
	Well installation	USD/meter	12.32	From household survey data

Energy values	Item	Units	Value	Notes
Inputs	Human Labor	MJ/PD	17.25	Pimentel and Pimentel, 2008
	Gasoline	MJ/litre	32.20	Hofstrand, 2008
	Electricity	MJ/kwh	10.78	Pimentel, 2009
	Feed concentrate	MJ/kg	7.70	Pimentel and Pimentel, 2008
	Antiseal spray	MJ/litre	140.91	Pimentel and Pimentel, 2008 (Referred to as "Medicine" - assumed same energy values)
	Deworming medicine	MJ/litre	140.91	Assume same as medicine
	Vaccine	MJ/litre	140.91	Assume same as medicine
Outputs	Pork	MJ/kg	9.81	Pimentel and Pimentel, 2008 (assuming 72% dress weight)
	Dung (from all animals)	MJ/kg	15.57	

Intensive pigs: CH, Vietnam

Inputs/Outputs (I/O), by Year	Unit	Year 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
System Establishment																						
Activities																						
Pen installation																						
Construction/installation																						
Hired labor	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00
Herd Management																						
Activities																						
Feeding																						
Hired labor	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD	37.72	37.72	60.23	60.23	82.73	82.73	82.73	82.73	82.73	82.73	82.73	82.73	82.73	82.73	82.73	82.73	82.73	82.73	82.73	82.73	692.28
Watering																						
Hired labor	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD	37.72	37.72	60.23	60.23	82.73	82.73	82.73	82.73	82.73	82.73	82.73	82.73	82.73	82.73	82.73	82.73	82.73	82.73	82.73	82.73	692.28
Pen cleaning and dung removal																						
Hired labor	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD	3.02	3.02	4.82	4.82	6.62	6.62	6.62	6.62	6.62	6.62	6.62	6.62	6.62	6.62	6.62	6.62	6.62	6.62	6.62	6.62	55.38
Vaccination																						
Hired labor	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD	8.27	8.27	13.20	13.20	18.13	18.13	18.13	18.13	18.13	18.13	18.13	18.13	18.13	18.13	18.13	18.13	18.13	18.13	18.13	18.13	151.73
Deworming medicine																						
Hired labor	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD	10.33	10.33	16.50	16.50	22.67	22.67	22.67	22.67	22.67	22.67	22.67	22.67	22.67	22.67	22.67	22.67	22.67	22.67	22.67	22.67	189.67
Antiviral spray																						
Hired labor	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	20.00
Pen maintenance and repairs																						
Hired labor	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	PD	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	50.00
Inputs																						
Feed concentrate (young animals)	kg	1,785.00	1,785.00	2,850.00	2,850.00	3,915.00	3,915.00	3,915.00	3,915.00	3,915.00	3,915.00	3,915.00	3,915.00	3,915.00	3,915.00	3,915.00	3,915.00	3,915.00	3,915.00	3,915.00	3,915.00	32,760.00
Feed concentrate (old animals)	kg	21,123.75	21,123.75	33,750.00	33,750.00	46,376.25	46,376.25	46,376.25	46,376.25	46,376.25	46,376.25	46,376.25	46,376.25	46,376.25	46,376.25	46,376.25	46,376.25	46,376.25	46,376.25	46,376.25	46,376.25	388,005.00
Antiviral spray	100 cc	52.00	52.00	52.00	52.00	52.00	52.00	52.00	52.00	52.00	52.00	52.00	52.00	52.00	52.00	52.00	52.00	52.00	52.00	52.00	52.00	520.00
Deworming medicine	num	119.00	119.00	190.00	190.00	261.00	261.00	261.00	261.00	261.00	261.00	261.00	261.00	261.00	261.00	261.00	261.00	261.00	261.00	261.00	261.00	2,184.00
Vaccination (piglets)	num	119.00	119.00	190.00	190.00	261.00	261.00	261.00	261.00	261.00	261.00	261.00	261.00	261.00	261.00	261.00	261.00	261.00	261.00	261.00	261.00	2,184.00
Vaccination (BFs)	num	10.00	10.00	16.00	16.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	184.00
Insemination fee	num	12.50	12.50	20.00	20.00	27.50	27.50	27.50	27.50	27.50	27.50	27.50	27.50	27.50	27.50	27.50	27.50	27.50	27.50	27.50	27.50	230.00
Pen repairs	num	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	10.00
Commercialization																						
Activities																						
Sales and Marketing																						
Family labor	PD	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	100.00
Farm Management																						
Family labor	PD	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	200.00
Capital costs																						
Establishment																						
Pig pen	num	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Breeding females	num	5.00	0.00	3.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.00
Irrigation																						
Well	meters	108.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	108.00
Management																						
Sprayer	num	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Motorbike	num	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Yields																						
Piglets	kg	5,950.00	5,950.00	9,500.00	9,500.00	13,050.00	13,050.00	13,050.00	13,050.00	13,050.00	13,050.00	13,050.00	13,050.00	13,050.00	13,050.00	13,050.00	13,050.00	13,050.00	13,050.00	13,050.00	13,050.00	109,200.00
Breeding females	num	3.00	0.00	3.00	0.00	3.00	0.00	3.00	0.00	3.00	0.00	3.00	0.00	3.00	0.00	3.00	0.00	3.00	0.00	3.00	0.00	15.00
Dung	kg	20,622.50	20,622.50	32,996.00	32,996.00	45,369.50	45,369.50	45,369.50	45,369.50	45,369.50	45,369.50	45,369.50	45,369.50	45,369.50	45,369.50	45,369.50	45,369.50	45,369.50	45,369.50	45,369.50	45,369.50	379,454.00
Total Labor																						
Family labor	PD	140.05	134.05	191.97	191.97	249.89	249.89	249.89	249.89	249.89	249.89	249.89	249.89	249.89	249.89	249.89	249.89	249.89	249.89	249.89	249.89	2,157.35
Hired Labor	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Labor	PD	140.05	134.05	191.97	191.97	249.89	249.89	249.89	249.89	249.89	249.89	249.89	249.89	249.89	249.89	249.89	249.89	249.89	249.89	249.89	249.89	2,157.35
Total labor (system life)	PD	4,656.20																				
Total family labor (system life)	PD	4,656.20																				

Intensive pigs: CH, Vietnam

Inputs/Outputs (I/O), by Year	Unit	Year 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
System Establishment																					
Activities																					
Pen installation																					
Construction/installation																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Herd Management																					
Activities																					
Feeding																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Watering																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Pen cleaning and dung removal																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Vaccination																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Deworming medicine																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Antiviral spray																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Pen maintenance and repairs																					
Hired labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Inputs																					
Feed concentrate (young animals)	USD/kg	0.19	0.21	0.22	0.21	0.21	0.22	0.23	0.24	0.26	0.28	0.31	0.38	0.41	0.44	0.52	0.57	0.61	0.63	0.64	0.66
Feed concentrate (old animals)	USD/kg	0.13	0.14	0.14	0.14	0.14	0.15	0.15	0.16	0.18	0.19	0.20	0.25	0.27	0.29	0.35	0.38	0.41	0.42	0.43	0.44
Antiviral spray	USD/100cc	0.13	0.14	0.14	0.14	0.14	0.15	0.15	0.16	0.18	0.19	0.20	0.25	0.27	0.29	0.35	0.38	0.41	0.42	0.43	0.44
Deworming medicine	USD/unit	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04
Vaccination (piglets)	USD/app	1.93	2.07	2.16	2.12	2.11	2.20	2.27	2.44	2.64	2.84	3.07	3.79	4.05	4.41	5.24	5.71	6.09	6.34	6.39	6.60
Vaccination (BFs)	USD/app	1.55	1.66	1.73	1.70	1.69	1.76	1.81	1.95	2.11	2.27	2.46	3.03	3.24	3.53	4.19	4.57	4.87	5.07	5.11	5.28
Insemination fee	USD/time	2.58	2.77	2.88	2.83	2.82	2.93	3.02	3.26	3.52	3.79	4.10	5.05	5.40	5.88	6.98	7.62	8.12	8.45	8.52	8.80
Pen repairs	USD	19.34	20.75	21.60	21.23	21.14	21.95	22.66	24.41	26.44	28.39	30.75	37.85	40.52	44.12	52.36	57.12	60.88	63.37	63.93	66.00
Commercialization																					
Activities																					
Sales and Marketing																					
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Farm Management																					
Family labor	USD/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
Capital costs																					
Establishment																					
Pig pen	USD	193.42	207.47	216.01	212.32	211.40	219.50	226.57	244.15	264.37	283.89	307.47	378.54	405.25	441.16	523.55	571.17	608.82	633.70	639.26	660.00
Breeding females	USD	16.53	17.74	18.47	18.15	18.07	18.76	19.37	20.87	22.60	24.27	26.28	32.36	34.64	37.71	44.76	48.83	52.04	54.17	54.65	56.42
Irrigation																					
Well	USD/meter	3.61	3.87	4.03	3.96	3.95	4.10	4.23	4.56	4.93	5.30	5.74	7.07	7.56	8.23	9.77	10.66	11.36	11.83	11.93	12.32
Management																					
Sprayer	USD	58.03	62.24	64.80	63.70	63.42	65.85	67.97	73.24	79.31	85.17	92.24	113.56	121.57	132.35	157.07	171.35	182.65	190.11	191.78	198.00
Motorbike	USD	147.85	158.59	165.12	162.30	161.60	167.79	173.19	186.63	202.08	217.01	235.03	289.36	309.77	337.22	400.21	436.61	465.39	484.40	488.66	504.51
Yields																					
Piglets	USD/kg	0.23	0.34	0.45	0.56	0.72	0.88	0.70	0.96	0.97	1.04	1.18	1.81	1.66	1.56	2.24	2.08	1.96	2.17	2.07	2.04
Breeding females	USD/animal	16.53	17.74	18.47	18.15	18.07	18.76	19.37	20.87	22.60	24.27	26.28	32.36	34.64	37.71	44.76	48.83	52.04	54.17	54.65	56.42
Dung	USD/kg	0.0025	0.0025	0.0028	0.0031	0.0034	0.0037	0.0041	0.0046	0.0050	0.0055	0.0061	0.0068	0.0075	0.0082	0.0091	0.0100	0.0111	0.0122	0.0135	0.0149

Intensive pigs: CH, Vietnam		Year																			
Energy Inputs/Outputs (I/O), by Year	Units	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
System Establishment																					
Activities																					
Pen installation																					
Construction/installation																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Herd Management																					
Activities																					
Feeding																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Watering																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Pen cleaning and dung removal																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Vaccination																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Deworming medicine																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Antiviral spray																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Pen maintenance and repairs																					
Hired labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Inputs																					
Feed concentrate (young animals)	MJ/kg	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70
Feed concentrate (old animals)	MJ/kg	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70
Antiviral spray	MJ/100cc	14.09	14.09	14.09	14.09	14.09	14.09	14.09	14.09	14.09	14.09	14.09	14.09	14.09	14.09	14.09	14.09	14.09	14.09	14.09	14.09
Deworming medicine	NA																				
Vaccination (piglets)	NA																				
Vaccination (BFs)	NA																				
Insemination fee	NA																				
Pen repairs	NA																				
Commercialization																					
Activities																					
Sales and Marketing																					
Family labor	MJ/PD	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Farm Management																					
Family labor	MJ/PD	0.84	1.00	1.54	1.89	2.23	1.07	2.93	3.28	3.62	3.97	4.32	4.67	5.01	5.36	5.71	6.06	6.40	6.75	7.10	8.08
		17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
Capital costs																					
Establishment																					
Pig pen	NA																				
Breeding females	NA																				
Irrigation																					
Well	NA																				
Management																					
Sprayer	NA																				
Motorbike	NA																				
Yields																					
Piglets	MJ/kg	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81
Breeding females	MJ/kg	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81
Dung	MJ/kg	15.57	15.57	15.57	15.57	15.57	15.57	15.57	15.57	15.57	15.57	15.57	15.57	15.57	15.57	15.57	15.57	15.57	15.57	15.57	15.57

Intensive pigs: CH, Vietnam

Inputs/Outputs (I/O), by Year	Unit	Year 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
System Establishment																						
Activities																						
Pen installation																						
Construction/installation																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	USD$	5.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.05
Herd Management																						
Activities																						
Feeding																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	USD$	31.77	37.72	92.61	113.54	184.74	88.52	242.26	271.02	299.79	328.55	357.31	386.07	414.83	443.59	472.36	501.12	529.88	558.64	587.40	668.49	6,610.21
Watering																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	USD$	31.77	37.72	92.61	113.54	184.74	88.52	242.26	271.02	299.79	328.55	357.31	386.07	414.83	443.59	472.36	501.12	529.88	558.64	587.40	668.49	6,610.21
Pen cleaning and drug removal																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	USD$	2.54	3.02	7.41	9.08	14.78	7.08	19.38	21.68	23.98	26.28	28.58	30.89	33.19	35.49	37.79	40.09	42.39	44.69	46.99	53.48	528.82
Vaccination																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	USD$	6.96	8.27	20.30	24.89	40.49	19.40	53.10	59.40	65.71	72.01	78.31	84.62	90.92	97.23	103.53	109.83	116.14	122.44	128.75	146.52	1,448.81
Deworming medicine																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	USD$	8.70	10.33	25.37	31.11	50.61	24.25	66.37	74.25	82.13	90.01	97.89	105.77	113.65	121.53	129.41	137.29	145.17	153.05	160.93	183.15	1,811.01
Antiviral spray																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	USD$	1.68	2.00	3.08	3.77	4.47	2.14	5.86	6.55	7.25	7.94	8.64	9.33	10.03	10.72	11.42	12.11	12.81	13.50	14.20	16.16	163.66
Pen maintenance and repairs																						
Hired labor	USD$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	USD$	4.21	5.00	7.69	9.43	11.16	5.35	14.64	16.38	18.12	19.86	21.59	23.33	25.07	26.81	28.55	30.29	32.02	33.76	35.50	40.40	409.16
Inputs																						
Feed concentrate (young animals)	USD$	345.25	370.34	615.64	605.11	827.64	859.35	887.01	955.84	1,035.00	1,111.44	1,203.73	1,481.99	1,586.54	1,727.13	2,049.71	2,236.12	2,383.53	2,480.92	2,502.72	2,583.90	27,848.89
Feed concentrate (old animals)	USD$	2,723.80	2,921.71	4,860.29	4,777.16	6,536.03	6,786.41	7,004.93	7,548.45	8,173.57	8,777.25	9,506.09	11,703.55	12,529.19	13,639.47	16,186.98	17,659.06	18,823.19	19,592.29	19,764.43	20,405.55	219,919.38
Antiviral spray	USD$	6.71	7.19	7.49	7.36	7.33	7.61	7.85	8.46	9.16	9.84	10.66	13.12	14.05	15.29	18.15	19.80	21.11	21.97	22.16	22.88	258.20
Deworming medicine	USD$	1.53	1.65	2.74	2.69	3.68	3.82	3.94	4.25	4.60	4.94	5.35	6.59	7.05	7.68	9.11	9.94	10.59	11.03	11.12	11.48	123.77
Vaccination (piglets)	USD$	230.17	246.89	410.42	403.41	551.76	572.90	591.34	637.23	690.00	740.96	802.49	987.99	1,057.69	1,151.42	1,366.48	1,490.75	1,589.02	1,653.95	1,668.48	1,722.60	18,565.93
Vaccination (BFs)	USD$	15.47	16.60	27.65	27.18	37.21	38.63	39.88	42.97	46.53	49.97	54.11	66.62	71.32	77.64	92.15	100.53	107.15	111.53	112.51	116.16	1,251.38
Insemination fee	USD$	32.24	34.58	57.60	56.62	77.51	80.48	83.08	89.52	96.93	104.09	112.74	138.80	148.59	161.76	191.97	209.43	223.23	232.36	234.40	242.00	2,607.93
Pen repairs	USD$	0.00	20.75	21.60	21.23	21.14	21.95	22.66	24.41	26.44	28.39	30.75	37.85	40.52	44.12	52.36	57.12	60.88	63.37	63.93	66.00	725.46
Commercialization																						
Activities																						
Sales and Marketing																						
Family labor	USD$	8.42	10.00	15.38	18.85	22.33	10.70	29.28	32.76	36.24	39.71	43.19	46.66	50.14	53.62	57.09	60.57	64.05	67.52	71.00	80.80	818.31
Farm Management																						
Family labor	USD$	16.85	20.00	30.75	37.71	44.66	21.40	58.56	65.52	72.47	79.42	86.38	93.33	100.28	107.23	114.19	121.14	128.09	135.05	142.00	161.60	1,636.63
Capital costs																						
Establishment																						
Pig pen	USD$	193.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	193.42
Breeding females	USD$	82.67	0.00	55.40	0.00	54.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	192.28
Irrigation																						
Well	USD$	389.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	389.93
Management																						
Sprayer	USD$	58.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	58.03
Motorbike	USD$	147.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	147.85
Yields																						
Piglets	USD$	1,376.72	2,034.67	4,299.16	5,349.68	9,371.94	11,543.48	9,100.00	12,556.34	12,688.37	13,600.74	15,380.14	23,577.63	21,707.58	20,365.63	29,276.46	27,126.59	25,536.36	28,360.16	26,998.51	26,649.72	326,899.88
Breeding females	USD$	49.60	0.00	55.40	0.00	54.22	0.00	58.10	0.00	67.80	0.00	78.85	0.00	103.93	0.00	134.27	0.00	156.13	0.00	163.94	0.00	922.24
Dung	USD$	51.97	51.97	91.78	101.29	153.72	169.66	187.26	206.68	228.11	251.76	277.87	306.69	338.49	373.59	412.33	455.09	502.28	554.37	611.86	675.31	6,002.08
Annual Benefits																						
Total annual costs	USD$	4,345.03	3,753.75	6,354.01	6,262.67	8,674.49	8,638.52	9,372.41	10,129.72	10,987.69	11,819.21	12,805.12	15,602.60	16,707.90	18,164.33	21,393.59	23,296.29	24,819.14	25,854.70	26,153.91	27,189.65	
Total Annual revenue	USD$	1,478.29	2,086.65	4,446.33	5,450.97	9,579.87	11,713.15	9,345.36	12,763.02	12,984.28	13,852.50	15,736.86	23,884.32	22,150.00	20,739.23	29,823.06	27,581.68	26,194.78	28,914.53	27,774.31	27,325.03	
Annual net income	USD$	-2,866.74	-1,667.11	-1,907.68	-811.70	905.38	3,074.62	-27.05	2,633.30	1,996.59	2,033.29	2,931.74	8,281.72	5,442.10	2,574.90	8,429.47	4,285.39	1,375.64	3,059.82	1,620.40	135.38	
Annual discounted net benefits	USD$	-2866.74	-1,515.55	-1,576.59	-609.84	618.39	1,909.10	-15.27	1,351.30	931.42	862.31	1,130.31	2,902.69	1,734.02	745.86	2,219.74	1,025.89	299.38	605.37	291.44	22.14	
Economic Indicators																						
Net Present Value of System	USD$	10,065.37																				
Returns to land	USD$/ha	100,653.66																				
Returns to family labor	USD/PD	2.16																				
Returns to family labor/market wage rate		0.53																				

Intensive pigs: CH, Vietnam																					
Inputs/Outputs (I/O), by Year	Unit	Year 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
System Establishment																					
Activities																					
Pen installation																					
Construction/installation																					
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	MJ	103.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Herd Management																					
Activities																					
Feeding																					
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	MJ	650.63	650.63	1,038.91	1,038.91	1,427.19	1,427.19	1,427.19	1,427.19	1,427.19	1,427.19	1,427.19	1,427.19	1,427.19	1,427.19	1,427.19	1,427.19	1,427.19	1,427.19	1,427.19	1,427.19
Watering																					
Hired Labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	MJ	650.63	650.63	1,038.91	1,038.91	1,427.19	1,427.19	1,427.19	1,427.19	1,427.19	1,427.19	1,427.19	1,427.19	1,427.19	1,427.19	1,427.19	1,427.19	1,427.19	1,427.19	1,427.19	1,427.19
Pen cleaning and dung removal																					
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	MJ	52.05	52.05	83.11	83.11	114.17	114.17	114.17	114.17	114.17	114.17	114.17	114.17	114.17	114.17	114.17	114.17	114.17	114.17	114.17	114.17
Vaccination																					
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	MJ	142.60	142.60	227.71	227.71	312.81	312.81	312.81	312.81	312.81	312.81	312.81	312.81	312.81	312.81	312.81	312.81	312.81	312.81	312.81	312.81
Deworming medicine																					
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	MJ	178.25	178.25	284.63	284.63	391.01	391.01	391.01	391.01	391.01	391.01	391.01	391.01	391.01	391.01	391.01	391.01	391.01	391.01	391.01	391.01
Antiviral spray																					
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	MJ	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50	34.50
Pen maintenance and repairs																					
Hired labor	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Family labor	MJ	86.25	86.25	86.25	86.25	86.25	86.25	86.25	86.25	86.25	86.25	86.25	86.25	86.25	86.25	86.25	86.25	86.25	86.25	86.25	86.25
Inputs																					
Feed concentrate (young animals)	MJ	13,744.50	13,744.50	21,945.00	21,945.00	30,145.50	30,145.50	30,145.50	30,145.50	30,145.50	30,145.50	30,145.50	30,145.50	30,145.50	30,145.50	30,145.50	30,145.50	30,145.50	30,145.50	30,145.50	30,145.50
Feed concentrate (old animals)	MJ	162,652.88	162,652.88	259,875.00	259,875.00	357,097.13	357,097.13	357,097.13	357,097.13	357,097.13	357,097.13	357,097.13	357,097.13	357,097.13	357,097.13	357,097.13	357,097.13	357,097.13	357,097.13	357,097.13	357,097.13
Antiviral spray	MJ	732.73	732.73	732.73	732.73	732.73	732.73	732.73	732.73	732.73	732.73	732.73	732.73	732.73	732.73	732.73	732.73	732.73	732.73	732.73	732.73
Deworming medicine	NA																				
Vaccination (piglets)	NA																				
Vaccination (BFs)	NA																				
Insemination fee	NA																				
Pen repairs	NA																				
Commercialization																					
Activities																					
Sales and Marketing																					
Family labor	MJ	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50	172.50
Farm Management																					
Family labor	MJ	16.85	20.00	30.75	37.71	44.66	21.40	58.56	65.52	72.47	79.42	86.38	93.33	100.28	107.23	114.19	121.14	128.09	135.05	142.00	161.60
Capital costs																					
Establishment																					
Pig pen	NA																				
Breeding females	NA																				
Irrigation																					
Well	NA																				
Management																					
Sprayer	NA																				
Motorbike	NA																				
Yields																					
Piglets	MJ	42,008.71	42,008.71	67,072.73	67,072.73	92,136.74	92,136.74	92,136.74	92,136.74	92,136.74	92,136.74	92,136.74	92,136.74	92,136.74	92,136.74	92,136.74	92,136.74	92,136.74	92,136.74	92,136.74	92,136.74
Breeding females	MJ	21.18	0.00	21.18	0.00	21.18	0.00	21.18	0.00	21.18	0.00	21.18	0.00	21.18	0.00	21.18	0.00	21.18	0.00	21.18	0.00
Dung	MJ	321,092.33	321,092.33	513,747.72	513,747.72	706,403.12	706,403.12	706,403.12	706,403.12	706,403.12	706,403.12	706,403.12	706,403.12	706,403.12	706,403.12	706,403.12	706,403.12	706,403.12	706,403.12	706,403.12	706,403.12
Annual Energy Balance																					
Total annual energy inputs	MJ	179,217.88	179,117.53	285,550.01	285,556.96	391,985.64	391,962.38	391,999.54	392,006.49	392,013.45	392,020.40	392,027.35	392,034.31	392,041.26	392,048.21	392,055.16	392,062.12	392,069.07	392,076.02	392,082.98	392,102.58
Total annual enery outputs	MJ	363,122.21	363,101.03	580,841.63	580,820.45	798,561.04	798,539.86	798,561.04	798,539.86	798,561.04	798,539.86	798,561.04	798,539.86	798,561.04	798,539.86	798,561.04	798,539.86	798,561.04	798,539.86	798,561.04	798,539.86
Annual net energy output	MJ	183,904.34	183,983.50	295,291.62	295,263.49	406,575.40	406,577.48	406,561.50	406,533.36	406,547.59	406,519.46	406,533.69	406,505.55	406,519.78	406,491.65	406,505.88	406,477.74	406,491.97	406,463.84	406,478.06	406,437.28
Total energy input (system life)	MJ	7,202,029.31																			
Total energy output (system life)	MJ	14,664,692.50																			
	EROI MJ	2.04																			