Livestock and livelihoods of smallholder cattle-owning households in Cambodia: the contribution of on-farm and off-farm activities to income and food security

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Abstract
The majority of smallholder farming households in Cambodia are rural based and rely on agriculture to support their livelihoods. However, in recent years, growth in the agriculture sector has stagnated with farmers facing several challenges including declining prices for traditional crops and irregular rainfall patterns. This has led to a need for farmers to diversify income sources with livestock promoted as a more viable livelihood activity, particularly the raising of cattle and poultry. However, uncertain profitability of livestock activities is a common perception by smallholders, especially where animals have not been traditionally viewed as a primary income source. To address this, information is required which compares the income and expenses associated with livestock raising to other on-farm activities and off-farm sources. This study reports on a survey of livelihood survey of 17 male and 21 female representatives of 20 households owning cattle in Cambodia, comparing the associated income and expenses of the various livelihood activities in the 12-month period from January to December 2016. Combined total household income from both on-farm and off-farm sources ranged from USD875 to 17730 with an average of USD6779, representing 51% and 49% from on-farm and off-farm activities, respectively. Cattle raising was the most common source of on-farm income (85%), contributing USD1064 and representing 22% of total household income. General household expenses, such as food and transportation (including expenses associated with off-farm employment), represented the majority of total household expenses (79%). Gross profit calculations indicated higher values for pig raising (USD1841.79), cattle (USD950.80) and non-rice crops (USD884) whilst the highest gross margin value was recorded for cattle (89.33%) followed by vegetables (85.27%) and non-rice crops (83.08%). Whilst wet season and dry season rice returned a negative gross profit value of USD197.27 and USD90.60 on average per household, respectively, both were ranked as most important for household consumption, followed by poultry, providing the main source of energy (rice) and protein (chicken meat) and sustaining household food requirements. The study concludes that although smallholder cattle-owning households in Cambodia undertake a diverse range of on-farm activities, as cattle raising provides a superior income source due to higher returns and lower variable costs, it could be promoted as a preferred livelihood activity by agencies conducting rural extension...
activities. Although consideration of available labour and monetary funds to invest in cattle raising is required, it was observed that income from off-farm sources may prove beneficial in providing the additional monetary funds to support cattle-raising activities and assist in providing generally poor smallholder households with enhanced economic resilience.

Keywords Mixed farming systems · Livestock · Financial analysis · Returns

Introduction

In South-East Asia, efforts to improve food security and reduce poverty rely on the development of smallholder farms that produce an estimated 75% of food commodities and provide a source of nutrition and income for millions of households (Lowder et al. 2016; Herrero et al. 2017). Driven by higher commodity prices and increases in production of staple commodities, such as rice, maize, and cassava, Cambodia experienced one of the strongest periods of agricultural growth in the world from 2004 to 2012 with an average annual growth rate of 5.3% (WorldBank 2015). However, agricultural growth has stagnated in recent years (1% in 2013–2014) and further attention is required if continued poverty reduction, largely driven by the agricultural sector, is to be achieved.

At present, poverty is still a serious issue for many households with 33.8% of the population deprived of adequate health, education, and living standards and classed as multidimensionally poor (UNDP 2016). Rural households that rely on agriculture for their livelihoods are particularly vulnerable and face a number of challenges as they transition from keepers to producers, including declining prices for traditional crops, a diminishing agricultural labour workforce and irregular rainfall patterns (CDRI 2011; MAFF 2014; WorldBank 2015). These factors indicate that smallholder farmers need to diversify their income sources to mitigate these risks with livestock raising being promoted as a source of income and livelihood development (MAFF 2015).

Agriculture is an integral part of life in Cambodia with an estimated 1.9 million households (73%) classed as an “agricultural holding”. This term is used to describe an enterprise comprising of at least 2 large livestock (cattle, buffalo, horses) and/or 3 small livestock (sheep, goats) and/or 25 poultry (chickens, ducks) and/or land with a size of at least 300 m² used for agricultural purposes (NIS 2013). For smallholder cattle-owning households, cattle provide a source of income and asset store and are often managed alongside other livelihood activities, such as rice production, poultry and/or pig raising and off-farm employment (Young et al. 2014b; Samkol et al. 2015; Hasnah et al. 2016). Driven by a growing demand for beef in the region, these households are encouraged to invest in cattle as a primary livelihood strategy to increase household income and meet market demand for live animals (Young et al. 2014a).

However, uncertainty regarding the profitability of cattle raising and the benefits of intensifying production is common amongst smallholders. This is particularly evident where management of animals is subsistence-based and farmers are unsure of the costs associated with improving productivity, including health and husbandry practices, such as forage feeding, drenching, vaccination and meeting marketing specifications. Information regarding potential income and expenses associated with cattle raising compared to other on-farm and off-farm activities is required to assist farmers in making informed decisions to identify the most beneficial activities for their households to undertake and motivating them to increase household incomes.

For livestock researchers, there is increasing importance in the use of socioeconomic studies to understand the complexity of smallholder systems and the role of livestock in these systems (Herrero et al. 2013). Previous research investigating the value of on-farm and off-farm activities for rural households in Cambodia suggests that there is a lack of consensus as to the most profitable livelihood activities for rural households to undertake. A recent study reported crop production as the largest contributor to total household income for rural households whilst also stating that business operators and large-scale farmers, followed by mixed crop–livestock producers generated the highest annual household incomes (Jiao et al. 2017). However, this finding is largely dependent on the sample selection and the type of household interviewed. For livestock-owning households and particularly those that own cattle, rice farming and cattle keeping have been reported as the most important sources of income (Samkol et al. 2015). However, few reported studies have attempted to assess rural livelihoods in Cambodia with a particular focus on smallholder cattle raising, involving assessment and comparison of the value of on-farm and off-farm activities in contributing to overall household income, consumption and expenditure.

This study examined the livelihood activities of 20 smallholder cattle-owning households in Cambodia, comparing income and expenses per activity and at the household level. The study aimed to assess the profitability of different on-farm activities to identify those activities more likely to provide better financial return to smallholder farmers. This information will provide improved understanding of the relative importance of different activities for overall household livelihoods, potentially providing evidence for cattle-owning
households to consider investing in cattle raising as a primary livelihood strategy.

Materials and methods

Target survey population

Target households for the livelihood survey were households participating in the “Village-based biosecurity for livestock disease risk management in Cambodia (VBLDRM)” project, a collaborative research project facilitated by the University of Sydney and the General Directorate of Animal Health and Production Cambodia, funded by the Australian Centre for International Agricultural Research (ACIAR). These villages had previously been selected for involvement in the VBLDRM project according to the following selection criteria: farmer, village leader and local government commitment to the project, a minimum of 25 smallholder farmers with current or intention to own ≥3–4 cattle, land available for forage establishment and year-round access to main roads and markets. Further information on this project is available at http://aciar.gov.au/project/ah/2011/014.

Survey design

The household livelihood survey consisted of three parts to capture household income and expenditure over a 12-month period from January 2016 to December 2016. Information captured was tabulated (Table 1). Part 1 examined on-farm income. For crop income, this included rice and non-rice crops, fruit and vegetables for the corresponding area (ha), yield (kg/ha), amount sold and price per unit tonnes/ha, per kg, individual fruit, bunch or total depending on the crop) to provide a total annual income. For livestock, income was recorded according to type of livestock category and product, selling unit (head/kg/cart/number of eggs), number sold and price per unit to provide a total annual income for each livestock category. Livestock categories included beef cattle, buffalo, pigs and poultry whilst livestock products included live animals, meat, manure, eggs and breeding service (mating provided by a bull).

Part 2 examined off-farm income. This was considered to be any income not directly attributable to on-farm activities undertaken by the household. For salary employment, this included all employment undertaken as a staff member of a government, non-government and/or private organisation and income included monthly wages and any bonuses received. Paid labour included on-farm labour, factory work, construction work and any other labour provided in return for monetary payment. Village duties included income received from duties performed within the village as a member of a village committee, such as village chief or vice-chief and/or any income receive from participating in workshops and/or training. For veterinary services and supplies, this included services provided as a local village animal health worker (VAHW) and/or selling of animal feed and medicine. Remittances included all income received from relatives within and outside of Cambodia. Interest represented any income earned on loans provided to other farmers and/or interest on savings held within a financial institution or village savings group. Lastly, income received from leasing machinery, such as a tractor or hand tractor, was recorded as well as any other income not directly associated with crops grown or livestock raised directly by the household.

Part 3 examined the recorded expenses for on-farm activities. For crops, this included seed purchases, land preparation, chemical fertiliser, manure, pesticides, herbicides, irrigation costs, processing, packaging and transportation. Livestock expenses included feed, vaccinations and other medicines, purchasing of replacement animals, breeding and selling and transportation costs. Part 3 also recorded general household expenses, and these were separated into their respective categories as shown in Table 1. Expenses for off-farm sources were included in general household expenses as respondents were not able to separate these costs from day-to-day expenses. For example, food prepared and taken to work was included in the total household food and beverage amount as it was difficult to determine the proportion of food costs for that specific job. Similarly, fuel costs for travel to and from work were included in household transportation expenses as it was difficult to separate fuel costs for a specific job as it was often combined with travel to the market, relatives and friends houses and/or the pagoda. Households also reported any savings used, money borrowed including the loan amount and interest rate, and any capital investments such as purchasing land, building or renovating housing, animal pens or ponds and/or purchasing machinery, equipment or transportation. This information (income, expenses, savings, loans and capital investments) was used to calculate the total disposable income (income – expenses), total adjusted disposable income (total disposable income + savings and loans) and total net position (total adjusted disposable income – capital investments) at the end of the 12-month period for each household.

Pilot study

A pilot study was carried out in January 2017 to test survey questions and the length of time required for interview. A total of eight households were interviewed in the pilot study including four households in Sen Ouk village, Takeo province, and four households in Ampil Chrum village, Tbong Khmum
province. After the completion of the pilot study, survey questions were simplified according to feedback, and additional study villages in Battambang and Siem Reap were included to address potential regional differences between villages.

**Selection of participating households**

A total of 20 households were selected for the current study including six households in Sen Ouk village, Kous commune, Tramkok district, Takeo province, six households in Ampil Chrum village, Tonle Bet commune, Tbong Khmum District, Tbong Khmum province, four households in Boeung Prey village, Sneung commune, Banan district, Battambang province and four households in Tbeng Lech village, Tbeng commune, Bantheay Srey district, Siem Reap province (Fig. 1). These households were randomly selected from a list of participating households in each village using a random list generator (Microsoft Excel 2010®). Only four households were selected in the project villages in Battambang and Siem Reap provinces due to the time and resource constraints and limited availability of farmers due to the religious holidays in September.

**Data collection and analysis**

The survey was conducted between June and September 2017. Project staff travelled to each village and conducted interviews with each household although for each household, interviews were conducted on three separate visits. The first interview consisted of parts 1, 2 and 3 with the exclusion of household expenses and took approximately 2.3 h. The second interview consisted of capturing household expenses, loans and capital investments and took approximately 2 h. All information was entered in Microsoft Excel 2010®. Income and expenses were calculated for each activity and at the overall household level with a detailed summary produced. For the last interview, the detailed summary was presented, and the results of the study confirmed with each household. Households were then asked to rank their individual on-farm and combined off-farm activities in order of importance from 1 (most important) to 5 (least important) for household income and consumption (two separate rankings). For household consumption, on-farm activities, such as rice, non-rice crops, fruit, vegetables and livestock, were included and ranked whilst off-farm activities were excluded as they did not qualify as a consumption source. Ranking scores were totalled for each activity and divided by the number of households that reported that activity to provide an overall ranking score.

Total time spent interviewing each household was 5–7 h. All interviews were conducted with the household head(s) in Khmer language and translated and recorded in English on survey answer sheets. To avoid potential bias and ensure consistency, the same staff member from the GDAHP conducted all interviews and provided translations. Where possible, information was collected from the relevant household person responsible for the activity. For example, for rice production data, the household person responsible for rice cultivation was interviewed for rice income and expenses whilst for

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household expenses the person responsible for managing household expenses was interviewed. Values were recorded in Cambodian riel (KHR) or United States dollars (USD) with conversion between the two currencies based on 4000 KHR = 1 USD according to the average exchange rate for 2016 (XE 2017).

**Gross profit and gross margin analysis**

To assess and compare the profitability of reported on-farm activities, both the average gross profit (GP) and average gross margin (GM) were calculated for each activity according to the following equations:

\[
\text{GP(USD)} = \frac{\text{income} - \text{variable costs}}{\text{income}}
\]

\[
\text{GM} (\%) = \left( \frac{\text{income} - \text{variable costs}}{\text{income}} \right) 
\]

Both GP and GM are economic indicators that can be used to evaluate and compare the profitability of on-farm activities by calculating the difference between the gross income and the total variable costs of an activity (Devendra and Frio 2000; Rushton 2009). These values can then be used to rank different on-farm activities and select the best combination and/or compare the profitability of similar enterprises between farms (Devendra and Frio 2000; Rushton 2009). Both values were based on a period of 12 months (January–December 2016 inclusive) and did not take into account fixed costs, such as unpaid labour, depreciation of machinery and any variables that cannot be assigned to a specific activity (Rushton 2009).

For income, this included all money received from a specific activity and was calculated based on the amount of product sold multiplied by the product price to provide total income received. For this study, the product price was the price received by the farmer at the point of sale and was reported in KHR or USD. For activities with multiple sources of income, income categories were added together to provide a total income for that activity. For variable costs, this included all costs associated with a specific activity and was calculated according to the amount used multiplied by the cost of that item to provide a total annual cost. Variable costs for each on-farm activity were added together to provide a total variable cost per activity. All values were entered in Microsoft Excel 2010® and converted into USD. Average GP and GM values
for each activity were then calculated as per the equations specified above.

Results

Household livelihood survey

Household information and livelihood activities

A total of 38 household representative(s) were interviewed from the 20 participating households including 17 male household representatives and 21 female household representatives. The average age of interviewed respondents was 43 years old and ranged from 26 to 57 years old. On average, each household had five household members and was located 11 km from the nearest market (range 3–30 km). Overall, cattle and poultry raising were the most common on-farm activity reported (100%) followed by fruit growing (75%), wet season rice (70%) and non-rice crops (60%) (Table 2). No households reported raising buffalo. Off-farm, paid labour was the most common off-farm activity with 35% of households providing on-farm labour for other households or engaging in factory work. Salary employment and/or village duties was also performed by 25% of households, and this included employment as a teacher, staff member of a biogas project, logistics manager at a local water factory, village chief and village vice-chief.

Contribution of income from on-farm and off-farm activities to total household income

All households reported income from on-farm activities, with an average of four income sources per household and income sources differing between households (Table 2). Overall, cattle raising contributed the most to total household income (22%) with an average USD1064 per household (range USD0–2300). Whilst pig raising generated a high-average income across all households (USD511), the average contribution to total household income was low (5%) as only three households generated income from this activity. Similarly, whilst average income from non-rice crops was moderate (USD479), contribution to total household income was also low (8%). For the remaining on-farm activities, average income per household was low (USD67–293) and contribution to total household income was 5% or less. Total income from on-farm activities was highly variable, ranging from USD25 to 6433 with an average of USD3064 per household, with contribution to total household income ranging from 2 to 100% at an average of 51% per household.

The majority of households (90%) reported income from off-farm sources. Paid labour was the most common off-farm income source with 35% (n = 7) of households providing labour during planting and harvesting for rice, cassava, pineapple and other crops and for other on-farm works, such as cutting wood, peeling peanuts and constructing houses. Income from paid labour, remittances and salary employment represented 13%, 12% and 11% of total household income, respectively. For two households, income received via remittances was substantial with both receiving USD1000 per month from sons working in the Republic of Korea, for a total amount of USD12000 per year per household. Average income from salaried employment was also high (USD917) where earnings ranged from USD2400 to USD5980 for the five households that reported income from this activity. Total income from off-farm activities was also highly variable, ranging from USD110 to 12625 at an average of USD3715 per household, representing 49% of total household income (range 0–98%). Overall, total household income from on-farm and off-farm activities ranged from USD875 to 17730 with an average of USD6779 per household.

Importance of livelihood activities for household income and domestic consumption

For household income, off-farm income ranked highest with a score of 1.08 and represented the most important income generating activity followed by cattle (1.78), pigs (2.67), non-rice crops (3.63), dry season rice (3.67), poultry (3.71) and wet season rice (3.92). Fruit and vegetables were ranked the least important for income with scores 4.22 and 5.00, respectively. For household consumption, wet season rice, dry season rice and poultry represented the most important activities for household consumption with ranking scores of 1.00, 1.50 and 1.78, respectively, followed by pigs (2.50), vegetables (3.17) and fruit (3.22). Non-rice crops and cattle were ranked the least important activities for household consumption with ranking scores of 3.50 and 3.83, respectively.

Use of monetary savings and borrowings

Of the 20 interviewed households, eight households reported savings to supplement on-farm and off-farm income, with amounts ranging from USD400 to 10,000 at an average of USD1803 per household. More than half of the interviewed households (60%) had also borrowed money during the 12-month period, borrowing on average USD2170 at an interest rate of 19% p.a. (range USD250–11,000 and 14–34% interest rate). One household that had borrowed money did not wish to disclose this information.

Household expenditure

Expenses associated with on-farm activities and general household expenses are tabulated (Table 3). Overall, expenses associated with on-farm activities accounted for
21% of total household expenditure and were highly variable, ranging from USD15 to 3606 with an average of USD1367 per household. Wet season rice production had the highest average expenses of all on-farm activities representing 7% of total household expenses at an average of USD431. Whilst pig raising was associated with the second highest on-farm expense (USD235), the proportion of total household expenses was low (3%). For cattle and poultry raising, households spent an average of USD114 and USD194 on these activities, respectively, representing 2 and 3% of total household expenses. For general household expenses, food and beverages accounted for the majority of total household expenses (33%) with households spending an average of USD1843 on meat, vegetables, fruit, cooking oils and other food items. Social events accounted for a large proportion of household expenses (16%) with over USD900 spent on weddings, funerals and religious celebrations on average per household. Similarly, transportation costs for motorbikes (no households reporting owning a car) represented 10% of total household expenses where households spent USD634 on average for fuel and repairs. For households with children attending school and/or university, associated expenses were high on average (USD514) especially for one household where costs for two children to attend university totalled USD2340. For other household expenses including non-drinking water, electricity, cooking, health, clothing, cosmetics, communications and donations, average expenses were less than USD250 and represented less than 5% of total household expenses. Overall, general household expenses accounted for 79% of total household expenditure, with mean total household expenses for all activities (on-farm, off farm and general household) of USD6076.

**Use of monetary funds for capital investments**

The majority of households (75%) reported capital investments during the 12-month period. Purchasing of land was

### Table 2. Livelihood activities, income reported and percentage of total household income for cattle owning households in Cambodia in 2016

<table>
<thead>
<tr>
<th>Livelihood activity</th>
<th>Min</th>
<th>Med.</th>
<th>Max.</th>
<th>Average</th>
<th>% of total HH income (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>On-farm</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wet season rice</td>
<td>0</td>
<td>0</td>
<td>2000</td>
<td>293</td>
<td>4% (0–26%)</td>
</tr>
<tr>
<td>Dry season rice</td>
<td>0</td>
<td>0</td>
<td>710</td>
<td>67</td>
<td>&lt;1% (0–4%)</td>
</tr>
<tr>
<td>Non-rice crops</td>
<td>0</td>
<td>0</td>
<td>5000</td>
<td>479</td>
<td>8% (0–86%)</td>
</tr>
<tr>
<td>Vegetables</td>
<td>0</td>
<td>0</td>
<td>1033</td>
<td>170</td>
<td>3% (0–19%)</td>
</tr>
<tr>
<td>Fruit</td>
<td>0</td>
<td>29</td>
<td>1875</td>
<td>236</td>
<td>3% (0–23%)</td>
</tr>
<tr>
<td>Cattle</td>
<td>0</td>
<td>1250</td>
<td>2300</td>
<td>1064</td>
<td>22% (0–77%)</td>
</tr>
<tr>
<td>Buffalo</td>
<td></td>
<td></td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pigs</td>
<td>0</td>
<td>0</td>
<td>5788</td>
<td>511</td>
<td>5% (0–38%)</td>
</tr>
<tr>
<td>Poultry</td>
<td>0</td>
<td>51</td>
<td>1488</td>
<td>244</td>
<td>5% (0–52%)</td>
</tr>
<tr>
<td><strong>Total on-farm per HH</strong></td>
<td>25</td>
<td>2805</td>
<td>6433</td>
<td>3064</td>
<td>51% (2–100%)</td>
</tr>
<tr>
<td><strong>Off-farm</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salary employment</td>
<td>0</td>
<td>0</td>
<td>5980</td>
<td>917</td>
<td>11% (0–75%)</td>
</tr>
<tr>
<td>Paid labour</td>
<td>0</td>
<td>0</td>
<td>2650</td>
<td>352</td>
<td>13% (0–97%)</td>
</tr>
<tr>
<td>Village duties</td>
<td>0</td>
<td>0</td>
<td>600</td>
<td>105</td>
<td>2% (0–11%)</td>
</tr>
<tr>
<td>Vet services/sup.</td>
<td>0</td>
<td>0</td>
<td>3660</td>
<td>208</td>
<td>2% (0–39%)</td>
</tr>
<tr>
<td>Remittances</td>
<td>0</td>
<td>0</td>
<td>12,000</td>
<td>1375</td>
<td>12% (0–90%)</td>
</tr>
<tr>
<td>Interest</td>
<td>0</td>
<td>0</td>
<td>500</td>
<td>63</td>
<td>1% (0–8%)</td>
</tr>
<tr>
<td>Lease machinery</td>
<td>0</td>
<td>0</td>
<td>400</td>
<td>36</td>
<td>1% (0–7%)</td>
</tr>
<tr>
<td>Village shop</td>
<td>0</td>
<td>0</td>
<td>4050</td>
<td>203</td>
<td>1% (0–25%)</td>
</tr>
<tr>
<td>Cassava trading</td>
<td>0</td>
<td>0</td>
<td>3938</td>
<td>197</td>
<td>2% (0–44%)</td>
</tr>
<tr>
<td>Selling land</td>
<td>0</td>
<td>0</td>
<td>2000</td>
<td>100</td>
<td>2% (0–46%)</td>
</tr>
<tr>
<td>Vegetable selling</td>
<td>0</td>
<td>0</td>
<td>1800</td>
<td>90</td>
<td>1% (0–27%)</td>
</tr>
<tr>
<td>Other*</td>
<td>0</td>
<td>0</td>
<td>700</td>
<td>70</td>
<td>1% (0–13%)</td>
</tr>
<tr>
<td><strong>Total off-farm per HH</strong></td>
<td>110</td>
<td>2180</td>
<td>12,625</td>
<td>3715</td>
<td>49% (0–98%)</td>
</tr>
<tr>
<td><strong>Total household</strong></td>
<td>875</td>
<td>5711</td>
<td>17,730</td>
<td>6779</td>
<td>100%</td>
</tr>
</tbody>
</table>

*HH households
Other off-farm income: selling water pumped from a communal pond, rice wine and rice milling.
the most common, with nine households (45%) purchasing an average of 1.12 ha for USD6111. Investment in farm infrastructure and transportation was also common with 30% of households reporting either or both activities. For farm infrastructure, nine households invested an average of USD502 on upgrading existing cattle pens (n = 4), building chicken housing (n = 3) and/or building a pond to raise fish for household consumption (n = 1). One household invested USD10,000 to build a shop at the front of the house, install a fence around the property boundary and build two bathrooms. For transportation, nine households reported purchasing a new motorbike in the 12-month period at an average cost of USD1700. Other types of capital investments included purchasing a television (n = 5), purchasing household furniture (n = 4) and purchasing machinery and equipment for farm use (n = 3).

**Summary of household finances and net position**

A summary of average household finances, including all income, expenses, reported savings, loans and capital investments, and calculation of net position is tabulated (Table 4). Total average disposable income was USD703 (total household income less total household expenses). Taking into account reported savings (USD1084) and loans (USD2170), total adjusted disposable income was USD3957. After taking into account capital investments made, an average household net position of USD $576 was calculated for the 12-month period. To cover this shortfall, farmers reported using additional savings not previously disclosed.

**GP and GM analyses**

**Wet and dry season rice**

On a per hectare (ha) basis, average income and variable costs for wet season rice (n = 14) and dry season rice (n = 4) resulted in a GP of USD $142.50 and USD $47.96 and a GM of $75.62% and $12.84%, respectively (Table 5). For wet season rice, harvesting represented the largest variable cost (33%)
Table 4. Summary of household finances and net position

<table>
<thead>
<tr>
<th>Description</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. On-farm activities</td>
<td>3064</td>
</tr>
<tr>
<td>b. Off-farm activities</td>
<td>3715</td>
</tr>
<tr>
<td>c. Total household income (a + b)</td>
<td>6779</td>
</tr>
<tr>
<td>Expenses</td>
<td></td>
</tr>
<tr>
<td>d. On-farm activities</td>
<td>1367</td>
</tr>
<tr>
<td>e. General household</td>
<td>4709</td>
</tr>
<tr>
<td>f. Total household expenses (d + e)</td>
<td>6076</td>
</tr>
<tr>
<td>g. Total disposable income (c – f)</td>
<td>703</td>
</tr>
<tr>
<td>h. Savings</td>
<td>1084</td>
</tr>
<tr>
<td>i. Loans</td>
<td>2170</td>
</tr>
<tr>
<td>j. Adjusted disposable income (g + h + i)</td>
<td>3957</td>
</tr>
<tr>
<td>k. Capital investments</td>
<td>4533</td>
</tr>
<tr>
<td>l. Net position (j – k)</td>
<td></td>
</tr>
<tr>
<td>Proportion of household with a positive net position</td>
<td>35%</td>
</tr>
<tr>
<td>Proportion of household with a negative net position</td>
<td>65%</td>
</tr>
</tbody>
</table>

where households paid for contract labour to harvest by machine (n = 8), by hand (n = 4) or both (n = 2). For dry season rice, planting accounted for the largest proportion of total variable costs (36%) for most households (75%) where labour was hired to plant seedlings at a cost of USD200–214.29 per ha. For both activities, if 100% of rice produced was sold (2.09 tonnes for wet season rice and 3.83 tonnes for dry season rice), GP values indicated a profit of USD256.87 and USD263.06 per ha and an average GM of 43.70% and 38.43%, respectively.

Non-rice crops, vegetables and fruit

For non-rice crops, four households produced an average 2.1 tonnes of cassava on 1.38 ha of land earning an average of USD735 less variable costs (USD442.38) for an average GP of USD292.62 (USD212 per ha) (Table 6). A small number of households (n = 3) also produced and sold peanuts, reporting an average income of USD148.50 less variable costs (USD43.89) for an average GP of USD104.61. For one household, sale of 4 tonnes of cashews (USD5000) resulted in a GP of USD3727.50 after harvesting and transportation costs. For another household, sale of 1.3 tonnes of lotus seed provided a net income of USD646.25 after purchase of seed and chemical fertiliser and land preparation, planting and irrigating and harvesting expenses. For vegetables, eggplants resulted in the highest GP (USD575.62), followed by cabbages (USD570) and chillies (USD375.84). In general, average GP values for fruit were low (< USD100) with the exception of custard apples (USD583.33), bananas (USD345) and coconuts (USD195). For one household, an income of USD1500 was generated through sale of pineapple, although the GP was low (USD85) due to high variable costs, particularly seed and fertiliser. Overall, the average GM for non-rice crops, vegetables and fruit was 83.08%, 85.27% and 62.12%, respectively.

Livestock

Overall, pig raising had a higher GP value (USD1841.79) compared to cattle (USD950.80) and poultry (USD50.16) although the GM calculation showed the highest value for cattle (89.33%) followed by pigs (54.05%) and poultry (20.54%) (Table 7). For pigs, income was generated from the sale of fattened pigs (USD2745), followed by sale of piglets (USD1200). At the household level (n = 3), total average income from pig raising was USD3407.50 less variable costs (USD1565.71) with supplementary feed representing the majority of expenses (93%). For cattle, sale of live animals was the most common source of income (70%), generating USD970.63 on average per household (n = 14). One household reported income of USD1250 from breeding services at USD12.50 per joining, with three households earning USD25 on average from sale of manure. Expenses associated with cattle raising were low (USD113.58) with inputs to forage plots, breeding and purchasing of supplementary feed representing 36%, 28% and 17% of total variable costs, respectively. Similarly, for poultry, average variable costs were low (USD194) for all households (n = 20) with supplementary feed representing 82% of total costs. Total income from poultry was USD244.16 per household with sale of live birds the most common income generating activity (60%). For two households, sale of chicks was an important income source generating USD700 on average, whilst for another household, sale of embryos generated USD500 over the course of the year.

Discussion

The results from this study indicate that whilst cattle-owning households undertake a range of livelihood activities, cattle account for the majority of total household income (22%) contributing an average of USD1064 per household over a 12-month period. This finding has been noted in other studies of smallholder cattle-owning households in Cambodia, where 69% of households ranked cattle as the main contributor to household income (Samkol et al. 2015) and average income from cattle per household was USD918 (Darit et al. 2016). Off-farm income sources were also shown to be important, with 55% of households valuing off-farm income above cattle raising as the most important income generating activity for the household. However, for both activities (cattle raising and off-farm sources), the wide range of income reported (USD0–2300 and USD110–12,625) and contribution to total household income (0–77% and 0–98%) indicates remarkable
Table 5. Gross margin analysis of reported values for wet season (WS) rice and dry season (DS) rice

<table>
<thead>
<tr>
<th>Activity</th>
<th>n</th>
<th>Area (ha)</th>
<th>Prod. (t)</th>
<th>Sold (t)</th>
<th>Price ($/t)</th>
<th>Total (A)</th>
<th>Seed</th>
<th>Land prep</th>
<th>Chem. fert.</th>
<th>Peide</th>
<th>Heide</th>
<th>Plntng</th>
<th>Irrig.</th>
<th>Hrvst</th>
<th>Mill</th>
<th>Pkg</th>
<th>Trans</th>
<th>Total (B)</th>
<th>GP ($)</th>
<th>GM (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per household</td>
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</tr>
<tr>
<td>WS rice</td>
<td>14</td>
<td>2.11</td>
<td>4.19</td>
<td>1.74</td>
<td>281.25</td>
<td>417.86</td>
<td>3.50</td>
<td>143.98</td>
<td>130.55</td>
<td>11.27</td>
<td>16.43</td>
<td>50.29</td>
<td>3.33</td>
<td>207.86</td>
<td>21.16</td>
<td>12.87</td>
<td>14.13</td>
<td>615.13</td>
<td>-197.27</td>
<td>-47.21</td>
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<tr>
<td>If 100% sold</td>
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<tr>
<td>DS rice</td>
<td>4</td>
<td>0.83</td>
<td>3.13</td>
<td>1.88</td>
<td>178.75</td>
<td>333.75</td>
<td>60</td>
<td>31.38</td>
<td>68.13</td>
<td>6.56</td>
<td>18.31</td>
<td>87.50</td>
<td>70.63</td>
<td>69.38</td>
<td>0</td>
<td>6.23</td>
<td>6.25</td>
<td>424.35</td>
<td>-90.60</td>
<td>-27.15</td>
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<tr>
<td>If 100% sold</td>
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<tr>
<td>WS rice</td>
<td>14</td>
<td>1.00</td>
<td>2.09</td>
<td>0.67</td>
<td>281.25</td>
<td>188.44</td>
<td>5.06</td>
<td>71.21</td>
<td>58.39</td>
<td>3.40</td>
<td>7.01</td>
<td>48.54</td>
<td>2.74</td>
<td>108.87</td>
<td>14.23</td>
<td>4.92</td>
<td>6.57</td>
<td>330.94</td>
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<td>-75.62</td>
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<td>If 100% sold</td>
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</tr>
<tr>
<td>DS rice</td>
<td>4</td>
<td>1.00</td>
<td>3.83</td>
<td>2.09</td>
<td>178.75</td>
<td>373.59</td>
<td>55.55</td>
<td>28.27</td>
<td>73.39</td>
<td>10.72</td>
<td>12.82</td>
<td>153.57</td>
<td>78.96</td>
<td>96.88</td>
<td>0</td>
<td>7.27</td>
<td>9.51</td>
<td>421.55</td>
<td>-47.96</td>
<td>-12.84</td>
</tr>
<tr>
<td>If 100% sold</td>
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</tr>
<tr>
<td>WS rice</td>
<td>14</td>
<td>0.53</td>
<td>1.00</td>
<td>0.29</td>
<td>281.25</td>
<td>81.56</td>
<td>2.20</td>
<td>32.67</td>
<td>31.60</td>
<td>1.76</td>
<td>3.27</td>
<td>21.62</td>
<td>1.47</td>
<td>57.29</td>
<td>6.38</td>
<td>2.85</td>
<td>3.32</td>
<td>164.41</td>
<td>-82.85</td>
<td>-101.58</td>
</tr>
<tr>
<td>If 100% sold</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DS rice</td>
<td>4</td>
<td>0.27</td>
<td>1.00</td>
<td>0.55</td>
<td>178.75</td>
<td>98.31</td>
<td>14.38</td>
<td>7.52</td>
<td>19.35</td>
<td>2.73</td>
<td>3.39</td>
<td>40.00</td>
<td>20.65</td>
<td>25.04</td>
<td>0</td>
<td>1.89</td>
<td>2.52</td>
<td>109.97</td>
<td>-11.66</td>
<td>-11.86</td>
</tr>
<tr>
<td>If 100% sold</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

No farmers reported expenses for manure for fertilizer as they used manure from their own cows

<table>
<thead>
<tr>
<th>Activity</th>
<th>Production</th>
<th>Variable costs</th>
<th>GP ($)</th>
<th>GM (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area (ha)</td>
<td>Prod (t)</td>
<td>Selling unit</td>
<td>No. sold</td>
</tr>
<tr>
<td>Non-rice crops</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cassava</td>
<td>4</td>
<td>1.38</td>
<td>21</td>
<td>35</td>
</tr>
<tr>
<td>Peanut</td>
<td>3</td>
<td>0.17</td>
<td># kg</td>
<td>270</td>
</tr>
<tr>
<td>Corn</td>
<td>1</td>
<td>0.30</td>
<td># cobb</td>
<td>1600</td>
</tr>
<tr>
<td>Cashew</td>
<td>1</td>
<td>4.00</td>
<td>1.3 kg</td>
<td>1300</td>
</tr>
<tr>
<td>Lotus</td>
<td>1</td>
<td>0.90</td>
<td>1.3 kg</td>
<td>1300</td>
</tr>
<tr>
<td>Overall</td>
<td>10</td>
<td>1064</td>
<td>578.00</td>
<td>884.00</td>
</tr>
<tr>
<td>Vegetables</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cucumber</td>
<td>3</td>
<td>0.13</td>
<td># kg</td>
<td>130</td>
</tr>
<tr>
<td>Chili</td>
<td>2</td>
<td>0.65</td>
<td># kg</td>
<td>305</td>
</tr>
<tr>
<td>Eggplant</td>
<td>3</td>
<td>0.85</td>
<td># kg</td>
<td>3000</td>
</tr>
<tr>
<td>Longan</td>
<td>1</td>
<td>0.08</td>
<td># kg</td>
<td>600</td>
</tr>
<tr>
<td>Guava</td>
<td>1</td>
<td>0.04</td>
<td># Kg</td>
<td>240</td>
</tr>
<tr>
<td>Morning glory</td>
<td>1</td>
<td>0.02</td>
<td># Kg</td>
<td>240</td>
</tr>
<tr>
<td>Overall</td>
<td>11</td>
<td>339.38</td>
<td></td>
<td>0.00</td>
</tr>
<tr>
<td>Fruit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coconut</td>
<td>4</td>
<td>22.50</td>
<td># fruit</td>
<td>780</td>
</tr>
<tr>
<td>Custard apple</td>
<td>3</td>
<td>0.67</td>
<td># area</td>
<td>607</td>
</tr>
<tr>
<td>Mango</td>
<td>1</td>
<td>1.25</td>
<td># kg</td>
<td>27.50</td>
</tr>
<tr>
<td>Orange</td>
<td>1</td>
<td>0.50</td>
<td># kg</td>
<td>1500</td>
</tr>
<tr>
<td>Pineapple</td>
<td>1</td>
<td>0.87</td>
<td># fruit</td>
<td>67</td>
</tr>
<tr>
<td>Banana</td>
<td>1</td>
<td>1.00</td>
<td># bunch</td>
<td>250</td>
</tr>
<tr>
<td>Jackfruit</td>
<td>1</td>
<td>2.00</td>
<td># kg</td>
<td>27.50</td>
</tr>
<tr>
<td>Overall</td>
<td>17</td>
<td>248.16</td>
<td></td>
<td>0.00</td>
</tr>
</tbody>
</table>

a For one household that received income from cassava, total variable costs (USD700) equaled the price paid for existing cassava on purchased land.

b Average area represented as number of trees.

^ Transportation costs included with longan because farmer transports cabbage and morning glory at the same time.
Table 7. Gross margin analysis of reported values for livestock (cattle, pigs and poultry)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Income</th>
<th>Variable costs</th>
<th>GP ($)</th>
<th>GM (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Selling unit</td>
<td>No. sold</td>
<td>Price ($/unit)</td>
</tr>
<tr>
<td>Cattle</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sale of live animals</td>
<td>14</td>
<td>Head</td>
<td>~ 1.6</td>
<td>592.86</td>
</tr>
<tr>
<td>Sale of manure</td>
<td>3</td>
<td>Cart</td>
<td>10</td>
<td>2.50</td>
</tr>
<tr>
<td>Breeding services</td>
<td>1</td>
<td>Per time</td>
<td>100</td>
<td>12.50</td>
</tr>
<tr>
<td>Per household</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pigs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sale of piglets</td>
<td>1</td>
<td>Head</td>
<td>24</td>
<td>50</td>
</tr>
<tr>
<td>Sale of fattening pigs</td>
<td>2</td>
<td>Head</td>
<td>~22</td>
<td>125.21</td>
</tr>
<tr>
<td>Sale of sows</td>
<td>1</td>
<td>Head</td>
<td>6</td>
<td>131.25</td>
</tr>
<tr>
<td>Per household</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poultry</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sale of live birds</td>
<td>12</td>
<td>Head</td>
<td>59</td>
<td>4.71</td>
</tr>
<tr>
<td>Sale of chicks</td>
<td>2</td>
<td>Head</td>
<td>700</td>
<td>1.00</td>
</tr>
<tr>
<td>Sale of embryos</td>
<td>1</td>
<td>Egg</td>
<td>2000</td>
<td>0.25</td>
</tr>
<tr>
<td>Sale of eggs</td>
<td>1</td>
<td>Egg</td>
<td>100</td>
<td>0.225</td>
</tr>
<tr>
<td>Per household</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Vacc vaccinations, Vit vitamins, Breed breeding
variation in income choices for Cambodian cattle-owning households. For some households, off-farm sources are likely viewed as more important as they provide a stable source of income with salary and/or remittance received at monthly intervals, enabling daily expenses to be regularly met. For most households, the average sale price of cattle reported (USD971) represents a large lump sum that can be saved and used to support the household over an extended period of time. However, in most cases, sale of cattle is sporadic with animals often only sold when cash is needed and/or when calves are mature (Hasnah et al. 2016). Extended inter-calving intervals of cattle in smallholder systems in Cambodia estimated at 18, 18.6 and 20.2 months (Sath et al. 2008; Pen et al. 2013; Young et al. 2014b) suggests sale of live animals (particularly calves) may not occur every year. Therefore, income from cattle may be underestimated in the current study, and further research investigating annual income from cattle raising is advised to provide a more reliable comparison of this activity compared to off-farm activities. This study also did not assess and include non-monetary contributions of cattle including manure and draft power. However, it is likely that farmers benefitted from use of cow manure for crop fertilisation, particularly those households utilising a biodigester for production of biogas and bio-slurry. Use of this technology would have reduced energy costs and expenses for chemical fertiliser with biogas and bio-slurry replacing the need for these inputs. Also, very few farmers in the current study utilised cattle for draft power. Therefore, this was not included as a non-monetary contribution for participating farmers.

For interviewed households, rice cultivation and poultry raising were considered valuable for household food requirements with product retained for human (milled rice and chicken meat) and animal consumption (rice meal and rice straw). This is not surprising, considering rice forms the basis of the Cambodian diet and accounts for almost two-thirds of caloric intake, and household scavenging poultry acting as a readily accessible low-cost source of protein (FAO 2009; ADB 2012). However, rice production is currently a contentious issue with government agencies promoting rice intensification, despite farmer concerns over price volatility, water availability and high prices for fertilisers and pesticides (ADB 2014). For poultry, exposure of backyard flocks to infectious diseases, such as Newcastle Disease, and Highly Pathogenic Avian Influenza presents food security and human health concerns (Conan et al. 2013; Pfeiffer et al. 2013; Osbjer et al. 2015). However, it is likely that smallholders will continue to produce rice and raise poultry despite these challenges especially where funds are limited and households produce these goods to ensure basic food requirements are met. Current efforts under the VBLDRM project to improve biosecurity at the village level for livestock disease risk management are important and necessary, particularly where the reduction of morbidity and mortality in poultry contributes to provision of a more reliable source of protein for household consumption.

Currently, the use of GMs to compare cropping and livestock activities at the smallholder household level in Cambodia is limited, although GMs have been used to assess the profitability of crop choice and planting time for upland crops, such as cassava, maize, peanut, soybean and sunflower (Belfield et al. 2013; Montgomery et al. 2016; Montgomery et al. 2017). In Vietnam, GM analysis has been used to evaluate the economics efficiency of smallholder pig production systems in North Vietnam (Lemke et al. 2007). Our study compared various crop and livestock activities through the use of GMs to determine and compare the profitability of these activities, with cattle raising suggested to be the most profitable on-farm activity providing an average GM return of 89.33%. For GP, pig raising provided the highest return (USD1841.79) followed by cattle (USD950.80), although there was an exception where one household generated USD3727.50 from produce and sale of cashews over one calendar year. However, several households reported that they no longer raised pigs as they did not consider this activity to be profitable due to the high feed costs and amount of labour required for this activity on a daily basis. When considering variable costs, expenses associated with pig raising was more than 12 times that of cattle raising on average (USD1565.71 vs. USD113.58). For households involved in pig raising, high feed costs may be justified by potential income (USD3407.50) as demonstrated by three households in the current study. However, this is dependent on the scale of the enterprise and market demand, and it is likely that for the average smallholder engaging in pig raising on a small scale, the amount and cost of feed to fatten and sell a small number of animals are not worth the monetary and labour investment that can be directed towards other activities. Therefore, when comparing variable costs and labour requirements for livestock, the low-variable costs for cattle raising may be more attractive to smallholders where forages can be grown at home at minimal expense (USD 41.37) and labour requirements of cattle feeding due to improved forage availability are reduced. These factors, combined with the increasing demand for beef in the region, likely present cattle as a more attractive livestock species to invest in for smallholders in Cambodia. However, smallholders need to consider the labour and funds required to invest in cattle raising, with income from off-farm sources likely providing additional monetary funds to support this activity.

There are a number of considerations associated with this study. Firstly, the results present a snap shot of activities undertaken during the course of one calendar year and it is recognised that the livelihood strategies of interviewed households will change over time (Jiao et al. 2017). Secondly, comparison of on-farm activities proved challenging due to both
the wide range of activities reported and highly variable results observed between households. For commonly reported activities, such as rice, cattle and poultry, the values obtained may be considered representative for smallholder cattle-owning households. However, for other activities, such as pig raising, non-rice crops, fruits and vegetables, where sample sizes were small, further research is recommended to improve the validity of these results, particularly if they are to be used for wider application. Further investigation of potential geographical differences between households is also warranted given lowland Mekong areas represent the majority of data obtained in this study. For future studies, it would be beneficial to expand the study area to include greater representation of upland areas where livelihood activities differ (Samkol et al. 2015). Further, as very few of the farmers kept accurate records, the values obtained in this study relied on farmer recollection and may be subject to recollection bias. Basic record keeping of farm income and expenses should be established as a priority in order to recommend wider use of these economic tools at the smallholder level.

The results of the current study provide a unique assessment of the livelihoods of smallholder cattle-owning households in Cambodia where all household income and expenses have been considered to provide a completed financial record for one calendar year. High returns and low variable costs suggest that cattle raising is a more profitable on-farm activity when compared to other on-farm activities, as determined by GM analysis of the values provided by 20 smallholder cattle-owning households in Cambodia. However, consideration of rice cultivation and poultry raising is recommended as these activities provide important food resources for household consumption. For livestock researchers and policy-makers, continued support of smallholder cattle and poultry raising is recommended with a need to address and overcome challenges facing smallholders to support their transition from keepers to producers and efforts to increase income and improve livelihoods. In particular, reducing extended inter-calving intervals that limit potential income from sale of calves on a yearly basis is advised. For these households, an assessment of current livestock management practices and benefits of project participation to ensure higher level cattle husbandry skills would be beneficial, particularly where training has been provided to improve animal nutrition and biosecurity at the village level.

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Compliance with ethical standards

Statement of human rights Human ethics approval for this study was obtained from the University of Sydney Ethics Committee (project no. 2014/783) in compliance with the State Act and National Codes of Practice. Informed consent was obtained from all individual participants included in the study. This article does not contain any studies with animals performed by any of the authors.

Conflict of interest statement The authors declare that they have no conflict of interest.

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