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Effectiveness and implementation challenges of a livestock asset transfer intervention for smallholders in community-protected areas in Cambodia

Sokchea Huy[1] | Buntha Pheng[1] | Borin Khieu[1] | Ty Chhay[1] | Joshua N. M. Philp[2] | Arata Hidano[3]

[1]General Directorate of Local Community, Ministry of Environment, Phnom Penh, Cambodia

[2]School of Agriculture, Food and Wine, The University of Adelaide, Adelaide, Australia

[3]Faculty of Public Health and Policy, London School of Hygiene and Tropical Medicine, London, UK

Correspondence
Sokchea Huy, General Directorate of Local Community, Ministry of Environment, Phnom Penh, Cambodia.
Email: huysokchea@gmail.com

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Abstract

Background: Limited opportunities to generate income in community-protected areas (CPAs) often lead to the illegal harvesting of wildlife and natural resources, undermining the aim of protected areas. Sustained livestock production can be an alternative income source.

Objectives: To understand the effectiveness and feasibility of livestock production in CPAs.

Methods: We conducted a livestock asset transfer intervention in 25 CPAs across three agroecological zones in Cambodia. We monitored livestock mortality, consumption and sales of livestock over 2 years. Participant observations and structured questionnaires were conducted to elicit information about constraints for livestock production perceived by the participants. A total of 756 households were recruited and 320, 184 and 252 households received chicken, pigs and cattle, respectively. All participants received technical training in livestock production and biosecurity management practices.

Results: After the intervention, the number of chickens, pigs and cattle increased on average by 5.9 (range: 0.3–26.3), 0.5 (−1 to 2.7) and 0.12 (0–0.35) per 1 input animal, respectively. The extent of increase was significantly different between zones only for chickens (Kruskal–Wallis test $p = 0.004$). The number of chickens and pigs sold per household was significantly different among zones. We observed that training was ineffective to alter livestock management practices in some CPAs, which partially explains their suboptimal performance of livestock production.

Conclusions: Understanding contextual factors required for successful livestock production in CPAs is crucial for improving livelihoods and preventing biodiversity loss in Cambodia.

KEYWORDS
community-protected area, implementation, intervention, livestock transfer

1 | INTRODUCTION

Establishing a sustainable income source in community-protected areas (CPAs) is a pressing One Health issue in Cambodia. A total of 174 CPAs, encompassing 45,923 households, have been established in the protection areas by the Ministry of Environment to contribute to natural resource management and non-timber forest products harvesting sustainably for the livelihood because they are located in far-flung areas with limited access to large cities (Ministry of Environment [MoE], 2017). Their livelihoods rely on natural resources, such as harvesting non-timber forest products, hunting wild animals and logging. It is estimated that non-timber forest products account for 16%–23% of household income ($100–$340/year) for vulnerable populations in the CPAs (Clements et al., 2014; Hansen & Top, 2006; McKenney et al., 2004; Nuppun Institute for Economic Research [NIER], 2019; Ruiz-Pérez et al., 2004). Thus, CPAs play a vital role in managing sustainable NTFPs harvesting and controlling illegal forest clearing which is likely to cause biodiversity loss and an increase in contact between humans and wildlife in the region. This can cause the emergence and transmission of novel zoonotic diseases (Keesing et al., 2010).

The majority of the CPAs are spread across three agroecological zones in Cambodia; Northern of Tonle Sap Lake, Southern of Tonle Sap Lake and Eastern of Mekong River. Each of these zones has a distinct geography, ecology and biodiversity. Northern Tonle Sap Lake includes five provinces (Kampong Thom, Preah Vihear, Siem Reap, Banteay Meanchey and Odormeanchey) and has a total of 74 CPAs. Southern Tonle Sap Lake includes six provinces (Pursat, Kampong Chhnang, Battambang, Kampong Speu, Kampot and Koh Kong) and has 49 CPAs. Eastern Mekong River has four provinces (Kratie, Stung Treng, Ratanakiri and Mondulkiri) and has 38 CPAs. The population in CPAs increased by 15.7% between 2014 and 2019 (from 203,000 to 235,000 persons), which is much higher than that of the national level (5.9%). As of 2020, 43% of the population in CPAs were below 15-year old and women accounted for nearly 50%. The majority (71%) of the households comprised approximately five to seven members, and 85.6% were headed by men (Bannister-Tyrrell et al., 2018). Only 32% of the population received some form of education because children work for their families' livelihood and schools are not easily accessible (CARE-International Cambodia, 2002).

Livestock production using local breeds has the potential to reduce poverty and contribute to environmental conservation in CPAs (Poulsen et al., 2015). Products from local breeds are preferred by local populations, generally fetching a higher price in Cambodia. Local breeds are also more adapted to local harsh environments and endemic diseases (Bishop, 2012; Thornton et al., 2009). Scavenging and free-grazing animals can contribute to improved soil quality and greater vegetation coverage through regenerative agriculture (Ba Diao, 2006; Steinfeld et al., 1997; Zhang et al., 2020). Despite these benefits, it is estimated that only 20%–30% of the households in CPAs can make a profit from livestock (personal communication with the Provincial Department of Agriculture, Forestry and Fishery). This low percentage is partially attributable to the suboptimal livestock management practice in CPAs.

Livestock asset transfer coupled with training programs has been frequently used in development programmes. Through donating livestock, these interventions aim to improve the nutrition status and economic stability of rural populations (Flax et al., 2021; Glass et al., 2017; Janzen et al., 2018; Thompson & Magnan, 2017). Although some of these trials showed promising impacts (Banerjee et al., 2015), others showed no lasting impact on livelihoods (Bauchet et al., 2015). This disparity is attributable mostly to local contextual factors; for instance, Bauchet et al. (2015) reported that many participants dropped out of the intervention because of an increase in local wages, leading to the limited long-term impact of the intervention. Indeed, local factors often hinder extrapolating the identified efficacy of interventions under controlled settings (e.g. randomized control study) to other settings. Interventions may bring unintended outcomes for various reasons. Participants may not uptake the intended intervention or interventions are not implemented as designed (Peters et al., 2014). Successful livestock transfer asset programs, therefore, require an understanding of what motivates smallholders to continue livestock production in the context, how diseases impact production and how feasible livestock rearing is. Nevertheless, the literature provides limited information on these factors in the CPA context. With this background, we examined (1) the effectiveness of the livestock asset transfer intervention which was conducted in selected CPAs in Cambodia, and (2) contextual factors relevant to livestock health and production that affected the implementation of this intervention.

2 | MATERIALS AND METHODS

This study was approved by the Ministry of Environment, Cambodia and part of the project 'Improvement of livelihood of the people living in community protected areas to contribute to natural resource protection and conservation' (2017 No. 968 Sor.Chor.Nor).

2.1 | Project intervention

2.1.1 | Study site

This study purposively selected 25 CPAs; 11 CPAs from Northern Tonle Sap Lake, 9 CPAs from Southern Tonle Sap Lake and 5 CPAs from Eastern Mekong River. The selection was based on the proposal and suggestion from the Provincial Department of Environment, which has continuously assessed the need of each CPA. Figure 1 shows the provinces that have the CPAs selected in this study and three agroecological zones.

2.1.2 | Intervention

We conducted a systematic review to develop a theory of change for the livestock asset transfer intervention in CPAs, Cambodia. The theory of change describes hypothesized causal pathways to impacts,

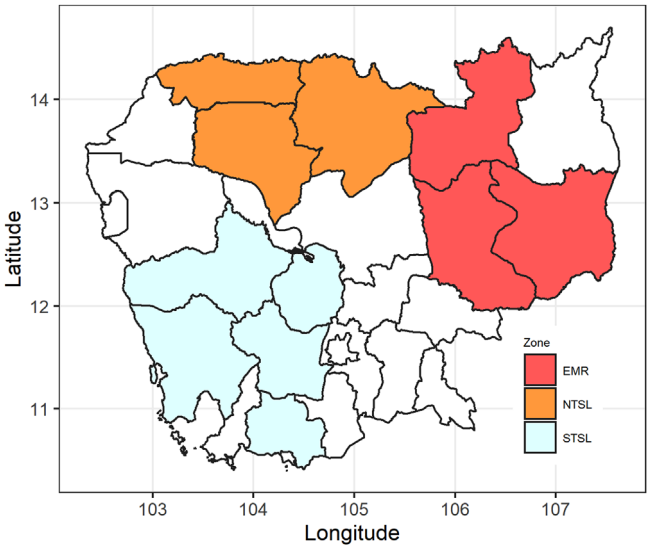

FIGURE 1 Map of Cambodia and three intervention zones: EMR, Eastern Mekong River; NTSL, Northern Tonle Sap Lake; STSL, Southern Tonle Sap Lake.

providing an account of 'how and why' an intervention works (De Silva et al., 2014). We searched PubMed and Scopus databases using terms ('livestock transfer' OR 'livestock productive asset transfer' OR 'livestock asset transfer') AND (intervention* OR program* OR trial*), which identified a total of 14 papers as of January 2022. All papers were reviewed and information relevant to the theory of change was extracted. Two papers explicitly presented the theory of change they used (Flax et al., 2021; Kafle et al., 2019). Drawing on these and expert opinions from the General Directorate of Local Community (GDLC), the Ministry of Environment, a theory of change was developed for this intervention (Figure 2). The theory of change assumes that a provision of livestock coupled with training increases recipients' knowledge and skills for livestock management. Individuals will then adopt appropriate management practices, which in turn reduce livestock mortality and increases the consumption and sales of animals. These increases will generate income and motivate individuals to implement Passing on the gift. In this study, we monitored the effectiveness of the intervention on three intermediate outcomes and Passing-on-the-gift outcome. The outcome data collected from each household were aggregated on the CPA level by the field data collectors to ensure anonymity, which was used for analyses as described later.

2.1.3 | Selection of direct beneficiaries and animal distribution

The initial meetings with the villagers were held to introduce the purposes of the project (including the benefit of Passing on the gift to communities) between June and November 2016 in the selected CPAs. Discussions with local authorities were then held to select the beneficiaries. The beneficiaries were selected using the primary and secondary criteria set by GDLC. The primary criterion was to prioritize widows as well as poorer individuals who did not own livestock. The secondary criterion was to select individuals who had sufficient labour to care for livestock and space for livestock housing. In total, 756 households from 25 CPAs were invited to participate in this project; 377, 193 and 186 households were recruited from Northern Tonle Sap Lake, Southern Tonle Sap Lake and Eastern Mekong River, respectively. The invited beneficiaries were given detailed explanations of the project, including the requirement of Passing on the gift as explained later. All households agreed to participate in this project. Beneficiaries could choose to receive one of two livestock species. Offered livestock species (either pig or chicken or cattle or chicken) varied among CPAs and were based on the preference of each community. Three pigs (2 female and 1 boar), 10 heads of chicken (9 female and 1 cock) or 1 female cattle (heifer) were offered. All distributed animals in this study were local breeds such as Yellow cattle (Harding et al., 2007; Saroeun et al., 2007) rather than improved or exotic breeds. The distribution commenced in September 2017. Overall, 252 households received cattle, 184 received pigs and 320 received chickens.

2.1.4 | Training course

Four training courses, tailored to each livestock species, were provided for all beneficiaries by livestock production specialists from GDLC. All training courses were conducted in beneficiaries' communities and scheduled so that they did not disturb beneficiaries' jobs. All training was designed following the farmer field school approach, which was developed by Food and Agriculture Organization (FAO, 2006). The farmer field school focuses on co-producing learning opportunities for individuals to shift to sustainable production and solve contextual problems (FAO, 2006). The first training focused mainly on livestock housing and was conducted before the livestock distribution. The other three courses focused on the principles and skills of breeding, feeding and feed management, livestock management and biosecurity practices, respectively. The timing of the training was adjusted for the growth stage of animals so that the beneficiaries could apply the learned skills immediately.

2.1.5 | Passing on the gift

This intervention adopted the concept of Passing on the gift approach to generate a sustainable impact on the community (De Vries, 2012). When the direct beneficiaries' animals (first-generation) produced offsprings (second-generation), these beneficiaries reared the second-generation animals until they reached a similar age as the first-generation animals when they were initially distributed. The second-generation animals were then given to villagers who did not receive the first-generation animals. The number of animals to pass on depended on the number of first-generation animals they received. For instance,

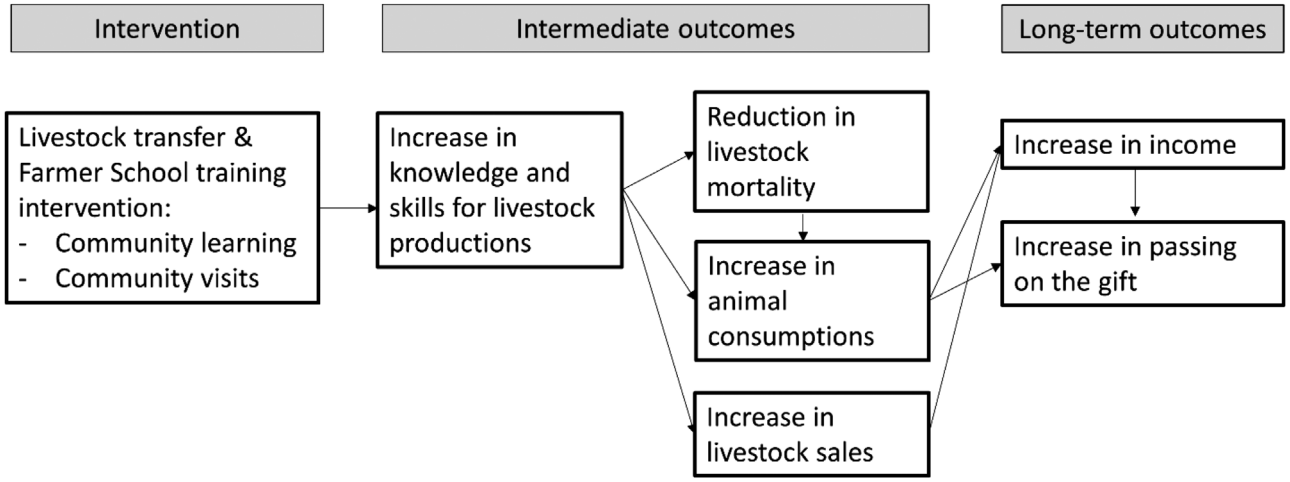

FIGURE 2 The theory of change for the livestock transfer and training intervention.

those who received one first-generation animal were required to pass on two animals; one animal was passed on to a villager and another one was sold to support the administration and monitoring of this project. All the beneficiaries were asked to complete Passing on the gift within 3 years unless their animals died.

2.1.6 | Feeding and feed management

The intervention prescribed that the diet of animals should be based mainly on locally available feed resources, such as natural grasses field, rice straw, forage, cooked rice, rice bran, vegetable waste and solid kitchen waste. The beneficiaries were asked to graze cattle in the forest and feed with supplementary rice straws in the evening. For pigs, the prescription was to feed twice a day with cooked rice, vegetable wastes and rice bran. The main feed for chickens was through scavenging supplemented with a small amount of paddy rice and broken rice in the morning or afternoon. However, hens with their chicks were not allowed to scavenge for 30 days, and the chicks were fed with concentrate feed to improve the growth performance. Sows and cattle that just gave birth were fed solely with home-made and concentrated feed until 45 and 90 days, respectively, to ensure that they were able to produce milk for their newborns.

2.1.7 | Livestock management and biosecurity practices

Vaccines are in general not accessible in these CPAs and were not provided in this intervention to avoid any disease outbreaks due to improper use of vaccines. Chicks were kept in small net cages for at least 30 days, whereas cattle and pigs with their newborns were not allowed to scavenge for 90 and 45 days. This was to reduce the mortality rate caused by predators, environmental conditions and infectious diseases.

2.2 | Monitoring and evaluation

Project staff from GDLC made regular visits to the CPAs between December 2018 and 2020, in which the staff observed the beneficiaries' livestock management and biosecurity practices. Where deemed necessary, further on-the-job training was provided during the monitoring to enhance beneficiaries' livestock management skills. After 2 years from the commencement, structured questionnaires and visual observations were conducted to elicit information about the number of animals present (excluding any animals kept by participants before the intervention), gave births, died, consumed, sold and passed on to others. The beneficiaries were also asked to share their perceived constraints on rearing and managing their livestock. Field notes were taken during and immediately after fieldwork. The weights of the animals were recorded at the distributions to calculate the average daily gain (ADG). Pigs and cattle were weighed at 8 and 12 months after the distribution, respectively. Chickens were weighed when they produced chicks, which were also weighed approximately at 5 months.

2.3 | Statistical analyses

Various household-level statistics were calculated by dividing their corresponding CPA-level statistics by the number of households in each CPA. For instance, average mortality per household was calculated by dividing the total number of deaths in a given CPA by the number of households that received a given livestock species. The Kruskal–Wallis test was carried out to evaluate the difference across zones. The number of animals increased per input animal Δ was calculated for each CPA, as shown in the following equation, and used as a proxy for a reproduction performance:

$$\Delta = \frac{\gamma + \pi - \theta}{\theta}$$

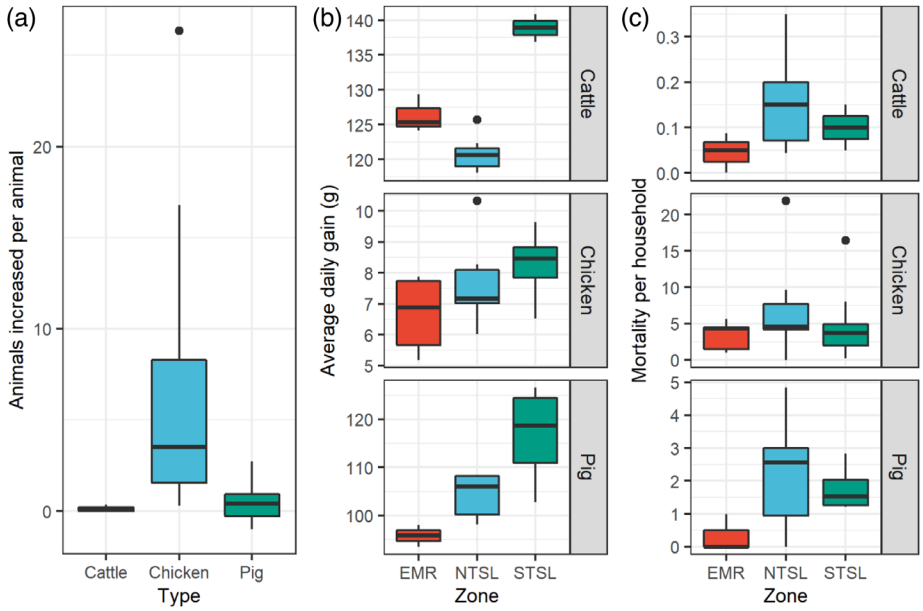

FIGURE 3 Distributions of livestock production indicators in community-protected areas (CPAs). (a) The numbers of animals increased per input animal calculated for each CPA stratified by livestock types; (b) average daily gains in CPAs and their distributions across zones; (c) mortality per household in CPAs and their distributions across zones. EMR, Eastern of Mekong River; NTSL, Northern of Tonle Sap Lake; STSL, Southern of Tonle Sap Lake.

where γ, π and θ represent the number of animals present after 2 years, the number of animals removed (due to sales, consumption and passing) and the number of animals distributed at the beginning, respectively.

3 | RESULTS

3.1 | Performance of livestock production

After 2 years from the commencement, the number of chickens increased substantially compared to that at the beginning (Figure 3A); the provision of one chicken generated on average 5.9 heads (range: 0.3–26.3) in the studied CPAs. However, this increase was significantly different across zones ($p = 0.004$), with Eastern Mekong River having the smallest increase (Table 1). The provision of one pig generated 0.5 heads (range: −1 to 2.7); the number of pigs decreased after 2 years in four CPAs. One CPA in Northern of Tonle Sap Lake lost all pigs provided. The number of cattle was more consistent across CPAs and did not substantially change after 2 years (0.12 heads increased per animal, range: 0–0.35). ADG varied substantially across zones (Figure 3B); there was a significant difference between zones for cattle ($p = 0.026$) and pigs ($p = 0.019$) but not for chickens ($p = 0.068$). Generally, ADG was higher in Southern Tonle Sap Lake compared to the other two zones. There was no significant difference in the average mortality per household between zones. On average, 5.2 heads (range: 0–21.9) of chickens, 1.6 heads (range: 0–4.83) of pigs and 0.11 heads (range: 0–0.35) of cattle died per household over 2 years (Figure 3C).

3.2 | Sales, consumptions and passing of livestock

During the 2 years, 10.8 chickens (range: 0–104.9) were sold per household with a significant difference between zones ($p = 0.015$). The average number of pigs sold was 0.98 (range: 0–3.39), with the sales in Southern Tonle Sap Lake being significantly higher than that in Eastern Mekong River. Out of 25, 24 CPAs sold at least 1 chicken, and 17 CPAs sold at least 1 pig. No cattle were sold in any CPAs. On average 9.5 chickens per household were consumed at home, and there was a significant difference in this number between zones ($p = 0.041$); the consumption per household was significantly higher in Southern Tonle Sap Lake than that in Eastern Mekong River. No pigs or cattle were used for consumption. The mean number of chickens passed per household was 1.40 (range: 0–15.5), with no significant difference between zones. Similarly, the mean number of pigs passed per household was 0.06 (range: 0–0.56) with no significant difference between zones. Eight CPAs passed on at least one chicken, and five CPAs passed on at least one pig. No cattle were passed on to other households in any CPAs.

3.3 | Constraints for livestock productions and intervention implementation

The interviews and field observations revealed various constraints for livestock production in CPAs. Across the CPAs, the beneficiaries demonstrated concerns for seasonal infectious diseases and perceived the clustered deaths of pigs were due to disease. Better access to

TABLE 1 The number of animals distributed, present after 2 years and exited from the population.

Zone	No. households	No. animals provided	No. animals present after 2 years	No. animals sold	No. animals consumed	No. animals passed
Chicken						
NTSL	139	1363	4153	743	911	144
STSL	99	737	4259	2068	1488	242
EMR	82	1101	2030	294	321	0
Pig						
NTSL	92	276	258	47	0	4
STSL	54	216	400	154	0	10
EMR	38	168	114	11	0	0
Cattle						
NTSL	146	146	171	0	0	0
STSL	40	40	43	0	0	0
EMR	66	66	69	0	0	0

Note: Each number presents the sum of community-protected areas for each zone.
Abbreviations: EMR, Eastern of Mekong River; NTSL, Northern of Tonle Sap Lake; STSL, Southern of Tonle Sap Lake.

technical support for livestock health (e.g. agricultural extension workers) was often cited as a priority but absent. The lack of market access was also often cited as a significant constraint by the beneficiaries; they described the difficulty in negotiating the selling price of their animals because they felt ill-informed of the current market information.

Implementing the intervention with fidelity was the key obstacle. The project staff observed that it was challenging for many beneficiaries in Eastern Mekong River to feed twice a day, which was prescribed in the intervention protocol. Those in Northern Tonle Sap Lake and Southern Tonle Sap Lake had in general more experience in pig production compared to those in Eastern Mekong River. Although further training was offered in Eastern Mekong River to fill this gap, the beneficiaries in Eastern Mekong River were often away from home for their jobs such as NTFP collections, which hindered the delivery of sufficient training. Consequently, the staff observed that the livestock management practices in Eastern Mekong River did not alter markedly. A factor that positively influenced the uptake of training and improved livestock management was the active involvement of local CPA committees. Although the project staff made regular visits to the study sites, the voluntary monitoring made by some CPA committees was crucial to keep the beneficiaries engaged in the intervention and hence completing Passing on the gift. Many CPAs which established this voluntary monitoring in Northern Tonle Sap Lake and Southern Tonle Sap Lake completed at least one Passing on the gift.

4 | DISCUSSION

Conservation of wildlife and natural resources in CPAs in tropical countries is one of the key priorities for preventing the emergence of disease that has pandemic potential. Improved livestock productions in CPAs may contribute to this objective through improving livelihoods of people and averting unplanned harvest of natural resources. Our results showed that livestock asset transfer coupled with training can be useful for improving livestock production in CPAs; however, the impact of such interventions can be limited in some CPAs due to contextual factors. Sustained 'Passing on the gift' of animals is the key to a sustained impact of livestock transfer interventions, and we showed that this cannot be achieved without strong support and willingness from local communities.

The average numbers of chickens consumed, sold and passed on per household over 2 years were highest in Southern Tonle Sap Lake. This zone also showed the largest increase in the number of chickens. Field observations suggested that individuals in Southern Tonle Sap Lake maintained quality chick management and provided sufficient feed supplements. Although the beneficiaries in Southern Tonle Sap Lake tended to sell chickens rather than consume them, the opposite trend was observed for those in Northern Tonle Sap Lake. These trends are likely to be an outcome of complex factors, such as market access, availability of other human food and timing of chicken production. The practice of selling chickens observed in Southern Tonle Sap Lake is likely to be attributed to the existing poultry market chains that connect villages and large cities (PIN, 2015). Our result suggested that this practice was difficult for other zones with limited market access. Local chicken breeds have a high market demand in Cambodia for their meat texture and taste (PIN, 2015), especially during festivals and celebrations (Heng, 2018). However, the window for selling chickens at their premium price is rather short because the value of chickens drops once chickens weigh more than 1.2–1.5 kg as their meat texture is less preferred. The establishment of farmer groups and contract farming may be an option to improve market access; however, rigorous evaluations are crucial to ensure that this strategy is sustainable and profitable for individuals in CPAs. Unlike chickens, pigs and cattle were not used for consumption in any zones. People generally do not slaughter pigs and cattle in Cambodia for home consumption except for special occasions such as weddings and funeral ceremonies.

As expected, the number of cattle did not substantially increase due to their long production cycles. The observed increase in Northern Tonle Sap Lake (10%) was, however, larger than the average increase in all CPAs (4%) between 2014 and 2019 reported elsewhere (CSIP, 2021), suggesting that cattle productions in CPAs may be feasible if smallholders receive appropriate training such as one conducted in this study. The ADG of cattle was highest in Southern Tonle Sap Lake (138.89 g/day), and we reason that this figure can serve as a target for other CPAs in Cambodia. Some controlled experiments conducted for local Yellow cattle breeds in Cambodia (Phanthavong et al., 2018; Sath et al., 2008) reported higher ADG values, which are difficult to achieve in many CPAs where cattle feed other than rice straw is limited. The use of supplementary feed that is locally available, such as sun-dried groundnut foliage, may improve the ADG (Samkol et al. 2017). Therefore, further studies are warranted to identify feasible strategies to improve cattle growth in each CPA.

Based on our interviews with the participants and field observations, pig productions were challenging in the studied CPAs. It appeared that pig productions in Northern Tonle Sap Lake and Eastern Mekong River were not sustainable, at least in this project, for several possible reasons. First, the pig management in Northern Tonle Sap Lake and Eastern Mekong River was suboptimal. We observed that the investment required for pigs was much more than that for chicken and cattle. Furthermore, humans and pigs share the same diet (e.g. rice and grains) in many CPAs that rely on subsistence farming, and this was cited as a problem, particularly by those in Northern Tonle Sap Lake and Eastern Mekong River who generate less income compared to Southern Tonle Sap Lake. These together resulted in a suboptimal feeding practice for pigs. Although chickens and cattle could find most feed resources on their own, pigs require elaborated feed management. Second, the presence of endemic diseases, such as Classical Swine Fever and African Swine Fever in the region (Denstedt et al., 2021), also poses a threat to sustainable pig production, which potentially undermines producers' willingness to invest in biosecurity. Those in Northern Tonle Sap Lake and Eastern Mekong River also cited that they suffer from predation on livestock, particularly piglets and chickens. The difficulty of pig production is also highlighted in a recent study that reported the number of pigs in CPAs decreased by 39% between 2014 and 2019 (CSIP, 2021). Third, our project staff observed that the provided training did not sufficiently improve the management skills for pigs in some CPAs (especially CPAs in Eastern Mekong River), although we did not quantify these changes in this study. We reason that some training contents were not optimized for individuals that had lower education levels and/or limited time available to attend training. The training was also not designed for individuals from minority ethnic groups in Eastern Mekong River that have distinct livestock management practices (Huy et al., 2018). Therefore, some participants may have felt inappropriate or they were unable to implement practices that were recommended. Household sizes in this study were much smaller than the average household size in CPAs in Cambodia (Bannister-Tyrrell et al., 2018). The illiteracy rate in the studied population, especially for Eastern Mekong River, was also higher than the rate estimated for all CPAs (14.4%) and the national level (4%) (CSIP, 2021). Sub-populations of CPAs may hold distinct perceptions towards livestock and their management. Previous studies showed that such perception is affected by contextual factors, such as accessibility to markets, availability of animal health services, perceived food security and the community's culture for cooperation (Chenais et al., 2021; Limon et al., 2014, 2017; Lumborg et al., 2021). A follow-up qualitative study is crucial to understand how contextual factors affected the extent to which participants were engaged in livestock management practices recommended in this study.

Several limitations of this study should be noted. This study did not conduct a randomized livestock allocation because we reasoned it was unethical to provide participants with livestock species which they did not want or were not able to manage. The effectiveness of the intervention we reported, therefore, requires a cautious interpretation. Furthermore, the age and weight of cattle were not entirely controlled when distributed because it was infeasible. This may have contributed to the observed difference in reproductive performance between CPAs as mating might have been delayed for younger and lighter cattle (Shorten et al. 2015). To fully capture the intervention impact, it is important to monitor the change in household income and compare these changes between intervention and control groups. This was not possible in this study because of the budget limitation. Although a completion of at least one Passing on the gift was a requirement for participants, this was not strictly reinforced nor the successful participants did not receive any rewards; this might have affected the extent of the commitment from participants and hence their productions. The data collected through interviews and observations in this study are likely to be influenced by the experience and position of field investigators, who are government officials.

The use of evidence-based practices, such as livestock transfer intervention, is crucial for improving the livelihood of vulnerable populations. Yet, many evidence-based practices fail to provide intended outcomes in real-world settings because these evidence-based practices are not adopted by the target population and are not implemented as prescribed (Lobb & Colditz, 2013; Peters et al., 2014). Implementation science discipline tackles this so-called Know-Do gap or Research-to-Practice gap in public health interventions, but such studies are scarce in veterinary medicine. Our study covered a wide geographical area of CPAs in Cambodia, highlighting the important variation in the intervention effectiveness and implementation challenges across agroecological zones. These results serve as an important stepping stone to better understanding which livestock-related interventions work and why in each local context.

5 | CONCLUSION

We demonstrated that livestock productions are feasible for individuals in CPAs, thereby potentially contributing to the protection of biodiversity in Cambodia. The impact and feasibility of livestock production, however, varied between agroecological zones. Knowledge and skills required by individuals for livestock production also seem

to vary across subpopulations. Therefore, a one-size-fits-all livestock asset transfer intervention does not exist and interventions, including training, should be tailored to each CPA by accounting for contextual factors. Donners and policymakers should be engaged in communications with farmers and make rigorous and continuous evaluations before, during and after the asset transfer projects. This is the only way to accumulate knowledge on what works and why in different contexts in Cambodia, which is crucial for addressing many One Health challenges.

AUTHOR CONTRIBUTIONS

Conceptualization; data curation; formal analysis; investigation; project administration; writing – original draft: Sokchea Huy. Data collection; investigation and project administration: Buntha Pheng. *Project administration; writing – review and editing*: Borin Khieu. *Writing – review and editing*: Ty Chhay and Joshua N. M. Philp. *Formal analysis; visualization; writing – original draft; writing – review and editing*: Arata Hidano.

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CONFLICT OF INTEREST STATEMENT

The authors declare that there is no conflict of interest.

DATA AVAILABILITY STATEMENT

Data are available on request due to privacy restrictions.

ORCID

Sokchea Huy https://orcid.org/0000-0001-6709-8661

TRANSPARENT PEER REVIEW

The peer review history for this article is available at https://publons.com/publon/10.1002/vms3.1191.

ETHICS STATEMENT

The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to. No ethical approval was required as there is no local ethics committee for animal health research in Cambodia; however, this project followed the guidelines of Ministry of Environment (MoE), Cambodia and was approved by MoE.

STATEMENT OF ANIMAL RIGHTS

The international and/or national guidelines for the care and use of animals were strictly followed.

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