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Intensive forage cultivation reduces labour input and increases cattle production income in smallholder mixed farming communities of South Central Coastal Vietnam

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ABSTRACT

We investigated the impact of growing introduced forages on cattle production in three communes (Cat Trinh, An Chan and Phuoc Dinh) in South Central Coastal Vietnam. New forages, management, and feeding practices were introduced to 45 selected Best Bet Farmers (BBF) using participatory-adaptive methods over a 3-year period. The BBF changed their cattle production system from grazing and harvesting of native forages to partial grazing plus stall-feeding of cultivated forages. This changed production system reduced the labour time for the BBF because they spent less time managing and cutting native forage for their cattle. The reduction in labour time enabled farmers to re-allocate saved labour to diversify their activities, and increase household income and social interaction within the community. The process succeeded because the BBF accepted the new forage species and applied the new farming practices delivered within a participatory-adaptive framework. The smallholder farmers' acceptance and ownership of proposed techniques are important for optimising livelihood benefits and ensuring the scaling-out of such techniques to other farmers.

1. Introduction

Livestock production is the primary livelihood source for around one billion poor people around the world [1]. Improved animal husbandry is a fundamental step in helping poor rural communities out of poverty in developing nations [2]. According to Delgado [3], livestock are important to rural livelihoods, and function as living assets, which contribute to food consumption, household income, and well-being.

Per capita meat consumption in Vietnam has increased since 1990. During the 2000s, the average per capita meat consumption in Vietnam increased faster than in the region or the world. From approximately 20 kg/capita/year in 1999, it increased to nearly 50 kg/capita/year in 2009 and 55 kg/capita/year in 2013 [4]. Rising demand for meat creates significant opportunities to increase the benefits gained by smallholder farmers from their livestock and increase income as sales increase and markets develop. However, to date in Vietnam there have been few studies focusing on the ability of smallholder farmers to take advantage of these opportunities [5,6]. Despite increasing beef demand, the number of cattle in Vietnam declined from 6.7 million cattle in 2007 to 5.2 million cattle in 2012 [7] due to the high cost of imported concentrates for feeding cattle, outbreaks of animal disease, lack of market linkage, and poor management skills. The Vietnamese government has identified strategies to develop cattle production to meet the increasing demand and to benefit smallholder farmers [8]. These strategies need to examine fundamental constraints, including limited availability and quality of feed supply, especially in the dry season; and poor capacity to improve cattle productivity through means such as improved cattle feeding, housing, and management practices.

South Central Coastal (SCC) Vietnam is characterised by sandy infertile soils, a long dry season (6–9 months), and low annual rainfall (1160–1710 mm). Natural resource constraints are a major impediment to development and poverty alleviation in this region [9]. In the face of harsh natural conditions, the local governments plan to improve socio-economic conditions of farmers through development of cattle

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production as a complement to crop production. Cattle numbers in the SCC region constitute 22% of the total cattle population in Vietnam [10] and beef production is the main livelihood for about 36% of the smallholder farming population. Cattle production systems in this region can be categorised into two broad types: extensive and intensive [11]. Extensive production systems rely on local breeds of cattle grazing common land, supplemented by often poor quality crop residues such as rice straw. In contrast, intensive production systems largely depend on stall-feeding Zebu and Zebu-cross cattle with cultivated forages, crop by-products and purchased concentrates [12]. In practice, there is a degree of overlap between these two broad production systems, with some essentially intensive-system farmers still using seasonal grazing to a greater or lesser extent and some extensive-system farmers growing small areas of king grass (*Pennisetum purpureum* x *P. glaucum*) and supplementing with rice bran and water spinach 'soup'. Intensive forage systems need to combine the best available species and cultivars with appropriate fertiliser and cutting management to maintain production and quality of forage [13,14].

While cattle continue to play a role in providing draught power, manure for fertiliser and income for smallholders, the lack of high quality on-farm feeds and the cost of commercial alternatives are key constraints to improved productivity. Despite many attempts to increase cattle nutrition and productivity through improved feed resources, feeding and management practices, little progress has been made, possibly due to the poor fit of generically applied technologies to the specific needs of individual smallholders [15]. In recent times, however, there has been a trend toward the use of a more holistic approach to new technology introduction and integration into smallholder farming systems, in which the specific circumstances and needs of farmers are taken account of [16,17]. For example, Lisson et al. [16] used a stepwise participatory-adaptive approach that they termed the 'Best Bet' method, which involved the following steps: (1) identify existing constraints and opportunities within study communities; (2) select a representative range of 'Best Bet' farmers to participate in the study; (3) introduce selected 'Best Bet' intervention options to these farmers to test and monitor under their own farm conditions; and (4) use these 'Best Bet' Farmers (here-in called BBFs) as primary agents for technology transfer to other farmers, utilising their experience and knowledge acquired through participation [16,18].

The objective of this paper was to examine the effect of implementing the Best Bet method, focusing on new forage introduction, on labour use for cattle production by smallholder farmers in South Central Coastal Vietnam. The hypotheses were that small areas of well-managed forage grasses could reduce the labour time needed to feed cattle, and reduce the costs of cattle production.

2. Materials and methods

A participatory-adaptive approach similar to that used by Lisson et al. [16] (and described in the introduction) was employed to assess current constraints and opportunities for improvement of smallholder cattle production in three SCC Vietnam communes. Farmers who agreed to participate in this study implemented a range of best-practice forage development, cattle feeding, and management options, and their progress was monitored. The key steps in this methodology are described below.

2.1. Study commune selection

In 2009, three communes in South Central Coastal Vietnam (Cat Trinh in Binh Dinh province; An Chan in Phu Yen province, and Phuoc Dinh in Ninh Thuan province) were selected as part of a larger research for development project. Selection criteria included practice of a representative farming system, sufficient cattle population, and average farm size, and were assessed using existing provincial, district and commune level data and expert knowledge. Key descriptive characteristics of the selected communes are shown in Table 1, and results in more detail are also available [11]. Cattle production in Ninh Thuan is more extensive, with larger areas, more cattle, and less focus on stall-feeding.

2.2. Best Bet farmer selection

Farmer meetings were then conducted in each commune to raise awareness of project aims, discuss current constraints to and opportunities for improved cattle production, and receive farmer feedback and input, as part of the participatory process. Using baseline survey data an initial 10 BBFs in each commune were then selected in July 2010, in collaboration with commune extension staff. A further five BBFs were selected in February–March 2011 bringing the number of BBFs per study commune to 15 (45 in total). The overarching criterion for selection was that the individual farms should be representative of the prevailing farming systems. Specific selection criteria included possession of cattle, access to sufficient land for new forage development, and availability of labour to implement agreed interventions.

The study also included control farmers (here-in referred to as Non-Best bet farmers or Non-BBFs) to compare with the BFFs. These Non-BBFs were selected with input from commune extension staff, based on following the criteria: (1) ownership of 5–7 head of cattle per household; (2) their location is a different village from the BBFs to minimize the chance of them receiving any support or technical advice from BBFs; (3) they are willing to be involved in the research process from the beginning. As a result, there were nine Non-BBFs households across the three communes selected to participate.

2.3. Selection and introduction of Best Bet interventions

A range of Best Bet intervention options were introduced to each BBF in a stepwise process, starting with new forage introduction, then progressing to improved forage management and cattle feeding practices and improved cattle management, based on individual farmer readiness, need and preference.

2.4. Data collection and monitoring

The study used a 'mixed methods' approach to data collection, using both structured quantitative survey and semi-structured qualitative survey techniques [19]. Regular interviews were conducted with BBFs to monitor the progress of adoption and adaptation of introduced practices and evaluate the impact of practice change on the farming systems, resource allocation and livelihoods of participating smallholder households. Quantitative data on area of new forages planted, forage management and feeding practices, labour input, cost of cattle production, and household income were captured during bi-monthly monitoring visits using a structured questionnaire. Qualitative data on farmer responses to interventions and impacts on knowledge and skills acquisition, household wellbeing, labour allocation, and decision-making were conducted every 3–4 months using semi-structured interview techniques.

2.5. Data organisation and analysis

Data from both quantitative and qualitative monitoring interviews were collated using spreadsheet formats for initial examination using descriptive statistics to explore relationships between new forage introduction, labour use and production costs. Data – focusing on labour

Table 1
Average values for selected farm characteristics, for the three study communes.

	An Chan	Cat Trinh	Phuoc Dinh
Area of agricultural land (m^2)	3070	6090	32070
Female cattle > 12 months	1.6	1.7	9.9
Stall-feeding only (%)	41	42	6

saving impacts of Best Bet intervention practice – were then analysed with general linear mixed models (PROC MIXED, SAS v9.4, SAS Institute, 2008) with the denominator degrees of freedom approximated using the Satterthwaite method. Commune and month were fixed factors. Data from the seven BBFs who failed to proceed with forage establishment was excluded from these analyses. For analyses over time, the REPEATED statement was used, with farmer as the subject, using an autoregressive (AR1) covariance structure. Graphs of changes over time were constructed using the geosmooth function in ggplot2 [20], which plots a smoothed regression line with 95% confidence intervals.

3. Results

3.1. Forage area expansion

The area of newly introduced forages planted per BBF increased significantly ($P < 0.001$) over time during the project in all three communes (Table 2) reflecting a continuing expansion of forage production and use by participating Best Bet farmers. However there was a significant interaction between forage development time and communes ($P < 0.001$), signifying that the trends over time were different for the communes.

During the first 18 months of the study, the average area of new forages per household nearly tripled from around 120 m^2–400 m^2 in An Chan and Phuoc Dinh and from 50 m^2 to 180 m^2 in Cat Trinh (Fig. 1). In the last year of the project (2013), the mean area of new forages per BBF in An Chan and Phuoc Dinh increased from 400 m^2/household to approximately 600 m^2/household, while in Cat Trinh the total area of new forage only reached 200 m^2/household over the same period. Cat Trinh also had the lowest percentage of farmers (80%) who tried the new forage varieties offered. Reasons for not trying new forages included lack of space, prioritization of limited spare land for cultivating cash crops or unavailability of labour. Of those who tried new forages in Cat Trinh, 73% went on to expand their planting areas by project end. In contrast, 90% of Phuoc Dinh and An Chan best-bet farmers had developed new forage areas after 2 years of engagement.

3.2. Change in grazing and cut and carry time for cattle production

The result indicated that the BBFs spent less time on cattle management than the Non-BBFs (Fig. 2). In particular, time spent on cattle production (the sum of grazing time and cut and carry time) decreased

Table 2
Significance of the effects of commune and time on forage development area and labour time for best-bet farmers (BBFs) and Non-BBFs.

	Probability > F		
	Commune	Time	Commune * Time
Forage area (BBFs)	<0.001	<0.001	<0.001
Grazing labour			
BBFs			
Male and Female	0.065	<0.001	0.720
Male	0.618	<0.001	0.798
Female	0.081	0.016	0.046
Non-BBFs	0.043	0.006	0.796
Cut and carry labour			
BBFs			
Male and Female	0.917	<0.001	0.710
Male	0.807	<0.001	0.384
Female	0.625	<0.001	0.682
Non-BBFs	0.057	<0.001	0.387
Total labour			
BBFs			
Male and Female	0.037	<0.001	0.314
Male	0.382	<0.001	0.309
Female	0.162	<0.001	0.049
Non-BBFs	0.003	0.283	0.432
Total cost (BBFs)	0.029	<0.001	0.022

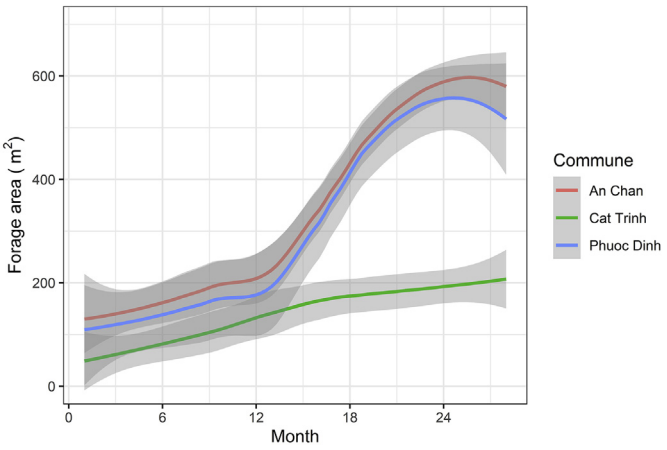

Fig. 1. Cultivated forage area of Best Bet study farmers (n = 38) for three communes in South Central Coastal Vietnam. Coloured lines are smoothed regression lines and the shaded areas are 95% confidence intervals.

significantly ($p < 0.001$; Table 2) over the study period, but not for Non-BBF ($p = 0.283$; Table 2). Moreover, both male and female labour time allocation for cattle production decreased over time, although the trajectories were different (Fig. 2).

There was a significant difference between communes in total labour time for cattle production ($p = 0.037$; Table 2). The decline in required labour over time was highly significant for all communes ($p < 0.001$; Table 2); however the decrease was greatest for An Chan commune. Average labour for cattle production decreased from 440 min/household/day at the beginning of the study to 65 min/household/day at the end of the study (Fig. 3).

Average time spent supervising grazing prior to the development of new forage resources was above 300 min/household/day for both BBFs and non-BBFs across the three study communes at the start of the study (Fig. 4). This decreased to an average of around 70 min/household/day for BBFs by the end of the study, and to 115 by non-BBFs over the same period ($p < 0.006$; Table 2). Time spent supervising grazing by BBFs was initially more than twice as much for males as for females, and consequently the decrease over time was greater for males. However, this decrease was significant for both male ($p < 0.001$) and female ($p < 0.016$) members of the household (Table 2).

The study also found that the average time spent gathering native grass prior to new forage development was approximately 110 min/

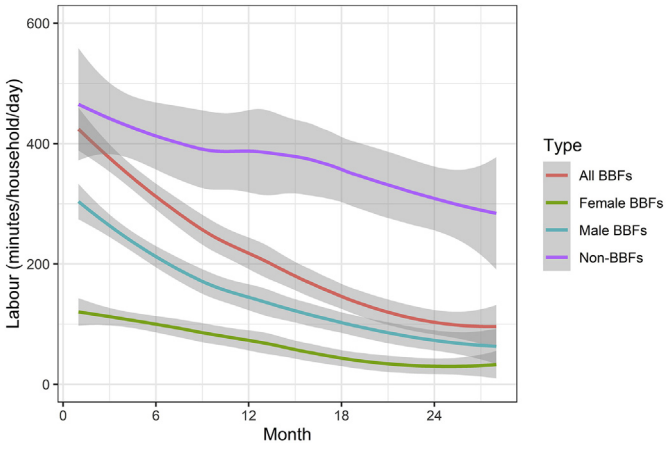

Fig. 2. Changes in the average time allocated to cattle production by men and women Best Bet farmers (BBFs) (n = 38), and non-Best Best farmers (n = 9) across the three study communes. Coloured lines are smoothed regression lines and the shaded areas are 95% confidence intervals.

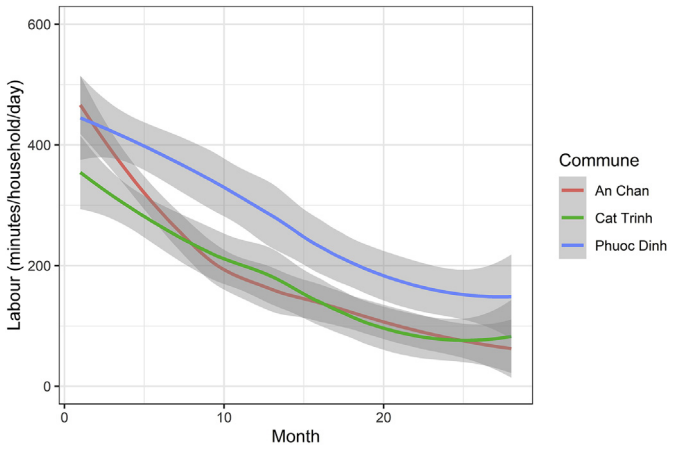

Fig. 3. Changes in the average time allocated to cattle production of Best Bet study farmers (n = 38) for three communes in South Central Coastal Vietnam. Coloured lines are smoothed regression lines and the shaded areas are 95% confidence intervals.

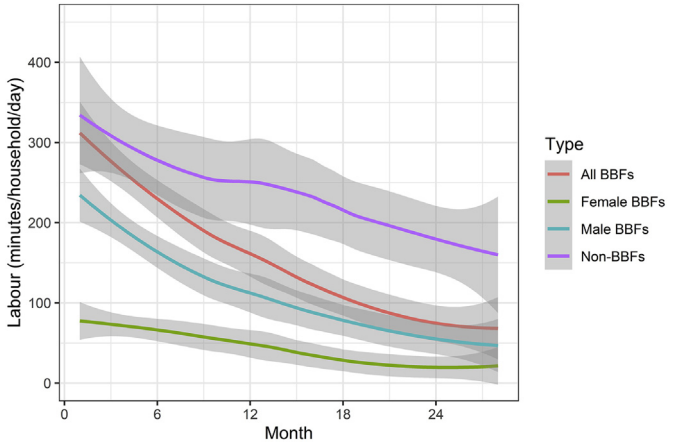

Fig. 4. Changes in the average time allocated to cattle grazing by men and women Best Bet farmers (BBFs) (n = 38), and non-Best Best farmers (n = 9) across the three study communes. Coloured lines are smoothed regression lines and the shaded areas are 95% confidence intervals.

household/day for BBF households and 120 min/household/day for non-BBF households across all study communes (Fig. 5) at the start of the study. For non-BBF households there was a significant change over time; although by the end of the study period, the average time spent was similar to the starting value (140 min/household/day). In contrast, for BBF households, the average time spent gathering local forage dropped to less than 30 min/household/day by the end of the study. This comparatively small amount of time was mostly spent on managing and harvesting new forages. Men initially spent more time gathering cut and carry forage than women. However, the reduction in time spent was significant ($p < 0.001$) for both male and female household members (Table 2).

3.3. Costs of cattle production

The changes in total costs for cattle production over time were different for BBFs in the three communes ($p = 0.022$; Table 2). For Phuoc Dinh, where concentrates are not typically used, the costs remained low throughout the study period, averaging 210,000 VND/month (Fig. 6). For An Chan and Cat Trinh, where stall-feeding is combined with concentrate use, the costs decreased from an average of 725,000 VND/month to around 145,000 VND/month by the end of the study.

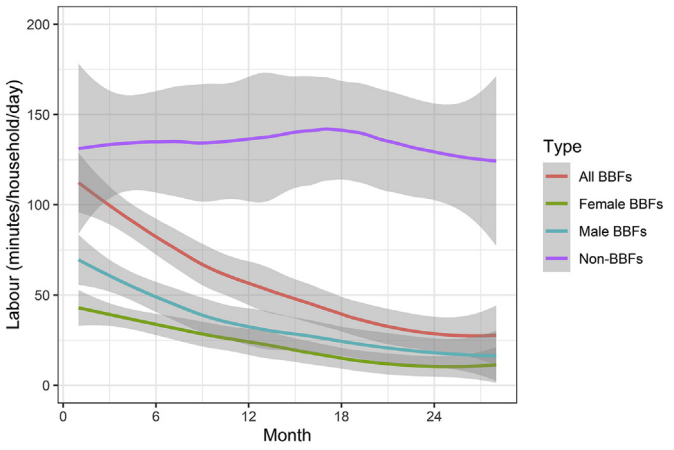

Fig. 5. Changes in time allocated to native grass cut and carry gathering by men and women Best Bet farmers (BBF) (n = 38), and non-Best Best farmers (n = 9) across the three study communes. Coloured lines are smoothed regression lines and the shaded areas are 95% confidence intervals.

3.4. Use of saved labour and time and impact on household income

Development of intensively managed new forage plantings influenced the allocation of labour and time saved to other income generating on-farm and off-farm activities (Table 3). BBF time and labour freed-up from cattle management due to new forage development was usually re-allocated to other income generating on-farm, non-farm, or off-farm activities, thus increasing household income. Forty-seven percent of BBFs in Cat Trinh and Phuoc Dinh reported using their freed-up time to develop cash crops such as chillies, peanuts and vegetables, which provided in excess of 1 million VND/crop. Around 40% of Cat Trinh and An Chan BBFs reported using their saved labour and time to look after poultry and pigs, generating additional on-farm income. Time and labour saved from cattle management also enabled some BBFs to undertake other non-farm or off-farm income generating work.

4. Discussion

Farmer interviews indicated that the early labour saving benefits experienced by participating BBFs was a strong motivation for development and rapid expansion of new forages introduced during this study. For example, a male farmer from Phu Kim village, Cat Trinh commune, Binh Dinh, commented that

> "Normally my wife is responsible for managing the crop production. Sometimes I also help her; however, I am quite busy with my work as a carpenter. Previously I was not able to earn a lot of money from this activity because I looked after my cattle. But now I can save time from cattle production activities because I have my own forage area in my garden. For this reason, I will try to spend time making more furniture to earn money".

Labour saving due to the development of forage plantings also produced other important non-income generating social benefits for participating BBF households. This was typified in the story of the 12-year-old daughter of one An Chan BBF who said:

> "When my mother had to take cattle grazing, I had to cook the lunch. For this reason, I sometimes went to school late and spent a part of my learning time cooking meals. But now, my mother can cook meals for my family because she no longer takes cattle grazing, and I can spend my time learning".

The study is consistent with others which indicate that applying alternative techniques in agricultural production can enhance labour efficiency and save labour costs. For example, Wilson [21] and Gautam

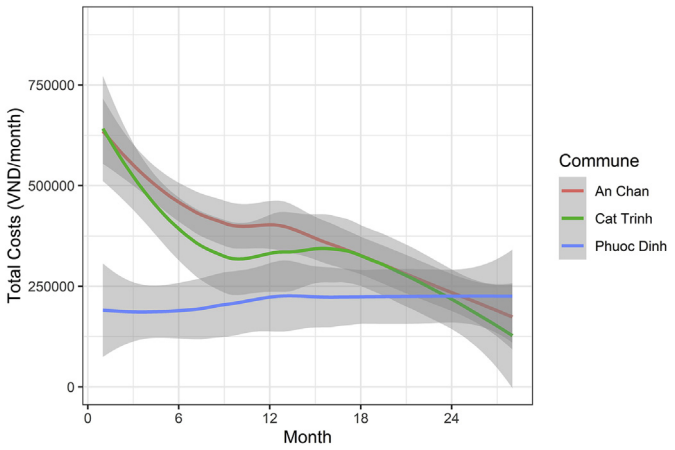

Fig. 6. Changes in costs related to cattle production of Best Bet study farmers (n = 38) for three communes in South Central Coastal Vietnam. Coloured lines are smoothed regression lines and the shaded areas are 95% confidence intervals. VND are Vietnamese Dong.

Table 3
Re-allocation of saved labour time to other activities (Number of farmers).

List of activities	Cat Trinh (n = 12)	An Chan (n = 14)	Phuoc Dinh (n = 12)
Manage crops	5	4	6
Clean the cattle house	3	7	3
Look after pigs and poultry	6	6	4
Off-farm work	4	4	4
Monitor the children's studies	2	5	2
Do housework	6	9	7
Look after the grandparents	2	6	4
Cut and carry of forage	5	4	6

et al. [22] applied improved techniques in animal husbandry to achieve higher efficiency and labour saving. In particular, the employment of Best Bet intervention in cattle production increased cost savings and enhanced labour efficiency. This is analogous to crop production, where alternatives such as efficient use of water, management of fertilizer, planting method [23], and controlling weeds with herbicides [24,25] can reduce the labour cost for irrigation, weeding and other operations. The result from these studies suggest that since farmers can eliminate labour input in agricultural production, they can achieve increased profitability from saving labour costs, and potentially improve their income from other sources.

Labour and cost saving benefits demonstrated by BBFs in this study also provided strong motivations for other farmers to try new forages, once the original BBFs had sufficient new forage planting material to share with them. By early 2012 (roughly one year after most BBFs had received new forages) 17% of BBFs had supplied 3 or more Scale Out Farmers (SOFs) with planting material. By the end of the study in April 2013, this had risen to 83%, with 59% of BBFs supplying 4–9 SOFs and 24% supplying 10 or more SOFs. Some 60% of SOFs sought both forage planting material and knowledge about applying various Best Bet practices, with 83% of those technical enquiries being about new forage management and 52% about feeding new forages. By the end of this study in 2014, at least 231 other farmers had scaled out new forages and associated practices from the original BBFs [26].

The intervention methods used in this study helped increase the active participation of farmers and changed their attitude toward the uptake of improved technologies and practices for feeding and managing cattle. Traditional district and provincial level extension activities in Vietnam typically focus on existing farmer groups (Farmers' Union, Women's Union, Cooperatives) for new knowledge delivery. In contrast, the Best Bet methods used here involved working intensively with selected individual farmers, then using them as primary change agents for new knowledge transfer to other farmers and communities. This approach is founded on knowledge gained from several studies [16,27,28] that farmer-to-farmer learning is the most preferred, trusted and effective option for new knowledge transfer between smallholder farmers. While cost and resources might constrain extension work with individual farmers, the principle of working intensively with smaller groups of farmers then utilising them to demonstrate (and communicate) application and adaptation of new technologies under real farm conditions has proved to be highly effective in scaling up and scaling out new forage and associated technologies [16,27,28]. Such research and extension methods are especially useful where more complex individual or multiple technologies require stepwise introduction, as it allows other farmers to witness and assess their progressive adaptation, integration and cost/benefits under real farm conditions. For this to work effectively, it is imperative that participating farmers are carefully selected to represent a critical balance between the diversity of production systems present in a community (in order to assess the adaptability of new technologies), while also meeting minimum resource and attitude requirements to ensure new technologies can be effectively implemented. This requires close collaboration between stakeholders from target communities and government agencies to ensure mutual understanding of shared goals, engender trust in the application of agreed practices and cooperative problem solving [18,29,30]. The results of post-study interviews in 2013 and 2014 indicated that outcomes from this study could well provide long-term benefits and impacts for livelihoods of smallholders in the target study communes and well beyond [31].

5. Conclusion

Smallholder farming systems are inherently complex agro-ecosystems, which often benefit from holistic problem solving approaches [32–36] and in turn may generate unexpected interactions and outcomes. Thus, whilst the primary goal of new intensive forage development was to improve cattle nutrition and productivity, a major early benefit was the saving of labour and time previously used for supervised grazing, gathering native forage, and other feeding-related activities. This freed-up labour (on average 40% or over 3 h per day) was re-allocated to improve crop management such as fertilizing and weeding, and to develop and expand other crops (e.g. chillies, maize) that in turn resulted in improved income. These labour savings also enabled some household members to take on other non-farm or off-farm work, further improving household income and wellbeing. For women especially, time liberated from native forage cut and carry gathering enabled them to spend more time managing the household; and children often gained more time for studying instead of doing chores. All of these outcomes not only directly benefited participating households, but encouraged participating farmers to trust the advice of study team members to try more new practices associated with forage development, feeding and cattle management, bringing further productivity, income and wellbeing benefits to these communities. Observation by other farmers of the combined benefits derived by participating BBFs led to considerable scale-out of both new forages and importantly associated cattle feeding and management practices to other farmers within all three selected communities and beyond [26]. Significantly, many of these scale-out farmers were either women or older couples seeking to move away from cropping into more intensive cattle production, due to a desire to reduce the heavy labour demands of cropping. Thus, the labour saving benefits of intensive forage production and stall-feeding (rather than grazing) offered a particular attraction to farmers already keeping cattle and those wishing to move into more efficient cattle production.

Declaration of competing interest

The authors confirm that they have no conflict of interest to declare for this publication.

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