Conference Paper

Action Research into a Flood Resilient Value Chain – Biochar-Based Organic Fertilizer Doubles Productivity of Pea in Udayapur, Nepal

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Abstract

Green growth and flood resilient value chain development have been foremost in the minds of vegetable growers in six villages of Udayapur District when they agreed to join pea field trials for a self-made biochar based organic fertilizer. Like so many Nepalese women and men who depend on farming for their livelihoods their top concern was getting high crop yields while lowering their input costs. Farmers of six villages (240 migrant workers' families) are now showing how boosting agriculture productivity and saving costs at the farm level can go hand in hand with national climate change strategies particularly in replacing chemical fertilizers in tropical soils of Nepal, an Action Research project result revealed. The results demonstrated that the biochar based organic fertilizer has enhanced the nutrient efficiency by increasing yields of at least four vegetable crops (peas, bottle gourd, cauliflower, and tomato) in the study area, and this technology was found more resilient to adverse climate (flood and drought) conditions. The trials have further investigated that the combination of biochar and cow urine, a source of nutrients readily available to farmers, have increased fresh pea yields double folds from (3 to 7) $t \cdot ha^{-1}$ in off season (end of Dec. to Mar.). With this learning, a flood resilient pea value chain was developed, where farmers could get increase in income from 9.92 % (traditional value chain) to 44.32 % (upgraded value chain). Further benefits of biochar based organic fertilizer have been recorded with increase of soil organic matter content in the root zone of crops and soil moisture content.

Keywords: biochar based organic fertilizer; chemical fertilizer; flood resilient value chain, fresh green Pea, migrant workers' family; yield.

1. Introduction

There is a significant gap between current and potential agricultural production in Nepal. The low levels of productivity are the result of several factors including a high level of subsistence farming, low level of access to and adoption of suitable improved technologies (both on farm and post harvest), poor availability of inputs (planting material, improved breeds, fertilizer, feed, plant and animal health protection, irrigation, electricity, finance), and limited investment in the agricultural sector [1].

One of the major problems in Nepal is that farmers have poor access to chemical fertilizers. In 2012, the quantity of plant nutrients used per unit of arable land was 28.4 kg · ha^{-1}, which is very low even by South Asian standards [2]. Nepal imports all of its chemical fertilizers but the supply is not sufficient to meet the demand. The fertilizer supply problem is occasionally further aggravated by unofficial blockades and strikes. Although the country has a fertilizer subsidy policy [1], subsidized fertilizer forms only a tiny fraction of the total fertilizer supply. The remainder is supplied through uncontrolled informal channels, facilitated by the open and porous border with India to the south. As with other inputs, the quality of the supply is also a serious issue. Application of poor quality fertilizer results in lower than anticipated impacts on crop productivity and profitability [2, 3]. The imported fertilizers are expensive and prices are rising, which further limits access, especially for poor farmers. Finally, even where the supply and quality of fertilizer is sufficient, application tends to create environmental and soil acidity problems [4].

The problem is not only one of low productivity and poor input supply. Both the input and the output markets are poorly integrated. Farmers, especially smallholders, not only lack access to quality inputs, the link to the markets for their products is also weak due to lack of infrastructure such as farm-to-market roads, collection centers, and storage facilities, and poor access to information about markets and prices. The problems of market access and farmers being able to achieve a fair return from their produce can be addressed using a value chain approach to identify the most suitable crops for a specific situation and the leverage points for increasing return to producers [5, 6].

Low productivity can then be addressed using innovative approaches to inputs. Gathorne-Hardy et al. [7] have suggested that a number of the problems associated with fertilizer access and use can be overcome through use of biochar, a type of fine-grained charcoal created by burning wood and agricultural by-products slowly, at low temperatures, with a reduced oxygen supply, in combination with locally available fertilizer products. Treatment with biochar combined with compost or manure has been shown to be effective in restoring severely depleted soils [8, 9]. A combined fertilizer and soil improvement product can be prepared from cow urine and biochar and, used in combination with legume crop farming, can be an important tool for increasing food security and cropland diversity in areas with severely depleted soils, scarce organic resources, inadequate water for irrigation, and limited supplies of chemical fertilizer [10]. This type of sustainable technology using locally available products is highly relevant for smallholder farmers in a country like Nepal.

An action research project to identify and analyze the most feasible flood resilient value chain option integrating economic and environmental integrity was carried out in six villages of Udayapur district in Nepal. Udayapur is regularly affected by floods during the monsoon period. Many smallholder farmers migrate for work, either seasonally or for longer periods, as a means of coping with the economic challenges resulting from floods. The migrant workers families' that are left behind are often headed by women who face the difficulties of carrying out both farm and household work and cultivating the small plots of land in flood prone areas to provide a supplementary subsistence income. The best option for these families was found to be cultivation of green peas, with crop productivity raised using a biochar-based organic fertilizer prepared on farm. The paper describes the flood resilient value chain selection process and comparison of the effects of biochar based organic fertilizer and chemical fertilizer on vegetable crops, especially green peas. Finally, suggestions are made for the future actions both locally and country-wide.

2. Methods and materials

The research was carried out in between November 2015 and May 2016 together with the Nepal Institute for Development Studies (NIDS) and migrant workers' families in six village development committee areas (VDCs) in Udayapur District Hadiya, Jogidaha, Sunderpur, Tapeswori, Rampur (formerly Thoksila), and Risku (Fig. 1). These VDCs were selected as they are vulnerable to floods from the Koshi river and the majority of households cultivate vegetables. The communities are poor and their economic development is a priority for the government.

2.1. Selection of best option value chain

A commodity matrix ranking approach was used to identify the most promising option for a flood resilient value chain in the study area VDCs [11]. Six flood resilient value chain options were selected for the initial study: green peas and beans, goat, chicken and duck, piggery/fishery, milk plus bullock power, and moringa leaf and pods. They were evaluated using seven criteria: market and market demand, economy of scale and outreach, high value flood resistant variety, stakeholders' (women and migrant' workers households) interest and commitment, coordination, short turnover, and leverage. Each criterion was given a score from 1 to 5, with 5 representing maximum compliance and 1 minimum compliance. Overall compliance was determined using a weighted average of the seven criteria.

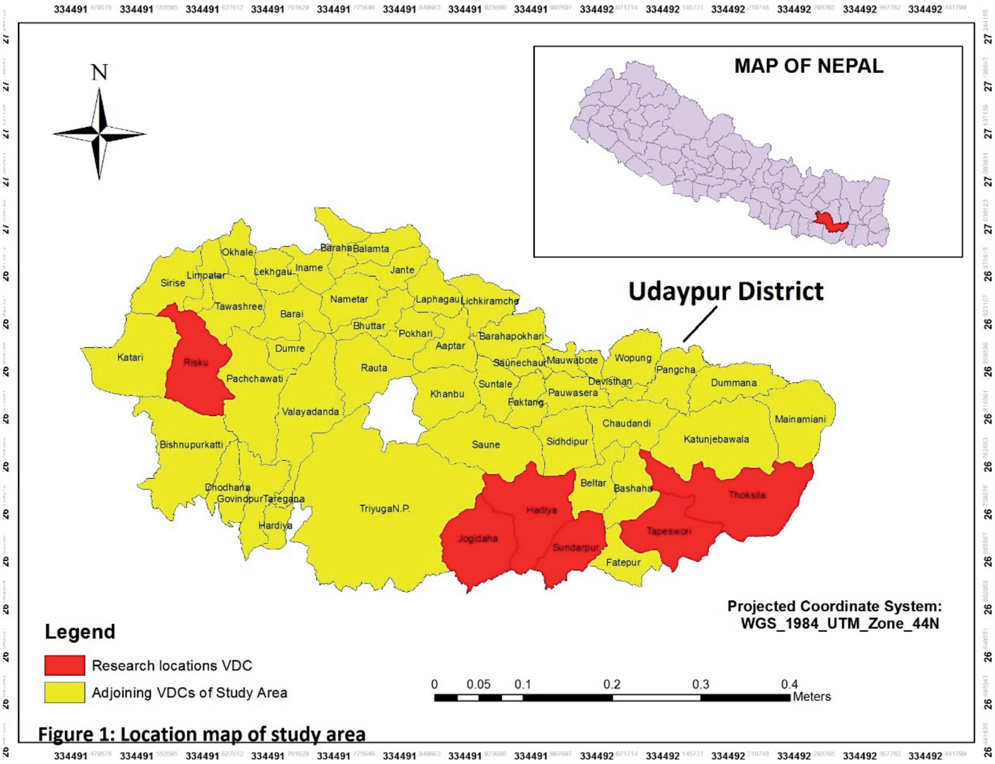

Figure 1: Location map of study area.

2.2. Action research approach and value chain information

The action research methodology was designed to integrate economic, environmental, and social factors in the value chain analysis, while emphasizing strategic and political approaches to ensuring sustained improvements for disadvantaged groups [12]. Action research was used as it takes place in real-world situations and is aimed at solving specific problems and involves the target group and stakeholders as co-researchers [12].

Preliminary information on the green pea value chain (selected as the best option, see results) was gathered from a literature review and meetings with key stakeholders from the District Agriculture Development Office (DADO), District Cooperative Office (DCO), NIDS, representatives of traders and farmers in the VDCs, and representatives of NGOs working on vegetable farming in Nepal.

Three broad categories of stakeholders have a role in facilitating the value chain functions and processes: (i) the upstream actors, *i.e.* the vegetable growers, especially migrant workers' families; (ii) the downstream actors, *i.e.* village and district traders; these are powerful actors as they have linkages with end markets in Nepal and India and influence the prices and terms of trade; and (iii) facilitators, including the government, who are responsible for regulating and implementing agricultural policies, and NGOs, who facilitate the participation of farmers in value chains by mobilizing them, providing information, and organizing training. Detailed information on the value chain such as production, markets, costs, profit margins, and problems and opportunities was obtained from all three groups as follows.

A list of households was obtained from the NIDS office. From the list, 114 households comprising almost half (47.5 %) of the 240 migrant worker households in the six VDCs were selected at random. Baseline information on the income from peas and the farmers' practices in pea growing was collected from face-to-face interviews with members of migrant workers' households using a close-ended questionnaire in December 2015. Six focus-group discussions (one per VDC) were organized with the downstream actors and facilitators to understand the functioning of the vegetable value chain in general and the pea value chain in particular.

2.3. Pea and biochar action research trials

One of the important leverage points in the value chain was to increase crop productivity so that farmers would have a greater volume to sell from the small plots available. Biochar with organic fertilizer was investigated as an appropriate, low cost, and locally sustainable method of soil improvement.

2.3.1. Biochar production

Project staff (the principal investigator and NIDS field staff) carried out hands-on training events on producing biochar in a Kon-Tiki soil pit kiln at all six sites in November 2015 with participants from all 114 selected families.

The Kon-Tiki soil pit kiln method, also known as flame curtain pyrolysis, was introduced in 2014 as a simple and inexpensive way for small farmers to produce high quality biochar in bulk, avoiding both the emissions associated with other methods and the high costs of modern technological approaches [13]. The method is being distributed as an open source technology [13, 14] by the Ithaka Institute for Carbon Strategies, Switzerland. Essentially it consists of heating biomass layer by layer in a conically formed soil pit kiln 1.5 m in diameter at the top and 0.75 m deep in such a way that the powerful flames from each fresh layer provide a 'curtain' which excludes oxygen from the pyrolyzing mass below. Initially, a small amount of fast burning biomass is fired to reach a high temperature; further thin layers of biomass are added as soon as ash starts to appear on the top surface. The manual layering is repeated until the soil pit is filled at which point the pyrolysis process is ended by quenching with water. Biochar produced in this way is of very high quality, while emission of greenhouse gases and other toxic substances is very low. The biochar yield generally lies between 15 % and 30 % of the original feedstock on a dry matter base. In Udayapur, we mainly used Eupatorium species (an invasive forest shrub known in Nepal as 'forest killer') as feedstock, together with some leftover animal waste material. The cooled biochar was mixed with urine collected from stall fed cattle in the ratio 10 L of urine to 1 kg biochar.

2.3.2. Field trials

Empirical trials using biochar-urine as a soil treatment for pea farming were carried out by farmers' at all six sites (28 farmers in total). Scientific tests with pea were carried out in four farmers' fields in Hadiya and with other vegetables (bottle gourd, cauliflower, and tomato) in three farmers' fields in Jogidaha. The trials were carried out in 10 m^2 plots with five repetitions of each. Three different treatments were used in the pea plots: A = 1 kg urine + 1 kg biochar + 10 kg FYM; B = 60 g N_2o + 80 g P_2O_5 + 60 g K_2O; C = 10 kg FYM per plot (farmer's practice). Peas were planted at 25 cm intervals in rows 1 m apart in late November 2015 and harvested from late December to March 2016. Only treatments A and C were used for the other vegetables. The planting scheme is given in the results section.

3. Results and discussion

3.1. Selection of priority flood resilient livelihood diversification options

The results of the assessment of the six potential value chains considered for livelihood diversification are shown in Table 1. Green peas and beans were the most favored option with a score of 4.2. Beans were only cultivated by four of the 114 selected farmers and green peas were clearly preferred. Moringa was mainly planted by farmers in Sundarpur and Tapeswori which are relatively far from the market; the crop had provided little benefit and thus had the lowest rating. The pea value chain was selected for the action research trials.

3.2. The green pea value chain

Green (garden) peas (*Pisum sativum* L.) are used as a cash crop in many parts of Nepal and their potential to contribute to the national economy and to generate income for farm families in flood vulnerable areas has been well recognized in recent years. They mature earlier than other crops and provide a bridging income before the rainy (monsoon) season - and before flooding occurs. The crop is cultivated both for the tender and immature peas, which are used as a vegetable or in soup, and for the

Criterion	Weighting (%)	Value chain					
		Goat	Milk and bullock power	Peas and beans	Piggery or fishery	Chicken and ducks	Ole and moringa
Markets and market demand	20	0.87	0.67	0.87	0.67	0.53	0.40
Economy of scale and outreach	15	0.70	0.35	0.65	0.30	0.50	0.35
High value flood resilient variety	15	0.35	0.30	0.65	0.40	0.45	0.40
Stakeholders' commitment - participation of women from migrant workers' households	15	0.60	0.35	0.55	0.50	0.40	0.30
Short turnover (returns within 6 mo)	15	0.45	0.25	0.70	0.35	0.45	0.30
Coordination	10	0.37	0.20	0.40	0.23	0.30	0.20
Leverage	10	0.37	0.13	0.37	0.27	0.33	0.13
Total	100	3.7	2.3	4.2	2.7	3.0	2.1

Table 1: Selection of value chain diversification options.

mature dried peas, which can be stored and are used as a pulse. Peas are highly nutritious, they have a high content of digestible protein ($7.2\ g \cdot 100\ g^{-1}$), carbohydrate (15.8 g), vitamin C (9 mg), phosphorus (139 mg), and minerals [15]. Fresh peas can be preserved in canned, frozen, or dehydrated form for use during the off-season, including at times of flood [16].

Peas as a crop have the added advantage that as legumes they can add nitrogen to the soil and reduce the amount of fertilizer required by the follow-on crop. The soil enriching and conditioning properties mean that pea is an integral component of sustainable agriculture. Farmers reported that when maize is planted after the legumes, the yield is better, and less fertilizer is needed for the maize. The farmers also practiced intercropping with maize, potato, and wheat crops and along the boundary of cole crops (cabbage and cauliflower), especially where farmland is limited. Peas thus provide a self-sustaining system as they sustain soil fertility and use less water (making use of residual moisture during the winter season and a small amount of irrigation at other times), which fits well with efforts to counter the negative effects of climate change and floods. Peas can be promoted as a soil fertility improvement initiative in the flood victim areas.

In Udayapur, two pea crops can be grown in a year, one from January to March (pre monsoon) and one from late September to early December. Peas are sown by broadcasting or dibbling at a depth of (2.5 to 5.0) cm, and spacing of 50 cm × 25 cm (50 kg to 60 kg seed/ha) in flat or raised beds surrounded by bunds. Yield is higher in the September sown crop; the temperature increases from March onwards which hastens the maturity and reduces the yield, and pea quality can also be lower due to the conversion of sugars to hemicellulose and starch at higher temperatures. However, although the yield of January sown crops is lower, the fresh peas fetch a higher price [17]. In the study villages in the lower part of Udayapur, peas can only be grown as a winter crop as temperatures are too high at other times of year.

Peas can be marketed in three forms, fresh pods, dried (fresh) peas, and mature dry peas (seeds). In some areas in Nepal, peas are grown as an additional source of income (secondary to others such as cereals and sugarcane), while in others they are considered a high-income crop, better than maize, especially when production is high. The total production of peas in Nepal in 2014 was 19 383 t and market demand is rising. There is a potential to increase income by harnessing urban city markets [18]. The key challenges to realizing the potential of peas to contribute to farm income include the lack of storage for longer periods post harvest due to the need for immediate cash to meet regular needs; poor information about markets; lack of structured markets; planting of multiple crops on a single plot; and lack of access to quality seed.

As with most vegetables, green pea cultivation is highly labor intensive and requires high application of manure and fertilizer [19]. The biggest cost is for manure and fertilizer, followed by draft (bullock) power and human labor, and pesticides and other chemicals.

3.3. Pea production in the six villages

The present status of pea growing and potential for success of a promoting peas was assessed in the six VDCs. Before the project, close to 70 % of farmers were growing peas for home consumption in a mixed or intercropping system with major crops such as rice and maize, and sometimes with other vegetable crops during the summer season. However, only 5 % to 10 % were growing pea for sale in pure stands, generally as a winter crop using irrigation and residual moisture. These farmers were mostly in Hadiya and Jogidaha VDCs, which lie closer to the district capital Gaighat. Some NGOs had promoted growing of peas and beans in Sundarpur among very poor farmers who have access to suitable land but cannot afford the inputs needed to grow other crops (cabbage, cauliflower). However, compared to other crops, there are generally few promotion activities targeting pea production and marketing. Altogether the farmers produced around 37 t annually, but only 4 t was sold in 2014/15 year from the winter crop, or approximately 5 % of the 2 t of fresh green peas per day required by the/one wholesale trader at Gaighat. The remaining demand for peas in Gaighat is met from Siraha and Sunsari districts as well as other parts of Udayapur.

Only a few of the farmers in Hadiya and Jogidaha used improved seeds, which are very expensive with 1 kg seeds costing around NPR 7 000 (USD 65). Most of these used

VDC	Rank	Reasons for rank
Hadiya	1	Traditional part of the farming system, available land, good soils, cash culture already present, motivated women's group promoting pea value chain, close to 50 % of families already growing peas on a very small scale
Jogidaha	2	Available land, proximity to key market (Gaighat), many organizations promoting activities (MEDEP, cooperatives), scope to grow mature dried peas as seeds, peas traditional to region due to good soils and good climate
Sundarpur	3	Dry area, sandy soils, distant from markets, peas and beans only grown by a few farmers, one advantage would be that women are involved in growing peas and beans
Tapeswor	4	Small landholdings with many competing crops grown mostly for food and priority given to other crops, poor transport, few promoters, very wet land
Rampur	5	Bigger landholdings but poor transport, distant from markets, few promoters, rainfed, irrigation, priority given to other crops
Risku	6	Far from district headquarters and markets, many other competing crops, farmers focus on goats as a livelihood strategy as the settlement has forest attached
Source: Field value chain survey 2015		

Table 2: Priority ranking of villages for growing peas.

VDC	Total land (average per household)	Land allocated for pea growing (average per household) (dhur[a])	Percentage of available land allocated to pea	% of total in the six VDCs
Hadiya (n = 21)	307 (14.6)	287 (13.7)	93	41.2 %
Jogidaha (n = 26)	333 (12.8)	150 (5.8)	45	21.5 %
Sundarpur (n = 21)	382 (18.2)	165 (7.9)	43	23.7 %
Tapeswori (n = 15)	217 (14.5)	50 (3.3)	23	7.2 %
Rampur (n = 19)	98 (5.4)	15 (0.8)	15	2.2 %
Risku (n = 12)	107 (8.9)	30 (2.5)	28	4.3 %
Total (n = 114)	1,444 (12.7)	697 (6.1)	48	100.0 %
[a]8 of 114 households are landless				
[b]1 dhur = 0.03 ha or 333 m^2; 1 ha = 30 dhur				
Source: Value chain survey 2015				

Table 3: Farmers' commitment to grow peas in the winter 2015/16.

their own seed (from the improved seed crop) in subsequent years. Use of improved seeds also depended on the level of education among farmers. Improved seeds were mostly obtained from research institution experiments or through District Agriculture Development Office subsidy programs. Where farmers are well organized, they sometimes acquire some seeds on loan, which they repay in kind to their associations.

The potential for introducing pea cultivation as a flood resistant livelihood option was assessed in the six villages. The inability to access or purchase seed hinders pea growing, but there appears to be a high willingness to grow peas if seeds can be made available locally. The VDCs were ranked in order of preference for promotion; the rank and reasons for ranking are shown in Table 2.

There is a considerable potential to increase pea production. More than half of the farmers (62 of 114) said that they would be interested in growing peas in the 2015/16 winter season and in promoting the biochar-based pea value chain. The total amount of land available to the study households in each VDC, and the area allocated for pea production in 2015/16, is shown in Table 3. The farmers committed 48 % of the total land available to winter pea production, ranging from 93 % in Hadiya to 15 % in Rampur. Hadiya has a very motivated and empowered women's group who are committed to promoting the pea value chain.

3.4. Pie and biochar action research trials

3.4.1. Biochar and pea

The value chain can be improved by reducing the cost of inputs, thus the action research investigated replacing costly chemical fertilizer with locally produced organic urine biochar fertilizer.

The results of the trials growing peas with different types of soil treatment are summarized in Table 4 and Fig. 2. The yield from plots treated with urine/biochar was almost double the yield in plots treated with NPK only or FYM only (farmers' control); when FYM was added to the urine/biochar the yield increased to 221 % ($p < 0.01$) of yield with NPK only, and 292 % ($p < 0.001$) of yield with FYM only. The yield differences were similar in all four plots although the overall yields differed slightly among farmers. The increase in production using biochar is in line with results observed by other authors for many other crops *e.g.* pumpkin, tomato and potato [2, 20, 21]. The difference in pea crop yield between NPK and FYM only treatment was not significant, which indicates that substituting chemical fertilizer for FYM would not lead to a meaningful increase in yield. One farmer (Dhan Maya) reserved pea seeds for planting in the next season, in the hope of decreasing dependency on outsiders for seed supply.

3.4.2. Other vegetable crops

The results of the trials growing other vegetables with and without biochar are summarized in Table 5. As with pea, the yield from plots treated with biochar/urine was markedly higher (from 170 % to 200 %) than the yield from untreated plots. The yield of bottle gourd in the biochar plot was equivalent to 90 $t \cdot ha^{-1}$, which is consistent with the results obtained for pumpkin with biochar application elsewhere in Dhading district (82 $t \cdot ha^{-1}$) [2]. In the interviews, farmers indicated a high motivation for using

Farmer	Yield in g/plot			Treatment difference (%)		
	A.Urine/biochar/FYM	B. NPK	C. FYM	A and B**	A and C***	B and C*
Nira Thapa	7 132	3 718	2 562	192	280	146
Januka Poudel	6 601	2 674	2 699	256	248	99
Mandira Thapa	7 226	2 975	2 145	243	352	144
Dhan Maya	9 312	4 846	3 236	193	288	150
Total	7 568	3 553	2 660	221	292	135
A = 1 kg urine + 1 kg biochar + 10 kg FYM per plot						
B = 60 mg N_2O + 80 g P_2O_5 + 60 g K_2O per plot						
C = 10 kg FYM per plot (farmer's practice)						
Paired t-test $^*p < 0.01$ $^{**}p < 0.001$ $^{***}p < 0.001$						

Table 4: Yields in farmers' pea trials with biochar and other treatments.

Crop	Farmer's name	Plot size	No. of plants per plot	Yield		
				Biochar plot (kg)	Non - biochar plot (kg)	Difference (%)
Bottle gourd	Ms. Mahakali	10 m^2	2	90	44	205
Cauliflower	Devi Khadka	10 m^2	6	18	10	180
Tomato	Bhagabati	10 m^2	6	15	9	167
Source: Farmers' records						

Table 5: Yields in farmers' pea trials with biochar and other treatments.

biochar/urine in other vegetable crops; one (Ms. Mahakali) had already produced more than 1 t of biochar to use for her summer crops.

3.5. Actors and value chain mapping

The value chain for pea grown in Udayapur district was analyzed in order to identify different options and leverage points to increase the income for growers. The results are shown in Fig. 3. A large number of intermediaries are involved in the movement of vegetable produce from producer to consumer; they retain a large proportion of the final sale price and the share returned to the producer is very low. If ways can be found to reduce the number of intermediaries by marketing both fresh green peas and mature pea seeds to new supply chains involving large-sized buyers (for example in Mugling and Dumre), the market margin would be higher. This type of marketing model improves marketing efficiency through vertical integration and coordination and gives a higher price to the producers. Fig. 3 shows the potential benefit of marketing to large buyers rather than village traders, with a tripling of the marketing margin for farmers (to 33 % from 10 %). Direct sale to local (district) consumers also increases profitability providing a marketing margin of 39 %. The highest marketing margin of 44

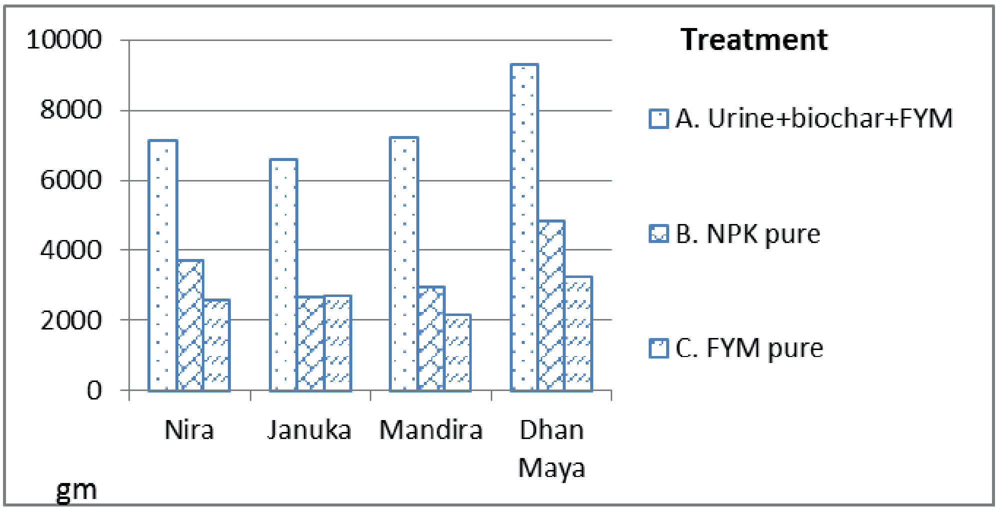

Figure 2: Fresh pea yield per plot (10 m^2) in farmers' trials with various treatments.

% would be obtained from direct marketing of fresh green peas to department stores and supermarkets (such as Bhat Bhateni) in Kathmandu (proposed strand III).

The farmer's margin when selling to village traders is 10 % for fresh green pods, 26 % if it is sold to district wholesale traders and 33 % at the national whole sale market (Fig 3). However, if green peas are packed or canned, the prices would be more than double (to at least NPR 110 · kg^{-1}). This would be less complicated than selling seeds, which entails considerable administrative costs for certification.

There are many other key actors involved in marketing of peas in Nepal. At the national level, there are agro-vet and seed marketing cooperatives and companies such as the Nepal Agroforestry Seed Cooperative Limited (NAFSCOL), and Nepal Agroforestry (NAF) Seed Company and Agriculture Marketing Division. At the district level, there are district cooperatives, district small cottage industry offices, and district agriculture development offices as well as private agro-vet dealers and traders, private agri-business companies, and municipal marketing centers. At the local level, there are many small farmers' associations (cooperatives) such as the NGOs CEAPRED Nepal, Local Development Forum Nepal, WORAC Nepal, and NIDS Nepal; the Suva Laxmi Cooperative in Hadiya and Sundarpur deals specifically with pea and vegetable marketing. The UNDP (United Nations Development Program) Micro-Enterprise Development Program (MEDEP) is also keen to support farmers in micro enterprise development. In the planned pea business plan training, these agencies and projects can be invited for discussion on ways to ensure synergy. Agro-vet centers will supply seeds of green pea in the first year. From the second year onwards, the farmers' federation will be able to produce its own seeds.

A large part of pea and vegetable marketing is through local vendors to household consumers. The main role of these vendors and other market actors is to offer farmers a market outlet for their products. Vendors go from door to door in search of peas.

Some offer warehouse facilities. Gaighat Municipality provides space for marketing farmers' produce; farmers can hire a 2.5 m × 2.5 m area to sell their produce for NPR 50 to 100 per day. A system of vendors around the country is used by buyers to source products and by farmers to sell them. The vendors that large-scale traders buy from are usually equipped with weighing scales for the transactions with farmers. The price depends on the type of vendor and season. NIDS, LDFN, and CEAPRED facilitate the formation of cooperatives, while farmer associations like Subha Laxmi and the Small Farmers associations in Jogidaha, Hadiya, and Sundarpur are more interested in ensuring that farmers receive a good price. The District Agriculture Development Office at Gaighat has agronomists and horticulturists to support farmers in growing of peas and marketing.

Farmer-based associations are empowered to sign contracts with producers in the form of purchase agreements (specifying the quality of peas required) after signing agreements with an identified buyer. Most green pea pods are bagged in gunny bags, while some are stored in bulk in the warehouses. Products are loaded by farmers manually and buyers collect their products from them. The weight of bags depends on the buyer but 50 kg is common. Grading is rarely used other than ensuring that peas are of a single type rather than being mixed.

3.6. Seasonality of trade

There are seasonal variations in the quantities traded related to the cropping season and harvest of peas. Peas are mostly grown in winter and the crop is rainfed. Across Nepal, prices are highest from September to December (most common planting period), lowest from April to mid June, and average from June to August. In flood prone areas, farmers avoid growing pea in rainy season to prevent flood losses. Prices drop during the harvest season, but farmers still sell at the lower price both because they need immediate cash to cover their needs and because they fear post-harvest losses if they try to store the peas. Further, buyers only come to the villages at harvest time, so finding a buyer to sell to later could be difficult. Farmers do not even store for their own consumption, preferring to sell and buy for later consumption from others. In Gaighat, green peas or pods sell for around NPR 60 per kg. Prices in the Kathmandu wholesale market generally range from NPR (50 to 60) per kg (lowest) to more than NPR 110 (highest), but they can rise to as much as NPR (130 to 160) per kg in October to December in the major cities (Biratnagar, Narayangad, Pokhara and Kathmandu). During the high price months, farmers are usually looking for peas to plant as well as peas for consumption. We however avoid lowest price season because of rainy season, which is not good in terms of flood effect.

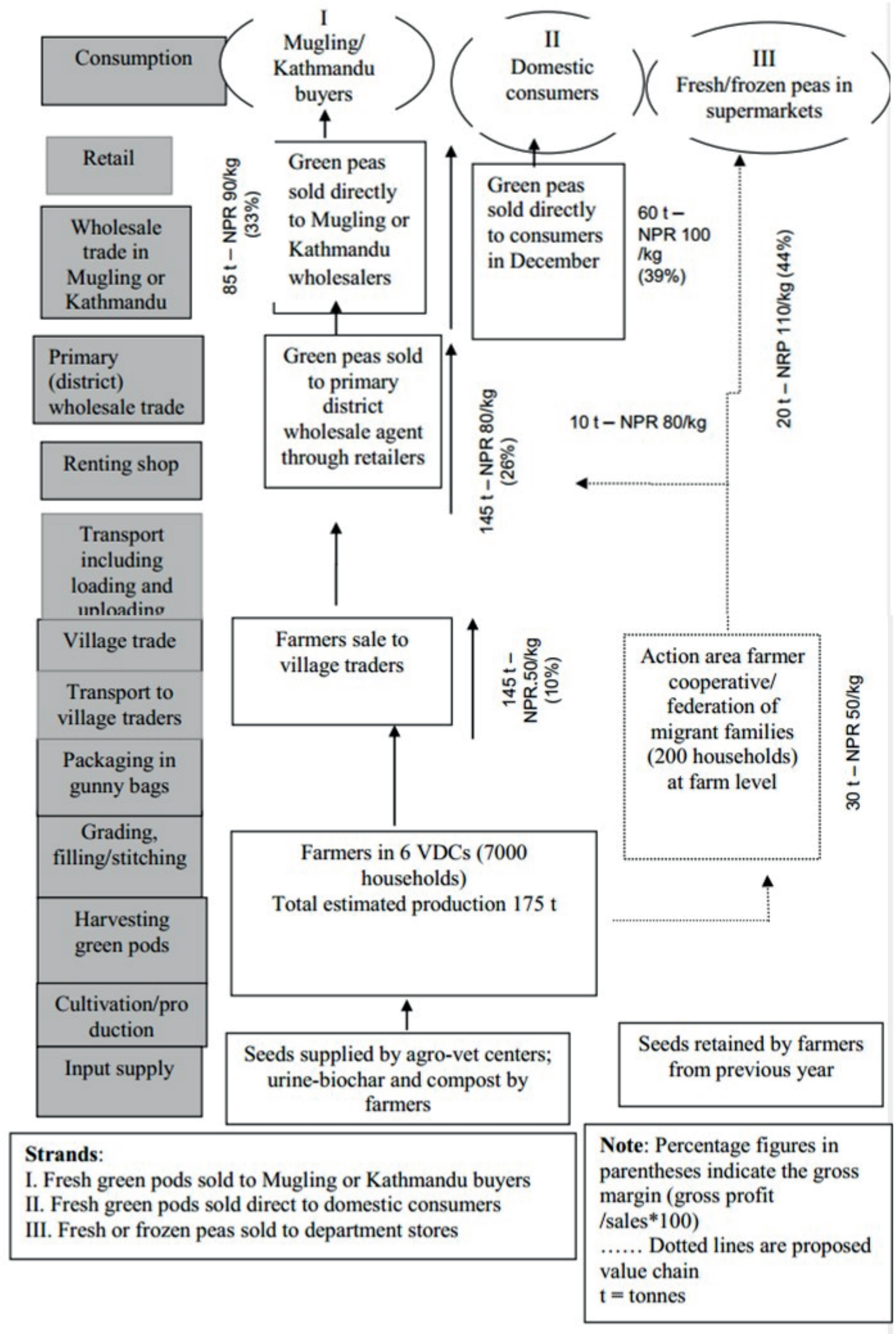

Figure 3: Fresh green pea value chain map for Udayapur, Nepal.

3.7. Financing

Most farmers finance their own planting activities from the money they receive from sales. However, some have access to bank credit and/or special project financing,

VDC	Well off	Medium	Poor	Ultra poor	Total
Hadiya	10	5	3	3	21
Jogidaha	8	9	7	2	26
Sundarpur	11	4	4	2	21
Tapeswor	3	4	5	3	15
Rampur	6	4	5	4	19
Risku	5	3	2	2	12
Total	43	29	26	16	114
Well off = annual household income above NPR 200 000 (USD 1 870)					
Medium = annual household income from NPR 100 000 (USD 935) to 200 000 (USD 1,870)					
Poor = annual household income from NPR 50 000 (USD 467) to 100 000 (USD 935)					
Ultra poor = annual household income less than NPR 50 000 (USD 467)					

Table 6: Disposable income of families of migrant workers (mainly from remittances).

especially important when they transport and deliver their produce themselves. When banks finance, some of the payments usually are through banks, which then withhold their loaned funds before paying the farmers or associations.

Farmers are sometimes financed by village cooperatives. There are two village cooperatives in the pilot villages (Subha Laxmi and Small Farmers) which provide loans according to need. The Small Farmers Cooperative has total savings of 240×10^6 NPR (USD 225 000) and Subha Laxmi Cooperative has almost NPR 1.5×10^6 (USD 14 000) available for investment. A total of 240 migrant workers in the six VDCs have started pooling their savings; the six groups have collected between 50 000 NPR and 70 000 NPR each and deposited these funds in the cooperatives.

The amount of disposable income available to the families of migrant workers from remittances and other sources is shown in Table 6. The amount varies considerably. Approximately 38 % of those interviewed (43 households) had an annual income greater than NPR 200 000 (USD 1 870) while 14 % had an annual income of less than NPR 50 000 (USD 467). Notwithstanding the disparity in income, almost all families expressed their willingness to invest in value chain development activities at a meeting held to discuss introducing the pea value chain as a means of generating income.

4. Conclusions and future directions

Sustainable farming technologies are becoming increasingly relevant for farmers with depleted soils, especially smallholder farmers, given the poorly integrated input markets and lack of access to affordable quality fertilizer and other inputs. The imported chemical fertilizers are expensive and prices are rising; urine biochar offers a cheap, effective, and locally available alternative, acting both as a fertilizer and a soil improvement treatment. Urine biochar in combination with legume crop farming can be an important tool to increase food security and cropland diversity in areas with degraded soils, scarce organic resources, and inadequate water and chemical fertilizer supplies. The families of migrant workers in the study districts in Udayapur already have considerable savings available for investment or financing a business and are thus in a good position to develop the pea value chain to maximize the returns from their small plots of land and reduce their vulnerability to the impact of floods.

The beneficial effects of biochar have been recognized by many groups worldwide [10] and were clear from the results of the farmers' trials. The Government of Nepal (GoN) has been emphasizing the promotion of organic farming. The National Agriculture Policy 2061 (2004 CE) emphasizes promotion of organic farming with the support of organic certification. The Agriculture Development Strategy (ADS) document includes complementary measures to improve productivity and fertilizer use efficiency. Biochar-based organic fertilizer can play an important role in sustainable organic production and, at a supplementary or complementary level, can help sustain soil fertility and minimize the use of inorganic fertilizers while maintaining productivity.

The analysis of the pea value chain in Udayapur showed that at present villagers sell peas to wholesalers at a low margin. Selling pure grains directly to wholesalers has no benefit, and can even be a loss. Sale of green peas has almost equal benefits and profits at the three levels from village traders to wholesalers and retailers. Selling seeds to wholesalers is more profitable than selling green peas or dried peas but the administration is considerably more complicated. Farmers could increase their margin from 9 % to 25 % by selling pea pods directly to Kathmandu wholesalers, and to 44 % by selling direct to Kathmandu supermarkets. For this they need to organize themselves into an association which can replace the various intermediaries currently involved. Other possibilities such as direct sale to consumers and packing or canning dried peas should also be explored.

Future directions

Two types of recommendation can be drawn from the research; recommendations for actions and policies for the whole country and recommendations for introducing the pea value chain approach in the study districts in Udayapur.

Countrywide recommendations:

- Promotion of biochar-based organic fertilizer should be made a priority in Nepal to help meet the government target of increasing organic matter content in soil from 1 % to 4 % over the next 20 yr.
- The introduction of legume crops with biochar based organic fertilizer such as peas is an important approach for achieving the government's goal.

Urine-biochar fertilizer with pea farming can complement government plans and policies. The district agriculture development offices are mandated to supply inputs (seeds and fertilizer) in their respective districts. This can be a leverage point for development of the urine-biochar based pea value chain. Government interventions should focus on reducing use of chemical fertilizers and replacing them with urine-biochar based organic fertilizer.

- Extension on best practices and demonstrations involving private sector suppliers and manufacturers of biochar is needed to further improve agricultural productivity.
- Establishment of commercial bio-fertilizer production enterprises based on municipal biomass and agro processing waste should be facilitated.

Recommendations for the pea value chain in Udayapur:

- The opportunities for linking smallholder farmers in Udayapur to other major markets in Nepal (Biratnagar, Janakpur, Narayangad, Pokhara, Kathmandu) and not only the nearest market (Gaighat) for sale of peas should be investigated.
- Farmers should organize into producer groups or associations that can access larger markets.
- Opportunities should also be explored for targeting key institutions with processed pea products (such as frozen peas) and for seed production. NGOs and others can provide key linkages for farmers to access these markets, including relevant training on markets.
- Migrant workers' family groups in all six VDCs have established savings mechanisms and are linked to big cooperative institutions (Subha Laxmi and Small Farmers' Cooperative Bank Ltd). The finance available should be used to support development of the pea value chain.
- Feedstock for making biochar is available locally (*Eupatorium* and crop residues) and biochar making needs to be scaled up.
- The government policy support system could help promote the pea value chain in the region to provide opportunities for smallholder farmers in.

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