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Are non-market benefits of soybean production significant? An extended economic analysis of smallholder soybean farming in Upper West region of northern Ghana

Francis Akabo Asodina[1], Faizal Adams[1*], Fred Nimoh[1], Emmanuel A. Weyori[2], Camillus Abawiera Wongnaa[1] and John Edudes-Andvi Bakang[1]

Abstract

Background: Traditional cost–benefit analysis of soybean production tends to largely focus on financial benefits to farmers, and less so on non-market co-benefits in sustaining smallholder farming systems. Relying solely on the standard financial analysis undermines the actual benefit of soybean production, which often results in ineffectual policy designs. An economic analysis that incorporates key non-pecuniary co-benefits of soybean production provide vital insight that contributes to improving productivity and overall economic well-being of farmers. Cross-sectional data were collected from 271 farmers to estimate the overall economic benefit of soybean that captures both market and non-market attributes in three major producing districts (Sissala-West, Wa-East, and Dafiama-Busie-Issa (DBI)) of Ghana.

Results: When non-market co-benefits were omitted, soybean production was not profitable (−Gh¢103.10/ha or −US$22.91) in DBI while Sissala-West and Wa-East had modest profit margins. However, the financial analysis changed dramatically when an average non-market value of Gh¢345.69 (US$76.82) was incorporated in the analysis. The soybean system was, therefore, financially viable for all the districts when the non-market attributes of the crop were considered.

Conclusions: The findings demonstrate the importance of the non-pecuniary benefits of soybean in smallholder farming systems for policy decision-making. For instance, farmers' motivation for soybean production is closely linked to those ancillary benefits like the biological nitrogen fixed in the soil for cultivation of other crops. Similarly, crop administrators and policy makers' support for conservation agriculture and green environment is tied to these non-market co-benefits.

Keywords: Soybean, Non-market benefits, Economic analysis, Food security, Smallholder farming systems sustainability

Background

The economic value of soybeans (*Glycine max* L.) towards sustaining smallholder farming systems and rural livelihoods in sub-Saharan African economies are prompting governments and non-governmental organizations to promote the production and utilization of the crop for poverty reduction, food and nutritional security

*Correspondence: fazztop@gmail.com; fadams.canr@knust.edu.gh
[1] Department of Agricultural Economics, Agribusiness and Extension, College of Agriculture and Natural Resources, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
Full list of author information is available at the end of the article

[1–3]. In Ghana, like many sub-Saharan African countries, soybean farming is a smallholder business with holdings less than 2 hectares of farmland. The farmers rely on rudimentary agriculture technologies such as cutlasses and hoes [4], but are responsible for about two-thirds of the national food demand in the country [5]. In such farming systems, the production of soybean is not only limited to potential incomes from the sales of grains [1, 6, 7], but also to generate other non-pecuniary co-benefits which sustains the entire farming systems and overall farm household well-being [3, 8]. However, conventional economic analysis of smallholder soybean farming systems primarily focuses on financial gains from the sales of grains to farmers [1], and less so on the non-tradable co-benefits [9, 10]. The weakness of the traditional economic analysis of the smallholder soybean farming raises a fundamental research question: *Does the associated non-pecuniary co-benefits of soybean affect its economic viability in a smallholder farming system*?

A consideration of the non-market co-products of soybean is vital to facilitate decision-making so as to improve production and productivity. For instance, the primary motivation of smallholder farmers to invest in soybean enterprise may go beyond the production of tradable products such as grains to include other non-tradable functions such improving soil fertility through biological nitrogen fixation (BNF) [8, 11]. This function of soybean helps improve soil fertility saving resource-poor farmers the cost of inorganic fertilizers as well as enhancing biodiversity [3, 11]. Soybean residue is a known source of important nutrients that are important for livestock production. Other important reasons could be for control of noxious parasitic weeds such as *Striga hermonthica*, controlled soil erosion, and to reclaim degraded lands for agricultural purposes [12]. On the other hand, policy support for smart agricultural production technologies such as conservation agriculture, and production of safer and chemical-free food products are strongly associated with such non-market benefits [13]. More so, in rural economies of sub-Saharan Africa where malnutrition and poverty incidences are chronic and pervasive, the inclusion of soybean food products in farm household diet particularly for children, pregnant and lactating mothers can generate relevant policy discussions and interest among governments, non-governmental organizations and rural development practitioners [13]. Therefore, the limitations associated with the production of soybean need to take account of the multiple benefits the crop offers in smallholder farming systems.

However, analysis of smallholder soybean production has largely been restricted to only traded or financial analysis with little mention of non-market benefits [1, 14, 15]. Reasons such as valuation difficulty of these benefits may be adduced for this apparent lack of data. For example, the improved soil fertility role of biological nitrogen fixation by soybean may have little or no market demand outside the farm making it near impossible to quantify and place economic value on. Hence, the economic value of the improved soil fertility will satisfy only farmers' demand per the use of the land for the next production season.

In economic evaluation studies, all resources and benefits from an enterprise must be accounted for, whether such resources and benefits are marketed or non-marketed to determine efficient use of society's resources [16]. Thus, the use of only market benefits in determining income from soybean production is likely to be biased downwards with impact on resource use efficiency. Although, some studies [15, 17] have attempted to conduct rigorous economic evaluation of smallholder soybean farming, they all fall short of going beyond traditional cost and benefit analysis to account for other non-traded benefits. In conclusion, the smallholder soybean production system is criticized as being unprofitable, which, in turn, affects resource allocation and policy direction to improve its production. On the contrary, [18] and [19] observe that the low returns of the smallholder soybean system may imply other intrinsic motivations that drive farmers' decision to venture into its production, however such inherent but relevant motive has received less research audience. In view of this, the current study critically investigates all motivations of soybean farmers by empirically accounting for both traded and non-traded benefits in the Upper West region of Ghana. The remaining of the paper is organized as follows: Part two presents the non-market value of soybean in smallholder farm households. Section three outlines the theory and research methods adopted underlying the study. Results and discussions are presented in section four while section five concentrates on conclusions and recommendations.

Literature review

Non-market value of soybean in smallholder farm households

The multiple uses of soybean beyond its industrial and home consumption are well documented in the literature [2, 9, 11]. Soybean is referred to as a food security crop due to its versatility and the numerous benefits it presents to humanity, especially in rural economies [13]. According to [20, 21] people are food secured when they have access to affordable, safe, and nutritious foods to meet their dietary needs and food preferences for healthy growth. Within this context, village level production of soybean provides a feasible option to improve the food security of farm households in numerous ways. First, the soil fertility enhancement properties of soybean help to diversify households' food sources to include production of cereal crops at affordable costs. Further, the use of soybean residues to feed livestock also help to improve household animal protein requirement. Moreover, home consumption of soybean grains as food further assists households to improve and diversify their essential nutrient demand. More importantly, the recent definition of food security in terms of utilization through proper nutrition, preparation, and feed practices [22] characterized rural-based soybean production as a significant food security crop at the village level. These attributes of soybean in rural household food security are discussed below:

Soil fertility improvement

Ghana has one of the highest rates of soil nutrient depletion among sub-Saharan African countries with annual projected losses of 35 kg N, 4 kg P and 20 kg K per hectare [23]. The extent of nutrient depletion is widespread across all agro-ecological zones with nitrogen and phosphorus being the most deficient nutrients. Meanwhile, no conscious effort is made to replace such nutrient losses. According to [23] data, the annual inorganic fertilizer application rate of 8 kg per hectare in Ghana is the lowest in the sub-Saharan Africa region [23]. As a result, food crop productivity in the country is low and agricultural production systems are not also sustainable [24]. To reverse this negative trend requires a consideration of sustainable forms of agricultural intensification via pragmatic and less cost-effective strategy like the cultivation of soybeans in the country.

The roots of soybeans contain bacteria called rhizobia which is responsible for converting atmospheric nitrogen into a form readily available for crop use in the soil [3, 11, 25]. On the average, soybean fixes an equivalent of over 150 kg (more than 2 bags) of urea into the soil. After harvesting, approximately 49 kg and 450 kg N per hectare are left in the soil for subsequent use by other crops grown on the land [26, 27]. The residues from soybean (falling leaves/stover) also represent an additional source of nitrogen that improves soil fertility and organic matter [28]. In a study in Malawi, [11] observe that maize farms following soybean production in a crop rotation outperformed maize in a continuous production due to significant residual of atmospheric nitrogen fixed in the soil. This trait of soybean makes the crop an important part of a crop rotation system with other heavy nitrogen consuming crops [27].

Financial evidence for smallholder farmers shows that farmers who incorporate soybean in crop rotation with other cereals improve overall household income between 50 and 70% compared with a cereal mono-cropping system. For instance, [26] observed that the yield of maize in a soybean intercropped system is likely to increase between 0.5 and 3.5 tonnes per hectare. Therefore, integrating soybean production in smallholder farming systems is thus considered a cost-effective and sustainable way of maintaining and improving soil fertility for improved crop productivity and general well-being of resource-constrained farmers. While this role of soybean has qualitatively been recognized and acknowledged, no quantitative analysis has been conducted to assess its contribution to the overall soybean benefit in a typical smallholder farming system.

Source of livestock feed

In Ghana, livestock contributes significantly to household income and dietary protein needs (meat, eggs, and milk). The demand for livestock and related products is even higher and keeps growing because of urbanization mainly from population and income growth [29, 30]. The rise in urbanization, however, has significantly reduced both potential and actual grazing lands for livestock production. Meanwhile, of the country's landmass (23.9 million hectares), less than 6 million hectares are actually available for natural grazing as livestock feed [31, 32]. Therefore, the need to explore other alternatives for livestock feeding is imperative given the critical role of livestock in the food security and the welfare triangle for most households in developing countries [33]. Research shows that, the addition of soybean and soybean residue can be an important additive for livestock feed, especially in the dry seasons when most pastures and grasses dry up [34, 35]. According to [36], the leaf and stem of soybean contain about 12% and 5.9% protein, respectively, which is good for livestock development. Soybean residue can be used in the short-term situations as an alternative feed for dry and moderate conditioned beef cattle [35]. The residue, though not all that palatable, but are packed with nutrients and can, therefore, be used as a supplemental feed for livestock, particularly for large and small ruminants. Typical composition of soybean residue is 42% total digestible nitrogen (TDN), 0.43 McalNEm/lb, and 5% crude protein [35].

Aside from the rich nutrient content of soybean residue, ease of access, especially for livestock and farmers in areas where soybean is produced is an added advantage. Similarly, it is also easy to transport over long distances to dry ecological zones to address perennial feed availability and nutritive problems stagnating the livestock sector [34].

Improvement of rural household nutrition

Soybean is considered as the crop with the utmost nutritional value and the cheapest for resource-constrained farm households in rural economies [3, 13]. The crop contains 40% protein with amino acid pattern and 20% of desirable fats with a proportion of unsaturated fatty acids and thus higher than the protein content of any other crop including other legumes [37]. According to [38] soybean grains have high total digestible nutrient percentage of 91.99% more than the 79.52% from cowpea grains. The protein content of soybean seeds has all the essential amino acids required for human nutrition; isoleucine, leucine, lysine, methionine and cysteine, phenylalanine and tyrosine, threonine, tryptophan, valine and histidine [39]. The high lysine content of soybean grains, which is deficient in many cereal diets, makes it important to include soybean meal in menus of rural households who find it difficult to afford higher animal protein-based foods such as beef, mutton, chevron, egg, among others.

At the village level, soybean grains have been processed into "weanimix", which is often used as a food supplement for infants. Moreover, the crop is processed into 'dawadawa", a local spice, for the preparation of household dishes [40]. The bean is also milled into soy flour and used as additives in dishes and thus, the best substitute for meat and fish protein sources.

Besides processing soybean into highly nutritious food products, the processing equipment is rudimentary and unsophisticated whose capital demand is not beyond the resource-poor farm household [6]. Though soybeans cannot be boiled and eaten like other legumes, the milled soy flour could be mixed with other ingredients to form a nutrient-rich protein blend that could be served as a porridge. As a result, many governmental projects such as the Women in Agricultural Development (WIAD) of MoFA and other NGOs, including MEDA-GROW have been promoting the production and utilization of soybean in northern Ghana to improve the nutritional status of rural farm families. However, in most economic analysis of the smallholder soybean farms, the component of grains reserved for home consumption is frequently ignored in the financial analysis. This study, therefore, treats such grains for home consumption as part of the non-market co-benefits of soybeans.

Methodology

Replacement cost theory

The replacement cost (RC) theory is a form of revealed preference theory which has extensively been used to estimate non-market values of agricultural and environmental goods and services [40]. The RC theory denotes that individuals' utilities are derived from the actions they undertake which eventually reveals their actual desires [41]. Unlike the random utility theory, which is based on probability of choices, the replacement cost theory uses observable data from actual behavior and choices of individuals [42, 43]. The theory, therefore, applies the concept of opportunity costs to value non-tradable products or resources in economic analyses.

Empirically, the replacement cost theory employs the extended traditional gross margin (GM) analysis to quantify the overall economic cost and benefit of products that do not have market values based on their opportunity costs [44]. For instance, [45] applied the RC approach to compare erosion costs of soybean cultivation by conventional tillage and no-tillage technologies on the Brazilian Cerrado region. The author used the method to value on-farm erosion costs using the market prices of major soil nutrients lost by the erosion extrapolated from fertilizer market prices under the two scenarios. In a related study, [40] concluded that the RC method is an efficient framework to estimate the monetary value of soil nutrient by comparing the quantity gained or lost with the market price of fertilizers needed to maintain a certain level of crop productivity.

The RC approach is cheaper to use, especially in a situation where data are readily available and the degree of similarity and substitutability between the non-market goods or service and individuals' observable actions are well defined. However, the application of the replacement cost theory in rural economies has been heavily criticized, particularly in communities with high prevalence of food insecurity and poverty incidences. Under such conditions, households' choices are not necessarily a true reflection of their desires and wants [46] and as a result, they make production and consumption choices based on resources available to them which may not reveal their true preferences. However, the technique has widely been used because it provides approximations to measure the value of a product which has no market value and not traded [41]. In this study, since the auxiliary benefits of soybean such as soil fertility improvement and crop residue for livestock have no market prices, the replacement cost method was the best technique to provide an approximation of the monetary values of these products.

Study area

The study was carried out in the Upper West region of Ghana. The Upper West region is located in the northwestern corner of Ghana with 11 districts and covers a geographical area of approximately 18,478 km^2 representing 12.7% of the total land area in Ghana. The region is characterized by a high incidence of poverty and food insecurity. Households are largely agriculture dependent, small-scale farmers and with the lowest levels of agricultural input use such as inorganic fertilizers in Ghana. For example, according to official statistics, approximately 88% of households in the region are poor while 79% remain vulnerable to falling into extreme poverty in the

Table 1 Distribution of respondents by districts and communities

Region	District	Communities	Soybean farmers population	Sample size (treatment)	Sample size (counterfactual)
Upper West	Sissala-West	Nyimati	135	43	
		Bullu	71	23	15
		Jawia	100	32	
	Wa-East	Goripie	119	38	
		Bunaa	121	39	15
		Viehaa	52	17	
	DBI	Fian	111	35	
		Chebaa	34	11	15
		Tabiesi	102	33	
Total	3	9	845	271	45

future [47]. According to the [47], 70% of the regional population are food insecure, 25% of children are stunted growth while a further 13% are wasting. Main food crops cultivated include maize, soybean, groundnuts, and cowpea and cash crops such as cotton as well as livestock rearing on a small-scale basis [48].

Research design and method of analysis

The study used a mixed research approach by employing both qualitative and quantitative survey techniques. Adoption of the mixed research methodology helps to improve the validity and reliability of the data collected for the study. Qualitative methods such as key informant interviews and focus group discussions were used to obtain information on farmers' views on non-market benefits of soybean production. On the other hand, a structured questionnaire was developed to collect quantitative data including cost on factors of production, the quantity of soybean sold, reserved for home consumption, market prices of soybean outputs, and inventory of farm assets. The study used a cross-sectional data collected in December 2017 in two phases. Phase one consists of randomly selecting 150 farm households as a counterfactual group who do not grow soybean, but practiced maize continuous cropping system. Information solicited at this stage included data on maize production activities, particularly cost on inputs and the revenues obtained.

The second phase focused on soybean farmers working with government and non-governmental agencies in the study area. Prior to the actual data collection process, the structured questionnaire was pre-tested in the study area. The objective was to examine the appropriateness of the instrument vis-à-vis the stated objective of the study. In addition, it also gave the opportunity to make revision and include important questions which were not previously considered. Fifteen (15) soybean farmers were randomly selected, five (5) from each Sissala-West, Wa-East, and DBI districts for the survey instrument pre-testing.

The survey was carried out for 3 weeks spanning from the second to fourth week of December 2017. A multistage sampling technique was used to sample 271 soybean farmers based on Yamane's (1967) sampling formula and 150 farmers in a maize continuous cropping system. Stage one was a purposive sampling of 3 districts (Sissala-West, Wa-East, and DBI) based on their significant contribution to soybean production in the region. A simple random selection was applied at the second stage to select 9 communities, 3 each from the districts (Table 1). Finally, the 271 soybean farmers were selected through a simple random selection from a sampling frame sourced from non-governmental and governmental projects on soybean from each community. Proportional sampling was then used to determine the sample size for each community based on the populations of soybean farmers. However, equal proportions of 50 non-soybean farmers each from the three districts were randomly selected as the counterfactual group for data collection.

Descriptive statistics such as the mean, frequency tables, and bar charts were used to describe and summarize the data. An extended gross margin analysis based on the replacement cost theory was used to capture both market and non-market co-products of soybean. Soybean production data from the previous 2016 production season was used for the evaluations on a hectare basis. An analysis of variance (ANOVA) was also carried out to determine whether there was a significant difference in mean values calculated across the three districts.

Empirical evaluation of non-market benefit of soybean production

Table 2 summarizes the evaluation techniques used to estimate the various non-market benefits and quantity

Table 2 Estimation of non-market benefits

No.	Non-marketed components	Description	Estimation
1	Improve soil fertility	Cost saved from the purchase of nitrogen in chemical fertilizer from soybean production in crop rotation	Average quantity of nitrogen fixed multiplied by market price/kg of nitrogen 15:15:15 50 kg-NPK fertilizer contains 15% of N_2
2	Consumption	Quantity of soybean consumed per hectare	Quantity of soybean consumed (kg) multiplied by the market price/kg of soybean
3	Residue	Mean cost of soap saved from the use of soybean residue soap	Mean cost saved per month multiplied by lifespan of soybean residue soap (months)

of soybean consumed in a farm household. In Malawi, [11] used an experimental approach to determine the extra amount of maize yield attributed to accumulate nitrogen in a soybean–maize crop rotation system compared with continuous maize cropping system. In a similar analysis, this study uses an economic approach to estimate the monetary value of nitrogen for maize production in a maize–soybean cropping system. The estimation was carried out by determining the cost saved on inorganic fertilizer for maize production in a soybean–maize cropping system compared with the cost (inorganic fertilizer) incurred in a continuous maize cropping system. From the study, the mean quantity of NPK chemical fertilizer saved per hectare from a soybean–maize rotation was estimated at 138.40 kg of NPK for the three districts; this was found to be the extra fertilizer applied in a maize farm/ha calculated from the differences between (i) farmers in a soybean–maize crop rotation system and (ii) farmers in a maize continuous cropping system. This implies that maize farmers in the continuous cropping system applied 138.40 kg of NPK/ha more than farmers who cultivated maize in a soybean–maize crop rotation system. The nitrogen active ingredient contained in the 138.40 kg NPK saved in the soybean–maize crop rotation was then compared with the quantity and the price of 50 kg NPK fertilizer from the traditional market in the study area. The average cost of a 50 kg NPK (15:15:15) fertilizer, in the study was GH¢87.00. The 50 kg NPK (15:15:15) fertilizer implies 15% each active ingredient of nitrogen, phosphorus and potassium. This suggests that the 50 kg NPK fertilizer contains 22.5 kg (45%) of active nitrogen, phosphorous, and potassium with the cost of each active ingredient estimated at GH¢3.87.

Given these approximations, the quantity of nitrogen-active ingredient in the 138.40 kg NPK fertilizer saved in the soybean–maize crop rotation was calculated as 20.76 kg (138.40*0.15) per hectare. Therefore, the monetary value of nitrogen fixed per hectare was Gh₵80.24 (20.76 kg* GH¢3.87). The procedure was repeated to determine the monetary value of nitrogen saved per hectare for each of the study districts.

The quantity of soybean used for farm household nutrition was also considered as non-market because most traditional financial cost–benefit analysis failed to account for this component. In this study, the monetary value of reserved soybean for home consumption was calculated by multiplying the quantity with the market price per kg of soybean.

Lastly, the monetary value of soybean residue which is not traded was estimated. The literature on the economics of soybean reveals that the major uses of soybean residue are for livestock feeding or grazing, and mulching for soil quality improvement [1, 9, 13]. However, the current study reveals that soybean residue was used to prepare soap at the village level. This product was only noticed in DBI, hence, the monetary value of soybean residue soap/hectare in the district was determined by the cost of soap saved/month. The estimated amount was then multiplied by the lifespan of the soybean residue soap to arrive at the full monetary value of soybean residue soap per hectare used by the farm household. For the remaining two districts (Sissala-West and Wa-East), the residue was left on the farm as mulch, thus contributing more nitrogen for subsequent maize cultivation which has been captured in the monetary value of nitrogen determined previously.

Gross margin analysis

The difference between total variable costs (TVC) and total value revenue (TVR) of an enterprise is the gross margin (GM) (Mlay, 1984). In smallholder farming systems, the use of fixed capital is negligible, hence the gross margin technique (Adeyeye and Ditto, 1988) is the best analytical tool to measure profitability and return to resources.

Key attributes of the GM that make it the best analytical tool for farm level estimation of cost and returns is because the technique is mathematically friendly and easy to understand. The method is widely used in economies where smallholder farmers' dominant with a low fixed capital requirement and more importantly, where such capital assets are used for the production of several enterprises as in the case of smallholder farming system in sub-Saharan African (Erhabor and Kalu, 1993; Olukosi

Table 3 Description of *TVC*, *TR* and *FC* for smallholder soybean production

Items	Description	Calculations
Total revenue	Quantity of grains sold in kg	Quantity multiplied by selling price per kg at the farm gate
Variable costs	Operation cost items such as seed, ploughing, labor, agrochemicals, fertilizer, and inoculants incurred to produce soybean grains	Quantities of items or services rendered multiple by unit price
Gross margin	–	Total revenue − ∑variable costs
Fixed costs	Capital expenditure items such as cost of land, hoe, cutlass, knapsack sprayer	Depreciation of items determined over lifespan of each items
Net gross margin	–	Gross margin − ∑(variable and fixed costs)

Table 4 Gross margin analysis (Gh¢) of soybean farm in the Upper West region

Components	Districts			
Variable cost (per ha)	Sissala-West(Gh¢)	Wa-East(Gh¢)	DBI (Gh¢)	Pooled (Gh¢)
Seed	75.73	61.84	60.56	66.04
Ploughing	185.79	229.39	148.59	187.92
Fertilizer	43.45	45.51	11.39	33.45
Inoculants	2.34	17.24	8.60	9.39
Labor cost				
Family labor	526.39	220.76	337.20	361.45
Hired labor	194.72	293.56	250.20	246.16
Total labour cost	721.11[a]	514.32[b]	587.40[c]	607.61
Agrochemicals	73.92	40.50	52.67	55.70
Land rental	52.30	54.78	27.88	44.99
A. Total variable cost	1154.64[a]	963.58[b]	897.09[c]	1005.10
B. Output of soya (marketed) (kg/ha)	825	836.50	533.68	731.73
C. Output price/kg	1.96	1.39	1.52	1.62
D. Total revenue (B*C)	1617.00[a]	1162.74[b]	811.19[c]	1185.40
E. Gross margin (D–A)	462.36	199.16	(85.90)	191.87
F. Fixed cost (depreciation)	34.02	8.03	17.2	19.75
G. Net margin (E–F)	428.34[a]	191.12[b]	(103.10)[c]	172.12

Figure in brackets means loss. Values with different superscripts denotes means are significantly different while same superscripts denote means are not different across rows. Official exchange; US$1 = Gh¢4.5 in 2017

and Erhabor, 1988). When farmers have investments in some fixed assets, depreciation is calculated on the assets and the value subtracted from the GM to yield the net gross margin (NGM). Mathematically, [49] expressed gross margin (GM) as:

$$GM = TR - TVC, \tag{1}$$

where *GM* denotes gross margin,[1] *TR* is total revenue and *TVC* is total variable cost (Gh¢). Table 3 presents a description of how *GM* and *NGM* were computed from *TVC* costs, *TR* and fixed costs (*FC*).

[1] All monetary values are measured in Ghana cedis (Gh¢) and converted in US$ at official exchange rate of Gh¢4.5 = US$1.

Results

Market benefit (gross margin analysis)

The data on gross margin analysis that captures the explicit market benefit of soybean production are presented in Table 4. The results show an average variable cost of producing a hectare of soybean grains to be Gh¢1, 005.10. Labor cost that includes both hired and family contributed 60% (Gh¢ 607.61) of the overall variable cost which was significantly different across the three districts. The overall output from producing a hectare of soybean was 731.73 kg which was sold at Gh¢1.62/kg. Accordingly, a total revenue of Gh¢ 1185.40 was reported for the pooled sample households. The data also show a significant difference in revenue across the three districts with smallholder farmers in DBI recording a negative gross margin. Farm households in the Sissala-West

Table 5 Estimates of non-market benefits

Non-market component	Districts			
	Sissala-West	Wa-East	DBI	Overall
A. Nitrogen fixation				
Mean quantity (kg/Ha)	17.07[a]	16.96[b]	29.85[c]	21.29
Mean unit price (GH¢)	3.87	3.87	3.87	3.87
Total value (GH¢)/Ha	66.06[a]	65.64[b]	115.52[c]	82.41
B. Consumption				
Mean quantity (kg/Ha)	143[d]	124[d]	143[d]	136.67
Mean unit price (GH¢)	1.96	1.39	1.52	1.62
Total value (Gh¢)/ha	280.28[a]	172.36[b]	217.36[c]	223.33
C. Residue (soap)*				
Mean cost saved//Ha	0	0	14.1	4.70
Life span of soap (months)	0	0	8.5	2.83
Total value (GH¢)/Ha	0	0	119.85	39.65
Total (A + B+C) (GH¢)	346.34[a]	238.00[b]	452.73[c]	345.69

*Soybean residue was used for soap preparation only in DBI district. Values with different superscripts denotes means are significantly different at 5% while same superscripts denote means are not different. Official exchange; US$1 = Gh¢4.5

district had the highest market value (Gh¢1, 617.0) on a hectare of soybean grains sold. Similarly, the Sissala-West district recorded the highest net margin (Gh¢428.34) when capital expenditure was included in the balance sheet analysis with DBI reporting more negative returns (Gh¢ −103.1).

Non-market benefits

The results in Table 5 show the non-market benefits of soybean which were categorized into three main components. The monetary value of nitrogen was estimated first before quantification of the various uses of soybean residue. The data also capture the monetary value of soybean grains saved for consumption to improve farm household nutrition, but often ignored in conventional cost-and-benefit analysis of the crop. According to the result, approximately 21.29 kg/ha of atmospheric nitrogen was left in the soil for subsequent use by other crops after harvesting soybean grains. Farm households in DBI reported the highest soluble nitrogen with 29.85 kg/ha before Sissala-West (17.07 kg/ha) and the least being Wa East district (16.96 kg/ha). In monetary terms, a unit of the nitrogen was estimated to be sold at Gh¢3.87/kg. Consequently, the total value of the atmospheric nitrogen was quantified to be Gh¢82.41/ha in the pool sampled. Across the districts, a higher nitrogen value was estimated for DBI district compared with SissalaWest and Wa-East districts. Likewise, the data show a significant difference in the amount of soybean grains used for home consumption across the three districts. Sissala-West recorded the highest (Gh¢280.28) grains used as food to complement local dishes before DBI (Gh¢217.36 (48.30)) and Wa East (Gh¢172.36). In terms of residue usage, only farm households in DBI district used the soybean residues to prepare soap for bathing and cleaning household chores. Such monetary value from the soap was estimated to be Gh¢119. 85. In the two remaining districts, it was observed that the soybean residue was left to decompose in the field to further improve soil fertility for subsequent production of other crops, especially cereals. This soil enhancement benefit of the residue was not quantified for the two districts because it was implicitly captured in the previous nitrogen estimation. Overall, a non-market co-benefit of Gh¢345.69 was accrued from producing a hectare of soybeans in the study area. Sissala West district recorded the highest non-market benefit (Gh¢346. 34) before BDI (Gh¢452. 73) and Wa East (Gh¢238. 00) districts.

Overall economic benefit of soybean

Table 6 depicts the overall economic benefit of soybean production. The benefit represents a summation of values from the estimated non-market benefits and the gross margins. On the average, the gross economic benefit was Gh¢537.50 which varies significantly across the three districts. Farm households in Wa East district had the highest benefit of Gh¢437.16 after Sissala West district with Gh¢808.7. However, the gross economic benefit

Table 6 Overall economic benefit of soybean

Market and non-market variables	District			
	Sissala-West (GH¢)	Wa-East (GH¢)	DBI (GH¢)	Overall (GH¢)
A. Gross margin (Table 4)	462.36[a]	199.16[b]	(85.9)[c]	191.87
B. Non-market value (Table 5)	346.34[a]	238.00[b]	452.73[c]	345.69
C. Gross economic benefit (A + B)	*808.7[a]*	*437.16[b]*	*367.73[c]*	*537.50*
D. Total production cost (A + F)	1188.7	1162.7	914.29	*1024.85*
E. Return on investment (%)	68.03%	37.6%	40.2%	*52.4%*

Values with different superscripts denotes means are significantly different at 5%. Official exchange; US$1 = GH¢4.5

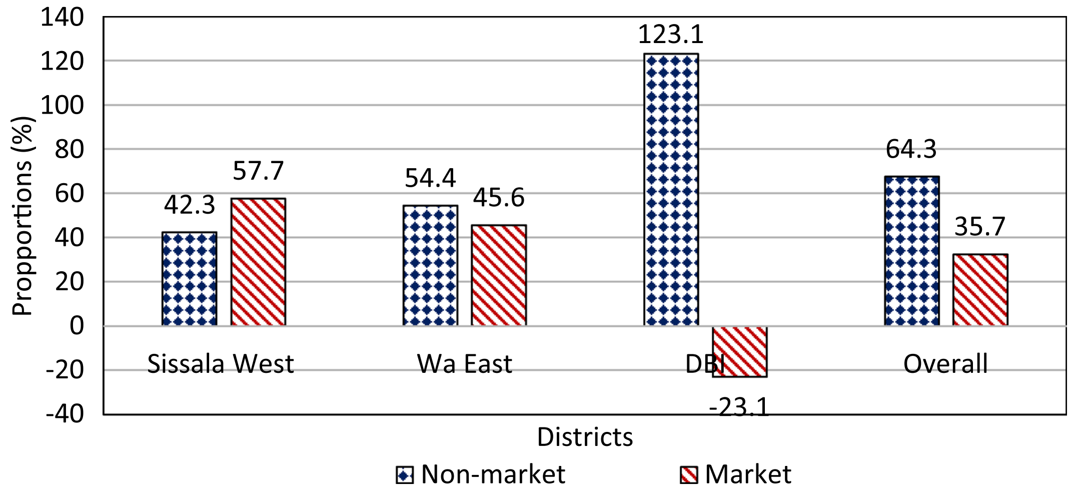

Fig. 1 Contribution of market and non-market values to gross economic benefit

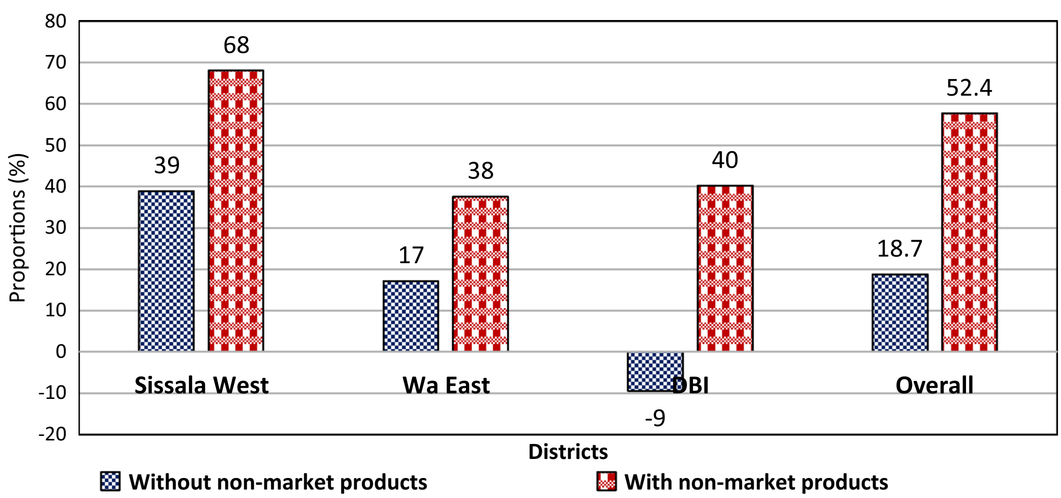

Fig. 2 Proportions of return on soybean investment with and without non-market co-products

of Gh¢367.73 recorded at the BDI district was the lowest among the three districts. The data further revealed a non-market contribution of 42.3%[2] in Sissala-West, 54.4% in Wa-East and 123.1% in DBI derived from soybean production (Fig. 1). On the contrary, the market benefit (gross margin) accounted for less than 40% (35.7%) of the overall economic benefit in the pool data and −23% in DBI district. The results also depict a return on soybean investment of 52.4% of the pool sampled households. Across the districts, the rate is high representing 68.03% in Sissala-West, 37.6% in Wa-East and 40.2% in DBI districts.

The data in Fig. 2 show the proportions of returns on soybean production with and without non-market co-products. Without non-market co-benefits, the rate of return on capital invested in the soybean business was low representing 18.7%. Similarly, when the analysis was limited to only market sales, the return on investment was 17% in Wa East, 39% in Sissala West and -9% in BDI district.

[2] Formula for percent calculation as: $\frac{non-market\ value}{gross\ economic\ value} \times 100\%$.

Discussion

In examining the market benefit of soybean, the result shows that labor mainly from family workforce contributes the highest costs of soybean production in the study area (Table 4). This significant labor cost reinforces the claim that most of the soybean production activities in Ghana are rudimentary and driven by manual technologies [4]. Therefore, strategies that will mechanize the production process would be appropriate for commercialization of the crop and, will ultimately propel production and improve farmers' income and welfare. The significant difference in gross margins across the three districts may be attributed to the higher revenue received by farmers in Sissala-West district compared to the two districts. Such an improved revenue for the Sissala-West district could be traced to the better market price of soybean output received from Burkinabe's traders because the district shares a common local market (*Leo*) with neighboring Burkina Faso. The data show a positive gross margin for the pool data. However, the negative value for farmers in DBI district gives an indication that soybean production is not profitable in the district. We explain the negative gross margin as a consequence of lower productivity in BDI and the higher output prices received in Sissala- and Wa-East districts. Even though farmers in the Sissala-West and Wa-East districts show positive gross margins, the actual profits are low when compared with the opportunity costs of capital of 35% per annum in the study area. Further, the proximity of these two districts to the Leo market than BDI district allows the former districts to enjoy a positive spillover effect of transborder trade with Burkina Faso which further explains the disparities in the gross margins observed. The low market returns shown in Table 4 are in line with previous findings among smallholder soybean farmers across Africa [1, 18, 19].

The results presented in Table 5 captures the non-market co-benefits of soybeans with a nitrogen fertilizer replacement value of 21.29 kg/ha which is consistent with the 25 kg/ha of nitrogen recorded from experimental fields by [22]. The findings imply that farm households who cultivate soybean in a crop rotation system with cereal crops could be saving GH¢82.41 on the purchase of inorganic fertilizers. This non-pecuniary function of soybean is more important for resource-constrained households who could not afford inorganic fertilizer to produce heavy nitrogen feeder crops such as maize, a staple food crop in the study region [13]. Soybean is fortified with substantial quantities of amino acids and desirable fats [37]. Therefore, as expected, a considerable amount of the harvested soybean grains estimated at Gh¢223.33 were reserved to improve farm household nutrition. These results agree with studies conducted across the sub-Saharan Africa region [13, 15] which reported a significant amount of soybean grains consumed to improve farm household nutrition. On residue uses, only farmers in DBI use it to prepare soap. This revelation is novel and perhaps not known to policy-makers and development practitioners. The soap attributes of the crop residue will need further investigation for improvement and wide acceptance and usage. If proven to be efficient and easy to use without any side effect on humans, more female farmers could be encouraged into soya bean production since this added benefit can help alleviate the cost of farm household consumables especially purchase of soap, while improving personal hygiene in rural communities and also creating additional employment avenue for women. In Sissala West and Wa East, the soybean residues that were left on the field to further improve soil fertility, according to [50] contributes the significant amount of soybean nitrogen fixed in the soil after harvesting the grains.

In estimating the overall non-market benefit of soybean, it was observed that 49.9% of the total Gh¢399.16 non-market co-benefit was attributed to home consumption while nitrogen contributed 20.1% and, residue which accounted for 30% (Table 5). The results also show a higher non-market contribution of soybean in the DBI (Gh¢452.73) compared with the other two districts. The significant importance of such non-market products in DBI district could be traced to the significant contribution of soybean nitrogen and residue soap for sustaining farm families as well as the smallholder farming system compared with the remaining districts.

As hypothesized, the non-market contribution was high representing 64.3% of the overall economic benefit derived from soybean production (Table 6 and Fig. 1). In fact, such non-market function was 55% in Wa-East district and 123% in DBI district. The implication is that farmers in Wa-East and BDI may be less motivated by only the sales of soybean grains to venture into soybean production in the districts. For instance, farmers will continue to produce soybean despite the negative market returns, as long as, framers' saved fertilizer cost for major food crops such as maize and sorghum; improved household protein requirements; and also saved cost on household consumables such as soap for washing and bathing. This finding relates well with [18] and [19] who observed that other factors besides monetary gains from soybean might motivate smallholder farmers into soybean production.

The primary objective of any economic agent is to maximize profit while minimizing cost of production [51]. The overall economic benefit of soybean production was profitable when the non-market co-benefits were included in the analysis. However, profit alone is not enough to determine how efficiently the factors of production are utilized. The best criterion is to determine input use efficiency by evaluating the returns per unit of input employed [52]. The 52% return on soybean investment exceeds the average interest of 35% charged by financial institutions in the study area. The implication is that soybean production is a viable business option when its non-market products are considered. Across the districts the rate of return on capital invested exceeds the interest rate by more than 33, 2.6, and 5 percentage points in Sissala-West, Wa-East and DBI districts, respectively. However, when the analysis was limited to only market sales, the 17% return on investment for farmers in Wa-East is 18 percentage points lower than the 35% opportunity cost of capital. Similarly, the rate of return is 44 percentage points lower than the interest rate for farmers in DBI. However, there was a modest return on investment which is 3 percentage points higher than the opportunity cost of capital for farmers in Sissala-West district. The foregoing statistics support previous studies [1, 15] to suggest that investment in soybean production in northern Ghana is not profitable when only marketable products of the crop were considered in the financial analysis. However, with the inclusion of non-market co-benefits, this current study shows a financially viable and competitive soybean business under the smallholder farming system in the Upper West region of Ghana. These findings on the resource use efficiencies are relevant as taking policy decisions based on the market benefit would mean that resources should not be committed to soybean production, which could be inimical to the development of the crop for food security and poverty alleviation.

Conclusions

The study estimates the overall economic benefit of smallholder soybean production that accounts for market and non-market benefits in the Upper West region of Ghana. Key non-market co-products including the quantity of atmospheric nitrogen fixed in the soil, soybean grains reserved for family nutrition, and soap making from soybean residues are essential towards the sustenance of the farm household and improving the competitiveness of smallholder farming systems. The standard cost-and-benefit analysis (GM) that captures sales of grains show that investment in soybean is only marginally profitable for farmers in Sissala-West (GH¢428.34) and Wa-East (GH¢191.12) districts while DBI district (GH¢-103.10) recorded negative returns. However, with the inclusion of the non-market benefits of GH¢399. 16/ha in the financial analysis, soybean production becomes more financially viable for smallholder farmers. Such non-market co-benefits contribute 42.3% in Sissala-West, 54.4% in Wa-East and 123.1% in DBI of the total benefit from soybean production. The study further reveals a rate of return on soybean investment of 57.7%, which far exceeds the opportunity cost of capital by 22 percentage points when non-market co-products were considered. However, when the analysis was limited to only market sales, the return on investment is 19%, which suggests that soybean production is uncompetitive and not a viable business enterprise.

The general implication is that smallholder soybean production is only financially viable and competitive when non-market co-benefits are included in the economic analysis. We, therefore, argue that any policy recommendation based on only market returns could be futile for improving soybean production in the study region. Smallholder farmers' investment in soybeans may not be limited to explicit financial gains from sales of grains, but also implicit benefits from the fixation of soil nitrogen, residues for soap making or livestock feeding, and improvement of household nutrition. Therefore, crop administrators and policy-makers need to take cognizance of the significant importance of these auxiliary benefits in devising specific programs for soybean smallholder farmers. Recent research works on rhizobia modulation such the N_2-Africa projects which focus attention on the improvement of the nitrogen fixation potential of soya should be intensified, since this benefit will not only improve subsequent crop productivity, but will also help farmers to save cost on inorganic fertilizer. Lastly, a further investigation may be required to assess the health implication of using soap from soybean residue so as to commercialize the product at the village level for an extra income generation for poverty alleviation, especially for rural women.

Abbreviations

BNF: Biological nitrogen fixation; NPK: Nitrogen phosphorous potassium; GSS: Ghana Statistics Service; GM: Gross margin; MOFA: Ministry of Food and Agriculture; BDI: Bussie Daffiama Issa; TDN: Total digestible nitrogen; RC: Replacement cost; WIAD: Women in agricultural development; NGO: Non-governmental organisation; MEDA-GROW: Mennonite Economic Development Associates Greater rural opportunities for women; GLSS: Ghana Standard Survey Living; ANOVA: Analysis of variance; TVC: Total variable cost; NGM: Net gross margin; FC: Fixed cost.

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Authors' contributions

FAA wrote the proposal, collected the data and did the analysis and wrote the paper. FA, FN, CAW also participated in the data collection and performed the analysis. EAW and JEB edited and reviewed the manuscript. All authors read and approved the final manuscript.

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Competing interests
The authors declare that they have no competing interest.

Author details
[1] Department of Agricultural Economics, Agribusiness and Extension, College of Agriculture and Natural Resources, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. [2] Institute of Development and Agricultural Economics, Leibniz Universitat Hannover, Hannover, Germany.

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