Modelling the Impact of Credit on Intensification in Mixed Crop-Livestock Systems: A Case Study from Ethiopia

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Abstract:

Access to credit is one strategy for promoting the adoption of yield-enhancing technologies. However, advancing credit to smallholder farmers for encouraging technology adoption is a complex policy issue. The objective of this paper is to identify appropriate and sustainable credit repayment policies to encourage intensification in the Ethiopian Highlands. Using a household model, we analyze the impact of advancing in-kind credit in the form of fertilizer and seed to smallholder farmers in the Ethiopian highlands and alternative credit repayment strategies. The results indicate that in kind input credit of fertilizer and seed provided to farmers in the highland of Ethiopia increased the value of household crop output moderately and hence allowed the household to increase its consumption. This scheme requires borrowers to sell their crop immediately at harvest to repay their credit. An alternative repayment scheme of extending the repayment period to allow households to capture seasonal price variation is proposed. The amount repaid is also tied to yields of wheat

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Introduction

Livestock plays an essential role in diversifying the portfolio of economic activities of farming households in mixed, crop-livestock systems of Sub-Saharan Africa. It is often the primary investment opportunity for smallholder mixed crop-livestock farmers, acting as their major source of farm cash income through sales of animals and products, and the primary source of traction and a source of food. While the use of manure as a fertilizer can make livestock complementary to crops, crop residues are also the main source of animal feed. Hence, there is a trade-off in using animals to maintain soil fertility (Sanders, et al., 1996).

Interactions between crop and livestock production can have a significant impact on productivity of both activities. Evidence from other Sub-Saharan countries indicates that substantial potential exists for improvement of livestock productivity as long as crop intensification is possible. In southern Mali, for example, farmers are using higher levels of inputs on most crops including cotton, maize and sorghum, and improved leguminous feed crops such as *Dolichos lablab* and *Stylosanthes spp.* are being introduced along with improvements in the management and storage of crop residues and cowpea hay.

In the mixed crop-livestock system of the Ethiopian highlands, the potential for crop intensification also exists and strategies to promote such intensification are becoming an important policy issue due to high population pressure and land scarcity. Under these conditions, crop intensification is likely to lead to opportunities for improvements in livestock feed and productivity. Agricultural intensification entails a multi-dimensional process of responses to increasing population density, technological change and commercialisation or to any combinations of these. It is characterized by substitution of labour for land in the initial stages followed by more continuous cropping, systems of crop rotation and soil improvement and additional modern yield-enhancing inputs such as inorganic fertilizer (Migot-Adholla, et al., 1991). One useful policy question is how can intensification of crop and livestock activities be promoted.

Access to credit is one strategy for promoting the adoption of yield-enhancing technologies. Governments have often used credit programs to promote agricultural output, and credit policy could play a more efficient and equitable role in development if appropriate policies were adopted (Adams and Vogel, 1990). However, advancing credit to smallholder farmers for encouraging technology adoption is a complex policy issue. Among the related issues are the amount and form of credit, the interest to be charged, which farm households to target, and repayment schemes. The objective of this paper is to identify appropriate and sustainable credit repayment policies to encourage intensification. In this paper, we analyse the impact of advancing in-kind credit in the form of fertilizer and seed to smallholder farmers in the Ethiopian highlands and alternative credit repayment strategies.

The results indicate that in kind input credit of fertilizer and seed provided to farmers in the highland of Ethiopia increased the value of household crop output moderately and hence allowed the household to increase its consumption. This scheme requires borrowers to sell their crop immediately at harvest to repay their credit. An alternative repayment scheme of extending the repayment period to allow households to capture seasonal price variation is proposed. The amount repaid is also tied to yields of wheat.

In this paper, we first examine the linkages between crop intensification, productivity and credit under population pressure and land scarcity in mixed farming systems. Second, the modelling approach of household decisions in mixed farming systems is described. Results of credit policy simulation and conclusions are then presented.

Conceptual framework

Land degradation is a severe problem in the highlands of East Africa. Soil nutrient depletion is also a critical problem. Ethiopia is among the sub-Saharan Africa countries with the highest rates of soil nutrient depletion. FAO (1986) has estimated that one-half of the arable lands in the Ethiopian highlands are moderately to severely eroded. These problems contribute to low agricultural productivity, poverty and food insecurity in the highlands. Poverty and malnutrition are also endemic in the country (Smaling, 1993). In other settings, the technological response to soil erosion and nutrient depletion is adoption of effective erosion control measures and improving soil fertility management technology – principally the use of inorganic fertilizers.

In the absence of technological response, smallholder, poor farmers respond by cultivating more land to compensate for low crop yields. In the Ethiopian highlands, high population growth shifts the demand for food outward. In response to increasing food demands, crop cultivation expands into pasture and steeply sloping marginal lands that are highly vulnerable to soil loss. The immediate consequence is further crop yield decline and rapid soil erosion rates. With the expansion of crop land, farmers need to increase the number of animals kept for traction, leading to higher animal populations. At the same time, the conversion of pasture land for cultivation reduces the amount of feed available for livestock, which leads to feed inadequacy and further leads to low milk yields, high young stock mortality, longer parturition intervals, and low animal weights (McIntire et. al., 1992, p. 103). The consequences of the resultant low crop and livestock productivities are poverty, malnutrition and food insecurity. Soil nutrient depletion, therefore, resulting in low crop productivity, inadequate livestock feed availability and inadequate human nutrition are strongly linked.

The lack of quality feed is a major constraint to improving livestock productivity in the highlands of Ethiopia mainly because of a shortage of grazing land due to the expansion of crop production on grazing area, lack of available concentrates, and the generally low quality of remaining pasture. Despite recognition of this and the efforts to overcome it through feed research and development, progress in extending feed technologies, particularly forage crops, has been slow. This is principally because farmers feel they cannot afford to allocate land to forages at the expense of food crop production. In modelling results for Selale, increased fertilization of barley, the major crop in the area, increased adoption of an oats-vetch intercrop substantially (Ahmed, et. al., 2000). This suggests that increasing land quality by improving its productivity through better soil fertility management can ease the competition for land between food and feed crops. That is more efficient land use by food crops can free up land for forage production.

Substantial evidence supporting the productivity and profitability gains from fertilizer application and intensification exists. With the increased use of mineral fertilizer during the 1995-96 and 1996-97 crop seasons, Ethiopia recorded its highest harvests of the major crops ever in history (Quiones et. al. 1997). This came also as result of increased use of improved seed, better extension advice, and favourable rainfall over most of the country.

Intensification also reduces the need to expand cropping onto steep slopes and, thus, reduces erosion. Thus, intensification is a land-saving strategy and impressive savings similar to those that have accrued to China and India through application of modern technology to raise yields (Quiones et. al. 1997) can be expected. Since improved soil fertility management enhances crop stands and vegetative growth, this will also enhance straw production for animal feeds, thus, improving animal productivity. Improving animal productivity will contribute to food security, better nutrition and increased incomes. Besides, availability of more manure will contribute to further improvement in soil fertility and structure.

However, adoption of intensive crop production technologies requires that inputs be available and that farmers have access to these inputs, i.e. can afford them. Farmers often have limited financial resources to carry them through to harvest time, and short-run consumption needs may prevent them from purchasing inputs even when productivity increases are substantial. A sound credit policy can help alleviate this financial constraint either by providing inputs via in-kind credit or cash.

Governments have often used credit programs to increase agricultural output or the adoption of new technology. There have also been attempts to help the rural poor through credit. Because of the complexity of agricultural credit policy, past experience around the world indicates that these programs have included both successes and failures (Adams, et al. 1990). Among the relevant issues are whether the credit will be used for the intended objective of increasing output, the form of credit, targeting of the credit program both in terms of the recipients and use of the credit, and repayment plans.

Governments often have a limited amount of credit to be allocated to smallholder farmers and effective allocation of credit resources is an important objective. Therefore, issues of targeting a specific crop or farmer group come into play. For instance, some governments may choose to target major food crops with cheap credit as the case of rice in Southeast Asia or sorghum in Sudan to compensate farmers for low prices of these important food crops. However, the low prices cause the expected returns from investment in crops with low prices to be low. Under these circumstances, borrowers will often divert the additional liquidity provided by credit to activities with higher returns. In this case, credit will not be used for its intended objective. While this diversion of credit may be illegal, it is difficult to control when large numbers of borrowers are involved and they are geographically dispersed, making monitoring of their actions difficult or impossible. Moreover, granting in-kind loans (e.g., in the form of seed and fertilizer), does not obviate this problem because farmers can usually sell unwanted inputs provided on credit in secondary markets and buy other goods or services.

Credit policies may target a specific group of farmers. The poorest farmers usually face a severe financial constraint that limits their access to purchased inputs. However, this group usually lacks the collateral for credit through normal channels, and in case of crop failure, may be unable to repay either the principle or interest on the loan. On the other hand, wealthier farmers may have access to the purchased inputs even without the credit.

Most agricultural credit programs require farmers to repay their loans immediately after harvest. This is justifiable given that the limited funds available to run the credit program need to be recycled back to producers before the next season. However, due to the relatively inelastic demand for agricultural output, prices are usually lowest at harvest time. By selling at least part of their output at harvest to repay their loans, farmers may reduce the profitability of using purchased inputs. The research of this paper will analyse some of the issues related to credit policy.

Modeling impact of credit

A household model of the mixed, crop-livestock, farming system of the highlands of Ethiopia is under development for analysis of the impact of a wide range of technologies and policies affecting smallholder farmers. The objective of this activity is to develop and apply a tool for assessment of the impacts of alternative policies and technologies on production patterns and welfare of Ethiopian smallholder households.

Conceptually, the crop-livestock, household model is based on the bio-economic framework displayed in Figure 2. In this framework, the household has two integrated enterprises, crop and livestock production. Crops provide feed for livestock while livestock is the principal supplier of traction power to till the land and manure for improving soil fertility. Therefore, in selecting a crop plan, the farmer considers, among other things, the available traction capacity, the expected quantity of feed for livestock, available manure resource for fertilizing the land and the expected grain produced to feed the household. The productivity of both enterprises is determined by the biophysical environment including soil productivity and weather, and by the available technology including traditional and improved seeds, inorganic fertilizer, and soil fertility management and erosion control.

The household supplies feed and labor to the livestock herd and labor and crop inputs to the farm. In return, the household receives livestock services and livestock and crop products for own consumption and sale as well as manure for burning as a fuel, improving soil fertility and sale. Through the market, the farm surplus is exchanged for food, feed, fuel and cash (or other consumption goods).

The policy environment affects the outcome of the marketing activities. For instance, infrastructure improvement may improve the price received by the farmer, creates higher demand for farm products, in particular perishable products such as milk and, ensures timely delivery of farm inputs at lower cost. Other institutions such as land tenure systems facilitate land transactions and may ease certain resource constraints. For example, a farmer facing a labor or traction constraint may rent out, on either a share or cash basis, some of his land. Alternatively, additional land can be acquired when land is the binding constraint. Credit systems and input subsidies are other examples of policies affecting households.

The model consists of activities broadly relevant to crop production, livestock production, resources management and consumption. To reflect uncertainty, crop yields and prices are allowed to vary depending on the state of nature. Consequently, consumption is also state-dependent. In each state, the household objective function is a direct function of consumption. A Cobb-Douglas utility function whose arguments are the monthly consumption levels of all goods is used to reflect household preferences over food items. i, .e.,

$$u(c_{it}) = \prod_{t=1}^{12} \left(\prod_{i=1}^{j} c_{it}^{a_{it}} \right)$$

where c_{it} is the level of consumption of the i^{th} good in period (month) t, and a_{it} is the expenditure share of the i^{th} good (i=1,…,j) in period t. Details of the model activities and constraints are documented in Ahmed, Preckel and Ehui, 2000.

Data

The model developed is applied to data collected from Holetta area located 40 to 70 km west of Addis Ababa, in the vicinity of two small towns: Holetta and Addis Alem. The altitude of the area is around 2600 m.a.s.l and receives an average annual rainfall of 1100 mm. Average minimum and maximum temperature are, respectively, 11.6° and 15.3° C. The main rainy season, *mehr*, extends from June to September when more than seventy percent of the rain falls. The short rains season, *belg*, extends from late February to May and is mainly used to break and prepare the soil for the main crop season. Farmers in this area exclusively depend on rain-fed agriculture and most crops are grown in the main rainy season.

The Holetta area is characterized by variable soils with a predominance of red brown soils, with a low water holding capacity on the slopes and poorly drained heavy dark clay soils (vertisols) mostly in the valleys. Three types of soils can be identified on household plots: vertisols, light and mixed upland soils, and heavy upland soils with vertisol properties. The average household owns about 0.35 ha of vertisol land, 0.95 ha of the light mixed upland soil land, and, 0.95 ha of the heavy upland soil land. Land redistribution in Ethiopia is implemented in such a way that farmers receive separate plots of each of the three major land types. In addition, the household uses the communal grazing resources and may also own about a hectare of grazing land.

The farming system in this area is typically a mixed, crop-livestock system. Farmers produce a wide range of cereal and legume crops on small parcels of land. The production is geared towards satisfying the household food requirements as well as provision of feed in the form of straw and hay for livestock. The main crops are barley in the *belg* season, and wheat, teff, oats, and horse beans in the *mehr* season. Other minor crops include field peas, chickpeas, linseed, sorghum and rape seed. Table 1 summarizes the average cropping plan on the three types of land. Farmers usually use manure, urea and diammoium phosphate for soil fertility management. These inputs are either used individually or in combination, depending on availability, type of soil of the plot and the crop grown.

Holetta is one of the areas where crossbred cows were introduced to increase dairy production to meet the increasing demand of the neighboring urban areas and to improve farmers' incomes and nutrition. However, the practice of growing fodder crops for animals is rare, and there is an acute shortage of high quality feeds necessary for maintaining crossbred cows. Some of the newly introduced feeds intended to alleviate this problem include fodder beet, oat-vetch intercrop and leguminous trees.

Beside crops, the household keeps a herd of animals, mainly consisting of dairy cows, at least two oxen for plowing, heifers, bulls, goats, sheep and chicken. Because of the dependency on animal traction for crop production, keeping at least a pair of oxen and a follower herd (heifers and bulls) for replacement is necessary despite the feed shortage. To ease the feed shortage, dairy-draft crossbred cows are encouraged. This technology allows the farmer to reduce the herd size while maintaining the capacity for both animal traction and milk production. However, farmers are reluctant to use crossbred cows.

Impact of credit

Smallholder farming households are usually characterized by substantial variability of resources available on the farm such as land and labour, leading to substantial differences in levels of assets and wealth. Since the level of the farm household's wealth is among the important determinants of the adoption of new technologies (Feder and Umali, 1993), this leads to varying levels of technology adoption. As such, farmers cannot be treated as a homogenous group. In addition, subsistence communities rely on producing wide range of products, most of which is for home consumption with little marketed surplus. These characteristics make accurate prediction of resource allocation, especially crop land, a complex and difficult task, from modelling perspective. For model validation, we compare observed and predicted average crop land allocation and annual consumption patterns of Holetta sample farmers.

The average household in Holetta area cultivates 1.84 ha of land. Most of the land (1.30 ha) is allocated to the three major crops: wheat, teff and barley (Table 1). About 0.32 ha is allocated to pulses, mainly horse beans and field peas. Small area (0.04 ha) of land is allocated to gardening and other minor crops. Though these may be important for household income and consumption, these were not included in the model due to the difficulties in characterizing productivity and resource requirements of these minor crops. Predicted land allocation appears to be very close to the observed in the area (Table 1). However, the model underestimated land allocated to wheat (0.308 ha) and overestimated the area allocated to teff (0.878 ha) as compared to the observed area of 0.51 and 0.57 ha, respectively. The model predicted closely the area allocated to the two pulse crops as well as other crops. However, the model successfully predicted the diversification behaviour of the household.

On the consumption side, the model predictions of calorie and protein intake are very similar to observed behaviour (Table 2). However, model predictions of individual consumption goods vary across commodities. The model underestimated milk consumption, and overestimated beef, butter and beans and peas consumption substantially while predicted other consumption goods within a margin of less than 15%. Taking cereals together (barley, wheat, teff and sorghum), the model predicted a household intake of 998 kg per year compared to the observed average consumption of 951 kg or about 5% higher. Similarly, the model predicted total household consumption of pulses (field peas and horse beans) of 105 kg compared to the average observed consumption of 76 kg. Overall, both calorie and protein intake predicted are very close to observed values (Table 2).

Given the complexity of the farming system, the large number of crop and consumption choices and the possibility of substitution between them, we conclude that the model approximate observed behaviour satisfactorily and hence can be used with confidence to measure response to alternative scenarios.

Simulation of alternative credit options

Using the above model, the following options were simulated:

1. Fertilizer and seed are available in the open market and farmers are able to borrow unlimited cash at an interest rate of 20 percent to purchase inputs. Repayment also is due at harvest.
2. Fertilizer and seed credit is available to smallholder households in-kind from government agencies at terms similar to the currently practiced. Households have to pay a minimum down-payment of 10 percent of the total value of the credit and repay the remainder at harvest at an annual interest rate of 18 percent.
3. Fertilizer and seed are available in the open market but credit is unavailable.
4. The household has no access to both credit and inputs.

The first scenario is the ideal situation with the input and credit markets efficiently functioning. In this case, the household can borrow credit to purchase inputs according to the optimality condition, i.e, marginal value product of inputs equals marginal cost under certainty. However, under risk household may operate below this point. In contrast, the last scenario reflects the case of perfectly absent markets.

Table 3 compares the cropping plans, value of crops produced, fertilizer use and extent of borrowing associated with the above credit options. The value of crops produced is the lowest in absence of credit and fertilizer input among the alternative scenarios. In contrast, households still apply some quantity of fertilizer (33 kg of Diammonium phosphate (DAP)) to their crops even in absence of credit market, given that the input market is functioning. As a result, the value of crops produced increased to Birr 3,652.53 or by 31 percent. With access to in-kind credit, fertilizer use increases to 205 kg or more than six-folds compared to the case of no credit. This allows the household to increase the value of crops produced by 64 percent over what would have been produced without fertilizer and credit and 37 percent or a net profit of 11 percent in absence of credit. This income increase is the impact of both fertilizer and credit.

Despite access to cash credit, the average household applies less than half of the fertilizer input (98 kg), compared to in-kind credit. This is because most of the credit is diverted to early consumption. Despite the capital constraint facing the household, they may still purchase fertilizer in absence of credit. How they can afford to do that? According to modelling results, the household substitutes preferred food for less preferred food, and consume lower calories and thus spends less on current consumption. This reflects the high profitability of fertilizer application.

When credit is available, the household, apparently, diverts its available resources for current consumption. With access to cash credit, the household may use some for current consumption substituting current consumption for future consumption. This reflects the degree of capital constraint of the households. In reality, households usually resort to selling livestock to finance immediate cash needs.

The above results suggest that functioning of credit and input markets promote intensification through use of inorganic fertilizer and high-yielding seed. In-kind credit in form of fertilizer appears to be most effective compared to cash credit. Though based on the situation in the highlands of Ethiopia, these results are relevant to smallholder farmers in many other sub-Saharan countries where governments are attempting to promote intensification and increase crop productivity.

Alternative credit repayment strategy

The most important policy issue to be analyzed remains to be evaluated is the repayment schedule. As farmers are required to repay loans immediately following harvest, they may be forced to sell their products at low prices given the seasonal variability of output prices. Farmers also face frequent crop failure due to the erratic rainfall. In bad years, crop failure may lead to inability to repay credit, increased indebtedness and poverty of farmers and low recovery of credit. This approach is unsustainable and the government in Ethiopia is now exploring other possibilities. We proposed a flexible repayment strategy in which borrowing household is to be given the choice of either repaying in January at harvest or late in the season in August when crop prices begin to rise with additional payment of interest. In addition, the amount of repayment is to be proportional to wheat yields, a major food crop targeted by both improved seed and fertilizer in the current scheme. The yields of wheat are expected to reflect the success or failure of the season. The yield of wheat ranges from 71.5 in bad years to 1.44% in good years of the long-term average yield.

Table 4 compares the price gains from delay crop sale from harvest time to August. The seasonal price movement due to supply fluctuation results in dramatic increases in farm prices of most crops ranging from 4% for barley to 68% for sorghum. However, market forces may tend to equalize these seasonal fluctuations when most farmers are able to adjust their marketing strategies.

Table 5 presents crop area allocation, fertilizer use and value of crop output associated with the flexible repayment schemes in contrast to current policy. Compared to in kind credit in which the household must repay all debt at harvesting time, the household borrows lower quantity of inputs with an early flexible repayment schedule linked to wheat yield. Total value of inputs borrowed in this case was Birr 810 compared to Birr 931 in the inflexible repayment strategy. The farmer reduces fertilizer use by 15%. This underlines the optimal borrowing capacity in low harvest year when the repayment capability of the household is expected to be lower. With lower borrowing, the value of crop produced and value of consumption goods fell slightly. The crop plan is roughly the same with slight shift to less of wheat and teff.

When the household is allowed to delay repayment until later in the season, the household's borrowing and fertilizer use are almost equal to that associated with inflexible repayment. However, the value of crop produced and value of annual consumption increased. There is slight adjustment in crop land allocation. It is to be noted that area allocated in teff is much higher in these scenarios than currently observed. Teff is more likely to be used for the repayment of credit due to its relatively higher price and the relatively higher price gains in August (Table 4).

The above analysis demonstrate that thee new repayment strategy is feasible. It allows the household to gain from delaying credit repayment through later sales in the season and still achieve the credit program objectives of applying modern inputs.

Conclusions and implications

As in most other developing countries, rural credit market is not well developed. Formal credit institutions are yet to be able to cover the whole country and provide credit to smallholder farmers for financing input purchases. To fill the gap, the government of Ethiopia has been active in providing credit to smallholder farmers in form of seed and fertilizer. The analysis in this paper considers the effect of this type of in kind credit and cash credit on crop production and expenditure on food and non-food. The results support our hypothesis that credit will encourage intensification of the smallholder farming system of the Ethiopian highlands through use of inorganic fertilizers and high-yielding seed. Expenditure on consumption increases by as much as 40 percent.

Continued population growth, shortfall in agricultural production, and widespread of rural poverty will force policy makers to continue to promote agricultural development. Agricultural credit will continue to be a major part of these efforts. Where the environment is conducive to increasing crop productivity through input use, e.g., the high rainfall highlands of Ethiopia, credit appears to contribute significantly to increases in incomes and expenditure on food. In-kind credit in form of fertilizer appears to be most effective in targeting increase in input use compared to cash credit. As the rural credit market is not presently functioning in Ethiopia, in the short run the government should continue provide credit in kind to smallholder farmers in areas with high potential for productivity increases from these inputs. However, the terms of repayment need to be flexible allowing farmers to gain from seasonal price fluctuation through late sale. Farmers may need also pay lower than their credit in low harvest years and higher in good years. Modelling results indicate that this flexible strategy is feasible and achieves the objectives of the credit program of promoting intensification. In the long run, credit and input markets should be promoted. Formal and rural institutions should be encouraged and rural credit mechanisms should be developed. Such institutions can play a significant role in mobilizing voluntary private savings in rural areas.

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Table 1. Observed and predicted crop land allocation

Crop	Observed area[a] (ha)	Predicted area[b] (ha)
Oats	0.032	0.007
Barely	0.223	0.112
Wheat	0.510	0.308
Teff	0.572	0.878
Sorghum	0.086	0.132
Horse beans	0.201	0.204
Field peas	0.119	0.110
Rape seed	0.046	0.092
Lin seed	0.043	0.007
Total area	1.845	1.850

a. Observed area is the actual average crop land allocation in the area
b. Predicted area is the locally optimal model results under comparable conditions.

Table 2. Observed and expected yearly consumption pattern of average household in Holetta area.

	Observed consumption[a]	Expected consumption[b]	Percentage difference
Milk (litre)	54.82	43.80	-20.10
Barley (kg)	149.30	136.33	- 8.69
Wheat (kg)	282.49	270.87	- 4.11
Teff (kg)	493.39	558.94	13.29
Sorghum (kg)	26.24	31.57	20.31
Horse beans (kg)	54.02	77.23	42.97
Field peas (kg)	22.09	27.64	25.12
Eggs (kg)	1.17	1.26	7.69
Butter (kg)	6.42	7.54	17.45
Cheese (kg)	8.16	9.45	15.80
Chicken	1.24	1.41	13.71
Mutton (kg)	3.72	3.99	7.25
Beef (kg)	12.98	18.72	44.92
Other food (Birr)	808.46	752.06	- 6.97
Non food (Birr)	1,013.16	1,036.25	2.28
Per capita calorie intake per day (cal)	1,428.04	1,541.97	7.97
Per capita protein intake per day (g)	41.18	45.49	10.46

a Observed consumption of the average household in Holetta area

b. Expected consumption denotes the quantity of consumption goods predicted by the model under comparable conditions.

Table 3. Crop land allocation (ha), fertilizer use (kg) and value of crops under alternative credit scenarios

	No fertilizer/no credit	No credit	In-kind credit	Cash credit
Oats	0.001	0.007	0.007	0.007
Barely	0.187	0.149	0.112	0.104
Wheat	0.555	0.381	0.308	0.385
Teff	0.549	0.724	0.878	0.521
Sorghum	0.160	0.286	0.132	0.168
Horse Beans	0.257	0.168	0.204	0.213
Field peas	0.042	0.028	0.110	0.353
Rape seed	0.092	0.092	0.092	0.92
Lin seed	0.008	0.015	0.007	0.007
Total land use	1.850	1.850	1.850	1.85
Quantity o f fertilizer	0.00	33.35	205.95	98.04
Total credit value	0.00	0.00	931.85	1,000.00
Value of crop produced	3,035.11	3,652.53	4,991.08	4,658.67
Value of annual consumption	3,286.52	3,975.09	4,600.19	5,651.60

Table 4. Seasonal price fluctuation of crop prices (1997) in Holetta area

Crop	Average farm price in January	Average farm price in August	Percentage difference
Wheat	1.28	1.66	29.69
Teff	1.51	1.93	27.81
Oats	1.04	1.04	0.00
Barley	1.18	1.23	4.23
Sorghum	0.97	1.63	68.04
Rape seed	1.19	1.50	26.05
Field peas	1.44	2.25	56.25
Horse beans	1.65	1.96	18.79
Lin seed	1.67	2.24	34.13

Table 5. Crop land allocation (ha), fertilizer use (kg) and value of crops under the proposed credit scenarios

	In-kind credit	Flexible early repayment	Flexible late repayment
Oats	0.007	0.012	0.007
Barely	0.112	0.109	0.110
Wheat	0.308	0.268	0.296
Teff	0.878	0.793	0.842
Sorghum	0.132	0.160	0.132
Horse Beans	0.204	0.312	0.178
Field peas	0.110	0.096	0.185
Rape seed	0.092	0.092	0.092
Lin seed	0.007	0.008	0.007
Total land use	1.850	1.850	1.850
Quantity of fertilizer	205.95	175.75	201.41
Total credit value	931.85	810.29	905.96
Value of crop produced	4,991.08	4,876.98	5,032.36
Value of annual consumption	4,600.19	4,457.58	4,693.03

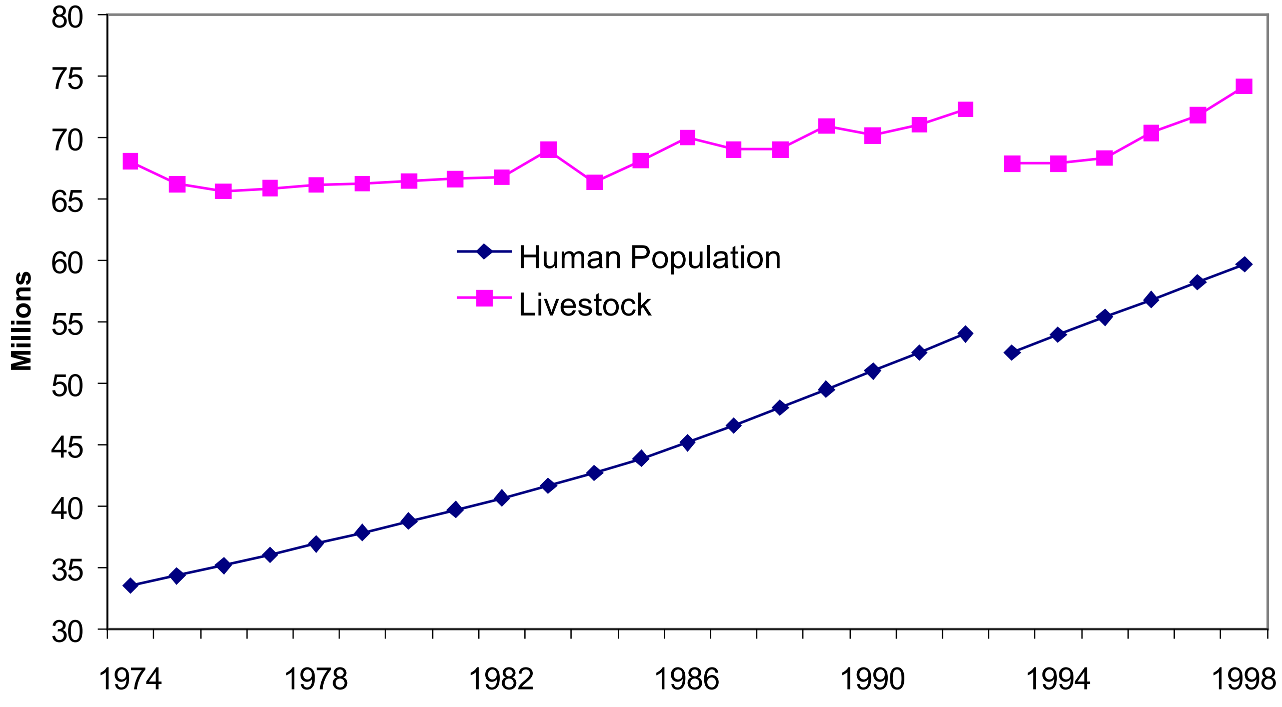

Fig. 1: Human and livestock population in Ethiopia

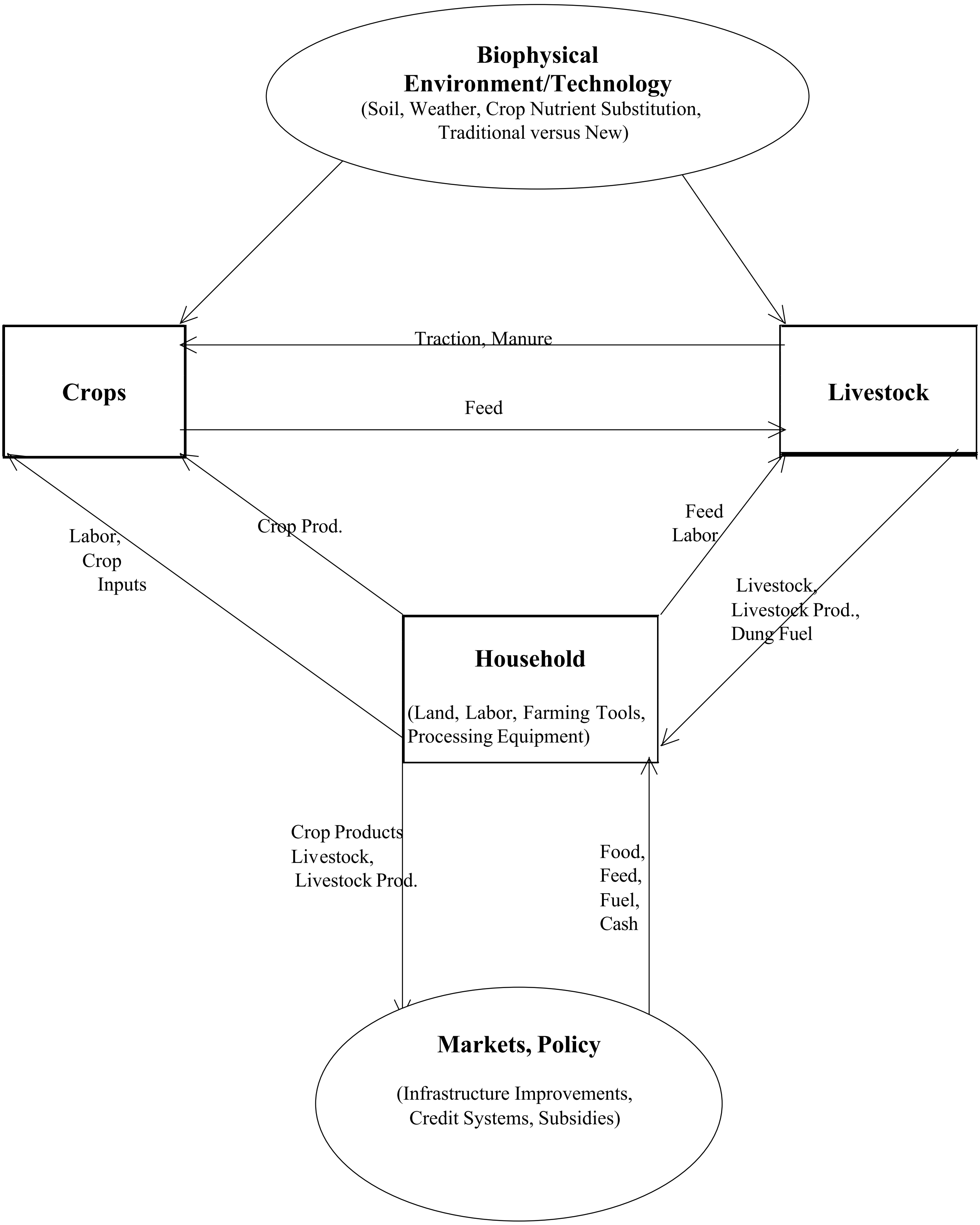

Figure 2: Conceptual framework of bioeconomic modelling approach