An exploratory assessment of the economic impact of forage options for beef production on smallholder farms in the Red Soils Region of China.

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Introduction

The agricultural sector of the Peoples Republic of China has experienced an unparalleled rate of growth. For example, while beef represents only 8% of the total meat output, it expanded by 1100% during the 15 year period to 2000 (Longworth *et al.* 2001). Despite the emergence of specialised feedlots (e.g. 50+ cattle on feed), beef production is oriented to low value local markets dominated by smallholder production units where meat production is a secondary consideration to draught use. Cattle husbandry and nutrition is typically poor; with most of the diet based on low quality crop residues and limited tethered or free grazing of fallowed land, roadsides, terraces and wastelands (Xie 1991). More recent public policy for promoting beef production is directed to the use of planted forages and energy dense or protein-augmented crop residues to improve diet quality and raise productivity (e.g. Xie *et al.* 1992).

The Red Soils Region of southern China, encompassing 2.6 million km^2 of land across 14 provinces has been identified as an area in which beef production based on forages might be successfully encouraged (Sturgeon 1991). A series of agronomic projects sponsored by the Australian Centre for International Agricultural Research (ACIAR) in partnership with the Chinese Government, collectively identified palatable forage species that are persistent and productive in the region and fertiliser regimes to correct the major soil nutrient deficiencies (e.g. Clements *et al.* 1997). In 2000, ACIAR sponsored a new project (project AS2/98/35) to integrate the outputs of the previous research through a series of trials that covered cattle feeding, the growing and handing of forages, residues and energy dense supplements, and the definition of `feed year' plans for the Red Soils Region. The work was conducted at 2 sites (Nanchang, Jiangxi and Qiyang, Hunan) and is being promoted through demonstration farms established by the Animal Husbandry Bureau. The project also sought to provide an economic assessment of the prospective benefit to smallholder households of incorporating forage-based cattle feeding systems within their existing farming systems. This paper presents an

assessment, based on modelling and a synthetic case study, of the prospective impact on the profitability of a smallholder household that incorporates a modest cattle finishing activity, based on the use of farm-grown forages, crop residues and purchased supplements, within its existing cropping system. The feeding regime is based on a feed year plan that is consistent with the ACIAR project recommendations and the level of animal performance is based on the mean results for the cattle feeding trials. The analysis includes a simple sensitivity test of changes in two key variables; viz. finished stock prices and liveweight gain. Some implications for the farmer demonstration programs are presented.

Material and methods

The ACIAR Project is seeking to develop economically viable forage-based beef production systems in the Red Soils Region. As economic data for smallholder farms within the Red Soils Region is essentially non-existent, the impact of forage production and feeding strategies for beef production activities is illustrated using a synthetic farm modelling approach. A case study is presented for a typical smallholder household located in Chunqiutang Village, Hunan Province.

Household surveys

A survey in 4 counties with a strong interest in promoting economic development through increased beef production in Jiangxi (Taihe and Gao'an) and Hunan (Dao and Jiangyong) Provinces provided baseline data for smallholder enterprises and to calibrate an economic model. Smallholder households were surveyed in 6 villages in Jiangxi by students from Jiangxi Agricultural University and in 5 villages in Hunan by students from Hunan Agricultural University in October and November 2002. Detailed results from the surveys are included in the project report (MacLeod *et al.* 2004). To demonstrate the application of the economic model, data only for Chunqiutang village is considered in this short paper.

Economic model

The context for the forage and feeding practices promoted by the ACIAR project involves immense numbers of resource-constrained households whose welfare is intricately linked to their farm resources and the wider economy; with complex dependencies between the household and an array of agricultural and industrial activities. There are many interdependencies between farm activities (e.g. cropping, forages, livestock) that draw on or supplement resources (e.g. animal draught power, feedstuffs, manure etc). This complexity is captured within an Excel® spreadsheet model that includes planted forages and a wide range of other farm and off-farm activities. The structure of the model is depicted in Figure 1.

Data relating to the demand for resources by each activity (land, labour, materials, transport services, working capital, feedstuffs, draught etc) or their contribution to household resources (feedstuffs, working capital, manure etc.) are specified in the *Input Data* module. This module captures data on crop and forage yields, by-produce, livestock sales, liveweight gains, reproduction and mortality etc; family structure and labour availability and capital infrastructure, including livestock, plant and equipment, buildings etc.

Farm and other household activities are linked through resource pools within the *Resource Reconciliation* module – including land, forages and feedstuffs (grain, by-products, straws, oilcake, tops), manure, labour (family and hired), animal draught, and working capital. Final products (e.g. crops and sale livestock), and surpluses of intermediary produce (e.g. manure and edible residues), generate revenue; while resource deficits can be filled through purchases from outside the farm (included as expenditures in the calculation of farm costs). The crop, forage and livestock activities (including both final and intermediate farm activities) represent the farm enterprise. Off-farm activities (e.g. contract ploughing, planting, weeding, harvesting, factory employment etc) contribute to, or draw on, the resources available to the household for

production, consumption or wealth accumulation. The model provides an indication of whether different crop and forage options will contribute to or detract from household welfare.

The *Profit Measures* module integrates the input, output, price and cost data and presents an array of summary measures, including gross and net income for the impact of production and feeding strategies on the profitability of the smallholder enterprise. The contribution of cattle production to gross farm income and net farm income is separated from the crops and other livestock. Opportunity costing is used to value non-marketed inputs and outputs to the various crop, forage and livestock activities (e.g. draught and manure used for crops), and consumption of crop produce and by-products by livestock. These are treated as transfers of revenue between the producing and consuming activities and give an indication of the real contribution of the activities to the economic welfare of the household. Because these economic transfers do not involve actual exchanges of cash, estimates are also calculated for net cash income, which is the cash that the households would actually receive as a result of employing a given mix of activities.

The profit measures used in the present analysis for the case study farm household include:

1. *Total farm revenue* (Gross revenue from the sale of crop, forage, and livestock products, including finished animals, plus the opportunity values of transfers of by-products, residues and other surplus materials between activities).
2. *Total farm costs* (Total cash outlays on purchased inputs for farm activities including land lease and produce taxes, plus the opportunity values of transfers of by-products, residues and other surplus materials between activities, depreciation of specialised farm assets, opportunity value of family labour and interest on capital invested in farm assets and livestock).

3. *Return to management* – (Total farm revenue – total farm costs plus income from off-farm activities). This measure is interpreted as the full economic return or profit to the smallholder enterprise after all opportunity costs are accounted for, including the opportunity value of by-products, residues and other surplus materials that are consumed by farm activities; off farm income and the value of the small holder family's capital and labour that is utilised for on-farm and off-farm activities.
4. *Net cash income* (Total cash revenue – total cash expenses, plus cash income from off-farm activities).

Case study household

A case study is presented for a synthetic smallholder farm household located in Chunqiutang Village, Hunan Province. The average household size in this village in 2002 was 4.9 people with a total lease landholding of 5.7 mu (1 mu = 0.07 ha). Approximately two thirds of the leased land is paddy land and a further 30% is dryland that is suited to growing crops and pastures. Less than one half of the village households (43%) actually own cattle, and for these households the average number of cattle is marginally greater than 1 animal, with a slightly higher proportion being young bulls or steers that are speculatively held for fattening and re-sale. A little over one half of the total household income is comprised of off-farm work. Crop income is almost double that for livestock which is mostly derived from raising pigs and poultry. Income from cattle constitutes less than 10% and 2% of livestock income and total household income. From this data, the model has been calibrated for a representative farm-household whose main characteristics are described in Table 1.

Feed Years

A central task of the ACIAR project was to promote an improved understanding of the year-around feed requirements of cattle given the high level of seasonality in the climate of the Red

Soils region and its impact on forage growth and availability. A series of feed year plans have been developed (Nolan *et al.* 2004) that include planted forages, conserved hay or silage, or other low digestibility feedstuffs (e.g. rice straw or dry native grass).

Scenarios

Four scenarios are presented for the profitability assessment; viz a baseline case (Scenario 1) which is then modified by increasing the liveweight gain to a level consistent with the average results of the feeding trials (Scenario 2), reducing the average daily liveweight gain of the livestock (Scenario 3), and reducing the sale value of finished stock (Scenario 4).

Scenario 1 (baseline) – The case study household is comprised of 4 persons (Table 1), which equates to 2.75 labour units that are available for on-farm and off-farm activities. Off-farm labour availability is limited to 0.8 labour units per year. Two rice crops followed by a winter fallow are grown on 3.8mu of paddy land, and peanuts are grown on 3 mu of cultivable dryland. Cattle are grazed in spring and summer on 10 mu of native grassland available to the household. In addition to 3 pigs, 10 chickens and an aged cow for draught use, the household purchases 3 steers at 100kgs per steer average weight. These steers are fed for 200 days on a ration of local forages and crop residues (rice straw and peanut tops). Average daily liveweight gain of the steers is 150g/day, which is consistent with the average results for such diets obtained from the feeding trials (Nolan *et al.* 2004). The finished steers are sold in a local market at 130 kgs average liveweight for 5 yuan per kg liveweight. This selling price is consistent with markets for animals of this condition in Dao County in 2005. A summary of other input and output parameter values used in the analysis is presented in Table 2.

Scenario 2 - 2.0mu of ryegrass is grown in place of the fallow phase after 2 rice crops on the 3.8 mu of paddy land. Hybrid elephant grass is sown on 1mu of cultivable dryland along with

peanuts (2 mu). The cattle still have grazing access to the 10 mu of native grassland in spring and summer. The 3 steers (100kgs average weight) and are fed for 200 days on a mixed ration of forages, residues and supplements at an average daily liveweight gain of 0.6 kg/steer/day and sold locally at 220kg average liveweight at 6 yuan per kg liveweight. The higher selling price is consistent with the better quality of the finished animals which should attract a premium in local markets.

Scenario 3 – Liveweight gain is reduced to 0.5kg/steer/day, other parameters identical to Scenario 2 (i.e. steers are fed for 200 days, selling price 6 yuan per kilogram). This level of animal performance lies within the lower range of the results from the feeding trials, and is consistent with the limited feeding and husbandry skills of households with little prior experience in raising beef cattle.

Scenario 4 – Selling price of the steers is reduced to 5 yuan per kilogram liveweight, other parameters identical to Scenario 2 (i.e. steers are fed for 200days, liveweight gain 0.6kg/steer/day). This assumes that the market does not differentiate between different animals on the basis of weight and finish.

Results

Economic results are summarised in Tables 3 to 6. The various revenue, cost and profit measures derived by the model are presented for the crop and forage activities and the livestock activities as aggregate measures. Income from off-farm activities is also included to provide an estimate of total household income. The crop and forage activities are combined because they both provide important sources of feedstuffs for the livestock and are generally integrated within the same land area on the farms (e.g. sharing draught, labour or intercropped). The aggregate livestock measures are also presented separately for the cattle and other livestock activities to provide an indication of the relative contributions of these different activities to farm and household income. The total revenue and cost measures (Tables 3 to 6)

include both cash and imputed non-cash items; the latter representing the internal transfers as `sales' and `purchases' of the various forages, crop by-products, residues, manure and draught between the crop and forage activities and the livestock activities, depreciation, unpaid household labour and interest on capital. While the resource transfer values offset each other in the calculation of return to management, their identification is necessary to determine the specific contribution of the various activities to the economic performance of the total farm enterprise. (Tables 3 to 6). The effect of including or removing these opportunity values is shown in the differences between the estimates of return to management and net cash income.

Baseline (Scenario 1) – The economic challenges facing smallholders who may be intending to rear some cattle, but have limited skills and experience in growing and feeding forages, are illustrated in the measures of return to management and net cash income (Table 3). The return to management for each of the farm activities, including the cattle rearing activity is negative. While the poor level of animal performance and the cost of labour and capital committed to cattle rearing is the main contributor to this poor farm performance, the crop and forage activities are also failing to cover the cost of the labour and capital committed to them as well. This implies that the smallholder farm household would not be able to maintain the investment that is has in farm production assets over time, without diverting valuable funds that have been earned through access to the off-farm employment activities. Unless it can increase the productivity of its farm activities (e.g. Scenarios 2 to 4), the welfare of the household would be improved by almost 60% if it abandoned them altogether. However, the need for the household to explore these choices may be clouded by the positive contribution of the farm activities to net cash income, which is projected to exceed the cash contribution of the off-farm activities by 40%. Nevertheless, the cattle raising activities still generate a negative contribution to cash income, which should either reduce the commitment of the household to cattle raising or spur its' interest in increasing the efficiency of this activity.

Effect of changing livestock performance (Scenario 2) -This option leads to a marked improvement in all of the income measures for the model household (Table 4). The return to management from the combined farm activities is positive (cf. Scenario 1), although the return from the cropping and fodder activities remains negative, and for the other livestock activities is small (25 yuan). This implies that these two parts of the farm operation might be profitably reduced in favour of increased commitment to either cattle raising or off-farm activities. The overall economic position for the household remains one in which the contribution of all of the farming activities to household economic welfare remains modest, contributing only 11% to the total net return to management of 3492 yuan. This economic conclusion, however, might still be masked by the positive levels of net cash income for all of the farming activities. For example, these particularly favour the crop and forage activities by a significant margin, and are more than double the level of off-farm income. Moreover, the net cash income estimates rate the 2 livestock activities almost equally and ignore the relatively high imputed value of the provision of draught and manure to the crop and forage activities.

Effect of changing livestock performance (Scenario 3) – Despite being less productive than the previous scenario, this still represents a significant improvement over the baseline animal performance, and is reflected in each of the income measures (Table 5). The cattle raising activity has lifted the overall level of farm performance and the return to management for both livestock activities is positive, indicating that these activities are a worth including in the household production mix. The net return to all farm activities is, however, negative (-66 yuan) due to the cattle raising activity failing to offset the negative return for crop and fodder activities. Economic performance might be enhanced by reducing the area of land allocated to cropping and forage activities in favour of purchases of crop residues and other forages for the cattle and other livestock activities. The net cash income projections may indicate that the crop and fodder activities are an attractive option that contribute almost as much to total household

cash income as the off-farm activities. The cash income derived from the other livestock activities also exceeds that for the cattle raising activities by 20%. Smallholders who might make their investment decisions on the basis of cash flows, rather than economic returns, may be attracted towards crop and forage activities and other livestock activities, rather than the higher returning cattle raising activity.

Effect of changing livestock price (Scenario 4) – As was the case for reducing the production efficiency of the cattle rasing activity (Scenario 3), reducing the price of the finished animals (17% to 5 yuan/kilogram) necessarily reduces the profitability of both this activity and the contribution of the total farm enterprise to the various measures of household income (Table 6). Nevertheless, this scenario still represents a marked improvement over the economic performance of the baseline case (Scenario 1, Table 4). However, similar to the outcome for Scenario 3, the combined return to management for the farm activities is negative (-351 yuan), because the reduced return to management for the cattle raising activity is still failing to offset the negative return for crop and fodder activities. Despite this, the cattle raising activity has lifted the overall level of farm performance above the baseline levels (Table 5) and the return to management for both livestock activities is positive. As is the case for each of the previous 2 scenarios (Table 4 and Table 5), the contribution of all of the farm activities to net cash income is positive (Table 6) and is collectively almost double the level of off-farm income. The skewing of the apparent relative attractiveness of the farm and off-farm activities, based on the net cash income, is also evident in that these activities generate similar levels of net cash income, but have quite divergent economic returns. For example, net cash income favours the cropping and forage activities and other livestock activities over cattle raising, whereas, the economic return to the former is negative and the latter is generating only 4% of the return from the cattle rasing activity.

Discussion

The rapid expansion of cattle numbers in China, mainly on smallholder farms with a limited history of cattle raising, has been attributed to a favourable perception of the profitability of cattle raising and government encouragement (Longworth *et al.* 2001). While the results support the perception and reality of cattle raising being profitable, this can not be guaranteed without more planning and management than simply increasing the number of cattle. The baseline case (Scenario 1) suggests that a modest level of cattle raising without providing adequate feedstuffs is unlikely to be economically viable. This conclusion is consistent with Longworth *et al.* (2001) whose findings suggested that the economic returns to beef raising activities on smallholder farms was at best marginal if not uneconomic. However, that study focussed on low quality feedstuffs with low levels of animal performance, while the ACIAR project is specifically asking whether growing and feeding better quality forages to cattle is economic. This is answered by the results for the remaining 3 scenarios.

The results for the scenario that is directly based on growing and feeding improved forages (Scenario 2) suggest that the cattle raising activities is potentially economic when liveweight gain performance is consistent with the average results for the feeding trials under the prices prevailing during the study period. From a cash flow perspective, which may attract the interest of resource poor smallholders, this may also be an attractive one as it offers a substantial increase in the projected level of net cash income. The positive economic outlook for cattle raising is conditional on prevailing market prices for cattle remaining buoyant, and the smallholder households being sufficiently skilled in producing and feeding adequate quality forages to cattle to reap animal performance outcomes similar to those assumed for Scenario 2.

The remaining scenarios (Scenarios 3 and 4) examined the consequences if either of these conditions was challenged, and the general result was similar. The impact of the adverse

change in parameter values was not sufficient to prevent the cattle raising activity from yielding a full economic profit (i.e. positive return to management). However, the total mix of farm activities generated an economic loss (negative return to management), because the crop and forage activities yield insufficient income to cover the opportunity costs of labour and capital invested in the farm. This suggests that improved economic performance may be achieved by improvements in the production and marketing elements of the crop and forage component of the farming system, as well as the efficiency of the livestock activities.

Conclusions

Cattle raising activities based on producing and feeding improved forages can potentially increase the economic welfare of smallholder households in the Red Soils Region, conditional on both the efficiency with these activities and good livestock prices. Under less favourable production and price assumptions there is scope for economic losses for the farm activity mix, although cattle raising remains profitable. A significant source of economic loss lies in the poor application of valuable livestock services (e.g. draught and manure) to crop and forage activities. It may be more profitable to divert these resources to off-farm uses or to reduce the level of cropping and divert resources to specialised forage activities or to source feedstuffs from off –farm. A positive economic result is unlikely when cattle raising relies on diets of poor quality feedstuffs (Scenario 1), although positive net cash incomes may continue to generate interest and short-term commitment to this activity. A series of extension campaigns supported by demonstration farms in various counties will be implemented to disseminate the results of the ACIAR project feeding trials and feed year plans (CSIRO 2004). A key focus of these campaigns should be to highlight the economic imperative of carefully planning forage production and management strategies, and to promote appropriate skills in both crop and animal husbandry management. In so doing, the high level of interest and commitment to profitable cattle production in the Red Soils Region can be more appropriately linked.

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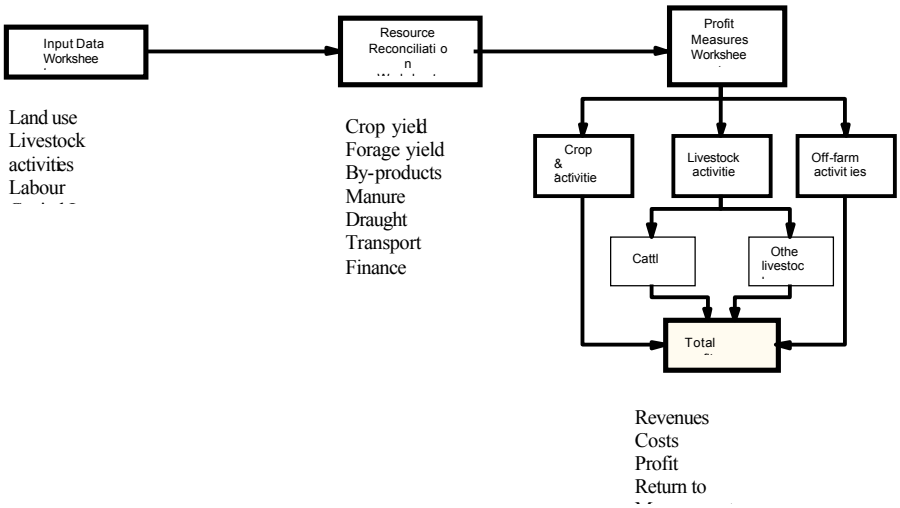

Figure 1. Structure of the economic model

Table 1. Characteristics of model household, Chungquitang Village, Hunan Province.

No. of persons	- working age adults	2
	- aged adults (60years +) and children (under 10 years)	2
Number of labour units (adult labour equivalent)		2.75 per annum
Land area	- paddy land (rice X 2 crops, fallow)	3.8 mu
	- dryland cultivation (peanuts X 1 crop, fallow)	3.0 mu
	- buildings, paths etc	0.2 mu
Allocated native grassland		10 mu
Capital invested in farm assets (sheds, pens, tools, barrows etc)		20,000 yuan
Livestock	- cows (aged for draught)	1 head
	- feeder steers purchased at 100kgs/liveweight/steer	3 head
	- pigs	3 head
	- chickens	10 head

Table 2. Selected household parameter values for scenario modelling.

Crops	- rice grain yield (tonnes/mu) early crop/late crop	0.4/0.45 tonnes
	- rice grain selling price (yuan/tonne) early crop/late crop	1,200/1,600 yuan
	- peanut grain yield (tonnes/mu)	0.15 tonnes
	- peanut selling price (yuan/tonne)	3,600 yuan
Forages	- astragulus yield (tonnes/dry matter.mu)	0.15 tonnes
	- elephant grass hybrid (tonnes/dry matter/mu)	0.8 tonnes
	- native grasses (tonnes/dry matter/mu)	0.2 tonnes
Fertiliser	- urea application (kg/mu) rice	22 kgs
	- urea price (yuan/kg)	1.7 yuan
	- manure (tonne/mu) all crops	0.2 tonnes
Livestock	- purchase price of feeder steers (liveweight)	6 yuan
	- selling price of feeder steers (liveweight)	6 yuan
	- cattle manure (yuan/tonne/dry weight)	120 yuan
	- draught selling/hiring price (yuan/day)	60 yuan
	- selling price of pigs (yuan/head)	610 yuan
Labour	- hire rate (yuan/day)	60 yuan

Table 3. Revenue, costs and profit measures for Scenario 1.

LWG = 0.15kg/steer/day Price = 6Y/kg liveweight	Farm activities		Livestock		Total farm	Off-farm	Total household
	Crops & fodder Y Rmb	Total Livestock Y Rmb	Cattle Y Rmb	Other Y Rmb	Y Rmb	Y Rmb	Y Rmb
Total revenue	6402	3915	1917	1998	10317		
- cash revenue	4818	2655	670	1985	7472		
- resource transfers	1584	1260	1247	13	2844		
Total costs	7067	5130	3104	2024	12197		
- cash costs	1531	1406	1136	269	2937		
- resource transfers	1260	1583	738	845	2844		
- depreciation	500	500	250	250	1000		
- family labour	3276	953	641	312	4229		
- interest on capital	500	687	339	348	1187		
Return to management	-665	-1214	-1188	-27	-1880	3120	1240
Net cash income	3287	1249	-466	1716	4536	3120	7656

Table 4. Revenue, costs and profit measures for Scenario 2.

LWG = 0.60kg/steer/day Price = 6Y/kg liveweight	Farm activities		Livestock		Total farm	Off-farm	Total household
	Crops & fodder Y Rmb	Total Livestock Y Rmb	Cattle Y Rmb	Other Y Rmb	Y Rmb	Y Rmb	Y Rmb
Total revenue	6511	6335	4337	1998	12846		
- cash revenue	4818	5056	3075	1980	9874		
- resource transfers	1693	1279	1262	18	2973		
Total costs	7143	5331	3358	1974	12474		
- cash costs	1510	1429	1211	218	2939		
- resource transfers	1279	1694	848	846	2973		
- depreciation	500	500	250	250	1000		
- family labour	3354	953	641	312	4307		
- interest on capital	500	755	408	348	1255		
Return to management	-632	1004	979	24	372	3120	3492
Net cash income	3308	3627	1864	1762	69356	3120	10055

Table 5. Revenue, costs and profit measures for Scenario 3.

LWG = 0. 50kg/steer/day Price = 6Y/kg liveweight	Farm activities		Livestock		Total farm	Off-farm	Total household
	Crops & fodder	Total Livestock	Cattle	Other			
	Y Rmb	Y Rmb	Y Rmb	Y Rmb	Y Rmb	Y Rmb	Y Rmb
Total revenue	6512	5885	3887	1998	12397		
- cash revenue	4818	4606	2625	1980	9424		
- resource transfers	1694	1279	1262	18	2973		
Total costs	7168	5295	3313	1981	12463		
- cash costs	1535	1404	1178	225	2939		
- resource transfers	1279	1694	848	846	2973		
- depreciation	500	500	250	250	1000		
- family labour	3354	953	641	312	4307		
- interest on capital	500	744	396	348	1244		
Return to management	-656	590	574	17	-66	3120	3054
Net cash income	3283	3203	1447	1755	6485	3120	9605

Table 6. Revenue, costs and profit measures for Scenario 4.

LWG = 0. 60kg/steer/day Price = 5Y/kg liveweight	Farm activities		Livestock		Total farm	Off-farm	Total household
	Crops & fodder	Total Livestock	Cattle	Other			
	Y Rmb	Y Rmb	Y Rmb	Y Rmb	Y Rmb	Y Rmb	Y Rmb
Total revenue	6512	5585	3587	1998	12097		
- cash revenue	4818	4306	2325	1980	9124		
- resource transfers	1694	1279	1262	18	2973		
Total costs	7186	5262	3275	1987	12448		
- cash costs	1553	1386	1155	231	2939		
- resource transfers	1279	1694	848	846	2973		
- depreciation	500	500	250	250	1000		
- family labour	3354	953	641	312	4307		
- interest on capital	500	729	381	348	1229		
Return to management	-674	323	312	11	-351	3120	2769
Net cash income	3265	2920	1170	1749	6185	3120	9305