

2.8 Economic Impact of Smallholder Dairy Technologies at the Farm (Household) Level

The agricultural sector model (ASM) provides a description of expected impact on production, trade, and economic welfare at regional, national, and global scales for a technological change in agriculture. It also provides information on changes in resource allocations, prices, and quantities consumed. The ASM approach does not, however, examine impacts of technological innovation at the farm level. By incorporating equilibrium price and quantity changes from the ASM solutions into a farm-level economic model such as Farm Level Income and Policy Simulation (FLIPSIM), an assessment of the impacts of a technological innovation at the farm level may be achieved.

2.8.1 Brief Description of FLIPSIM Model

Representative farms were used to evaluate the farm-level economic impacts of adopting the smallholder dairy technologies in Kenya. The farm-level analysis considered both deterministic and stochastic conditions with regard to commodity prices and yields for representative farms. In both types of analyses, the FLIPSIM model was used to simulate the impact on individual farms of adopting the smallholder dairy technologies. The stochastic simulations describe the risk to a producer associated with adoption of a technology through use of yield and price variations over time and generation of probabilistic projections of future outcomes. Figure 2.8.1-1 describes the general steps in performing the analysis.

Base macro-economic and technology conditions for representative farms in each dairy production zone were established through a joint effort between U.S. researchers and research/extension personnel in Kenya. Results from the ASM baseline analysis were examined by the East Africa personnel and modified

Table 2.7.4.4.2 Welfare Comparison between Current and Full Adoption Scenarios Under 2015 Demand and Yield Increase and 18 Ksh/kg Milk Import Price

<u>Unit: Million Ksh, %</u>		
Welfare Measure	Improved Dairy Current Adoption (Value)	Improved Dairy Full Adoption (Change in Value)
Consumers' Surplus		
all commodities	160416	181541 (113.17)
dairy technology only		385 (0.24)
Foreign Surplus		
all commodities	89260	274 (0.31)
dairy technology only		158 (0.17)
Producers' Surplus		
all commodities	6761	11794 (174.43)
dairy technology only		-944 (-13.96)
Home Consumption Expenditure		
all commodities	-54471	-58296 (107.02)
dairy technology only		4607 (8.46)
Total Social Welfare		
all commodities	201967	135312 (67.00)
dairy technology only		4206 (2.08)
<p>(Note) Consumers's surplus is the Kenya domestic consumers' surplus. Foreign surplus is the trade surplus including import and export in Kenya. Producers' surplus is the Kenya domestic producer's surplus. Home consumption expenditure is the Kenya farmer and family home consumption expenditure. Total social welfare is the summation of consumers' surplus, foreign surplus, producers' surplus, and home consumption expenditure. The numbers in parentheses represent the percentage change between full adoption and Improved Dairy Current Adoption scenario.</p>		

to represent alternative technology scenarios for the representative farms. On-farm data collection was conducted by a Kenya Agricultural Research Institute (KARI) livestock specialist working on secondment to ILRI (Kaitho; Staal).

Results from the ASM were used to determine changes in equilibrium commodity prices under the different dairy technology scenarios. These national crop and livestock price forecasts were used as a reference base for estimating representative farm-level commodity prices. Prices from the ASM results were modified by randomly selected error terms, calculated as percentage deviations from observed historical mean prices, and used as initial prices for all years in the FLIPSIM stochastic runs. Certain macro-economic variables included in FLIPSIM, such as the inflation rate, were held constant in the farm-level analysis.

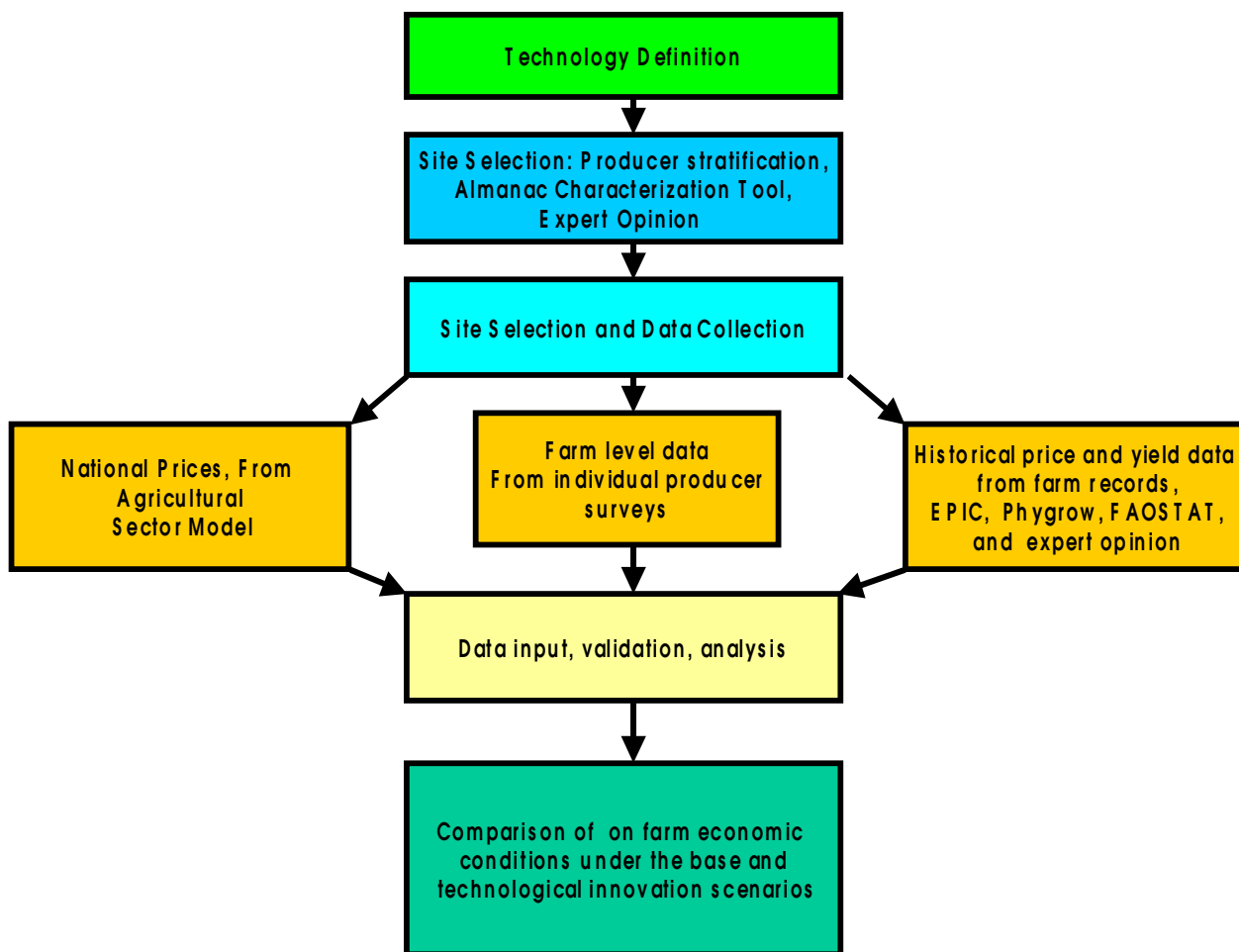


Figure 2.8.1-1. Farm level economic analysis methodology.

2.8.2. Representative Farms for Impact Assessment at Household Level

Table 2.8.2.1 provides a profile of seven representative farms in Kenya. Each representative farm is associated with a particular dairy zone dominated by a commodity (e.g., coffee, tea, horticultural crops, sheep, wheat) or a location (e.g., peri-urban, coast). Land cropped by each farm ranges from 0.149 hectares for the peri-urban farm to 1.68 hectares for the coastal zone representative farm. Productivity constraints vary among zones. The coastal zone faces high cattle disease pressures and low soil fertility, whereas the sheep and wheat zones face low forage production due to cold temperatures. Grass land available to producers varies from 0 hectares in the peri-urban zone with high population density and the coastal zone to communal grazing with undetermined available hectares. Most representative farms had 1.2 or more hectares of grass land. Producers also had access to an organized milk collection system and dairy processing facilities in most of the country's seven dairy zones.

<i>Table 2.8.2.1 Kenya Representative Farms Profile Under Current Conditions</i>							
Variable	Dairy Zone						
	Coffee	Hort	Tea	Peri_urban	Sheep	Wheat	Coast
Latitude	-0.7773	-0.5606	-0.9868	-1.1782	-0.7149	-0.3086	-4.2717
Longitude	37.0610	37.2708	36.7316	36.8915	36.8587	35.7402	39.5814
District	Muranga	Kirinyaga	Kiambu	Nairobi	Muranga	Nakuru	Kwale
Cropland (ha)	1.214	1.335	1.255	0.149	1.639	1.214	1.680
Grass Land [*] (ha)	1.38	1.38	1.48	0	1.27	Communal	0
Napier (ha)	0.10	0.03	0.1	0	0.35	0	0
Cattle Type Current Technology	Friesian	Friesian	Friesian	Friesian	Friesian	Friesian	Friesian
Current Mean Milk Yields (kg/cow)	1222	1206.25	1531.25	1625	1025	1185	1000
Number of Dairy Cows	1	1	1	2	2	3	1
Cattle Type Old Technology	Zebu	Zebu	Zebu	Zebu	Zebu	Zebu	Zebu
Traditional Milk Yields (kg/cow)	643	635	806	855	529	623	526

^{*}Estimated based on current population of humans and animals, and farm numbers (source Angerer)

Historic crop yields were sought by interviewing producers on the representative farms. Most producers were unable to provide a 10-year history of yields. In instances where historical yields were incomplete for a farm, the EPIC crop model was used to generate yield estimates. These estimated yields from the biophysical model were adjusted to represent the farms' yields. The ratio of simulated yield to historic yield for years that historical yield data existed for a farm was calculated and used to estimate historic yields for the missing years.

Forage yields were estimated with the PHYGROW forage simulation model. Available nutrients for animal consumption were then calculated from these estimated yields. Surveys of land use conducted in the 1970's in Kenya were used to estimate the amount of grazing land available for cattle on communal lands and the

resulting hectares allocated to each representative farm. Yields estimated from the PHYGROW model applied to the estimated land area provided an estimate of forage yield variation for the representative farms. These yield variations were used in the FLIPSIM analysis to estimate the farm-level impacts of the dairy technologies. Producers were assumed to sell surplus forage, or conversely, to purchase forage if yields did not meet feed requirements of animals on the farm. For each representative farm surveyed, producers that did not produce Napiergrass on their farm but had Napiergrass in their dairy rations were assumed to purchase Napiergrass for their cows.

2.8.3 Results from the Deterministic Analysis

The deterministic analysis used mean yields and prices in the simulations. Results from adopting the dairy technologies on each representative farm in the seven dairy zones are summarized in Table 2.8.3.1. Net present value (NPV) increased for the horticulture, peri-urban, and coastal farms. NPV is defined as the present value of net cash farm income plus changes in real net worth over the 10-year planning horizon. The horticultural farm experienced a 27.0% increase in net present value, whereas the growth in NPV was only 4.9% for the peri-urban farm and 2.5% for the coastal farm. The NPV became less negative for the coffee farm (by 28.2%) and the wheat farm (by 2.9%). However, an actual decline in NPV resulted for the tea (-4.1%) and sheep (-1.0%) farms.

Table 2.8.3.1 Kenya Representative Farms Deterministic Mean Net Present Values, Total Cash Receipts, Total Cash Costs, Net Cash Farm Income, and Real Net Worth Under the Base (old) and Current Small Holder Dairy Technology in 1,000's Kenya Shillings.

Dairy Zone	Net Present Value		Total Cash Receipts		Total Cash Costs		Net Cash Farm Income		Real Net Worth	
	Old	Current	Old	Current	Old	Current	Old	Current	Old	Current
Tea (% change)	1420.0	1220.0 (-14.08)	90.0	100.0 (11.11)	30	50 (66.67)	60	50 (-16.7)	1570	1460 (-7.01)
Coffee (% change)	-390	-280 (28.21)	40	50 (25.00)	50	50 (0.0)	-10	0.00 (100)	-70	-10 (85.71)
Hort. (% change)	850.0	1080.0 (27.06)	40	60 (50.00)	10	20 (100.0)	30	40 (33.33)	1010	1013 (0.29)
Peri - Urban (% change)	1230.0	1290.0 (4.88)	30	80 (166.67)	10	50 (400.00)	20	30 (50.00)	1500	1530 (2.00)
Sheep (% change)	970.0	960.0 (-1.03)	160	160 (0.00)	40	40 (0.00)	120	120 (0.00)	2720	2720 (0.00)
Wheat (% change)	-340.0	-330.0 (2.94)	60	70 (16.67)	60	70 (16.67)	0.00	0.00 (0.0)	3600.	3400.0 (-5.56)
Coast (% change)	5270.0	5400.0 (2.47)	560	580 (3.57)	60	70 (16.67)	500	510 (2.00)	3900.	3960.0 (1.54)

Total cash receipts increased for all representative farms except the sheep farm that maintained annual cash receipts of 160 thousand Ksh. The peri-urban and horticulture farms exhibited the largest relative growth in total cash receipts, 167% and 50%, respectively. However, total cash costs increased for all representative farms except the coffee and sheep farms. Resulting net cash farm income remained constant for the sheep and wheat farms; grew by 10 thousand Ksh annually for the coffee, horticulture, peri-urban and coast farms; and declined by 10 thousand Ksh annually for the tea farm. The horticulture, peri-urban, and coast farms experienced a positive change in real net worth (RNW) from adoption of the dairy technologies. Only the coffee farm continued to exhibit a negative RNW, but even this farm had a positive change (85.7%) in its RNW. The tea and wheat farms experienced RNW declines of 7.0% and 5.5%, respectively, after adoption of the dairy technologies. The horticulture, peri-urban, and coast farms had a slight growth in RNW whereas the sheep farm experienced no change in RNW. Figures 2.8.3-1. to 2.8.3-10 present these results graphically.

2.8.4. Results from the Stochastic Analysis

The stochastic analysis used probability distributions for commodity yields and prices in the simulations. The average net present value (NPV) under current adoption of improved technology declined on three repre-

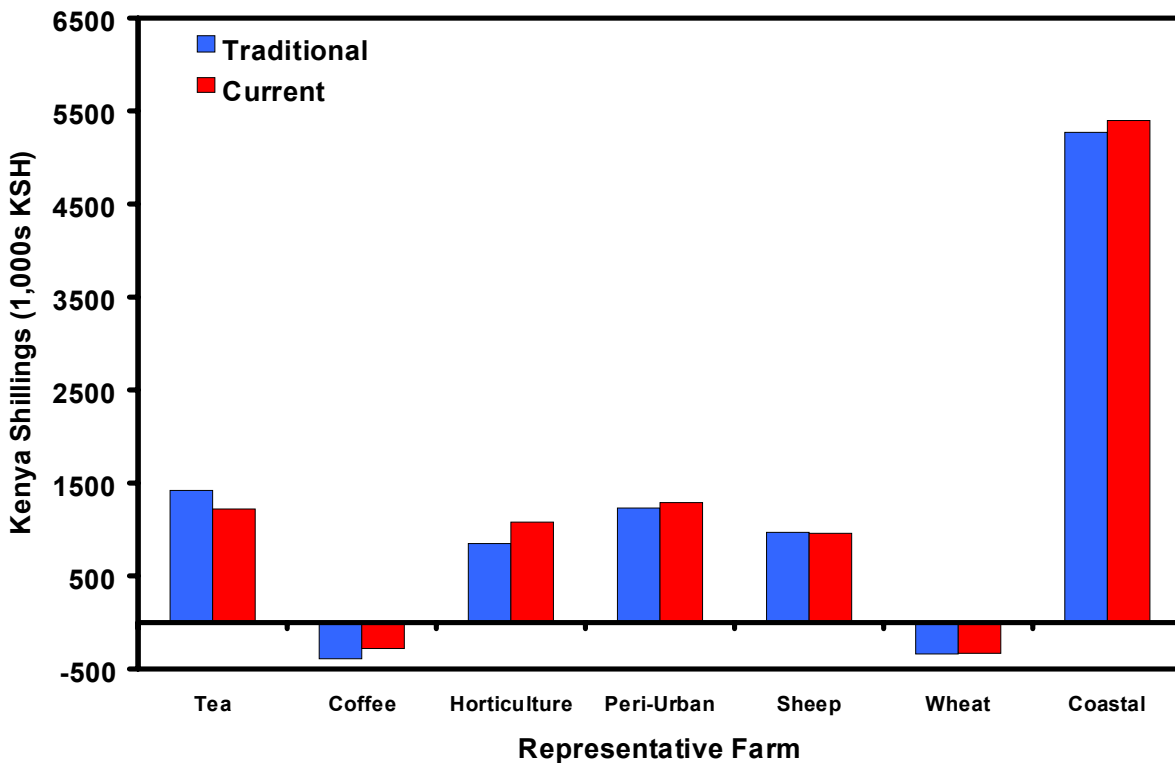


Figure 2.8.3-1. Net present value (NPV) for Kenyan representative farmers under the traditional (zebu cattle/native forage) and the current technology, deterministic scenarios.

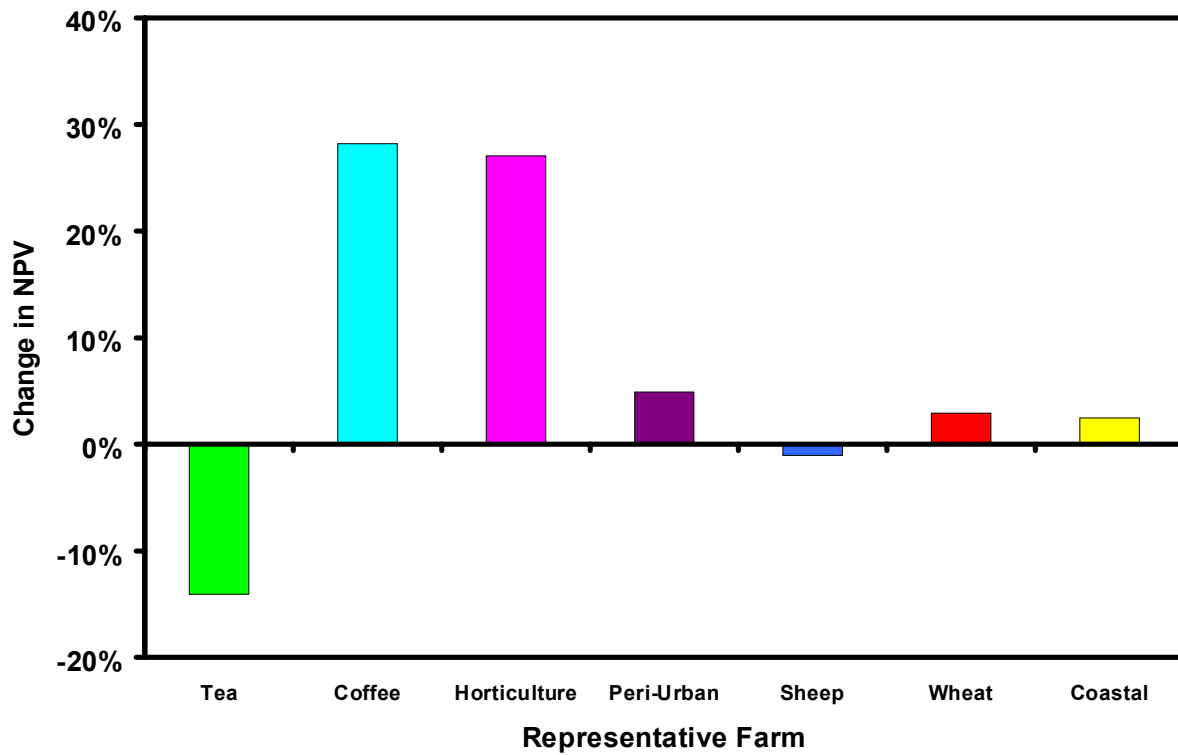


Figure 2.8.3-2. Percent change in net present value (NPV) for representative small holder dairy farmers changing from traditional (zebu cattle/native forage) to current technology for farms in seven dairy environments in Kenya under the deterministic scenario.

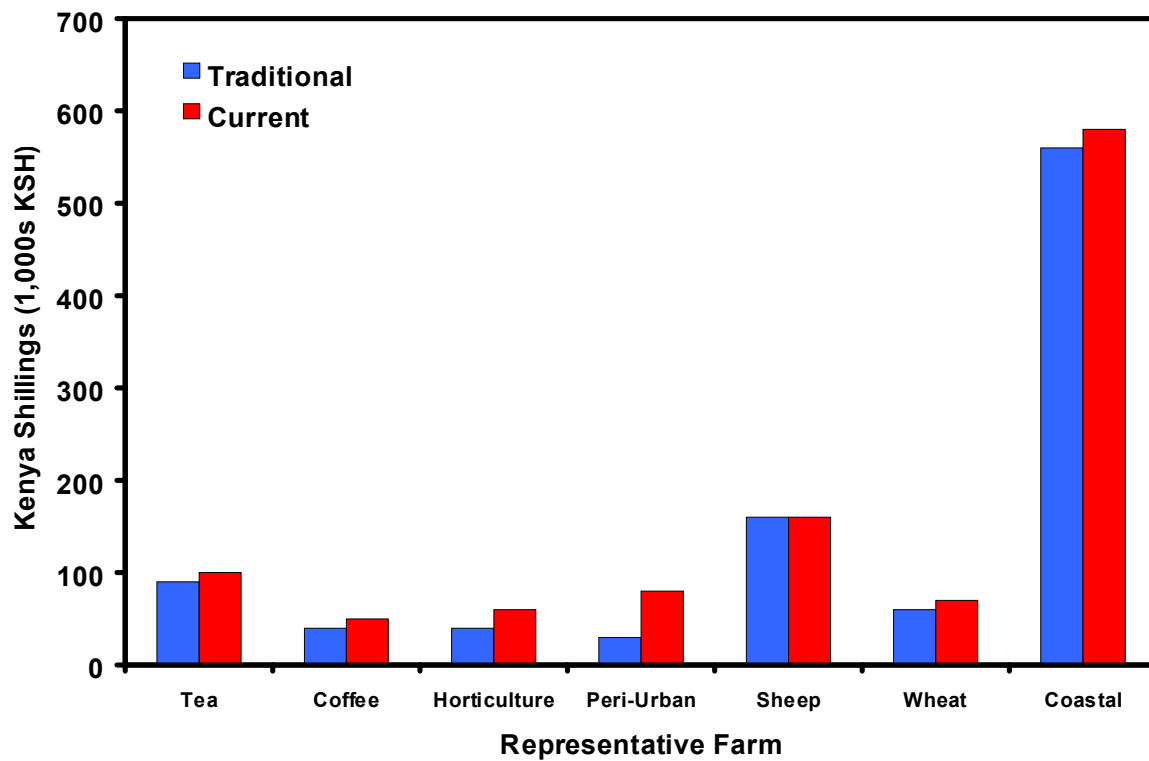


Figure 2.8.3-3. Total cash receipts for Kenyan representative farmers under the traditional (zebu cattle/native forage) technology and the current technology, deterministic scenarios.

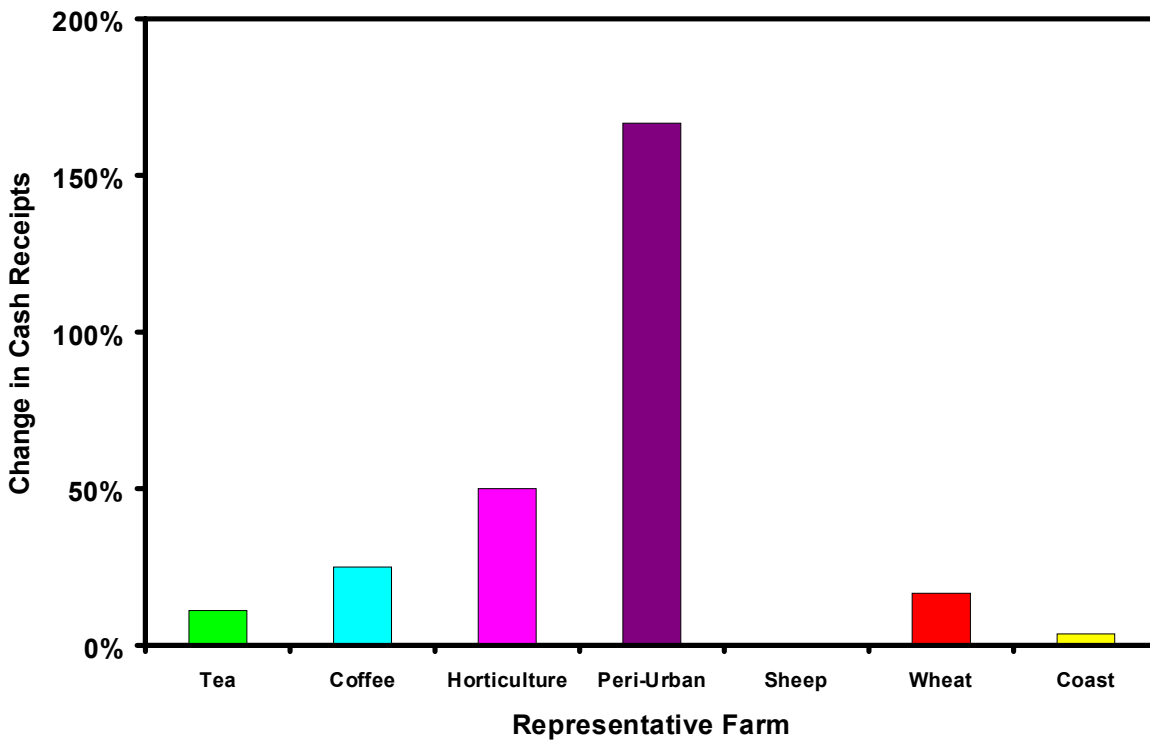


Figure 2.8.3-4. Percentage change in cash receipts for representative small holder dairy farmers changing from traditional (zebu cattle/native forage) to current technology for farms in seven dairy environments in Kenya under the deterministic scenario.

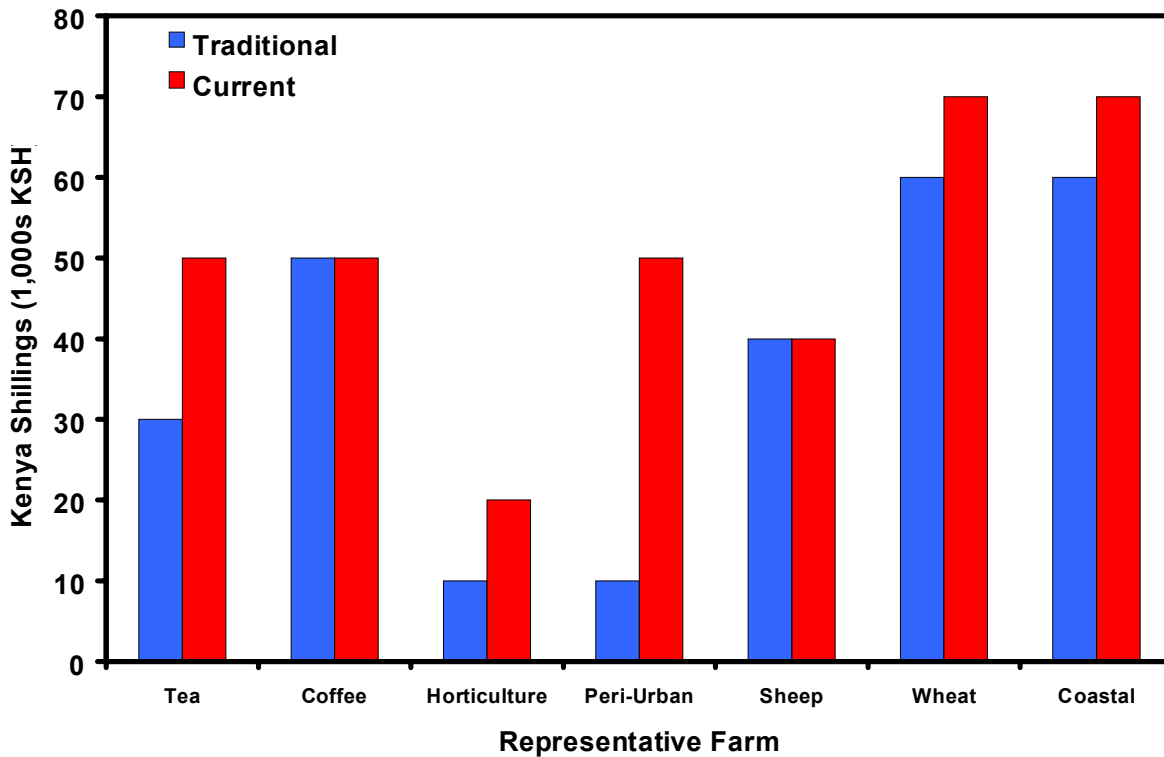


Figure 2.8.3-5. Total cash costs for Kenyan representative farmers under the traditional (zebu cattle/native forage) technology and the current technology, deterministic scenarios.

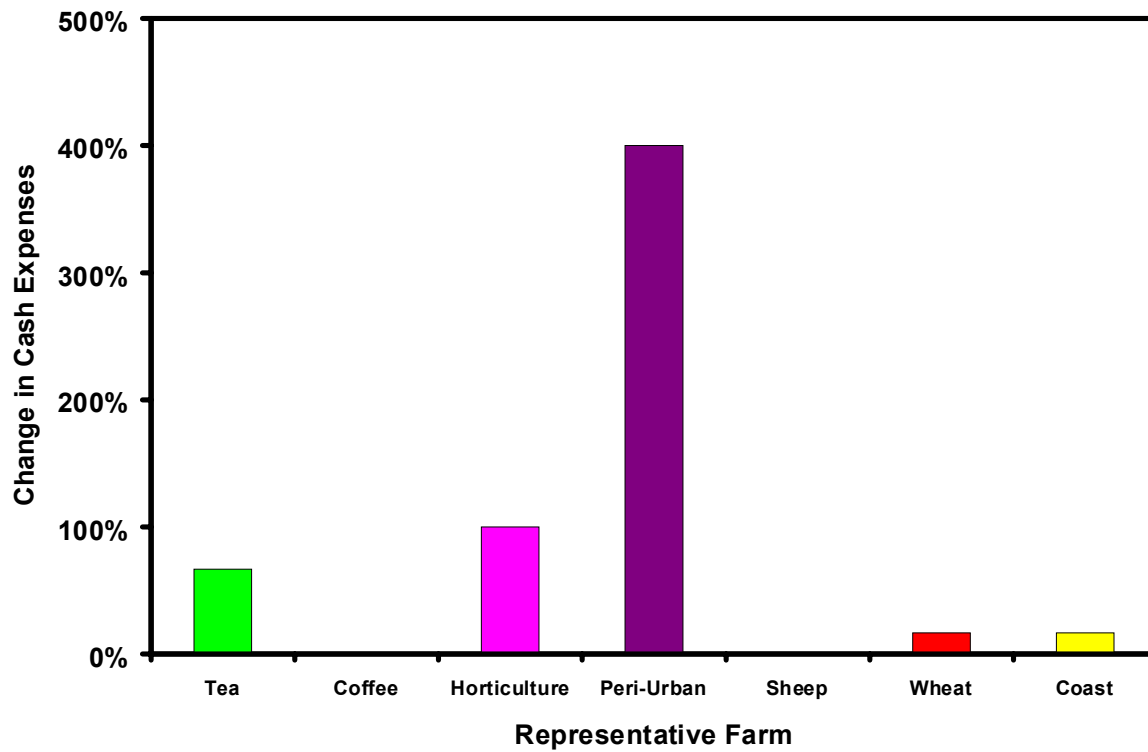


Figure 2.8.3-6. Percent change in cash expenses for representative small holder dairy farmers changing from traditional (zebu cattle/native forage) to current technology for farms in seven dairy environments in Kenya under the deterministic scenario.

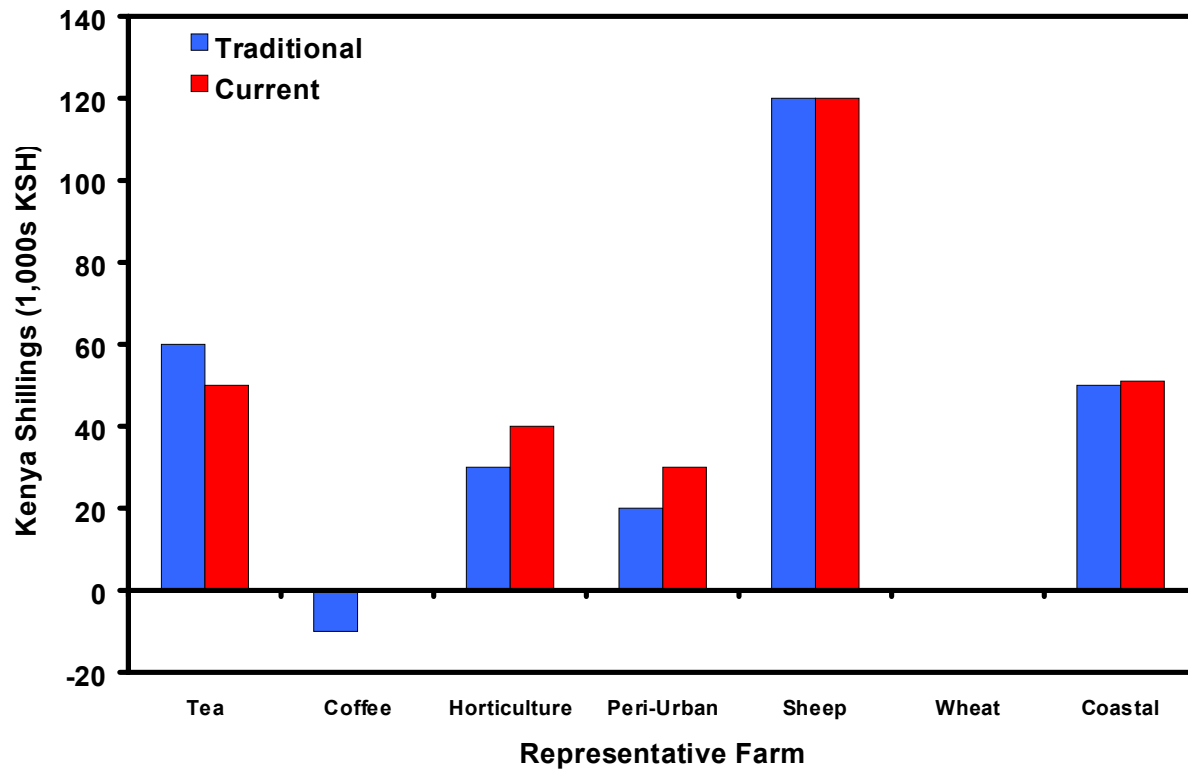


Figure 2.8.3-7. Net cash farm income for Kenyan representative farmers under the traditional (zebu cattle/native forage) technology and the current technology, deterministic scenarios.

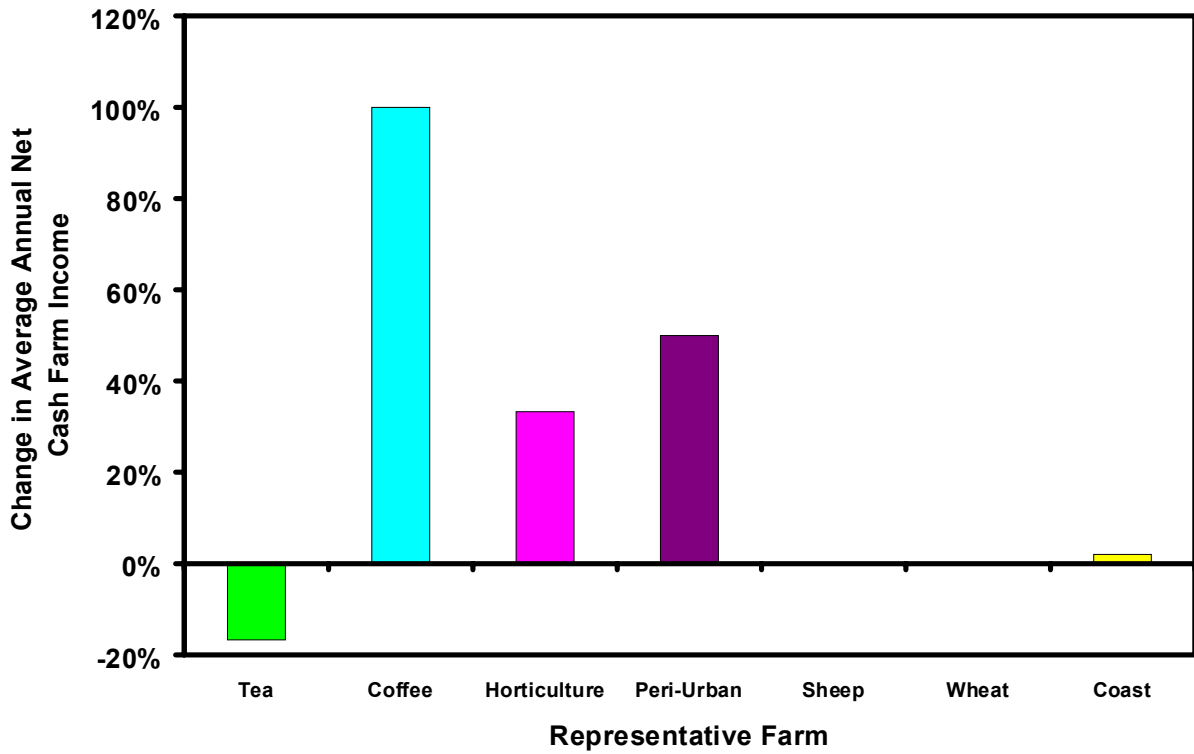


Figure 2.8.3-8. Percentage change in average annual net cash farm income for representative small holder dairy farmers changing from traditional (zebu cattle/native forage) to current technology for farms in seven dairy environments in Kenya under the deterministic scenario.

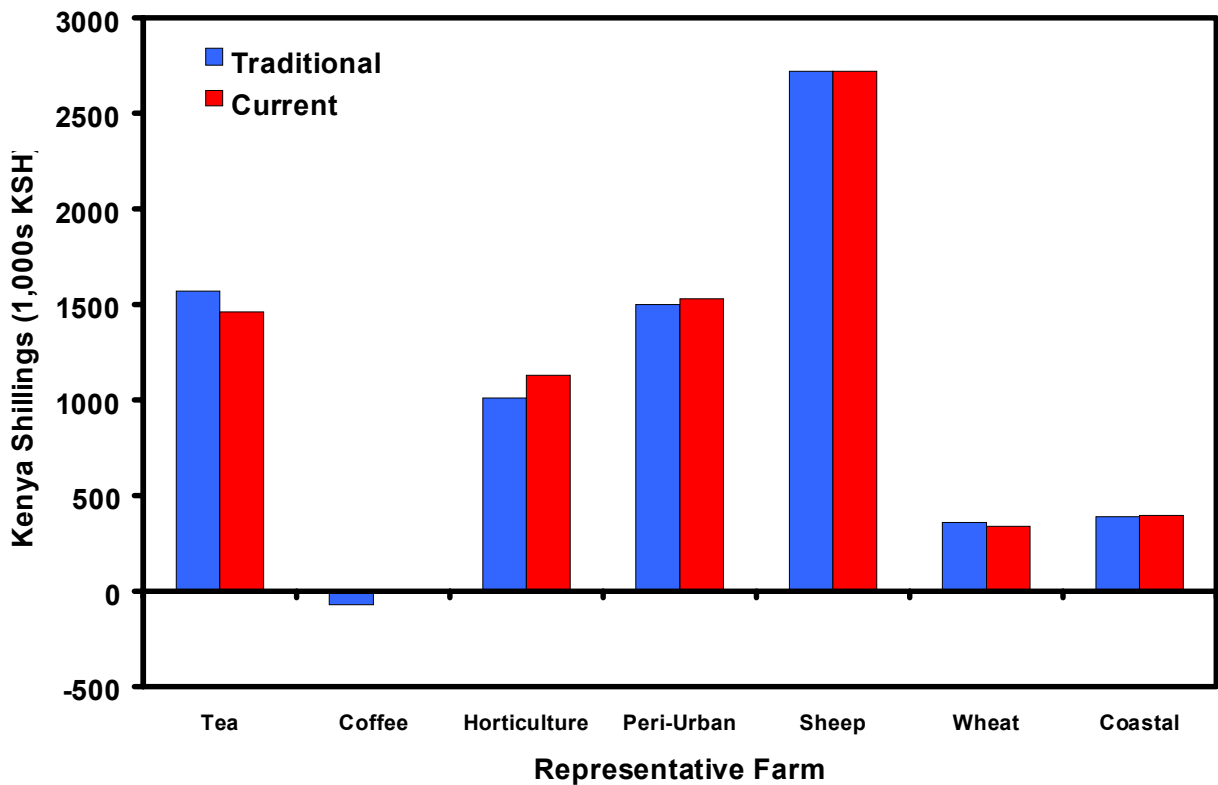


Figure 2.8.3-9. Real net worth (RNW) for Kenyan representative farmers under the traditional (zebu cattle/native forage) technology and the current technology, deterministic scenarios.

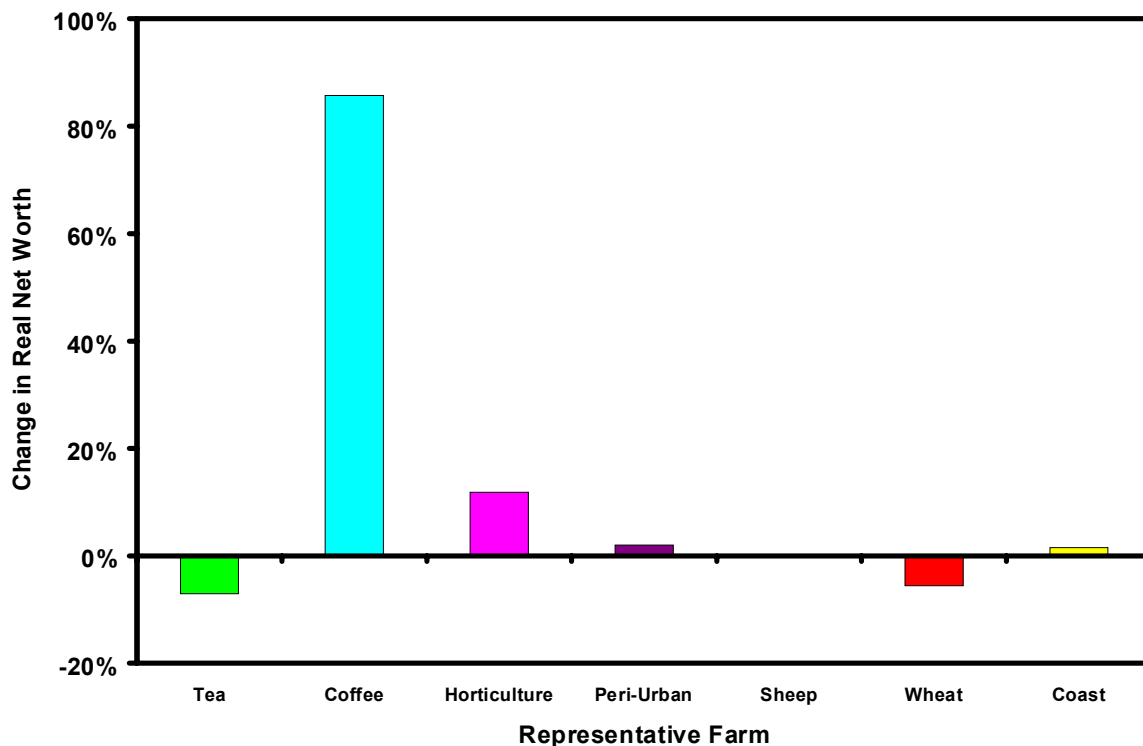


Figure 2.8.3-10. Percentage change in real net worth for representative small holder dairy farmers changing from traditional (zebu cattle/native forage) to current technology for farms in seven dairy environments in Kenya under the deterministic scenario.

representative farms (tea, peri-urban, wheat) after adoption of the new technology (Table 2.8.4.1). The wheat farm was most impacted, experiencing a 61.3% reduction in NPV. Net present value either became less negative (coffee) or increased on the remaining farms. Net present value increased 42% for the coffee farm did not become positive. NPV remained unchanged for the horticulture farm, and it increased by 2.4% for the coast and about 5% for the sheep farms. Differences in mean values for the deterministic and stochastic NPVs indicate a skewed distribution for the variable over the 10-year period. In general, mean values for total cash receipts were higher in the stochastic analysis than the deterministic analysis, and total cash costs remained relatively unchanged. Consequently, mean values of net cash farm income were slightly higher in the stochastic analysis than in the deterministic analysis.

Real net worth declined for the three farms that experienced decreases in NPV (wheat, peri-urban, tea). The wheat farm experienced a 37% reduction in RNW, whereas the peri-urban and tea farms had RNW declines of about 3%. The coffee farm had the greatest relative gain in RNW (300%) with a mean value increase of 60 thousand Ksh under the improved dairy technology relative to the base technology. Figures 2.8.4-1 to 2.8.4-10 exhibit the expected mean values of the economic variables for the base scenario and improved technology scenario and percentage changes. Figures 2.8.4-11 to 2.8.4-15 provide graphic examples of the distribution of the NPV, total cash receipts, total cash costs, net cash farm income, and RNW for the representative farm in the tea zone for the two scenarios.

Table 2.8.4.1: Kenya Representative Farms Mean and Standard Deviations (STD) of Net Present Values, Total Cash Receipts, Total Cash Costs, Net Cash Farm Income, and Real Net Worth Under the Base (old) and Current Small Holder Dairy Technology in 1,000's Kenya Shillings Under Stochastic Conditions

Dairy Zone	Net Present Value		Total Cash Receipts		Total Cash Costs		Net Cash Farm Income		Real Net Worth	
	Old	Current	Old	Current	Old	Current	Old	Current	Old	Current
Tea	1680.00	1600.00	120.00	140.0	30.00	50.00	90.00	90.0	1670.00	1610.00
(% Change)		(-4.76)		(16.67)		(66.67)		(0.00)		(-3.59)
STD	220**	240.00	17.13	18.14	0.00	0.00	15.78	19.32	481.00	457.00
Coffee	-310.00	-180.00	40.00	50.00	50.00	50.00	-10.00	0.00	-20.00	40.00
(% change)		(41.94)		(25.00)		(0.00)		(100.0)		(300.0)
STD	36.10	36.10	3.16	3.16	0.00	0.00	22.73	21.21	295.75	254.89
Horticulture	291.68	291.83	50.00	60.00	10.00	20.00	40.00	40.00	232.97	233.05
(% change)		(0.05)		(40.00)		(100.0)		(0.0)		(0.03)
STD	36.20	36.20	5.14	5.14	0.00	0.00	5.66	5.66	122.38	122.42
Peri - Urban	1290.00	1160.0	40.00	90.00	10.00	70.00	30.00	20.00	1670.00	1620.0
(% change)		(-10.1)		(125)		(600.0)		(-33.33)		(-2.99)
STD			8.43	4.22	3.16	3.16	4.22	6.75	147.66	108.55
Sheep	810.00	850.00	160.00	160.00	40.00	40.00	120.00	120.00	2640.00	2660.00
(% change)		(4.94)		(0.00)		(0.00)		(0.00)		(0.76)
STD			4.22	8.43	3.16	3.16	4.22	4.22	205.28	216.24
Wheat	1550.00	600.00	190.00	120.00	30.00	40.00	160.00	80.00	1480.00	930.00
(% change)		(-61.30)		(-36.8)		(33.33)		(-50.00)		(-37.16)
STD			41.91	23.12	0.00	0.00	42.70	24.15	389.40	159.55
Coast	5410.00	5540.00	580.00	600.00	60.00	70.00	520.00	530.00	3960.00	4020.00
(% change)		(2.40)		(3.44)		(16.67)		(1.92)		(1.52)
STD			22.14	24.24	5.16	9.94	24.70	24.40	1470.34	1511.70

* Mean in 1'000's of Kenya Shillings (Ksh)

**Standard deviation

Results from the FLIPSIM analysis indicated that farmers relied primarily on family labor for each representative farm. The coastal and wheat farms were exceptions which had hired labor costs of 18,000 and 24,000 Ksh per year, respectively. Introduction of zero-grazing technology and improved dairy cattle breeds increased revenues to producers but also increased costs. Consequently, net cash farm income increased only slightly (from 0 to 10 thousand Ksh annually) or decreased on farms where increased revenues did not offset increased costs given the price and yield variabilities faced by these farms. The representative farm in the dairy-wheat zone would experience the greatest absolute decline in net cash farm income (80 thousand Ksh annually).

2.8.5 Interpretation and Summary

Results from the deterministic and stochastic simulations of the representative farms indicate that the horticulture, peri-urban, and coast farms generally benefit most from the adoption of the improved dairy technologies. NPV, net cash farm income, and RNW are positive and increase as the dairy technologies are

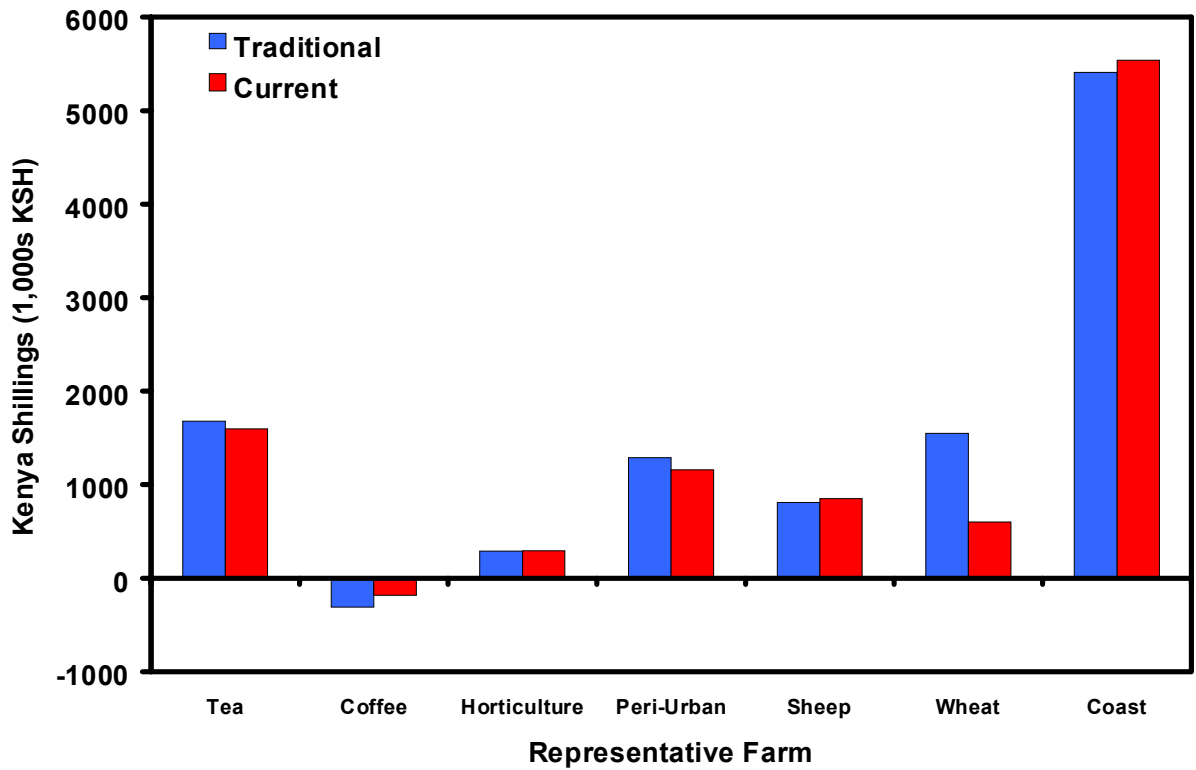


Figure 2.8.4-1. Net present value (NPV) for Kenyan representative farmers under the traditional (zebu cattle/native forage) and the current technology, stochastic scenarios.

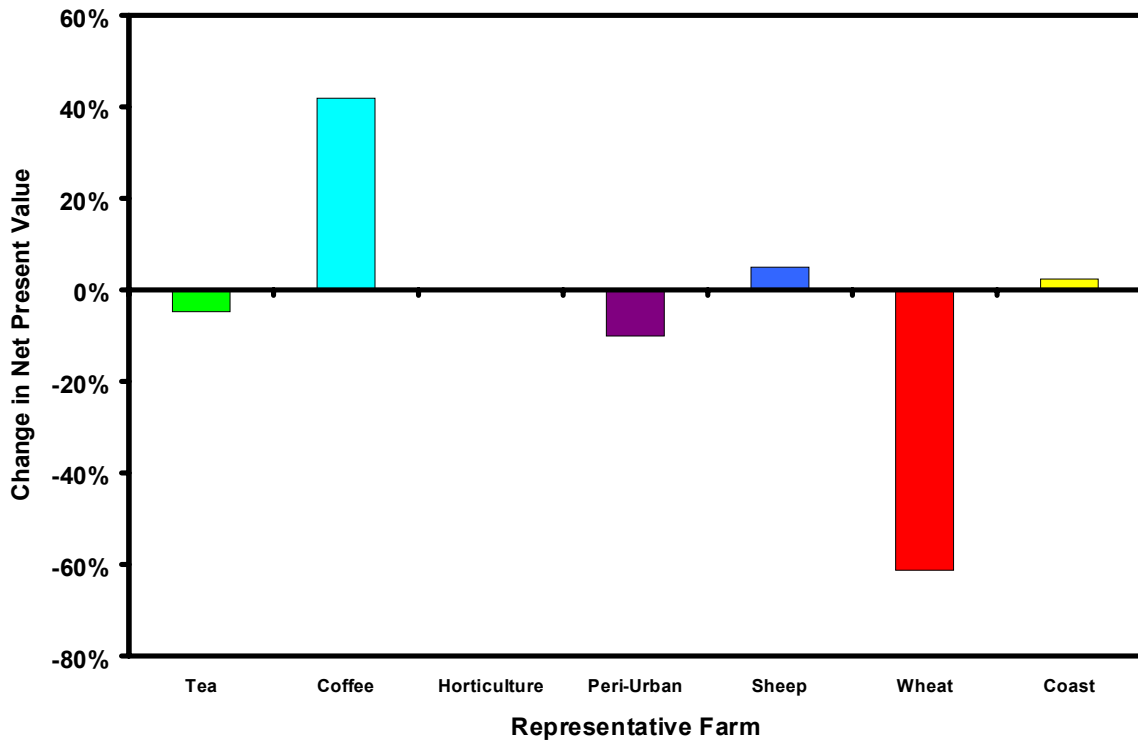


Figure 2.8.4-2. Percentage change in net present value (NPV) for representative small holder dairy farmers changing from traditional (zebu cattle/native forage) to current technology for farms in seven dairy environments in Kenya under the stochastic scenario.

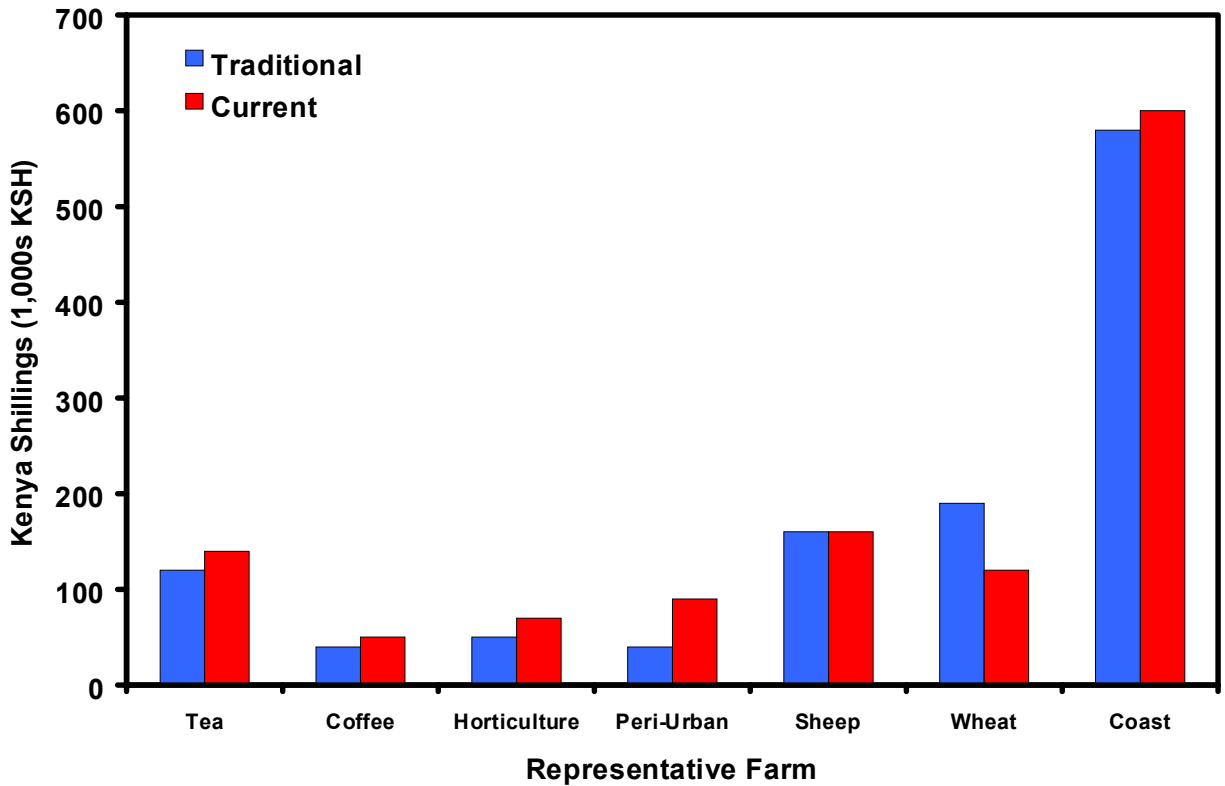


Figure 2.8.4-3. Total Cash Receipts for Kenyan representative farmers under the traditional (zebu cattle/native forage) and the current technology, stochastic scenarios.

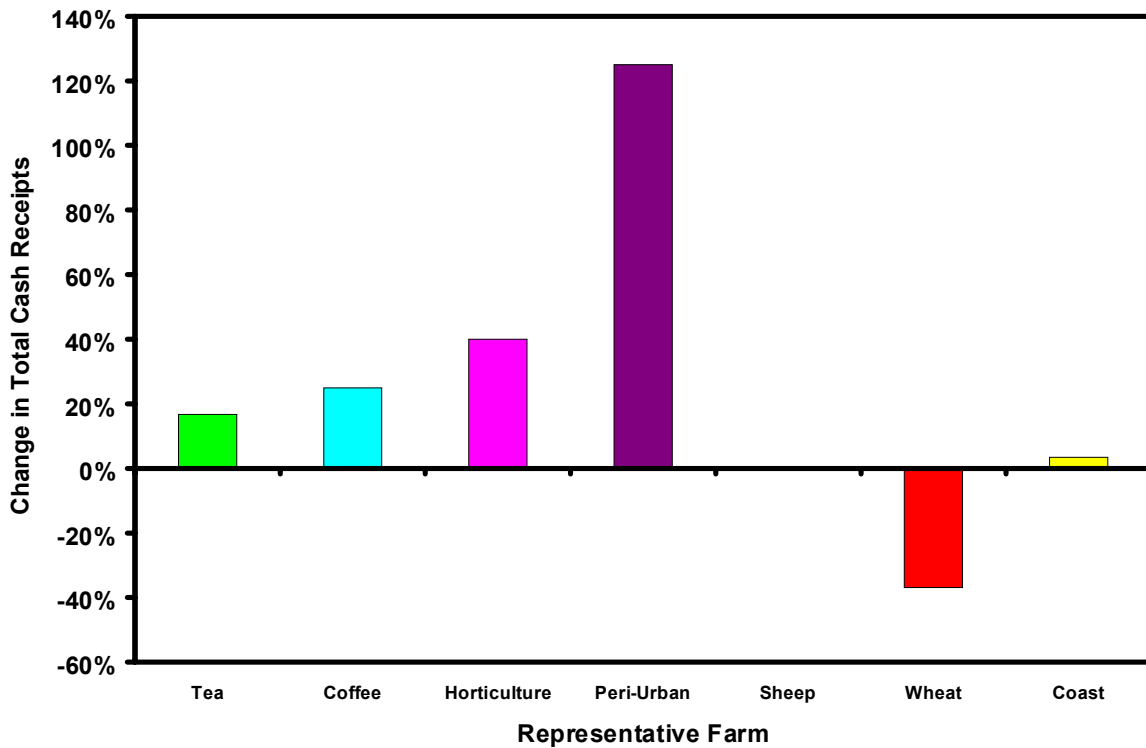


Figure 2.8.4-4. Percentage change in total cash receipts for representative small holder dairy farmers changing from traditional (zebu cattle/native forage) to current technology for farms in seven dairy environments in Kenya under the stochastic scenario.

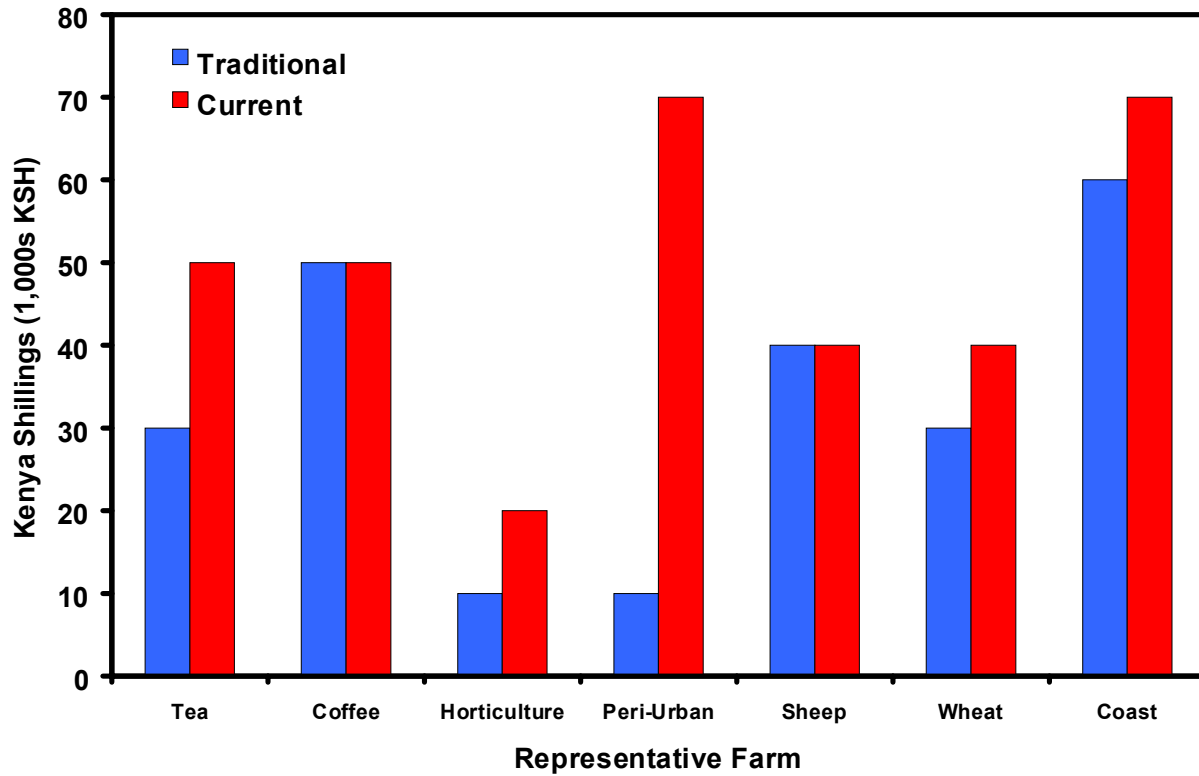


Figure 2.8.4-5. Total cash costs for Kenyan representative farmers under the traditional (zebu cattle/native forage) and the current technology, stochastic scenarios.

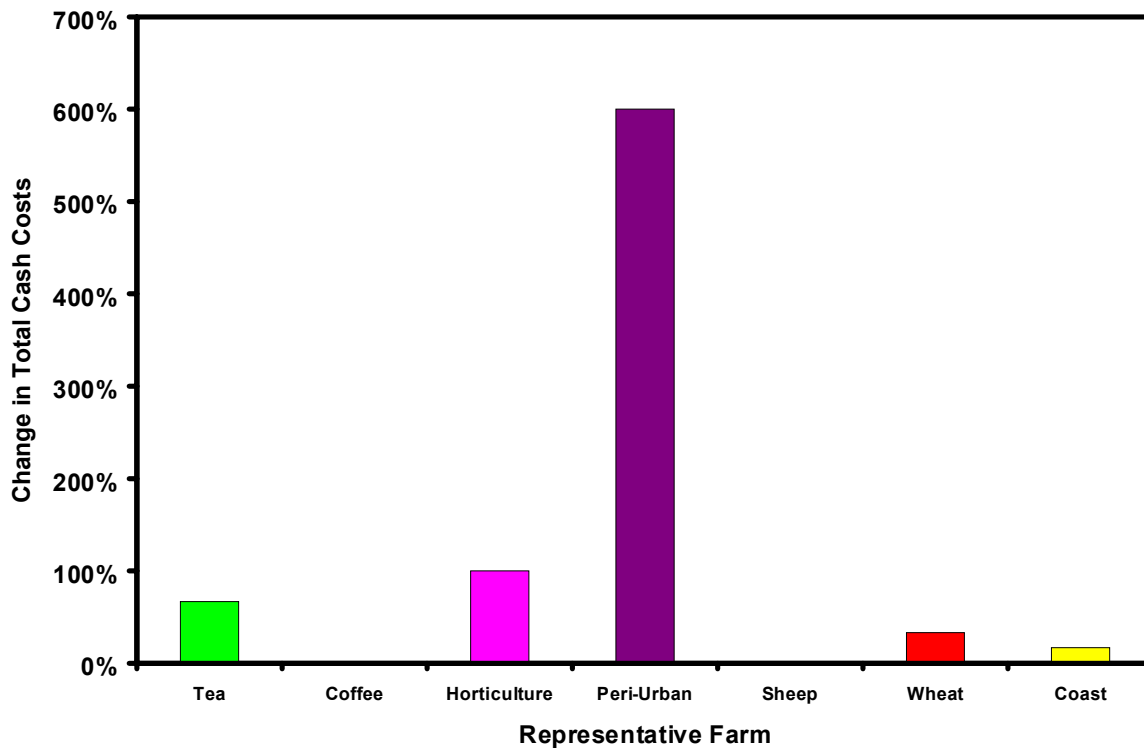


Figure 2.8.4-6. Percentage change in total cash costs for representative small holder dairy farmers changing from traditional (zebu cattle/native forage) to current technology for farms in seven dairy environments in Kenya under the stochastic scenario.

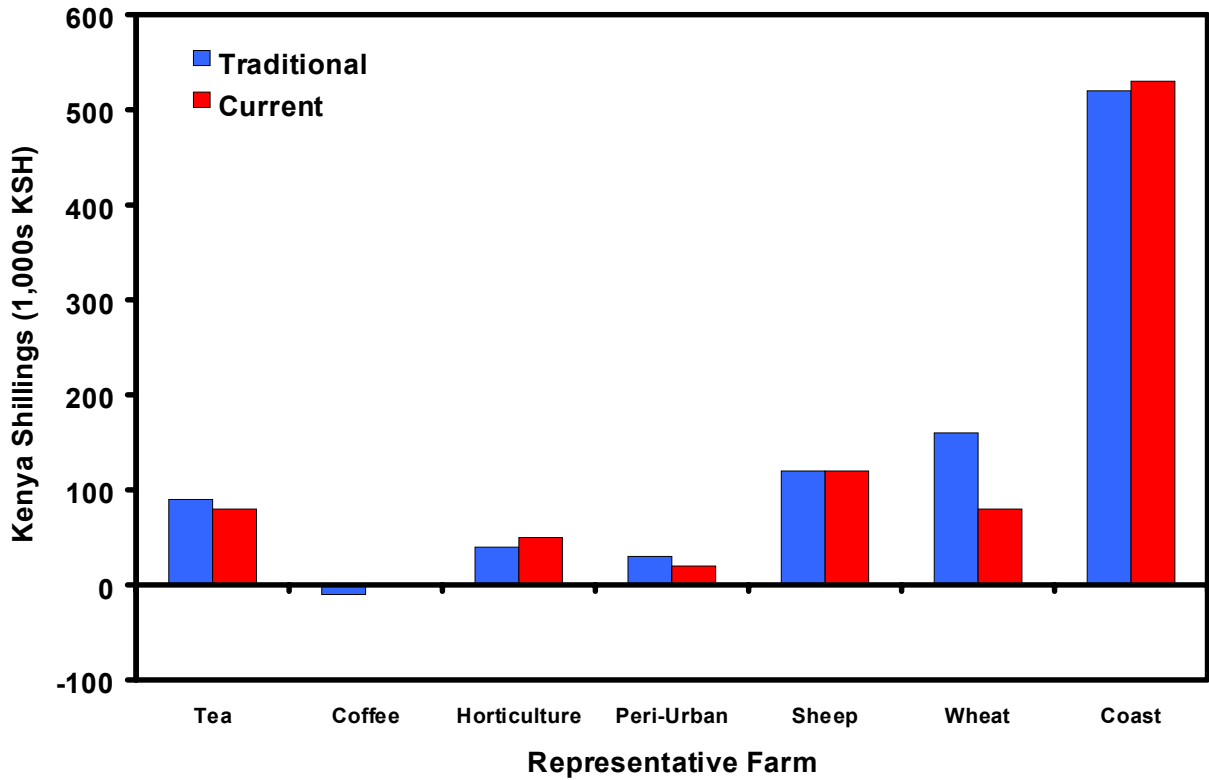


Figure 2.8.4-7. Net farm income for Kenyan representative farmers under the traditional (zebu cattle/native forage) and the current technology, stochastic scenarios.

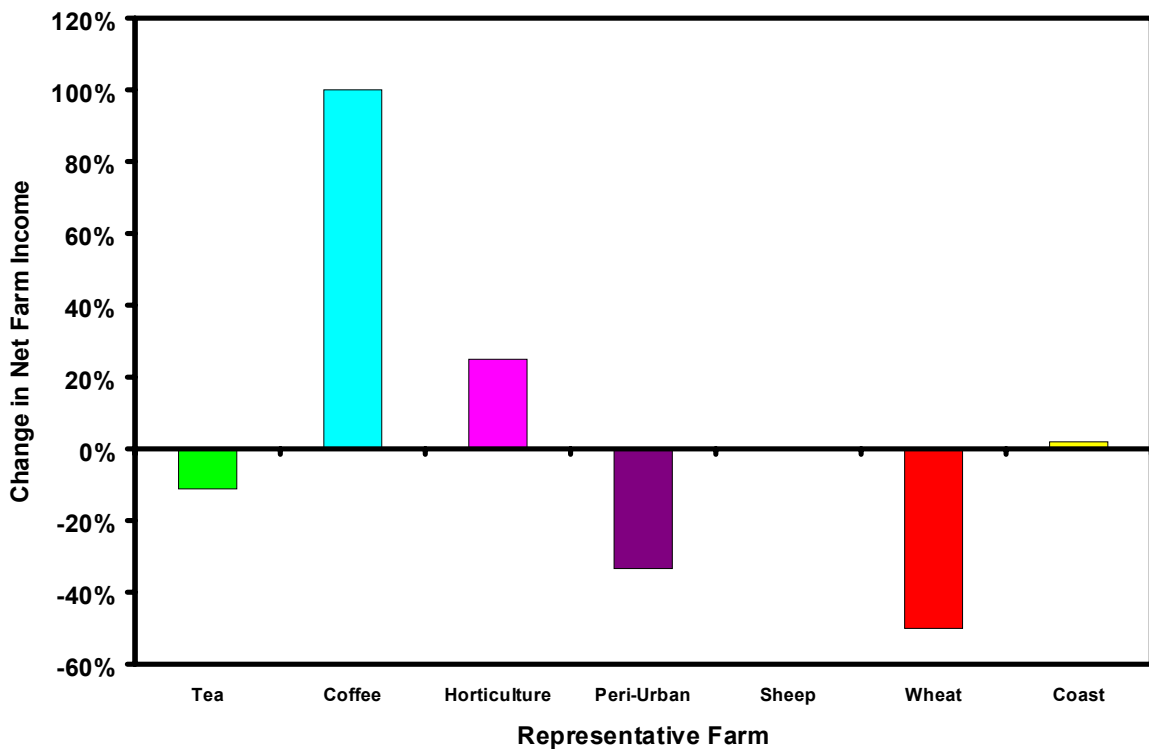


Figure 2.8.4-8. Percentage change in net farm income for representative small holder dairy farmers changing from traditional (zebu cattle/native forage) to current technology for farms in seven dairy environments in Kenya under the stochastic scenario.

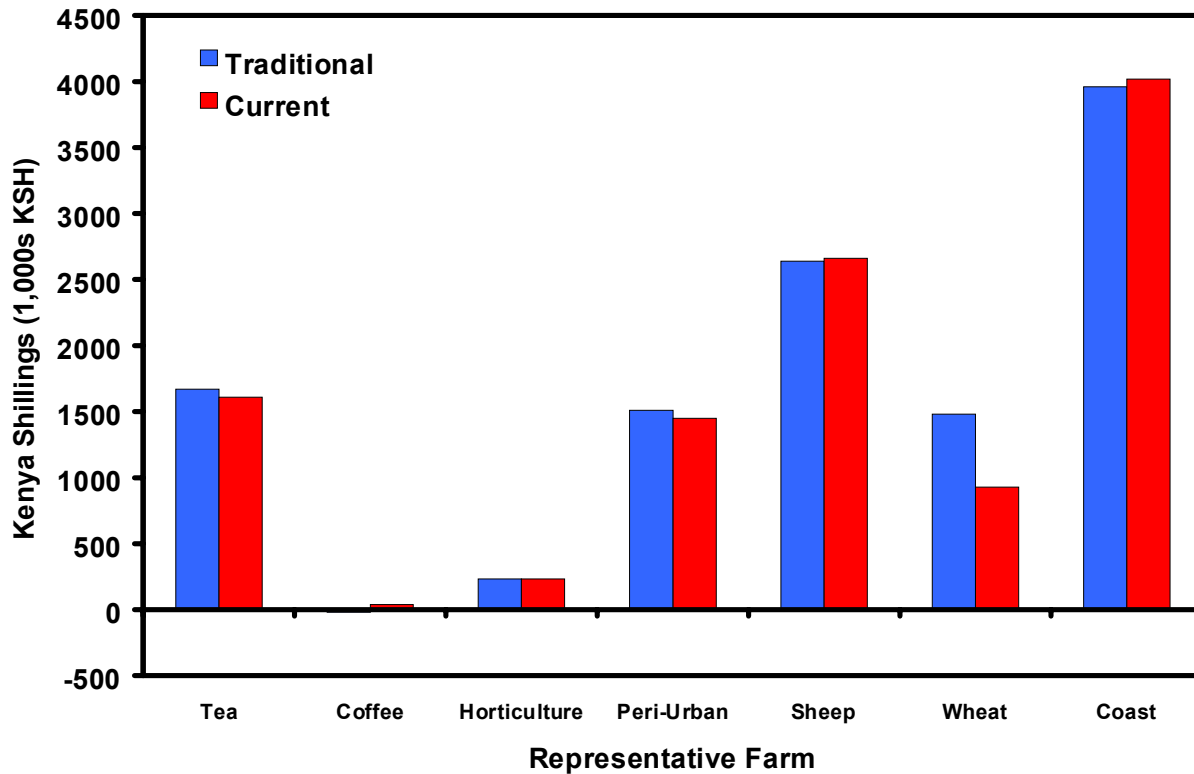


Figure 2.8.4-9. Real net worth (RNW) for Kenyan representative farmers under the traditional (zebu cattle/native forage) and the current technology, stochastic scenarios.

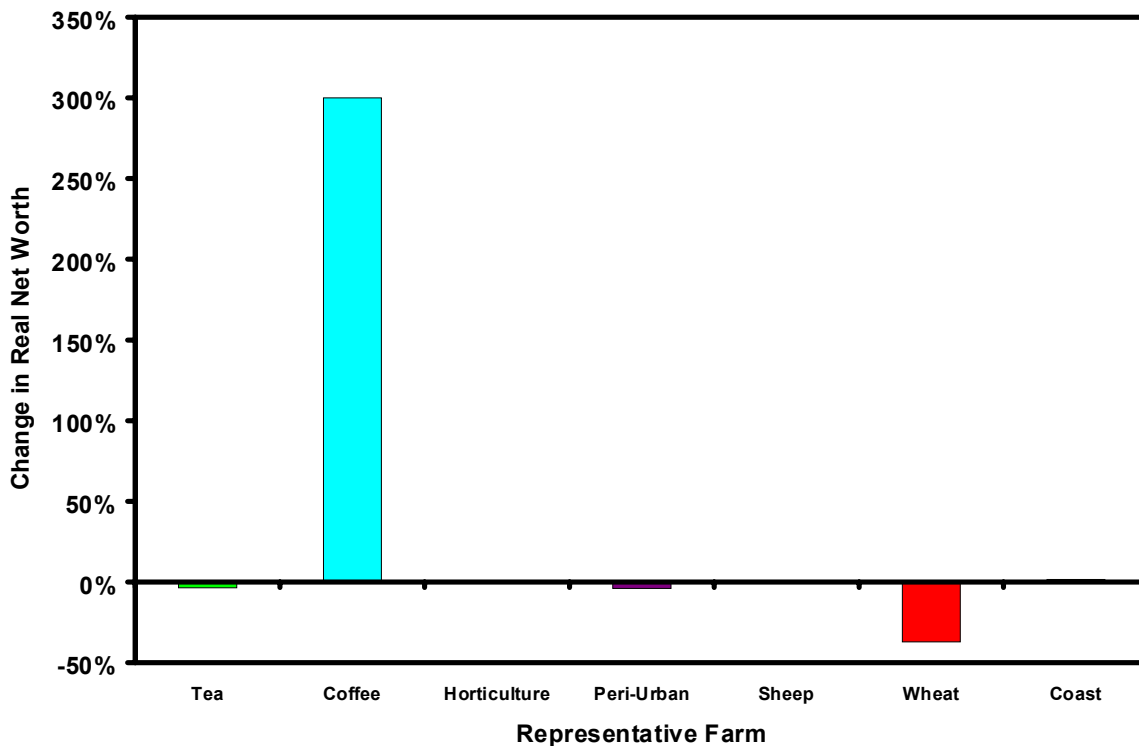


Figure 2.8.4-10. Percentage change in real net worth (RNW) for representative small holder dairy farmers changing from traditional (zebu cattle/native forage) to current technology for farms in seven dairy environments in Kenya under the stochastic scenario.

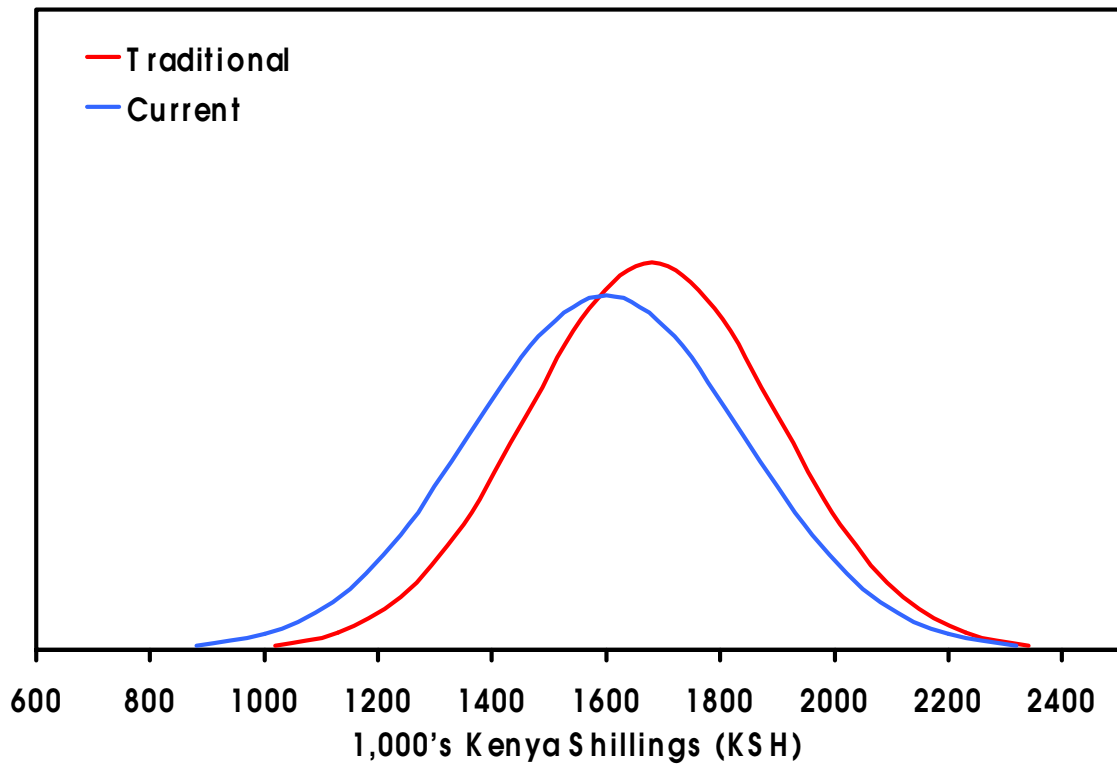


Figure 2.8.4-11. Distribution of net present value under traditional and current small holder dairy technologies on a representative tea farm in Kenya.

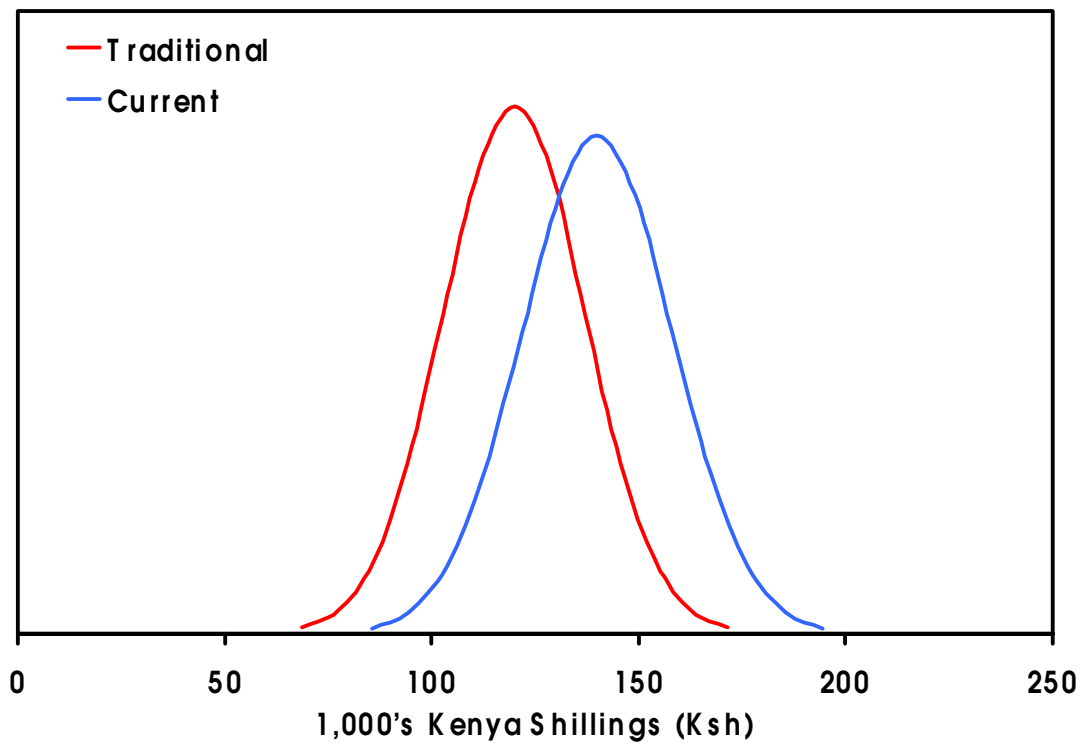


Figure 2.8.4-12: Distribution of total cash receipts under traditional and current small holder dairy technologies on a representative tea farm in Kenya.

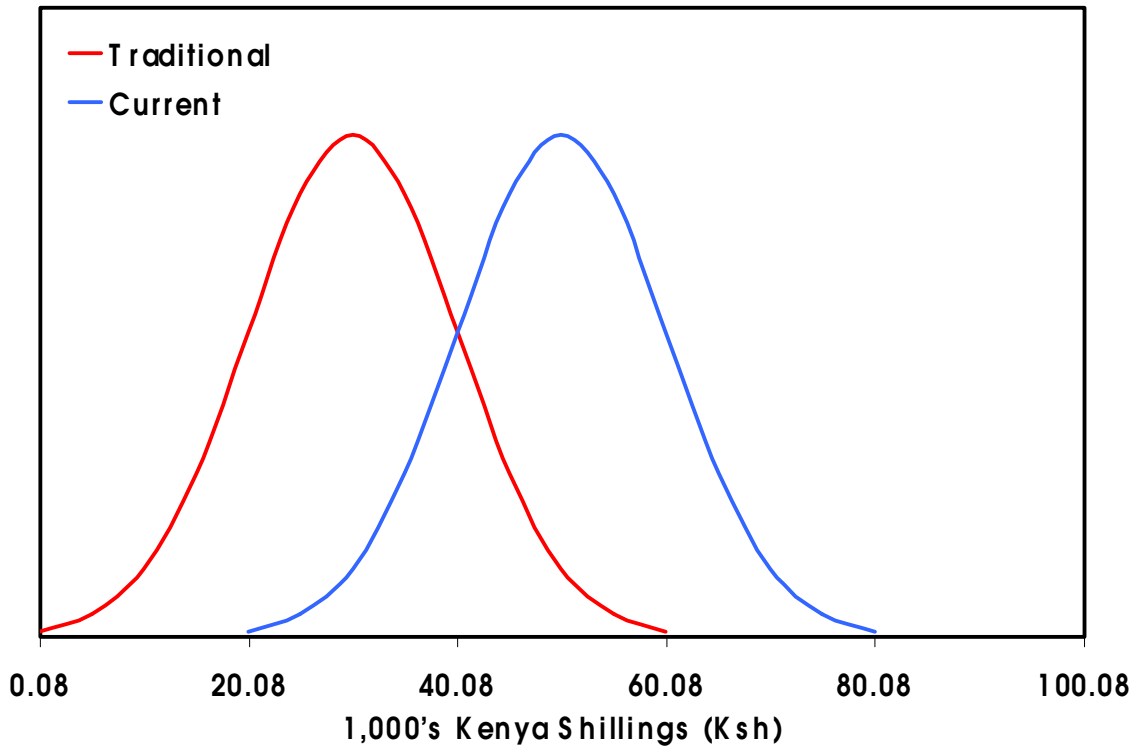


Figure 2.8.4-13. Distribution of total cash costs under traditional and current small holder dairy technologies on a representative tea farm in Kenya.

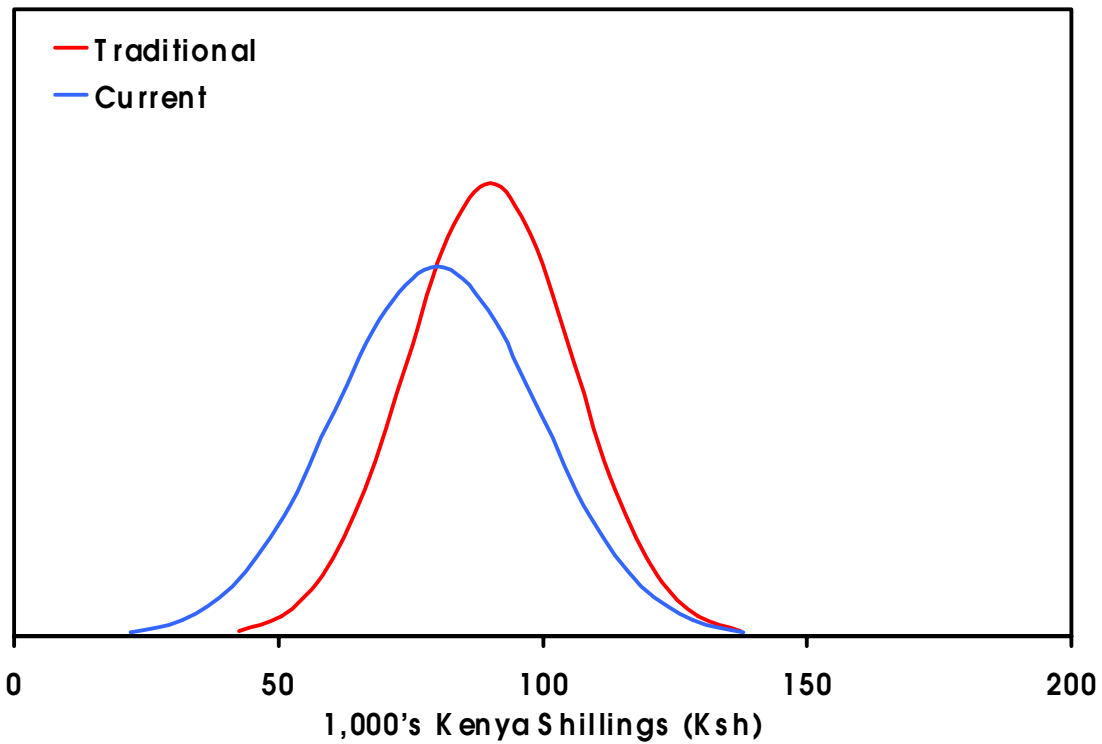


Figure 2.8.4-14. Distribution of net cash farm income under traditional and current small holder dairy technologies on a representative tea farm in Kenya.

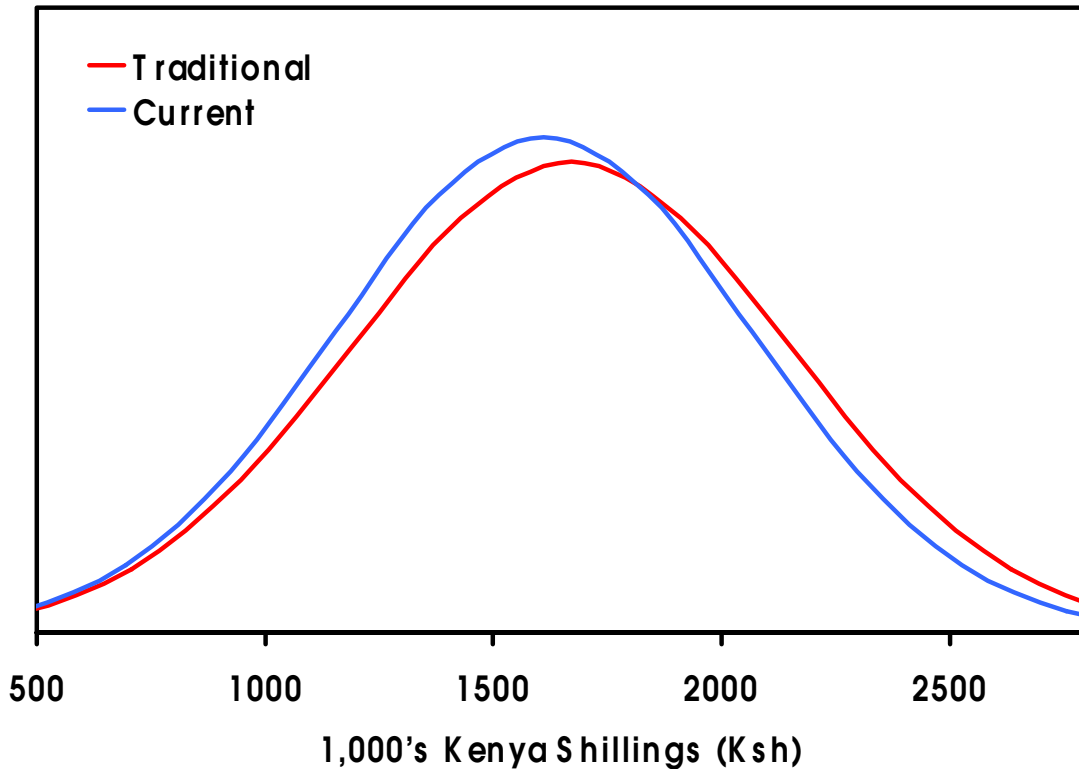


Figure 2.8.4-15. Distribution of real net worth under traditional and current small holder dairy technologies on a representative tea farm in Kenya.

adopted on these farms under deterministic conditions. When price and yield variabilities are taken into account, only the coast farm and the horticulture farm experienced slight increases in NPV, net cash farm income, and RNW from adoption of the improved dairy technologies. Other farms exhibit a mixed pattern of income and net worth mean values as a result of the dairy technologies. For example, the representative farm in the coffee zone consistently experienced negative NPV, net cash farm income, and RNW under both the deterministic and stochastic analyses for the base dairy technology. Under the improved dairy technology, NPV and net cash farm income mean values remained negative or zero, but the RNW under the stochastic analysis became positive. The representative farm in the sheep zone was little affected by the improved dairy technology, as the NPV, net cash farm income, and RNW mean values remained relatively unchanged under both the deterministic and stochastic analyses. The FLIPSIM analyses of the representative farms generally provided results at the household level that were consistent with the aggregative macro-level impacts as revealed by the ASM results for Kenya. These analyses are based on assumptions of current demand (population).