Chapter 4: Results and Analysis

I. Introduction

The purpose of this chapter is to discuss the results of the empirical model regarding the effects of IPM on farmer returns to fixed capital and the effect of government policies on the profitability of IPM. The first section of the chapter will evaluate the results from four base scenarios. The second section will take those base results and analyze the impact of changes in current policies on the profitability of IPM adoption. Finally, the chapter will conclude with a description of the policies not included in the model and the potential impacts on the profitability of IPM.

II. Base Scenario Results

Four initial scenarios of the model were run to provide base results for the policy analysis. Table 4.1 shows the highlights of the initial scenarios. Each of the scenarios has a listing of levels of production and input use as well as shadow prices.

Table 4.1 Base Scenario Results

		One	Two	Three	Four
	Units	Without IPM and without risk restrictions	Without IPM and with risk restrictions	With IPM and without risk restrictions	With IPM and with risk restrictions
Returns to fixed resources	$JM[a]	1,054,520	435,481	1,195,703	485,764
Total gross revenue	$JM	1,200,000	468,398	1,356,255	531,167
Hot pepper	Acres	10	1.1		
IPM hot pepper	Acres			8.51	1.1
Corn	Acres			1.19	0.15
Pumpkin	Acres		2.4		2.4
Sweet potato	Acres		1.8		
IPM sweet potato	Acres				1.8
Callaloo	Acres		.2		
IPM callaloo	Acres				.2
Cassava	Acres		1.7		1.7
Sugar cane	Acres				
Water – NIC	Total annual hours	2,080	2,080	2,080	2,080
Shadow price on water – NIC	$JM	190	11.4	235	11.4
Water – Market	Total annual hours	2,080	582	2,080	756
Shadow price on water – Market	$JM	202	0	224	0
Credit – Subsidized	$JM	50,000	58,224	50,817	60,492
Shadow price on credit – Subsidized	$JM	0	-.1	0	-.1
Credit – Market rate	$JM	0	0	0	0
Shadow price on credit – Market rate	$JM	0	0	0	0
Own labor[b]	People-days	320	298	392	313
Shadow price on own labor	$JM	500	400	500	400
Total hired labor	People-days	135	18	163	25

a. Nominal exchange rate of $JM35:$US1
b. Own labor is the quantity of owned labor a famer uses on his farm.

<u>No IPM Systems Available and No Risk Constraints</u>: The first scenario denied farmers the IPM systems as a way to produce their crops and allowed the farmers to specialize. Farmers did not have to limit the maximum quantity of acres they planted of a particular crop. The results allowed for evaluation of the impact of IPM and farmer's risk management strategies on the returns to the fixed resources.

The returns to the fixed resources were $JM1,054,520. (The nominal exchange rate is $JM35:$US1.) The farmer specialized in growing hot peppers using the conventional method for all ten acres planted. The farmer borrowed $JM50,000 at the subsidized credit rate, purchased 2,080 hours per year of the subsidized water from the

National Irrigation Commission (NIC), and pumped 2,080 hours per year of water from the river. The farmer sold all of the harvestable portion of the crop, 100,000 lbs., to domestic and export buyers for $JM12 per pound for a total gross revenue of $JM1,200,000.

Land was not the binding constraint and had no shadow price. If the farmer had access to eleven acres, he would plant only ten acres of hot pepper because of the availability of water. The binding constraint on the farmer was the maximum annual water obtainable from the NIC and the market. The shadow prices were $JM190 and $JM202, respectively for one additional hour of annual irrigation.

Credit was not a binding constraint because the farmer used only $JM50,000 of the $JM100,000 of subsidized credit. A farmer could supply up to 45 people-days per month of his own labor. If he needed additional people-days, he could hire workers. If he did not use all of his own labor, he would sell his remaining time. Therefore, all of the people-days available per month should have been used, either by the farmer for his farm or sold for off-farm labor. The farmer sold an average of 18 people-days per month of his own labor. The farmer hires labor and sells his own labor during the course of the production process as a result of the seasonal labor requirements.

No IPM Systems Available and Risk Constraints in Place: The second scenario incorporated the farmer's response to uncertainty in the marketplace. With the IPM systems still unavailable to the farmer, he was forced to limit the maximum number of acres he was willing to plant of any one particular crop as shown in Table 3.7.

The returns to fixed resources fell by 60% to $JM435,481. Because of the acreage restrictions, the farmer diversified his crops and planted the limit of hot pepper, pumpkin, sweet potato, callaloo, and cassava with acreage of 1.1, 2.4, 1.8, .2, and 1.7, respectively. Corn and sugar cane were not planted and the farmer did not use all available land. A total of 7.2 acres were planted indicating that if the farmer had planted any corn or sugar cane he would have needed to borrow capital and increase his water usage resulting in lower returns to fixed resources.

The farmer borrowed $JM58,224 of subsidized credit and none at the market rate for an increase of 16% over the first scenario. All of the available subsidized credit was not used and, therefore, the credit was not a binding constraint.

The farmer bought 2,080 hours per year of water from the NIC and used 582 annual hours of the river water. The quantity of river water used represented a drop of 72% from the first scenario. The constraint on NIC water was a binding with a shadow price equal to the difference in the two water prices ($JM11.4).

The farmer produced 11,000, 16,800, 4,680, 1,750 and 22,848 pounds of hot pepper, pumpkin, sweet potato, callaloo and cassava, respectively. The total gross revenue was $JM468,398 representing a decrease of 61% from the first scenario.

Land was not a binding constraint. The risk constraints, however, were binding with each crop planted. The shadow prices on the risk constraints for hot pepper, pumpkin, sweet potato, callaloo and cassava were: $JM82,832; $JM14,467; $JM5,854; $JM19,996; and $JM29,946.

<u>IPM Systems Available and No Risk Constraints in Place</u>: Without the risk constraints restricting crop acreage, the IPM systems were more profitable than the conventional practices. The farmer specialized in the IPM system for hot pepper growing 8.51 acres of hot pepper and 1.19 acres of corn for a total acreage used of 9.7.

The returns to fixed resources were $JM1,195,703 representing an increase of 11.8% above Scenario One when the farmer had no access to the IPM technologies. The farmer borrowed $JM50,817 of subsidized credit. The farmer harvested 110,630 pounds of hot pepper and 3,570 pounds of corn for a total revenue of $JM1,356,255.

Neither subsidized credit nor land were binding constraints. The farmer did not use all of the available land because the available water was the binding constraint. The farmer used all 2,080 hours a year of NIC water and 2,080 hours a year of the river water. The shadow prices on the NIC and river water were $JM235 and $JM224 per additional annual hour, respectively.

IPM Systems Available and Risk Constraints in Place: The final base scenario gave farmers the option to use IPM technologies but limited the maximum acres available for each crop. This scenario was designed to mimic reality where the farmers interviewed limit the acreage and access to all of the components of the IPM systems. Although farmers do not have all of the components, as discussed in Chapter 3, Scenario Four provided an estimate of the potential changes in profits for farmers as a result of using all components of the IPM systems.

Total returns to fixed resources were $JM485,764 which represented an increase of 10.3% over the second scenario where the farmer had risk constraints and no access to the IPM systems. The farmer planted no conventional hot pepper and 1.1 acres of IPM hot pepper with 0.15 acres of corn, the rotational crop of IPM hot pepper. The farmer was required to plant 14.3% as much corn as hot pepper but could plant additional acres if desired. The farmer also planted pumpkin, IPM sweet potato, IPM callaloo, and cassava. The acreage per crop was 2.4, 1.8, .2, and 1.7, respectively.

The resource use of Scenario Four was similar to the resource use of Scenario Two. The farmer borrowed $JM60,492 at the subsidized real interest rate an increase of 3.7% over the second scenario and the highest quantity of capital of the four scenarios.

The farmer bought the maximum amount of water available from the NIC (2,080 hours) and increased the use of river water of 23% from 582 to 756 hours per year. Water usage on the farm was a total of 2,836 hours per year. Total water usage rose from the Second Scenario by 6.1%.

The farmer sold 14,300 pounds of hot peppers, 462 pounds of corn, 16,800 pounds of pumpkin, 6,084 pounds of sweet potato, 2,275 pounds of callaloo and 22,848 pounds of cassava. The total returns above variable costs were $JM485,764 representing a decrease of 59.3% from the third scenarios with no risk constraints and access to the IPM systems.

An examination of the sensitivity of increased IPM returns to changes in selected coefficients will help to better evaluate the potential for IPM profitability for a farmer with risk averse behavior. The total operating cost of the IPM hot pepper technology could rise by $JM30,842 per acre before the profitability of the hot pepper IPM system fell below the profitability of the conventional system. If the farmer stopped growing IPM hot pepper, he would also stop growing corn as illustrated by Scenario Two.

The coefficient on IPM callaloo can also change by a significant amount before callaloo is no longer profitable to grow. The total operating cost on callaloo would need to increase from -$JM5,500 to -$JM15,500 before the farmer would shift away from January IPM callaloo and into September planting of IPM callaloo. The shift in the production timing of callaloo results from the harvest season of callaloo shifting from an October – November harvest to a January – February harvest when more of the owner's labor is available.

An important result from Table 4.1 is the profitability of the IPM systems. With and without the farmer restricting crop acreage, the IPM systems are more profitable than the conventional counterparts. Whether or not farmers diversify their production mix or specialize in one crop, the IPM technologies are more profitable. The higher profits from IPM are a result of the total higher profits per system, such as the combined total higher profits from IPM hot pepper and conventional corn, as required by the hot pepper IPM production practice.

This result illustrates the importance of viewing crop selection decisions in a systems framework. The IPM system for hot pepper includes intercropping corn as a barrier to prevent the spread of pests. Since corn needs to be grown with hot pepper in the IPM production method, the farmer must weigh the profitability of corn and IPM hot pepper against the profitability of conventional hot pepper. The hot pepper IPM system remains more profitable even when the price received by the farmer for a pound of corn is -$JM1.

Further sensitivity analysis was done to evaluate the incentives for adoption of IPM given new information on yield, chemical reduction and labor requirements. Table 4.2 below shows the first sensitivity analysis of the IPM coefficients. Scenario Four – A has the same labor requirements and chemical use requirements as the original Scenario Four. However, the increase in yield of the IPM systems was only 5% over the conventional yield (10,500 lbs./acre for hot pepper, 2,730 lbs./acre for sweet potato and 9,188 lbs./acre for callaloo) as opposed to the 30% (13,000 lbs./acre for hot pepper, 3,600 lbs./acre for sweet potato, and 11,375 lbs./acre for callaloo) used in Scenario Four.

The production decisions with respect to practicing hot pepper and sweet potato IPM do not change. However, the profitability of the callaloo IPM system falls below that of the conventional callaloo system and the farmer chooses to practice the conventional methods for callaloo. The total gross revenue and returns to fixed resources declined in Scenario Four – A as compared with Scenario Four while returns were $JM436,613 or .3% greater than when IPM was not available in Scenario Two.

Table 4.2 Effects of Lowering the IPM Yield Increase to 5% Above the Conventional Yield

		Scenario Four	**Scenario Four - A**
	Units	IPM and risk constraints	Scenario Four with the IPM yield increase of 5% above the conventional yield[a]
Returns to fixed resources	$JM[b]	485,764	436,613
Total gross revenue	$JM	531,167	481,502
Hot pepper	Acres		
IPM hot pepper	Acres	1.1	1.1
Corn	Acres	0.15	0.15
Pumpkin	Acres	2.4	2.4
Sweet potato	Acres		
IPM sweet potato	Acres	1.8	1.8
Callaloo	Acres		.2
IPM callaloo	Acres	.2	
Cassava	Acres	1.7	1.7
Sugar cane	Acres		
Water – NIC	Total annual hours	2,080	2,080
Water – Market	Total annual hours	756	756
Credit – Subsidized	$JM	60,492	60,192
Credit – Market rate	$JM		
Own labor	People-days	313	315
Total hired labor	People-days	25	23

a. IPM crop yields were lowered from 13,000 lbs./acre to 10,500 lbs./acre for hot pepper, from 3,600 lbs./acres to 2,730 lbs./acre for sweet potato and from 11,375 lbs./acre to 9,188 lbs./acre for callaloo.
b. The nominal exchange rate was $JM35:$US1.

Table 4.3 shows the changes in production between Scenario Four and Scenario Four – B. In Scenario Four – B, the yield increase and the labor requirements from the IPM systems remained unchanged from Scenario Four. Instead, the chemical usage was altered such that the quantities of chemicals required in the IPM systems were the same as the conventional systems.

Table 4.3 Effects of the IPM Technologies not Changing in the Quantity of Chemicals Required for Production

		Scenario Four	Scenario Four – B
	Units	IPM and risk constraints	Scenario Four and no change in chemical usage with the IPM systems
Returns to fixed resources	$JM[a]	485,764	482,294
Total gross revenue	$JM	531,167	531,167
Hot pepper	Acres		
IPM hot pepper	Acres	1.1	1.1
Corn	Acres	0.15	0.15
Pumpkin	Acres	2.4	2.4
Sweet potato	Acres		
IPM sweet potato	Acres	1.8	1.8
Callaloo	Acres		
IPM callaloo	Acres	.2	.2
Cassava	Acres	1.7	1.7
Sugar cane	Acres		
Water – NIC	Total annual hours	2,080	2,080
Water – Market	Total annual hours	756	756
Credit – Subsidized	$JM	60,492	60,492
Credit – Market rate	$JM		
Own labor	People-days	313	313
Total hired labor	People-days	25	25

a. The nominal exchange rate is $JM35:$US1.

If the only differences between the IPM and conventional production systems were the increased labor and yield from the IPM technologies, the IPM practices would continue to be more profitable than the conventional methods. The lack of chemical reduction between Scenario Four and Scenario Four – B resulted in no change in the mix of crops produced. The total returns to fixed resources declined by less than 1%.

Table 4.4 illustrated the changes between Scenario Four and Scenario Four – C. Scenario Four – C differed from Scenario Four by the labor requirements for the IPM technologies. The labor requirements in Scenario Four – C were increased to 150% of the level of Scenario Four. Chemical requirements and yield increase remained the same between Scenario Four and Scenario Four – C.

Table 4.4 Effects of Increasing IPM Labor Requirements By 150% Compared to the Original IPM Technologies[a]

		Scenario Four	**Scenario Four – C**
	Units	IPM and risk constraints	Scenario Four and IPM labor requirements increasing by 150%
Returns to fixed resources	$JM[b]	485,764	462,536
Total gross revenue	$JM	531,167	531,167
Hot pepper	Acres		
IPM hot pepper	Acres	1.1	1.1
Corn	Acres	0.15	0.15
Pumpkin	Acres	2.4	2.4
Sweet potato	Acres		
IPM sweet potato	Acres	1.8	1.8
Callaloo	Acres		
IPM callaloo	Acres	.2	.2
Cassava	Acres	1.7	1.7
Sugar cane	Acres		
Water – NIC	Total annual hours	2,080	2,080
Water – Market	Total annual hours	756	756
Credit – Subsidized	$JM	60,492	60,492
Credit – Market rate	$JM		
Own labor	People-days	313	363
Total hired labor	People-days	25	31

a. The annual labor requirements for IPM hot pepper rose from 61.25 people-days/acre to 91.88 people-days/acre, the annual labor requirements for IPM sweet potato rose from 22 people-days/acre to 33 people-days/acre and the annual labor requirements for IPM callaloo rose from 30.75 people-days/acre to 46.13 people-days/acre.

The increased labor requirements of the IPM systems from Scenario Four to Scenario Four – C did not cause the farmer to shift his production mix. The only change in the production process in Scenario – C was the increase in total labor used from 338 annual people-days to 394 annual people-days.

The farmer continued to use the IPM systems over the conventional practices because the IPM techniques had higher returns to fixed resources than the conventional methods. The returns to fixed resources for Scenario Four – C were $JM462,536 as compared with the returns in Scenario Two, without access to IPM, of $JM435,481.

When all three changes are incorporated simultaneously in the model: lower yield increases of IPM, no decrease in chemical requirements, and higher labor requirement of IPM; the profitability of IPM decreases below the conventional methods.

The conventional production systems become more profitable than the IPM systems and the farmer chooses to diversify according to Scenario Two.

III. Policy Effects on Production Methods and IPM Adoption

The following section will discuss the influence of the seven chosen policies on returns from IPM adoption. Scenarios Two and Four, the base scenarios with the risk constraints and with and without IPM, were used to evaluate the policy effects and establish boundaries defining the effects of the policies.

III a. Policies Included in the Model

Preclearance: As discussed in the previous chapter, to simulate farmers adopting preclearance, three groups of parameters were changed: harvest labor, export prices and export quantities. The preclearance simulation was evaluated for the scenarios with and without the IPM technologies to analyze the effect of the competing labor requirements. Results comparing the two scenarios are shown in Table 4.5. Scenario Five gives farmers no access to IPM technologies while Scenario Six allows farmers the choice to adopt IPM. In both scenarios, the farmers are forced to inspect their crops before shipping them to the preclearance station if they choose the preclearance option.

Table 4.5 The Effects of Preclearance on the Profitability of IPM[a]

		Scenario Two	**Scenario Four**	**Scenario Five**	**Scenario Six**
	Units	No IPM and no preclearance	IPM and no preclearance	No IPM and preclearance	IPM and preclearance
Returns to fixed resources	$JM[b]	435,481	485,764	482,120	538,910
Total gross revenue	$JM	468,398	531,167	528,119	598,420
Hot pepper	Acres	1.1		1.1	
IPM hot pepper	Acres		1.1		1.1
Corn	Acres		0.15		0.15
Pumpkin	Acres	2.4	2.4	2.4	2.4
Sweet potato	Acres	1.8		1.8	
IPM sweet potato	Acres		1.8		1.8
Callaloo	Acres	.2		.2	
IPM callaloo	Acres		.2		.2
Cassava	Acres	1.7	1.7	1.7	1.7
Sugar cane	Acres				
Water – NIC	Total annual hours	2,080	2,080	2,080	2,080
Water – Market	Total annual hours	582	756	582	756
Credit – Subsidized	$JM	58,224	60,492	58,224	60,492
Credit – Market rate	$JM				
Own labor	People-days	298	313	331	346
Total hired labor	People-days	18	25	18	27

a. With the preclearance policy farmers inspect their crops before shipping them to the preclearance station. Yields were assumed to rise by 10%, export price received to rise by 2.5% and labor to rise by 25% for hot pepper, pumpkin, sweet potato, callaloo and cassava.
b. Nominal exchange rate of $JM35:$US1.

Without preclearance, IPM causes returns to fixed resources to increase from $JM435,481 to $JM485,764 as 1.1, 1.8, and .2 acres of IPM hot pepper, IPM sweet potato and IPM callaloo are adopted, respectively. When farmers chose preclearance, the same pattern of crop acreage occurs with IPM adoption. With preclearance, IPM profitability rises by 9.8% from $JM485,764 to $JM538,910.

The increases in returns to fixed resources from the IPM systems, without and with preclearance, were $JM50,283 and $JM56,790, respectively. Preclearance raised the profitability of adopting the IPM systems over the conventional methods, because preclearance raised the export prices received by farmers and the export quantities. If the farmer adopts both the preclearance and the IPM systems, the exportable yields are significantly higher compared to yields from the conventional systems. For instance conventional hot pepper yields 10,000 lbs./acre while the IPM hot pepper with preclearance yields 14,300 lbs./acre and an export price 2.5% higher.

With preclearance, the shadow prices on the objective function coefficients did not change significantly when the farmers had access to the IPM systems. The shadow prices on the constraints remained fairly constant while the total land and labor usage increased with IPM adoption. Land acreage increased from 7.2 to 7.35 acres. Since the acres in production did not exceed total available acres, the shadow price on additional land did not increase from zero.

Total labor usage, under the preclearance policy, increased with the availability of the IPM systems. The farmer did not restrict production to conventional practices as a result of inspecting his crops before shipping them to the preclearance station. Hired labor increased from 18 people-days for the year to 27 people-days while owned labor increased from 331 people-days to 346 people-days. The increased labor from both of the production practices of IPM and self inspection have marginal benefits that are greater than the marginal cost of labor.

Water Subsidy: The elimination of the water subsidy was hypothesized to impact the profitability of IPM, in particular the sweet potato IPM system, because of the component of irrigation as part of the IPM package. The policy was evaluated by the farmer no longer having access to the subsidized water rate. The total annual hours of irrigation did not diminish because the farmer could still purchase the same quantity of water from the NIC except he would pay a rate equal to the rate he was paying for river water. Table 4.6 lists the results comparing scenarios Two, Four, Seven and Eight.

Table 4.6 Effects of the Elimination of the Water Subsidy[a]

		Scenario Two	**Scenario Four**	**Scenario Seven**	**Scenario Eight**
	Units	No IPM and water subsidy	IPM and water subsidy	No IPM and no water subsidy	IPM and no water subsidy
Returns to fixed resources	$JM[b]	435,481	485,764	411,781	462,064
Total gross revenue	$JM	468,398	531,167	468,398	531,167
Hot pepper	Acres	1.1		1.1	
IPM hot pepper	Acres		1.1		1.1
Corn	Acres		0.15		0.15
Pumpkin	Acres	2.4	2.4	2.4	2.4
Sweet potato	Acres	1.8		1.8	
IPM sweet potato	Acres		1.8		1.8
Callaloo	Acres	.2		.2	
IPM callaloo	Acres		.2		.2
Cassava	Acres	1.7	1.7	1.7	1.7
Sugar cane	Acres				
Water – NIC	Total annual hours	2,080	2,080	2,080	2,080
Water – Market	Total annual hours	582	756	582	756
Credit – Subsidized	$JM	58,224	60,492	58,224	60,492
Credit – Market rate	$JM				
Own labor	People-days	298	313	298	313
Total hired labor	People-days	18	25	18	25

a. A water rate policy change eliminated the water subsidy of $JM11.40 per hour.
b. The nominal exchange rate is $JM35:$US1.

The elimination of the water subsidy affected the profitability of IPM by lowering the returns to fixed resources from $JM485,764 with the water subsidy, to $JM462,064 without the water subsidy. Without the water subsidy 1.1, 2.4 and .2 acres of IPM hot pepper, IPM sweet potato and IPM callaloo are planted, respectively. The crop acreages do not change with the elimination of the water subsidy. The lower returns are a result of farmers paying more for the water. However, the increase in profits with the IPM systems over the conventional systems when farmers have access to the water subsidy is $JM50,283. The increase in profits from IPM adoption is not affected by the elimination of the water subsidy.

In both cases, with and without the water subsidy, the adoption of the IPM systems increases the water usage by 179 people-days annually. At the margin, the market rate is used between the conventional and IPM systems. Therefore, the increase in returns from IPM is not affected by the elimination of the water subsidy. More water is used with the IPM systems as a result of the additional .15 acre of corn as well as the inclusion of IPM sweet potato system in the production decision. IPM sweet potato requires higher quantities of water than conventional sweet potato.

The reduced costs and shadow prices on the objective function coefficients and the constraints do not significantly shift due to the lack of a water subsidy. The IPM requirement of increased irrigation for sweet potato combined with the elimination of the water subsidy does not reduce the profitability of the IPM systems.

Some crop production is achieved without irrigation in Ebony Park. However, irrigation increases crop production. In addition, irrigation is necessary for the sweet potato IPM system. Although the results from the model indicate that eliminating the water subsidy will not lower the profitability of the IPM systems below the conventional systems, access to water could potentially lower the profitability of IPM. When the availability of water was lowered by 50% to 1,040 hours a year, pumpkin no longer became profitable. However, even with the lower availability of water and the elimination of the credit subsidy, the farmer continued to use the IPM systems.

Lack of access to irrigation water may limit adoption of IPM in some parts of Jamaica. According to Karen Patterson (1996), "The high cost of water limits the amount of water farmers are able to buy and thus hinders crop production in several communities in Clarendon" (p. 103). In addition, "the lack of water also influences the crops this farmer [in Clarendon] grows. For example, he plants a great deal of cassava because it requires less water than some other crops such as sweet potato" (p.103). In some cases "the shortage of water is so severe that he [the farmer] regards this as a much more serious problem than pests" (p.103). Further research is needed on the potential for IPM adoption when farmers do not have access to irrigation.

<u>Credit Subsidy</u>: The credit subsidy of 22.5% was eliminated and the effects were evaluated for Scenarios Nine and Ten. The results are shown in Table 4.7. The farmers

had unlimited access to financial capital at the real market interest rate of 25.51%. If farmers were forced to pay higher real interest rates on borrowed money, then the higher initial costs of the IPM systems might reduce their profitability relative to the conventional production practices.

Table 4.7 Results of Elimination of the Credit Subsidy on the Profitability of the IPM Systems[a]

		Scenario Two	**Scenario Four**	**Scenario Nine**	**Scenario Ten**
	Units	No IPM and credit subsidy	IPM and credit subsidy	No IPM and no credit subsidy	IPM and no credit subsidy
Returns to fixed resources	$JM[b]	435,481	485,764	424,121	473,962
Total gross revenue	$JM	468,398	531,167	468,398	531,167
Hot pepper	Acres	1.1		1.1	
IPM hot pepper	Acres		1.1		1.1
Corn	Acres		0.15		.15
Pumpkin	Acres	2.4	2.4	2.4	2.4
Sweet potato	Acres	1.8		1.8	
IPM sweet potato	Acres		1.8		1.8
Callaloo	Acres	.2		.2	
IPM callaloo	Acres		.2		.2
Cassava	Acres	1.7	1.7	1.7	1.7
Sugar cane	Acres				
Water – NIC	Total annual hours	2,080	2,080	2,080	2,080
Water – Market	Total annual hours	582	756	582	756
Credit – Subsidized	$JM	58,224	60,492		
Credit – Market rate	$JM			58,224	60,492
Own labor	People-days	298	313	298	313
Total hired labor	People-days	18	25	18	25

a. The credit subsidy of 22.5% was eliminated for farmers borrowing financial capital. All farms were charged the market real interest rate of 25.51%.
b. The nominal exchange rate is $JM35:$US1.

The returns to fixed resources from IPM, when the credit subsidy is available to farmers, are $JM485,764 as 1.1, 1.8, and .2 acres of IPM hot pepper, IPM sweet potato and IPM callaloo are planted, respectively. When the credit subsidy is eliminated, the same cropping pattern is followed but the returns from IPM decline slightly to $JM473,962 as farmers pay more for capital.

The increase in returns from IPM over the conventional practices, with the credit subsidy available, was $JM50,283. When the subsidy was eliminated, the increase in returns from IPM adoption was $JM49,841, a drop of .8%. The elimination of the credit subsidy lowered the returns to fixed resources but had little affect on the increase in returns of the IPM systems over the conventional methods.

With or without the credit subsidy, the adoption of the IPM systems caused the quantity of capital borrowed to increase from $JM58,224 to $JM60,492. The IPM systems increased returns significantly such that the farmer increased the quantity of financial capital borrowed by 9.5%. IPM continued to be more profitable than the conventional systems when the credit subsidy was no longer available to farmers.

The elimination of the credit subsidy did not erect a barrier to adoption for the IPM systems and the IPM systems continued to be more profitable. Farmers, when given the access to IPM technology, chose to adopt the alternative production practices as a result of receiving higher returns to fixed resources.

Real Interest Rate: The real interest rate effects were analyzed after simulating a 25% drop in the real interest rate. The subsidized real interest rate dropped to 2.25% and the real market rate dropped to 19.31%. A drop in the real interest rate was hypothesized to shift production away from labor intensive IPM. The farmers interviewed reported that they did not use financial capital to pay for hired labor. Therefore, if financial capital were available at a lower rate, the farmers might take advantage of the situation and borrow more money to use on the conventional production practices and not for IPM. The results from the real interest rate drop are shown in Table 4.8.

Table 4.8 Results of a Reduction in the Real Interest Rate[a]

		Scenario Two	**Scenario Four**	**Scenario Eleven**	**Scenario Twelve**
	Units	No IPM and original real interest rate	IPM and original real interest rate	No IPM and lowered real interest rate	IPM and lowered real interest rate
Returns to fixed resources	$JM[b]	435,481	485,764	435,918	486,218
Total gross revenue	$JM	468,398	531,167	468,398	531,167
Hot pepper	Acres	1.1		1.1	
IPM hot pepper	Acres		1.1		1.1
Corn	Acres		0.15		0.15
Pumpkin	Acres	2.4	2.4	2.4	2.4
Sweet potato	Acres	1.8		1.8	
IPM sweet potato	Acres		1.8		1.8
Callaloo	Acres	.2		.2	
IPM callaloo	Acres		.2		.2
Cassava	Acres	1.7	1.7	1.7	1.7
Sugar cane	Acres				
Water – NIC	Total annual hours	2,080	2,080	2,080	2,080
Water – Market	Total annual hours	582	756	582	756
Credit – Subsidized	$JM	58,224	60,492	58,224	60,492
Credit – Market rate	$JM				
Own labor	People-days	298	313	298	313
Total hired labor	People-days	18	25	18	25

a. Interest rate change reduced the real interest rate by 25% to 2.25% and 19.31%, respectively, for the subsidized and market interest rates.
b. The nominal exchange rate is $JM35:$US1.

In both Scenario Eleven and Scenario Twelve the farmer had access to the lower interest rate and, therefore, less expensive capital. Returns to IPM with the lower real interest rate were $JM486,218 representing a rise of .09% or $JM454 over the returns to IPM with the original interest rate. Crop selection with the lower interest rate was unchanged from selection with the original interest rate.

The increase in returns of the IPM systems over the conventional systems was $JM50,300 with the lower interest rate as opposed to an increase of $JM50,283 with the original interest rate. The returns for the IPM systems, with the lower interest rate, might be higher than the returns with the original interest rate, but the increases in returns from adoption of the IPM systems were equal.

The shadow prices on the constraints and the reduced costs of the objective coefficients changed less than 1%. With a lower real interest rate and the credit subsidy, the IPM systems were more profitable than the conventional practices with a lower real interest rate as well as the IPM practices with a higher real interest rate. The lower real interest rate did not affect the profitability of IPM.

Duty Concession: The elimination of the 20% duty concession was modeled by raising the capital cost of tractor services by 20% as explained in Chapter 3. If the machinery services became more expensive, farmers might shift production practices which rely less on machinery services such as the IPM systems. The results of the elimination of the duty concession rate on the two comparative scenarios are shown in Table 4.9.

Table 4.9 Effects on IPM Profitability Resulting from the Elimination of the Duty Concession Rate[a]

		Scenario Two	**Scenario Four**	**Scenario Thirteen**	**Scenario Fourteen**
	Units	No IPM and duty concession	IPM and duty concession	No IPM and no duty concession	IPM and no duty concession
Returns to fixed resources	$JM[b]	435,481	485,764	434,799	485,067
Total gross revenue	$JM	468,398	531,167	468,398	531,167
Hot pepper	Acres	1.1		1.1	
IPM hot pepper	Acres		1.1		1.1
Corn	Acres		0.15		0.15
Pumpkin	Acres	2.4	2.4	2.4	2.4
Sweet potato	Acres	1.8		1.8	
IPM sweet potato	Acres		1.8		1.8
Callaloo	Acres	.2		.2	
IPM callaloo	Acres		.2		.2
Cassava	Acres	1.7	1.7	1.7	1.7
Sugar cane	Acres				
Water – NIC	Total annual hours	2,080	2,080	2,080	2,080
Water – Market	Total annual hours	582	756	582	756
Credit – Subsidized	$JM	58,224	60,492	58,886	61,168
Own labor	People-days	298	313	298	313
Total hired labor	People-days	18	25	18	25

a. The elimination of the vehicle duty concession raised the price of mechanical imports by 20%
b. A nominal exchange rate of $JM35:$US1.

With the duty concession, IPM caused returns to fixed resources to increase from $JM464,481 to $JM485,764 or by 8.9% as 1.1, 2.4 and .2 acres of IPM hot pepper, IPM sweet potato and IPM callaloo are planted, respectively. Without the duty concession, IPM causes returns to rise from $JM434,799 to $JM485,067 or by 10.4% as the cropping scheme does not change. Eliminating the duty concession causes the farm's net returns to fall from $JM485,764 to $JM485,067 or by .1%. The farmer is planting the same acreage of crops which entails the same quantity of machinery services both with and without the duty concession. Without the duty concession, the machinery services are more costly and decrease the farm's net returns. The farmer must borrow more capital to pay for the higher price for machinery services which increases interest costs. Shadow prices and reduced costs did not change more than 1% between the two scenarios.

The increase in returns from adoption of the IPM systems as a result of the elimination of the duty concession falls from $JM50,283 to $JM50,268. However, even if the duty concession rate is eliminated and farmers are forced to pay higher prices on machinery services, they will continue to take advantage of the IPM systems if the systems are available. The IPM systems are more profitable than the conventional production practices under the no duty concession scenarios.

Common External Tariff: A 11.25% reduction in the Common External Tariff (CET) was simulated by a 5% fall in the price of machinery services (with the exception of labor supplied) as shown in Table 3.8 and a 5% fall in the price of chemicals. The reduction in the cost of chemicals and in machinery services might result in a lower profitability of the IPM systems and, therefore, farmers choosing not to adopt the IPM technologies. The results of the CET policy change are shown in Table 4.10.

Table 4.10 Results of the 11.25% Reduction of the Common External Tariff[a]

		Scenario Two	**Scenario Four**	**Scenario Fifteen**	**Scenario Sixteen**
	Units	No IPM and no CET reduction	IPM and no CET reduction	No IPM and CET reduction	IPM and CET reduction
Returns to fixed resources	$JM[b]	435,481	485,764	438,536	488,713
Total gross revenue	$JM	468,398	531,167	468,398	531,167
Hot pepper	Acres	1.1		1.1	
IPM hot pepper	Acres		1.1		1.1
Corn	Acres		0.15		0.15
Pumpkin	Acres	2.4	2.4	2.4	2.4
Sweet potato	Acres	1.8		1.8	
IPM sweet potato	Acres		1.8		1.8
Callaloo	Acres	.2		.2	
IPM callaloo	Acres		.2		.2
Cassava	Acres	1.7	1.7	1.7	1.7
Sugar cane	Acres				
Water – NIC	Total annual hours	2,080	2,080	2,080	2,080
Water – Market	Total annual hours	582	756	582	756
Credit – Subsidized	$JM	58,224	60,492	56,853	59,092
Credit – Market rate	$JM				
Own labor	People-days	298	313	298	313
Total hired labor	People-days	18	25	18	25

a. A reduction in the CET by 11.25% caused the price of all imports to fall by 5%
b. A nominal exchange rate of $JM35:$US1.

The 11.25% fall in the CET caused returns to fixed resources with IPM to rise from $JM485,764 to $JM488,713 or by .6%. The increase in returns is a result of the lower cost of chemicals and machinery services as well as lower capital borrowed by the farmer. The crop mixture stayed constant with 1.1, 1.8, and .2 acres of IPM hot pepper, IPM sweet potato and IPM callaloo being planted in both Scenario Four and Scenario Sixteen.

The returns from IPM adoption fell from $JM50,283 without the CET reduction to $JM50,177 with the CET reduction. Given the lower input costs and the availability of the IPM systems, the farmer continued to choose to adopt the systems as a substitute for the conventional production practices because of the higher returns to fixed resources. Although the returns to IPM adoption fell slightly, the systems were more profitable than the conventional systems both with and without the CET reduction.

Real Exchange Rate: A 5% appreciation in the real exchange rate was simulated by: a 5% fall in the price of machinery services (with the exception of the labor) as illustrated by Table 3.9, a 5% fall in the price of chemicals, and a 5% fall in the export price received by farmers. The appreciation of the real exchange rate would lead to a lower cost of chemicals and a lower cost of machinery services. The appreciation would result in lower prices received by farmers because US buyers would not be willing to pay higher prices for Jamaican agricultural goods and exporters would be forced to lower their prices paid to farmers. Results of the appreciation in the exchange rate are shown in Table 4.11.

Table 4.11 Profitability and Changes in Production Resulting from a 5% Appreciation of the Real Exchange Rate[a]

		Scenario Two	**Scenario Four**	**Scenario Seventeen**	**Scenario Eighteen**
	Units	No IPM and original real exchange rate	IPM and original exchange rate	No IPM and exchange rate appreciation	IPM and exchange rate appreciation
Returns to fixed resources	$JM[b]	435,481	485,764	415,116	462,340
Total gross revenue	$JM	468,398	531,167	444,978	504,793
Hot pepper	Acres	1.1		1.1	
IPM hot pepper	Acres		1.1		1.1
Corn	Acres		0.15		0.15
Pumpkin	Acres	2.4	2.4	2.4	2.4
Sweet potato	Acres	1.8		1.8	
IPM sweet potato	Acres		1.8		1.8
Callaloo	Acres	.2		.2	
IPM callaloo	Acres		.2		.2
Cassava	Acres	1.7	1.7	1.7	1.7
Sugar cane	Acres				
Water – NIC	Total annual hours	2,080	2,080	2,080	2,080
Water – Market	Total annual hours	582	756	582	756
Credit – Subsidized	$JM	58,224	60,492	56,853	59,092
Own labor	People-days	298	313	298	313
Total hired labor	People-days	18	25	18	25

a. The real exchange rate appreciated by 5% causing the price of imports and exports to fall by 5%. The real exchange rate is reduced from $JM5.4:$US1 to $JM5.13:$US1

b. A nominal exchange rate of $JM35:$US1.

With the original real exchange rate, the returns to IPM were $JM485,764 as 1.1, 2.4, and .2 acres of IPM hot pepper, IPM sweet potato and IPM callaloo were planted, respectively. With an appreciated real exchange rate, the returns to IPM decreased by 4.8% to $JM462,340 as the crop acreage remained constant. Shadow prices and reduced costs changed by less than 1% between Scenario Seventeen and Scenario Eighteen.

With the original real exchange rate, the increase in returns from IPM adoption was $JM50,283. The increase in returns with the appreciated real exchange rate was $JM47,224. Returns from IPM adoption fell with the appreciated real exchange rate because the cost of labor rose relative to the cost of chemicals and farmers faced lower prices received for their harvests.

A 5% depreciation in the real exchange rate was evaluated and the results showed that IPM continued to be more profitable than the conventional systems with the returns to fixed resources being $JM509,188, representing an increase in returns of $JM53,342 over the conventional practices. A depreciation in the real exchange rate would raise the returns to fixed resources above the returns to fixed resources from an appreciation ($JM462,340 to $JM509,188) and would raise the returns from IPM adoption from $JM47,224 to $JM53,342.

The profitability of the IPM systems was also evaluated with respect to the elimination of the water subsidy, the credit subsidy and the duty concession simultaneously. The results are shown in Table 4.12 below.

Table 4.12 Profitability and Changes in Production Resulting from the Elimination of the Water Subsidy, the Credit Subsidy and the Duty Concession Rate[a]

		Scenario Four	**Scenario Nineteen**
	Units	IPM and all subsidies available	IPM and no subsidies available
Returns to fixed resources	$JM[b]	485,764	446,948
Total gross revenue	$JM	531,167	531,167
Hot pepper	Acres		
IPM hot pepper	Acres	1.1	1.1
Corn	Acres	0.15	0.15
Pumpkin	Acres	2.4	2.4
Sweet potato	Acres		
IPM sweet potato	Acres	1.8	1.8
Callaloo	Acres		
IPM callaloo	Acres	.2	.2
Cassava	Acres	1.7	1.7
Sugar cane	Acres		
Water – NIC	Total annual hours	2,080	2,080
Water – Market	Total annual hours	756	756
Credit – Subsidized	$JM	60,492	63,198
Credit – Market rate	$JM		
Own labor	People-days	313	313
Total hired labor	People-days	25	25

a. The water subsidy was $JM11.39, the credit subsidy was 22.49% and the duty concession rate was 20%. The elimination of these subsidies raised the price of water, credit and machinery services.
b. A nominal exchange rate of $JM35:$US1.

The profitability of the IPM systems dropped by 7.9% from $JM485,764 to $JM446,948 with the elimination of all three subsidies. The cropping patterns stayed constant. The returns to fixed resources decreased as a result of eliminating the subsidies because the cost of inputs rose while the output prices did not change. However, IPM continued to be more profitable than the conventional practices.

Table 4.13 was constructed to help illustrate the increased profits from IPM adoption under the different policy scenarios for the risk-constrained farmer. The increase in profit is shown along with increases in total labor use and total water use.

The eight results show the difference between the scenarios with risk constraints for all of the eight various policy areas. For example the Base policy row shows the difference between scenarios Two and Four while the Preclearance row shows the difference between scenarios Five and Six.

Table 4.13 Changes in Profit, Total Labor Use, and Total Water Use as a Result of Access to IPM Technologies

Policy area	Increase in profit from adopting IPM systems[a]	Increase in total labor from adopting IPM systems	Increase in total water used from adopting IPM systems
Unit	$JM[b]	People-days	Hours/season
Base	50,283	22	174
Preclearance	56,790	24	174
No water subsidy	50,283	22	174
No credit subsidy	49,841	22	174
Reduced real interest rate	50,300	22	174
No duty concession	50,268	22	174
Reduced CET	50,177	22	174
Appreciation of the real exchange rate	57,177	22	174

a. Increase in returns was calculated by subtracting the returns without IPM from the returns with IPM. For instance in the base scenarios, the returns without IPM (Scenario Two) were subtracted from the returns with IPM (Scenario Four). $JM485,764 - $JM435,481 = $JM50,283.
b. The nominal exchange rate is $JM35:$US1.

An interesting observation to Table 4.13 is that only the preclearance policy affected the people-days. The preclearance policy raised the increase in labor from 22 to 24 people-days, or by 8.3%, because of the extra labor involved with the farm level inspections of the additional harvest from the IPM crops. None of the policy changes affected the production mixture of the farm. Therefore, the total water increase did not change. The policies affected the increase in returns from adopting the IPM technologies.

The policies interact with the profitability of the IPM systems very little. The range of change in the returns to fixed resources from the policy change is from a decline of .5% (no credit subsidy) to a rise of 12.6% (preclearance). The policy changes raised total labor by a maximum of 36 people-days per year as well as increasing the water usage by a maximum of 386 hours per year. With every policy change, IPM continued to be more profitable than the conventional production practices.

III b. Policies Not Included in the Model

Import Restrictions and Tax: As discussed in Chapter 2, all pesticides are imported into Jamaica and are subject to a .5% per volume tax. If the tax is increased to 1%, the impact on the profitability of IPM will be minimal. The actual percentage of the increase passed on to farmers will be a function of the elasticity of the demand for the pesticides. The rise in pesticide prices as a result of doubling the pesticide tax would be minimal and, therefore, would have a minimal effect even with an inelastic demand for pesticides. The effects of the CET shift, a close approximation to the pesticide tax shift, was minimal which would imply that the effect of the pesticide tax on the returns to fixed resources would be very limited.

Inflation Rate: The inflation rate for the first four months of 1998 were .7%, .1%, .8%, and .4%, respectively. The Bank of Jamaica is keeping a tight low inflation policy. The impact of a change in the inflation rate would most likely not affect the farmer's incentive to adopt the IPM systems as indicated by the previous results of policies incorporated into the model (real interest rate and real exchange rate).

However, inflation is also a function of price expectations. If farmers begin to expect higher prices, they will shift their production accordingly, even without concrete evidence of price increases. The empirical model was not designed to mimic price expectations. The expectations could affect input prices and not output prices or affect outputs and not input prices.

A fall in the inflation rate will cause the real exchange rate to depreciate[1]. A depreciation in the real exchange rate would result in higher real prices on imported inputs and higher prices received for exported crops. A 5% depreciation in the real exchange rate was analyzed above and no significant impact was found on the returns to the IPM systems. The returns from IPM adoption rose from $JM50,283 in Scenario Four to $JM53,342 with the depreciation.

Returns to fixed resources rise by 4.6% from $JM485,764 with the base real exchange rate to $JM509,188 with the depreciated exchange rate. Total gross revenue increased by 8%. The increase in returns from adopting the IPM systems rose from $JM50,283 in the base scenario to $JM53,342 with the depreciation because of the lower reliance on chemicals and machinery services.

Income Tax Relief: A farmer receiving the income tax relief would have higher profit margins than those not receiving the relief. The higher profit resulting from the tax relief was assumed not to have an influence on the decision of a farmer to use the IPM technologies. There was no indication that the farmers interviewed would prefer to invest their additional profit in fixed capital such as tractors as opposed to land, labor or other investments. Any effect of the tax relief would be indirect and over a long run time horizon.

Minimum Wage: Farmers in Clarendon are paying over the weekly minimum wage. A rise in the minimum wage, however, could still potentially affect the profitability of the IPM systems. A rise in the minimum wage could potentially constrict the labor supply for farms. Higher wages could induce workers to migrate to the urban areas and away from the farms. The smaller labor supply in the farming communities could force farmers to raise their wages to compete for a smaller labor pool which would lower the

[1] Using the equation from Chapter 2, Footnote 1, a 5% decrease in the inflation rate would lower the Jamaican CPI from 1115.9 to 1060.12. The equation would then change from (36.51/1) X (162.2/1115.9) to (36.51/1) X (162.2/1060.12). The

profitability of IPM. The indirect impact would be a long run problem and could be reduced by public or private investment in the rural infrastructure, thus giving workers less incentive to move to the cities.

A scenario was run with the model where the hired labor wage was raised by 100% from $JM500 to $JM1,000. The farmer did not change his production mixture but did experienced a drop in the returns to fixed resources. The returns as a result of the higher minimum wage were $JM473,132 as opposed to the returns of $JM485,764 in Scenario Four but still above the returns of $JM435,481 in Scenario Two with no access to IPM. The increase in returns from IPM adoption fell from $JM50,283 with the lower hired labor wage to $JM46,481 with the higher price of labor.

Land Taxes: Farmers receive a 50% land tax reduction. Including the effects of the tax reduction in the model would likely have no direct effect on the adoption of IPM because the land tax was a fixed cost. A higher or lower tax would not shift the economic incentives for IPM adoption because the farmer would choose the production method that had the highest returns to fixed resources. The returns are based on variable costs and not fixed costs. As with the income tax relief, any impact from a change in the land tax would have an indirect effect on the profitability of IPM and would be evident only over a long run time horizon.

Research Allocation: A possible reason for farmers not adopting the IPM technologies is the recent development of IPM for the three non-traditional crops of hot pepper, sweet potato and callaloo. The IPM systems have not been completely tested. If the Jamaican Ministry of Agriculture allocated more funding to the research of IPM, adoption rates by farmers could potentially be higher than the present rates because technologies would be developed sooner.

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real exchange rate would shift from $JM5.307:$US1 to $JM5.586:$US1 representing a 4.9% depreciation of the Jamaican dollar.

Figure 4.1 shows the real research allocation over time as a percentage of the real budget of the Ministry of Agriculture. The percentage of the budget allocated to research has remained below 10% throughout the 1990's. Most of the IPM research being conducted is not done by the Ministry of Agriculture but instead by CARDI. Collaborating research by the Ministry of Agriculture could help to provide final IPM systems for hot pepper, sweet potato and callaloo sooner than reliance on CARDI efforts alone.

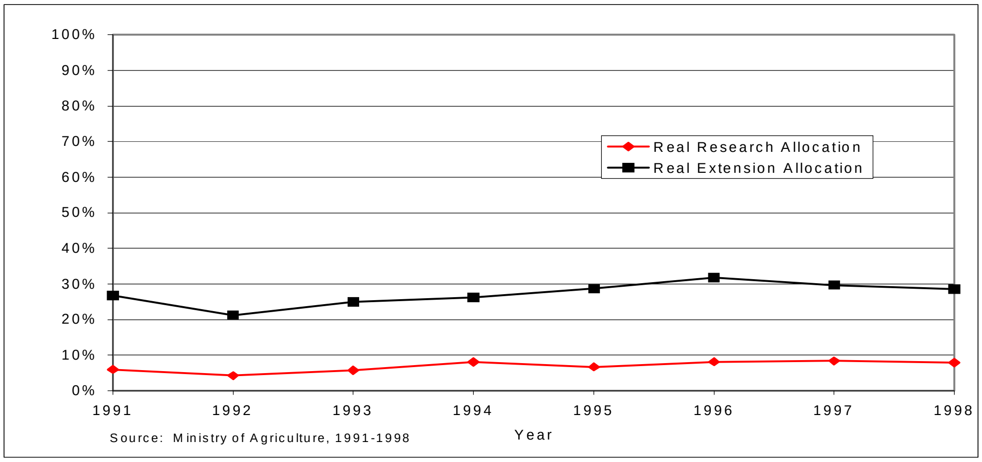

Figure 4.1 Real Research and Extension Allocation Over Time as a Percentage of the Total Budget of the Ministry of Agriculture

Extension Allocation: Farmers lack knowledge of the benefits of IPM and have preconceived notions on the pest management production practices. Education regarding the benefits is necessary for higher IPM adoption rates. Furthermore, farmers also need to be educated to the methods and production changes that the IPM systems require. According to RADA agents, the current funding system from the Ministry of Agriculture is unable to supply RADA with sufficient resources to achieve the goals of extension.

Figure 4.1 also shows the real extension allocation over time as a percentage of the total Ministry of Agriculture budget. Interviews with RADA officials (Chung, 1998)

(Lawrence, 1998) discussed the constraints to extension regarding IPM technologies. Available labor and transportation were the two most significant barriers to extension. More extension agents and more reliable transportation to bring extension agents to the farmers would result in higher IPM adoption rates.

IV. Summary

This chapter discussed the results of the empirical model. Four base scenarios were constructed to analyze the impacts of IPM and risk constraints on farmers production methods. Scenarios Two and Four, incorporating the risk constraints with and without the IPM technologies, were then used to evaluate the impacts of government policy changes. Seven policies were included into the model and run for the two scenarios. Additionally, policies not in the model were examined for potential impacts, both direct and indirect, on the adoption of IPM. The following chapter will provide a discussion of the study results and implications.