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Developing Rapid Climate Decision Analysis Tool in Small-holder High-Value Crop Farming in Atok, Benguet

Sonny N. Domingo, Anna Jennifer L. Umlas, and Katrina Mae C. Zuluaga

CONTACT US:

RESEARCH INFORMATION DEPARTMENT
Philippine Institute for Development Studies

18th Floor, Three Cyberpod Centris - North Tower
EDSA corner Quezon Avenue, Quezon City, Philippines

publications@mail.pids.gov.ph
(+632) 8877-4000

https://www.pids.gov.ph

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Katrina Mae C. Zuluaga

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Abstract

Weather and climate information are useful tools for smallholder farmers to manage climate risk. The Philippine Atmospheric, Geophysical and Astronomical Services Agency, the national meteorological and hydrological agency in the Philippines, have various products that can support farmers in making decisions. However, there is a gap in access and utilization of weather and climate information.

The Action ready climate knowledge to improve disaster risk management for smallholder farmers in the Philippines project aims to contribute in bridging the gap between producers and users of information. Among others, the project explores the context faced by farmers in making farm decisions that are influenced by weather and climate information.

This paper discusses the data collection and initial results in developing the rapid climate decision analysis tool applicable to smallholder high value crop farming in Atok, Benguet. The excel-based tool harnesses the knowledge of farmers and agricultural extension workers and aims to aid them in decisionmaking. Information gathered are yields, production costs and prices by crop, season and amount of rainfall

Keywords: decision analysis, agriculture, smallholder farming

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Sonny N. Domingo, Anna Jennifer L. Umlas, and Katrina Mae C. Zuluaga[2]

1. Introduction

Smallholder farmers are vulnerable to extreme climate variability. The effect on agricultural productivity is visible as lower yields due to heavy or insufficient rainfall or outbreak of pests or diseases. Access to weather and climate forecasts has the potential to help smallholder farmers enact risk reduction measures to protect themselves against the adverse impacts of climate variability. Farmers need reliable, accurate, timely and useful weather and climate forecasts. Technological advancements have brought improvements in weather and climate forecasts and in understanding its impact on agriculture. Delivery of weather and climate information has upgraded as television, radio and currently the internet and mobile phones have reached more people than before. In spite of these developments, there are still gaps in the access and utilization of weather and climate information.

The Action ready climate knowledge to improve disaster risk management for small holder farmers in the Philippines project aims to improve the communication flows between the Philippine Atmospheric, Geophysical and Astronomical Services Agency (PAGASA), the national meteorological and hydrological agency in the Philippines, and users of weather and climate information specifically smallholder farmers and agricultural extension workers. The project is introducing a decision tool called Rapid Climate Decision Analysis (RCDA) to aid agricultural extension workers and farmers in decision-making and dealing with uncertainty in forecasts. This paper discusses the decisions in vegetable farming and construction of RCDA tool in the context of smallholder vegetable farming in Atok, Benguet.

2. Rapid climate decision analysis

Farmers having knowledge of seasonal climate variability before the start of the cropping season and incorporating it into their farm decisions can help to limit the adverse impact of climate variability. The RCDA is an excel-based tool that aims to aid in decision-making that considers uncertainty in the forecast. It steers the decision-maker to lay out the assumptions and describe the context of a decision as well as outcomes and alternatives of a decision choice. The tool uses the decision-maker's knowledge about potential yields, estimates of gross income, growing costs, gross margins and uncertainty in weather and climate forecasts in coming up with a decision. The results in RCDA serves only as a guide and ultimately depends on the understanding and information provided by the decision-maker and quality of the forecast.

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[2] Senior Research Fellow, Supervising Research Specialist, and Research Analyst at PIDS. Views expressed here are those of the authors and do not necessarily reflect those of the institution they are part of.

The steps in RCDA are the following. First, the decision-maker identifies a climate-sensitive decision in cultivating crops and describes the context of the decision. This exercise helps to provide clarity by laying out the decision choices or alternatives and its corresponding outcomes. Each decision choice and climatic state is matched with corresponding yields or biophysical outcomes that are then converted to gross margins. This entails estimates of expected prices during harvest or selling time and estimates of production costs. After checking if the over-all estimates fit, the tool allows the decision-maker to use probabilistic forecasts from PAGASA to determine a decision and the decision changes with variations in the climatic odds and assumptions.

3. Data Collection

Description of the study area

Benguet province is a major producer of cabbages, carrots and white potatoes in the Philippines. In 2018, Benguet accounts for more than 70 percent of the total production of cabbages, carrots and white potatoes in the country. The focus of this study is the municipality of Atok in Benguet province. Atok has a land area of 22,385.5 hectares where two-thirds have 40-60 percent slope and characterized as hilly or mountainous while the remaining one-third has above 60 percent above slope and described as rugged mountain areas. Atok is considered high elevation with the highest elevation in the municipality is at 7,400 feet above sea level while the lowest elevation is at 600 meters above sea level. Because of its topography and terrain, farmers build terraces to plant their crops. Moreover, the cool temperature makes it suitable in producing high value crops such as cabbages, carrots, white potatoes among others as well as cut flowers and succulents. Like the rest of Benguet, Atok has Type I climate classification meaning it has a distinct wet and dry season. The wet season is from May to October and the dry season is from November to April.

The Office of the Municipal Agriculturist (MAO) in Atok estimates that 5,000 ha are dedicated to farming. Sixty percent of farms, including rice fields, are rain-fed while the remaining forty percent have supplemental irrigation. If focusing only to farms producing vegetables, the share of rain-fed farms increase to 80 percent and only 20 percent have supplemental irrigation.

Data collection

This study used qualitative methods to gather information among smallholder farmers, local government officials and agricultural extension workers in Atok, Benguet. Five smallholder farmers, three local government officials who are also engaged in farming and five agricultural extension workers participated in multiple discussions to gather information needed for RCDA namely identifying climate-sensitive decisions and collecting estimates for yields, gross income and production costs. This allows the project team to explore with a range of climactic conditions and farm decisions in a cost-effective manner relative to conducting a long-term empirical research, which may also be restricted by financial, political and institutional factors.

The Office of the Municipal Agriculturist provided assistance in inviting the farmers. Farmers are composed of one female and three males. They have been farming for at least 20 years and farm size ranges from half to three hectares. On the other hand, the local government officials are males and have been engaged in farming for 10 years on average, and farm size ranges

from half to one hectare. All of them are cultivating carrots, cabbage, potatoes and other crops such as celery, lettuce, Chinese cabbage and radish.

Data collection started with smallholder farmers and local government officials. Then, agricultural extension workers and experts familiar with vegetable farming in Benguet validated the information or provided additional inputs. Production materials from the Department Agriculture and the Agricultural Training Institute are also used as reference.

4. Results and discussion

To identify the climate-sensitive decisions, the discussion started with the standard crop calendar from the Municipal Agriculturist (Table 1). The crop calendars show the sowing and harvest month for a variety of crops. April to October are the planting months for carrots and June to December are the harvesting months. April to May and Sept to October are the planting months for white potatoes while June to August and December are the harvesting months. April to September are the planting months of cabbage and June to December ate the harvesting months. Farmers are familiar with the crop calendar since they provided support to the Municipal Agriculturist Office in creating it.

Table 1. Crop Calendar from the Office of Municipal Agriculturist in Atok, 2019

	Calendar Months											
Crop	Jan	Feb	Apr	Mar	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Carrots												
White Potato												
Cabbage												

Legend	
Plant	
Harvest	

Source: Office of the Municipal Agriculturist in Atok, Benguet

Then, the farmers described their culture and management of cultivating crops starting from crop choice up to marketing of the produce to the trading post. Next, for each physiological stage of crop growth or planting activity, the farmers identified the weather and climate risks and its effect on crop growth or farming activity. This exercise produced a crop climate calendar. Table 2 lists the climate risks applicable in Atok, its impact on the crops and actions done to address adverse impacts of the climate risks.

Table 2. List of climate risks of rain-fed vegetable farms in Atok, Benguet

Climate risk	Impact	Actions to address adverse impact of climate risks
Water deficit or insufficient rain	Low yield and poor quality of the crop Too little water will damage the seedling and prevent it from growing For cabbages, more pests	Supplemental irrigation For cabbages, spray at closer intervals to reduce pests
Accumulated rain or too much rain	Low yield and poor quality of the crop Too much water will wash away the seeds or crop will rot For carrots and potatoes, more prone to diseases	Use greenhouses or crop covers Plant crops that can tolerate water Drain soil For carrots and potatoes, spray at closer intervals to protect from diseases
Accumulated heat	For cabbages, more pests For carrots, too much heat can cause the roots to split resulting to poor quality	Spray at closer intervals to manage pests Hilling up
Typhoons	Destroy crops Higher price if crop survives after typhoon	Adjust timing of planting such that harvest season do not fall during typhoon months Early harvest if feasible
Temperature	Low yield and poor quality of the crop if temperature is not appropriate to support crop growth	Plant appropriate crop or crop variety
Frost	Low yield or poor quality of the crop	Plant crops that have higher tolerance for low temperatures Do not plant in areas where frost occurs during frost-occurring months of December to February
Seasonal rainfall		Choose crop or crop variety that is suitable to the amount of rainfall
Onset of rainfall	Early onset of rainfall Late onset of rainfall leads to longer cropping period. Harvesting period during the	Adjust timing of planting Supplemental irrigation Spray at closer intervals

	wet season might fall in the typhoon months of July-August	Early harvest depending on the stage of growth of the crop and typhoon forecast
Excess sunlight	Too much sunlight will cause severe wilting of the newly harvested cabbage heads Root tops of carrots turn green Tubers' exposure to sunlight results in green, poisonous tubers	Hilling-up to cover the roots
Hail	Damage to farms, lower yields Seedling stage is very susceptible to damage	Get crop insurance Install crop covers (but might be ineffective depending on the size of hail)

The municipal agriculturist identified three climate-sensitive decisions namely decision on crop choice, investment on supplemental irrigation and decision on when to start planting.

4.1 Crop choice

Farmers must decide on the type of crop to plant whether it be cabbage, carrots or potatoes for the coming cropping season. Table 3 lists the advantages and disadvantages of cultivating cabbages, carrots and potatoes. Cabbage has high yields but relatively low prices. It is also susceptible to pests when there is too little water or to frost during cooler temperatures. On the other hand, carrots can fetch higher prices compared to cabbages, but yields are lower and labor costs are high. It can however tolerate lower temperatures depending on its stage of growth. Lastly, white potatoes are similar to carrots that it can be sold at higher prices but have lower yields compared to cabbages. It also has lower water requirements compared to carrots and cabbages.

Cabbages are susceptible to pests during the dry season so farmers spray at closer intervals. On the other hand, carrots and potatoes are susceptible to diseases when there is too much water so farmers spray more often during the wet season. Identifying the pros and cons of cultivating each crop and quantifying these can help farmers decided on which crop to plant.

In practice, the choice of crops is not limited to these three. Other crops in Benguet are radish, Chinese cabbage, lettuce, chayote, among others. Farmers also practice multi-cropping to diversify production and price risks. The exercise can aid the farmer on which crop should get the highest allocation of land.

Table 3. Crop choice

Crop	Advantages	Disadvantages
Cabbage	High yield	Low price Susceptible to Frost Susceptible to pests during dry conditions
Carrots	High price Can tolerate cooler temperatures	Lower yields compared to cabbages Susceptible to diseases during wet conditions Labor-intensive

Potatoes	High price Can tolerate dry conditions	Lowest yield compared Susceptible to diseases during wet conditions Difficult to access input materials particularly seeds

Next, the information on estimated yields per climate state are collected. Each crop has a classification depending on the size, quality and color of the crop. There are three classifications for cabbages namely first, second and third class. This depends on the size, weight and color of the cabbage. A first-class cabbage is bigger, heavier and a deeper green color. Meanwhile a third-class cabbage is smaller, has fewer leaves and leaning to white than green. Carrots and potatoes have its own classification as well. For carrots, these are big, small and lumpia, and depends on size, color and shape. Carrots that have forked roots are sold at lower prices. Potatoes have six classifications namely Jumbo, Super XL/XL, Extra, Big, Small and Marble. Like the other crops, size and weight are the factors considered. Bigger and heavier potatoes get higher prices while the opposite is cheaper. If prices are very low, farmers will not sell the cheaper potatoes and use it instead as inputs in future cropping seasons.

When rainfall conditions are favorable to the water requirements of the crop, the proportion of higher quality class is higher. Table 4 shows the estimate yields for cabbages for one ha rain-fed farm. During the wet season, average rainfall state will give the highest yield at 30,000 kg while way below rainfall and way above rainfall provide the lowest yield. Below average rainfall results to lower yields compared to above average rainfall because farmers have limited options to address insufficient water. However, too much water will also result to lowest yield because standing water causes cabbages to melt and rot. During the dry season, way above average rainfall condition is preferred and deemed to produce the highest yield. The yield drops to 10,000 kg if the conditions are very dry or way below average rainfall.

Table 4. Estimate yield in kg for cabbages, by classification, season and amount of rainfall for one cropping season

	Wet season					Dry season				
	way below ave rainfall	below ave rainfall	ave rainfall	above ave rainfall	way above ave rainfall	way below ave rainfall	below ave rainfall	ave rainfall	above ave rainfall	way above ave rainfall
1st class	9,000	14,000	24,000	20,000	8,250	4,000	7,500	17,500	21,000	24,000
2nd class	5,250	5,000	5,400	3,750	5,250	4,000	6,750	6,250	6,440	5,400
3rd class	750	1,000	600	1,250	1,500	2,000	750	1,250	560	600
Total	15,000	20,000	30,000	25,000	15,000	10,000	15,000	25,000	28,000	30,000

Table 5 shows estimate yields for carrots of a one ha rain-fed farm. During the wet season, average rainfall produces the best yield at 20,000 kg while way above average rainfall has the lowest yield at only 7,000. Too much water causes more diseases on carrots resulting to lower yields and poorer quality. In addition, it is difficult for smallholder farmers to address too much water because of the high costs of greenhouses. Like cabbages, the way above average rainfall state on a dry season produces the highest yield at 20,000 kg and best quality.

Table 5. Estimate yield in kg for carrots, by classification, season and amount of rainfall for one cropping season

	Wet season					Dry season				
	way below ave rainfall	below ave rainfall	ave rainfall	above ave rainfall	way above ave rainfall	way below ave rainfall	below ave rainfall	ave rainfall	above ave rainfall	way above ave rainfall
Big	4,800	11,250	15,000	3,500	1,400	2,100	4,000	9,750	12,600	16,000
Medium	4,200	2,250	4,000	6,300	2,800	3,150	4,000	3,000	3,600	3,000
Lumpia	3,000	1,500	1,000	4,200	2,800	1,750	2,000	2,250	1,800	1,000
Total	12,000	15,000	20,000	14,000	7,000	7,000	10,000	15,000	18,000	20,000

Table 6 shows the estimate yields for potatoes of a one ha rain-fed farm. Potatoes have the lowest maximum yield at only 16,000 kg compared to carrots (20,000 kg) and cabbages (30,000 kg). During the wet season, average rainfall state has the best yields. The yield drops to 9,900 as the amount of water increases because of diseases and low water requirement of potato. Like the other crops, way above normal rainfall during the dry season produces the best yield. Even for potatoes that prefer dry conditions, the way below average rainfall during the dry season, results to lowest yield.

Table 6. Estimated yield (in kg) for Potatoes, by classification, season and amount of rainfall, for one cropping season

	Wet season					Dry season				
	way below ave rainfall	below ave rainfall	ave rainfall	above ave rainfall	way above ave rainfall	way below ave rainfall	below ave rainfall	ave rainfall	above ave rainfall	way above ave rainfall
Jumbo	600	2,250	4,000	1,200	100	100	650	1,500	2,700	4,000
Super XL/XL	8,400	11,250	14,000	8,400	800	800	9,100	10,500	13,500	14,000
Extra	1,800	900	1,200	1,200	6,000	6,000	1,950	1,500	1,080	1,200
Big	600	300	400	600	2,000	2,000	650	750	360	400
Small	480	150	200	480	1,000	1,000	520	600	180	200
Marble	120	150	200	120	100	100	130	150	180	200
Total	11,400	12,750	16,000	10,800	9,900	9,900	12,350	13,500	15,300	16,000

Each classification has different prices. The farmers stressed that prices depend on the market and are hard to predict. In general, prices of vegetables increases after a typhoon or heavy monsoon rains. Minimum, mode and maximum prices of the crop, for both the wet and dry season, are collected to compute for gross income. Aside from production risk, farmers are also concerned of price risks due to oversupply and importation of vegetables. There are discussions of crop programming within Atok and among municipalities in Benguet. However, this is not formalized or acted upon. At best, agricultural extension workers provide advice on what to plant but the decision solely lies on the farmer.

Table 7 shows the minimum, mode and maximum price of a kilo of cabbage at the trading post, for wet and dry season that are provided by the respondents. The estimated price is a random number based on triangular distribution of minimum, mode and maximum prices and is used in estimating gross income.

Table 7. Price of cabbages per kilo at the trading post, by season and class of cabbage

	Wet season				Dry season			
Prices	min	mode	max	est price	min	mode	max	est. price
1st class	30	35	40	33	30	35	40	33
2nd class	20	25	30	24	20	25	30	25
3rd class	6	10	15	10	6	10	15	7

Table 8 shows the farm gate price of a kilo of carrots for wet and dry season. Prices during the wet season is higher compared to the dry season. During the wet season, the prices of high quality carrots, big class, are double than the medium class. In contrast, during the dry season, the maximum price of high quality carrots decreases to half and there is little difference in prices of big and medium class.

Table 8. Price of carrots per kilo at the trading post, by season and class of carrot

	Wet season				Dry season			
Prices	min	mode	max	est price	min	mode	max	est. price
Big	30	40	60	36	20	25	30	24
Medium	15	20	30	19	15	20	25	20
Lumpia	5	10	12	6	5	6	7	6

Table 9 shows the farm gate prices of potatoes per kilo. Prices during the wet season are generally higher compared to the dry season. Farmers primarily focus on Jumbo to Extra class because it can be sold at higher prices. When prices are very low, farmers consider storing and using some of the lower potato classes as planting materials instead of selling it to the market.

Table 9 Price of potatoes per kilo at the trading post, by season and class of potato

	Wet season				Dry season			
Prices	min	mode	max	est price	min	mode	max	est. price
Jumbo	30	40	60	44	30	35	40	35
Super XL/XL	20	35	50	44	20	25	30	26
Extra	20	25	30	29	15	20	25	21
Big	15	20	25	21	15	20	25	24
Small	15	20	25	17	15	20	25	21
Marble	15	20	25	18	15	20	25	20

The production costs are computed by listing the farm inputs and labor requirements for both dry and wet cropping season. These are difficult to collect because farmers do not keep financial records. Their narrative of farming practices is used as guidelines in listing production inputs and labor requirements.

Table 10 lists the production costs of cabbage for a one ha rain-fed farm, for wet and dry season. Farmers prefer Scorpio variety over the other varieties such as Rareball and Wonderball

because of its better taste and higher farm gate price. Meanwhile, rareball variety is more suitable for the wet season. During the dry season, farmers spray at closer intervals leading to additional number of sprays to combat pests. In addition, farmers practice cocktail spraying to save on labor costs. However, agricultural extension workers do not recommend cocktail spraying because the impact of the mixture on the crop is unclear. They also recommend stopping spraying a month before harvest to reduce crop residue. Labor costs for harvesting and hauling depend on the yield. The highest yield of 30,000 kg needs 10 pax working for 4 days or 40 mandays. If computed per kilo, this is PHP 0.54/kg. Transportation cost is fixed at PHP 2/kg.

Table 10 Production costs of cabbage for one cropping season, by season

	unit	cost per unit	number of units		amount in PHP	
			wet	dry	wet season	dry season
Est. total cost of seed (Scorpio variety)	25 grams per can	450	25	25	11,250	11,250
Fertilizers	unit	cost per unit	number of units		amount	
			wet	dry	wet	dry
chicken dung	sacks	70	250	250	17,500	17,500
complete 14-14-14	sacks	1200	15	15	18,000	18,000
urea 46 0 0	sacks	1500	10	15	15,000	22,500
Est. total cost of fertilizers					**35,500**	**35,500**
Number of sprays						
wet season number of spray	6	*less spray during the wet season*				
dry season number of spray	12	*more spray because of more pests, spray at closer intervals*				
Chemicals	unit	cost per spray	number of sprays		amount	
			wet	dry	wet	dry
Lorsban	liter	700	6	12	4,200	8,400
Score	500 ml	1500	6	12	9,000	18,000
Kocide	kg	800	6	12	4,800	9,600
Ammate	spray	230	6	12	1,380	2,760
Foliar	kg	230	6	12	1,380	2,760
Est. total cost of chemicals					**20,760**	**41,520**
1 manday =	₱400.00					
			number of mandays		amount	

Labor	unit	cost per unit	wet	dry	wet	dry
Land prep	md	₱400.00	40	40	16,000	16,000
Planting	md	₱400.00	20	20	8,000	8,000
Weeding, Hilling up and fertilizer	md	₱400.00	30	30	12,000	12,000
*Spraying (x 4 separate chemical applications)	md	₱400.00	36	72	57,600	115,200
Fungicide (separate spraying)	md	₱400.00	6	6	14,400	28,800
Harvest	md	₱400.00	30	30		
Est. total cost of labor					**108,000**	**180,000**

Table 11 shows the total production costs of cabbages for one ha rain-fed farm for wet and dry season. Production costs are higher during the dry season because farmers have to spray at closer intervals and assuming they do not practice cocktail spraying. This results to higher labor and chemical costs.

Table 11. Total production costs of cabbage for one cropping season, by season and amount of rainfall

	Wet season					Dry season				
	way below ave	below ave	ave	above ave	way above ave	way below ave	below ave	ave	above ave	way above ave
Yield	15,000	20,000	30,000	25,000	15,000	10,000	15,000	25,000	28,000	30,000
Prod cost	213,510	226,177	251,510	238,843	213,510	293,603	306,270	331,603	339,203	344,270

Table 12 lists the production cost pf carrots for a one ha rain-fed farm. Farmers prefer Terracotta over Chunhong variety. Unlike cabbages, farmers spray more often during the wet season to protect the crop against diseases. Similar to cultivating cabbages, farmers practice cocktail spraying to save on labor costs in spite of the opposite recommendation of agricultural extension workers. Harvest costs depend on the yield. A potential yield of 30,000 kg of carrots for one ha need 40 mandays to harvest. PHP 0.53/kg is the estimate harvest cost per kilo and transportation cost is PHP 2/kg.

Table 12. Production costs of one ha of carrots for one cropping season, by season

	unit	cost per unit	number of units		amount in PHP	
			wet	dry	wet	dry
Est. cost of Terracotta seeds	100 grams per can	700	32	32	**22,400**	**22,400**
Fertilizer	unit	cost per unit	number of units		amount	
			wet	dry	wet	dry
chicken dung	sacks	70	250	250	17,500	17,500

complete 14-14-14	sacks	1,200	15	15	18,000	18,000
urea 46 0 0	sacks	1,500	10	10	15,000	15,000
Est. total cost of fertilizers					**35,500**	**35,500**
wet season number of sprays	12	*more spray to protect from diseases*				
dry season number of sprays	6					
Chemicals	unit	cost per unit	number of units		amount	
			wet	dry	wet	dry
Dithane M-45 fungicide	1.5 kg/pack (3 x16packs for 1 ha at P600 per pack)	28,800	1	1	28,800	28,800
Daconyl	liter	720	12	6	8,640	4,320
Lambda	spray	250	12	6	3,000	1,500
Foliar	spray	230	12	6	2,760	1,380
selective herbicide	kg	2,000	1	1	2,000	2,000
Est. total cost of chemicals					**45,200**	**38,000**
1 manday =	₱400.00					
			number of mandays		amount	
Labor	unit	cost per unit	wet	dry	wet	dry
Land prep	mandays	₱400.00	40	40	16,000	16,000
Planting	mandays	₱400.00	30	30	12,000	12,000
Thinning	mandays	₱400.00	40	40	16,000	16,000
Hilling Up and apply fertilizer	mandays	₱400.00	50	50	20,000	20,000
Spraying x 5 chem	mandays	₱400.00	72	36	144,000	72,000
Harvest	mandays	₱400.00				
Est. total cost of labor					**208,000**	**136,000**

Table 13 shows the estimate production cost of carrots for one cropping season of a one ha rain-fed farm for wet and dry season. Production costs are higher during the wet season because farmers spray more often resulting to higher labor and chemical costs.

Table 13. Estimate total production cost of carrots for a one ha rain-fed farm, by season

	Wet season					Dry season				
	way below ave rainfall	below ave rainfall	ave rainfall	above ave rainfall	way above ave rainfall	way below ave rainfall	below ave rainfall	ave rainfall	above ave rainfall	way above ave rainfall
Yield in kg	12,000	15,000	20,000	14,000	7,000	7,000	10,000	15,000	18,000	20,000
Prod cost	341,500	349,100	361,767	346,567	328,833	249,633	257,233	269,900	277,500	282,567

Table 14 shows the prices of potato seeds by variety and season. The price of local seeds changes on the season. Farmers also mentioned difficulty in buying tubers or input materials, which is not the case for cabbages and potatoes. Imported seeds are also more expensive than local seeds but the imported variety can be used for almost 5 years before changing to another variety. The estimated price is a random number based on triangular distribution of minimum, mode and maximum prices and used in estimating the production cost.

Table 14. Price of potato seeds, by variety and season

Seeds	unit	number of units per ha	Price of seed per unit							
			Wet season				Dry season			
			min	mode	max	est. price	min	mode	max	est. price
Igorota, Granola	kg	1,500	40	50	70	67	30	40	50	38
Granola imported	kg	1,500	90	100	120	110	90	100	120	103

Table 15 lists the production costs of potatoes for one cropping season of a one ha rain-fed farm for dry and wet season. Compared to cabbages and carrots, the prices of input materials of potatoes are the most expensive and changes depending on the season. Production costs are higher during the wet season because spraying is done at closer intervals to protect from diseases. The higher number of spraying leads to increase in chemical and labor costs. Similar to cabbage and carrots, cocktail spraying is practiced by the farmers in spite of the opposite recommendation of the agricultural extension workers. Hauling cost is PHP 0.48/kg based on 30 mandays at PHP 400 per manday to haul 30,000 kg of potatoes.

Table 15. Estimate production costs of potatoes for once cropping season of a one ha rain-fed farm, by season

			number of units		amount	
			wet	dry	wet	dry
Est. total cost of seed	**Igorota, Granola**		1,500	1,500	**100,500**	**57,000**
Fertilizer	unit	cost per unit	number of units		amount	
			wet	dry	wet	dry
chicken dung	sacks	70	250	250	17,500	17,500
complete 14-14-14	sacks	1200	15	15	18,000	18,000
Est. total cost of fertilizers					**35,500**	**35,500**
Lime	sacks	300	15	15	4,500	4,500
wet season number of spray	12	*more spray, spray at closer intervals to protect from diseases*				
dry season number of spray	6	*less spray*				
Chemicals	unit	cost per unit	number of units		amount	
			wet	dry	wet	dry
Curzate	kg	700	12	6	8,400	4,200
Daconyl	liter	720	12	6	8,640	4,320
Lambda	spray	250	12	6	3,000	1,500
Foliar (dry season only)	spray	230		6	-	1,380
Ridomil	spray	230	12		2,760	-
Sticker (wet season only)	spray		12		-	-
Est. total cost of chemicals					**22,800**	**11,400**
1 manday =	₱400.00					
			number of mandays		amount	
Labor	unit	cost per unit	wet	dry	wet	dry
Land prep	mandays	₱400.00	40	40	16,000	16,000
Planting	mandays	₱400.00	20	20	8,000	8,000
Weeding	mandays	₱400.00	30	30	12,000	12,000
Hilling Up and apply fertilizer	mandays	₱400.00	30	30	12,000	12,000
*Spraying (x5 chemical applications)	mandays	₱400.00	72	36	144,000	72,000
Harvest	mandays	₱400.00	30	30	12,000	12,000
Hauling	mandays	₱400.00	30	30		
Est. total cost of labor					**204,000**	**132,000**

Table 16 shows the estimate production costs of potatoes for one ha rain-fed farm. Production costs in the wet season are because of high price of tubers and higher chemical and labor expenses due to spraying at closer intervals.

	Wet					Dry				
	way below ave	below ave	ave	above ave	way above ave	way below ave	below ave	ave	above ave	way above ave
Yield in kg	12,000	15,000	20,000	12,000	10,000	10,000	13,000	15,000	18,000	20,000
Prod cost	397,060	404,500	416,900	397,060	392,100	265,200	272,640	277,600	285,040	290,000

Table 16. Estimate total production cost of potatoes for one ha rain-fed farm, by season

	Wet					Dry				
	way below ave	below ave	ave	above ave	way above ave	way below ave	below ave	ave	above ave	way above ave
Yield in kg	12,000	15,000	20,000	12,000	10,000	10,000	13,000	15,000	18,000	20,000
Prod cost	397,060	404,500	416,900	397,060	392,100	265,200	272,640	277,600	285,040	290,000

A farmer is facing the decision on what to plant on the next cropping season or which crop will get the highest allocation. Among the three, cabbage has the highest gross margin in both wet and dry season. Higher yields of cabbage compensate its relatively lower price. Moreover, during the wet season, cabbages are cheaper to produce because of lower labor costs due to less spraying. During the dry season, cabbages are more expensive to produce because of higher labor costs from more spraying but the higher yields can compensate the extra costs.

In practice, farmers practice crop rotation to maintain the quality of soil and lessen the probability of pests and diseases. For example, if cabbages are planted the previous cropping season, then cabbages will not be planted in the next cropping season.

Figure 1 shows the crop choice decision between cabbages and carrots during the dry season. Cabbages are preferred across all rainfall states. Cabbages have higher gross margins from its relatively higher yields and lower production costs.

Figure 1. Crop choice between cabbage and carrots, wet season, of a one ha rain-fed farm

Figure 2 shows the crop choice between cabbage and carrots during the wet season. Similar to Figure 1, cabbages are preferred across all climatic states because cabbages have higher gross margins. The production costs of cabbages is higher during the dry season than the wet season because farmers spray at closer intervals to protect against pests. Cabbages also have higher yields compared to carrots which contribute to its high gross income.

Figure 2. Crop choice between cabbage and carrots, dry season, of a one ha rain-fed farm

Figure 3 shows the crop choice decision between cabbage and potato for the wet season. Cabbages have higher yields across all rainfall states, which contribute to its higher gross income and gross margins. Moreover, cabbages have lower productions costs because of cheaper input materials and less spraying compared to potatoes.

Figure 3. Crop choice between cabbage and potatoes, wet season, of a one ha rain-fed farm

Figure 4 shows the crop choice decision between cabbage and potato during the dry season. Again, cabbages have higher yields across all rainfall states, which results to high gross income. However, production costs of cabbages are higher because farmers spray at closer intervals while potatoes have lower production costs from less spraying. Overall, cabbages have higher gross margins and is preferred over potatoes during the dry season.

Figure 4. Crop choice between cabbage and potatoes, dry season, of a one ha rain-fed farm

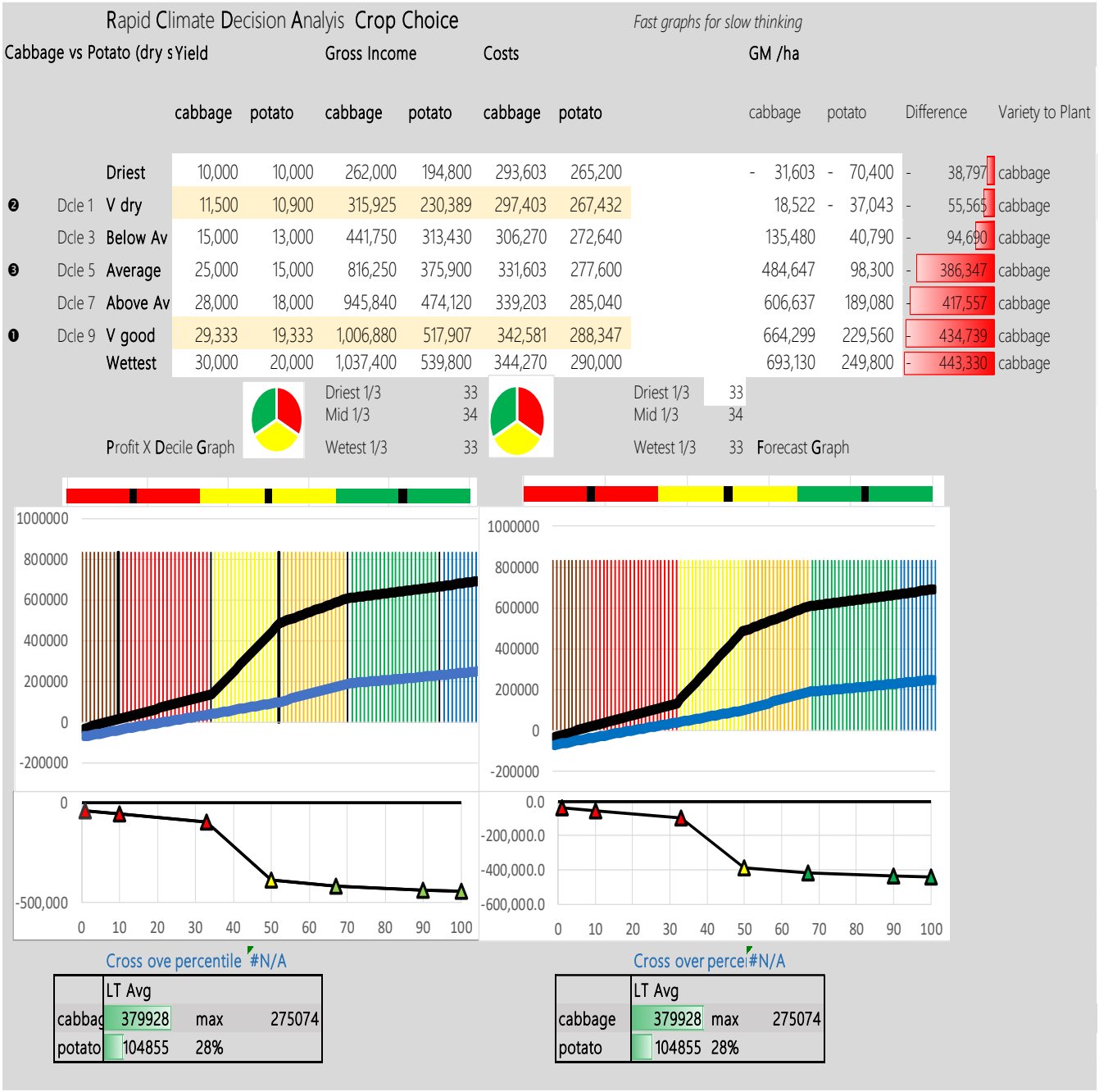


Figure 5 shows the crop choice decision between carrots and potatoes during the wet season. Both crops have the same yields from driest to average rainfall states. Carrots have lowest yields when the amount of rainfall is wettest. However, gross income from carrots is higher as most of it are sold at higher prices. Production costs are also higher for potatoes because of its expensive input materials. Both crops have higher spraying costs during the wet season because farmers spray at closer intervals to protect it from diseases. In the wet season, carrots is preferred over potatoes across all states of rainfall.

Figure 5. Crop choice between carrots and potatoes, wet season, of a one ha rain-fed farm

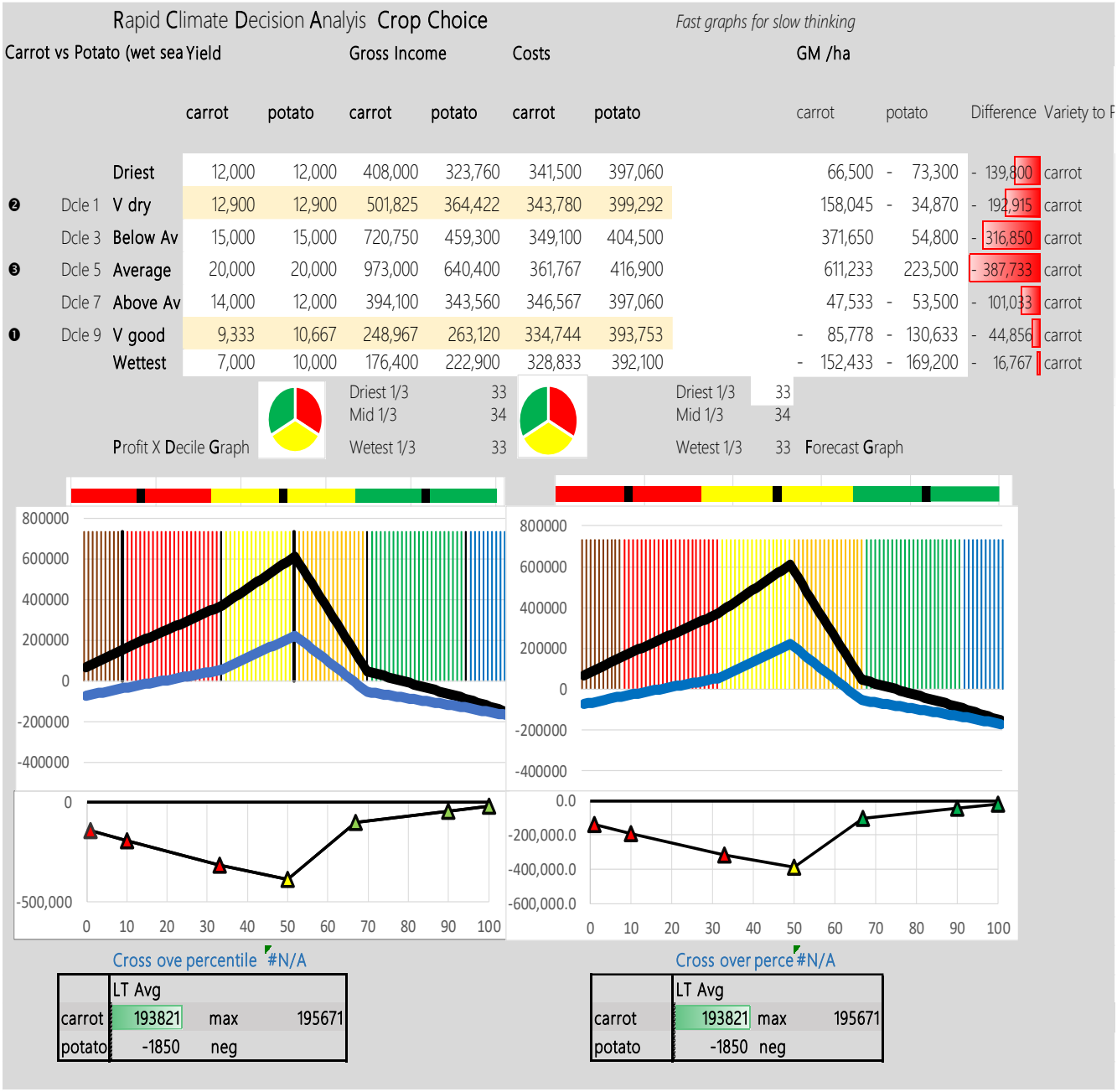
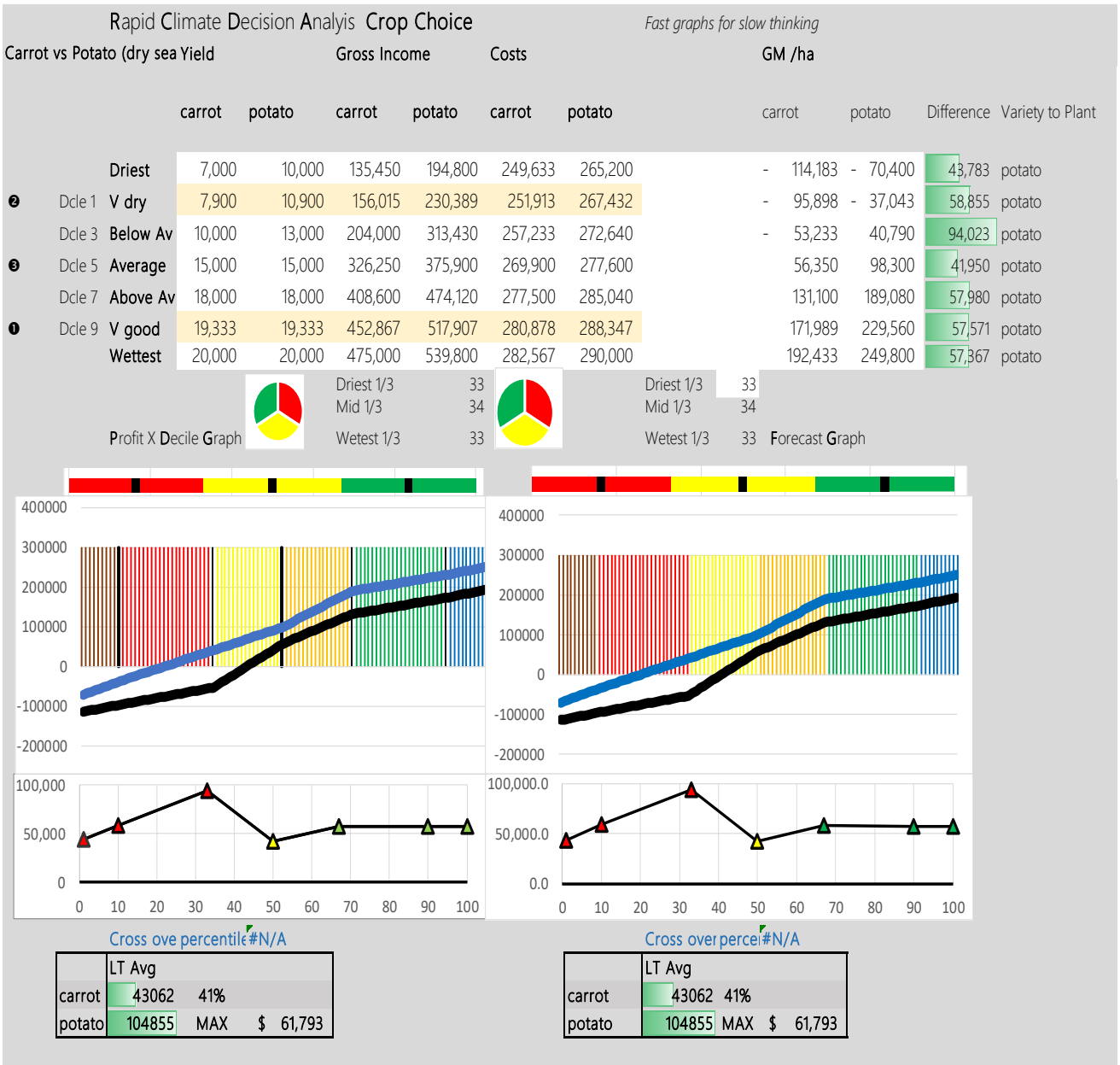


Figure 6 shows the crop choice decision between carrots and potatoes during the dry season. Gross income from potatoes is higher because it is sold at higher prices. Production costs decreased for both crops because of less spraying. During the dry season, potatoes are preferred over carrots across all states of rainfall.

Figure 6. Crop choice between carrots and potatoes, dry season, of a one ha rain-fed farm



Supplemental irrigation

As discussed, rainfall is an important factor in cultivating vegetables in Atok, Benguet. Rain-fed farms have one to two cropping periods in a year. The first cropping period begins in March and harvests around June. Meanwhile the second -cropping period is from September and ends around December in time for the higher demand for vegetables during the holiday season. Farmers avoid planting or harvesting in June, July and August because of the typhoons. If a farm has supplemental irrigation, the number of possible cropping periods increase to three and allows the farmer to plant anytime.

The sources of water for supplemental irrigation such as rivers are also dependent to rainfall as source of water. Hence, if there is low rainfall, the sources of supplemental irrigation most likely also have low amount of water. Other factors also determine if a farm can have supplemental irrigation such as the size and availability of water storage, farm size, farm location, distance of the farm from the source of water and terrain of the farm. It also needs pumps tailored to highland farm conditions. Buying water from the lowland and transporting it to Atok are tedious and will entail additional costs for farmers because of the distance from Atok to the lowlands and the poor road conditions. These factors make it very difficult for farmers to have full irrigation.

The farmers estimate that the total cost of supplemental irrigation is PHP 50,000, which includes the cost of pump, sprinklers and hose that are good for three years. The additional expense in operating the pump is fuel only because the sources of water like rivers are free. The additional yield brought by supplemental irrigation is difficult to estimate for the farmers. Hence, in this exercise, the assumption is supplemental irrigation can support the water requirements of the crop to reach highest possible yield.

Figure 7 shows the result of whether a farmer planting cabbage during the wet season should invest in supplemental irrigation. If with supplemental irrigation, the farmer will reach the maximum yield even if rainfall condition is insufficient to support the growth of the crop. If the amount of rainfall is more than the amount needed by the crop, the yield with supplemental irrigation is the same as the yield without supplemental irrigation.

Without the forecast, the farmer will invest in supplemental irrigation. With forecast, the platform shows that the farmer should invest in supplemental irrigation only if rainfall condition is below average to driest. The higher yields can cover the additional expense of supplemental irrigation. On the other hand, if rainfall condition is average to wettest, the yield of with and without supplemental irrigation are the same but there is an additional expense from installing supplemental irrigation. Hence, it is better if the farmer not install supplemental irrigation if rainfall is average to wettest condition.

Figure 7. Decision to invest in supplemental irrigation for cabbages during the wet season

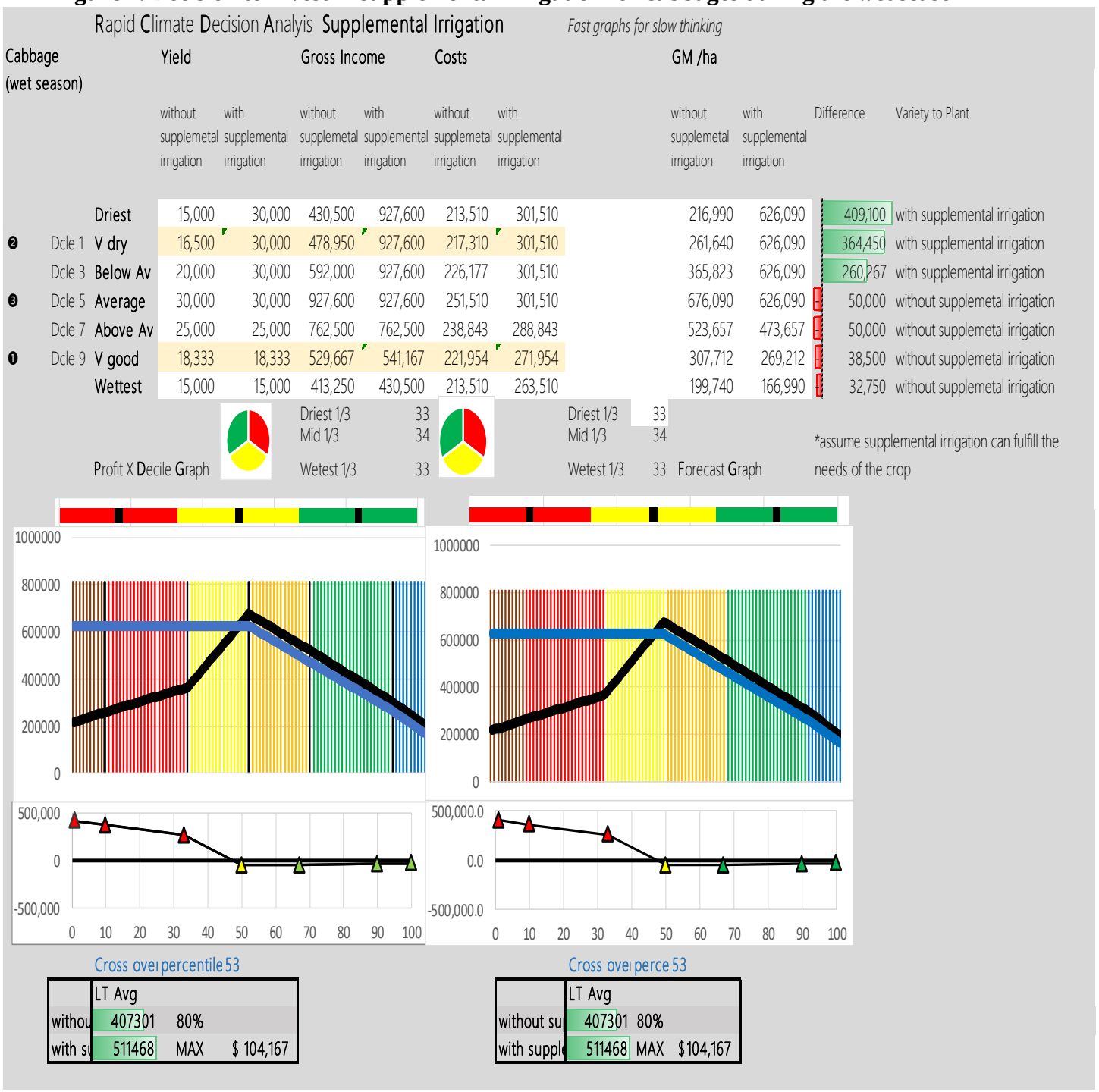


Figure 8 shows the decision if a cabbage farmer should invest in supplemental irrigation during dry season. With supplemental irrigation, the yield increases to 30,000 kg. Supplemental irrigation pays only if above average rainfall state to drier states during the dry season.

Figure 8. Decision to invest in supplemental irrigation for cabbages during the dry season

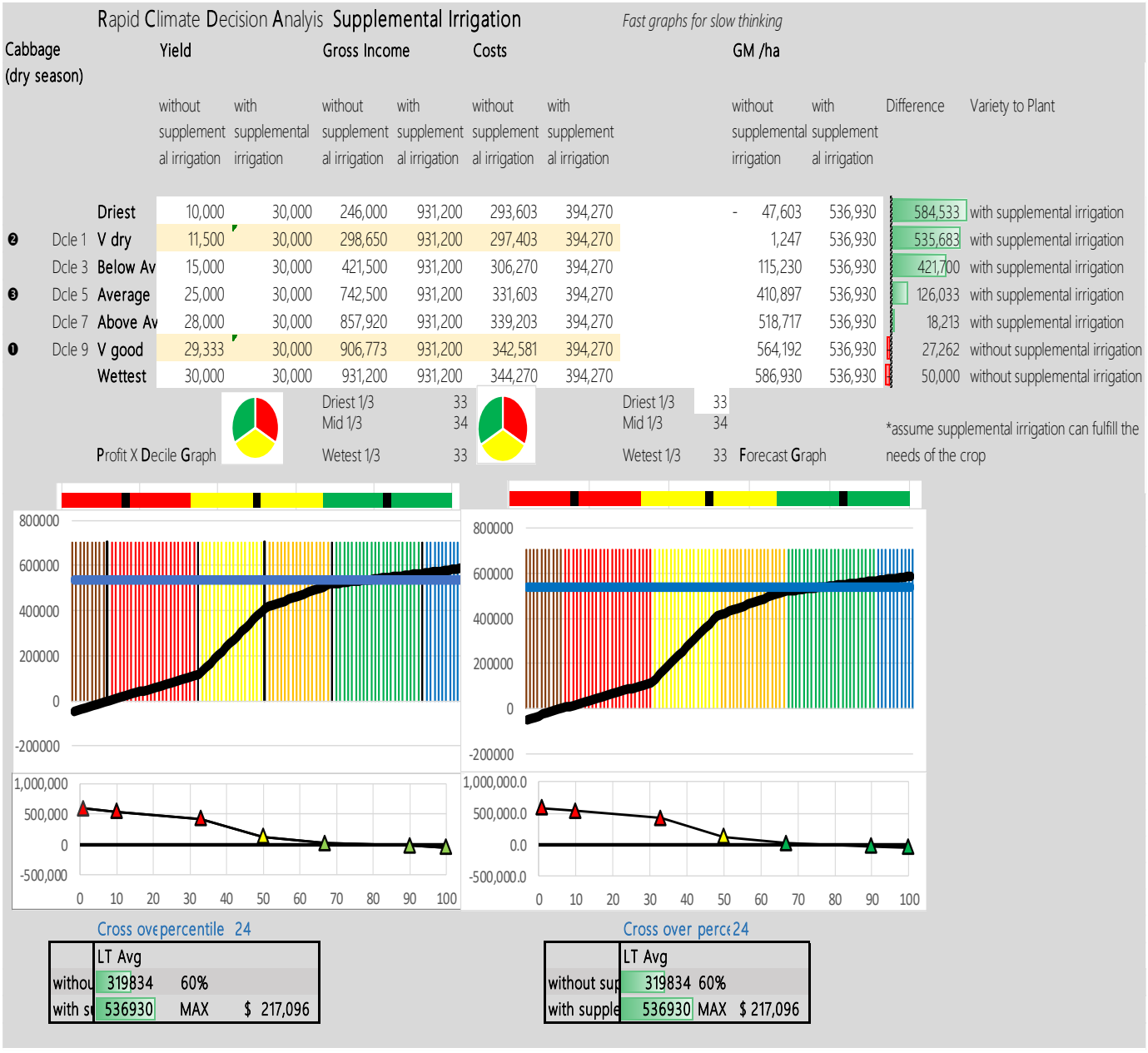


Figure 9 shows if a farmer cultivating potatoes on a one hectare rain-fed farm should invest in supplemental irrigation during the wet season. The highest yield for potatoes without supplemental irrigation during the wet season is 20,000 kg if it is average rainfall state. Since farmers find it difficult to estimate the additional yields due to supplemental irrigation, the assumption is supplemental irrigation can support the water requirements of the crop. If the farmer invests in supplemental irrigation, the yield increases to 20,000 kg for below average rainfall or drier states while yields for above average rainfall and wettest states remain the same. Without forecast, the farmer will invest in supplemental irrigation. With forecast, the

farmer will invest in supplemental irrigation during the wet season if rainfall is below average to driest state. The income from the additional yield can cover the extra costs from supplemental irrigation. If rainfall is average to wettest state, farmers are better off without supplemental irrigation because there are no additional yields but have to incur the cost of supplemental irrigation

Figure 9. Decision to invest in supplemental irrigation for potatoes during the wet season

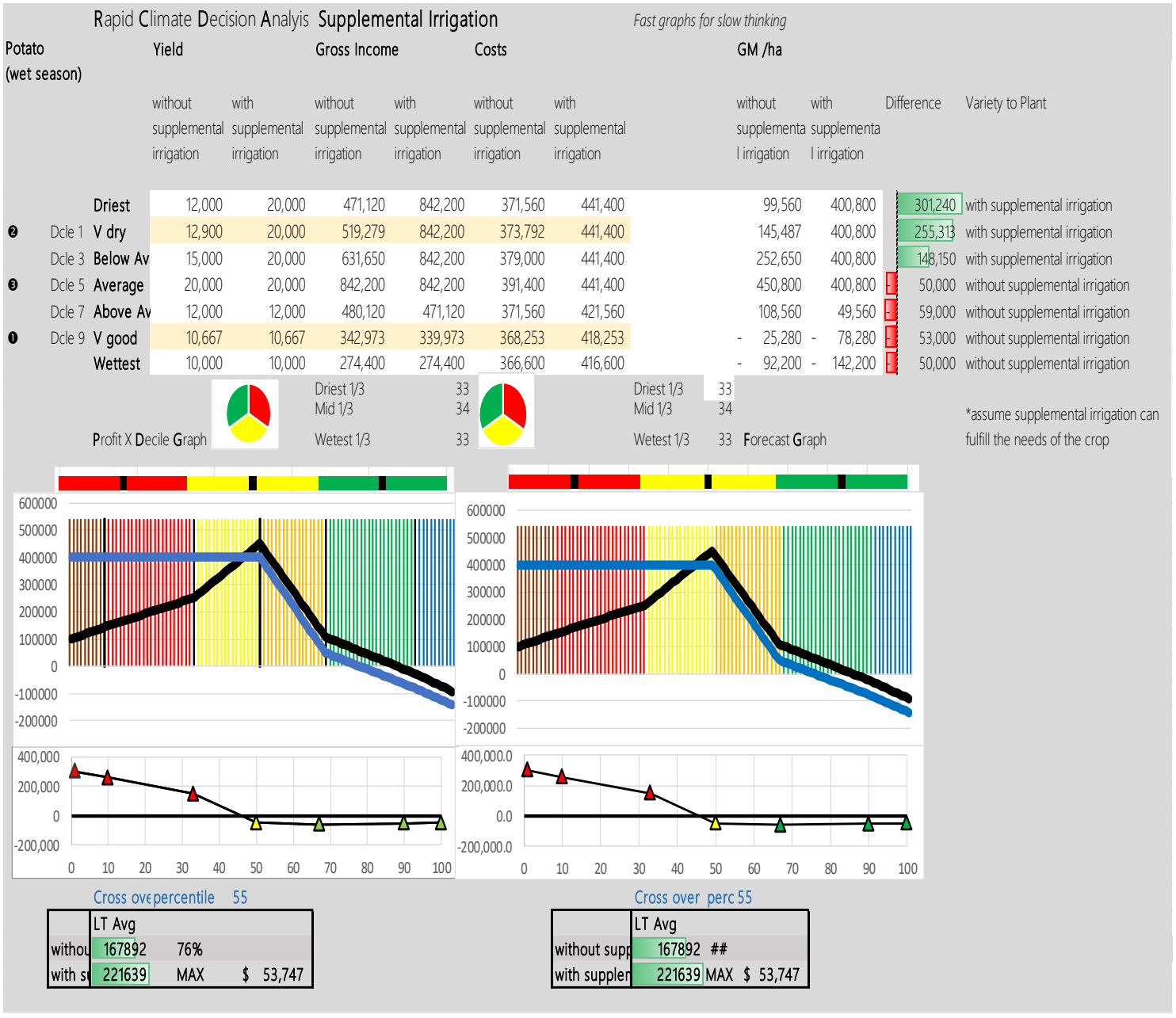


Figure 10 shows the decision to invest in supplemental irrigation during the dry season for one-hectare rain-fed potato farm. Wettest rainfall state has the highest yield of 20,000 kg if without supplemental irrigation. If the farmer invests in supplemental irrigation, the yield increases to 20,000 kg assuming it can support the water requirements of the crop. With forecast, the farmer will invest in supplemental irrigation if rainfall is above average rainfall to driest state. The increase in yields can pay for the additional costs of supplemental irrigation and have higher gross margins compared to not investing in supplemental irrigation.

Figure 10. Decision to invest in supplemental irrigation for potatoes during the dry season

Figure 11 shows the decision to invest in supplemental irrigation for a one-hectare rain-fed farm cultivating carrots during the wet season. Similar to the other crops, average rainfall state has the highest yield of 20,000 kg. It is assumed that supplementary irrigation can support the water requirements of the crop so the yield increases to 20,000 kg if rainfall is below average to driest state with supplementary irrigation. Without forecast, the farmer will invest in supplementary irrigation. With forecast, the farmer is better off to invest in supplementary irrigation only if rainfall is below average rainfall to driest state.

Figure 11. Decision to invest in supplemental irrigation for carrots during the wet season

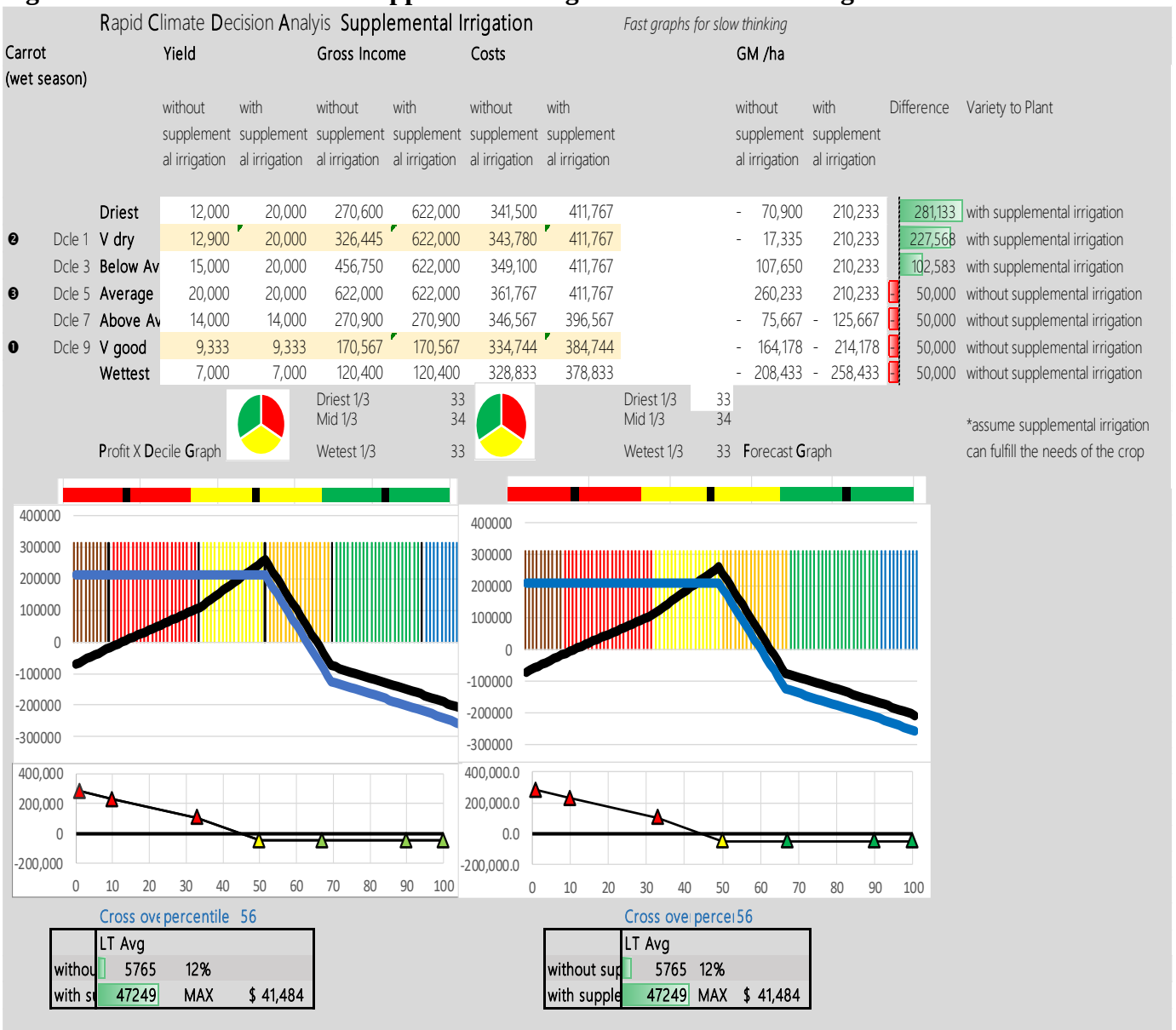
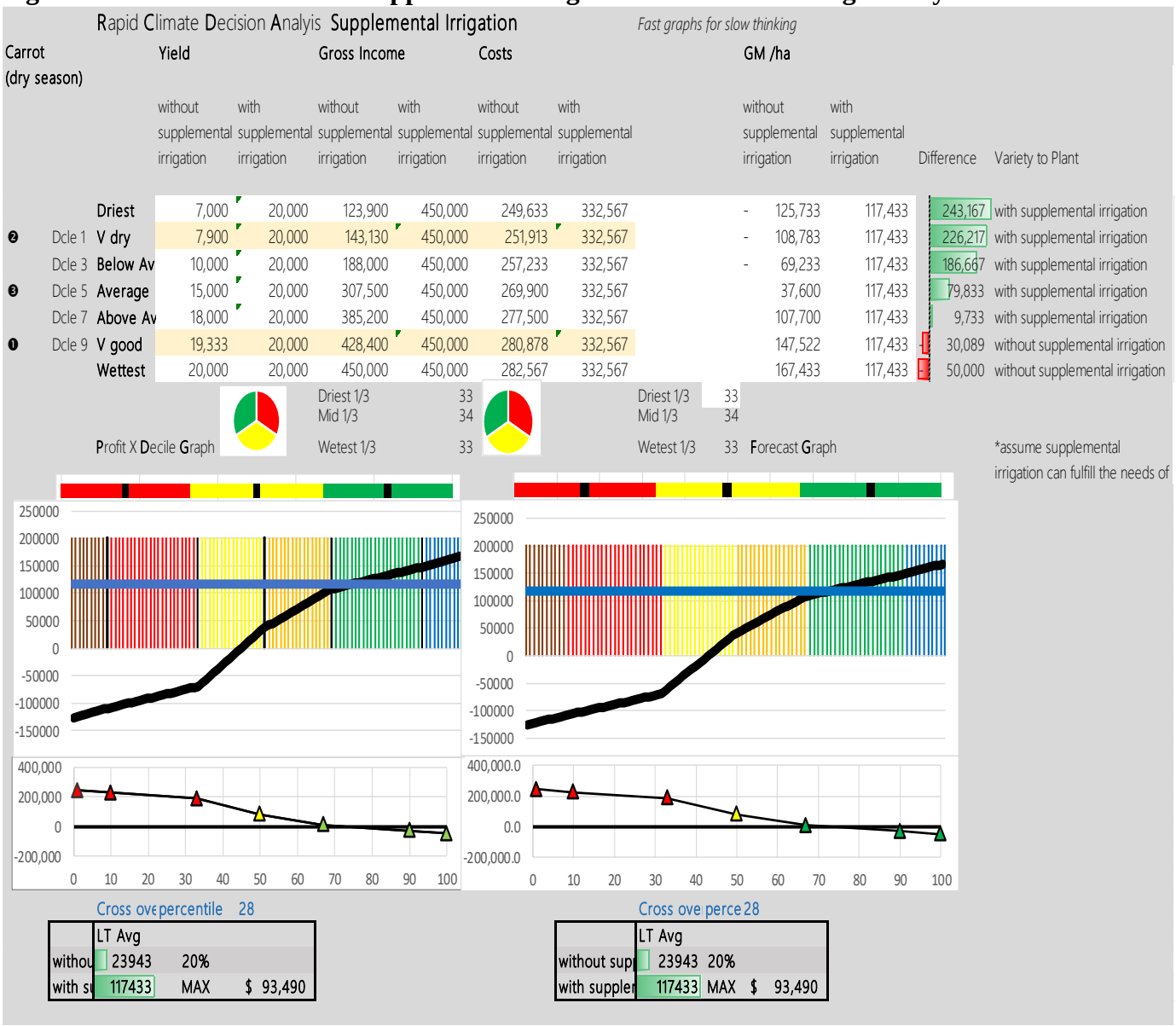


Figure 12 shows the decision to invest in supplemental irrigation for a one hectare rain-fed farm cultivating carrots during the dry season. Similar to the other crops, wettest rainfall state has the highest yield of 20,000 kg. It is assumed that supplementary irrigation can support the water requirements of the crop so the yield increases to 20,000 kg if rainfall is below wettest rainfall state with supplementary irrigation. Without forecast, the farmer will invest in supplementary irrigation. With forecast, the farmer is better off to invest in supplementary irrigation only if rainfall is above average to driest state.

Figure 12. Decision to invest in supplemental irrigation for carrots during the dry season



Planting decision

Aside from seasonal rainfall forecast, other aspects of rainfall affect cultivation of vegetables in Atok. The onset of rainfall influences when farmers start planting. During the wet season. farmers begin planting or transplanting in March. If a farmer plants and the onset of rainfall is late, the crop will not grow because of insufficient water. On the other hand, if a farmer delays planting and wait for the onset of rainfall until May, the farmer will not have to do supplemental irrigation. Instead, farmers will spray at closer intervals to boost the growth of the crop and make it suitable, at least, for harvest before the occurrence of typhoons or heavy rainfall.

Delaying planting results to a longer cropping period and the farmer risks possible loss or decrease in yields brought upon by typhoons and heavy monsoon rains in July and August. Alternatively, if typhoons and monsoon rains not affect the farm, the farmer will benefit from the high prices. Farmers are aware of these risks and consequences and would often mention that farming is a gamble.

Figure 13 to Figure 15 show the results of the RCDA runs if a farmer delays planting during the wet season and assuming that the farmer is not affected by typhoons or monsoon rains. In Figure 13, if a farmer plants cabbages as usual and there is delay in the onset of rainfall, the yield for cabbages is lowest at only 15,000. The inadequate amount of water during this stage can cause seeds to die and not sprout, assuming the farmer did not implement supplementary irrigation and remain completely rain-fed. If the farmer delays planting, the yield depends on the amount of rainfall, assuming the farm is unaffected by typhoons or heavy monsoon rains. In addition, the farmer has to spend additional chemical and labor costs from spraying at closer intervals. In this scenario, the farmer should delay planting if the rainfall state is between very dry to very good rainfall. If at the driest or wettest states, the farmer is better off planting as usual as the delay in planting results to no extra yields but with additional costs from spraying.

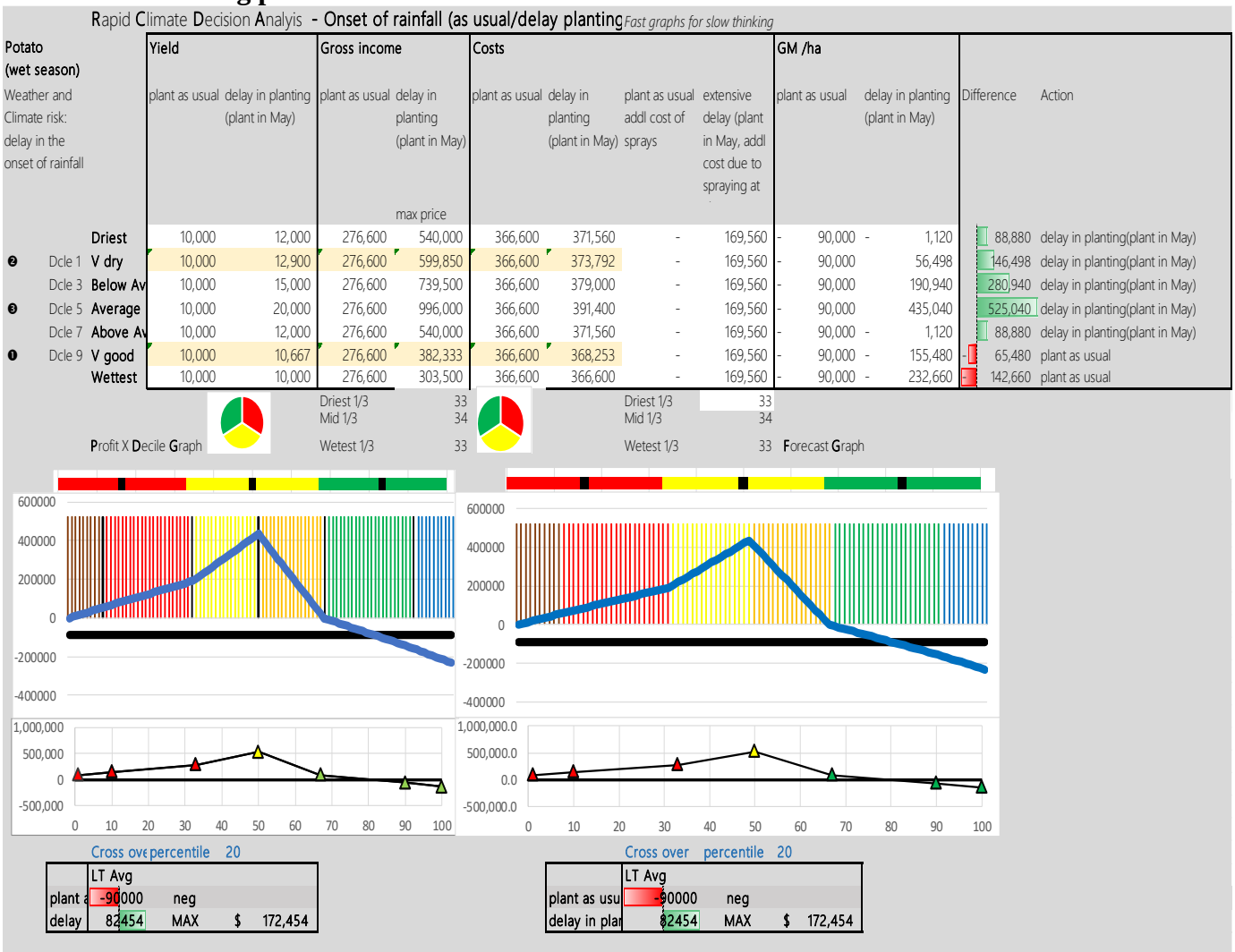
Figure 13. Decision to delay planting during the wet season of a one ha rain-fed farm cultivating cabbages

In Figure 14, if a farmer plants carrots as usual schedule and there is delay in the onset of rainfall, the yield for carrots is lowest at only 7,000. Similar to cabbages, carrot seeds will not develop if water is insufficient at early stages of growth. If the farmer delays planting, the yield will depend on the amount of rainfall, assuming typhoons or heavy monsoon rains did not destroy the crops. Moreover, the farmer will have to spray at closer intervals so there is extra costs in spraying. In this example, the farmer should delay planting if the rainfall state is between driest to above average rainfall.

Figure 14. Decision to delay planting during the wet season of a one ha rain-fed farm cultivating carrots

Figure 15 shows if a farmer should plant potatoes as usual schedule or delay planting if there is delay in the onset of rainfall during the wet season. If a farmer plants as usual schedule and there is delay in the onset of rainfall, the yield for potatoes is lowest at only 10,000. Similar to cabbages and carrots, potato tubers will not mature if water is insufficient at early stages of growth. If the farmer delays planting, the yield will depend on the amount of rainfall, assuming typhoons or heavy monsoon rains did not destroy the crops particularly during harvest. The farmer will have to spray at closer intervals like in the previous examples to support the growth of the crop. This brings additional costs in spraying from chemical and extra labor. In this instance, the farmer should delay planting if the rainfall state is between driest to above average rainfall.

Figure 15. Decision to delay planting during the wet season of a one ha rain-fed farm cultivating potatoes



In practice, farmers do supplemental irrigation by buying water in drums to water their crops if they planted as usual and the onset of rainfall is late. However, this is costly for farmers because alternative sources of water in Atok is scarce and dependent on rainfall. It is also expensive to buy water in the lowlands and transport it to Atok.

Figure 16 to Figure 18 show the results of the RCDA runs if a farmer delays planting during the wet season. However, in these examples, it assumes that typhoons or heavy monsoon rains have destroyed the crops and the farmer did not harvest early. If the farmer plants as usual, the yields depend on the amount of rainfall during the wet season. Yields do not decrease because by planting as usual schedule, the farmer is able to harvest before typhoons or heavy monsoon rains occur in July or August.

Meanwhile, if the farmer decides to delay planting and plant in May, typhoons or heavy monsoon rains might destroy the crops so yields are at its lowest for delay planting. In these settings, the farmer is better off to plant as usual because of higher yields and at the same time farmer does not incur additional costs from spraying.

Figure 16. Decision to delay planting during the wet season for a one ha rain-fed farm cultivating cabbage

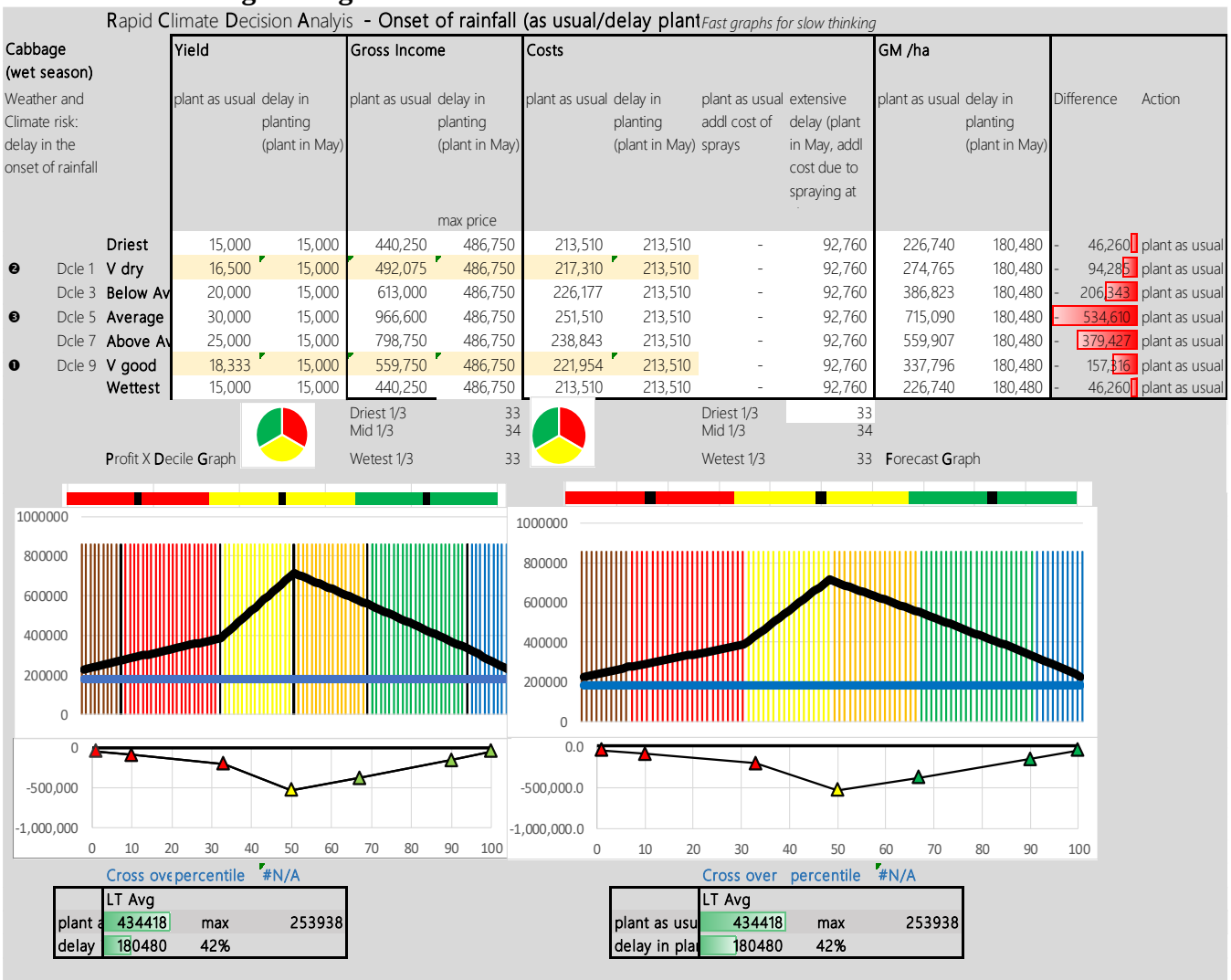
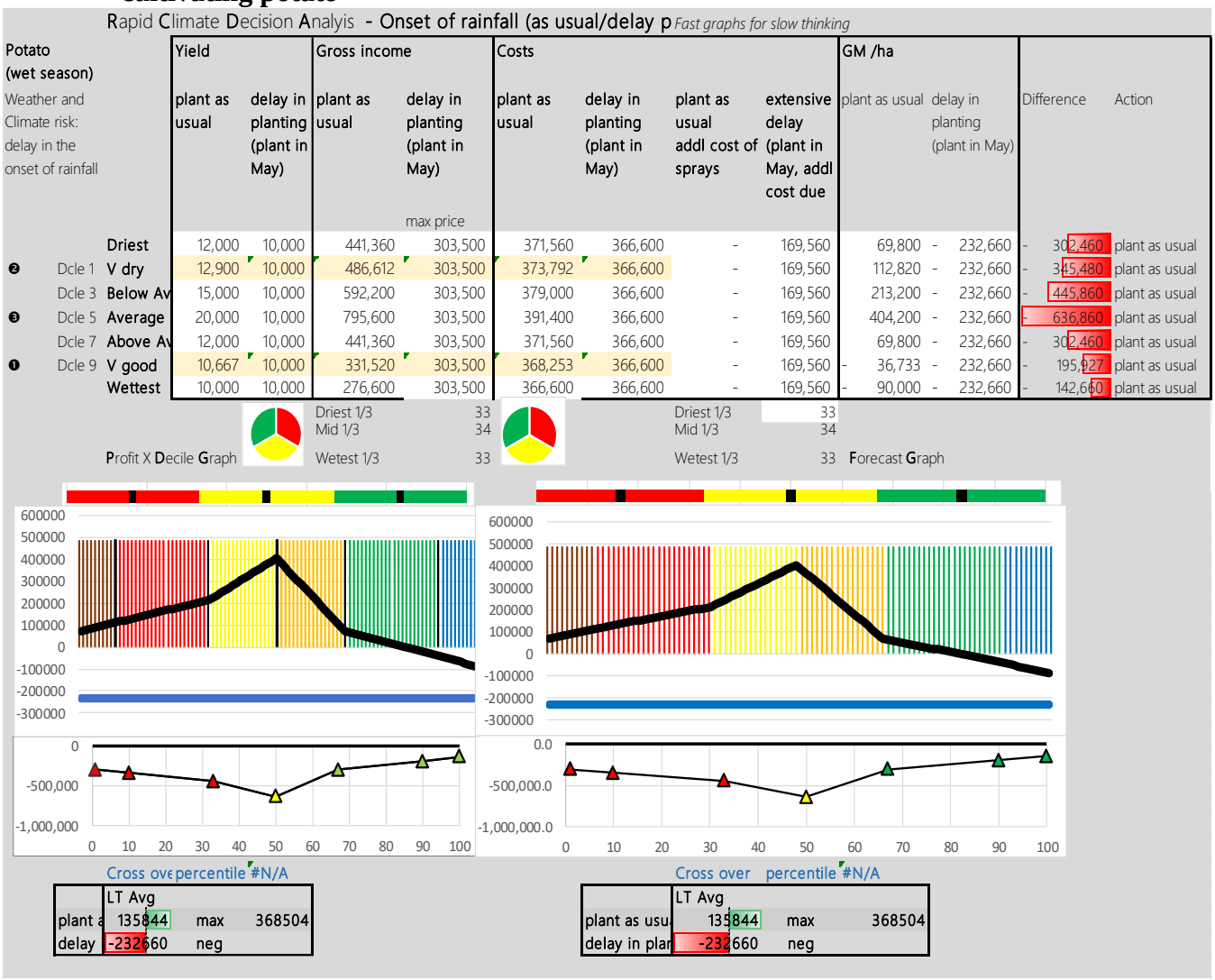


Figure 17. Decision to delay planting during the wet season for a one ha rain-fed farm cultivating carrot

Figure 18. Decision to delay planting during the wet season for a one ha rain-fed farm cultivating potato



Preliminary comments on collecting information for RCDA

Rainfall is the most important climate factor in cultivating vegetables in Atok. The RCDA tool requires information based on states of rainfall such as near normal, above normal, below normal etc. It is possible that the understanding of the farmers does not necessarily match the definition of PAGASA since farmers do not scientifically measure rainfall. The farmers' descriptions of rainfall revolve on how often it occurs in a period. Description of rainfall intensity like heavy rainfall, light rainfall or moderate rainfall are subjective and depends on personal experience. Having a common description aside from numbers might be useful in building a common understanding. There are also initiatives in PAGASA toward impact based forecasting.

The estimates for yields per climatic state are also difficult to collect as well as production costs. Most farmers do not keep records and rely on recall. A template can be useful in starting the discussions such as production costs. In addition, for the agricultural extension workers and farmers, having beyond three climatic states are a relatively new concept.

The actual RCDA excel platform has not been shown yet to the farmers, agricultural extension workers and change agents. Next steps for the project team are to revalidate, introduce the platform and simulate how changes in the forecasts affect the decisions, as well as linking the PAGASA products useful in making the decision, to the farmers, agricultural extension workers and other change agents involved in smallholder farming.

The tool also allows the end-user to change the climatic odds of a dry, near normal and wet season as well as the yields, prices and production costs. This will ultimately change the results shown in this exercise.

Conclusion

Access to weather and climate forecasts can help farmers enact adaptation strategies to protect themselves against adverse impacts of climate variability. Timely, relevant and reliable forecasts are needed. PAGASA has a wide range of products available to the public. However, there is a gap between available weather and climate information and what users find useful. RCDA hopes to contribute in bridging this gap. It is a decision tool that considers uncertainty in forecasts and incorporates it into decision-making. Rainfall is the most important weather and climate risk in Atok because most farms are rain-fed and with limited sources for supplemental irrigation. Among various farm decisions, three climate sensitive decisions are explored namely crop choice, investment in supplemental irrigation and beginning of planting date. Results of RCDA tool depends on the end-user and such methodology allows for fast simulations without investing in long-term empirical research. The tool is still being fine-tuned to make it more appropriate and user-friendly to end-users such as farmers, agricultural extension workers and other change agents involved in smallholder farming.

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