"Decision-making" in the Anthropocene: adaptation, coffee growers and climate change in South India

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In this paper I discuss three perspectives, which in certain distinct ways explain the implications of monsoonal rainfall in the coffee growing belt of the Western Ghats (South India). The perspectives are made of a range of quantitative and qualitative perceptions generated by a) the coffee growers; b) the insurance group specifically Agriculture Insurance Company of India (AICI) and c) Meteorological organizations such as the Indian Meteorological Department (IMD) and the Karnataka State Natural Disaster Management Cell (KSNDMC).

In thus pointing out that distinct and often sharply different narratives explain the problem of monsoonal rainfall in South India, I aim to make a strong case for 'bottom-up' decision-making with regard to climate change adaptation strategies. That is , in contrast to the top-down expert defined and expert led policies that currently make up the literature on climate adaptation strategies, I argue that varied knowledges and local complexity urge for a strong reconsideration for bottom up adaptation strategies.

Field work for this study was carried out over a period seven months spread across 2011 to 2015. In total 4 coffee growing districts in 2 south Indian states (Karnataka and Tamil Nadu) were visited. Detailed interviews with 78 coffee growers were carried out. 65 more growers responded to a set of written questionnaires which was circulated through planters' association offices, association souvenirs, regional planters' magazine and an online blog. States and district visited: Hassan, Chikmagalur and Coorg in Karnataka and Palini (Dindigul district) in Tamil Nadu. Seven month long field work was carried in four visits. In the last visit, along with interviewing planters numerous presentations were made at different association gatherings to receive growers' feedback on the work.

Given the nature of my enquiries this study is largely ethnographic in orientation, with the qualitative approach being broadly influenced by perspective of interpretivism in the social sciences. In the interpretive tradition it is accepted that human societies cannot be studied in the same way as natural sciences. Qualitative interviews are an opportunity to delve and explore precisely those subjective meanings that positivists seek to strip away in their search of standardization.[1]

The ethnographic study was carried through focused interviews after a small period was spent as participant observer to get sensitized with the settings. Initial forays in the region were made through the good offices of the Hassan District Planters Association members (HDPA), Karnataka Growers Federation (KGF) and through the Bangalore based NGO Centre for Social Market (CSM).

Irrigation and Insurance

In south Indian coffee plantations insurance and irrigation both deal with the same issue: the issue of failed rainfall. A 1974 article in Indian Coffee Magazine reviews the use of artificial irrigation in Indian coffee plantations and argues that it can also serve as an insurance against crop losses.[2] This article

[1] Karen O' Reilly, *Ethnographic Methods* (New York: Routledge,2005), 114.
[2] S.R. Gopalan (1974), A Review of Irrigation in Coffee, *Indian Coffee,* p.46.

was written much before the Rainfall Insurance scheme was introduced for coffee growers.[3] The attempt to promote irrigation as an insurance against failure of crop was carried out in a very different time from today when together with an insurance scheme Coffee Board of India also provides subsidy to small growers for installing irrigation system. How does irrigation insure against failure of crop?

Dr. Chandra Gupt Anand, Divisional Head, Plant Physiology, Central Coffee Research Institute (CCRI) explained the effects of delayed or inadequate blossom shower[4] on the coffee plants:

> Coffee is a perennial plant with an annual bearing habit. The flower buds having been initiated by about August- September grow rather slowly and attain a size of 7 -8 mm by February and stop growing further. Rain or overhead irrigation at this stage induces anthesis[5] of buds which open usually within 8-10 days. Successful blossom will be obtained with about 13mm for Robusta and 25.4 mm for Arabica, depending upon overhead shade. Prolonged drought and inadequate showers provoke retardation of growth and production of star and snake mouthed flowers.[6]

Picture1: Deformed star mouthed coffee flowers. The deformation is a result of inadequate blossom shower. These deformed flowers do not pollinate and hence result in loss of crop.
Source: Central Coffee Research Institute

Picture 2: Deformed snake mouthed coffee flowers. The deformation is a result of inadequate blossom shower. These deformed flowers do not pollinate and hence result in loss of crop.

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[3] Rainfall Insurance Scheme for Coffee Growers (RISC) was introduced in the year 2007-2008.
[4] Blossom shower is the first rainfall of the crop season which is received between 1st March to 15th April for Robusta and 1st March to 30th April for Arabica for the bud to flower.
Arabica (*Coffea arabica*) and Robusta (*Coffea canephora*) are two varieties of coffee grown in India.
Backing showers are the rainfall that are received from 18th day of the starting of blossom shower till 40th day to achieve full fruit development & retention.
[5] Anthesis refers to flowering period of a plant, from the opening of the flower bud.
[6]Dr.Chandra Gupt Anand, Divisional Head, Plant Physiology, Central Coffee Research Institute (CCRI), Interviewed on 12/2/15, 5.00pm at his office in CCRI Balehonnur.

Source: Central Coffee Research Institute

In case of inadequate or delayed blossom showers overhead irrigation either supplement natural showers or independently result in successful blossom and crop set, thus avoiding crop losses by way of pinking, pedding and drying up of buds. Prolonged drought after blossom shower results in poor development of berries and thus poor harvest. It is here that overhead irrigation serves to check the vagaries of inadequate or delayed blossom showers/ backing showers thus serving as an insurance against heavy loss.

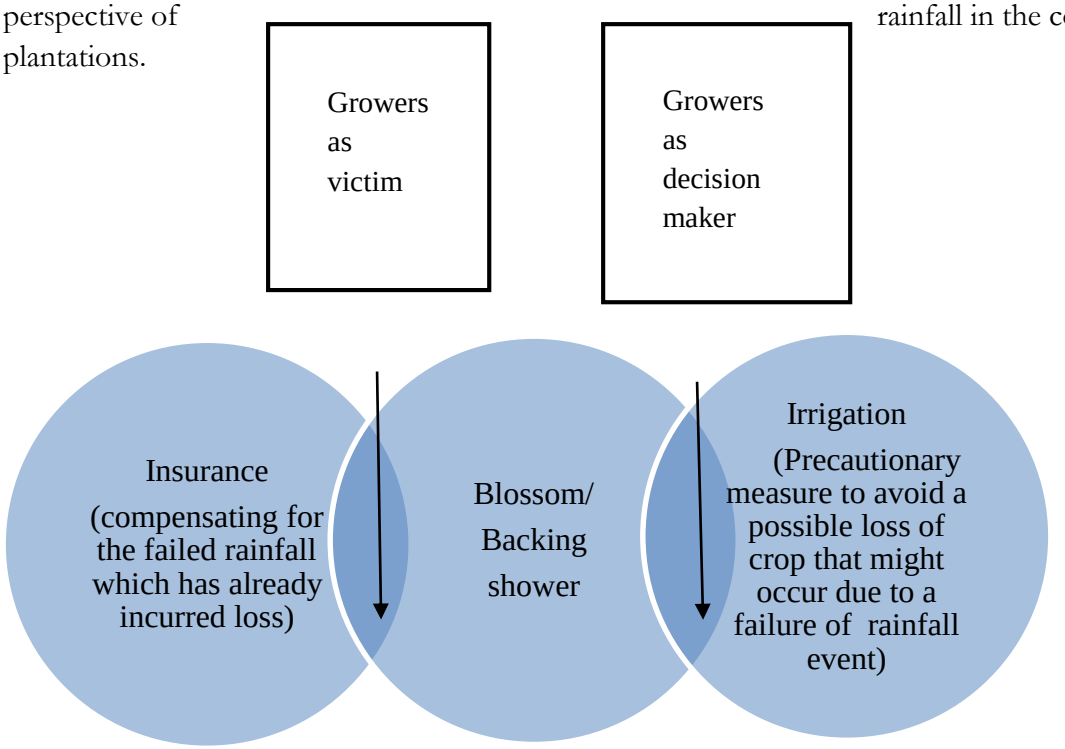
There is striking resemblance between the role of irrigation as understood initially and Rainfall Insurance scheme (RISC) which came much later. Amongst the various options available RISC insures blossom and backing. For example the condition for blossom cover payout in Aldur Zone, Chikmaglur district in Karnataka for the year 2014 states that payout will commence if cumulative rainfall is less than 25mm in 5 consecutive days during the specified period.
Table 1: Blossom cover payout for Arabica in Aldur Zone, Chikmaglur district in Karnataka for the year 2014.

Source: Rainfall Insurance Scheme for Coffee (RISC) 2015. Available on Coffee Board website: http://www.indiacoffee.org/

RF< (In mm)	Payout (in Rs) (per hectare)
25	2500
20	3500
15	5500
10	7500
5	10,000

So in case of insufficient blossom shower, overhead irrigation compensates by providing the amount of water not received through rainfall whereas insurance compensates by triggering off the respective payout. In case of insurance it is compensating the loss incurred but in case of irrigation, growers are avoiding the loss that could have happened. In case of insurance, planter is a victim who has suffered loss due to failed rainfall. In case of irrigation planter has the power to undo the impact of failed rainfall and hence he is the decision maker.

Figure 1: Diagrammatic representation of insurers and growers (aided by their ability to irrigate) perspective of rainfall in the coffee plantations.



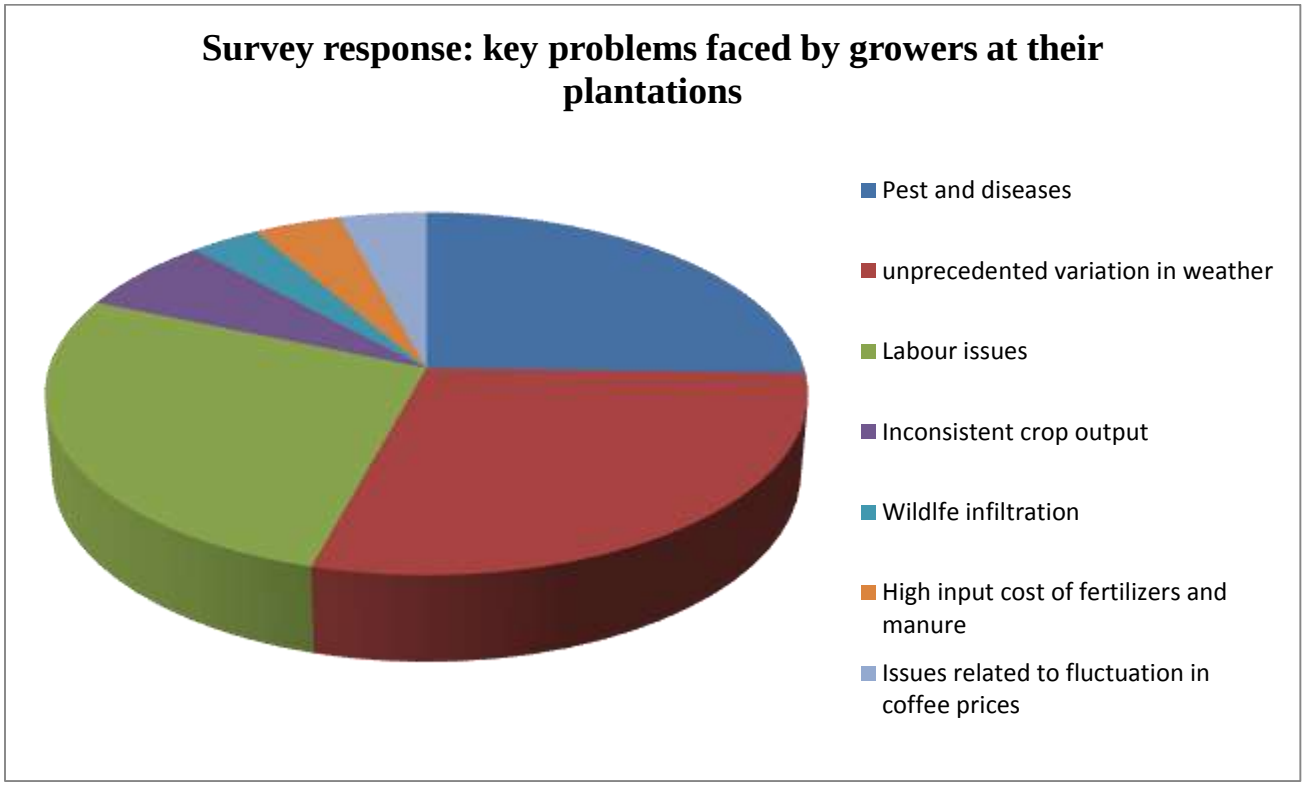
Coffee grower: the decision maker

As a decision maker coffee grower has the power to undo the impacts of failed rainfall through artificial irrigation. Running an irrigation system at a coffee plantation requires a) a regular source of water b) infrastructure which includes sprinklers, pipes, motor and running expenditure of fuel c) timely availability of labor and d) weather information.

However, as the field work revealed for different reasons these requirements are not entirely under growers' control. Availability of water and investment in infrastructure depends on a) where the water source is located. The cost will be higher if water source is a particular point located at the fringe of the plantation b) the total number of heads or sprinklers installed because that would decide the number of engines and motors required c) the compactness of the estate. An estate which is shaped as a strip and is not square or round is probably going to incur more cost d) the acreage planned to be covered in one round of irrigation.

Additionally, availability of labor turned to be one of the most sensitive issues that growers are facing at present. In a written survey 27% of the growers mentioned labor as an urgent concern second only to the issues faced by unprecedented variation in weather.

Figure 2: Pie chart showing key problems faced by coffee growers at their plantations.
Data source: Primary. The Survey was conducted on 18th January, 2015 at University of Agriculutre and Horticulture Sciences, Shimoga University, Mudigere, Chikmaglure, Karnataka.



The authority that comes along with installing an irrigation system which can counteract the impact of failed, delayed or inadequate showers is diluted by these contingent factors. As rainfalls become increasingly unreliable in terms of their arrival and discharge, concern about gaining more control over contingent factors which can dilute the impact of successful artificial irrigation have become a top priority.

Dr. Anand Perriera, a planter in Sakleshpur region, widely known for his intensive investment in irrigation system shared his opinion on the previously used technology in irrigation system and why there is need to change it.

> Over the years irrigation system used in coffee plantation are the sprinkling set up (tanks + tubewells + engines+ pipes +sprinklers). These systems fail to consider the need to irrigate in a specified period of time. After all, time is the essence in irrigating the entire farm. In most cases the mainline supplying water to the lateral lines are undersized creating tremendous friction loses at the first step itself, resulting in overloading of the engine and pump. Also, in time of emergency, when there are unseasonal rains irrigation cannot be completed within the reasonable time window. Our experience is that sprinkler system are labor intensive and inefficient with regard to the expectation from irrigation systems in today's time. [7]

Expectation from irrigation system refers to the evolved cultivation practices. Robusta growers, as I noticed, do not wait for blossom showers. They have a set schedule by when the plants need to be irrigated and at the arrival of appropriate time they will start the irrigation system. Rains are checked not for initiating blossoms but rather for ensuring that they do not coincide with the blossoming of the plants which is induced by irrigation.

To meet these improved expectations of irrigating maximum area in minimum time and reducing the dependence on labor still further investments are made in irrigation. The sprinklers system is being increasingly replaced with rain guns. Rain guns have two primary advantage a) large quantities of water are sprayed over a huge distance within short period of time b) it is least dependent on laborers. Following is a quick comparison in the scale of operation between sprinklers and raingun.

Table 2: A comparison between the scale of operation of rainguns and sprinklers.

Source: Data for the Gemini raingun is obtained from Dr. Anand Pereira and Dr. Geetha N. Pereira (2009), Ecofriendly Coffee, volume (1), p.137. Data for sprinklers is obtained through primary interviews.

[7] Dr. Anand Pereira, Joe's Sustainable Farm, Kirehully Estate, Sundekere Post, SakleshpuraTaluk , Hassan District, 21/2/14.

	Nozzle diameter	Pressure (bar)	Pump discharge (liters per minute)	Jet throw (radius in feet)	Irrigated area (ft^2)
Rain gun	34mm	4.90	3000	210	138544
		5.9	3000	225	159043
Sprinkler	12-13mm	0.01	11	39	4778
		0.02	14.61	41	5281

The key concern associated with artificial irrigation has been overlap of blossoming with rains i.e if on the day of blossoming, which is induced through artificial irrigation, rain were to occur it would greatly affect the fruit set and thus total output during harvest time. In the case of one estate (on the Giris) with Arabica selections 10-12 years old, overhead irrigation of 3 inches induced bloated blossom with thick petals and blossom to crop ratio was poor. With heavy irrigation followed by rain, the pollen were found to be moistened and not easily blown off for successful pollination.[8]

Early research pacified this concern by observing that rain in the morning hour affected blossom-berry ratio, and afternoon rains did not show much adverse effect. Given the limited range of technology used for irrigation then, overhead sprinklers covered only small area each day. Blossoming occurred on different dates for different parts of the estate. Even if the rains were observed it affected only small portion of the estate, major area escaped rains on blossom and was protected.[9]

However, with technology like rain gun which aims at covering maximum area in minimum time, essentially substituting for natural rainfall, mostly it is the entire or nearly entire estate which blossoms at the same time much like it would do in response to a natural rainfall. On the one hand growers have single handedly done away with their dependence on rainfall on the other hand they are now most vulnerable if rains were to occur on the blossom day.

From a coffee grower's perspective performance of rains in the form of blossom and backing showers have become secondary. Priority is weather information about these rainfalls. Worse than a failed shower is receiving rainfall on the day blossom is set through artificial irrigation.

RISC for Coffee grower: the victim

An insurance scheme was introduced much later in 2007-2008 after the coffee growing region suffered a serious drought in 2002-2005. The scheme is known as Rainfall Insurance Scheme for Coffee Growers (RISC). It was introduced by Agriculture Insurance Company of India (AICI) in association with Coffee Board of India. The scheme is structured on the format of Index Based Weather

[8]S.R. Gopalan (1974), A Review of Irrigation in Coffee, *Indian Coffee,* p.48.
[9]S.R. Gopalan (1974), A Review of Irrigation in Coffee, *Indian Coffee,* p.46.

Insurance.[10] As is understood and expected weather information should help the scheme in locating growers who have not received sufficient amount of rainfall. However, the information instead of aiding the scheme is identifying for it who is the victim and who is not.

In order to reduce moral hazard[11] the scheme follows a standard set of rain gauges known as Reference Rain Gauge (RRG) and Telemetric Rain Gauge set (TRG) monitored by Karnataka State Disaster Monitoring Cell (KSNDMC), National Collateral Management Services (NCMSL) and Indian Meteorological Department (IMD). Each RRG and TRG is allocated a specific number of villages. This allocation is prerogative of Coffee Board in consultation with AICI. At present there is one main RRG and one back up RRG per *Hobli*[12].

In IBWI schemes, of which RISC is an example, basis risk is a known shortcoming. It refers to the risk arising from different amount of rainfall received at the standard rain gauge and at a particular plantation in that *Hobli*. In case of Western Ghats this risk is further accentuated because there is high variation observed on the ground in terms of rainfall received. [13]

RISC is viewing rainfall in this geographic space through the data that has been compiled by these RRGs and TRGs. Following that line of thought the location of RRGs and TRGs is of prime importance. However their location is not decided by insuring body (AICI). It is decided by the respective authority which monitors the station. In this case either KSNDMC, NCMSL or IMD. Within these agencies the rationale of installing a rain-gauge at a particular location depends on its easy accessibility, monitoring and maintenance.

In case of RISC the decision of payout is not informed by the information required but instead by the information available. Here weather information is not aiding decision making rather it is driving it. As a result payouts are given to those have not necessarily suffered the loss but are identified as victim by the data gathered through standard rain-gauge. Hence you have incidence where a grower has not received sufficient rainfall but the standard rain gauge in the area has recorded normal rain. He does not get a payout. On the contrary there are chances that he receives rainfall but standard rain-gauge

[10] In Index Based Weather Insurance the insurance contract responds to an objective parameter (e.g. measurement of rainfall or temperature) at a defined weather station during an agreed time period. The parameters of the contract are set so as to correlate, as accurately as possible, with the loss of a specific crop type suffered by the policyholder. All policyholders within a defined area receive payouts based on the same contract and measurement at the same station, eliminating the need for in-field assessment.

[11] Moral hazard refers to the risk that a party to a transaction has not entered into the contract in good faith, has provided misleading information about its assets, liabilities or credit capacity, or has an incentive to take unusual risks in a desperate attempt to earn a profit before the contract settles.

[12] A hobli is defined as a cluster of adjoining villages in a state. This clustering of villages was formed mainly to streamline the collection of taxes and maintenance of land records by the revenue department of the State. Each Hobli consists of several villages and several hoblis together form a Taluq.

[13] Please refer to Appendix-1 which shows a vulnerability assessment for Arabica and Robusta growers. Assessment of vulnerability is carried in terms of returns on investment in irrigation and insurance both of which are decisions made by the grower.

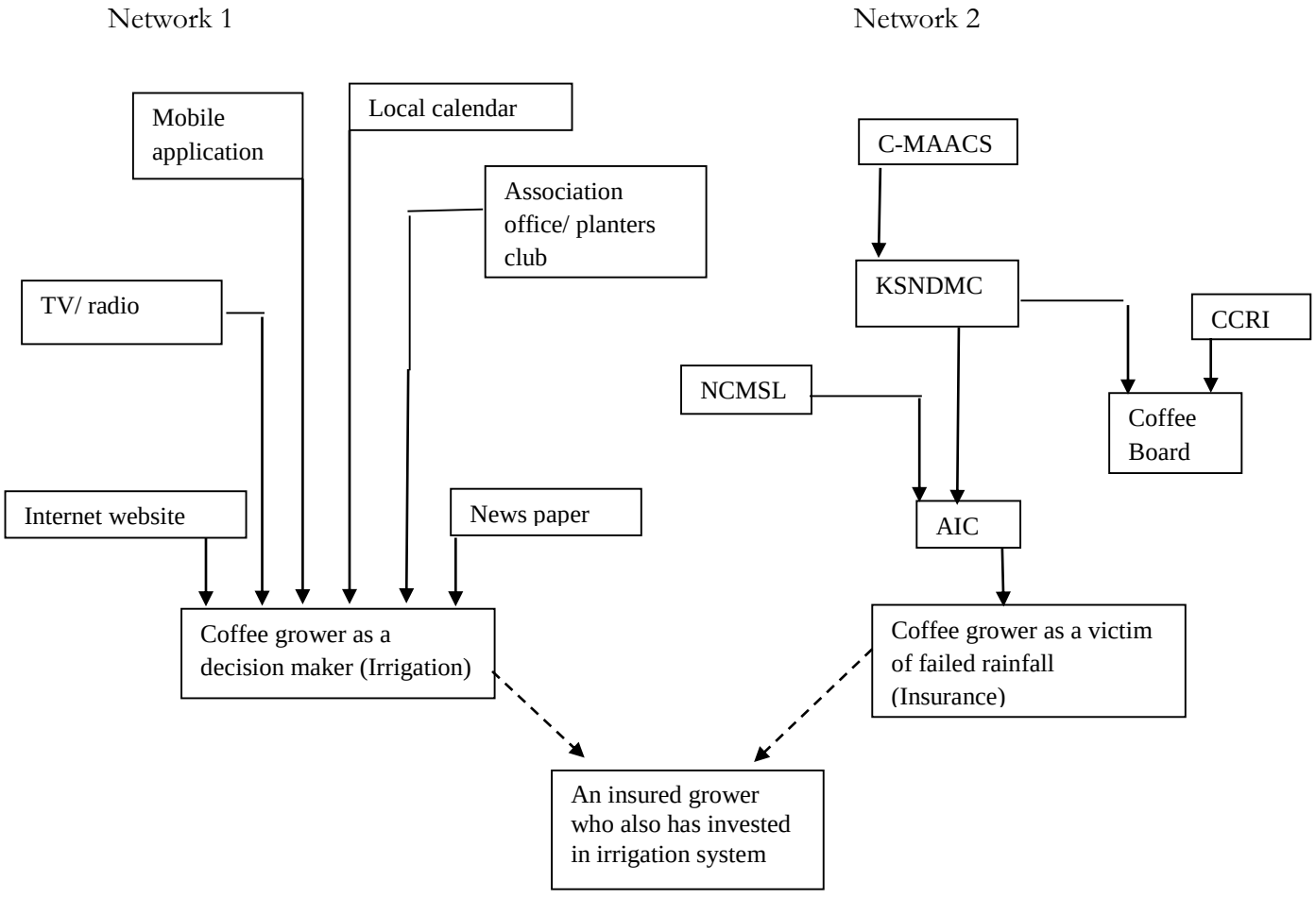
does not register a normal rainfall. He does get a payout. It is not the weather event but weather information that decides who has suffered a loss and who is a victim.

Insurers monitor a weather event through the weather information network. The performance of a weather event like rainfall is decided by the location of RRGs and TRGs. Identifying the victims of a failed rainfall is a function of the weather information network and not the weather event directly.

Making weather work: Role of weather information network

Coffee grower's perception of a rainfall event in order to make irrigation decision or insurer's perception of a rainfall to identify those who have suffered a loss is a direct function of the weather information network. Following figure shows the two network of weather information followed by these two groups: coffee growers and insurers.

Figure 3 : Flow charts showing the network of weather information in the coffee growing areas.



Network 1: Grower as decision maker: as a decision maker grower is capable of operating an irrigation system at will that can counteract the impacts of failed, delayed or inadequate rainfall. However, in order to ensure that blossoming induced by irrigation do not coincide with the natural rainfall shower growers check weather forecast. As a decision maker it is growers' prerogative to choose the source of weather information. The information he is looking for is forecast.

Network 2[14]: Grower as a victim of failed rainfall: Network 2 is different from network 1 in significant number of ways: a) In this network grower does not chose his source of information though he can choose if he wants to be a part of the network or not. b) Network decides the extent of compensation, the triggers of compensation and most importantly who has suffered the loss. C) Meteorologically network 1 relies on forecasts which are products of weather models and network 2 on observed data.

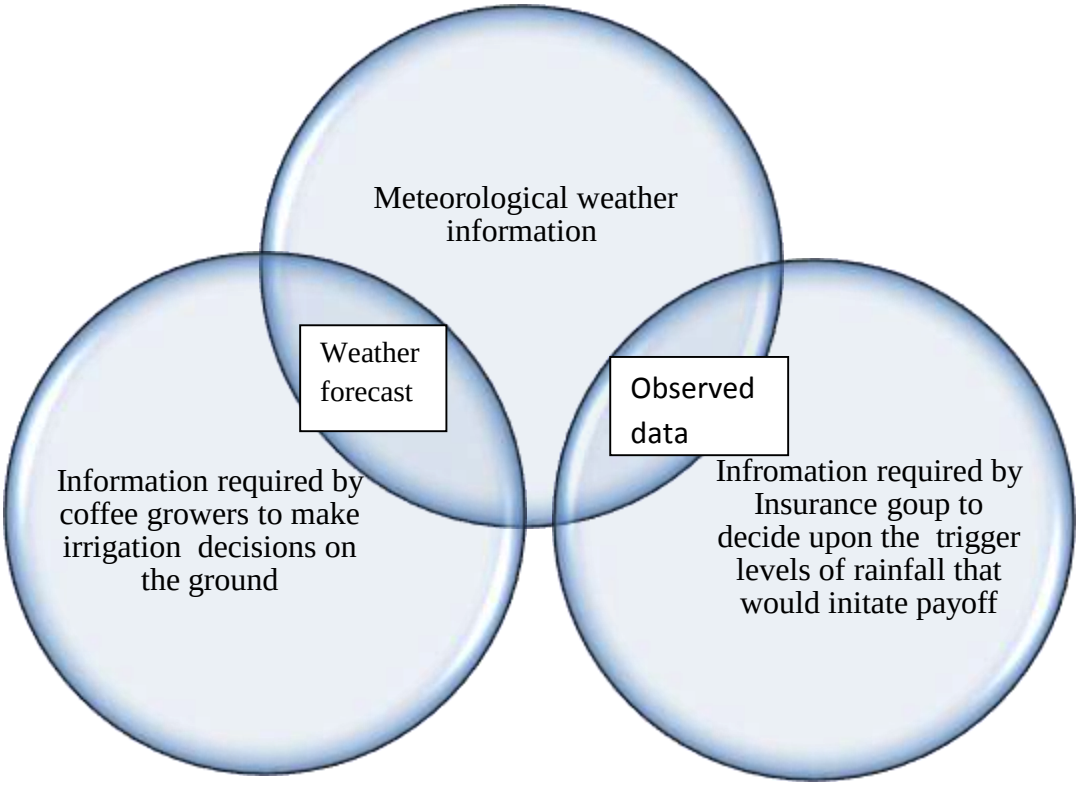
From meteorological perspective the success of rainfall is decided by calculating its percentage deviation from the normal. Success of a rainfall forecast is decided through the use of statistical tools comparing the observed with the forecasted. The link between the assessment of a weather event and its forecast is the observed data which in the immediate year informs the success of forecast and when added to the previous data informs the calculation of normal climate.

However there is a lag period between the time this data informs the immediate forecast and time it gets incorporated in the climatological calculations to inform the normal climate. It is a considerable time lag to be overlooked considering that the 30 year window used for calculating normal rainfall ends at 1990. Thus it does not take in account the variations which are observed after that.

Therefore, it can be argued that there is no visible overlap between the two sets of weather information and hence information network which are concerned with the two perspectives of rainfall on the ground.

- Figure 4: Figure showing the two sets of weather information used by coffee growers in 2 different capacities. As a decision maker in case of irrigation (forecast) and as a victim of failed rainfall in case of insurance (observed data). Meteorological

[14]Dr. Babu Reddy, Agronomist, Head, Market Research and Intelligence Unit in Coffee Board and the Chief RISC negotiator from Coffee Board gave an overview of this network. The triggers provided by Agriculture Insurance company of India (AIC) are consulted with Central Coffee Research Institute (CCRI). CCRI provides information about how the plant will react under different degrees of water stress. Upon consultation with scientists at CCRI it stood out that their inputs are not frequently revised. Rather, they were actively involved when the scheme was drafted for the first time in 2007-2008. the rain gauges used for collecting data are the ones installed by Karnataka State Disaster Management Cell (KSNDMC). But it is the prerogative of Coffee Board to decide which rain-gauge will be read for which area. KSNDMC is involved in providing weather data for the insurance scheme. Additionally it consults C-MMACS, a CSIR lab for mathematical simulations and computer modeling, to calculate the probability of the triggers suggested by AIC.



Conclusion

In case of irrigation weather information can turn decision making power into source of vulnerability because grower needs information prior to irrigation to ensure that he does not receive rainfall on the day of blossom. On the other hand in case of insurance it is the expanse of weather information, in the form of rain gauges installed and the area they cover, and not the weather event which decides who has suffered adversely and who has not. It can be argued that as unpredictability increases the perspective of a weather event in a particular geographic space is informed more by the weather information then the weather event itself. The argument is supported by the assessment provided in the appendix showing that vulnerability in terms of returns on investment peaks in a situation where weather event has not even failed.

As unprecedented weather variation increases various strategies employed on the ground to counteract the impact of weather fluctuation would engage with weather science in different capacities forging their own networks. As these networks with different narratives address the same problems of a single community the role of weather information becomes more complicated. A useful information would require a rigorous engagement with local knowledges in order to remain relevant.

Appendix 1

The vulnerability is assessed in terms of growers' investment in both irrigation and insurance and their possibility of receiving return on the investment.

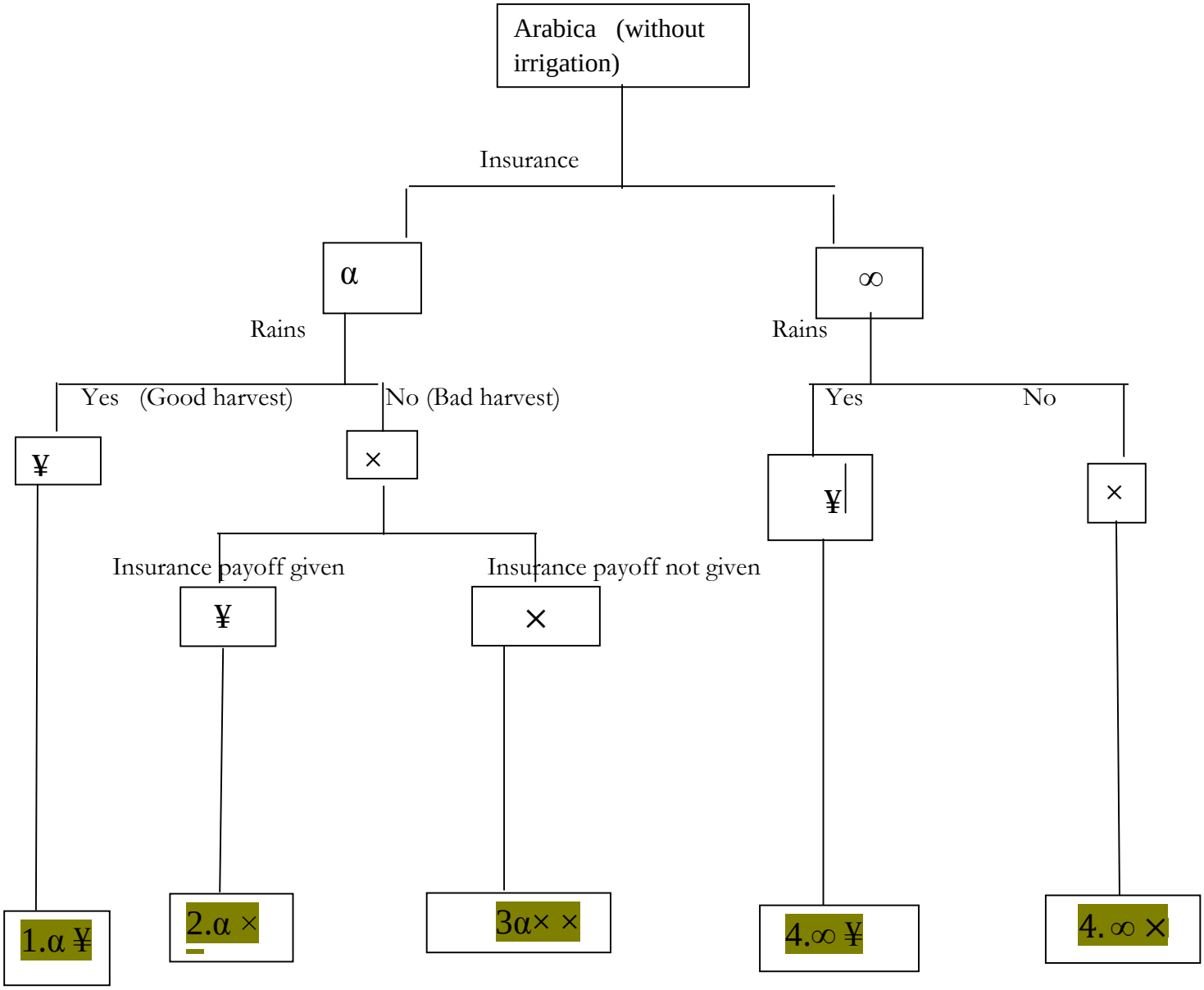
In the assessment process we follow a flow chart where a grower's choice to invest (in insurance and irrigation) would be represented by α symbol. The opposite ie his choice not to invest would be represented by ∞ symbol. The points where grower receive returns on investment in the form of good harvest or payout from the insurance scheme will be represented by ¥ symbol. Whereas in cases where grower is unable to receive returns and suffers a loss would be represented by × symbol.

Following is the quick guide to the symbols used:

a) α: represents investment made.
b) ∞ : represents investment not made
c) ¥ : returns were received.
d) × : returns were not received.

Each chain of decision making will be followed through the flow chart till the end to calculate total number of α, ∞, ¥ and × in every case. In the overall assessment more number of α will signify higher financial stakes. More number of × will represent failure in receiving returns on the investment. So a set of choices which eventually adds upto maximum number of α× would represent the most vulnerable situation. Whereas a combination of choices ∞¥ will represent less vulnerability. In order to keep these assessment simple loan cycle has not been taken in consideration. It needs to be flagged that loan further accentuates vulnerability and it is the investment in the schemes, technologies and fertilizers and pesticides for which grower borrow loans. In a way, investment in irrigation and insurance is partly reflective of the loan pressure as well

Figure 4: Flow chart representing assessment of Arabica growers' vulnerability in terms of their returns on investment in insurance and irrigation (sprinklers and rain guns).



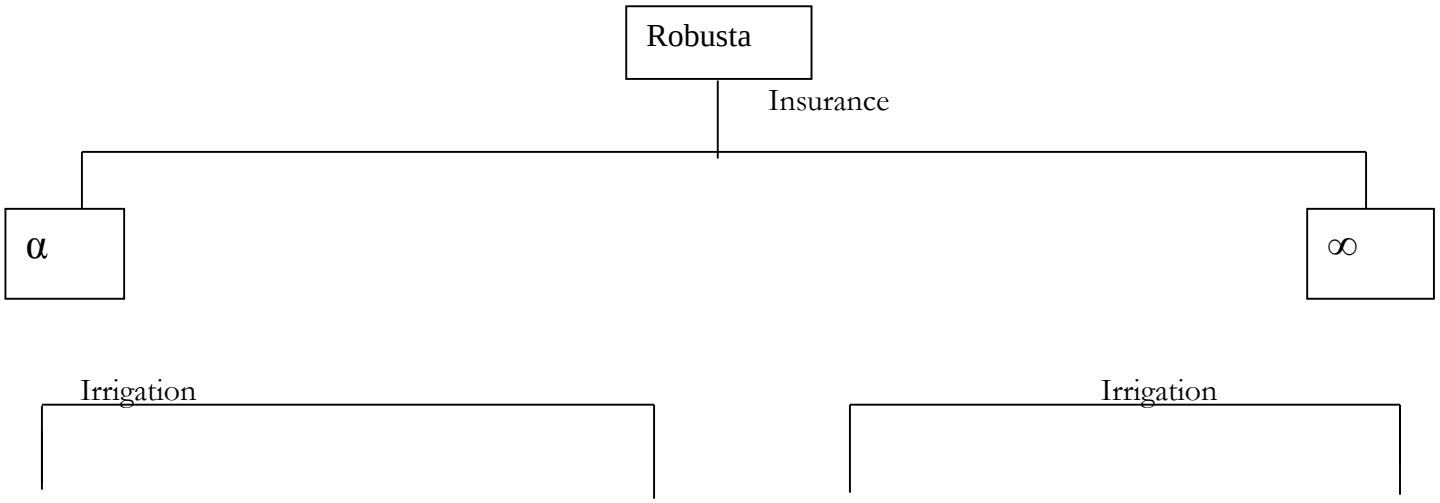
1. α ¥- The grower gains from a good harvest but not from the investment made in insurance.
2. α × ¥- Grower losses crop but gains from the investment in insurance.
3. α × ×- Grower losses crop and his investment in insurance.
4. ∞ ¥- Grower does not invest in insurance and gains simply from his crop.
5. ∞ ×- Grower looses crop due to rain failure. Makes no investment in insurance derives no benefit.

Arabica planters do not invest in irrigation because plant has deep roots and it does not respond to artificial irrigation well. Therefore Arabica growers are essentially dependent on rainfall. In the

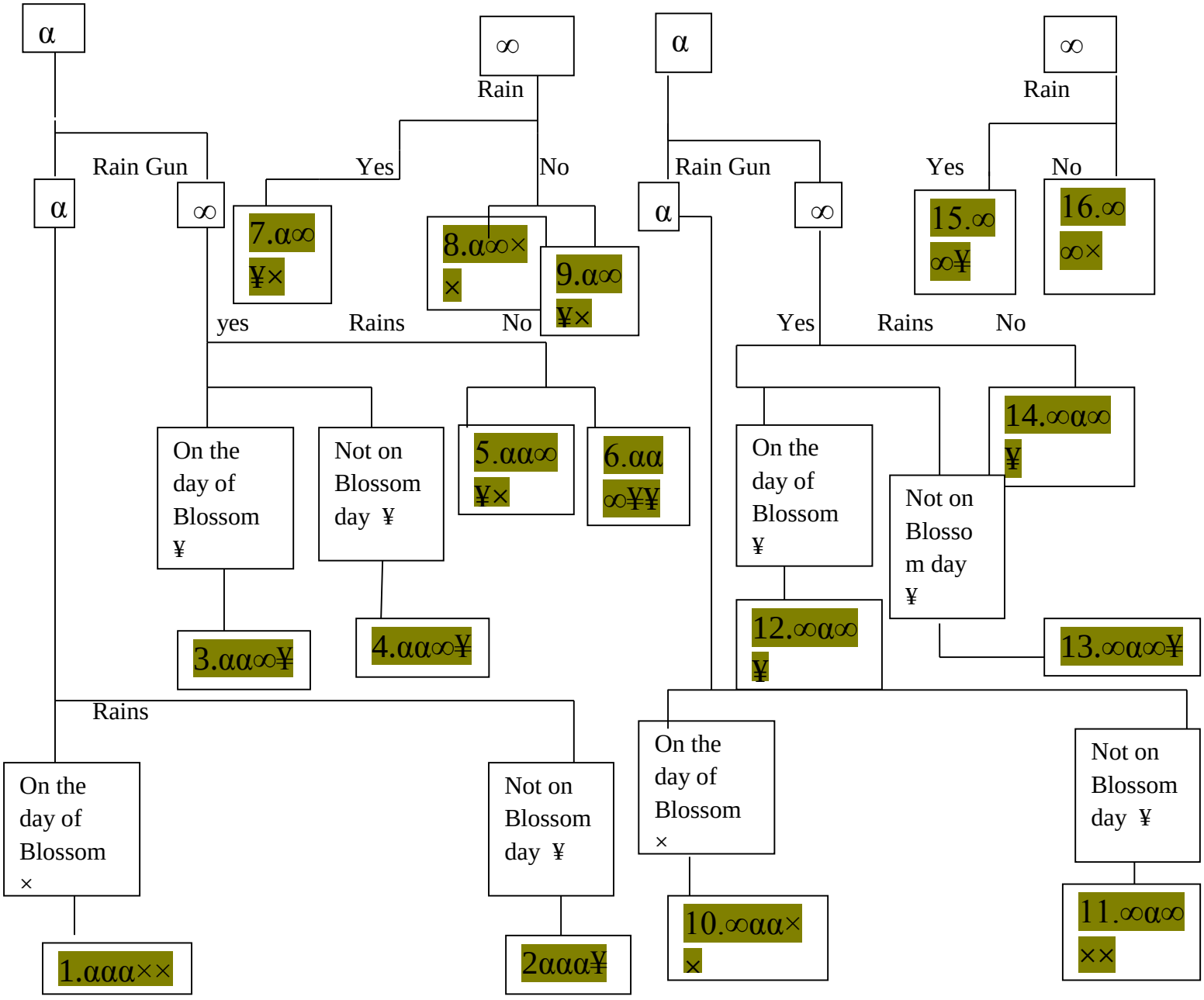
assessment for Arabica we have, hence, not considered irrigation as an investment option. In the above assessment Arabica grower number 3rd would be most vulnerable and 4 would be least vulnerable. 3rd grower received minimum returns on his investment whereas 4th grower received maximum returns on his investment. The 3rd grower invested in insurance, suffered a loss due to failed rainfall and did not receive compensation due to basis risk problem in the scheme.[15] Whereas 4th grower did not invest in irrigation and luckily rains performed as per expectations and he received returns more than the investment he made.

In case of Robusta this calculation is still trickier because not only do majority grower have invested in irrigation there are considerable number who have gone a notch higher and invested in rain guns which as explained previously work on a scale where unlike sprinklers it is not just supporting the plant through a stress period but is potentially replacing the rainfall.

Figure 5[16]: Flow chart representing assessment of Robusta growers' vulnerability in terms of their returns on investment in irrigation (sprinklers and rain guns) and insurance.



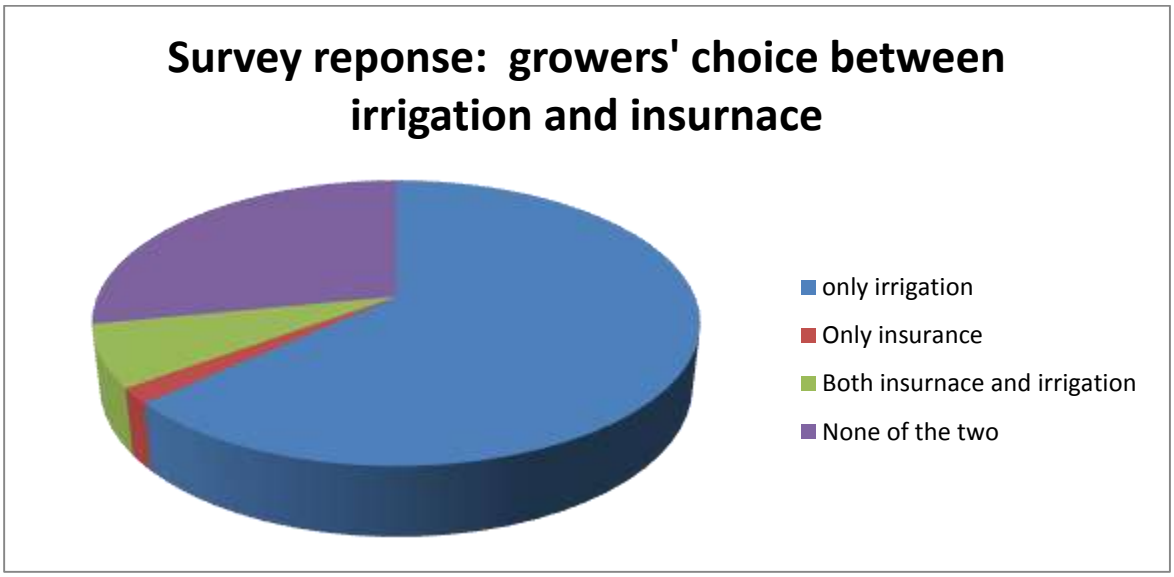
[15] For exploring detail implications of basis risk for the insurance scheme please refer to chapter one.
[16] The detailed key to the symbols used is attached at the end.


α
∞
Rain
Rain Gun
Yes
No
α
∞
7.α∞¥×
8.α∞××
9.α∞¥×
yes
Rains
No
On the day of Blossom ¥
Not on Blossom day ¥
5.αα∞¥×
6.αα∞¥¥
3.αα∞¥
4.αα∞¥
Rains
On the day of Blossom ×
Not on Blossom day ¥
1.αααα××
2αααα¥
α
∞
Rain
Rain Gun
Yes
No
α
∞
15.∞∞¥
16.∞∞×
Yes
Rains
No
On the day of Blossom ¥
Not on Blosso m day ¥
14.∞α∞¥
12.∞α∞¥
13.∞α∞¥
On the day of Blossom ×
Not on Blossom day ¥
10.∞αα××
11.∞α∞××

In the entire scheme of combination most vulnerable in terms of returns on investment is number 1 with maximum number of α×. Strikingly, vulnerability is highest when the rains have not failed. Planter suffers loss because rains came on the same day as his blossom. So he loses investment in irrigation, investment in insurance and the crop itself. His vulnerability is emerging from his decision making power to irrigate the plantation at a particular point in time. This decision taken by him is informed by weather information. As unpredictability about rainfall increases weather information has the potential of transforming authority and power to face a weather condition into a source of vulnerability.

The most vulnerable is the planter who has invested in rainguns as well as insurance. Least vulnerable would be growers who have invested in neither of the two or only in sprinkler irrigation. Same pattern is visible in growers' response to the written questionnaire.

Figure 6: Pie diagram showing survey response of growers towards their choices regarding irrigation and insurance.



Growers have automatically chosen the least vulnerable combinations in terms of returns on investment thus validating the vulnerability assessment carried out above.

Key to the symbols used in the vulnerability assessment of Robusta coffee growers.

1. αααΧΧ represents a Robusta grower who has invested in insurance and for irrigation has opted raingun technology which has double the investment cost. However, he received rainfall on the day of blossoming and unlike his counterparts who have opted for sprinklers and where artificial irrigation induces blossoms one block at time is witnessing a full bloom at his plantation when the rainfall occurs. Additionally, insurance does not fill in for the crop loss because technically the rains did not fail.

2. **ααα¥** represents the Robusta grower who invested in in insurance and rain gun irrigation. Did not receive rainfall on the blossom day and harvested his returns in the form of a good crop.

3. **αα∞¥×** represents a Robusta grower who invested in insurance and in sprinkler irrigation. He received rains on the day of Blossom. But because only part of his estate was blossoming he did not lose much. He will harvest a decent crop but might receive relatively less returns then his counterpart number 4th. Insurance did not pay because rains did not fail.

4. **αα∞¥** represents a Robusta grower who invested in insurance and in sprinkler irrigation. He did not receive rains on the day of blossoms. He receives the harvest as expected.

5. **αα∞¥×** represents investment in insurance and sprinkler irrigation. The rains did not come. Sprinklers help in setting the blossom. Though total output of the crop will be less then what is expected from rains or rainguns but grower will not lose investment. In this scenario he does not receive compensation because of basis risk.

6. **αα∞¥¥** represents investment in insurance and sprinkler irrigation. The rains did not come. Sprinklers help in setting the blossom. Though total output of the crop will be less then what is expected from rains or rainguns but grower will not lose investment. In this scenario he receives payoff from the insurance.

7. **α∞¥×** represent a Robusta grower who invests in insurance but does not invest in irrigation. This choice of combination is rare to find on the ground because all the Robusta growers have installed irrigation systems moreover the faith in insurance in very shaky. Nonethless, this scenario is possible. In a such a case where rains did perform grower will even out his investment in insurance through a good harvest.
8. **α∞¥¥** represent a Robusta grower who invests in insurance but does not invest in irrigation. This choice of combination like the previous case is rare to find on the ground because all the Robusta growers have installed irrigation systems. In this case rains did perform. Returns of investment are received and unlike other times here basis risks works in favor of the grower. He received payout because his standard rain gauge recorded shortage of rainfall whereas he did not.

9. **α∞¥×** represents a Robusta grower who invests in insurance but does not invest in irrigation. This choice of combination like the previous case is rare to find on the ground because all the Robusta growers have installed irrigation systems. In this case rains did not perform but he gets compensated through insurance.

10 to 15 are similar situations but in them growers are not insured.

10. ∞ααα× × represents Robusta grower with rain gun irrigation system but no insurance. Rains do come on the blossom day. He loses major part of the crop. But unlike his counterpart (1) who is insured but can't claim the payoff because rains have not failed he has not invested in insurance and is thus less vulnerable economically.

11. ∞α∞×× No rains, rain guns, no insurance. Returns are received through the harvest but no investment is lost in the insurance.

12. ∞α∞¥ No insurance, irrigation through sprinklers, rains on the blossom day but doesn't impact the crop adversely.

13. ∞α∞¥ no insurance, irrigation through sprinklers, no rain on blossom day. Harvest is as expected.

14. ∞α∞¥ no insurance, irrigation through sprinkler system. No rains. Crop received through artificial irrigation. This is similar in symbolize to 12.

15. ∞∞¥ no insurance, no irrigation. Rains received and harvest accomplished.

16. ∞∞× no rains, no irrigation. Rains fail. Crop fail. Loss of income but no investment in irrigation or insurance.