TYPES AND EFFECTIVENESS OF ADAPTATION STRATEGIES ON CLIMATE CHANGE: LESSON LEARNED FROM DAERAH ISTIMEWA JOGYAKARTA

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Abstract

This paper consist of types of adaptation strategies and its effectiveness of the various adaptation strategies carried out by farmers in *Daerah Istimewa Yogyakarta*. The research done during 2011 fiscal year, data collected from 10 groups of farmers experienced with floods and 10 groups with drought impact of climate change and the information presented descriptively. The effectiveness of adaptation strategies evaluated through the ratio of income to cost of rice production (R/C), both for adaptation conditions (R/Ca) and normal conditions (R/Cn). For flood, types of anticipative adaptation were changing commodities, changing planting system and making drainage channels and maintaining/deepening of drainage channels. The responsive adaptation were cropping pattern adaptation, changing commodities, planting submerged of resistant seed of rice and implementing appropriate dose of fertilizer. For drought, anticipative adaptation were making a dam, creating joined or share wells and provides drilled/pump wells. The responsive adaptation were changing Varieties and commodities. The effectiveness strategy adaptation on flood were effective, with value of R/Ca ratio 1:09 while R/Cn 1:56. In drought adaptation almost effective since the value of R/Ca 0.93 and R/Cn 1:48.

Keywords*:Component; Climate change; adaptation; effectiveness*

Introduction

Background

Climate defined as a condition of temperature, humidity, cloud, rain and sun in an area during about 30 years with climatology as the science [8] while weather is a condition of atmosphere as a general in a short time with metheorology as the science. The changing of climate is caused by human activities, namely the effect of glass house in atmosphere such as carbon dioxide and methane which destroy ozone in atmosphere. Its effect is significant for human life, includes economic, health, environment and the quality of water resources. To overcome the impact of climate change various program is now implemented. In overseas, green industries being developed for examples in the following big cities a special program being implemented i.e: 1) Seoul revitalizing 10,000 – 2030 buildings . 2) Austin, Texas implementing “no Waste” program with target done in 2040.

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3) London planning electrical vehicles before 2020. 4) Buenos Aires, Argentina plan to build special rail bus and taxi to increase the efficiency of fuel. 5) Tokyo implementing standard of energy efficiency more restrictedly for building big scale. 6) São Paulo, Brazil, reducing the use of fossil fuel for public transportation for 10% per year. Meanwhile 26% big cities in the world provide incentive, awards and special certificate to individual or organization who success in reducing the effect of glass house. Rio de Janeiro, provide cash to workers who success in achieve the target of carbon emmition. In Indonesia various program such as Go Green, Green Living, Green Lifestyle, Green Property, and planting thousands tree [1] and developing green town. At villages level, the Minister of Agriculture also conducting some efforts such as the use of organic fertilizer, climate vocational training for farmers and building some irrigation services. Ministry of Agriculture officially launching online integrated planting calendar which includes climate prediction as well as interaction map of timing on planting and some technical information to make easier to access [3].

Impact of climate change on agriculture production is worth to study since foods considered the survival of a nation and internationally as one out of 7 (seven) urgent actions needed to prevent recurring food crises [6] . At the moment the situation of Indonesia in food safety is in dangerous because more then 50% of the staple food of 235 million people is depending on import. To achieve the national food security should be started by its security at district level therefore information on farmers adaptation to climate change is important to study. Pasaribu *et al*. [10], reported some adaptation to climate change of farmers in East Nusa Tenggara. Farmer adaptation to climate change impact of agricultural management were reported by Miranda [11] and Iskandar [7] reported about climate change and adaptation to local population. However a success story from an area of Indonesia which achieve predicate as beginner of defence town on climate change ”Kota Berketahanan Iklim” (KBI), namely *Daerah Istemewa Jogyakarta (DIY)* as reported by Anonimous [1] is very important to learn. Especially DIY were also experience in the achievement of 3 (three) award at national food security in 2007, 2009 and 2010 in increasing production of rice, palawija, fish and animal [2]. It is worthwhile to present the success story of DIY province , as 37 nations were also studied its success through an “International Youth Conference 2011” participated by 144 youth [12].

Objectives

This paper present the types of adaptation that evolved farming community and its effectiveness of various adaptation strategies implemented to respond the impact of climate change include flood and drought cases of farmers in DIY. The information would be worth for farmers in other part of Indonesia to achieve success in farming activities which could support the food security at National level.

Methodology

Locations

The location were selected purposively at the area of Indonesia which achieved predicate as beginner as a defence town on climate change "*Kota Berketahanan Iklim*" *(KBI)* and success in national food security program namely *Daerah Istemewa Jogyakarta (DIY)*. At district level, locations were decided based on the result of discussion with some related institutions at province namely office of agriculture, research institute for agriculture assessment and technology (*Balai Pengkajian dan Teknologi Pertanian*)and office of metheorology and geophysics . Discussion were also done at office of agriculture at district and sub-district level for choosing the villages. District whit experienced to climate change impact on flood is *Bantul* while for drought is *Gunung Kidul*.

Samples

Samples were farmers' group at village which have the biggest number of groups in order to get various information namely village of Sri Gading, Sanden sub-district, Bantul for flood case while for drought case in village of Lo Gandeng, Playen sub-district. From the existing number of groups in the village, ten groups were selected as respondents. The responden during the group interviw were represented by the group's leader, secretary and three members of farmers with various land holding. Beside from farmers' group, information were also collected from 8 (eight) persons such as head of the village and extension services workers.

Data and the Analysis

Information includes responsive and anticipative adaptation strategies for flood and drought and the effectiveness of all the strategies have been implemented. The types of

responsive and anticipative adaptation strategies for flood and drought were analyzed descriptively reffered to Cashly and Khumar [5].

To analysis the effectiveness of the adaptation strategies to climate change, a quantitative analysis [9] was done by calculating the ratio of income to the cost of rice production (R/C), both for adaptation conditions (R/Ca) and in normal conditions (R/Cn). Category of the effectiveness of adaptations to cope flood or drought was formulated as follow: R/Ca<1 considered to be ineffective; R/Ca=1 categorized effective; R/Ca>1 considered very effective.

Types of Adaptation on Flood Impact

A. Anticipative Adaptation

- Changing Commodities, based on empirical experiences, during high rainfall or flood farmers decided to change their commodities in order to secure their farming activities, namely planting rice instead of beans or onion since beans and onion were only appropriate in dry land. Without changing the commodities, farmers will lost all the farming input that had been allocated and at the same time they will harvest nothing. Another benefit by planting rice instead of beans and onion were first it could cut the cycle of pest, therefore pest attack could be avoided and the second the rice waste product is also important for the land reenrichment in fertilization and sustainability.
- Changing planting system, that were implemented during high rainfall was monoculture system such as planting rice only in row cropping systems called *tandur jajar legowo*. Some benefit for implementing monoculture cropping system were: (a) management of rice farming easier; (b) the rice perform good growth, (c) higher productivity (number of panicles, the largest number of rains, grain more pithy), (d) better quality production, and (e) provide greater benefits, and (f) has been traditionally practicing.
- Provide drainage were done after having group discussion, namely provide drainage done through *gotong royong* or working in group as well as by dues in covering the funding needed for making the drainage. In addition, farmers were also doing the vacuuming of water in their farm land using a water pump with diesel power belongs to the group or hire. When they have to hire the diesel,

meaning farmers have to pay the cost of rental and the fuel for operating the diesel. All the expenses will be paid collectively or share among the farmers in the group.

B. Responsive Adaptation

- Cropping pattern adaptation in normal condition are (1) rice-onion - onion, (2) rice-onion /other vegetables, (3) rice-crops-onion. During the climate change where rainfall is higher, farmers implementing cropping patterns: (1) rice-rice-rice, (2) rice-rice-onion, (3) rice-rice-other vegetables. These different cropping pattern were due to the land position where at upper position farmer practicing types number one and two and in lower position practicing the other types.
- Changing commodities were done by farmers to be responsive to climate change, farmers who fail in growing rice immediately plant short-lived plant such as peanuts, cucumber, salad, spinach and sweet potatoes to adjust the next planting season. When the climate normal they go back to planting commodities in accordance with normal conditions. Since the benefit of planting beans and vegetables relatively higher than rice, farmers keep practicing this type of adaptation during climate change.
- Planting Submerged implemented when the water rainfall to much beyond their expectations while the plant age under one month. This condition made most plant collapse of to much water, therefore most farmers (80%) done the stitching. In addition, farmers make a trench in the plot line and drained the field to reduce the volume of the water.
- Appropriate Dose of Fertilizer was controlled by farmers based on experiences since most farmers use fertilizers simultaneously, single and compound fertilizer although farmers know that the elements in single and compound fertilizer were the same. Farmers perceived that in single fertilizer the ingredients is smaller than that of the compound, therefore by implementing those two kinds of fertilizer they believe would increase their confidence in the success of their farm. Beside that, most farmers were also use organic fertilizer especially for the shallots commodities. In terms of efficiency, the use of both types of fertilizers is at once can be viewed as a waste. However, if viewed from the aspect of adaptation to climate change, it can also be categorized as a responsive adaptation strategies, because the farmer can manage the addition or subtraction of fertilizer according to

the perceptions related to crop nutrient needs based on climatic conditions. Moreover, in general during the wet season farmers reduce the use of urea and increase the use of organic fertilizers.

Types Of Adaptation On Draught Impact

A. Anticipative Adaptation

Anticipatory adaptation on climate change is not an instant strategies but had been designed and initiated by the government from a long time ago when DIY was famous as a dry area. There are 3 (three) kinds of anticipatory adaptation has been implemented such as trench dams, jointly or share wells, and drill / pumps wells.

- Trench dam is a water ditch that flowed from dam that was funded by government Directorate General of Land and Water Management in stages starting in 2002 by . The funds amounting Rp. 5 million for the material and supported by farmers in the form of labor which equals to Rp 7.5 million. Water from the dam is then supplied to farmers' land by pipe which provided by farmers themselves according to the distant from dam to their land. Currently there are 3 three dam in the District of *Gunung Kidul* such as in *Lo gandeng* that was built in 2008, *Siyono Kulon*, 2009 and 2010 Mid-year in *Siyono*. Given the dams, the impacts of climate change could significantly reduced since only 25% of the farmers whose production is decrease, especially in areas that do not get a touch of technology.
- Joint/ shared wells called *Sumur Renteng* have been developed successively since 1990, the average well depth of 15 meters was made by the public at a cost of about Rp 4 million . These wells can irrigate an area of 400 meters square with the help of an electric pump which cost about Rp 10 thousand per day. The wells are located in the farm fields, farmers without wells being unable to make their own can ride in a way to connect the cable from the wells to their homes so that the well was called or known as well as jointly or severally be shared *sumur renteng*.
- Drill /pumps wells were owned by all farmers, most use “Kubota” brand pump that can irrigate about 2000 meter2 land with the price of Rp. 250 thousand per unit. The cost of drilling the wells is Rp. 2 million while the remaining costs incurred by farmers were pipe and tubing from the well towards the irrigated land. The use of drilled wells is very practical and simple since farmers are able to maintain (maintenance) or fix it by themselves if there is any technical disorder to the pump.

To operate the pump 2 liters of gasoline were needed per day per 14 square meters.

B. Responsive Adaptation

As in flood case, the responsive adaptation implementing by farmers were depend on the rainfall situation. A smart strategies is needed to handle the situation, however there are two main basic types of responsive adaptation such as changing varieties and commodities as describes below.

- Adaptation of varieties carried out according to the location of the field and timing of planting. According to the field location, the suitable variety in low-lying areas are *Ciherang* instead of *IR64*. For *perengan* location, variety of *IR64* and *Sledreng* were still suitable to use. For mountainous areas, *Towuti* and *Situ Bagendit* were appropriate. Other varieties of rice used ware a short life span rice such as *Silugonggo, Segreng* and *Godogan*. Soybean varieties used during drought were *Willis, Grobogan, Baluran* and *Anjasmoro* while for corn there was unchanged varieties such as "*Bisi Dua*".
- Changing commodities during dry season from planting soybean and corn to other commodities such as *cantel,* peanuts, vegetables, spinach , eggplant and green beans were done by farmers. To grow this such plants farmers got water from their fishpond which is already exist in their farm, called *mina-padi* system . During the normal climate beside the fish pond there are rice. Most farmers were also grow corn that is harvested in young age as baby corn for vegetable or elephant grass for cattle feed.

The Effectiveness of Adaptation Strategy

A. Flood Case

The total expenditure of rice farming in normal climate Rp 10. 003750 per ha, this condition indicates that rice farming requires a fairly high cost (Table 1). The rice production cost structure shows that the largest proportion of costs are used to wage labor (including tractors) of Rp. 4.19 million (41.90%), then the cost to lease land for Rp. 3 million (30.00%), cost of production input of Rp. 2.76 million (27.60%), and other costs amounting to Rp 500 thousand (5.00%).

The results of the analysis of R / C ratio of rice farming in normal climatic conditions is 1.56, indicates that the use of one unit will produce 1.56 units of input per unit output. The payback rate of rice farming is still effective, so the rice commodity to be financially viable for the effort since if the rental value of land is not taken into account, the value of R / C ratio reaches 2.23.

During flooding the cost of rice farming on climate change conditions during flooding is slightly higher than normal conditions Rp 10.40 million per ha. This high cost of rice farming especially due to the re land preparation, making drainage channels, do the stitching, or replanting, and suck up the water with diesel.

The rice production cost structure shows that the largest proportion of costs are used to wage labor (including tractors) up to Rp 4.64 million (44.20%), then the cost to lease land for Rp. 3 million (28.57%), the production input of Rp. 2.62 million (24.95%), and other costs up to Rp 240 thousand (2:31%). It appears that the flood impact increased costs for labor.

The average productivity of rice were 4.5 tones per ha per season with an average price of Rp 2.600 per Kg therefore the revenue Rp 11.70 million, with the net profit of Rp 1.30 million per ha per season. If the rental value of land is not taken into account, the profit reach Rp. 4.3 million per ha per season. These results showed that the analysis of R / C ratio under adaptation to flood is 1.09, indicated that the use of one unit will produce 1.09 units of input per unit output and its concluded as effectiveness.

Table 1. The Comparative Analysis of Input Output Between Normal Conditions and Adaptation Period During Flooding in District of Bantul, Yogyakarta, 2010/2011

Items	Normal		Adaptation	
	Quantity	Value (Rp)	Quantity	Value Rp
I. Expenditure	xxxxx	Xxxxx	xxxxx	Xxxxx
1. Seed (Kg)	35	297500	50	425000
2. Fertilizer (Kg)	xxxxx	Xxxxx	xxxx	xxxx
(1) Anorganik (Kg)	xxxxx	Xxxxx	xxxx	xxxx
a. Urea Tablet (Kg)	250	490000	200	392000
b. ZA (Kg)	50	65000	40	52000
c. SP-36 (Kg)	250	410000	200	328000
d. KCl (Kg)	15	45000	10	30000
e. PONSKA (Kg)	187,50	438750	150	351000
(2) Organik (Kg)	625	625000	650	650000
3. Pesticides	xxxxx	Xxxxx	xxxxx	xxxxx
a. Solid (Kg)	10	140000	10	140000
b. Liquide (Lt)	1,25	250000	1,25	250000
4. Labor	xxxxx	Xxxxx	xxxxx	xxxx
(1) Land preparation	xxxxx	Xxxxx	xxxxx	xxxx
(a) Tractor (Rp)	xxxxx	500000	xxxxx	500000
(b) Livestoct	xxxxx	-	xxxxx	-
(c) Household labor (Rp)	5	150000	8	240000
(d) Hired labor (Rp)	5	150000	8	240000
(2) Planting	xxxxx	Xxxxx	xxxxx	xxxx
(a) Household labor (Rp)	-	-	-	-
(b) Hired labor (Rp)	18	540000	18	540000
(3) Replanting				
(a) Household labor (Rp)	-	-	2	60000
(b) Hired labor (Rp)	-	-	7	210000
(4) Maintenance	xxxxx	Xxxxx	xxxxx	xxxx
(a) Household labor (Rp)	21	630000	21	630000
(b) Hired labor (Rp)	42	1260000	42	1260000
(5) Harvest and transportation	xxxxx	Xxxxx	xxxxx	xxxxx
(a) Household labor (Rp)	2	60000	2	
(b) Hired labor (Rp)	30	900000	30	60
5. Land lease (Rp)	xxxxx	3000000	30	900000
6. Tax (Rp)	xxxxx	22500	xxxxx	22500
7. Other expenditure (Rp)	xxxxx	30000	xxxxx	220000
Total expenditure (Rp)	xxxxx	10003750	xxxxx	10500500
8. Productivity (Kg)	6000	Xxxxx	4500	xxxxx
9. Income (Rp)	xxxxx	15600000	xxxxx	11700000
10. Net Income (Rp)	xxxxx	5596250	xxxxx	1299500
11. Income without land lease (Rp)	xxxxx	8596250	xxxxx	4299500
12. R/C Ratio	xxxxx	1,56		1,09
13. R/C Ratio without land lease	xxxxx	2,23		1,58

B. Drought Case

The analysis of costs and benefits of rice farming in normal climatic conditions compare to adaptation condition is presented in Table 2. The cost of rice farming in normal condition is Rp 8.91 million / ha, its indicates that rice farming need a fairly high

cost. The rice production cost structure showed that the largest proportion of costs were used for wage labor (including tractors) of Rp. 3.29 million (36.89%), then the cost of production of Rp. 3.07 million (34.49%), to lease land for Rp. 2.5 million (28.06%), and other costs Rp 50 thousand (0.56%).

Table 2. The Comparative Analysis of Input Output between Normal Conditions and Adaptation Period During Drought in District of Gunung Kidul, Yogyakarta, 2010/2011

Items	Normal		Adaptation	
			xxxxx	Xxxxx
I. Expenditure	35	280000	8000	320000
1. Seed (Kg)	xxxx	xxxx	xxxxx	Xxxxx
2. Fertilizer (Kg)	xxxx	xxxx	xxxxx	Xxxxx
(1) Anorganik (Kg)	275.00	508750	1850	462500
a. Urea Tablet (Kg)	50	62500	1250	43750
b. ZA (Kg)	-	-	-	-
c. SP-36 (Kg)	250	400000	1600	280000
d. KCl (Kg)	15	42000	2800	28000
e. PONSKA (Kg)	150	337500	2250	225000
(2) Organik (Kg)	600	600000	1000	650000
3. Pesticides	xxxxx	xxxxx	xxxxx	Xxxxx
a. Solid (Kg)	10	130000	13000	130000
b. Liquide (Lt)	1,5	262500	175000	262500
4. Labor	xxxxx	xxxx	xxxxx	Xxxxx
(1) Land preparation	xxxxx	xxxx	xxxxx	Xxxxx
(a) Tractor	xxxxx	450000	xxxxx	450000
(b) Livestoct	xxxxx	-	xxxxx	-
(c) Household labor	6	150000	25000	150000
(d) Hired labor	6	150000	25000	200000
(2) Planting	xxxxx	xxxx	xxxxx	Xxxxx
(a) Household labor	-	-	-	-
(b) Hired labor	20	500000	25000	500000
(3) Replanting			xxxxx	Xxxxx
(a) Household labor			-	-
(b) Hired labor			25000	250000
(4) Maintenance	xxxxx	xxxx	xxxxx	Xxxxx
(a) Household labor	22,5	562500	25000	562500
(b) Hired labor	45	1125000	25000	1225000
(5) Harvest and transportation	xxxxx	xxxxx	xxxxx	Xxxxx
(a) Household labor	4	100000	25000	100000
(b) Hired labor	28	700000	25000	600000
5. Land lease	xxxxx	2500000	xxxxx	2500000
6. Tax	xxxxx	20000	xxxxx	20000
7. Other expenditure	xxxxx	30000	xxxxx	120000
Total expenditure	xxxxx	8910750	xxxxx	9079250
8. Productivity	55,00	xxxxx	240000	xxxxx
9. Income	xxxxx	13200000	xxxxx	8400000
10. Net Income	xxxxx	4289250	xxxxx	(679250)
11. Income without land lease	xxxxx	6789250	xxxxx	1820750
12. R/C Ratio	xxxxx	1,48	xxxxx	0,93
13. R/C Ratio without land lease	xxxxx	2,06	xxxxx	1,28

During drought the cost of rice farming is Rp 9.08 million / ha, indicates that rice farming in drought conditions of climate change requires a slightly lower cost than normal climatic conditions. This is due to the reduced of inputs, because the use of fertilizer depend on the availability of water. In addition, in the event of extreme drought farmers usually switch the rice to crops, vegetables, tobacco, and even some farmers let the land fallow or not planted.

The rice production cost structure shows that the largest proportion of costs are used for wage labor (including tractors) Rp 4.04 million (44.47%), the cost to lease land for Rp. 2.50 million (27.54%), purchase production input Rp. 2.08 million (22.93%), and other costs up to Rp 140 thousand (1.54%).

The average productivity of paddy is only 3.5 tons per ha per season, with an average price of Rp 2.40 thousand per Kg therefore farmer get revenue Rp 8.40 million / ha / season. Meaning farmers suffered losses of Rp 680 thousand / ha / season. If the rental value of land is not taken into account, the profit rate of rice farming reached Rp. 1.82 million / ha / season.

The results of the analysis of R / C ratio of rice farming under climate change during drought is 0.93, indicates that the use of one unit of input will only produce 0.93 units output and concluded that the adaptation is not effective but when the rental value of land is not taken into account, the value of R / C ratio reached 1.28 was.

Table 2 indicated that the comparetion of R / C ratio between normal conditions and drought adaptation 1.48 in vs 0.93. Thus R / C ratio in drought adaptation is much lower than the R / C ratio in normal conditions , therefore categorized as not effective. However farmer done the adaptation strategies is intended to maintain production and reduce the risk of greater losses.

Conclusions and Recommendations

A. Conclusions

1. Technologies adaptation implementaed by farmers include: (a) the creation of dams, wells jointly and severally, tube wells, wells and pumps, (b) planning of cropping patterns adapted to climatic conditions (high rainfall and dry weather to plant rice with crops), (c) the use of seed short lifespan of varieties during the dry season (variety Situgonggo and Godogan), (d) a complete and balanced fertilization, adapted to climatic conditions, through reduction of urea fertilizer and

add organic fertilizer, and (e) improving farmers' knowledge about climate change and climate change impacts including the explosion of pests and plant diseases, through SLPHT, SLPTT, SLI.

2. Effectiveness of adaptation strategies pursued by groups of farmers to overcome the floods is very effective because the value of R/C ratio in flooding conditions is more than one.
3. The effectiveness of adaptation strategies pursued by farmers' groups to overcome the severe drought is not effective because the value of R/C ratio in drought conditions is smaller than one. This condition occurs because of adaptation strategies pursued by farmers' groups are not precise and intensity of drought occurring is quite high.

B. Recommendations

1. In order to get more effective adaptation strategies on climate change especially for drough and flood, forms of adaptation that is anticipatory and adaptive/responsives should continue to be extracted, developed and disseminated. At the same time, the availability of climate information system that is able to provide information to accurately forecast climate change should be improved, so that all stakeholders (BMKG, Department of Agriculture, BPTP, PPL, and farmer groups) can take appropriate action that is anticipatory and adaptive/responsives.
2. Local and central government through the relevant institutions should develop early warning system of climate change. The development of such systems need to be supported by hardware development (climate monitoring equipment), institutional development, and human resource capacity. Some basic information should be generated are: (1) the estimated magnitude and the time period of climate change, (2) the estimated area that is potential of negative impacts, and (3) the estimated magnitude of the negative impacts that may result
3. Climate information system that is developed should provide benefits to the agricultural sector and are able to reach out to groups of farmers or farmers in rural communities. The main function of the system is to deliver climate information generated from monitoring early to farmers quickly and accurately. To be worthwhile, the institution must provide information of weather forecast or

climatic conditions, long before the growing season so that the groups of farmers are able to anticipate climate change that will happen.

4. Operational policies in development and maintenance of agricultural facilities and infrastructure damaged by the impact of climate change should be prioritized. Development of agricultural infrastructure need to be focused on the development of rural roads, farm roads, irrigation networks, irrigation pumps, agricultural equipment and machinery (water pumps, tractors, power threshers, grain dryers).
5. Strengthen the monitoring system, especially the major pests and diseases that could potentially explosive in the climate change, especially for various pest and diseases, intencity of pest and the potential areas attact by the pest and diseases, estimation of negative impact and efforts to overcomes the problem. It is suggested to provide medical, tools and workers to prevent the pest and diseases.
6. In order to get more effective performance of farming during climate change could be done by: (a) using varieties suitable for drough and flood sircumtances, (b) appropriate planting systems, (c) developed irigation systems suitable for the climate, (d) using amount of fertilizer properly and (e) Best timing in harvesting and post harvest as well as using appropriate tools such as power thresher and dryer.

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