Rain-fed Farmers’ Strategy of adapting to climate change

W P Dewi¹, Sugihardjo¹, E Lestari¹, E Rusdiyana¹*, Widiyanto¹ and R Setyowati¹

¹Faculty of Agriculture, Universitas Sebelas Maret, Jl.Ir. Sutami No. 36.A, Kentingan, Jebres, Surakarta, 57126, Indonesia
*Corresponding author: eksarusdiyana@staff.uns.ac.id

Abstract. Climate change has led to changes in various sectors, one of those is the agricultural sector. The agricultural sector is a sector that is very vulnerable towards climate change because it affects on planting patterns, planting time, harvest quality and quantity output impact. Climate change’s phenomenon causes adaptive strategy from farmers in order to maintain the results of their own. This research aimed to find out the strategy taken by the dry land farmers to adapt to climate change. The subjects of research were rain-fed farmers in Gondangrejo Sub District, Karanganyar Research. The research design used was descriptive qualitative one with purposive sampling and snowball sampling techniques. Data collection was conducted using observation, in-depth interview, focus groups discussion, and documentation. The result of research shows that the adapting strategy taken by the farmers in dealing with climate change includes: changing planting pattern, changing plant variety used, changing fertilizer pesticide, and herbicide doses, developing irrigation technology, and changing post-harvest activities.

1. Introduction
Climate change has resulted in change in some sectors, one of which is farming sector. Farming sector is the one highly vulnerable to climate change because climate change affects cropping pattern, harvesting time, and harvest outcome, both qualitatively and quantitatively. Climate change also affects adversely the water supply and tends to decrease the quality of harvest outcome, and thereby ending up with harvest failure [1]. Climate change also affects directly harvest outcome, attack, and phosphate (P) removal [2].

Climate change also affects water supply in farming land, including dry land. Dry land is the one never inundated or filled with water in most of time along the year [3]. Although dry land in certain developing countries have watershed and irrigation channel, water supply for irrigation unsurely increases, particularly in farming sector [4]. Basic problem encountered in improving dry-land farming productivity is related to environmental factors, particularly the climate change and the shift of season beginning.

Wonosari village is one of regions in Gondangrejo Sub district, most areas of which are dry land. Wonosari is at 150m altitude, located on 7°29’50” SL and 110°51’26” EL. Climate condition of Wonosari village belongs to tropical climate with average rainfall of 3.151 mm per year, air temperature of 25-32°C, and air humidity of 68-97% [5]. Wonosari Village area width is 495.59 ha consisting of farmland (147.00 ha), dry land (341.19 ha), and etc (7.40 ha). By its use, dry land in Wonosari Village is 341.19 ha wide, belonging to two use categories: building or yard (132.09 ha or 61%), and garden or moor (209.10 ha) [6]. The cropping pattern of dry land farmers is so far determined by water supply (irrigation and rain-fed) [7]. Karanganyar Regency shows the tendency of climate change, as indicated with the change of rainfall. Gondangrejo Sub district has encountered the
decrease in rainfall rate from 2000-2500 mm before 1960 to 1500-2000 mm after 1980 [8]. Adapting strategy is very important to take by the farmers to survive amid climate change and to minimize the potential risk occurring in the following planting period, so that the purpose of research is to find out adapting strategy the dry land farmers take in Wonosari Village, Gondangrejo Sub district, Karanganyar Regency, in dealing with climate change.

2. Method

2.1. Fundamental research method
This research employed a qualitative approach with descriptive method analyzing the adapting strategy the dry land farmers take to face climate change occurring in Wonosari Village. The location of research was selected purposively by referring to dry land area in Wonosari Village, Gondangrejo Sub district, Karanganyar Regency. Most areas of Gondangrejo Sub district are dry land and still belong to Cemoro sub-watershed constituting the part of Bengawan Solo watershed.

2.2. Method of selecting informant
The method of selecting informant used in this research was purposive sampling (see on Table 1). Purposive sampling was used when an author has specific reason to choose certain respondent in his/her research [9]. The main informants in this research were selected using snowball sampling technique. Snowball sampling technique is a non-probability sampling one considered as unintentional sampling [10].

| No. | Method of Selecting Informant | Informants |
|-----|-------------------------------|------------|
| 1   | Purposive sampling             | Farming, Food, and Fishery Office of Karanganyar Regency, Coordinator of Agricultural Extension Officer in Agricultural Extension Office of Gondangrejo Sub district, Head of Farmer Groups and Society Leader |
| 2   | Snowball sampling              | Farmers running farming business for >30 years |

Source: Primary Data Analysis, 2021.

2.3. Data collection technique
- (in-depth interview): in-depth interview is a process of acquiring information using face-to-face encounter between interviewer and informant or interviewee, with or without interview guide [11]. The in-depth interviews uncovered a whole raft of relevant usability issues that meant that a reconception of the research was needed [12].
- Participatory observation: participatory observation is a technique of collecting data conducted systematically through observation. Participatory observation is the type of observation involving the author in the activities conducted by the person being the target of research, without resulting in the change in corresponding activity. The author tends to play passive role in participatory observation because the author will never interact intentionally with target population to get or to create group behavior. It is nearly always conducted silently, with the author never revealing their identity and actual objective [13].
- Recording and documentation: documentation is used to collect data from document source and recording [14]. Recording was conducted by collecting secondary data obtained from corresponding institution related to territorial data of Wonosari village.
- Focus group discussion: focus group discussion is a method of collecting qualitative data through group discussion and used as a qualitative approach to get in-depth understanding on social issues [15]. The characteristic of focus group discussion is to explore in-depth; therefore, it can be called an explorative method [16]. The number of informants in a focus group discussion is 7-10 (other
than observer and facilitator) [17]. Focus group discussion involves 10 informants including 4 representatives of farmers and 6 heads of farmer groups in Wonosari Village.

2.4. Technique of analyzing data
Technique of analyzing data used in this research was Miles and Huberman’s interactive model of analysis (1984). There are three stages in this data analyzing technique:

- Data reduction: the research reduces data by sorting or selecting, focusing attention, simplifying, and abstracting all types of information supporting the research obtained and recorded during the process of exploring data in the field.
- Data display: data display is a set of information organized in the form of description and complete narration, arranged based on the basic findings contained in data reduction and displayed logically and systematically using the author’s language, and thereby understandable.

Conclusion drawing/verification: conclusion drawing is an activity of interpreting the result of analysis and the data.

3. Result and discussion
The adapting strategy taken by farmers to deal with climate change in Wonosari Village, Gondangrejo Sub District is as follows.

3.1. Planting autonomous change
Climate change occurring in Wonosari Village, Gondangrejo Sub District, Karanganyar Regency that has occurred in the last 30 years also affects the change of planning pattern indirectly. Cropping pattern is the way of planting several types of plants in turn or in rotation in every planting season (see on Table 2).

| No. | Cropping pattern 30 years ago | Current Cropping pattern |
|-----|--------------------------------|--------------------------|
| 1.  | Paddy-Horticultural plant     | Paddy-paddy-paddy        |
| 2.  | Paddy-Peanut                  | Paddy-paddy-horticultural plant (peanut) |
| 3.  | Paddy-paddy                   | Paddy-horticultural plant (Corn/Peanut) |

Source: Primary Data Processing, 2021.

Cropping pattern in Wonosari 30 years ago was divided into 3 (three): 1st Cropping pattern consisting of Paddy-Horticultural plant commodity, 2nd Cropping pattern consisting of Paddy-Peanut and 3rd Cropping pattern consisting of Paddy-Paddy. In addition to paddy and horticultural plant, farmers also plant sweet potatoes, corn, long bean, wijen, and various vegetables like tomato, chili, and mustard green. The farmers’ cropping pattern has changed now, due to the development of irrigation infrastructure available. There are three cropping patterns applied by farmers in the last years: 1st cropping pattern consisting of Paddy-Paddy-Paddy, 2nd cropping pattern consisting of Paddy-Paddy-Horticultural Plant (peanut), and 3rd cropping pattern consisting of Paddy-horticultural plant (Corn, Peanut). The cropping pattern applied by farmers 30 (thirty) years ago can harvest paddy once a year only but the current one can do so three times a year. The change in planting patterns is one example of autonomous adaptation. Autonomous adaptation is the form of reaction to climate change, for example: the farmers change planting timing or soil cultivation or harvesting timing due to the change of rainfall pattern [18].

3.2 The change of Seed Variety Use
The variety used by farmers in Wonosari 30 years ago has changed now. The change is supported with the presence of innovation made by government annually, related to the better variety. Table below
presents data on the use of paddy, corn, and peanut commodity varieties by farmers in Wonosari Village, Gondangrejo Sub District, Karanganyar Regency 30 years ago and currently (see on Table 3).

Table 3. The changing use of paddy, corn, and peanut commodity varieties.

| No. | Type of commodity | Varieties used 30 years ago | Varieties used currently |
|-----|-------------------|-----------------------------|--------------------------|
| 1.  | Paddy             | Gogo, Gondel, Cempo, PB 5, IR 32, 36, IR 42, IR 64, PP, Situ PB 26, PB 28, PB 29, PB 30, Bagendit, Rajalele, Mikongga, IR 36, IR 50, IR 64, Segreng | IR 32, 36, IR 42, IR 64, PP, Situ Bagendit, Rajalele, Mikongga, Ciherrang, Inpari 32, Inpari 33, Inpari 42, Inpari 47, Cakra Buana, Segreng |
| 2.  | Corn              | Local                        | Bisi I, Bisi II, Pioner, Bima, P21, P27 |
| 3.  | Peanut            | Local                        | Lokal                     |

Source: Primary Data Processing, 2021.

The use of commodity varieties cultivated by farmers, both paddy and corn, has changed. Paddy varieties used in ancient times were Gogo, Gondel, Cempo, PB 5, PB 26, PB 28, PB 29, PB 30, IR 36, IR 50, IR 64 and Segreng varieties. While the paddy varieties used today are IR 32, 36, IR 42, IR 64, PP, Situ Bagendit, Rajalele, Mikongga, Ciherrang, Inpari 32, Inpari 33, Inpari 42, Inpari 47, Cakra Buana, Segreng. Corn varieties used in ancient times were local varieties, while now the varieties used are Bisi I, Bisi II, Pioner, Bima, P21, P27. Changes in the use of paddy and corn varieties from year to year are due to technological advances and the wide spread of information on superior seeds that are resistant to pests, diseases to water shortages such as the Mikongga variety. Use of drought-resistant seed varieties is one which of farmers adaptation strategies to climate change [19]. Changes in the use of seed varieties is one of planned adaptation type. This type is comprehensive and multi-sectoral in nature. For example, the policy of distributing and selecting plant or seed variety based on region, corresponding to the climate of respective regions followed with the provision of farmers’ access to weather information and farming credit or input scheme corresponding to the plant variety [20]. The selection of corn varieties is also based on the selling value of corn with varieties Bisi I, Bisi II, Pioner, Bima, P21, P27 which have a higher economic value compared to local corn. Local corn in ancient times was only used for self-consumption and animal feed. However, currently the corn crop is used for commercial purposes.

3.3 The construction of irrigation channels
Wonosari Village is a dry or rain-fed land area that is highly dependent on rainwater. This has led farmers to take the initiative to develop irrigation technology in the form of shallow wells and deep wells. Irrigation is one form of adaptation strategy to climate change [21]. Shallow wells or wells are wells made with a depth of 0-25 meters with a water absorption capacity of only 12 meters as Figure 1. Shallow well rental services sourced from river water with services of IDR 20,000 - IDR 35,000 / hour. The second type of age is deep wells. The deep well in Wonosari Village which is used to irrigate agricultural land is divided into 2: PWS (and Sibel. Sibel is a deep well with a depth of> 50 meters as Figure 5. Irrigation services originate from Sibel, namely IDR 15,000-IDR 25,000 / hour. The second type of deep well is PWS as Figure 4. PWS is a type of deep well with a depth of up to 50-100 meters with a water discharge capacity of up to 1,000 m³ while usage services are IDR 80,000 / hour.

The source of water used for agriculture in Wonosari Village also comes from the embung. Embung is a small reservoir that functions as water storage during the rainy season and is used when water shortages usually occur in the dry season. Embung is a small reservoir that functions to hold water when the water is excessive in the rainy season and is used when there is a shortage of water in the dry season for various purposes, for example for drinking, irrigation, tourism, flood control and others [22]. The existing embung in Wonosari Village already has 6 points. The embung measures 5 x 25 x 2 meters as Figure 3. The last irrigation channels from river river which is part of Bengawan Solo River Basin as Figure 2.
3.4 The changing use of fertilizer dosage

The intensity of the use of fertilizers in Wonosari Village, either organic fertilizers or chemical fertilizers, has changed over years. The use of manure 30 years ago was more than the use of chemical fertilizers. However, for now, use of chemical fertilizers tends to be overused compared to manure or organic fertilizers. This is according to what Darmosukarto said:

“Jaman rumiyen niku namung ngangge pupuk kandang mawon mbak, pupuk kandang niku diberikan 1 kali dalam masa tanam (ketigosak derange wanci labuh, pupuk sampun diserbar sedayo wonten saben, mange hujan turun mboten kangelan nyebabar.) sebelum di tractor disukani pupuk kandang riyen. Sakniki selainn gangge pupuk kandang ugi ngangge pupuk kimia. Pupuk kandang naming sekedik, kathah pupuk kimia”

Meaning: I used manure in the past, manure was given once during planting period (dry season before the beginning of planting season). Before the soil was cultivated with tractor, manure has been spread first. Now chemical fertilizers are used in addition to manure, even its amount is larger than that of manure.

The current use of manure tends to decrease, while the use of chemical fertilizers tends to be excessive, so that agricultural land in Wonosari Village is already dependent on chemical fertilizers. Fertilization with chemical fertilizers is carried out 2-3 times in 1 planting period, while manure is only applied once during the dry season. The use of chemical fertilizers is widely used by farmers because with information, offers or promotions and the nature of farmers who tend to want to try new things, and the desire to get maximum yields, the level of dependence of farmers on chemical fertilizers is very high.

3.5 The changing use of pesticide and herbicide doses

The use of pesticides and herbicides has changed over years. Farmers in ancient times tended not to use pesticides or herbicides. Farmers eradicate pests and diseases by relying on natural enemies of pests or the disease itself. Meanwhile, in eradicating weeds, it is overcome by manually weeding or matun by hand. The use of pesticides and herbicides that are applied to farmers' land at present tends...
to be large or high. Farmers eradicate pests and diseases in their plants by applying various kinds of pesticides. Farmers also use various kinds of herbicides in addition to manual weeding. Farmers do the two combinations, namely manual weeding and the use of herbicides because the number and types of weeds or plant pests are increasing:

“hama dan penyakit saat sekarang lebih ganas sekarang, kalau kemarin-kemarin untuk mengatasi hama wereng cukup menggunakan pestisida dengan dosis yang rendah, tetapi untuk tahun tahun sekarang kandosinya harus lebih tinggi lagi. Suket niku kathah sak niki. Suket jaman niko naming dicabut imawon, sak niki suket e arang arang amarg anggunakne herbisida.”

Meaning: "Pests and diseases are now more virulent now. In the past, we only need to use a low dose of pesticides to overcome the plant hopper pests, but the dosage must be even higher presently.. The grass in the past was removed by hand only, it is now removed using herbicides."

3.6. The changing proportion of crop storage

Post-harvest rice commodities are activities that include harvesting rice in the fields, threshing of rice panicles, transporting crops, drying, storing and milling grain into rice so that it is ready for sale or for family consumption. Post-harvest activities carried out by farmers in Wonosari Village are also not much different; however, most farmers now prefer to be sold directly to middlemen while in the fields. Farmers in Wonosari Village in the past for the last 5 years had a storage area for their crops at the village level called the village barn. The village granary functions as a place to store crops, especially rice during the main harvest. However, in the last 5 years, the village barn in Wonosari Village has stopped operating due to the absence of any management willing to manage the village barn.

The percentage of crops that were brought home and sold directly in the fields 30 years ago has changed compared to now. The yields of 30 years ago were used 100% for their own consumption because in 1 year farmers could only harvest rice once so it took a long time to harvest rice again. Farmers now harvest during the first planting period or MT I, so the percentage of harvest that is sold is 70%, while only 30% are taken home. However, during the second planting period or MT II, only 30% of the yields were sold, while 70% were taken home. This was done because at the time of the third planting period or MT III the farmers were not certain about their yields because rainfed land or dry land, if at the end of the third planting period or MT III there was no rain, the farmers would experience crop failure, in addition, at the time of planting, the third planting or MT III farmers usually plant secondary crops in the form of corn and peanuts because these commodities do not need too much water or are resistant to water shortages.

Farmers with irrigated land have a different behavior in selling their crops from farmers with rainfed land. Farmers with irrigated land can harvest rice up to 3 times a year, so the percentage of harvest that is sold is more than the percentage of harvest that is brought home, there are even farmers who sell all of their crops (100%) to middlemen. However, this actually has an impact on food availability because at the end of the planting period irrigated farmers usually buy rice because the rice stock is running low.

4. Conclusion

Wonosari Village, Gondangrejo Sub district, Karanganyar Regency is dry land highly vulnerable to the climate change. Adaptation strategy is important to take to keep surviving in facing climate change and minimizing the potential risk in the following planting period. The strategies of adapting to climate change taken by the farmers in their farming are to change cropping pattern, to change the seed variety used, to construct irrigation channel, to change the dose of fertilizer used, to change the dose of pesticide and herbicide used, and to change the proportion of harvesting outcome stored.

References

[1] Ida N H and Suryanto S 2015 Pengaruh perubahan iklim terhadap produksi pertanian dan strategi adaptasi pada lahan rawan kekeringan J. Eko. & Stud. Pemb. 16 42–52
Zhaozhi W, Zhang T Q, Tan C S, Lulin X, Melissa B and Qi Z M 2021 Modeling impacts of climate change on crop yield and phosphorus loss in a subsurface drained field of Lake Erie region, Canada J. Agri. Sys. 190 103110

Dariah A, Rachman A and Kurnia U 2004 Erosi dan degradasi lahan kering di Indonesia dalam teknologi konservasi tanah pada lahan kering (Bogor: Badan Penelitian dan Pengembangan Pertanian)

Nur M A M and Normaz W I 2017 Land irrigation and food production in dry-land developing countries J. Agri. Forest. and Plant. 5 7–14

Sigma S 2018 Pemahaman petani terhadap program sekolah lapang iklim di Desa Wonosari, Gondangrejo, Karanganyar, Jawa tengah [Thesis] (Surakarta: Pascasarjana UNS)

BPS Karanganyar 2019 Kecamatan Gondangrejo dalam Angka 2019 (Karanganyar, Indonesia: Badan Pusat Statistik Kabupaten Karanganyar)

Andrianitya H, Hari H 2017 Analisis perubahan perilaku petani sebagai adaptasi terhadap dampak perubahan iklim di daerah iklim kering Nusa Tenggara Timur. Proc., Seminar Nasional Agroinovasi Spesifik Lokasi untuk Ketahanan Pangan pada Era Masyarakat Ekonomi ASEAN (Bogor: Balai Besar Pengkajian dan Pengembangan Teknologi Pertanian)

Komariah 2012 Analisis proses pergeseran musim sebagai dampak anomali iklim dan pengaruhnya terhadap perubahan system budidaya pertanian di lahan kering (studi kasus di kabupaten Karanganyar, Jawa Tengah) [Report] (Surakarta: Fakultas Pertanian, Universitas Sebelas Maret)

Carter R, Hay L and Elizabeth Domholdt 2011 Rehabilitation Research: Principles and Applications (Missouri: Elsevier Saunders)

Babbie E 2008 The Basics of Social Research, Fourth Edition (USA: Thomson Higher Education)

Linarwati M, Azis F and Maria M M 2016 Studi deskriptif pelatihan dan pengembangan sumber daya manusia serta penggunaan metode behavioral event interview dalam merekrut karyawan baru di Bank Mega cabang Kudus Journal of Management 2(2)

Adams A and Cox A L 2008 Questionnaires, in-depth interviews and focus groups Research Methods for Human Computer Interaction ed’ Cairns, Paul and Cox, Anna L (Cambridge, UK: Cambridge University Press) pp 17–34

Qaddo M 2019 Participant observation as research methodology: Assessing the validity of qualitative observational data as research tools [Online] Available: https://www.researchgate.net/publication/334726309_Participant_Observation_as_Research_Methodology_Assessing_theValidity_of_Qualitative_Observational_Data_asResearchTools

Borg W R and Gall M D 1989 Educational research (New York: Longman)

Nyumba T, Wilson, Derrick, Christina, Mukherjee and Nibedita 2018 The use of focus group discussion methodology: Insights from two decades of application in conservation. J. Method. in Eco. and Ev. 920

Sugarda and Yanti B 2020 Panduan praktis pelaksanaan focus group discussion sebagai metode riset kualitatif (Jakarta: PT. Gramedia Pustaka Utama)

Sugiyono 2017 Memahami Penelitian Kualitatif (Bandung: CV. Alfabeta)

Lasco R D, Habito C M D, Delfino R J P, et al. 2011 Climate change adaptation for smallholder farmers in Southeast Asia (Philippines: World Agroforestry Centre)

Gebru G W, Ichoku H E, & Phil-Eze, et al. 2020 Determinants of smallholder farmers’ adoption of adaptation strategies to climate change in Eastern Tigray National Regional State of Ethiopia J. Helioyon 6(7) 1-9.

Clements R, Haggar J, Quezada A, and Torres J 2011 Technologies for climate change adaptation - agriculture sector (Denmarks: Danmarks Tekniske Universitet, Risø Nationallaboratoriet for Bæredygtig Energi)

Menike L M C S and Arachchi K A G P K 2016 Adaptation to climate change by smallholder
farmers in rural communities: evidence from Sri Lanka *Procedia Food Science Journal* **6** 288–92

[22] Robert, Kodoatie J and Roestam S 2010 *Tata ruang air* (Yogyakarta: Andi Offset)