Agronomic and social strategies on food crop production for climate change adaptation at Palu Valley, Central Sulawesi, Indonesia

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Abstract. Climate change has become a threat to the agricultural sector, especially at the farmer level. Adaptation to climate change is now gaining wide attention; however, farmers still have the low adaptive capacity and do not have the essential technology for adaptation to climate change. Such adaptation to climate change is necessary to reduce the risk of losses in the agriculture sector. The study aims to know the perception and adaptation strategies to climate change on farmer level especially in food crop production, then correlated it with government recommendation strategies. A survey had been conducted to farmers in Palu Valley, Central Sulawesi, and a descriptive analysis approach is employed in this research. The findings show that there are challenging issues such as the socialization of meteorological information, a planting calendar application, the dissemination of essential technologies for climate change, and also social aspects such as insurance and indigenous knowledge. A number of recommendations were proposed to ensure the more efficient and beneficial use of technology recommendations in coping with climate change in food crop production. 1) Improving farmer’s knowledge by spreading climate change technologies dissemination. 2) Providing user-oriented features to increase farmer awareness and responses. 3) Enabling different institutions and stakeholders for programs cooperation in coping with climate change challenges.

1. Introduction
Climate change has become a threat to the agricultural sector especially in Indonesia where mostly farming cultivated by smallholder farmers. Smallholder farmer is greatly affected and becoming vulnerable to extreme climate change in developing countries [1]. However, farmer adaptations to climate change in developing countries are still low and not yet have a precise technology recommendation to cope with climate change [2]. Therefore adaptations to climate change becoming an important issue and gaining more attention from the Indonesian government, moreover gaining concern from around the world [3].

Agriculture as the biggest economic sector in Indonesia also Central Sulawesi is highly depended on the weather, even though some technology and infrastructure already built such as irrigation facilitation and climate change tolerant technologies. The climate change not only leads to water availability but also the lively plant itself where pest and plant diseases can be stimulated by the weather which caused loss production. The adverse impacts of climate change on agricultural production lead to an increase the poverty level [4]. For this reason, adaptation to climate change is necessary to reduce losses in agricultural production [5]. Furthermore, adaptive capacity to climate change becomes the main point which should not only as a priority but also a duty for the government to ensure the food security and farmer’s welfare [6,7].
Different options of adaptive strategies to climate change already known and have been studied around the world. It can be technical or social aspects. The studies found some strategies included crop management, land management, irrigation management, income diversification, and rituals [7]. On the other hand, the studies mentioned that farming activities are not always effective as a solution for coping climate variability [8]. Therefore, there is a need for alternative adaptation to effectively coping the climate change in agricultural production.

To anticipate the effects of climate change on the agricultural sector, it is necessary a direction and strategies for anticipating and preparing adaptation action programs, it can be supported by innovative and adaptive technology. Even the agriculture sector policy is positioning its adaptation efforts as a top priority. Adaptation efforts are seen as rescue measures in order that food security and development goals of agriculture can be achieved. Adaptation efforts are carried out through development agriculture that is tolerant of climate variability. Indonesian government specifically the ministry of agriculture provides some technologies as options to adapt to climate change such as (1) Improved water management, including irrigation systems and networks. (2) Development of water harvest technology, for example, a ditch dam, and efficient water system such as drip irrigation. (3) Development varieties which are tolerant of stress-stressed environments such as rising temperatures, drought, inundation (flooding), and salinity. (4) Development of land and plant management technologies to improve the adaptability of plants. (5) Development of farming protection systems from failures due to climate change or crop weather insurance [9].

Famers can use weather forecast information and technology recommendations to modify in agricultural production which results in the reduction of loses or adaptation cost to climate change [10]. The government already build a system to provide some tools and recommendations in climate change strategies including meteorological information. However, the applications of technologies in the farmer’s level are not being recorded yet. The study aims to find the answer of the following questions: (1) How is farmer’s awareness of climate change in Central Palu Valley? (2) What strategies (agronomic and social) are used by smallholder farmers to adapt to climate change variability in agricultural production?

2. Methodology
The study used primary and secondary data. Primary data were conducted by a survey on 80 respondents of farmers, used a simple random sampling method. The study conducted in Sigi Regency especially Palu Valley which covered four Sub-district Dolo, Dolo Barat, Sigi Bimoreo, and Gumbasa from May to August 2019. The data were analyzed descriptively. Proportion analysis was used to measure the perception of awareness farmers to climate change. Hypothesis for farmer perception to climate change are:
H0: P ≤ 50%
H1: P > 50%
H0: Being expected that less than or equal to 50% farmer in Sigi have high awareness to climate variability
H1: Being expected that more than 50% farmer in Sigi have high awareness to climate variability

The significance level is 0.05, used formula: 
\[ Z_{hit} = \frac{x - n \cdot p_0}{\sqrt{\frac{p_0 (1-p_0)}{n}}} \] .............................. (1)

3. Results and discussion
As agriculture’s dependency on optimal weather and water availability, recently climate variability becomes the main factor which is determining crop productivity. As climate change occurred, it gave direct and indirect effects on the agriculture sector. Farmers gave responses as an adaptation to climate variability which the government also gave intervention to trough dissemination or programs. The
adaptation can be agronomic, social-economic or even both of them. The study already formulates the framework of climate change adaptation as shown in Figure 1.

![Figure 1](image)

**Figure 1.** The framework of the climate change adaptive in Sigi, Central Sulawesi, 2019.

Climate change which occurred in Central Sulawesi has a direct and indirect effect on the agricultural sector as shown in Table 1.

**Table 1.** Summary of observed of the direct and indirect effect of climate change in the agricultural sector, 2019.

| Climate change phenomena | Direct | Effect | Indirect |
|--------------------------|--------|--------|----------|
| 1. Drought               | 1. Loss of production |
| 2. Intense rains and flood | 2. Lesser up to no farmer income |
| 3. Increasing pest and plant diseases | 3. Less focus on the farm because have another source income |
| 4. Failure harvest       | 4. Shift to another job or source income |

The effect of climate change in Indonesia especially in Central Sulawesi included drought, intense rain and flood, increasing pest and plant diseases, and finally failure to harvest. Because of the direct effect of climate change, the farmer might not get income from their fieldwork. Therefore they were looking for another source income both in the agriculture sector and the non-agricultural sector. Subsequently, farmers no longer focus on the field and have an impact on production and income.

Generally, farmers do not always know what climate change term is but they understand the effect of climate change. For instance, farmers don’t know about La Nina and El Nino, but they know about rainfalls which not follow the pattern in the past time. Farmers have a hard time to decide the right time of cropping or crop failures due to a long drought or unexpected rains. Farmers gave a response to climate change as they got an incident or effect of climate change. Base on the survey of 80 respondents in Palu Valley which were measured by proportion test. Farmers are more than 50% highly aware of climate change even though they don’t know the terms of climate change. It means that they used agronomic and social-economic adaptation as a response to climate change, even though some farmers still do nothing and just accepted the risk or effect.
Table 2. Summary proportion test on Farmers perception to climate change, 2019

| Null hypothesis | Significance level | Proportion test significance | Decision |
|-----------------|--------------------|------------------------------|----------|
| Being expected that less than or equal to 50% farmer in Sigi have high awareness of climate variability | 0.05 | 0.000 | Reject H0 |

Farmers will decide the kind of cultivated plants based on their experience and the recommendation from the government. Farmers have been implementing some adjustments in farm management practice as an adaptation in response to climate change. Autonomous adaptations are adaptation tips that have been independently applied by farmers without government intervention [11]. On the other hand, planned adaptation (planned adaptation) is an adaptation whose development involves institutions and policies, the goal of strengthening the adaptive capacity of farmers by maximally utilizing new technologies and infrastructure [12]. Reactive adaptation is a means of adjustment that is done when the impact of climate change has been felt, while anticipatory adaptation is an adaptation that is proactive and carried out before the full impact of climate change is felt [12]. In general, anticipatory adaptation is more effective, although in the short term the benefits are often not immediately felt. The study found some agronomic strategies done by farmers in Central Sulawesi and its category which are shown in Table 3.

Table 3. Agronomic adaptive of climate change and its category, 2019

| Adaptive Strategies | Frequency | Percentage (100) | Category | Characteristics |
|---------------------|-----------|------------------|----------|-----------------|
| Delay planting time | 12        | 15               | Autonomous adaptation | Reactive adaptation |
| Changing crop variety | 06       | 8                | Planned adaptation | Anticipatory adaptation |
| Changing commodity  | 15        | 19               | Autonomous adaptation | Anticipatory adaptation |
| Water management    | 07        | 9                | Planned adaptation | Anticipatory adaptation |
| Farming practices   | 27        | 34               | Autonomous adaptation | Anticipatory adaptation, Reactive adaptation |
| **Affected and do nothing** | **13**   | **16**           | None          | None             |
| **Total**           | **80**    | **100**          |             |                  |

Agronomic adaptive strategies include different adjustments related to agricultural techniques, water management, and soil conservation [13]. Developing agricultural techniques had significant effects on farmer adaptation to climate change in many countries such as the Middle East [14] and North America [15]. In some studies report that agronomic studies related to cultural practices such as shifting planting time, changing varieties, crop pattern, commodity diversification [16,17]. One of these strategies is delay planting time due to climate variability in order to avoid losses. For example, in drought season farmers will delay planting corn after starting the rain to get much available water while if the rain is too hard farmers also will delay the planting time to avoid much water that can make corn rotten in the early stage of its growth. Changing crop variety means switching from one crop variety to another to make an adjustment in response to climatic stresses and changes. Ministry of agriculture provides some new varieties which are adjusted to climate change such as rice for dry land Inbri Padi Gogo (Inpago) and composite varieties for the corn which drought tolerant. However, most farmers under programs
that used these varieties due to limitation of seed availability. Thus, there is a need for a system that provides the seed continually.

Every food crop commodity has a specific need for water. Rice needs more water than corn, therefore in some area farmers decide to switch to another commodity due to water availability. For example in Dolo Barat Sub-district water always become a social problem due to its water distribution. The long of drought influence some farmers to switch commodity from rice to corn, while in Biromaru Sub-district some farmers switch to a green bean which needs less water. Another agronomic strategy is water management. Alternatives for climate change are to provide water by making shallow wells that were combined with a sprinkler. The sprinkler irrigation system is recommended especially for a high-value commodity such as horticulture. The high cost as mainly the reason. Another water management system is to manage the water in rice namely intermittent irrigation. In these systems, the farmer needs to maintain field rice not to be continuously flooded to make maximum yields. Farming practices including made graded furrow in one seasonal crop such as corn. The furrows are using to control air in the rainy season to avoiding flooding. One farming practices is not to weed the plants in the dry season due to maintaining soil and plant moisture. In the rainy season, weeds are freed to maintain plant moisture.

Currently social-economic becomes important adaptive strategies also applied by farmers around the world. Some strategies included local wisdom, insurance, and program such as farmer empowerment. The social-economic of climate change adaptation and its category are shown in Table 4.

| Adaptive Strategies                      | Frequency | Percentage | Category       | Characteristics     |
|------------------------------------------|-----------|------------|----------------|--------------------|
| Government assistance                    | 10        | 13         | Planned adaptation | Anticipatory adaptation |
| Use indigenous knowledge/local wisdom    | 17        | 21         | Autonomous adaptation | Anticipatory adaptation |
| Access to credit                         | 03        | 04         | Autonomous adaptation | Anticipatory adaptation |
| Access to insurance                      | 0         | 0          | Planned adaptation | Anticipatory adaptation |
| Did not harvest to save expenses         | 02        | 03         | Autonomous adaptation | Reactive adaptation |
| Off-farm work                            | 12        | 15         | Autonomous adaptation | Reactive adaptation |
| Affected but do nothing related social and economic aspect | 36        | 45         | None            | None |
| **Total**                                | **80**    | **100**    | **None**        | **None**           |

One local wisdom is planting by looking at the moon in the sky. Farmers start to plant food crops in the middle of the moon in the sky because it is believed to be protected from disease. Logically, at the full moon, pests will come to the plant because of the influence of full light which attracts pests to come. For some Balinese farmers, planting is carried out on Hari Srigati mudhu/munggah, which mean time when at that time it is believed that the rice to be planted can produce at maximum and avoid pests and diseases. Local wisdom for determining other planting times is using kapok fruit, where the kapok fruit has started to become green, farmers will start planting because it is the beginning of the rainy season. If the fruit plants are tubers, the farmer will plant on Saturday, and then if the plants bear fruit on top or hanging fruit, the farmer will plant on Friday. If plants that contain or grain like rice, so that the plants can produce a maximum of farmers choose Thursday. If mangoes do well, farmers believe that the production will be good. Dense fruiting mango trees symbolize the stability of the climate where the nature of the rain is normal.
Currently, the adaptation of climate change by meteorological information and modern communication was already widely used in the agriculture sector. One of the meteorological technology recommendations from the Ministry of Agriculture is planting calendar. Planting calendar contains technology recommendations and production facility needs at the sub-district level throughout Indonesia. Factual analysis and using forecast data from the Meteorology Climatology and Geophysics Agency (BMKG) resulted in four possible scenarios of climate conditions and potential, namely: 1) existing conditions commonly used by farmers, 2) potential in wet years, 3) potential in normal years and 4) potential in dry years [17]. Based on Table 3 and Table 4 we know that in farmer respondents none that used meteorological information as direct guidance to adapt to climate change. They still used local wisdom and government assistant based on the program such as Upaya Khusus (Upusus). Even mostly farmers did not really react in social-economic ways to adapt to climate variability. Another program from the government is Rice farming Insurance or Asuransi Usaha Tani Padi (AUTP), as one agricultural insurance for rice farming as an instrument to protect failure harvesting caused by climate change such as drought, flooding, and pest and disease attack. The government gave subsidy up to 80% of the premium. However, none of the farmer’s respondents used this facility because of less information on farmer level especially non active farmers.

4. Conclusion and recommendation

The findings show that there are challenging issues such as the socialization of meteorological information, a planting calendar application, the dissemination of essential technologies for climate change, and also social aspects such as insurance. A number of recommendations were proposed to ensure more efficient and beneficial use of technology recommendations in coping with climate change in food crop production namely: 1) Improving farmer’s knowledge by spreading climate change technologies dissemination. 2) Providing user-oriented features to increase farmer awareness and responses. 3) Enabling different institutions and stakeholders for programs cooperation in coping with climate change challenges.

References

[1] Comoe H and Siegrist M 2015 Mitigate Adaptation Strategies GI 20 179–199
[2] Thornton T F and Comberti C 2013 Climate Change 115 611–628
[3] Lotze-Campen H L and Schellnhuber H J 2009 J Verbr Lebensm 4 145–150
[4] Misra A K 2012 Mitigation Adapt Strategy Global Change 18 673–689.
Connolly-Boutin LC and Smit B 2015 Reg Environ Change 16 385-399
[5] Hirota T, Usuki K, Hayashi M, Nemoto M, Iwata, Y, Yanai Y, Yazaki T, and Inoue S 2011 Mitig Adapt Strat Gl 16 791–802
[6] Bryan E, Deresa T, Gbetibouo G A, and Ringler C 2009 Environ Sci Policy 12 413–426
[7] Kibue G W, Pan G, Zheng J, and Mao L 2015 Environ Dev Sustain 17 379–391
[8] Esham M and Garforth C 2013 Mitigation Adaptation Strategy GI 18 535–549
Marshel N A, Gordon I J, and Ash A J 2011 Clim Change 107 511–529
Qiu Z and Prato T 2012 Mitig Adapt Strat Gl 17 223–242
[9] Research and Development Institute 2011 Adaptation of Climate Change in Agricultural Sector (Jakarta: Research and Development Institute. Ministry of Agriculture) p 73
[10] Traerup S and Stephan J 2014 Clim Change 131 435-449
[11] Lasco R D, Habito C M D, Delfi no R J P, Pulhin F B, and Concepcion R N 2011 Climate Change Adaptati on for Smallholder Farmers in Southeast Asia (Philippines: World Agroforestry Centre) p 65
[12] Dolan A H, Smit B, Skinner M W, Bradshaw B, and Bryant C R 2001 Adaptation to Climate Change in Agriculture: Evaluation of Options: a report Occasional Paper No. 26 (Canada: Department of Geography, University of Guelph)
Clements D R and Ditommaso A 2011 Weed Research 51 227-240
[13] Below T B, Schmid J C and Sieber S 2014 Reg Environ Change 15 1169-1180
[14] Iglesias A, Mougou R, Moneo M and Quiroga S 2011 Reg Environ Change 11 159–166
[15] Graso M and Feola G 2012 *Reg Environ Change* **12** 607–618
[16] Reidsma P, Ewert F, Lansink Ao and Leemans R 2010 *Eur J Agron* **32** 91–102
    Arbuckle Jr J G, Morton L W and Hobbs J 2013 *Clim Change* **118** 551–563
[17] Suwitra I K, Biolan H, Gafur S, Soeharsono and Raharjo Y P 2015 Kalender tanam KATAM solusi cerdas bagi petani ditengah perubahan iklim (Palu: Central Sulawesi Assesment Institute of Agricultural Technology)

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