Strategy for adaptation of rice plant management on the climate changes impacts in Soppeng Regency, South Sulawesi Province, Indonesia

Winarno, K Mustari and A Yassi
Department of Agronomy, Faculty of Agriculture, Hasanuddin University, Jl. Perintis Kemerdekaan KM 10 Makassar 90245, Indonesia

E-mail: yassi.amir@yahoo.com

Abstract. The global climate change resulting in shifting patterns distribution of rain was influenced to growth and development of rice plant. The aims of this study were to guide the implementation of rice cultivation technology based on climate change, to change the mind set of farmers from the hereditary habits to better system according to the climate change model, and to formulate the adaptation strategy to climate change impact in the management of rice plant in Soppeng Regency. The study began in January to April 2017 at 8 (eight) sub-districts in Soppeng Regency, South Sulawesi Province. The study employed descriptive quantitative study with survey model. Eighty farmers were selected purposively as respondents who are assumed to be able to answer the aspects studied such as production variables, diffusion of innovation, climatic elements, and government policy. Data analysis was descriptive quantitative analyzing rainfall according to Schmidt-Ferguson, SWOT analysis, and Analytical Hierarchy Process (AHP) with expert choice program 11. The results of analysis with AHP method indicate that cultivation technology adaptation that can be applied to the rice planting management in Soppeng Regency was based on the sequence of priority scales. The component of the planting schedule has the highest weight of 18.8%, followed by the improvement of planting patterns 15.8%, the use of improved varieties 15.6%, water management 14.6%, 14.0% system improvement, 7.9% fertilization, pest control 7.7%, and harvesting component of 5.6%. Some alternative activities or programs on climate change adaptation strategy in rice cultivation are: (1) field school activities; (2) cultivation technical training; (3) participatory pest surveillance; (4) site-specific climate information procurement; (5) climate change socialization activities; (6) creation of experimental farm; (7) matching cultivation variety with climate condition; (8) diversification and crop rotation; (9) seed procurement; and (10) budgets of farmers’ groups.

1. Introduction
Global warming causes an increase in the intensity of extreme climatic events (El-Nino and La-Nina) and seasonal irregularities. Future global climate change is predicted to cause the frequency and intensity of extreme climate events to increase. The earth's climate is changing rapidly due to increasing greenhouse gas (GHG) emissions as a result of human activities. Increasing the GHG content causes a GHG effect in the atmosphere. This GHG effect inhibits the release of heat from the atmosphere which causes the earth's temperature to increase.

Based on observations since 1900 there has been an increase in the earth's surface temperature of about 0.7 °C. Over the past 30 years there has been a rapid and consistent increase in global temperature...
of 0.2 °C per decade. The ten warmest years occurred in the period after 1990. Signs of change can be seen in both physical and biological mechanisms. For example, the displacement of various species as far as 6 km towards the poles every decade during the last 30-40 years [1].

Climatic factors greatly affect plant growth and production. Information on climate suitability is needed in the framework of planning land use allocations, expanding the planting area, recommending cropping patterns, and arranging a good planting schedule. In order to obtain optimal rice production, it is necessary to select a location and determine an appropriate planting schedule. The arrangement of cropping patterns related to water requirements and control of plant pests that are highly dependent on rainfall, in addition to other climatic factors, such as air temperature and sun exposure, also greatly affect plant growth so that it can produce optimal production. The availability of superior rice varieties that are adaptive to location conditions also plays an important role and contributes to the application of plant cultivation technology, facilities and infrastructure and good market guarantees [2].

According to Sembiring and Rachman (2008) cited in Saragih et al. [3], the success of increasing rice production is largely contributed by increased productivity compared to the increase in harvested area. In the 1971–2006 period, the increase in productivity contributed around 56.1%, while the increase in harvested area and their interaction contributed 26.3% and 17.5% respectively to the increase in rice production.

The problem that affects the level of crop production is the current irregular climate. This condition results in the quality of agricultural products that are not satisfactory and even fail due to a lack of good understanding in studying climate characteristics and extreme weather changes due to global warming. In a certain time scale, climate change will also form a certain pattern or cycle, either daily, seasonal, yearly, or cycles of several years. Human activities cause climate patterns to change in a sustainable manner, both on a global and local scale. Climatic elements such as temperature, rainfall, humidity, and solar radiation, in addition to soil conditions and plant pests (pests), greatly affect the growth, production and quality of rice yields.

The food crop sub-sector is one of the agricultural sectors that is very vulnerable to climate change which has an impact on crop productivity and farmers’ income. This impact can be directly over and under water and indirectly through pest attacks. Plant pests (OPT) are a limiting factor for crop production in Indonesia, both for food crops, horticulture, and for plantations. Plant pests are broadly divided into three, namely pests, diseases and weeds. The development of pests and diseases is very much influenced by the dynamics of climate change. Generally farmers are preoccupied with the control of rice plant diseases such as crackle, leafhoppers, and blast attacks, while in the dry season there are many pest problems such as rice stem borer and locust pests.

An increase in extreme climatic events marked by the phenomenon of flooding and drought, changes in rainfall patterns that have an impact on shifting seasons and cropping patterns, temperature fluctuations, and increasing humidity that can stimulate the development and types of plant pests (OPT) so that it will have a negative impact on the agriculture in Indonesia. To reduce the adverse effects of pests on crop production and productivity, anticipation and adaptation efforts to climate change are needed. Anticipation strategy and adaptation technology to climate change and pest attack is one of the important aspects that must be the strategic plan of the Ministry of Agriculture in addressing climate change. This study aimed to be a reference in the application of rice cultivation technology based on climate change, changing the mind set of farmers from hereditary habits towards a better fit with the climate change model, formulating strategies and adapting to the impacts of climate change in the management of rice plants in Soppeng Regency.

2. Research methodology

2.1. Research types and approach.

The approach used in this research is descriptive quantitative in the form of a survey with quantitative descriptive analysis method. Data collection is carried out by observation techniques covering various things related to observing certain field conditions, questionnaire/interview techniques are a form of
structured questions given to respondents according to research problems, literature study is a technique of collecting data from various sources of literature related to the object of research as well as collecting data from related agencies.

2.2. **Time and place of research**
The research implementation time was started from January to April 2017, and was carried out in 8 (eight) sub-districts of Soppeng Regency, South Sulawesi Province.

2.3. **Data analysis**
The data obtained consisted of primary and secondary data in the form of rice production data, the diffusion of farmer-level technological innovations, climate elements, and government policies. Data then were processed using several data analysis techniques. The data analysis to be carried out in this study are as follows:

2.3.1. **Rainfall analysis.** Before formulating an adaptation strategy for the impact of climate change on rice management efforts, the distribution of rainfall frequency was analysed by processing monthly rainfall data obtained from the rainfall station of the Agricultural Extension Agency office in each sub-district according to the distribution of the Schmidt-Ferguson climate type.

2.3.2. **SWOT analysis.** To formulate strategic planning and adaptation to the impacts of climate change in efforts to manage rice crops in Soppeng District, an analysis was carried out using a SWOT analysis (table 1).

| Criteria      | Strengths (S) | Weakness (W) |
|---------------|---------------|--------------|
| Opportunities (O) | Strategy S-O  | Strategy W-O |
| Treaths (T)   | Strategy S-T  | Strategy W-T |

According to Rangkuti [4], the SWOT analysis is divided into 2, namely: Internal environmental analysis includes, among others, strengths in the form of potential natural resources, human resources / community participation and the involvement of several stakeholders. The weaknesses are the lack of anticipation and adaptability of farmers to face the impacts of climate change, they are still weak in access to capital and institutional capacity of farmers. Analysis of the external environment includes opportunities, namely the existence of government support for the development of rice plants, high demand and market for rice commodities, as well as increasing developments in information and technology. Threats are in the form of extreme climate change and weak communication between sectors.

All internal and external factors that have been identified are then compiled and grouped in a SWOT matrix which are qualitatively combined in their respective quadrant groups to produce a strategy classification that includes four strategic alternatives.

S-O strategy, this category contains various alternative strategies that are to take advantage of opportunities by exploiting the strengths they have. W-O strategy, this category is to take advantage of opportunities and overcome weaknesses. S-T strategy, this category is to utilize or exploit strength to overcome threats. W-T strategy, this category is to overcome weaknesses to avoid threats.

2.3.3. **Focus Group Discussion (FGD).** Focus Group Discussion is a research method which is defined by Irwanto [5] as a process of gathering information on a specific problem which is very specific through group discussions. In other words, FGD is a process of gathering information not through interviews,
not by individuals, and not free discussion without a specific topic. The FGD method is a qualitative method. Like other qualitative methods (direct observation, in-depth interviews, etc.) FGD seeks to answer the types of how-and why questions, not the types of what-and-how-many questions that are typical for quantitative methods (surveys, etc.). FGD and other qualitative methods are actually more suitable than quantitative methods for a study that aims to "generate theories and explanations" [6].

The functions of using FGD include exploring people's attitudes, beliefs and opinions, to produce data and insights that can be accessed through interactions between groups, to reveal the level of diversity, attitudes, opinions and beliefs of community members in developing, implementing and evaluating a program.

2.3.4. Analytic hierarchy process (AHP). Analytic hierarchy process is a decision support model developed by Thomas L. Saaty. This decision support model will describe a complex multi-factor or multi-criteria problem into a hierarchical arrangement. According to Saaty and Ernest (1993) cited in Jafar [7], hierarchy is defined as a representation of a complex problem in a multilevel structure where the first level is the goal, followed by the level of factors, criteria, sub criteria, and so on down to the last level of alternatives. With a hierarchy, a complex problem can be broken down into groups which are then arranged into a hierarchical form so that the problem will appear more structured and systematic.

The stages in the AHP namely first system identification is done by studying several references in order to expand knowledge and discussing with experts or resource persons who master related fields of science and who are understand the problem, so that concepts relevant to the problem can be obtained. Second, in the preparation of a hierarchy or decision structure, it is done by describing the system elements or alternative decisions into a decision hierarchy abstraction. Third, by making the pairwise comparison matrix, it can be described the relative or influential contribution of each element to each of the goals or criteria / interests that are one level above it. Determination of the level of importance at each level of hierarchy or opinion is carried out using pairwise comparison techniques.

In particular, AHP is suitable for use in decision making that involves a comparison of decision elements that are difficult to assess quantitatively. This is based on the assumption that the natural human reaction when faced with complex decision making is to group the elements of these decisions according to their general characteristics. This grouping includes a hierarchy (ranking) of decision elements then makes a comparison between each pair in each group as a matrix. According to Mubarak [8], the standard value of inconsistencies that can be accepted in AHP is 0.25. The results of this hierarchical process analysis are the final results of a series of studies in determining strategies and adaptation to the impact of climate change in the management of rice plants in Soppeng Regency.

3. Results

3.1. Analysis of the rainfall distribution pattern

The identification of patterns of rainfall shifts that occur in Soppeng Regency can be seen based on the analysis of the frequency of rainfall in each district for several years before climate change occurs and after climate change occurs. Determination of the peak of rain is categorized based on the growing season in a year. For example, the results of the analysis of the frequency of rainfall that occurred in Mariolriwawo District, which is presented in figure 1, were calculated for last 13 years (1996-2008) and the last 8 years (2009-2016) of 192 mm was relatively the same, but in June and July it was 178 mm. Meanwhile, the frequency of rainfall in the growing season from April to September shows that the peak is in May as much as 192 mm and in the growing season from October to March the peak is in November at 126 mm. The conditions for dry months (extreme) are found in August-September. This rainfall information can be used as a reference in rice management.
3.2. SWOT analysis

Analysis of the potential and constraints (internally and externally) of planning strategies for adaptive management of rice plants to climate change in Soppeng Regency is based on data that has been obtained from surveys and field observations, both in the form of primary data and secondary data. SWOT analysis includes strengths, opportunities, weaknesses and threats. Where this method shows the performance results by determining the combination of internal and external factors. SWOT analysis comparing internal factors, namely strengths and weaknesses with external factors, namely opportunities, and threats can be seen in table 2.

Table 2. SWOT analysis results.

| Strategy Matrix | Strengths (S): | Weaknesses (W): | Opportunities (O): | Threats (T): |
|-----------------|----------------|-----------------|--------------------|--------------|
|                 | 1. Sufficient quantity of farmers | 1. Low grain quality |
|                 | 2. The potential of paddy fields is 28,743.8 ha | 2. The use of varieties is not appropriate for the season |
|                 | 3. Supporting geographic conditions | 3. Poor management of fertilizer use |
|                 | 4. The availability of supporting facilities and infrastructure | 4. Not optimal land use |
|                 | 5. Availability of seed breeders | 5. Lack of knowledge about the water management system |
|                 | 6. Availability of cultivation technology | 6. Pest control is not well targeted |
|                 | 7. The farming experience of local farmers is high | 7. Lack of access to farmers' capital |
|                 | 8. Farmers are aware of the impacts of climate shift | 8. Weak behavior and bargaining power of farmers |

| Strategy SO: | 1. It is necessary to hold technical counseling on rice cultivation to farmers in a systematic and participatory manner. |
|--------------|------------------------------------------------------------------------------------------------------------------|
|              | 2. Intensifying technology and information on specific climate locations to increase rice production |
|              | 3. It is necessary to have adequate laboratory facilities and rice seed breeding |

| Strategy WO: | 1. Procurement of superior and tolerant rice varieties to climatic conditions. |
|--------------|-----------------------------------------------------------------------------|
|              | 2. Revitalizing integrated field school activities related to the rice cultivation technology package program. |
|              | 3. Increasing efforts to diversify crops and rotate crops other than rice |
|              | 4. There is a need for intensive outreach activities on climate change from the government to farmers. |
|              | 5. Establish a special budget post for farmer groups to increase production. |

| Strategy ST: | 1. The planting of rice varieties is adapted to the prevailing climatic conditions |
|--------------|--------------------------------------------------------------------------------|
|              | 2. Involve the role of farmers in the process of escorting pest attacks in the field |
|              | 3. Need regular meetings between farmers and field extension workers. |

| Strategy WT: | 1. Establishment of demonstration plots to improve farmers' practical skills in managing rice crops |
|--------------|--------------------------------------------------------------------------------------------------|
|              | 2. Revitalizing the role of farmer groups to improve the welfare of their members. |

Figure 1. Rainfall distribution pattern in Marioriawo district 1996–2008 and 2009–2016.
3.3. **Focus Group Discussion (FGD)**
Based on the results of the SWOT analysis which produced the initial draft (I) which became the basis for the formulation of a rice plant management strategy, a Focus Group Discussion (FGD) was carried out with a number of stakeholders who were considered to have an interest in the problems being studied, both from farmers, representatives of farmer groups and a combination of farmer groups, village governments, representatives of the Agricultural Service, and representatives of Agricultural Extension, there were a number of obstacles and an agreement to improve the adaptation strategy for the rice cultivation technology package, including the following:

3.3.1. **Improved cropping systems.** The tile planting system commonly used by farmers has been changed to a legowo planting system with the consideration of photosynthetic efficiency, increasing population, and facilitating fertilization, weeding, and pest control. In addition, direct seed planting systems are recommended compared to transplanting systems for cost and labor efficiency, shortening harvest life and conserving water usage but high production.

3.3.2. **Use of high yielding varieties.** This means that the varieties used have superior traits that are reproduced in captivity and have a certification of adaptation to specific locations, especially tolerant to drought / water stress conditions.

3.3.3. **Proper water management.** This was implemented through innovative water delivery tailored to local water availability for efficient water use that ensures sustainable production and productivity. One of the water management techniques that can be applied is the reduction and limitation of irrigation of lowland rice for a certain phase until it becomes muddy.

3.3.4. **Variation in cropping pattern.** Rice cropping patterns are more varied and adapted to climatic conditions at certain time units. For example, the pattern of rice-secondary crops-bero, rice-paddy-secondary crops, or rice-crops-secondary crops, etc. The main purpose of this kind of cropping pattern is not only to increase the variation of farm income, but also to break the life cycle of plant-disturbing organisms and adaptation to climate shifts.

3.3.5. **Adjustment of the planting schedule.** The planting schedule was adjusted with climatic conditions according to the location. The goal is to make efficient use of rainwater and reduce water wasted due to shifting planting schedules. Other cultivation techniques, such as fertilization, controlling plant pests, and harvesting should follow the technical recommendations issued by the relevant agencies.

3.4. **Analytic Hierarchy Process (AHP)**
From the results of the Focus Group Discussion (FGD) which is draft II then used as a reference in concluding strategies and adaptation to climate change impacts in the management of rice plants in Soppeng Regency (draft III). The results of this strategy are in the form of a cultivation technology package for rice plant management and other strategic alternatives that were agreed upon in the FGD activity. Taking weights to set priorities with the Analytic Hierarchy Process using Expert Choice 11 software. Weighting with a paired comparative assessment of each criterion is carried out by several participants who are considered experts related to the problem, namely the Soppeng Regency Agriculture Service, Agricultural Extension, POPT Coordinator, KTNA Chair, and experts. rice plants. Based on figure 2, the results of the AHP synthesis of all participants to see the priority scale for all components of the adaptation strategy of rice cultivation technology to the impacts of climate change show that the order of the components and the technical criteria for cultivation required is from a total of 100% weight, the planting schedule component has the highest weight, namely 18.8%, followed by successively improved cropping patterns 15.8%, 15.6% use of superior varieties, 14.6% water management, 14.0% of cropping system improvement components, 7.9% fertilization, 7.7% pest control, and 5.6% harvest components.
Figure 2. Combined AHP synthesis of all participants for the component of rice cultivation technology.

Meanwhile, the development of rice farming is a system that includes the agribusiness system from the upstream to downstream agribusiness subsectors as well as the supporting subsystems, must be interrelated. Alternative rice crop management strategies that have cross-sectoral linkages are presented in figure 3. Based on these results, it shows the results of the priority scale arrangement of each alternative component of the climate change impact adaptation strategy in the management of rice plants according to a combination of all opinions of participants / stakeholders interviewed. Of the 100% weight, it was found that the component of field school activities had the highest weight, namely 14.8%, followed by successively aspects of cultivation technical counseling 13.6%, participatory pest control 12.6%, location-specific climate information 10.8%, socialization of climate change 9.8%, making demonstration plot 9.5%, adjusting varieties to climatic conditions 9.4%, crop diversification and rotation 7.1%, seed breeding 6.5%, and farmer group budget 5.8%.

Figure 3. Combined AHP synthesis of all participants for alternative components of adaptation strategies.

4. Discussion
This study found that there was a significant climate change in Soppeng Regency which could be seen from the shift in the rain distribution pattern in each district. Based on the results of the analysis of rain distribution patterns by calculating the chance of rain to predict the amount of rainfall intensity for each planting season, it shows that in Marioriwawo District in the April-September planting season the intensity of rain after climate change (2009-2016) is higher than before climate change (1996-2008) ie. an average of below 200 mm during one growing season. Changes also occur in the amount, intensity,
and duration of rain. To study this, a long series of rainfall data is required. Kaimuddin and Rosmana [9] reported that with the results of spatial analysis, the annual average rainfall in South Sulawesi, mostly in the southern area, is decreasing or decreasing, while in the northern part it actually increases.

These climate change conditions certainly affect farmers in practice. During the rainy season with high intensity and period, it causes disasters and damage to rice fields and plants are susceptible to disease [10]. On the other hand, during the dry season with insufficient water supplies for plants it can result in crop failure and trigger the attack of several pests. The results of research conducted in Soppeng Regency by Apiaty [11] show that there have been variations in pest attacks such as fierce grasshoppers between 42-48%, rats 0-21%, stem borer 93-100%, crackle disease 45-46%, and tungro disease 10-12% due to a shift in rain patterns.

This shift in rain patterns is absolute from natural phenomena and there should be adaptation efforts in the management of rice plants so that it is recommended to plant early and medium-aged rice in June such as Inpari 30, Ciherang, Cigeulis, and Mekonga varieties. Meanwhile, in the October-March planting season, the intensity of rain falling to the earth's surface is lower after the average climate change is below 150 mm, it is advisable to plant rice in January for early maturity varieties such as Inpari 4. Selection of varieties of rice plants adaptive besides having to be in accordance with climatic conditions, it is also acceptable to local farmers. Rice varieties are considered to be adaptive if they can grow well in the distribution area, have high and stable production, have high economic value, are socially acceptable, and are sustainable [12].

Climate behavior is very difficult to manipulate or manipulate. Therefore, in choosing a location for the development of rice plants, the climate factor is the first consideration, then other factors that affect the commodity. The opportunity to manipulate climate data is very small and unpredictable, so that zoning commodities must be adapted to cultivation and agricultural technology packages with local climatic conditions is the most appropriate approach [13].

Adaptation of rice cultivation technology to climate change can actually be done by using a reference to the results of the analysis of rainfall intensity in each sub-district that has been carried out. However, the development of rice plants well in an area is actually influenced by multi-complex and cross-sectoral factors. The reason is that it is necessary to carry out systematic steps to find problems and then arrange them in a more perfect adaptation strategy using a SWOT analysis to identify internal and external factors. By involving all parties with an interest in the development of rice plants, the results of the SWOT analysis, which were further refined in the FGD activities, found a number of rice cultivation technology packages in the face of climate change, such as setting planting schedules, determining the right types of varieties, and setting cropping patterns in accordance with local climatic conditions. Lambert and Loiselle [14] stated that the use of the FGD method requires a combination with other data collection tools to increase the wealth of data and make the resulting data more valuable and more informative to answer research problems.

The rice plant management plan then determines the priority scale of each component, both the cultivation technology package and other strategic alternatives using analytic hierarchy process (AHP). The results of the compilation or combination of opinions and assessments of each participant who was interviewed at the AHP stage indicated that the components of determining the rice planting schedule for each season were the most important aspects of cultivation in the future. Then followed by the component selection of varieties and cropping patterns adaptive to climate change. These three priority cultivation aspects are believed to be the key to the successful management of rice plants by farmers. So far, the determination of the planting schedule by farmers tends to follow relatively short weather conditions so that sometimes they get dry and lack of water supply during the growth phase which results in a decrease in the harvest index. In addition, the selection of varieties that are not appropriate for the growing season will reduce the quantity and quality of the harvest. The prediction of extreme months seen on the graph of rainfall intensity allows for the adjustment of cropping patterns for rice and secondary crops or rice and horticulture which requires relatively little water according to climatic conditions.
Weaknesses in the upstream agribusiness subsystem, such as seeds and production facilities, will have an impact on production and weaknesses in the downstream sector cause the inability to obtain added value and products are vulnerable to price fluctuations [3, 15]. Therefore, the rice crop management strategy in fluctuating climatic conditions must be based on a controlled system mechanism involving all parties involved in decision making and implementation. The results of the formulation of alternative strategies on climate change-adaptive rice crop management suggest maximizing field school activities and technical counselling for farmers, monitoring of participatory pests in the field, and providing information and routine socialization related to site-specific climatic conditions and climate changes that occur [16].

5. Conclusion
The conclusion of this study is that there has been a general climate change in Soppeng Regency. The management of rice plants carried out by farmers in response to climate change in the form of planting schedules still depends on the conditions of water availability and rain. Therefore, several recommendations for strategy formulation and climate change adaptation in the management of rice plants based on priority scales, namely; arranging planting schedules, improving cropping patterns, using superior varieties, managing water, improving planting systems, fertilizing, controlling, and harvesting. The management of rice plants should involve all relevant stakeholders by emphasizing the diffusion of cultivation technology that is most suitable to local climatic conditions for the efficiency of farming for sustainable production and productivity.

Reference
[1] Root T L, Mac Mynowski D P, Mastrandrea M D and Schneider S H 2005 Human-modified temperatures induce species changes: Combined attribution Proc. of the National Academy of Sciences 102 7465 – 7469
[2] Nazar A, Mustikawati and Yani A 2008 Teknologi Budidaya Padi (Lampung: Balai Pengkajian Teknologi Pertanian Lampung)
[3] Saragih D N S, Sumono and Ichwan N 2014 Kajian potensi produksi padi pada lahan sawah irigasi di Kabupaten Deli Serdang J Rek Pangan dan Pert. 2 (4)
[4] Rangkuti F 2009 Analisis SWOT Teknik Membedah Kasus Bisnis (Jakarta: Gramedia Pustaka Utama)
[5] Irwanto 1998 Focus Group Discussions (Jakarta : Pusat Kajian Pembangunan Masyarakat)
[6] Morgan D.L. & Krueger R.A. (1993). When to Use Focus Group and Why. dalam ed D.L. Morgan Successful Focus Groups, pp. 3 – 19. Newbury Park: California
[7] Jafar M I 2013 Evaluasi Peningkatan Produksi dan Produktivitas Tanaman Kakao (Theobroma cacao L) di Kabupaten Luwu, Sulawesi Selatan (Studi Kasus Penggunaan Analytical Hierarchy Process) [Theses] (Makassar: Universitas Hasanuddin)
[8] Mubarak S 2014 Penyempurnaan Sistem Budidaya Untuk Peningkatan Produksi dan Produktivitas Tanaman Kakao (Theobroma cacao) [Theses] (Makassar: Universitas Hasanuddin)
[9] Kaimuddin and Rosmana A 2011 Investigasi Perkembangan dan Penyebaran Organisme Pengganggu Tanaman Padi Sebagai Dampak Perubahan Iklim, Pola Waktu Tanam dan Pola Penggunaan Varietas di Sulawesi Selatan Research report (Makassar: Kerjasama Universitas Hasanuddin dengan Badan Penelitian Pertanian, Kementerian Pertanian)
[10] Yassi A, Mustari K, Guricci A, Syam’un E, Riadi M, Dariati T and Adyla S N 2020 Growth and production of lowland rice (Oryza sativa L.) with water management systems on the application of various combination of fertilizers and planting systems IOP Conf. Ser.: Earth Environ. Sci. 486 012111
[11] Apiaty A 2010 Adaptasi Petani Padi Terhadap Dampak Perubahan Iklim di Sulawesi Selatan [Theses] (Makassar: Universitas Hasanuddin)
[12] Somaatmadja S 1995 Prosess Sumber Daya Nabati Asia Tenggara 1 Kacang-kacangan (Jakarta:
[13] Las I and Makarim A K 2002 *Panduan Teknis Pengelolaan Tanaman dan Sumberdaya Terpadu Padi Sawah Irigasi* (Jakarta: Departemen Pertanian) 37p

[14] Lambert S D and Loiselle C G 2008 Combination individual interviews and focus groups to enhance data richness *Journal of Advanced Nursing* **P** 228-237

[15] Iswoyo H, Stoeber S, Kaimuddin, Yassi A, Dermawan R and Ramba T 2019 Empowering upland farmers to become more resilient towards climate change – experiences from Toraja, Indonesia *IOP Conf. Ser.: Earth Environ. Sci.* **235** 012039

[16] Farid M, Iswoyo H, Ridwan I, Nasaruddin and Dermawan R 2018 Assessment on the use and availability of rice certified seeds in Bone Regency, South Sulawesi province *IOP Conf. Ser.: Earth Environ. Sci.* **157** 012020