Increasing Cassava Yield in Kamphaeng Phet Province using Research Synthesis, Community Communication, and Geographic Information Systems

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Abstract. The objectives of the study were to: 1) select, analyze, and synthesize information from research in order to enhance the increase of cassava yield. 2) identify areas in the Kamphaeng Phet province that are suitable for growing cassava by using geographic information systems 3) set up community communication system to share knowledge from research into practice to increase cassava yield and 4) evaluate community communications.

The study found that 1) there were 16 research studies that investigated the increase of cassava yield, which provided cassava farmers with knowledge on all stages of cassava production, and there were in 7 fields. 2) suitable areas for cassava plantation in Kamphaeng Phet province can be divided into 3 types. 3) community communication that could transfer knowledge from research into practice on cassava production consisted of 8 media types, and 4) the satisfaction towards the community media was at high and very high level.

1. Introduction

Thailand's cassava industry consists of production, transformation and the following continuous stages. The end products are compressed crushed cassava and tapioca. The domestic production volume is up to 300,000 million Baht, while the volume of export is only 800 million. Up to 2.6 million farmers are working in cassava industry, implying the huge significance to the country's social and economic conditions. Ministry of Agriculture and Cooperatives has identified framework relevant to cassava production's planning strategy (2012-2014), and has stated that the location for planting cassava should be remained at 7.4 million rais (Rai is Thai area measurement unit with 1 rai equals to 0.395 acre), however in the short future, the average production rate is intended to be 5 tons/rai, in order to increase the export value from 46,000 to 55,000 million Baht. Moreover, a research from Food and Agriculture Organization (FAO) indicates the possibility of increasing the production rate up to 6.4 tons/rai.[1]

Kamphaeng Phet is one of south-northern regions in Thailand, with suitable condition for agricultural activities, due to its lowlands aspect of Ping River. Main salable agricultural products from this region are banana, cane, cassava, soy, etc. By growing these plants together in the large areas, farmers are able to save production costs, and supporting factors such as transforming product, commuting and irrigation processes would also be running more conveniently,[2] Approximately, the size of area used for growing cassava is 820,374 rais, ranking 2nd in Thailand following Nakhon Ratchasima with the total amount of 2.887 million metric tons of cassava having the value of around 5.775 million Baht. approximately 37,381 farmers are working in cassava production related businesses. 150 drying grounds covering the area of 4000 rais, 6 starch factories, and 3 registered cassava related product exporters are in Kamphaengphet.

Kamphaeng Phet has the highest number of cassava drying grounds and has high capacity of making raw cassava into pressed cassava sticks. It positions itself as city of agricultural transforming business. In addition, systematic planning with established committees is all set up in order to turn

the province into the center of cassava trading.[3] However, the current production rate is still considerably low per one area unit. Synthesizing knowledge from this research would enable Thailand to increase competitive ability and to become 'knowledge-based economy' country. Research is the main tool used to increase productivity and production capability. It also boosts social strength and develop human resource to be highly knowledgeable in response to demand of human resource and economic development, which would all lead to the development of the country. [4] In order to secure national economy, society and environment, it is crucial to synthesize knowledge gained from research and publicize it to community through communications as these steps would result in the increase of cassava productivity.

2. Tools and Methodologies

2.1 Information searching, selecting, analyzing and synthesizing the research's result were done by the following steps;

2.1.1 Selection of 16 research studies conducted by educational or public institutions during 1997 to present was made. The studies chosen must (1) be about the development of efficiency of cassava production, (2) be conducted during 2540 to present, (3) be conducted by educational institutes or government agencies, (4) be conducted based on the environmental context of Thailand and involved (a) the improving of productivity, (b) developing of cassava species that provide high crop yield, high percentage of starch, and were strong against diseases and insects, and (c) the development of agricultural zoning, and (d) the control of weeds. aspects to be considered for selecting the research studies were for about improving the quality of cassava production, quality improvement in relation to Thailand's environmental context in terms of boosting cassava production, high amount of flour and suitable level of controlling pests and weeds.

2.1.2 Synthesizing of the research's results into bodies of knowledge which could boost cassava production. The synthesis of the research results using content analysis technique was performed according to the following 7 aspects: 1) selection of mother plant, 2) planning and growing methods, 3) soil preparation and enrichment, 4) watering methods, 5) weed control, 6) fertilization, and 7) proper harvesting methods.

The tool used for Information searching is a survey that aimed at eliciting basic data regarding research methods, findings as well as innovations resulted from the research on increasing the amount of cassava production per unit. Content analysis was employed for the analysis of the data.

2.2. Identifying suitable areas for cassava cultivation by using Geographic Information system following two steps:

2.2.1 Study tools are computer programs; ARCGIS Version 10.2 and GPS (Global Positioning System)

2.2.2 Preparing Information

1) Spatial data, which is Shape file digital map, consisted of geographical map, political map that showed locations of villages, map showing the suitableness of soil (based on Soil View 2.0 program made by Land Development Department, Ministry of Agricultures and Cooperatives), map showing the proper zone to plant cassava (made by Department of Environmental Quality Promotion: DEQP, Ministry of Natural Resources and Environment) , the map illustrating how to manage the plantation areas made by Department of Forestry, Ministry of Natural Resources and Environment)

2) Descriptive information was about growing cassava gathered from farmers, experts and documents. Interview and using group discussion method were employed for collecting data.

2.2.3 the process to identification of suitable areas for cassava growing

1) The first step was the establishment of diagnostic factors which were used

for the analysis of suitable areas this is the factor of analyzing the suitability. These included soil condition, usage of areas, and suitable planting zone.

2) The second step was setting criteria to analyze suitable areas.

3) The third step was importing information into geographic information system

(Arc GIS), then checking for the accuracy and completeness of information, and standardizing to other maps for more precise analysis.

4) The next step was identifying areas which are not suitable for growing cassava which included swamp, steep land, residence and forestry areas.

5) The next step was making a map of suitable area for cassava growing according to individual factors. The score of appropriateness ranged from 1-3 (1 means least suitable, 2 moderately suitable, and 3 most suitable). Raster Calculation, then, was used to change the information into Raster form.

6) Next is computing the total score by overlaying the map of individual factors.

7) Next was reclassify the result of calculation by the method called 'Equal Interval', this this was done by dividing the result into 4 levels; most suitable location, moderately suitable location, lowly suitable location and not suitable location.

8) The final step was making map layout to show suitable area for cassava growing. Appropriate size of plantation sites was also calculated and presented in tables.

2.3. The producing of community medium in order to publicize research knowledge. The following steps were performed.

2.3.1 Preparation stage Information and people for media production was prepared. In order to transfer research knowledge into practice, proper communication plans were necessary. The medium needed to be reader friendly, accurate, and useful.

2.3.2 Production stage The knowledge and information gained from analysis and synthesis of research studies on cassava was made into community medium by using knowledge and information from information gathering step, and turning those theories into '7 ways to increasing average production per unit area of cassava in Kamphaeng Phet province'. The knowledge was communicated to farmers through different forms of medium including, media for farmer training, community radio station, planting demonstration, social network, printed media, board presentation, youth farmer activity, and community sound broadcasting.

2.3.3 Displaying information throughout cassava growing areas which included three zones according to the GIS analysis.

2.4. Evaluating the result of community communication

The evaluation was performed on two main aspects:

2.4.1 Validity Check The medium was checked for validity by 5 experts in the areas of Thai language, agriculture, geographic information system and publishing art work respectively. Revision was made based on the evaluation results.

2.4.2 Evaluation of the project The project was evaluated by 200 farmers from the three zones who received different types of media.

3.The results of the study

3.1. Searching, selecting, analyzing and synthesizing data.

3.1.1 The following Sixteen research studies and articles were selected for the analysis and synthesis of important knowledge and information on cassava cultivation. Such as Reaction to Nitrogen fertilizer and the amount of water on cassava growth rate (Researchers: Chakkapad Woonseesang and Nattawut Nontasri, MahaSarakham's Agricultural Research and Development Center) and Techniques for increasing the cassava yield per area unit (Researchers: Assachan Sookthamrong and Renu Khamlert)

3.1.2 Designation of research knowledge to 3 types of cassava growing site (unsuitable, moderately suitable, and highly suitable) into following ten areas:

1) Suitable cassava breeds for highly suitable areas included Rayong 5, Rayong 11, Rayong 72, Huaybong 60, Kasetsart 50. The cassava suitable for low suitability areas are Rayong 5, Rayong 72, Rayong 11, Huaybong 60, and Kasetsart 50

2) Planting method that were suitable for each different conditions of soil. For the most suitable areas, the best time to start growing cassava was at the beginning of summer (Feb-Mar) or the beginning of rainy season (April-May) or the end of rainy season (September-January). For the moderately suitable area, planted with the length of 3-12 months, however the beginning of rainy season is the best time as the rain falls the most and following excellent time is the end of rainy season. The least suitable areas casava should be planted early in the beginning of rainy season as well (April-May)

3) Concerning the improving and nourishing soil conditions, key knowledge can be as follows. For the most suitable areas, the proper method is burying cassava trunks left after the harvest in order to add fertilizer. This was equal to 100 kilograms of using formula 15-7-18 chemical fertilizer per Rai. This could be done by using a 3 or 4-disc plough together with 7-disc plough in order to send up the nutrition to the surface. This process also helped air to circulate better within the soil. For moderately suitable areas, appropriate fertilizers to be used was the chemical ones (Nitrogen, Phosphorus and Potassium). However, the diagnosis of soil's condition must be done before adding any fertilizers; and in case of using organic fertilizer the amount should be 500 kilograms/rai or more. Soil nourishing substances such as gypsum, lime, pumice and other synthesized chemical substances were also recommended. Organic fertilizers which could add soil nutrients were, for example, compost both from the harvesting process and from industry. For the least suitable areas for cassava cultivation, methods recommended for suitable and moderately suitable areas should be applied. To improve the condition of subsoil, ploughing must be made deeper to break the layer and turn it to the surface. It was also recommended that vetiver grass be planted for 1-2 years on the area as the root of this grass could reach the subsoil layer and helped break the hardness of the soil. Before improving soil quality, it was recommended that soil diagnosis be made every 3-5 years.

4) Initial ploughing was also necessary for the areas most suitable for growing cassava. First plowing should go as deep as possible using 3 or 4-disc plough together with at least one light plowing before planting to get rid of weeds. In the areas where insects and diseases were hit, 2-3 light plowings were needed in order to kill insect eggs and diseases. No burying of unwanted old plants should be done. Instead, postponing cassava planting by growing plants that can be used as compost to add nutrients to soil and stop insects and diseases to spread. This method would increase organic substance in the soil and could reduce the use of chemical fertilizer to up to 10-30 percent. For the moderately suitable areas, two times of bed-preparation plowing was needed for sticky soil; but only one bed-preparation plowing was enough for normal soil. For loose sticky soil, second time of plowing by seven-disc plough was required before making the bed. For sandy loose soil, second light plowing was not necessary. The planting bed should allow the mother pant to be put deep down so the plant could get enough moist which would result in higher rate of survival and would prevent weeds from growing. For least suitable area, dust stone should be added at around 25-100 kilograms/rai, this would reduce acidity level and also increase the holding capability of the soil which would make bacteria functions well.

5) Selecting the suitable mother plant could be done as follows. For highly suitable area, the age of the mother plants should be around 8-14 months. The bottom and middle part of the trunk should be used and the length of the mother plant should be 20-30 centimeters. Shorter mother plant (around 20 cms) could be suitable for the beginning of the wet season. Using shorter mother plant allowed farmers to save more cost on mother plant. In the moderately suitable areas, selecting the strong mother plant was crucial with age between 8-14 months and dense buds. Cutting these

plants should be done by sharp knife; the part to be buried should be around 2/3 of its total length. Lastly, in the least suitable location, at the end of rainy season longer mother plant (25-30 cms) was recommended.

6) Deciding space between each plant can be done as follows. In the most suitable areas, larger space was needed between each plant. The suitable distance was 1.0 x 1.2 meter (1 m. between rows and 1.2 m. between each plant) or 1,333 plants/rai. In planting sites where water can be effectively controlled, raised bed was not necessary. Raised bed was suitable for large or areas with no slope. Also it was easier to give fertilizer to cassava planted in raised beds. For moderately suitable areas, the space between rows and between each plant should be 1.00 meter or 1,600 plants/rai. In loose and sticky soil, 1.2 x 0.5- 1.0 was recommended. In lowly suitable areas with low nutrient soil such as sandy soil, the space should be reduced. For example, 1.0 x 0.8 m. or 0.8 x 0.8 were recommended or around 2,000 – 2,500 plants. /rai. In loose and sandy soil, the space of 0.8 x 0.5-0.8 was suitable.

7) Watering should be done as follows. In highly suitable areas, water should be given in the first 2 months of growing, after that watering depended on the amount of rainfall. During dry season, more water was needed. In moderately suitable areas, watering through springer together with on soil surface was a proper way. Around 64 m^3 of water/rai should be given to the plant every two weeks. This would turn out with higher amount of products than giving water every 4 weeks. Fertilizer could be given to cassava through watering system. Dropping water system could help plants to intake nutrients better, grow faster and give higher yield. The yield at month five of cassava using dropping water system was found higher than that without giving water especially the yield of cassava planted in sticky soil. To grow cassava in lowly suitable locations, combination of watering systems recommended for highly and moderately suitable areas should be applied.

8) In terms of weed controlling the following recommendations should be applied. In highly suitable areas, there were 3 distinctive phases of removing weeds. Firstly, during the bed preparation, plow the planting site deep to root up weeds and let them dry, then plow to send the dried weeds under the ground deep enough so they could not grow back. Leave the soil dry for 7-14 days before planting. Weed killers may be necessary if rain interrupted the above method. 0.8 Kilogram/rai of Paraquat or 3.6 Kilogram/rai of Glyphosate may be used for killing weeds. Secondly, in the first 3 months after planting, uprooting and burying weeds by plowing or using weed killers such as Alachlor Flumioxazin or Paraquat or Glyphosate. Thirdly, after 4 months onward, small-sized weeds should be left to grow under the plant as they would help protect the soil surface and maintain the suitable temperature, humidity level, and air-flow resulting in cassava having bigger in size and richer in starch. Four methods of removing weeds were:

(1) the first method was uprooting weeds by plowing; then waiting for the new weeds to grow back; then using weed killers. The distance between the sprayer and the plants should be 70-80 cm. This method was suitable during light rain period in October to March.

(2) The second method was similar to the first one, but with a single or combined weed controllers: the suppressing type and the killing type. This method was suitable during rainy period

(3) The third method was spraying weed killers immediately after growing the cassava. After that uprooting weeds should be done regularly. This method was suitable for beds with 0.5-0.8 m. of space between the plants and was recommended in case of it rained after growing the plant.

(4) The fourth method was spraying the weed controllers after planting. This method was recommended for beds with longer mother plant (50 centimeters). After the cassava grew 70 centimeter tall, weed-removing substances both the suppressing and killing type may be used. The same weed controlling methods may be applied to both moderately and lowly suitable areas.

9) Regarding the using of fertilizers, in highly suitable areas, diagnosing the soil's condition was recommended before planting cassava. Soil samples should be diagnosed every 3 to 5 years. In case of using organic fertilizers, the recommended amount was between 600 to 800 kilograms per rai. Faeces from pigs should be used 2 to 3 times more than faeces from chicken. Compost worked better in conditioning soil than adding nutrients to soil. The recommended amount of compost from fresh plants was 5-10 kilograms per rai and 50-100 kilograms per rai for chemical fertilizers. Chemical fertilizers should be given during the first three months after planting and be given right after the first and second round of weeds management. A proper manner of giving fertilizer was to make one or two 3-4-inch-deep holes and 6-8 inches away from the cassava trunk. Then put fertilizer in and cover up the hole. The soil should have suitable moist at the time of giving fertilizer. During very wet period, it was not a proper time to give fertilizer. In moderately suitable areas especially the areas that had been used for growing cassava for a long period of time, fertilizer was needed in order to keep the product at the same volume. In sandy and loose soil, for example, the yield decreased at the rate of 300 kilograms/rai/year. Main nutrients such as Nitrogen, Phosphorus, and Potassium were needed to be given along with nourishing the soil by using organic fertilizers and rotating plants.

10) Regarding harvesting recommendations were as follows. In highly suitable areas, cassavas can be harvested after 10-18 months of planting. Harvesting during the early rainy season (April-June) should be avoided because during this period the cassava generated low level of starch due to the cassava's producing new leaves. How to harvest was to cut the trunks and save them as mother plant for next growing season. The trunks had to be kept in bunches and put in shade and should not be kept over 60 days because the growing rate would drop up to 80 %. After harvesting the cassava should not be left for longer than 4 days as this could reduce the production up to 15-16 %. The cassava should be dug up within 30 days after cutting the trunk. The unwanted parts, such as leaf and stalk should be left on the bed as fertilizer. Harvesting method of cassava grew in the moderately and lowly suitable areas was the same.

3.2. In terms of suitable areas in Kamphaeng Phet to grow cassava, the result of using Geographic information system revealed that the total suitable area for growing cassava was 3,650,611.12 rais (68.45 %) and unsuitable area was 1,682,718.31 rais (31.55 %) (occupied by forest and residence area) the degree of suitability was of three levels; high, moderate and low. Regarding the area suitable for cassava growing, the results of the study indicated that majority of the area was lowly suitable, with the area of 1,456,789.50 rais (27.31 % of total suitable area). 1,109,385.06 rais (20.80%) was the moderately suitable area and highly suitable covered the area of 1,084,436.63 rais (20.33%).

3.3. Regarding the transferring of knowledge to actual practice in order to boost the production of cassava within Kamphaeng Phet province through community communication, the research findings can be summarized as follows.

3.3.1 The knowledge and information gained from analysis and synthesis of research studies on cassava was made into community medium by using knowledge and information from information gathering step, and turning those theories into '7 ways to increasing average production per unit area of cassava in Kamphaeng Phet province'. The knowledge was communicated to farmers through 8 different forms of medium including, media for farmer training, community radio station, planting demonstration, social network, printed media, board presentation, youth farmer activity, and community sound broadcasting.

3.3.2 The targeted villages to install community media kits included 1,058 villages in the area of suitable location to grow cassava. 373 villages (35.26%) were in the lowly suitable area. 249 villages (23.53%) in highly suitable area, and 219 villages (20.70 %) in moderately suitable area. The number of villages that were suitable for installing community media center was 483 based on the table of Krejcie & Morgan with acceptable deviation at 5 percent and 95 percent of validity. Among the 483 villages, 191 of them were in the lowly suitable area, villages, 140 in moderately

suitable area, and 152 in the most suitable area.

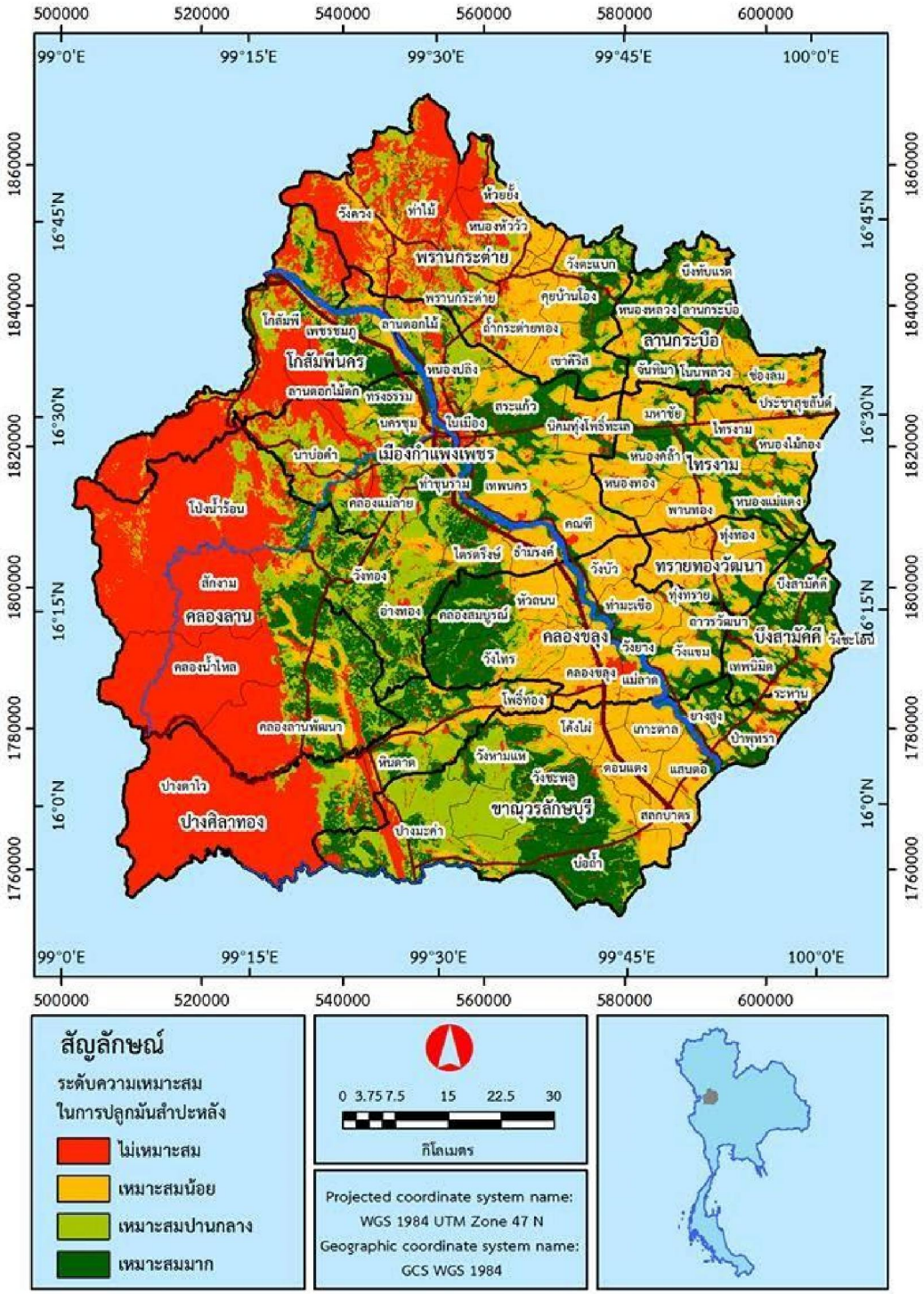

FIGURE 1: The areas suitable for cassava cultivation in Kamphaeng Phet province

3.3.3 The evaluation of content validity which focused of assessing content and experiences was performed according to the following two steps. First was the defining of variables that represented the concepts and purposes of the media. Second was the producing of community's media based on the selected variables. The media was analyzed by experts to see if it was complete in terms of content, layout, and the practical use. The result of the assessment was at the level of very good. The comments from the experts were used in the process of editing the media.

3.3.4 In publicizing of the media was done in the way that was appropriate with the nature of each media. 8 different forms of them were produced and publicized into two main patterns; regional level (Training for farmer project, community radio broadcasting, cassava demonstration farm, online information, and audio cable broadcasting) and wider level which aimed at distributing knowledge and information to areas suitable for cassava cultivation outside the province (consisting of community publishing project, board presentation, and youth farmer project).

3.3.5 The evaluation of community communication was conducted using satisfaction survey. The results revealed that people who got access to the medias were very satisfied with the training project, the community radio, online media, community broadcast, demonstration cassava farm, printed media, and board presentation. The satisfaction towards youth farmer project was at exceptionally high.

4.The discussion of the results

4.1. Both the knowledge regarding cassava cultivation and community communication were crucial and useful for farmers growing cassava in Kamphaeng Phet. The synthesis of knowledge must be done using recent research results as well as local wisdoms and knowledge indigenous to specific areas. Suggestions should be at the level of policy making and can also be implemented to actual practice.[5] The knowledge and information should be further distilled by extracting both best practices and failures in order to get good lessons. The result of the synthesis and distillation then must be used to produce medias. The production of community medias should focus on having all parties participate in the activities at all stages such as brainstorming, planning, and media making .[6][7]

4.2. The analysis of suitable area for cassava cultivation using GIS should be made in the context of the area and based on regional information so that the result could be used by both government and private agencies for systematic and effective decision making regarding agricultural zoning which was considered a key strategy for solving farming problems and land management.[8]

5. Conclusion

5.1. The retrieving and selecting of research studies on increasing cassava yield resulted in the researcher getting 16 studies. The analysis of the studies then resulted in 10 aspects of knowledge concerning proper conducts of cassava cultivation. The ten aspects of knowledge were made into 7 forms of medias called 'The Seven good: seven ways to increase cassava yield'. The medias focusing on distributing knowledge about growing cassava in three types of area including the highly suitable area, the moderately suitable area, and the lowly suitable area.

5.2. The results of the analysis of suitable areas for cassava growing using GISS showed that Kamphaeng Phet most of the area of the province was lowly suitable (27.31% of the total suitable area). The moderately suitable area covered 20.80 % of the total land, and highly suitable area covered 20.30% of the land.

5.3. The knowledge gained from the synthesis and distillation of knowledge and information regarding cassava cultivation was made into 8 forms of community media including training course, community radio, online information, printed media, board presentation, cassava demonstration farm, youth farmer project, and cable audio broadcasting. The level of satisfaction of people who gain access to seven medias was high and that of the people who gained access to youth farmer project was very high.

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