Mapping of Global Rice Paddy Map with MODIS and AMSR2 by Spatio-temporal Un-mixing Technique

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ABSTRACT: Rice is one of the most consumed grains in the world and produced more than 114 countries, that is why it become an important factor in view of food security. The global analysis of rice paddy area using FAO statistic data still can not be done because there are some country that have not being monitored. In order to monitor global rice paddy area, previous spatial distribution research of rice paddy field around the world was developed by combining NDVI and new water index. NDVI was developed from MODIS whereas new water index was developed by un-mixing LSWC from AMSR2 and V-S-W from MODIS. In this research, the country level of rice paddy fields developed by MODIS-AMSR2 was calibrated with statistic data from FAO, where around 118 countries data of rice paddy have been existing in FAO. The next goal is to analyze the spatio-temporal changes of rice paddy area from 2000 to 2014 by utilizing MODIS-AMSR2 data in selected region and country especially in countries that have no statistic data in FAO to analyze correlation between changes in rice paddy area with MDGs target achievement. Remote sensing approach has been an alternative technology for monitoring rice paddy area in global scale especially to complete the rice paddy area data in countries that had not documented by FAO. Some countries that was not documented are having actual large number of rice paddy area based on MODIS-AMSR2 data result. The result of long year analysis shows that there is a significant increasement and decreasement of rice paddy area in some countries. The future research is to analyze the phenomena of this rice paddy changes with some other factors such as rice paddy supply and demand, population growth, and gross domestic production (GDP) in country level.

1. INTRODUCTION

1.1 Background of this research

Year 2015 was the year of Millenium Development Goals (MDGs) evaluation of achievement, where the world as a unity had been trying to reach a strategic achievement in 15 years. One of the MDGs target was to eradicate extreme hunger and to ensure environmental sustainability (UN, 2015). Global trend in last 15 years shows that for the developing region as a whole, the share of undernourished people in total population has decreased significantly but in some region such as Southern Asia, Oceania, the Carribean and Southern and Eastern Africa the decreasement was in too slow pace (FAO, 2015). Until the MDGs achievement already evaluated, the global food security was not reached. Food security itself has four dimention in definition, two of them are economic and physical acsess to food and food availability (FAO,2013).

Rice is one of the most consumed grains in the world and produced more than 114 countries, that is why it become an important factor in view of food security (USDA, 2015). Long year rice field distribution monitoring in global scale will become an important method in order to evaluate the accomplishment of MDGs in decreasing hunger and also to asess the impact of evironmental changing to the availability of food. The result of analysis that conducted from this method can be used to construct a strategy for achieving Sustainable Development Goals (SDGs) target in food security 15 years later. Food and Agriculture Organization (FAO) as a world institution that is responsible to monitor rice paddy area have been publishing the statistic data of rice paddy area in global, regional and country level. However the global analysis of rice paddy area using FAO statistic data still can not be done because there are some country that have not being monitored.

Remote sensing had been introduced to monitor land use and land cover (LULC) for environmental use in a long period of time globally. The utilization of satelite image data for monitoring rice paddy area in different level of scope is continuesly being developed by many researcher (Xiao, 2006; Takeuchi, 2009a; Moshleh, 2015). Takeuchi, et al. has demonstrated the combination of normalized difference vegetation index (NDVI) and new water index to identify rice crop mapping in 1 km resolution (Jonai and Takeuchi, 2013). NDVI was developed from moderate resolution imaging spectroradiometer (MODIS) data whereas new water index was developed by un-mixing land surface water coverage (LSWC) from advance microwave scanning radiometer 2 (AMSR2) with the vegetation, soil and water (V-S-W) index from MODIS. Rice paddy map developed by this method will take the advantage of the daily coverage and cloud free imaging of AMSR2 and high resolution from MODIS.

1.2 Objective of this research

The aim of this research was to calibrate the result of rice paddy area map from MODIS-AMSR2 with the FAO statistic data in country level, where around 118 countries data of rice paddy have been existing in FAO. The second goal is to analyze rice paddy area in selected countries that have no existing rice paddy area statistic data from FAO. The final goal is to analyze the spatio-temporal changes of rice paddy area from 2000 to 2014 by utilizing MODIS-AMSR2 data in selected regions and countries.

2. METHODOLOGY

Figure 1 shows a flowchart of mapping and analyzing long year change of global rice paddy area with MODIS and AMSR2 by spatio-temporal un-mixing technique. First, the rice paddy map in 1km resolution was generated by combining MODIS NDVI dataset with new water index (Jonai and Takeuchi, 2013) After that, the rice paddy map was calibrated with rice paddy area statistic data from FAO by applying least square method. In this step, the data from 2014 was used as a representative to analyze the map accuracy. The next step was calculating rice paddy area in countries that have no FAO statistic data by referring to the result of calibration in 2014. The last one was analyzing the correlation between changes in rice paddy area with MDGs target achievement in selected regions and countries from 2000-2014. Table 1 show the selected regions and countries that represents three indicator of progress achievement in MDGs. The analysis of rice paddy area changes in 15-year period compared some variable of data which are rice paddy area data from FAO, total population data (UN, 2015), proportion of undernourished in total population (FAO, 2015), and single-double and triple cropping intensity map by MODIS-AMSRE2. This analysis also used some existing global map data for the comparison such as 1 km cultivated area map by GLC-2000 (Bartholome, 2002) and Irrigated-Rainfed cropland map by GlobCover in 2005 and 2009 (Bicheron, 2005; Bontemps, 2009).

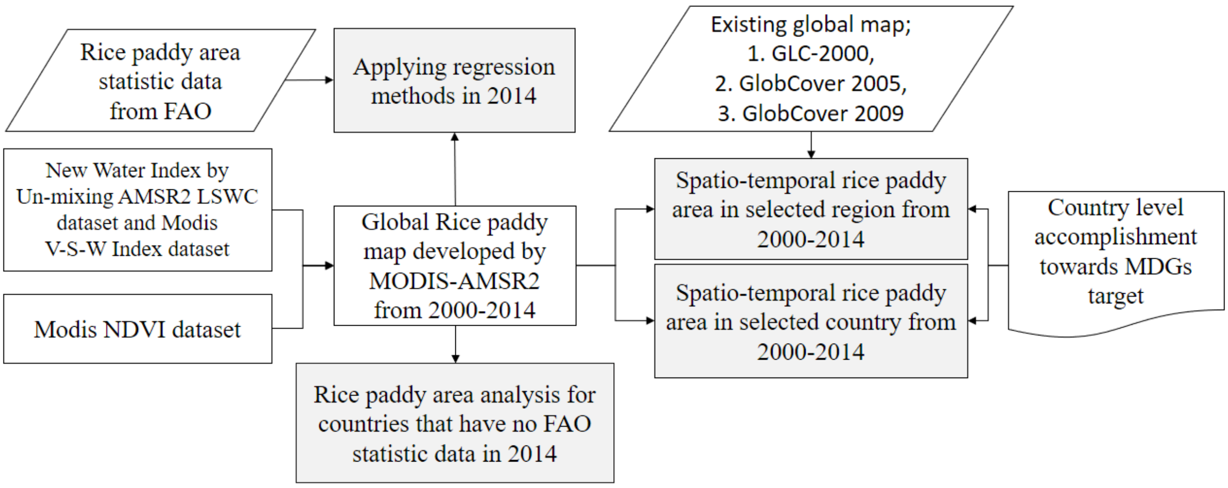

Figure.1 Flow chart of this research

Table.1 selected regions and countries that represents three indicator of progress achievement in MDGs

Regions/Countries	Proportion of undernourished in total population (%) 2000-02	2005-07	2010-12	2014-16	Change so far	Progress toward MDG target	Rice Consumption per capita (2000)
Middle Africa	44.2	43	41.5	41.3	23.2	not achieved, with lack of progress	
Southern Asia	18.5	20.1	16.1	15.7	−34.4	not achieved, with slow progress	
Western Africa	15	11.8	9.7	9.6	−60.2	achieved	
Madagascar	35.6	34.9	31.7	33	21	not achieved, with lack of progress	95.75 kg/yr
Guinea	26.1	22	17.8	16.4	−29.0	not achieved, with slow progress	86.83 kg/yr
Suriname	13.9	11.5	8.3	8	−48.2	achieved	75.67 kg/yr

3. RESULT AND DISCUSSION

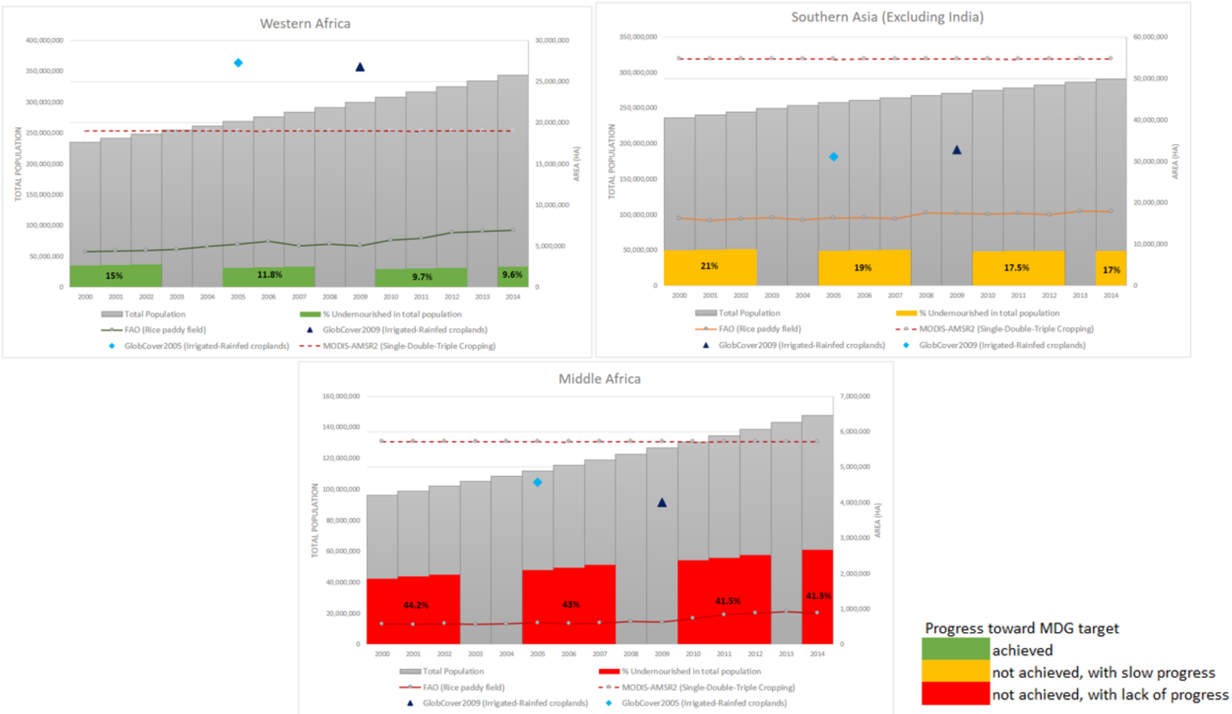

Figure.2 The dynamic change of rice paddy area in selected regions that represents three indicator of progress achievement in MDGs (achieved, not achieved with slow progress and not achieved with lack progress).

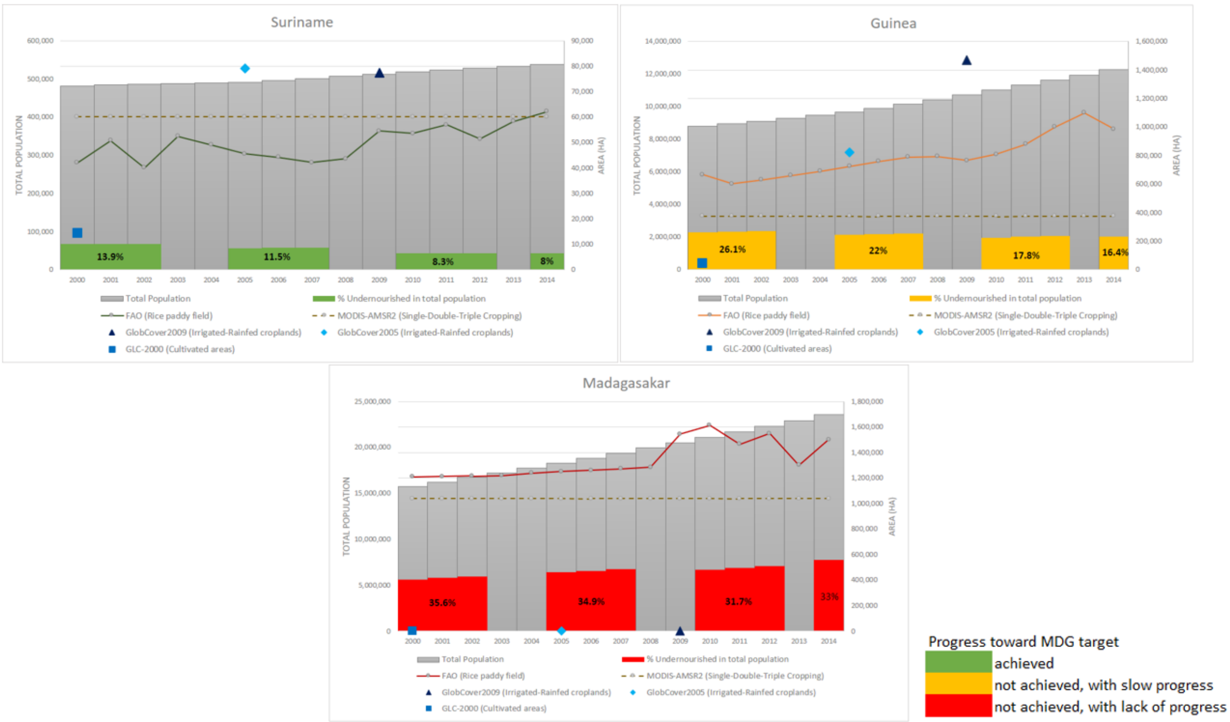

Figure.3 The dynamic change of rice paddy area in selected countries that represents three indicator of progress achievement in MDGs (achieved, not achieved with slow progress and not achieved with lack progress).

The comparison result between MODIS-AMSR2 crop intensity data with FAO rice paddy area data-especially in regional level-resulted as overestimation because of the crop type mixing in single cropping category. This point also can be seen in the result of cultivated area value by GLC-2000 and Irrigated-Rainfed cropland by GlobCover 2005 and 2009 which categorized as mixed crop. Further research will be conducted to minimalized errors in MODIS-AMSR2 data, so the rice paddy area can be analyzed more detail.

In regional level, the analysis of rice paddy area changes represented by Western Africa, South Asia (excluding India), and Middle Africa. Whereas for country level analysis, representing countries are Suriname, Guinea and Madagascar. Those regions and countries were chosen because of the achievement towards MDGs target in lowering undernourished level and the preference of rice consumption. Generally, when food production cannot meet the demand escalation, undernourished level will increase as a consequence. The extension of rice paddy area represents increasing in food production while the demand escalation caused by population growth. Extension of rice paddy area that was monitored in West Africa region can be stated as one of the important effort in decreasing undernourished level for that area. In country level, the increasing number of population in Suriname that did not followed by the raising of rice paddy area capacity was also one of the factor in failure achievement of MDGs target.

4. CONCLUSION AND FUTURE WORK

Remote sensing approach had been used as an alternative technology for monitoring rice paddy area in global scale especially to complete the rice paddy area data in countries that had not documented by FAO. Some countries that was not documented are having actual large number of rice paddy area based on MODIS-AMSR2 data result.

The result of long year analysis shows that there is a significant increasement and decreasement of rice paddy area in some countries. The unbalance between rice paddy area growth with rapid population growth resulted in unachieved MDGs target, it can be seen in Middle Africa and Madagascar area. The future research is to analyze the phenomena of this rice paddy changes with some other factors such as rice paddy supply and demand, population growth, and gross domestic production (GDP) in country level. Moreover it also can be used for analyzing the decreasement of rice paddy area caused by urbanization especially in arable land area for rice paddy and the failure in harvesting rice paddy caused by environmental disaster.

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