Projected Impact of Downscaled Climate Scenarios on Rice Production in Two Selected Provinces in the Philippines

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Background

- IPCC is unequivocal that warming of the climate system observed from the last 50 years has been attributed to the observed increase in greenhouse gas concentrations due to human activities.
**Background**

- Typhoon and long dry spell that caused severe water stress are the most destructive climate events experienced by Philippine farmers in the recent years.

*Figure 1. Distribution of palay production in the Philippines from 1990-2010*

*Source: Orge, 2012 (PhilRice)*
Changes in global climate system are most likely to continue in the future and climate scenarios are useful in characterizing future climate risks.

Table 1. The four storylines developed by the IPCC which defines plausible emission scenarios

<table>
<thead>
<tr>
<th>Storyline</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Very rapid economic growth; population peaks mid-century; social, cultural and economic convergence among regions; market mechanisms dominate. Subdivisions: <strong>A1F1</strong> – reliance on fossil fuels; <strong>A1T</strong> – reliance on non-fossil fuels; <strong>A1B</strong> – a balance across all fuel sources</td>
</tr>
<tr>
<td>A2</td>
<td>Self-reliance; preservation of local identities; continuously increasing population; economic growth on regional scales</td>
</tr>
<tr>
<td>B1</td>
<td>Clean and efficient technologies; reduction in material use; global solutions to economic social and environmental sustainability; improved equity; populations peaks mid-century</td>
</tr>
<tr>
<td>B2</td>
<td>Local solutions to sustainability; continuously increasing population at a lower rate than in A2; less rapid technological change than in B1 and A1</td>
</tr>
</tbody>
</table>
Background

Figure 2. Global temperature projections to the year 2100, based on a range of emission scenarios and global climate models

Source: HadCM3 based on four IPCC’s SRES future emissions scenarios (2007)
Background

• GCM climate projections have to be downscaled to represent the local-scale surface weather, and be used in impact assessment.
Objectives

1. To determine climate change trends and define possible climate change scenarios at the local level

2. To assess the potential impacts of climate change on rice production under different scenarios
Methodology

A. Study Sites:

- Tarlac and Pangasinan
- two municipalities per province
- two barangays per municipality
- three riceland ecozones per municipality: upland rainfed, lowland rainfed, lowland irrigated
- Crop studied: rice
Methodology

B. Data Collection

- KII/FGD with LGU officials
- interview with rice farmers
- desk review of weather records and soil profiles

C. Data Analysis

- estimated impact of climate scenario on rice yield in 3 time periods: 2020, 2050, 2080
D. Climate Projections (Downscaling)

• **Statistical Downscaling Model (SDSM)** using regression-based approach
  – GCM: CGCM3
  – Scenario: A1B

• **Dynamical downscaling using Providing Regional Climates for Impact Studies (PRECIS)**
  – GCM: HadCM3
  – Scenario: A1B
Methodology

E. Crop Modeling

• Crop simulation model using Decision Support System for Agrotechnology Transfer (DSSAT)
Methodology: Downscaling

**Figure 3.** Representation of the Philippines using three resolutions; 300km x 300km, 50km x 50 km, and 25km x 25km grids

“Even if global climate models in the future are run at high resolution, there will remain the need to ‘downscale’ the results from such models to individual sites or localities for impact studies (DOE, 1996; p34).”
Methodology: Downscaling of GCM Climate Projections

- **Dynamical Procedure** – uses limited-area, high-resolution model such as regional climate model (RCM) driven by boundary conditions from GCM to derive small-scale information (e.g. PRECIS model)

- **Statistical Technique** – involves determining quantitative relationships with GCM data as predictors and local climate variables as predictands (e.g. SDSM)
Methodology: Statistical Downscaling

Figure 4. CGCM3 global land/sea mask: land grid cells are in green, while sea grid cells are in blue.
Crop Simulation Model - DSSAT

Weather Data
(Daily minimum temperature, daily maximum temperature, daily solar radiation, daily rainfall)

Soil Data
(Physical and Chemical Properties of soil by horizon)

Crop Cultivar/Variety
(Genetic Coefficients)

Crop Management Practices
(Planting calendar, density, method, depth, application of irrigation, fertilizer, residue, tillage, etc, environmental adjustment and harvest schedule)

DSSAT-CSM
(CROPGRO, Ceres Wheat, Ceres-Rice, Ceres-Maize, etc.,)

Potential Yield/Predicted Yield

Figure 5. Schematic diagram of DSSAT-CSM model
Source: Jones, et al., 2003
Crop Simulation Model - DSSAT

• Crop simulation model is defined as the dynamic simulation of crop growth by numerical integration of constituent processes with the aid of computers (Sinclair and Seligman, 1996).

• Potential impacts of climate scenarios on rice yields were determined using Decision Support System for Agrotechnology Transfer (DSSAT) on crop simulation in which the generated daily weather data together with physiochemical properties of soil, rice crop management practices and genetic coefficients of standard rice crop variety were integrated to simulate the growth and development of the crop.
Results of Statistical Downscaling Model (SDSM)
Figure 6. Projected monthly mean temperature (°C) under medium-range emission scenario (A1B) of Coupled Global Climate Model 3 (CGCM3) for Tarlac, Philippines downscaled using regression based approach.

Figure 7. Projected monthly rainfall (mm) under medium-range emission scenario (A1B) of Coupled Global Climate Model 3 (CGCM3) for Tarlac, Philippines downscaled using regression based approach.
Results: SDSM - Pangasinan

**Figure 8.** Projected monthly mean temperature (°C) under medium-range emission scenario (A1B) of Coupled Global Climate Model 3 (CGCM3) for Pangasinan, Philippines downscaled using regression based approach.

**Figure 9.** Projected monthly rainfall (mm) under medium-range emission scenario (A1B) of Coupled Global Climate Model 3 (CGCM3) for Pangasinan, Philippines downscaled using regression based approach.
Results of Providing Regional Climates for Impact Studies (PRECIS)
**Results: PRECIS - Tarlac**

**Figure 10.** Projected change in monthly mean temperature (°C) under medium-range emission scenario for Tarlac, Philippines downscaled using PRECIS model.

**Figure 11.** Projected change in monthly rainfall (mm) under medium-range emission scenario for Tarlac, Philippines downscaled using PRECIS model.
Results: PRECIS - Pangasinan

**Figure 12.** Projected change in monthly mean temperature (°C) under medium-range emission scenario for Pangasinan, Philippines downscaled using PRECIS model.

**Figure 13.** Projected change in monthly rainfall (mm) under medium-range emission scenario for Pangasinan, Philippines downscaled using PRECIS model.
Results of Crop Simulation Modeling
## Results: Irrigated Lowland - Tarlac

![Bar chart showing relative change in crop potential yield during dry and wet season in Tarlac, Philippines under projected climate scenarios in 2020, 2050, and 2080.](image)

### Figure 14. Average percent change in crop potential yield during dry and wet season in Tarlac, Philippines under projected climate scenarios in 2020, 2050, and 2080

<table>
<thead>
<tr>
<th>Season</th>
<th>Baseline</th>
<th>2020</th>
<th>2050</th>
<th>2080</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ave. Potential Yield (kg/ha)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry season</td>
<td>3268.69</td>
<td>2967.10</td>
<td>2919.57</td>
<td>2907.59</td>
</tr>
<tr>
<td>CV (%)</td>
<td>22.85</td>
<td>32.93</td>
<td>37.78</td>
<td>43.94</td>
</tr>
<tr>
<td>Wet season</td>
<td>5710.50</td>
<td>5947.90</td>
<td>5609.80</td>
<td>3624.27</td>
</tr>
<tr>
<td>CV (%)</td>
<td>29.69</td>
<td>27.56</td>
<td>23.20</td>
<td>38.29</td>
</tr>
</tbody>
</table>
**Results: Rainfed Lowland - Tarlac**

**Figure 15.** Average percent change in crop potential yield during dry and wet season in Tarlac, Philippines under projected climate scenarios in 2020, 2050 and 2080.

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>2020</th>
<th>2050</th>
<th>2080</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dry season</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ave. Potential Yield (kg/ha)</td>
<td>2607.50</td>
<td>2766.27</td>
<td>2392.47</td>
<td>2535.41</td>
</tr>
<tr>
<td>CV (%)</td>
<td>30.23</td>
<td>38.06</td>
<td>36.67</td>
<td>33.59</td>
</tr>
<tr>
<td><strong>Wet season</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ave. Potential Yield (kg/ha)</td>
<td>6235.65</td>
<td>6210.50</td>
<td>6061.63</td>
<td>4096.67</td>
</tr>
<tr>
<td>CV (%)</td>
<td>24.34</td>
<td>29.02</td>
<td>23.42</td>
<td>36.17</td>
</tr>
</tbody>
</table>
Results: Rainfed Upland - Tarlac

Figure 16. Average percent change in crop potential yield during wet season in Tarlac, Philippines under projected climate scenarios in 2020, 2050 and 2080

<table>
<thead>
<tr>
<th>Wet season</th>
<th>Baseline</th>
<th>2020</th>
<th>2050</th>
<th>2080</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ave. Potential Yield (kg/ha)</td>
<td>3349.65</td>
<td>2628.03</td>
<td>2265.17</td>
<td>1532.50</td>
</tr>
<tr>
<td>CV (%)</td>
<td>31.62</td>
<td>55.65</td>
<td>52.48</td>
<td>77.27</td>
</tr>
</tbody>
</table>
Figure 17. Average percent change in crop potential yield during dry and wet season in Pangasinan, Philippines under projected climate scenarios in 2020, 2050 and 2080

Results: Irrigated Lowland - Pangasinan
**Results: Rainfed Lowland - Pangasianan**

**Figure 18.** Average percent change in crop potential yield during dry and wet season in Pangasian, Philippines under projected climate scenarios in 2020, 2050 and 2080.

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>2020</th>
<th>2050</th>
<th>2080</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dry season</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ave. Potential Yield (kg/ha)</td>
<td>2687.73</td>
<td>2779.83</td>
<td>2737.43</td>
<td>2933.10</td>
</tr>
<tr>
<td>CV (%)</td>
<td>25.38</td>
<td>24.31</td>
<td>18.89</td>
<td>18.72</td>
</tr>
<tr>
<td><strong>Wet season</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ave. Potential Yield (kg/ha)</td>
<td>7768.63</td>
<td>7821.30</td>
<td>8013.10</td>
<td>8172.20</td>
</tr>
<tr>
<td>CV (%)</td>
<td>11.50</td>
<td>17.75</td>
<td>16.59</td>
<td>11.82</td>
</tr>
</tbody>
</table>
**Results: Rainfed Upland - Pangasinan**

![Graph showing relative change in yield for wet season in Pangasinan, Philippines under projected climate scenarios in 2020, 2050, and 2080.](image)

**Figure 19.** Average percent change in crop potential yield during wet season in Pangasinan, Philippines under projected climate scenarios in 2020, 2050, and 2080.

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>2020</th>
<th>2050</th>
<th>2080</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wet season</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ave. Potential Yield (kg/ha)</td>
<td>2303.33</td>
<td>3137.03</td>
<td>3367.50</td>
<td>3415</td>
</tr>
<tr>
<td>CV (%)</td>
<td>84.58</td>
<td>62.52</td>
<td>56.65</td>
<td>55.66</td>
</tr>
</tbody>
</table>

Results:

Rainfed Upland - Pangasinan

International Conference on Climate Change Impacts and Adaptation for Food and Environmental Security 2012
Conclusions

• SDSM and PRECIS are comparable. They both projected an increase in mean temperature for both provinces. More pronounced rainfall is expected during wet season and drier dry season is expected for different climate scenarios in Tarlac. An increase in the amount of rainfall is more likely to occur throughout the year in Pangasinan.

• Impacts of climate change on crop productivity can be assessed more objectively using crop simulation model.
Conclusions

- Rice productivity is expected to reduce due to climate change. However, crop simulation study showed that rice yields in Pangasinan will increase.

- The combined effects of increases in temperature and rainfall on rice production vary depending on the time period, location, eco-zone, cropping season, and planting schedule.
Recommendations

• adjustment of cropping calendar
• crop rotation and diversification
• construction of small farm reservoir
• zero tillage for more effective water infiltration, and prevention of soil erosion and soil degradation
Recommendations

• use of appropriate crop varieties such as drought-resistant or submergence tolerant varieties

• farmers’ education - to improve the social acceptability of alternative conservation agriculture technologies and help farmers make informed decisions on appropriate technologies they can adopt considering the projected climatic changes
Maraming Salamat Po!