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Photography (right) from Chugoku-shikoku regional agricultural administration office website
Introduction
Research Motivation | Drought

- Drought can have social, economic, and environmental impacts on society
- Climate change is a growing concern for community resource management as it can cause more extreme weather events
- The frequency and duration of drought are projected to increase (IPCC AR5)
Research Motivation | CPR

- Common-Pool Resource (CPR) management requires collective action and cooperation, especially when resource users face extreme weather events.

- Previous studies, e.g. Ostrom (1990) suggest that resource users can sustain collective action and self-organise CPRs over time.

  - Cavalcanti et al. (2010)
    Study the effect of the beliefs about others’ cooperation on one’s willingness to contribute to more sustainable fishery management in Brazil.

  - Villamayor-Thomas (2014)
    Examines factors for cooperation in community-based irrigation management under severe drought conditions in Spain.
CPR Management in This Study

- The study empirically analyzes the water management during droughts by using the data on water restrictions
- Community-based drought response in Japan
  - Drought-response council to coordinate water use
  - Water restrictions by the groups of water users
  - Collective decision-making in water resource management
Research Objectives

CPR management

• To examine the determinants of collective decisions on water restrictions in drought management

• To investigate the conditions for cooperation among water user groups

Climate change adaptation study

• To examine the impact of climate change on drought management

• To find out whether / to what extent the severity of drought affects water restrictions
Background
Drought Response in Japan

BACKGROUND

DECLINE IN WATER LEVEL IN RESERVOIR

INCREASING RISK OF WATER SHORTAGE

DROUGHT-RESPONSE COUNCIL IN A RIVER BASIN

Water Users

River Admin.

Gov. Agencies

Local Gov.
Drought-Response Council

Aim

• To facilitate the coordination of water use among water users
• To implement water withdrawal restrictions

Policy background

• Article 53 of River Act (1964 - )
  providing for the coordination of water use by water users in the event of a drought
• Administrative notification in 1974
  regarding the implementation of the council in each river basin
Drought-Response Council (contd)

Water withdrawal restrictions

• Impose rates of reduction on water withdrawals from dams and rivers

• Applied to water supplies: domestic, agricultural, and industrial water uses

• Resulted from the collective decision-making by water user groups sharing the same water source
Collective Decision-Making in Drought Management

River Basin Community

Collective Decision/Action

Water Users

Resource System Characteristics

DOMESTIC

AGRICULTURAL

INDUSTRIAL

Water Withdrawal Restrictions

DROUGHT

Extreme Weather Events
Hypotheses

1. A water user group cooperates more for water conservation when other water user groups sharing water resource in their river basin community also cooperate.

2. Climate change has an adverse effect on the management of water resource.
Empirical Analysis
Data

- Pooled data
- Sample period: 1983 - 2013
- Observations: 207 cases of regional droughts in Japan
  - 56 dams included
  - Associated with water restrictions for multipurpose dams that supply water for domestic, agricultural, and industrial water uses
EMPIRICAL ANALYSIS

Model

OLS model

\[ Y_{ij} = \beta_0 + \beta_1 X_{ij} + \beta_2 D_{ij} + \beta_3 M_{ij} + \beta_4 Z_{ij} + \delta_{ij} + \varepsilon_{ij} \]

for dam \( i \) during drought \( j \)

**Dependent variable**

\( Y \)  Domestic water restriction rate

(A rate of reduction on water withdrawals from dams)

**Independent variables**

\( X \)  Water restriction rates for the other water user groups
\( D \)  Dam group characteristics
\( M \)  Meteorological characteristics
\( Z \)  Control variables
\( \delta \)  Year / region fixed effects
Independent Variables | Hypotheses

Water restriction rates for the other water user groups (H1)

- **Agricultural water restriction rate**
- **Industrial water restriction rate**
  
  A rate of reduction on water withdrawals from dams, applied to each water use

Meteorological characteristics (H2)

- **Dry days**
  
  Annual number of days with precipitation of less than 1 mm

- **Precipitation ratio**
  
  Ratio of annual precipitation to the mean annual precipitation from 1981 to 2010

- **Precipitation**
  
  Annual amount of precipitation
Independent Variables | Hypotheses (contd)

Dam group characteristics

- **Purposes of dam**
  Number of purposes for which a dam provides water resources

- **History of dam use**
  Operation period of a dam at the time a drought occurred

- **Storage capacity**
  Reservoir storage capacity for operating purposes
Independent Variables | Control Variables

Management characteristics

• Integrated management
  Water restrictions are jointly implemented on water withdrawals from multiple dams: no=0, yes=1

• Full Plan
  The river basin in which a dam is located is subject to a national government policy for water resources: no=0, yes=1

Domestic water user group characteristics

• Domestic water distribution
  Average daily amount of domestic water distribution to domestic water users

• Domestic water price
  Domestic water price charged per 10 m³ for bore diameters of 13 mm
Results
## Regression Results (OLS)

### Dependent variable: Domestic water restriction rate

<table>
<thead>
<tr>
<th>Water restriction rate of other water user groups</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural water restriction rate (%)</td>
<td>0.4385</td>
<td>0.4208</td>
<td>0.4126</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0883)</td>
<td>(0.0871)</td>
<td>(0.0753)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial water restriction rate (%)</td>
<td>0.0626</td>
<td>0.0788</td>
<td>0.0956</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0642)</td>
<td>(0.0644)</td>
<td>(0.0542)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Dam group characteristics

<table>
<thead>
<tr>
<th>Purposes of dam (purpose)</th>
<th>3.1859</th>
<th>2.929</th>
<th>2.3254</th>
<th>3.7602</th>
<th>3.6691</th>
<th>3.0434</th>
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</thead>
<tbody>
<tr>
<td>History of dam use (year)</td>
<td>-0.0264</td>
<td>-0.0311</td>
<td>0.0488</td>
<td>0.093</td>
<td>0.0987</td>
<td>0.1706</td>
</tr>
<tr>
<td>Storage capacity (100 million m³)</td>
<td>0.7072</td>
<td>0.5856</td>
<td>0.3281</td>
<td>0.5858</td>
<td>0.5959</td>
<td>0.2628</td>
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</table>

### Meteorological characteristics

<table>
<thead>
<tr>
<th>Dry days (day)</th>
<th>0.0917</th>
<th>**</th>
<th>0.0613</th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation ratio (%)</td>
<td>-0.0201</td>
<td></td>
<td>-0.1129</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Precipitation (mm)</td>
<td>0.0079</td>
<td>***</td>
<td>(0.0079)</td>
<td>***</td>
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<td></td>
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</table>

### Control variables

<table>
<thead>
<tr>
<th>Integrated management (dummy)</th>
<th>-2.9314</th>
<th>-2.6445</th>
<th>0.9286</th>
<th>-10.4072</th>
<th>***</th>
<th>-9.9598</th>
<th>***</th>
<th>-6.5962</th>
<th>***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1.8448)</td>
<td>(1.8611)</td>
<td>(2.0449)</td>
<td>(2.1845)</td>
<td>(2.1446)</td>
<td>(2.3986)</td>
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<tr>
<td>Full Plan (dummy)</td>
<td>9.6467</td>
<td>***</td>
<td>9.7672</td>
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<td>8.6967</td>
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<td>6.951</td>
<td>***</td>
<td>7.4278</td>
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<tr>
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<td>(1.9381)</td>
<td>(1.9531)</td>
<td>(1.7681)</td>
<td>(2.3248)</td>
<td>(2.3827)</td>
<td>(2.2065)</td>
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<tr>
<td>Domestic water distribution (1,000 m³)</td>
<td>-0.0030</td>
<td>-0.0030</td>
<td>0.0005</td>
<td>-0.0003</td>
<td>-0.0003</td>
<td>-0.0003</td>
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<tr>
<td></td>
<td>(0.0004)</td>
<td>(0.0004)</td>
<td>(0.0004)</td>
<td>(0.0006)</td>
<td>(0.0006)</td>
<td>(0.0006)</td>
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<tr>
<td>Domestic water price (yen)</td>
<td>0.0007</td>
<td>-0.0013</td>
<td>-0.0012</td>
<td>0.0061</td>
<td>0.0049</td>
<td>0.0046</td>
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<td></td>
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<tr>
<td></td>
<td>(0.0052)</td>
<td>(0.0050)</td>
<td>(0.0046)</td>
<td>(0.0058)</td>
<td>(0.0056)</td>
<td>(0.0049)</td>
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</tr>
<tr>
<td>Constant</td>
<td>-50.5776</td>
<td>***</td>
<td>-22.6943</td>
<td>***</td>
<td>-34.6486</td>
<td>***</td>
<td>-38.4269</td>
<td>*</td>
<td>-12.5822</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01
## Regression Results | Hypothesis 1

1. A water user group cooperates more for water conservation when other water user groups sharing water resource in their river basin community also cooperate

### Results

<table>
<thead>
<tr>
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<td>Meteorological variable</td>
<td>Dry days</td>
<td>Precipitation ratio</td>
<td>Annual precipitation</td>
<td></td>
</tr>
<tr>
<td>Robust standard errors in parentheses</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* p&lt;0.1, ** p&lt;0.05, *** p&lt;0.01</td>
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## Regression Results | Hypothesis 2

2. Climate change has an adverse effect on the management of water resource

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<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Meteorological characteristics</strong></td>
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Robust standard errors in parentheses

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Conclusions
Conclusions

The study examines the determinants of collective decisions on the water restrictions during droughts

- A water user group tends to apply the higher level of water restrictions as other water user groups sharing water resource also apply the higher level of water restrictions

- The level of cooperation for water conservation depends on other user groups’ cooperation

We also investigate the impact of climate change on drought management

- The drought-related weather patterns lead to the implementation of the higher level of water restrictions

- More stringent water restrictions may be needed if climate change becomes more serious
Water Withdrawal Restriction Rates

Domestic water restriction rate (%) vs. Agricultural water restriction rate (%)

N = 207
Water Withdrawal Restriction Rates

APPENDIX

Domestic water restriction rate (%) vs. Industrial water restriction rate (%)

N = 207
Number of drought events in Japan

Note: The start day of water restrictions is taken to calculate annual values. There are some cases that water restrictions imposed in a particular year continued in the following year.
Number of drought events by month in Japan (1983 - 2013)

Note: The start day of water restrictions is taken to calculate monthly values. Water restrictions imposed in a particular month may have continued in the following months.
Duration of water restrictions in Japan (1983 - 2013)

Note: The width of each bin is 10 days. The minimum duration of water restrictions is 2 days and the maximum duration of water restrictions is 330 days.