Experiences of application soil and land cover databases on soil management in Taiwan

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Crop production

Chickpea production

- deep soil
  - well-drained, loam-clay
- 350+ mm
  - cool season, av. 15°C
- pH 6–8 (in CaCl₂)
  - low salinity, Na & B
- two types
  - desi and kabuli

Benefits

- up to 70 kgN/ha fixed
- good returns for good quality
- different weed control options
- better cereal yields

Pulse Australia - Northern guide
Effect of range of pH on barley growth.
phosphorus-poor soils
Papaya-red lady cultivated **strong acid soil** – Kuan island

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Root length (mm)</th>
<th>Root weight (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CK</td>
<td>145 c</td>
<td>53 b</td>
</tr>
<tr>
<td>gypsum</td>
<td>514 b</td>
<td>286 a</td>
</tr>
<tr>
<td>Magnesium oxides</td>
<td>498 b</td>
<td>297 a</td>
</tr>
<tr>
<td>lime</td>
<td>595 a</td>
<td>298 a</td>
</tr>
</tbody>
</table>

*(adjusted soil pH from 4 changes to 6)*

Marler & Cruz 2001
Major symptoms are:
- White leaf tip followed by tip burning (salinity)
- Leaf browning & death (sodicity)
- Stunted plant growth
- Low tillering
- Spikelet sterility
- Low harvest index
- Less florets per panicle
- Less 1000 grain weight
- Low grain yield
- Change in flowering duration
- Leaf rolling
- White leaf blotches
- Poor root growth
- Patchy growth in field

Soil Salinity

Rice knowledge bank, IRRI
a. Well-structured soil

Air, water and nutrients stored in pores

b. Poorly structured soil

Water remains near surface

Water and nutrients move very slowly down profile; air may be excluded

Large pores

Very small pores

Agriculture Victoria
Soil structure
Strong to moderate soil structure
How to build the soil database?

- Legacy soil maps
- Soil survey programs
- Soil testing services
TARI and the legacy soil maps

Before 1945

◆ 1911年土壤鹽分之概略調查
◆ 1913年酸性土壤概略調查
◆ 1915-1925年各州廳之土性調查（1/100000）
◆ 1916年看天田之調查。

After 1945

◆ 全省分縣土壤調查（1/100000）
◆ 土壤調查及土壤肥力測定（1/500000）
◆ 農林邊際土壤調查（1/20000）
◆ 中部橫貫公路沿縣之土地可利用限度調查
◆ 台灣省農田肥力測定（1/100000）
◆ 台灣耕地土壤詳測調查（1/125000）
◆ 山坡地土壤調查（1/25000）
◆ 土壤肥力能限分類規範調查研究
◆ 農田土壤肥力管理與改良資訊系統之建立與應用（1/25000）
Providing soil information
Soil thematic maps

1967 soil reaction map

Diagram showing the relationship between soil pH and plant nutrition elements availability.
Soil reaction

Suitable soil pH for *Annona squamosa*

Soil fertility map - Soil pH
Phosphorus deficiency

Paddy rice response of phosphorus fertilizer

Soil fertility map - soil available phosphorus
Zinc deficiency

Paddy rice zinc deficiency

Soil fertility map-soil available zinc
Papaya boron deficiency

Soil fertility map - soil available zinc
Soil CEC map of Ser-Tou township
Paddy rice
Potassium deficiency

Soil potassium management of township
Tillage or not tillage

Ideal Seedbed Conditions
- Smooth
- Firm
- Free of clods
- Some residue

Footprint in seedbed no more than 1" deep
Tillage Definitions

**Conventional tillage systems:** <15% residue

**Reduced tillage systems:** 15-30% residue

**Conservation tillage systems:** > 30% residue

Residue remaining on soil surface after first tillage operation:
- Moldboard plow <10%
- Chisel plow 25-75%
- Disking 25-75%
- Ridge-planting and Till planting 40-60%
- No-till >90%

Source: Fundamentals of No-Till Farming, Chevron Chemical Co.
Food safety application

預測模式說明

模式：

\[
\log(\text{Cd-rice}) = \alpha + \beta \cdot \text{pH} + \gamma \cdot \log(\text{CEC}) + \delta \cdot \log(\text{Cd-soil})
\]

Cd-rice: 植株镉含量 (mg/kg)
pH: 土壤酸碱度，土液比=1:1(w:v)
CEC: 阳离子交换容量，cmol+/kg soil
Cd-soil: 土壤镉含量 (mg/kg)

( Römkens et al., 2009 )


Look up table for farmers

<table>
<thead>
<tr>
<th>Cadmium in soil</th>
<th>soil pH</th>
<th>Taisen no. 2 (very sensitive)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>4</td>
<td>0.1 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5</td>
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<tr>
<td>0.7</td>
<td>13 9 6 4 0.4 0.06 0.04 0.006 0.0006 0.00006 0.000006</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>20 14 9 6 0.6 0.06 0.04 0.006 0.0006 0.00006 0.000006</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>25 17 12 8 0.8 0.08 0.06 0.008 0.0008 0.00008 0.000008</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>30 23 18 11 0.9 0.09 0.07 0.009 0.0009 0.00009 0.000009</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>35 26 21 14 1 0.1 0.01 0.001 0.0001 0.00001 0.000001</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>40 28 23 16 1.2 0.12 0.012 0.0012 0.00012 0.000012 0.0000012</td>
<td></td>
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<tr>
<td>7</td>
<td>45 30 24 18 0.2 0.02 0.002 0.0002 0.00002 0.000002 0.0000002</td>
<td></td>
</tr>
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</table>

『農業方法達成降低鎘米發生風險』指引

- 管理項目
  - 選擇水稈品種 (0.7 – 2 ppm)
  - 降低鈣吸收量 (> 2 ppm)
  - 改變土地利用 (> 3-5 ppm)

- 土壤管理方式
  - 種植粳稻
  - 施用石灰
  - <土壤污染整治>
    - 水稻田物理處理
    - 植生複育法

單位: mg/kg
Soil Survey

Field observation

- Soil auger (1.5 M)
- Mini soil pit (0.6 M)
- Soil profile (2 M)
Soil chemical properties analysis
Soil particle size analysis
Soil physical properties analysis
Soil biota database
**PEDON**
observation and sampling

**ANALYSIS**
Soil texture, BD, Ks, Water potential

Soil Profile Image

- Characteristic Curve
- Sand micro-photo
- Wet/dry colour

2018/10/22
Pedo-geomorphological map of Pu-Li
Soil carbon baseline
Soil O.M. Map

Grid sampling sites

Kriging method

pedo-geomorphology map
Soil property thematic maps
Nitrogen fertilizer vulnerability map
Web site  http://soilsurvey.tari.gov.tw/
Pedo-geomorphological maps were applied for flooding hazard assessment
Land cover database
an agric-activity monitoring chain
Land cover database– (township scale)
Land cover database— (county scale)
Land cover database—(Taiwan scale)

- Monitoring processes regularly.
- Nearly-real time survey, timing and labor saving.
- Crop cultivation acreages will be published 3 times a year soon.
- Crop marketing early warning.
Cabbage production
(104.10.16至105.05.29衛星影像判釋)

<table>
<thead>
<tr>
<th>期作</th>
<th>105年一作</th>
<th>105年一期作</th>
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<tbody>
<tr>
<td>影像日期</td>
<td>105.10.16</td>
<td>105.11.07</td>
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<tr>
<td>平地成果面積</td>
<td>302.52</td>
<td>301.48</td>
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<tr>
<td>高山成果面積</td>
<td>—</td>
<td>—</td>
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<tr>
<td>總判釋成果面積</td>
<td>302.52</td>
<td>301.48</td>
</tr>
</tbody>
</table>

備註:
1. 影像日期欄中，黑字為平地判釋影像日期，紅字為高山判釋影像日期
2. 高山及平地影像於105.04.08至105.05.29間皆無可判影像，因此預期應判釋之高山日期105.05.08及平地105.05.10栽培面積未知
Paddy rice cultivation area and yield prediction
Climate database in Taiwan

Precipitation (mm), August 7-10, 2009

Precipitation (mm), Sept. 20, 2010

資料來源: 莫拉克風災調查報告 (國科會, 2008)

資料來源：中央氣象局

2018/10/22
Application of agricultural spatial information

Land cover map of Taiwan
Mango

Suitable soil pH 4.5-7.4
Magnesium deficiency of India Jujube
Forage crops suitability assessment map
Heavy rainfall affected high elevation vegetable production area (23130414)

Accumulated precipitation during litchi flowering stage of southern part of Taiwan
Disasters risk and agricultural insurance

合乎Global GAP農地評估

雲林縣農地暴雨量之淹水模擬
Flooding hazard assessment
Developing ICTs tools for smallholder farmers in Taiwan
小農農場經營管理系統
Smart farming management system for small-hold farmer
Based on Common Land Unit (CLU).

Using Expert Knowledge, Connecting the Farmland Management System.

According to the time differences, Giving a suitable management advice.

Precision AG Management : Building a small-hold farming institution.
Precision Agriculture Spatial Cloud Database

Common Land Unit

Spatial Attribute

GIS software

Agricultural Information

Spatial operation

Common Land Unit (CLU) Query

Data Visualization

Spatial Database

PostgreSQL
### Precision Agriculture Spatial Cloud Database

#### Agricultural Space Information
- Administrative areas, terrain elevation, land use status, traffic network

#### Agricultural meteorological data
- Weather station distribution, daily climate and historical climate data

#### Soil Information
- Soil Fertility, Soil Characteristics and Soil Heavy Metals

#### Farmland Management Information
- Fertilization management, land cover, flooding potential and crop growth information

#### Farmland real-time monitoring
- WSN Pest monitoring, Instant Climate

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<table>
<thead>
<tr>
<th>County</th>
<th>Agricultural Space Information</th>
<th>Agricultural meteorological data</th>
<th>Soil Information</th>
<th>Farmland Management Information</th>
<th>Farmland real-time monitoring</th>
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<td>New Taipei</td>
<td>1,000,574</td>
<td>1,590,834</td>
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<td>Tainan</td>
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<td>Yunlin</td>
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<td>Taipei</td>
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<td>Keelung</td>
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<td>Pingtung</td>
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<td>Hualien</td>
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<td>New Taipei</td>
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<td>Nantou</td>
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<td>Tainan</td>
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<td>Tainan</td>
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<td>Hualien</td>
<td>1,171,040</td>
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</tbody>
</table>

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*Over 10 million parcels data*
Smart farming management system for small-hold farmer

Combined 3S and LBS
**Historical Climate**

> Quickly grasp the historical climate information, as the basis for field cultivation and management.

## Smart farming management system for small-hold farmer

### Historical Climate - Quick grasp the historical climate information, as the basis for field cultivation and management

<table>
<thead>
<tr>
<th>Date</th>
<th>Average Temperature (°C)</th>
<th>Average Precipitation (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 September</td>
<td>24.2</td>
<td>125</td>
</tr>
<tr>
<td>2 September</td>
<td>23.9</td>
<td>118</td>
</tr>
<tr>
<td>3 September</td>
<td>23.6</td>
<td>112</td>
</tr>
<tr>
<td>4 September</td>
<td>23.3</td>
<td>108</td>
</tr>
<tr>
<td>5 September</td>
<td>23.0</td>
<td>103</td>
</tr>
<tr>
<td>6 September</td>
<td>22.8</td>
<td>98</td>
</tr>
<tr>
<td>7 September</td>
<td>22.5</td>
<td>93</td>
</tr>
<tr>
<td>8 September</td>
<td>22.2</td>
<td>89</td>
</tr>
<tr>
<td>9 September</td>
<td>22.0</td>
<td>84</td>
</tr>
</tbody>
</table>

### Monthly historical climate information for 1971-2015

#### 11月08日全日平均気候資料

<table>
<thead>
<tr>
<th>項目</th>
<th>單位</th>
<th>目前測定</th>
<th>最近三年的今天</th>
<th>最近五年的今天</th>
<th>最近十年的今天</th>
<th>歷史上的今天最高</th>
<th>歷史上的今天最低</th>
</tr>
</thead>
<tbody>
<tr>
<td>気温</td>
<td>摄氏</td>
<td>28.46</td>
<td>22.90(↑5.56)</td>
<td>22.72(↑5.74)</td>
<td>22.72(↑5.74)</td>
<td>23.28(↑5.18)</td>
<td>22.19(↑6.27)</td>
</tr>
<tr>
<td>湿度</td>
<td>百分比率</td>
<td>62.4</td>
<td>67.21(↑4.81)</td>
<td>65.83(↑3.43)</td>
<td>65.83(↑3.43)</td>
<td>74.41(↑12.01)</td>
<td>55.96(↑6.44)</td>
</tr>
<tr>
<td>累積雨量</td>
<td>毫米</td>
<td>0</td>
<td>0.32(↑0.32)</td>
<td>0.32(↑0.32)</td>
<td>0.32(↑0.32)</td>
<td>0.32(↑0.32)</td>
<td>0.32(↑0.32)</td>
</tr>
<tr>
<td>風速</td>
<td>公尺/秒</td>
<td>2.46</td>
<td>0.95(↑1.51)</td>
<td>0.98(↑1.48)</td>
<td>1.09(↑1.37)</td>
<td>0.77(↑1.69)</td>
<td></td>
</tr>
</tbody>
</table>

### 當前五天氣候統計

<table>
<thead>
<tr>
<th>項目</th>
<th>結果</th>
</tr>
</thead>
<tbody>
<tr>
<td>平均氣溫與前日差大於五度之天數</td>
<td>0(天)</td>
</tr>
<tr>
<td>下雨天日數（大於0.5）</td>
<td>0(天)</td>
</tr>
<tr>
<td>最大日雨量</td>
<td>0.33(毫米)</td>
</tr>
<tr>
<td>日雨量大於50mm天數</td>
<td>0(天)</td>
</tr>
<tr>
<td>旬平均氣溫</td>
<td>24.22(度)</td>
</tr>
<tr>
<td>旬平均風速</td>
<td>1.01(公尺/秒)</td>
</tr>
<tr>
<td>日平均風速大於10m/s天數</td>
<td>0(天)</td>
</tr>
<tr>
<td>旬平均凍度</td>
<td>74.45(%)</td>
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### 長期氣候統計

#### 历史氣溫

<table>
<thead>
<tr>
<th>月份</th>
<th>氣溫（℃）</th>
</tr>
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<tbody>
<tr>
<td>1月</td>
<td>5.9</td>
</tr>
<tr>
<td>2月</td>
<td>6.5</td>
</tr>
<tr>
<td>3月</td>
<td>7.7</td>
</tr>
<tr>
<td>4月</td>
<td>9.9</td>
</tr>
<tr>
<td>5月</td>
<td>10.1</td>
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<td>6月</td>
<td>11.2</td>
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<td>7月</td>
<td>12.5</td>
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<td>13.7</td>
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<td>14.5</td>
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<td>13.9</td>
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<tr>
<td>11月</td>
<td>12.7</td>
</tr>
<tr>
<td>12月</td>
<td>10.9</td>
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</table>

#### 历史降水量

<table>
<thead>
<tr>
<th>月份</th>
<th>降水量（mm）</th>
</tr>
</thead>
<tbody>
<tr>
<td>1月</td>
<td>50</td>
</tr>
<tr>
<td>2月</td>
<td>60</td>
</tr>
<tr>
<td>3月</td>
<td>70</td>
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<tr>
<td>4月</td>
<td>80</td>
</tr>
<tr>
<td>5月</td>
<td>90</td>
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<td>6月</td>
<td>100</td>
</tr>
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<td>7月</td>
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<td>10月</td>
<td>140</td>
</tr>
<tr>
<td>11月</td>
<td>150</td>
</tr>
<tr>
<td>12月</td>
<td>160</td>
</tr>
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</table>

### 氣候指數

- **辐射强度**
- **蒸发量**
- **降水量**

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**Note:** The data in the table and charts represent historical climate information from 1971 to 2015.
Agriculture climate disasters

- Drought: Precipitation for more than 20 days were less than 0.5 mm
- Cold damage: Daily average temperature below 15 degrees
- Heavy rain: Daily rainfall of 130 mm or more

Quickly grasp the time and frequency of occurrence of each type of disaster, in advance of preventive work.
Smart farming management system for small-hold farmer

Agricultural product transaction price

Quickly query nearby market agricultural product trading information through GPS and LBS services

Nearly 15 days of agricultural product trading prices and trading volume

Agricultural product trading price and trading volume in Taiwan
- Getting the farmland weather forecasting **Faster**!
- Doing disaster prevention **Earlier**!

**Climate Alarm**
- Grasping climate risk on time.

**Pest Alarm**
- Grasping pest risk on time.
Figure 12. Input data defining the environment in which the crop will develop
Fruit yield (t/ha)
- < 50
- 51 to 60
- 60 to 70
- > 70

Yield_{(t/ha)} = 37.05 + 1.14 \times 10^{-1}N - 1.15 \times 10^{-4}N^2 + 3.34 \times 10^{-2}K - 4.25 \times 10^{-5}K^2
R^2 = 0.81 (p<0.001)

**FIGURE 1** - Effect of N and K application on ‘Smooth Cayenne’ pineapple fruit yield. The marked values predict maximum fruit yield. Agudos (SP), 1997.
Optimizing Planting Date and Nitrogen Fertilizer Corn Grown in Camilla, Georgia; 45 Years of Weather (1951-95)
Thank you for your attention