# APPENDICES

## FOR

## HAWAII AGRICULTURAL WATER USE AND DEVELOPMENT PLAN

Submitted
to

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Department of Natural Resources and Environmental Management
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# HAWUDP (PRE-FINAL DRAFT) APPENDICES

[**Note**: Some of the clicks (links to other part of this document) do not work. This is because of removing some of the appendices from this document. The appendices were removed to reduce the size of the documents. The links are functional on the electronic copy of the document available on CD.]

# GIS MAP VOLUME [SEPARATE VOLUME]:

I. Studied Systems
I-1. Irrigation System / Service Area / ALISH
I-2. Irrigation System / Service Area / Soil Types (Land Capability Classes, LCC)
I-3. Irrigation System / Service Area / General Crop Types

II. Unstudied Systems
I-1. Irrigation System / Service Area
I-2. Irrigation System / Service Area / ALISH
I-3. Irrigation System / Service Area / Soil Types (Land Capability Classes, LCC)

III. Wastewater Reuse Maps
I-1. Studied Irrigation System / Service Area / Least-Cost Distance

# Appendix 3-A Calculation of daily $ET_o$ using temperature data

STEP 1: Extraterrestrial radiation (Ra) is calculated for each day using the following equations from Duffie and Beckman (1980) (reproduced from Snyder and Eching, 2002).

$G_{SC}$ = solar constant in MJ $m^{-2}$ $min^{-1}$

$$G_{SC} = 0.082$$

$\sigma$ = Steffan-Boltzman constant in MJ $m^{-2}$ $d^{-1}$ $K^{-4}$

$$\sigma = 4.90 \times 10^{-9}$$

$\phi$ = latitude in radians converted from latitude ($L$) in degrees

$$\phi = \frac{\pi L}{180}$$

$d_r$ = correction for eccentricity of Earth's orbit around the sun on day $i$ of the year

$$d_r = 1 + 0.033 cos\left(\frac{2\pi}{365} i\right)$$

$\delta$ = declination of the sun above the celestial equator in radians on day $i$ of the year

$$\delta = 0.409 sin\left(\frac{2\pi}{365} i - 1.39\right)$$

$\omega_s$ = sunrise hour angle in radians

$$\omega_s = cos^{-1}\left[-tan\,\phi\, tan\,\delta\right]$$

$R_a$ = extraterrestrial radiation (MJ $m^{-2}$ $d^{-1}$)

$$R_a = \left(\frac{24 \cdot 60}{\pi}\right) G_{SC} d_r \left[\omega_s \sin\delta \sin\phi + \cos\phi \cos\delta \sin\omega_s\right]$$

STEP 2: Calculate ET using 1995 Hargreaves equation (Hargreaves and Samani, 1985) (reproduced from Snyder and Eching, 2002).

Hargreaves-Samani equation for ET of a short, 0.12 m tall reference surface

$$ET_h = 0.408\left(0.0023 R_a [T_m + 17.8]\sqrt{T_x - T_n}\right)$$

where the 0.408 $= 1/\lambda$ factor converts from MJ $m^{-2}d^{-1}$ to mm $d^{-1}$.

Where: $T_m$ = mean daily temperature in $^{o}$C, $T_X$ = the maximum daily air temperature in $^{o}$C, and $T_n$ = the minimum daily air temperature in $^{o}$C.

# Appendix 3-B Supporting Tables and Figures

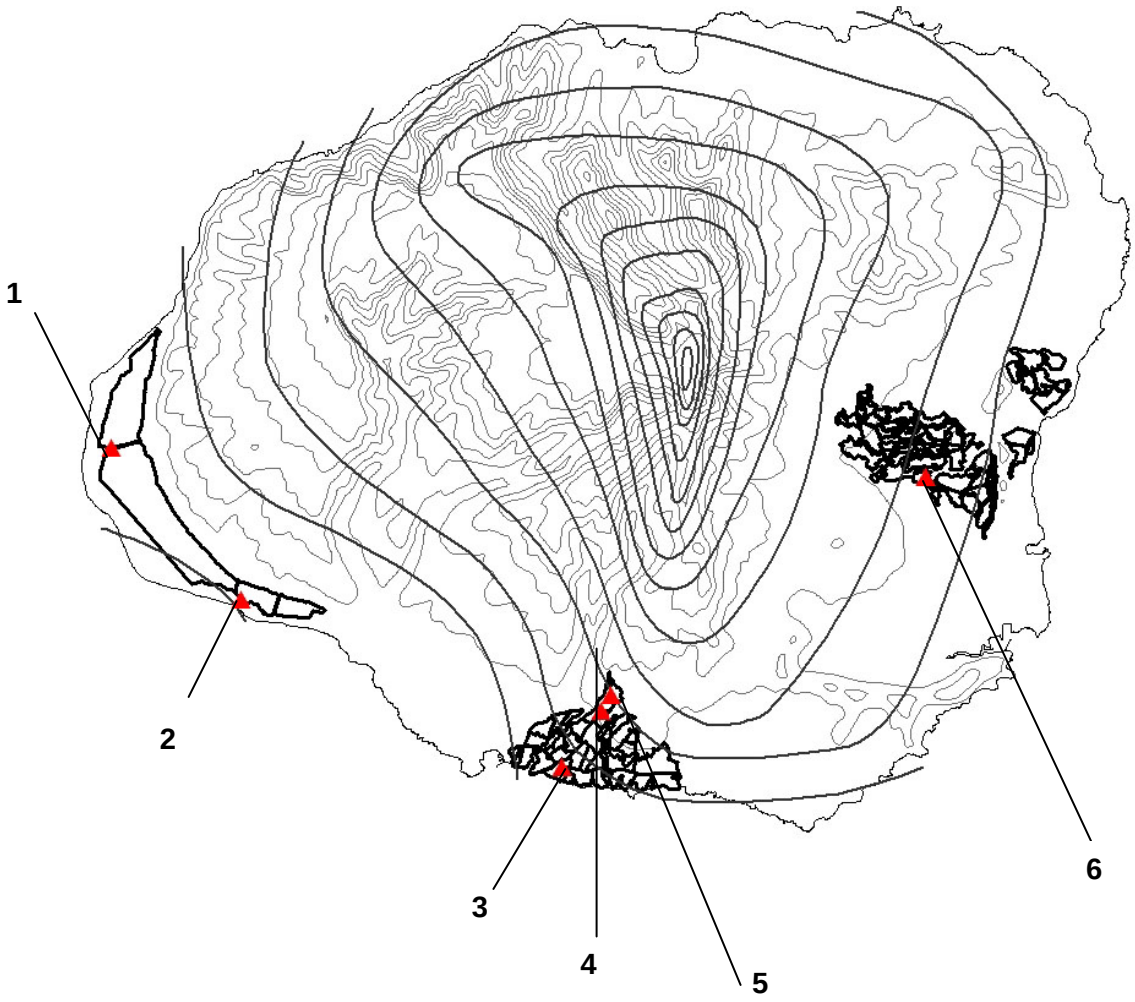


Figure 3.B.1 System boundaries and climate data stations for the Kekaha, Kauai and East Kauai systems. Station information is in Table 1. Isohyets indicate gradients in rainfall (dark) and elevation (light).

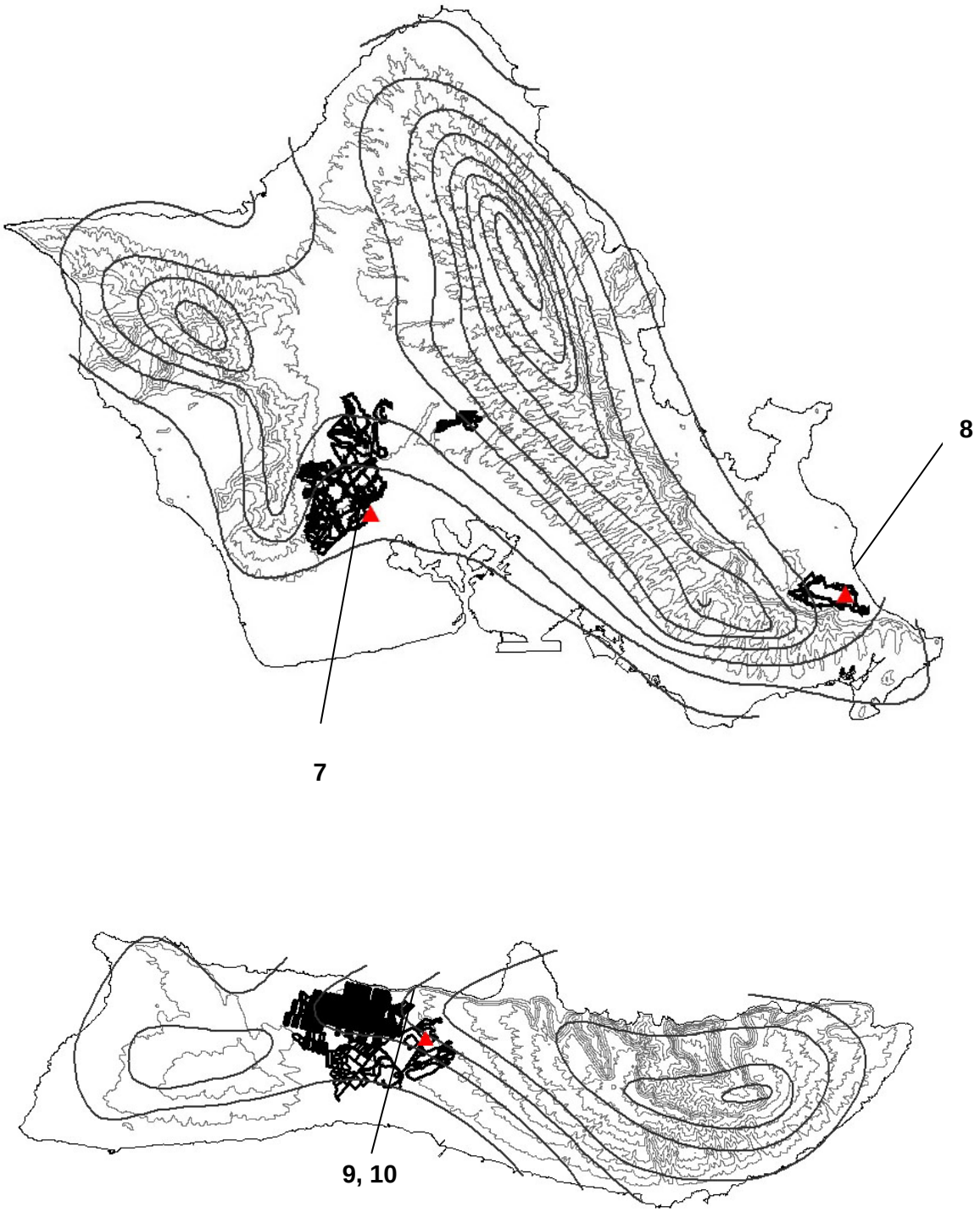


Figure 3.B.2 System boundaries and climate data stations for the Waiahole, Waimanalo and Molokai systems. Station information is in Table 1. Isohyets indicate gradients in rainfall (dark) and elevation (light).

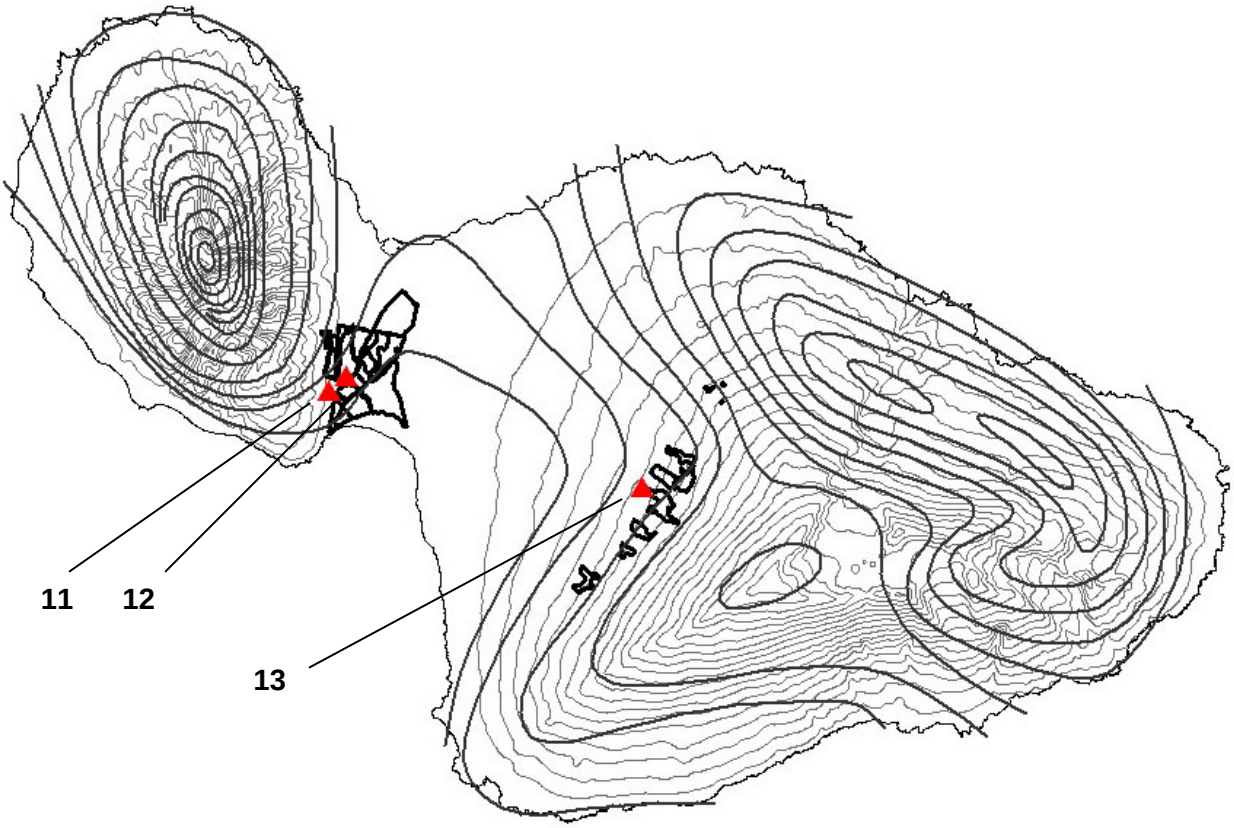


Figure 3.B.3 System boundaries and climate data stations for the West Maui and Kula systems. Station information is in Table 1. Isohyets indicate gradients in rainfall (dark) and elevation (light).

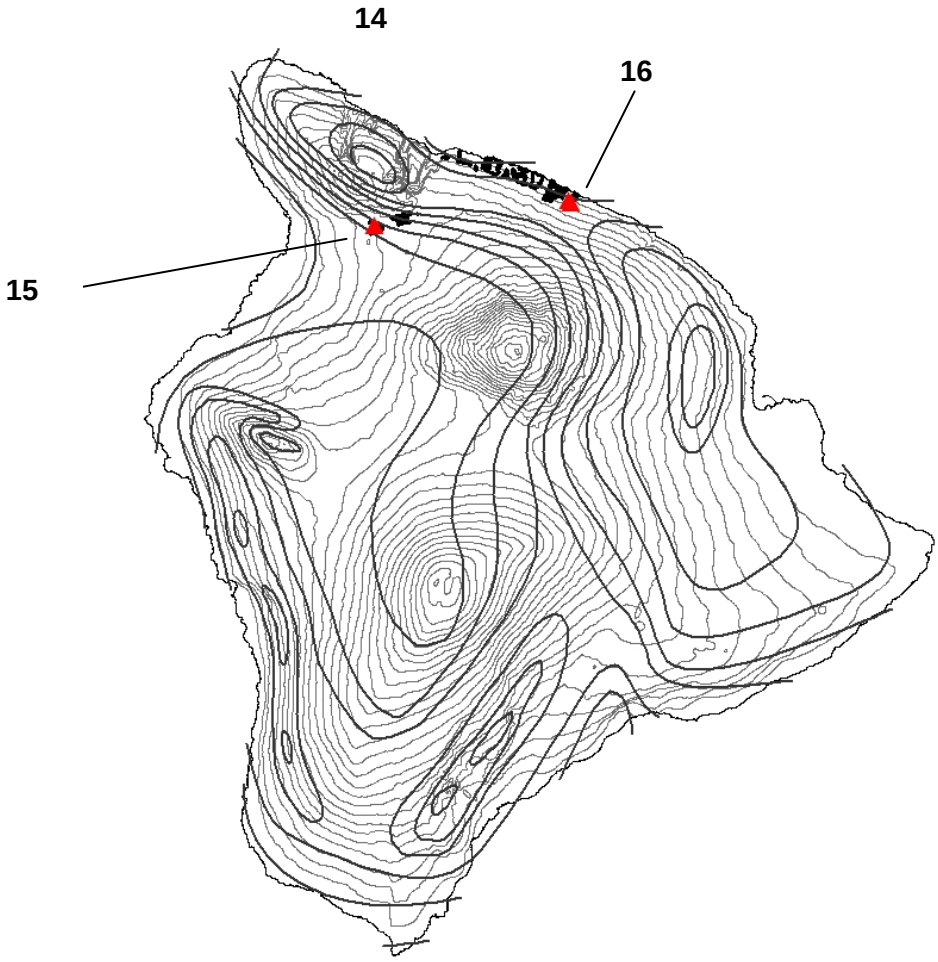


Figure 3.B.4 System boundaries and climate data stations for the Kamuela and Lower Hamakua systems. Station information is in Table 1. Isohyets indicate gradients in rainfall (dark) and elevation (light).

Table 3.B.1 Irrigation Water Requirements for Energy Crops

**East Kauai System**

| **Crop Type** | **Irrigation Season** | **Length (day)** | **Net Rainfall** | **Potential ET** | **Crop ET** | **Drainage** | **Runoff** | **Mean Irrigation Requirement** | **Maximum Irrigation Requirement** | **Minimum Irrigation Requirement** | **Mean Irrig.** (1000 Gal/Acre) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bana Grass (Sudan) 1st Cut | 11-1 TO 1-14 | 75 | 9.9 | 12.7 | 12.8 | 0.9 | 1.2 | 1.4 | 5.1 | 0 | 38 |
| Bana Grass (Sudan) 1st Cut | 4-15 TO 6-28 | 75 | 13.4 | 8.9 | 9 | 4.7 | 5.1 | 0.2 | 2.5 | 0 | 5 |
| Bana Grass (Sudan) 2nd Cut | 11-1 TO 12-15 | 45 | 6.6 | 7.5 | 7.5 | 0.7 | 1 | 0.1 | 2.6 | 0 | 3 |
| Bana Grass (Sudan) 2nd Cut | 4-15 TO 5-29 | 45 | 8.6 | 5.4 | 5.5 | 2.8 | 3.4 | 0 | 0 | 0 | 0 |
| Seed, Corn | 10-15 TO 2-15 | 124 | 23.9 | 15.2 | 14.6 | 10.6 | 7.0 | 1.0 | 5.0 | 0.0 | 27 |
| Seed, Corn | 4-15 TO 8-15 | 123 | 19.1 | 21.3 | 20.6 | 2.9 | 1.7 | 3.5 | 8.2 | 0.0 | 95 |
| Sugarcane, New- year 1 | 10- 1 TO 9-30 | 365 | 62.2 | 54.8 | 59.1 | 16.3 | 11.3 | 10.1 | 24.5 | 1.9 | 274 |
| Sugarcane, New- year 1 | 5- 1 TO 4-30 | 365 | 62.2 | 54.8 | 55.3 | 12.7 | 11.3 | 3.6 | 11.9 | 0.0 | 98 |
| Sugarcane, New- year 2 | 10- 1 TO 9-30 | 365 | 62.2 | 54.8 | 54.8 | 13.8 | 11.3 | 5.5 | 15.9 | 0.0 | 149 |
| Sugarcane, New- year 2 | 5- 1 TO 4-30 | 365 | 62.2 | 54.8 | 53.8 | 11.9 | 11.3 | 3.8 | 13.9 | 0.0 | 103 |
| Sugarcane, ratoon | 10- 1 TO 9-30 | 365 | 62.2 | 54.8 | 59.7 | 12.8 | 11.3 | 9.0 | 21.8 | 0.0 | 244 |
| Sugarcane, ratoon | 5- 1 TO 4-30 | 365 | 62.2 | 54.8 | 58.0 | 9.6 | 11.3 | 5.4 | 17.8 | 0.0 | 147 |
| Leucaena (Eucalyptus) | 1- 1 TO 12-31 | 365 | 62.3 | 54.8 | 54.9 | 12.9 | 11.3 | 6.9 | 22.5 | 0.0 | 187 |
| Leucaena (Eucalyptus Young) | 1- 1 TO 12-31 | 365 | 62.3 | 54.8 | 39.9 | 22.6 | 11.3 | 0.2 | 4.3 | 0.0 | 5 |

**Kauai Coffee (Wahiawa)**

| Crop Type | Irrigation Season | Length (day) | Net Rainfall | Potential ET | Crop ET | Drainage | Runoff | Mean Irrigation Requirement | Maximum Irrigation Requirement | Minimum Irrigation Requirement | Mean Irrig. (1000 Gal/Acre) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bana Grass (Sudan) 1st Cut | 11-1 TO 1-14 | 75 | 3.9 | 15.5 | 15.3 | 0 | 0.3 | 7.1 | 11.1 | 2.7 | 193 |
| Bana Grass (Sudan) 1st Cut | 4-15 TO 6-28 | 75 | 7.5 | 11 | 10.7 | 0.4 | 2.3 | 1.3 | 5.6 | 0 | 35 |
| Bana Grass (Sudan) 2nd Cut | 11-1 TO 12-15 | 45 | 2.6 | 9.2 | 9 | 0 | 0.3 | 3.4 | 5.6 | 0 | 92 |
| Bana Grass (Sudan) 2nd Cut | 4-15 TO 5-29 | 45 | 4.5 | 6.8 | 6.6 | 0.2 | 1.3 | 0.7 | 2.8 | 0 | 19 |
| Seed, Corn | 10-15 TO 2-15 | 124 | 13.6 | 19.0 | 17.3 | 2.0 | 3.6 | 4.5 | 9.5 | 0.8 | 122 |
| Seed, Corn | 4-15 TO 8-15 | 123 | 7.3 | 26.1 | 24.2 | 0.3 | 0.5 | 15.9 | 20.7 | 9.0 | 432 |
| Sugarcane, New- year 1 | 10- 1 TO 9-30 | 365 | 29.8 | 67.6 | 70.6 | 3.3 | 5.2 | 42.6 | 55.4 | 31.9 | 1157 |
| Sugarcane, New- year 1 | 5- 1 TO 4-30 | 365 | 29.7 | 67.6 | 64.9 | 0.3 | 5.2 | 33.6 | 46.4 | 17.8 | 912 |
| Sugarcane, New- year 2 | 10- 1 TO 9-30 | 365 | 29.8 | 67.6 | 65.2 | 1.6 | 5.2 | 35.5 | 50.5 | 23.4 | 964 |
| Sugarcane, New- year 2 | 5- 1 TO 4-30 | 365 | 29.7 | 67.6 | 64.1 | 0.2 | 5.2 | 34.7 | 47.6 | 19.1 | 942 |
| Sugarcane, ratoon | 10- 1 TO 9-30 | 365 | 29.8 | 67.6 | 71.8 | 1.3 | 5.2 | 42.7 | 58.5 | 30.0 | 1159 |
| Sugarcane, ratoon | 5- 1 TO 4-30 | 365 | 29.7 | 67.6 | 69.9 | 0.1 | 5.2 | 40.8 | 54.1 | 24.0 | 1108 |
| Leucaena (Eucalyptus) | 1- 1 TO 12-31 | 365 | 30.1 | 67.6 | 67.7 | 1.5 | 5.2 | 48.8 | 62.5 | 31.2 | 1325 |
| Leucaena (Eucalyptus Young) | 1- 1 TO 12-31 | 365 | 30.1 | 67.6 | 44.0 | 1.5 | 5.2 | 19.3 | 30.3 | 9.1 | 524 |

**Kauai Coffee (Brydswood)**

| Crop Type | Irrigation Season | Length (day) | Net Rainfall | Potential ET | Crop ET | Drainage | Runoff | Mean Irrigation Requirement | Maximum Irrigation Requirement | Minimum Irrigation Requirement | Mean Irrig. (1000 Gal/Acre) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bana Grass (Sudan) 1st Cut | 11-1 TO 1-14 | 75 | 7.9 | 14.8 | 14.8 | 0.5 | 1 | 4.3 | 8.3 | 0 | 117 |
| Bana Grass (Sudan) 1st Cut | 4-15 TO 6-28 | 75 | 11.3 | 9.7 | 9.6 | 2.7 | 3.8 | 0.4 | 4.1 | 0 | 11 |
| Bana Grass (Sudan) 2nd Cut | 11-1 TO 12-15 | 45 | 5.1 | 8.6 | 8.6 | 0.4 | 0.8 | 1.6 | 6.1 | 0 | 43 |
| Bana Grass (Sudan) 2nd Cut | 4-15 TO 5-29 | 45 | 7.1 | 6 | 5.9 | 1.5 | 2.4 | 0.2 | 2 | 0 | 5 |
| Seed, Corn | 10-15 TO 2-15 | 124 | 20.1 | 16.8 | 15.6 | 6.9 | 5.6 | 1.8 | 7.3 | 0.0 | 49 |
| Seed, Corn | 4-15 TO 8-15 | 123 | 15.1 | 25.1 | 23.9 | 1.3 | 1.4 | 9.5 | 13.9 | 1.1 | 258 |
| Sugarcane, New- year 1 | 10- 1 TO 9-30 | 365 | 50.1 | 62.5 | 66.5 | 11.0 | 9.1 | 26.1 | 38.1 | 14.4 | 709 |
| Sugarcane, New- year 1 | 5- 1 TO 4-30 | 365 | 49.9 | 62.5 | 61.2 | 3.8 | 9.1 | 13.0 | 30.9 | 0.0 | 353 |
| Sugarcane, New- year 2 | 10- 1 TO 9-30 | 365 | 50.0 | 62.5 | 61.1 | 8.2 | 9.1 | 18.2 | 30.6 | 6.2 | 494 |
| Sugarcane, New- year 2 | 5- 1 TO 4-30 | 365 | 49.9 | 62.5 | 60.3 | 5.3 | 9.1 | 16.6 | 33.4 | 6.4 | 451 |
| Sugarcane, ratoon | 10- 1 TO 9-30 | 365 | 50.1 | 62.5 | 67.1 | 7.4 | 9.1 | 23.8 | 37.3 | 11.2 | 646 |
| Sugarcane, ratoon | 5- 1 TO 4-30 | 365 | 49.9 | 62.5 | 65.2 | 4.0 | 9.1 | 20.5 | 39.8 | 8.0 | 557 |
| Leucaena (Eucalyptus) | 1- 1 TO 12-31 | 365 | 50.4 | 62.5 | 62.6 | 7.1 | 9.1 | 24.2 | 38.3 | 10.1 | 657 |
| Leucaena (Eucalyptus Young) | 1- 1 TO 12-31 | 365 | 50.4 | 62.5 | 43.2 | 11.3 | 9.1 | 5.2 | 11.9 | 0.0 | 141 |

**Kekaha (Kekaha)**

| Crop Type | Irrigation Season | Length (day) | Net Rainfall | Potential ET | Crop ET | Drainage | Runoff | Mean Irrigation Requirement | Maximum Irrigation Requirement | Minimum Irrigation Requirement | Mean Irrig. (1000 Gal/Acre) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bana Grass (Sudan) 1st Cut | 11-1 TO 1-14 | 75 | 1.5 | 14 | 13.4 | 0.1 | 0.2 | 8.7 | 9.6 | 5.5 | 236 |
| Bana Grass (Sudan) 1st Cut | 4-15 TO 6-28 | 75 | 5.8 | 9 | 8.6 | 1.1 | 1.6 | 2.4 | 5.5 | 0 | 65 |
| Bana Grass (Sudan) 2nd Cut | 11-1 TO 12-15 | 45 | 1.2 | 8.2 | 7.8 | 0 | 0.2 | 4.5 | 5.8 | 0 | 122 |
| Bana Grass (Sudan) 2nd Cut | 4-15 TO 5-29 | 45 | 3.2 | 5.6 | 5.3 | 0.6 | 0.9 | 1.4 | 3.7 | 0 | 38 |
| Seed, Corn | 10-15 TO 2-15 | 124 | 10.7 | 15.7 | 13.9 | 2.9 | 2.6 | 5.2 | 10.3 | 0.5 | 141 |
| Seed, Corn | 4-15 TO 8-15 | 123 | 2.5 | 23.3 | 21.1 | 0.2 | 0.2 | 18.6 | 21.2 | 14.8 | 505 |
| Sugarcane, New- year 1 | 10- 1 TO 9-30 | 365 | 17.7 | 58.9 | 60.9 | 3.8 | 3.6 | 48.5 | 56.8 | 37.5 | 1317 |
| Sugarcane, New- year 1 | 5- 1 TO 4-30 | 365 | 17.7 | 58.9 | 54.4 | 0.6 | 3.6 | 37.6 | 51.6 | 24.7 | 1021 |
| Sugarcane, New- year 2 | 10- 1 TO 9-30 | 365 | 17.7 | 58.9 | 55.9 | 2.2 | 3.6 | 41.3 | 51.3 | 27.6 | 1121 |
| Sugarcane, New- year 2 | 5- 1 TO 4-30 | 365 | 17.7 | 58.9 | 54.2 | 0.8 | 3.6 | 38.9 | 52.9 | 28.0 | 1056 |
| Sugarcane, ratoon | 10- 1 TO 9-30 | 365 | 17.7 | 58.9 | 61.9 | 1.9 | 3.6 | 47.9 | 58.2 | 33.7 | 1301 |
| Sugarcane, ratoon | 5- 1 TO 4-30 | 365 | 17.7 | 58.9 | 59.5 | 0.5 | 3.6 | 44.5 | 58.2 | 32.3 | 1208 |
| Leucaena (Eucalyptus) | 1- 1 TO 12-31 | 365 | 17.9 | 58.9 | 59.0 | 2.1 | 3.6 | 53.9 | 66.5 | 36.7 | 1464 |
| Leucaena (Eucalyptus Young) | 1- 1 TO 12-31 | 365 | 17.9 | 58.9 | 37.0 | 2.0 | 3.6 | 26.3 | 38.9 | 12.9 | 714 |

**Kekaha (Mana)**

| Crop Type | Irrigation Season | Length (day) | Net Rainfall | Potential ET | Crop ET | Drainage | Runoff | Mean Irrigation Requirement | Maximum Irrigation Requirement | Minimum Irrigation Requirement | Mean Irrig. (1000 Gal/Acre) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bana Grass (Sudan) 1st Cut | 11-1 TO 1-14 | 75 | 1.7 | 14 | 13.5 | 0 | 0.2 | 8.4 | 9.1 | 4.5 | 228 |
| Bana Grass (Sudan) 1st Cut | 4-15 TO 6-28 | 75 | 6 | 9.5 | 9.2 | 0.9 | 1.5 | 2.5 | 4.5 | 0 | 68 |
| Bana Grass (Sudan) 2nd Cut | 11-1 TO 12-15 | 45 | 1.3 | 8.2 | 7.9 | 0 | 0.1 | 3.9 | 4.6 | 0 | 106 |
| Bana Grass (Sudan) 2nd Cut | 4-15 TO 5-29 | 45 | 3.2 | 5.8 | 5.5 | 0.4 | 0.9 | 1.2 | 2.3 | 0 | 33 |
| Seed, Corn | 10-15 TO 2-15 | 124 | 11.1 | 16.6 | 14.8 | 2.5 | 2.5 | 5.5 | 10.4 | 0.0 | 149 |
| Seed, Corn | 4-15 TO 8-15 | 123 | 2.9 | 23.5 | 21.4 | 0.2 | 0.2 | 18.3 | 20.8 | 12.8 | 497 |
| Sugarcane, New- year 1 | 10- 1 TO 9-30 | 365 | 19.8 | 60.3 | 62.2 | 3.6 | 3.6 | 46.4 | 55.0 | 34.0 | 1260 |
| Sugarcane, New- year 1 | 5- 1 TO 4-30 | 365 | 19.9 | 60.3 | 56.3 | 0.6 | 3.6 | 36.7 | 47.7 | 23.8 | 997 |
| Sugarcane, New- year 2 | 10- 1 TO 9-30 | 365 | 19.8 | 60.3 | 57.4 | 1.9 | 3.6 | 39.5 | 49.1 | 24.0 | 1073 |
| Sugarcane, New- year 2 | 5- 1 TO 4-30 | 365 | 19.9 | 60.3 | 55.9 | 0.6 | 3.6 | 37.8 | 47.4 | 26.2 | 1026 |
| Sugarcane, ratoon | 10- 1 TO 9-30 | 365 | 19.8 | 60.3 | 63.4 | 1.6 | 3.6 | 46.2 | 57.3 | 29.6 | 1255 |
| Sugarcane, ratoon | 5- 1 TO 4-30 | 365 | 19.9 | 60.3 | 61.3 | 0.3 | 3.6 | 43.5 | 54.0 | 29.9 | 1181 |
| Leucaena (Eucalyptus) | 1- 1 TO 12-31 | 365 | 20.0 | 60.3 | 60.3 | 2.0 | 3.6 | 52.7 | 66.9 | 36.2 | 1431 |
| Leucaena (Eucalyptus Young) | 1- 1 TO 12-31 | 365 | 20.0 | 60.3 | 38.2 | 1.7 | 3.6 | 24.9 | 35.5 | 11.1 | 676 |

**Waiahole**

| Crop Type | Irrigation Season | Length (day) | Net Rainfall | Potential ET | Crop ET | Drainage | Runoff | Mean Irrigation Requirement | Maximum Irrigation Requirement | Minimum Irrigation Requirement | Mean Irrig. (1000 Gal/Acre) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bana Grass (Sudan) 1st Cut | 11-1 TO 1-14 | 75 | 1.6 | 13.5 | 13 | 0 | 0.2 | 8 | 9.1 | 6.5 | 217 |
| Bana Grass (Sudan) 1st Cut | 4-15 TO 6-28 | 75 | 4.7 | 8.6 | 8.1 | 1.2 | 3.1 | 2.7 | 6.7 | 0 | 73 |
| Bana Grass (Sudan) 2nd Cut | 11-1 TO 12-15 | 45 | 1.3 | 7.8 | 7.4 | 0 | 0.1 | 3.5 | 6.8 | 0 | 95 |
| Bana Grass (Sudan) 2nd Cut | 4-15 TO 5-29 | 45 | 2.7 | 5.5 | 5.2 | 0.9 | 2 | 1.8 | 4.4 | 0 | 49 |
| Seed, Corn | 10-15 TO 2-15 | 124 | 9.1 | 14.7 | 12.8 | 2.7 | 3.5 | 5.3 | 9.1 | 1.6 | 144 |
| Seed, Corn | 4-15 TO 8-15 | 123 | 2.6 | 22.9 | 20.8 | 0.2 | 0.3 | 17.5 | 20.5 | 14.7 | 475 |
| Sugarcane, New- year 1 | 10- 1 TO 9-30 | 365 | 16.3 | 56.8 | 58.3 | 3.5 | 4.5 | 45.1 | 51.6 | 35.8 | 1225 |
| Sugarcane, New- year 1 | 5- 1 TO 4-30 | 365 | 16.4 | 57.3 | 52.6 | 1.0 | 4.5 | 36.2 | 41.4 | 24.0 | 983 |
| Sugarcane, New- year 2 | 10- 1 TO 9-30 | 365 | 16.3 | 56.8 | 53.0 | 2.3 | 4.5 | 38.4 | 45.2 | 27.8 | 1043 |
| Sugarcane, New- year 2 | 5- 1 TO 4-30 | 365 | 16.4 | 57.3 | 53.3 | 0.6 | 4.5 | 37.9 | 43.3 | 26.4 | 1029 |
| Sugarcane, ratoon | 10- 1 TO 9-30 | 365 | 16.3 | 56.8 | 58.9 | 2.0 | 4.5 | 44.7 | 52.7 | 33.9 | 1214 |
| Sugarcane, ratoon | 5- 1 TO 4-30 | 365 | 16.4 | 57.3 | 58.3 | 0.5 | 4.5 | 43.7 | 49.4 | 30.0 | 1187 |
| Leucaena (Eucalyptus) | 1- 1 TO 12-31 | 365 | 16.3 | 57.0 | 57.0 | 1.1 | 4.5 | 51.9 | 63.0 | 36.1 | 1409 |
| Leucaena (Eucalyptus Young) | 1- 1 TO 12-31 | 365 | 16.3 | 57.0 | 35.2 | 1.5 | 4.5 | 24.9 | 32.2 | 14.1 | 676 |

**Waimanalo**

| Crop Type | Irrigation Season | Length (day) | Net Rainfall | Potential ET | Crop ET | Drainage | Runoff | Mean Irrigation Requirement | Maximum Irrigation Requirement | Minimum Irrigation Requirement | Mean Irrig. (1000 Gal/Acre) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bana Grass (Sudan) 1st Cut | 11-1 TO 1-14 | 75 | 4.3 | 11.2 | 11 | 0.3 | 0.8 | 3.8 | 5.3 | 0 | 103 |
| Bana Grass (Sudan) 1st Cut | 4-15 TO 6-28 | 75 | 10 | 7.3 | 7.3 | 3.1 | 3 | 0.2 | 2.6 | 0 | 5 |
| Bana Grass (Sudan) 2nd Cut | 11-1 TO 12-15 | 45 | 3.1 | 6.6 | 6.5 | 0.2 | 0.7 | 1.5 | 2.6 | 0 | 41 |
| Bana Grass (Sudan) 2nd Cut | 4-15 TO 5-29 | 45 | 5.5 | 4.4 | 4.4 | 1.5 | 1.6 | 0 | 0 | 0 | 0 |
| Seed, Corn | 10-15 TO 2-15 | 124 | 18.3 | 12.8 | 12.0 | 7.5 | 4.7 | 0.9 | 4.1 | 0.0 | 24 |
| Seed, Corn | 10-15 TO 2-15 | 123 | 7.3 | 18.5 | 17.2 | 0.9 | 0.9 | 8.7 | 13.0 | 4.1 | 236 |
| Sugarcane, New- year 1 | 10- 1 TO 9-30 | 365 | 35.6 | 47.4 | 50.2 | 10.8 | 7.1 | 21.8 | 32.2 | 12.1 | 592 |
| Sugarcane, New- year 1 | 5- 1 TO 4-30 | 365 | 35.6 | 47.5 | 45.4 | 4.5 | 7.1 | 11.9 | 26.1 | 2.8 | 323 |
| Sugarcane, New- year 2 | 10- 1 TO 9-30 | 365 | 35.6 | 47.4 | 46.2 | 8.2 | 7.1 | 15.8 | 26.0 | 3.9 | 429 |
| Sugarcane, New- year 2 | 5- 1 TO 4-30 | 365 | 35.6 | 47.5 | 45.0 | 4.7 | 7.1 | 14.2 | 27.9 | 7.8 | 386 |
| Sugarcane, ratoon | 10- 1 TO 9-30 | 365 | 35.6 | 47.4 | 50.7 | 7.6 | 7.1 | 19.8 | 32.3 | 8.0 | 538 |
| Sugarcane, ratoon | 5- 1 TO 4-30 | 365 | 35.6 | 47.5 | 49.0 | 3.6 | 7.1 | 17.2 | 32.2 | 9.8 | 467 |
| Leucaena (Eucalyptus) | 1- 1 TO 12-31 | 365 | 35.3 | 47.5 | 47.6 | 5.9 | 7.1 | 22.5 | 38.4 | 9.6 | 611 |
| Leucaena (Eucalyptus Young) | 1- 1 TO 12-31 | 365 | 35.3 | 47.5 | 31.8 | 8.9 | 7.1 | 6.6 | 14.9 | 0.0 | 179 |

**Molokai**

| Crop Type | Irrigation Season | Length (day) | Net Rainfall | Potential ET | Crop ET | Drainage | Runoff | Mean Irrigation Requirement | Maximum Irrigation Requirement | Minimum Irrigation Requirement | Mean Irrig. (1000 Gal/Acre) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bana Grass (Sudan) 1st Cut | 11-1 TO 1-14 | 75 | 2.7 | 21.4 | 20.9 | 0 | 0.2 | 14.1 | 16.2 | 11.4 | 383 |
| Bana Grass (Sudan) 1st Cut | 4-15 TO 6-28 | 75 | 7.7 | 16.3 | 15.6 | 0.5 | 2.4 | 5.9 | 11.2 | 0 | 160 |
| Bana Grass (Sudan) 2nd Cut | 11-1 TO 12-15 | 45 | 2.1 | 12.3 | 11.9 | 0 | 0.2 | 6.6 | 9.2 | 4.4 | 179 |
| Bana Grass (Sudan) 2nd Cut | 4-15 TO 5-29 | 45 | 4.2 | 10.1 | 9.7 | 0.2 | 1.5 | 3.3 | 6.9 | 0 | 90 |
| Seed, Corn | 10-15 TO 2-15 | 124 | 14.5 | 27.2 | 24.6 | 1.4 | 3.7 | 11.7 | 19.6 | 5.3 | 318 |
| Seed, Corn | 4-15 TO 8-15 | 123 | 4.6 | 36.1 | 33.3 | 0.1 | 0.3 | 29.1 | 33.1 | 24.0 | 790 |
| Sugarcane, New- year 1 | 10- 1 TO 9-30 | 365 | 28.1 | 94.2 | 96.9 | 2.3 | 5.8 | 75.5 | 89.2 | 59.6 | 2050 |
| Sugarcane, New- year 1 | 5- 1 TO 4-30 | 365 | 28.0 | 94.2 | 89.3 | 0.1 | 5.8 | 65.0 | 79.8 | 44.9 | 1765 |
| Sugarcane, New- year 2 | 10- 1 TO 9-30 | 365 | 28.1 | 94.2 | 89.3 | 0.9 | 5.8 | 65.7 | 81.5 | 49.6 | 1784 |
| Sugarcane, New- year 2 | 5- 1 TO 4-30 | 365 | 28.0 | 94.2 | 88.0 | 0.2 | 5.8 | 65.3 | 78.6 | 48.8 | 1773 |
| Sugarcane, ratoon | 10- 1 TO 9-30 | 365 | 28.1 | 94.2 | 98.7 | 0.7 | 5.8 | 76.6 | 92.5 | 60.9 | 2080 |
| Sugarcane, ratoon | 5- 1 TO 4-30 | 365 | 28.0 | 94.2 | 96.6 | 0.1 | 5.8 | 74.7 | 89.2 | 57.2 | 2028 |
| Leucaena (Eucalyptus) | 1- 1 TO 12-31 | 365 | 27.9 | 94.2 | 94.1 | 1.5 | 5.8 | 84.4 | 103.2 | 62.3 | 2292 |
| Leucaena (Eucalyptus Young) | 1- 1 TO 12-31 | 365 | 27.9 | 94.2 | 59.6 | 1.3 | 5.8 | 41.0 | 56.6 | 26.4 | 1113 |

**West Maui**

| Crop Type | Irrigation Season | Length (day) | Net Rainfall | Potential ET | Crop ET | Drainage | Runoff | Mean Irrigation Requirement | Maximum Irrigation Requirement | Minimum Irrigation Requirement | Mean Irrig. (1000 Gal/Acre) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bana Grass (Sudan) 1st Cut | 11-1 TO 1-14 | 75 | 1.1 | 18.1 | 17.6 | 0 | 0.1 | 12 | 12.5 | 9.6 | 326 |
| Bana Grass (Sudan) 1st Cut | 4-15 TO 6-28 | 75 | 5.2 | 12.3 | 11.6 | 0.5 | 1.5 | 4.6 | 7.3 | 0 | 125 |
| Bana Grass (Sudan) 2nd Cut | 11-1 TO 12-15 | 45 | 1 | 10.2 | 9.8 | 0 | 0.1 | 6.1 | 7.5 | 2.3 | 166 |
| Bana Grass (Sudan) 2nd Cut | 4-15 TO 5-29 | 45 | 2.6 | 7.8 | 7.4 | 0.3 | 0.5 | 2.7 | 4.9 | 0 | 73 |
| Seed, Corn | 10-15 TO 2-15 | 124 | 9.9 | 20.7 | 18.3 | 1.2 | 2.3 | 9.2 | 13.8 | 2.1 | 250 |
| Seed, Corn | 4-15 TO 8-15 | 123 | 1.7 | 31.3 | 28.7 | 0.1 | 0.1 | 27.8 | 29.8 | 22.9 | 755 |
| Sugarcane, New- year 1 | 10- 1 TO 9-30 | 365 | 16.0 | 77.7 | 79.9 | 1.6 | 3.3 | 68.4 | 78.9 | 56.6 | 1857 |
| Sugarcane, New- year 1 | 5- 1 TO 4-30 | 365 | 16.0 | 77.7 | 71.2 | 0.1 | 3.3 | 57.4 | 69.8 | 39.4 | 1559 |
| Sugarcane, New- year 2 | 10- 1 TO 9-30 | 365 | 16.0 | 77.7 | 72.2 | 0.7 | 3.3 | 59.1 | 71.8 | 44.1 | 1605 |
| Sugarcane, New- year 2 | 5- 1 TO 4-30 | 365 | 16.0 | 77.7 | 72.2 | 0.2 | 3.3 | 60.1 | 72.1 | 46.6 | 1632 |
| Sugarcane, ratoon | 10- 1 TO 9-30 | 365 | 16.0 | 77.7 | 80.3 | 0.6 | 3.3 | 68.4 | 80.4 | 51.8 | 1857 |
| Sugarcane, ratoon | 5- 1 TO 4-30 | 365 | 16.0 | 77.7 | 79.1 | 0.1 | 3.3 | 67.6 | 79.1 | 50.0 | 1836 |
| Leucaena (Eucalyptus) | 1- 1 TO 12-31 | 365 | 16.1 | 77.7 | 77.6 | 1.2 | 3.3 | 78.2 | 91.1 | 61.0 | 2123 |
| Leucaena (Eucalyptus Young) | 1- 1 TO 12-31 | 365 | 16.1 | 77.7 | 48.2 | 0.7 | 3.3 | 40.8 | 54.4 | 26.2 | 1108 |

**Upcountry**

| Crop Type | Irrigation Season | Length (day) | Net Rainfall | Potential ET | Crop ET | Drainage | Runoff | Mean Irrigation Requirement | Maximum Irrigation Requirement | Minimum Irrigation Requirement | Mean Irrig. (1000 Gal/Acre) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bana Grass (Sudan) 1st Cut | 11-1 TO 1-14 | 75 | 2.6 | 11.8 | 11.6 | 0.1 | 0.2 | 6 | 7.9 | 2.6 | 163 |
| Bana Grass (Sudan) 1st Cut | 4-15 TO 6-28 | 75 | 5.4 | 7.5 | 7.2 | 0.8 | 1.7 | 1.3 | 2.6 | 0 | 35 |
| Bana Grass (Sudan) 2nd Cut | 11-1 TO 12-15 | 45 | 1.8 | 6.9 | 6.7 | 0 | 0.2 | 2.3 | 5.3 | 0 | 62 |
| Bana Grass (Sudan) 2nd Cut | 4-15 TO 5-29 | 45 | 2.8 | 4.7 | 4.5 | 0.3 | 0.9 | 0.9 | 2.6 | 0 | 24 |
| Seed, corn | 10-15 TO 2-15 | 124 | 9.7 | 12.9 | 11.5 | 2.1 | 2.1 | 3.1 | 6.7 | 0.7 | 84 |
| Seed, corn | 4-15 TO 8-15 | 123 | 4.3 | 19.9 | 18.2 | 0.3 | 0.3 | 12.6 | 15.7 | 6.8 | 342 |
| Sugarcane, New- year 1 | 10- 1 TO 9-30 | 365 | 20.4 | 49.5 | 51.5 | 2.4 | 3.4 | 32.2 | 40.8 | 18.2 | 874 |
| Sugarcane, New- year 1 | 5- 1 TO 4-30 | 365 | 20.1 | 49.5 | 46.1 | 1.7 | 3.4 | 24.8 | 36.2 | 12.3 | 673 |
| Sugarcane, New- year 2 | 10- 1 TO 9-30 | 365 | 20.4 | 49.5 | 47.1 | 0.5 | 3.4 | 26.3 | 36.5 | 9.9 | 714 |
| Sugarcane, New- year 2 | 5- 1 TO 4-30 | 365 | 20.1 | 49.5 | 46.3 | 0.4 | 3.4 | 26.4 | 36.3 | 15.9 | 717 |
| Sugarcane, ratoon | 10- 1 TO 9-30 | 365 | 20.4 | 49.5 | 52.1 | 0.4 | 3.4 | 31.6 | 42.5 | 13.7 | 858 |
| Sugarcane, ratoon | 5- 1 TO 4-30 | 365 | 20.1 | 49.5 | 50.6 | 0.3 | 3.4 | 30.6 | 42.2 | 17.8 | 831 |
| Leucaena (Eucalyptus) | 1- 1 TO 12-31 | 365 | 20.4 | 49.5 | 49.6 | 1.7 | 3.4 | 38.3 | 48.8 | 19.1 | 1040 |
| Leucaena (Eucalyptus Young) | 1- 1 TO 12-31 | 365 | 20.4 | 49.5 | 31.4 | 1.9 | 3.4 | 16.0 | 26.0 | 4.3 | 434 |

**Waimea**

| Crop Type | Irrigation Season | Length (day) | Net Rainfall | Potential ET | Crop ET | Drainage | Runoff | Mean Irrigation Requirement | Maximum Irrigation Requirement | Minimum Irrigation Requirement | Mean Irrig. (1000 Gal/Acre) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bana Grass (Sudan) 1st Cut | 11-1 TO 1-14 | 75 | 1.8 | 11.5 | 11.2 | 0 | 0.1 | 6.9 | 7.9 | 5.1 | 187 |
| Bana Grass (Sudan) 1st Cut | 4-15 TO 6-28 | 75 | 3.7 | 8.1 | 7.7 | 0.1 | 0.9 | 2.3 | 5.2 | 0 | 62 |
| Bana Grass (Sudan) 2nd Cut | 11-1 TO 12-15 | 45 | 1.1 | 6.7 | 6.4 | 0 | 0 | 2.9 | 5.2 | 2.5 | 79 |
| Bana Grass (Sudan) 2nd Cut | 4-15 TO 5-29 | 45 | 1.8 | 5 | 4.7 | 0 | 0.3 | 1.4 | 2.6 | 0 | 38 |
| Seed, Corn | 10-15 TO 2-15 | 124 | 7.0 | 14.1 | 12.4 | 0.7 | 1.4 | 4.7 | 8.1 | 0.6 | 128 |
| Seed, Corn | 4-15 TO 8-15 | 123 | 3.0 | 19.5 | 17.8 | 0.1 | 0.1 | 13.4 | 15.0 | 11.2 | 364 |
| Sugarcane, New- year 1 | 10- 1 TO 9-30 | 365 | 14.9 | 51.4 | 52.6 | 1.3 | 2.2 | 40.1 | 50.0 | 28.6 | 1089 |
| Sugarcane, New- year 1 | 5- 1 TO 4-30 | 365 | 14.9 | 51.4 | 48.1 | 0.2 | 2.2 | 33.9 | 43.3 | 23.8 | 921 |
| Sugarcane, New- year 2 | 10- 1 TO 9-30 | 365 | 14.9 | 51.4 | 48.3 | 0.5 | 2.2 | 34.4 | 44.3 | 21.9 | 934 |
| Sugarcane, New- year 2 | 5- 1 TO 4-30 | 365 | 14.9 | 51.4 | 48.4 | 0.4 | 2.2 | 35.6 | 44.6 | 23.9 | 967 |
| Sugarcane, ratoon | 10- 1 TO 9-30 | 365 | 14.9 | 51.4 | 53.4 | 0.4 | 2.2 | 40.2 | 50.8 | 28.2 | 1092 |
| Sugarcane, ratoon | 5- 1 TO 4-30 | 365 | 14.9 | 51.4 | 52.9 | 0.2 | 2.2 | 40.7 | 50.3 | 30.3 | 1105 |
| Leucaena (Eucalyptus) | 1- 1 TO 12-31 | 365 | 14.7 | 51.4 | 51.5 | 1.2 | 2.2 | 47.3 | 58.1 | 31.2 | 1284 |
| Leucaena (Eucalyptus Young) | 1- 1 TO 12-31 | 365 | 14.7 | 51.4 | 32.2 | 0.9 | 2.2 | 22.8 | 32.3 | 10.6 | 619 |

**Lower Hamakua**

| Crop Type | Irrigation Season | Length (day) | Net Rainfall | Potential ET | Crop ET | Drainage | Runoff | Mean Irrigation Requirement | Maximum Irrigation Requirement | Minimum Irrigation Requirement | Mean Irrig. (1000 Gal/Acre) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bana Grass (Sudan) 1st Cut | 11-1 TO 1-14 | 75 | 11.3 | 15.3 | 15.6 | 2.8 | 2.7 | 4.7 | 10.6 | 0 | 128 |
| Bana Grass (Sudan) 1st Cut | 4-15 TO 6-28 | 75 | 15.8 | 10.3 | 10.1 | 6.5 | 6.1 | 0.2 | 2.6 | 0 | 5 |
| Bana Grass (Sudan) 2nd Cut | 11-1 TO 12-15 | 45 | 8.7 | 8.7 | 8.8 | 2.4 | 2.4 | 1.3 | 5.3 | 0 | 35 |
| Bana Grass (Sudan) 2nd Cut | 4-15 TO 5-29 | 45 | 10.7 | 6.5 | 6.4 | 4.5 | 4.1 | 0.3 | 2.6 | 0 | 8 |
| Seed, corn | 10-15 TO 2-15 | 124 | 28.0 | 17.3 | 16.2 | 13.5 | 9.3 | 1.6 | 6.5 | 0.0 | 43 |
| Seed, corn | 4-15 TO 8-15 | 123 | 20.9 | 25.4 | 24.7 | 5.8 | 4.0 | 9.1 | 19.4 | 0.6 | 247 |
| Sugarcane, New- year 1 | 10- 1 TO 9-30 | 365 | 73.8 | 63.7 | 67.7 | 26.7 | 21.2 | 19.1 | 39.1 | 2.0 | 519 |
| Sugarcane, New- year 1 | 5- 1 TO 4-30 | 365 | 73.8 | 63.7 | 62.0 | 21.6 | 21.2 | 10.4 | 31.9 | 0.0 | 282 |
| Sugarcane, New- year 2 | 10- 1 TO 9-30 | 365 | 73.8 | 63.7 | 62.0 | 24.5 | 21.2 | 11.4 | 29.9 | 0.0 | 310 |
| Sugarcane, New- year 2 | 5- 1 TO 4-30 | 365 | 73.8 | 63.7 | 61.6 | 23.6 | 21.2 | 13.7 | 36.6 | 0.0 | 372 |
| Sugarcane, ratoon | 10- 1 TO 9-30 | 365 | 73.8 | 63.7 | 68.0 | 22.4 | 21.2 | 16.0 | 36.4 | 1.9 | 434 |
| Sugarcane, ratoon | 5- 1 TO 4-30 | 365 | 73.8 | 63.7 | 66.7 | 21.0 | 21.2 | 16.5 | 42.3 | 0.0 | 448 |
| Leucaena (Eucalyptus) | 1- 1 TO 12-31 | 365 | 73.7 | 63.7 | 63.7 | 24.5 | 21.2 | 18.1 | 46.0 | 0.0 | 491 |
| Leucaena (Eucalyptus Young) | 1- 1 TO 12-31 | 365 | 73.7 | 63.7 | 44.9 | 32.9 | 21.2 | 5.0 | 19.4 | 0.0 | 136 |

**Appendix 4-A Field Survey Instruments**

Fig. 4.A-1 Interview Questionnaire for Irrigation System Superintendent

**Irrigation System Questionnaire**
**(Survey Questions for SUPERINTENDENT/MANAGER)**

**I. Water Supply**

**1. Water diversion and delivery**

**a) How much water on average is diverted by your system?**

**---------- million gallons/day**

**b) Of this amount, how much is delivered on average to water users?**

**---------- million gallons/day**

**c) Are there gauges for the streams that supply water to your system?**

☐ **Yes** ☐ **No** ☐ **Not sure**

**d) If "Yes" where are these located, and which is the agency that installed and operates these gauges?**

**e) Do you record the gauge data? If "Yes" please provide the latest data.**

**Water reliability**

**a) What is the water supply to your system in wet versus dry seasons relative to the overall annual average?**

**Wet Season ---------- (%)**

**Dry Season ---------- (%)**

**b) Consider the wettest and driest years over a 10-year period. In the wettest year, how much larger is your system water supply (in percent or mgd) relative to the 10-year average? How much smaller is the water supply in the driest year?**

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**Infrastructure**

**2. Water Capture, Diversion, and System Storage**

**a) Describe any problems with acquiring water for your system from its source(s) and diverting it to your system. Please indicate how widespread, how severe and how frequent these problems have been:**

| Problem type | Widespread | Severity | Frequency |
|---|---|---|---|
| Intake clogging | | | |
| Inadequate storage | | | |
| Difficult access to intake for maintenance, operations | | | |
| Inadequate control structures (broken, old) | | | |
| Other | | | |

**2. Water conveyance (defined in terms of ditches, flumes, pipes and tunnels)**

**a) Please refer to attached inventory and confirm or amend it.**

**b) Describe any problems you have with water conveyance to your irrigation system. Please describe how widespread, how severe and how frequent these problems have been:**

| Problem type | Widespread | Severity | Frequency |
|---|---|---|---|
| Cracked or leaking canals, pipes, flumes, etc. | | | |
| Siltation | | | |
| Blockages | | | |
| Inadequate control structures | | | |
| Other | | | |
| | | | |

**3. Distribution and application**

**i. What type of field application system is used to apply water in your irrigation system?**

| **Methods** | **Types** | **Check your system** | **Percentage of area it is applied to** |
|---|---|---|---|
| Surface Method | Furrows, Basins, Flood | ☐ | |
| | Crop type using this method: | | |
| Sprinkler Method | Center pivot, Pivot w/ corner, Linear Move, Big Gun, Side Roll | ☐ | |
| | Crop type using this method: | | |
| Sub-surface Method | Drip, Trickle | ☐ | |
| | Crop type using this method: | | |
| Other methods | | ☐ | |
| | Crop type using this method: | | |

**ii. Describe any problems you have experienced at your system with field distribution and application. Please indicate how widespread, how severe and how frequent these problems have been:**

| Problem type | Widespread | Severity | Frequency |
|---|---|---|---|
| Inadequate head or pressure | | | |
| Water quality (e.g. Silt accumulation) | | | |
| Leaks | | | |
| Inadequate control of water flow | | | |
| Inadequate water storage | | | |
| Other | | | |

**iii. Do you measure water flow? If "Yes" at what level of the system?**

| **System Level** | **Check which is applicable** |
|---|---|
| Individual Farm | ☐ |
| System Section | ☐ |
| Canal | ☐ |
| Intake/Pump | ☐ |
| Other | ☐ |

**iv. Control: Ability to control water**

**Please see attached inventory and confirm or amend.**

If no inventory is attached, can you provide us with an inventory document or descriptions of water control structures including gates, valves, check structures, and gauges?

## II. Environmental Problems

1. **What kind of environmental problems do you have at your irrigation system? Please describe how widespread, how severe and how frequent these problems have been:**

| Problem type | Widespread | Severity | Frequency |
|---|---|---|---|
| Water quality/pollution, aquifer contamination | | | |
| Pre-existing or ongoing water rights | | | |
| Drainage | | | |
| Others | | | |
| | | | |
| | | | |

## 2. Farming-related Problems

**What types of farming-related problems have you experienced? Please describe how widespread, how severe and how frequent these problems have been:**

| Problem type | Widespread | Severity | Frequency |
|---|---|---|---|
| Air quality (e.g. vog) | | | |
| Endangered or threatened species | | | |
| Invasive species | | | |
| Limitations due to land claims, deeds, or lease restrictions | | | |
| Other | | | |

**III. Current Management**

**1. Given the configuration of your system, are there any aspects that make it difficult to monitor, operate or maintain the system?**

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**2. What kind of delivery system do you use?**

☐ **Demand based** ☐ **Rotational** ☐ **Continuous**

**3. Do you have a plan to distribute irrigation water?**

☐ **Yes** ☐ **No** ☐ **Not Sure** ----------

**If "Yes," please provide summary or copy of your plan.**

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**What is the timeframe of the plan (e.g. daily, weekly, monthly, seasonal)?**

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**4. Does your system have a farmer advisory group or other irrigators' organization?**

☐ **Yes** ☐ **No** ☐ **Not sure** ----------

**5. Describe the channels and methods used for system managers to communicate with farmers and vice-versa regarding irrigation-related matters:**

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**6. What are the estimates of your average annual costs?**

**a) Operations and annual maintenance**

**$ ----------**

**b) Capital improvements to irrigation infrastructure and purchase of equipment:**

**$ ----------**

**IV. Describe any management problems you have experienced. Please indicate how widespread, how severe and how frequent these problems have been:**

| **Problem type** | **Widespread** | **Severity** | **Frequency** |
|---|---|---|---|
| Staff turnover | | | |
| Inadequate skilled staff | | | |
| Inadequate equipment | | | |
| Inadequate financial resources | | | |
| Lack of cooperation by irrigators | | | |
| Other | | | |

## V. Farm Infrastructure and Institutions

**1. What percentage of the irrigation service area is subdivided into farm lots with clear field boundaries?**

**---------- %**

**2. Please review the attached Phase I assessment and describe the impacts from the capital improvements. If there is an updated plan, can we get a copy?**

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**VI. Site Location**

**1. Describe any complaints or problems from the non-agricultural community. Please indicate how widespread, how severe and how frequent these problems have been:**

| Problem type | Widespread | Severity | Frequency |
|---|---|---|---|
| Farm thefts | | | |
| Vandalism | | | |
| Trespassing | | | |
| Neighbor complaints about farm operations (e.g. noise, smell) | | | |
| Lack of communication awareness and involvement | | | |
| Others | | | |

**2. Development pressure**

**a) Describe the types of non-agricultural development that have occurred in your area during the past 5 years:**

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**b) Looking to the next 25 years, what do you think is the likelihood that irrigated agricultural operations will continue in this area?**

☐ **Highly Likely** ☐ **Likely** ☐ **Somewhat likely**

☐ **Not Likely** ☐ **Never**

**c) How much of the service area is likely to remain in agriculture in the year 2030?**

☐ **All or nearly all (90% -100%)**

☐ **Most areas (70-89%)**

☐ **At least half (50-69%)**

☐ **Less than half (25-49%)**

☐ **Little or none (0-24%)**

Fig. 4.A-2 Interview Questionnaire for Farmers in Irrigation System

**Irrigation System Questionnaire**
**(FARMERS/USERS)**

**I. Current Management**

**1. What percent of the time do you get adequate water supply from the irrigation system?**

**----------%**

**2. Do you think there is an equitable and fair division of water resources?**

☐ **Yes** ☐ **No** ☐ **Not Sure ----------**

**3. Does system management respond to problems?**

☐ **Yes** ☐ **No** ☐ **Not Sure ----------**

**4. Can you rate the customer service from the irrigation system?**

☐ **Very good** ☐ **Good** ☐ **Fairly good**

☐ **Not so good** ☐ **Bad**

**5. Is there a water user organization for this irrigation system?**

☐ **Yes** ☐ **No** ☐ **Not Sure ----------**

**6. If "Yes" are you a member of this association?**

☐ **Yes** ☐ **No** ☐ **Not Sure ----------**

**7. Are there other organizations like farmer co-operatives that represent farmers to the irrigation system management and help solve irrigation problems?**

☐ **Yes** ☐ **No** ☐ **Not Sure ----------**

## II. Environmental Problems

1. **What kind of environmental problems do you have at your farm? Please describe how widespread, how severe and how frequent these problems have been:**

| Problem Type | Widespread | Severity | Frequency |
|---|---|---|---|
| Water quality/pollution, aquifer contamination | | | |
| Pre-existing or ongoing water rights | | | |
| Drainage | | | |
| Others | | | |

**2. What types of farming-related problems have you experienced? Please describe how widespread, how severe and how frequent these problems have been:**

| **Problem Type** | **Widespread** | **Severity** | **Frequency** |
|---|---|---|---|
| Air Quality(e.g.: vog) | | | |
| Endangered or threatened species inhabiting the area | | | |
| Invasive species | | | |
| Others | | | |

## III. Farm Infrastructure and Institutions

1. **Do you own the land that you farm in the irrigation service area? If "No" who is the lessor, and what is the length of the current lease (in years)?**

☐ **Yes** ☐ **No** ☐ **Not Sure**_____

**If lease: name of lessor:** _____

**Lease period:**_____

2. **Rate the transportation service for your community:**

☐ **Very good** ☐ **Good** ☐ **Fairly good**

☐ **Not so good** ☐ **Bad**

3. **Rate the conditions of the roads for availability, accessibility and condition:**

☐ **Very good** ☐ **Good** ☐ **Fairly good**

☐ **Not so good** ☐ **Bad**

**4. What percentage of your farm is fenced or has other security measures installed?**

**---------- %**

**5. Has your farming community implemented security measures? If "Yes" please specify:**

☐ **Yes** ☐ **No** ☐ **Not Sure ----------**

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**6. How strong is the commitment in your community to maintaining agriculture in this area?**

☐ **Very strong** ☐ **Strong** ☐ **Fairly strong**

☐ **Neutral** ☐ **No commitment**

## IV. Site Location

### 1. Development pressure

**a) Describe any complaints or problems from the non-agricultural community. Please indicate how widespread, how severe and how frequent these problems have been:**

| Problem type | Widespread | Severity | Frequency |
|---|---|---|---|
| Farm thefts | | | |
| Vandalism | | | |
| Trespassing | | | |
| Neighbor complaints about farm operations | | | |
| Lack of communication awareness and involvement | | | |
| Others | | | |

**c) Describe the types of non-agricultural development that have occurred in the last 5 years:**

**d)**

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**c) Looking to the next 25 years, what do you think is the likelihood that irrigated agricultural operations will continue in this area?**

☐ **Highly Likely** ☐ **Likely** ☐ **Somewhat likely**

☐ **Not Likely** ☐ **Never**

**d) How much of the area of your farm is likely to remain in agriculture by the year 2030?**

☐ **All or nearly all (90% -100%)**

☐ **Most areas (70-89%)**

☐ **At least half (50-69%)**

☐ **Less than half (25-49%)**

☐ **Little or none (0-24%)**

**2. Marketing**

**a) Where do you market your farm outputs? If more than one, estimate the percentage marketed to different outlets:**

| **Market Type** | **Percentage estimate** |
|---|---|
| Foreign exports | |
| Mainland | |
| Inter-island | |
| Local | |
| Others | |

**b) Describe any problems with procuring farm inputs such as fertilizer and equipment:**

| **Inputs** | **Check/describe problem** |
|---|---|
| Lack of nearby stores/outlets | ☐ |
| Reliability of input supplies | ☐ |
| High Costs | ☐ |
| Few Dealers | ☐ |
| Other | ☐ |

**c) Describe any problems with marketing farm outputs:**

| Outputs | Check/describe problem |
|---|---|
| Inadequate road transportation to main hub | ☐ |
| Inadequate shipping facilities and services from hub | ☐ |
| High costs for transport and shipping | ☐ |
| Lack of local outlets/buyers | ☐ |
| Poor telecommunications, infrastructure services | ☐ |
| Other | |

# 4-B Irrigation Model Delphi Survey

Panelists' names:

1. Bert Hatton (VP Campbell Estate)
2. Leland Lee (Belt Collins)
3. Phil Moravcik (WRRC)
4. Chris Smith (NRCS)
5. Dudley Kubo (NRCS)
6. Paul Singleton
7. Samir El-Swaify (UHM)

Fig. 4.B-1 Round 1 Questionnaire

## Delphi Survey on Scoring Model for Hawaii Irrigation Systems: Evaluating Future Agricultural Potential

### Introduction

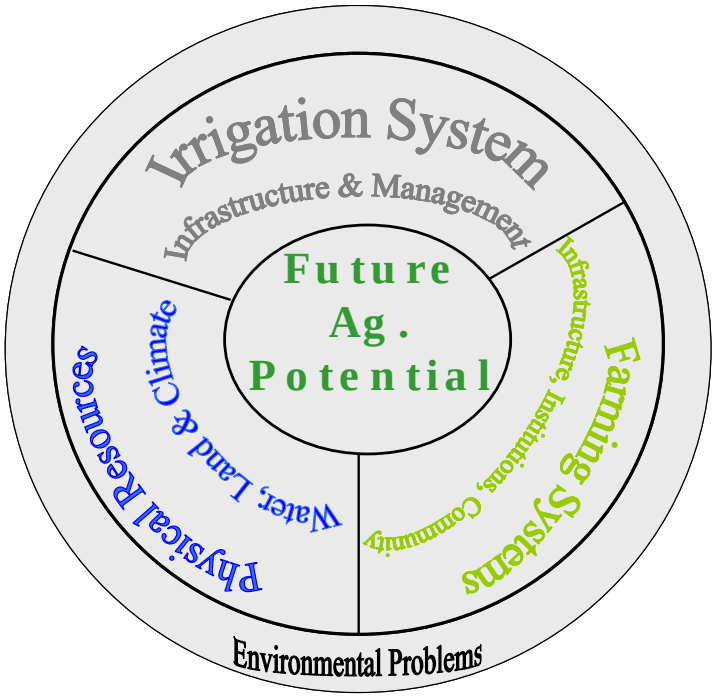
Thank you for your willingness to participate. The goal of this survey is to develop a scoring system to evaluate the potential of selected irrigation systems in Hawaii. We will be using the Delphi technique to accomplish this goal. The survey will be conducted entirely via e-mail and will take about 15-20 minutes per round to answer. The survey will consist of about four rounds. Instructions are provided at the beginning of each round. Complete anonymity will be maintained, with only a summary of the group's responses presented to the panelists.

We ask that you please return your completed Round 1 survey by or before Friday, June 23, by e-mailing this completed .doc file to: rchesler@hawaii.edu. Mahalo!

## Round 1

### Conceptual Model

The project has developed the following conceptual model which illustrates major elements determining the long-run agricultural potential of irrigation systems and their respective irrigable areas:




**Instructions**

The following exercise asks you to rank seven major components related to the above model. A description of each component is provided below. Please rate the importance of these components by ranking them 1-7 in the box corresponding to your choice, with 1 being the most important and 7 being the least important.

| Component | Rank 1-7 |
|---|---|
| *1.0 Irrigation Water Supply*: System-level availability and reliability of water and diversion of water over time. | |
| *2.0 Irrigation Infrastructure and Water Delivery*: Availability, condition, and adequacy of system- and farm-level facilities, and adequacy of farm water deliveries. | |
| *3.0 Irrigation System Management:* Effectiveness of system management and quality of irrigation service. | |
| *4.0 Land Resources*: Agricultural potential of lands and climatic resources within the system area. | |
| *5.0 Farm Infrastructure and Institutions*: Non-water facilities and conditions affecting farm viability and profitability. | |
| *6.0 Non-Agricultural Community*: Relations between the irrigation system/farmers and non-farm residents in the surrounding area. | |
| 7.0 *Environmental Problems and Limitations*: Water, land and other biophysical conditions negatively impacting irrigated agriculture. | |

Comments:
Please type any comments you have regarding this section into the box below. We are interested in your opinions on the model structure itself, the component descriptions, components you feel have been omitted, or included components you feel are irrelevant.

| *Comments:* |
|---|
| |

**Conceptual Indicators within Each Component**

We have identified several conceptual indicators for each of the above model components, relevant to evaluating the long-run agricultural potential of irrigated areas. In this section, we ask you to rank the importance of each indicator within a given model component. A box is provided after each ranking table for you to type comments about relevant indicators that you feel have been omitted, or opinions about specifying indicators for a model component.

**Instructions**

Within each of the tables below, please rank the importance of the indicators for the respective model component. There are 3-7 indicators listed for each component. Type a ranking number in the column with 1 being the most important Indicator. For example, Component 1.0: Irrigation Water Supply, has 4 conceptual indicators (listed a-d). So, you would place a 1 next to the indicator you consider to be most important, with a 2, 3, and 4 next to the others you feel are less important.

***1.0 Irrigation Water Supply:*** System level availability and reliability of water and diversion of water over time:

| Conceptual Indicator | Rank 1-4 |
|---|---|
| a. average daily supply | |
| b. seasonal variability (relative wet:dry) in water supply | |
| c. interannual variability (wet:dry year) in water supply | |
| d. diversion capacity | |

| *Comments:* |
|---|
| |

***2.0 Irrigation Infrastructure and Water Delivery:*** Availability, condition, and adequacy of system- and farm-level facilities, and adequacy of farm water deliveries:

| Conceptual Indicator | Rank1-6 |
|---|---|
| a. system water capture and intake infrastructure | |
| b. system water conveyances and control structures | |
| c. system water reservoirs (short-term storage only) | |
| d. farm water distribution and field application facilities | |
| e. average water deliveries to farms | |
| f. adequacy of farm water supplies relative to demand | |

*Comments:*

***3.0 Irrigation System Management:*** Effectiveness of system management and quality of irrigation service:

| Conceptual Indicator | Rank 1-7 |
|---|---|
| a. system management personnel | |
| b. system equipment for operations and maintenance (O&M) | |
| c. management systems including water planning and monitoring | |
| d. financial resources for system O&M | |
| e. financial resources for system capital improvements | |
| f. farmer participation in system management | |
| g. farmer satisfaction with irrigation service | |

*Comments:*

***4.0 Land Resources***: Agricultural potential of lands and climatic resources within the system area:

| Conceptual Indicator | Rank 1-3 |
|---|---|
| a. soil productivity for agriculture | |
| b. soil and other land limitations for agricultural uses | |
| c. climatic indicators affecting net demand for irrigation water (e.g., rainfall, solar radiation) | |

*Comments:*

***5.0 Farm Infrastructure and Institutions:*** Non-water facilities and conditions affecting farm viability and profitability:

| Conceptual Indicator | Rank 1-5 |
|---|---|
| a. agricultural property development including farm lots, field boundaries and private farm infrastructure including fences/other security measures | |
| b. security of farm land tenure | |
| c. public infrastructure including roads, electricity | |
| d. farm production costs, particularly purchased inputs | |
| e. farm revenues, particularly marketing outlets and sales | |

*Comments:*

***6.0 Non-Agricultural Community:*** Relations between the irrigation system/farmers and non-farm residents in the surrounding area:

| Conceptual Indicator | Rank 1-4 |
|---|---|
| a. conflicts for farms including theft and vandalism | |
| b. conflicts for non-farm residents including noise and smells | |
| c. pressure to develop irrigation system lands for non-agricultural uses | |
| d. protections to preserve irrigation system lands for agricultural use | |

*Comments:*

***7.0 Environmental Problems and Limitations:*** Water, land and other biophysical conditions negatively impacting irrigated agriculture:

| Conceptual Indicator | Rank1-6 |
|---|---|
| a. water pollution or other water quality problems | |
| b. air quality | |
| c. endangered species | |
| d. invasive species | |
| e. water rights disputes or conflicts | |
| f. disputed farmland claims or restrictions on deed or lease | |

*Comments:*

This concludes Round 1 of our survey. Please e-mail your completed survey as an attachment to: rchesler@hawaii.edu. Mahalo for your participation!

Fig. 4.B-2 Round 2 Questionnaire
NOTE: The Round 2 Appendix is not included here for the sake of brevity. The complete Round 2 questionnaire,
including its appendix is available on the CD-ROM accompanying this report ("Irrigation Delphi Round 2.doc").

# Delphi Survey on Scoring Model for Hawaii Irrigation Systems: Evaluating Future Agricultural Potential-Round 2

**Introduction**

Thank you for your prompt response to Round 1. The purpose of Round 2 is for you to reassess your responses based on the panel results from Round 1. In this round, we will also introduce you to empirical indicators available to quantify the conceptual indicators rated in Round 1, which may lead you to reassess the importance of a given factor. In addition, the end of this questionnaire asks questions about aggregating data from different sources and for composite indicators about irrigation problems.

Round 1 responses included selected comments from Delphi panelists. These comments are presented in an appendix to this document. A reader can jump to the comments by clicking the link provided. (You may have to hold down the Ctrl key and then left mouse-click to activate a link.) Some comments have been edited or paraphrased for clarity. After reading any comments from the other panelists and viewing the panel results, please re-vote the importance of model components and conceptual in the boxes provided.

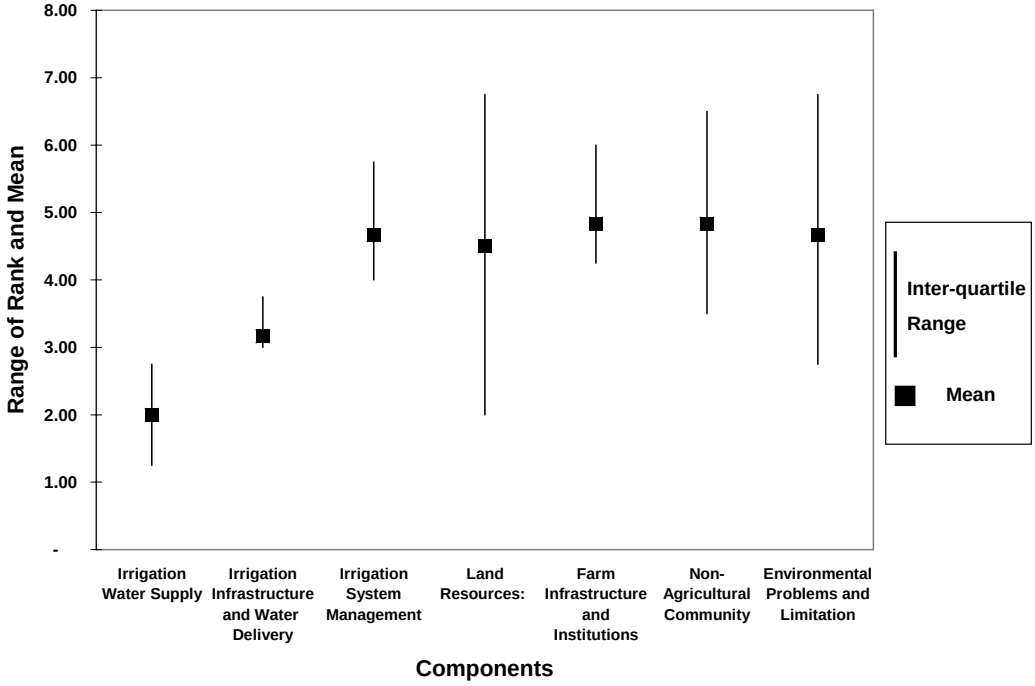
Please return your completed Round 2 survey to rchesler@hawaii.edu by or before Monday July 3, 2006. (The sooner they are completed, the sooner we are able to advance to the next round).

**1) Importance of Model Components**

**Instructions**

In Round 1 we introduced a model to evaluate the long run agricultural potential of an irrigated area. There are 7 major components to this model, for which Delphi panelists ranked the importance (1=most important, 7=least important) of each component.

The figure below shows the inter-quartile range and mean of panelist rankings of importance from Round 1.




To see panelists' comments for this component from round one, please click here

We ask you to re-rank the 7 major components in the table below.

| Component | Round 1 mean rank | Re-Rank 1-7 |
|---|---|---|
| *1.0 Irrigation Water Supply*: System-level availability and reliability of water and diversion of water over time. | 2.0 | |
| *2.0 Irrigation Infrastructure and Water Delivery*: Availability, condition, and adequacy of system- and farm-level facilities, and adequacy of farm water deliveries. | 3.2 | |
| *3.0 Irrigation System Management:* Effectiveness of system management and quality of irrigation service. | 4.7 | |
| *4.0 Land Resources*: Agricultural potential of lands and climatic resources within the system area. | 4.50 | |
| *5.0 Farm Infrastructure and Institutions*: Non-water facilities and conditions affecting farm viability and profitability. | 4.8 | |
| *6.0 Non-Agricultural Community*: Relations between the irrigation system/farmers and non-farm residents in the surrounding area. | 4.8 | |
| 7.0 *Environmental Problems and Limitations*: Water, land and other biophysical conditions negatively impacting irrigated agriculture. | 4.7 | |

Comments:

Please type any comments you have regarding this section into the box below. We are interested to understand your reasons for ranking a model component much higher or lower than Round 1 mean.

| |
|---|
| *Comments:* |

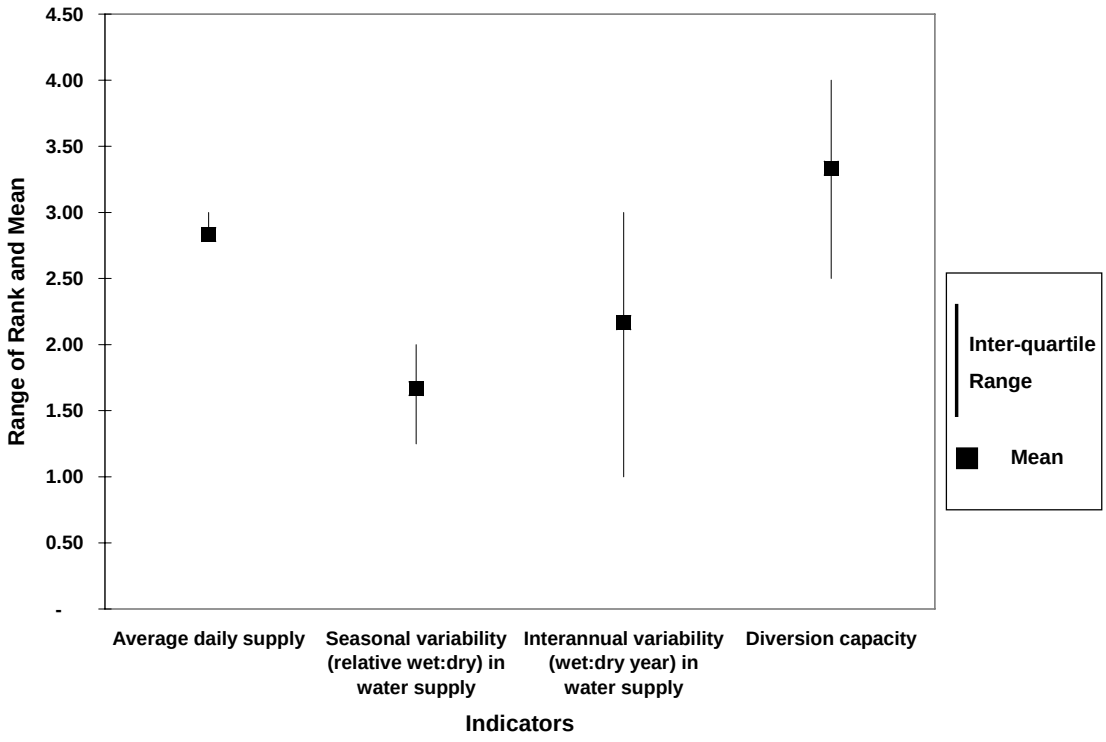
**2) Conceptual and Empirical Indicators within Each Component**

We have identified several conceptual indicators for each of the above model components, conceptual indicators relevant to evaluating the long-run agricultural potential of irrigated areas. In this round, we feedback statistics on the Round 1 rankings of the importance of the conceptual indicators within each model component. We also introduce empirical indicator(s) for each conceptual indicator. The empirical indicators were developed based on the available data from 10 Hawaii irrigation systems, including considerations on the quality of those data.

**Instructions**

Review the statistics on Round 1 rankings given in the figures below. For some model components, you can also link to panelist comments from Round 1. Below each figure of statistics, there is a table listing the conceptual and empirical indicators for a model component. Please re-rank the importance of the conceptual indicators by typing a number in the box corresponding to your choice. After a ranking table, there is a box for you to type comments about any relevant indicators not included in the list, specification of the empirical indicators, or your reasons for ranking an indicator much higher or lower than the Round 1 mean.

The figure below shows the inter-quartile range and mean rank for each conceptual indicator for component 1.

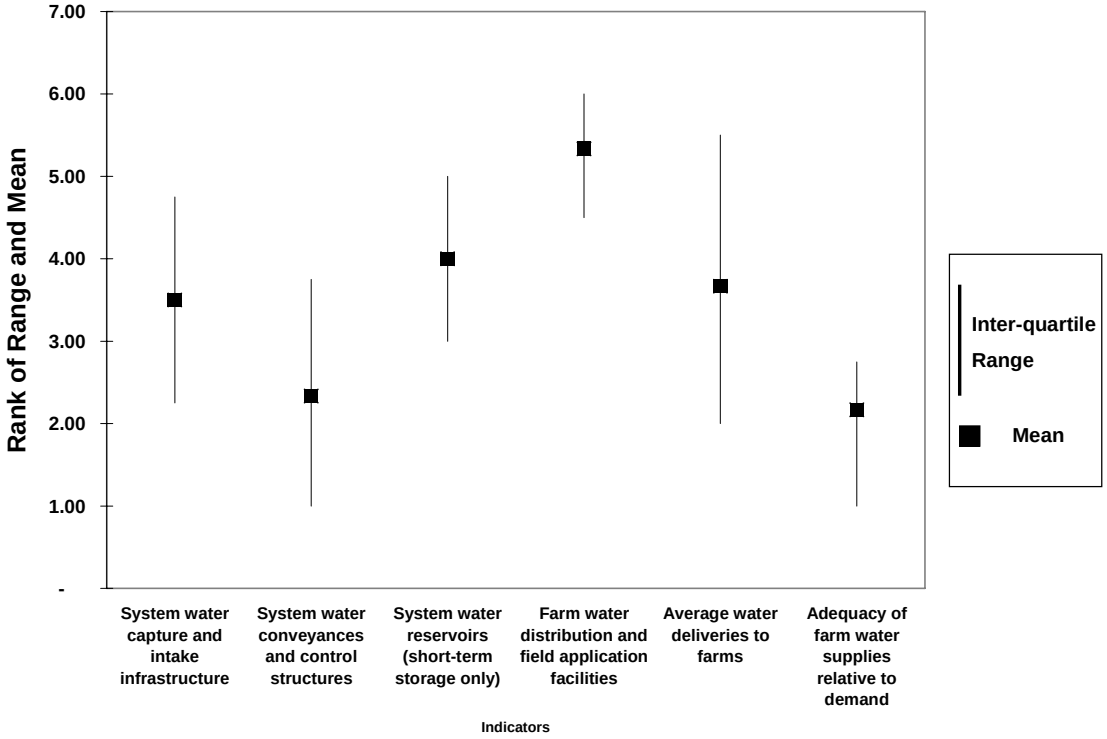



***1.0 Irrigation Water Supply:*** System level availability and reliability of water and diversion of water over time:

| Conceptual Indicators | Empirical Indicator(s) | Round 1 Mean Rank | Re-Rank 1-4 |
|---|---|---|---|
| a. average daily supply | Avg. water diverted per cultivated acre | 2.8 | |
| b. diversion capacity | Water diversion capacity per irrigable acre<br>% water diverted relative to water diversion capacity | 1.7 | |
| c. seasonal variability (relative wet:dry) in water supply | Ratio of wet to dry season water diversions | 2.2 | |
| d. interannual variability (wet:dry year) in water supply | Qualitative assessment of reliability: no. of sources, groundwater vs. surface sources, elevation and length of stream sources | 3.3 | |

*Comments:*

The figure below shows the inter-quartile range and mean rank for each conceptual indicator for component 2.0.

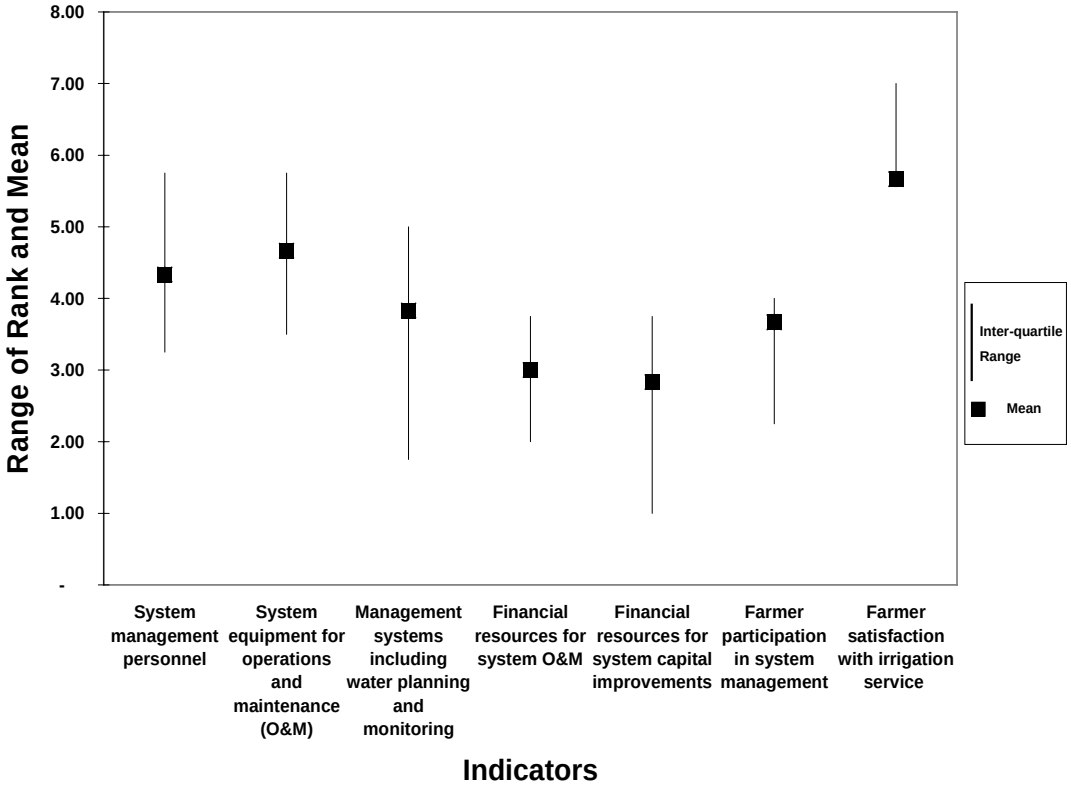


***2.0 Irrigation Infrastructure and Water Delivery:*** Availability, condition, and adequacy of system- and farm-level facilities, and adequacy of farm water deliveries:

| **Conceptual Indicator** | **Empirical Indicator(s)** | **Round 1 Mean Rank** | **Re-Rank 1-6** |
|---|---|---|---|
| | **Problem(s) reported by System or by Farmers** | | |
| a. System water capture and intake infrastructure | *Problems reported by system managers:* | 3.5 | |
| | - intake clogging | | |
| | - difficulty accessing infrastructure | | |
| | - inadequate control structures | | |
| | % Irrigable acres within 0.25 miles from conveyance | | |
| b/c. System water conveyances<br>System water control structures | *Problems reported by system managers:* | 2.3 | |
| | - cracked or leaking infrastructure | | |
| | - blockages of conveyances or structures | | |
| | - siltation/rocks in conveyances or structures | | |
| | - inadequate control structures | | |
| | - inadequate water head or pressure | | |
| | -System storage capacity per irrigable acre | | |
| d. system water reservoirs (short-term storage only) | Problems reported by system managers on inadequate storage | 4.0 | |
| e. Farm water distribution and field application facilities | *Problems reported by system managers:* | 5.3 | |
| | - leaks | | |
| | - inadequate control of water flows | | |
| | - inadequate water storage | | |
| f. average water deliveries to farms* | % water diverted actually delivered | 3.7 | |
| g. adequacy of farm water supplies relative to demand | Farmer assessments on adequacy of farm water supply | 2.2 | |
| | Presence of an alternative source of water supply | | |

*Comments:*

The figure below shows the inter-quartile range and mean rank for each conceptual indicator for component 3.0.



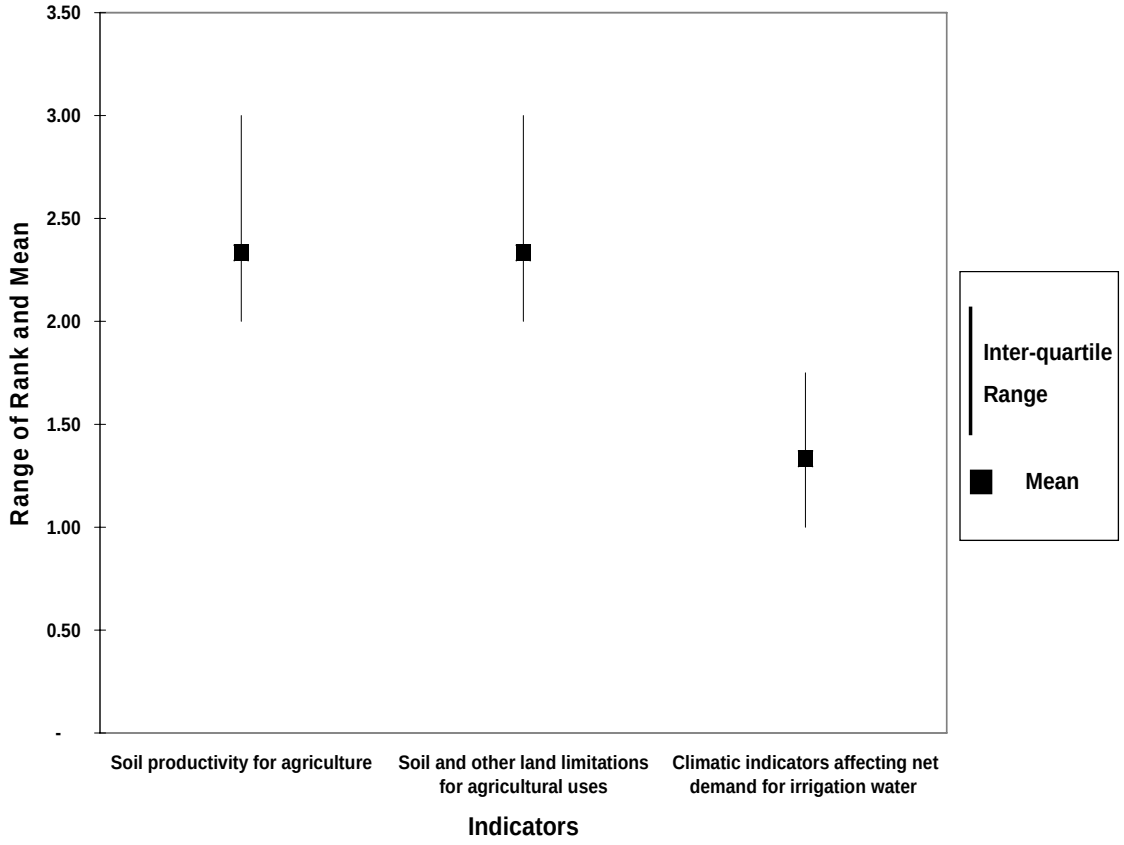

To see panelists' comments for this component from round one, please click here.

***3.0 Irrigation System Management:*** Effectiveness of system management and quality of irrigation service:

| **Conceptual Indicator** | **Empirical Indicator(s)**<br>**Problem(s) reported by System or by Farmers** | **Round 1 Mean Rank** | **Re-Rank 1-7** |
|---|---|---|---|
| a. system management personnel | *Problems reported by system managers:* | 4.3 | |
| | - staff turnover | | |
| | - inadequately skilled staff | | |
| b. system equipment for operations and maintenance (O&M) | Problems reported by system managers on inadequate equipment | 4.7 | |
| c. management systems including water planning and monitoring | Quantitative recorded water measures at system intake or major sections/conveyances and at farm level | 3.8 | |
| | Regularity (seasonal, emergency only, none) of planning for water allocation and delivery | | |
| | Farmer assessments on responsiveness of management | | |
| d. financial resources for system O&M | Cultivated area / $100,000 O&M budget | 3.0 | |
| | Irrigable area / $100,000 O&M budget | | |
| | Problems reported by system managers on financial security | | |
| f. financial resources for | Qualitative assessment on no. and size of capital improvement projects over last (approx.) 5 years | 2.8 | |
| g. farmer participation in system management | Degree of involvement by farmer advisory group in managing system | 3.7 | |
| | Problems reported by system managers on lack of cooperation by irrigators | | |
| | Presence of water user organization and farmer membership | | |
| | Presence of other organizations involved with irrigation | | |
| h. farmer satisfaction with irrigation service | Farmer assessments on fair and equitable water distribution | 5.7 | |
| | Farmer assessments on system customer service | | |

*Comments:*

The figure below shows the inter-quartile range and mean for each conceptual indicator for component 4.0.

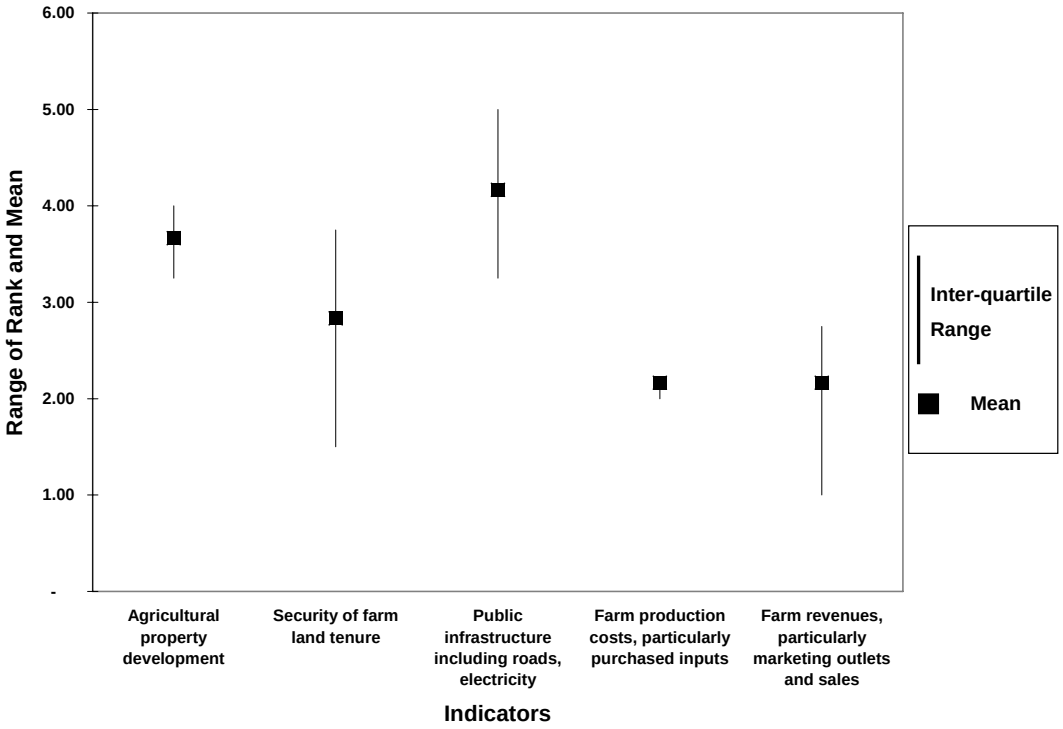


***4.0 Land Resources***: Agricultural potential of lands and climatic resources within the system area:

| **Conceptual Indicator** | **Empirical Indicator(s)**<br>**Problem(s) reported by System or by Farmers** | **Round 1 Mean Rank** | **Re-Rank 1-3** |
|---|---|---|---|
| a. soil productivity for agriculture | % Irrigable area rate Prime in ALISH (Agricultural Lands of Importance to the State of Hawaii) system | 2.3 | |
| b. soil and other land limitations for agricultural uses | % Irrigable acres by Land Capability Classes (LCC) for non-irrigated conditions | 2.3 | |
| | Qualitative assessment on availability of LCC data for irrigated conditions and average system increase in LCC class with irrigation | | |
| | *Problems reported by system manager and farmers:* | | |
| | - erosion | | |
| | - drainage | | |
| c. climatic indicators affecting net demand for irrigation water (e.g., rainfall, solar radiation) | Irrigation water requirement for reference crop (net of effective rainfall) | 1.3 | |

*Comments:*

The figure below shows the inter-quartile range and mean for each conceptual indicator for component 5.0.



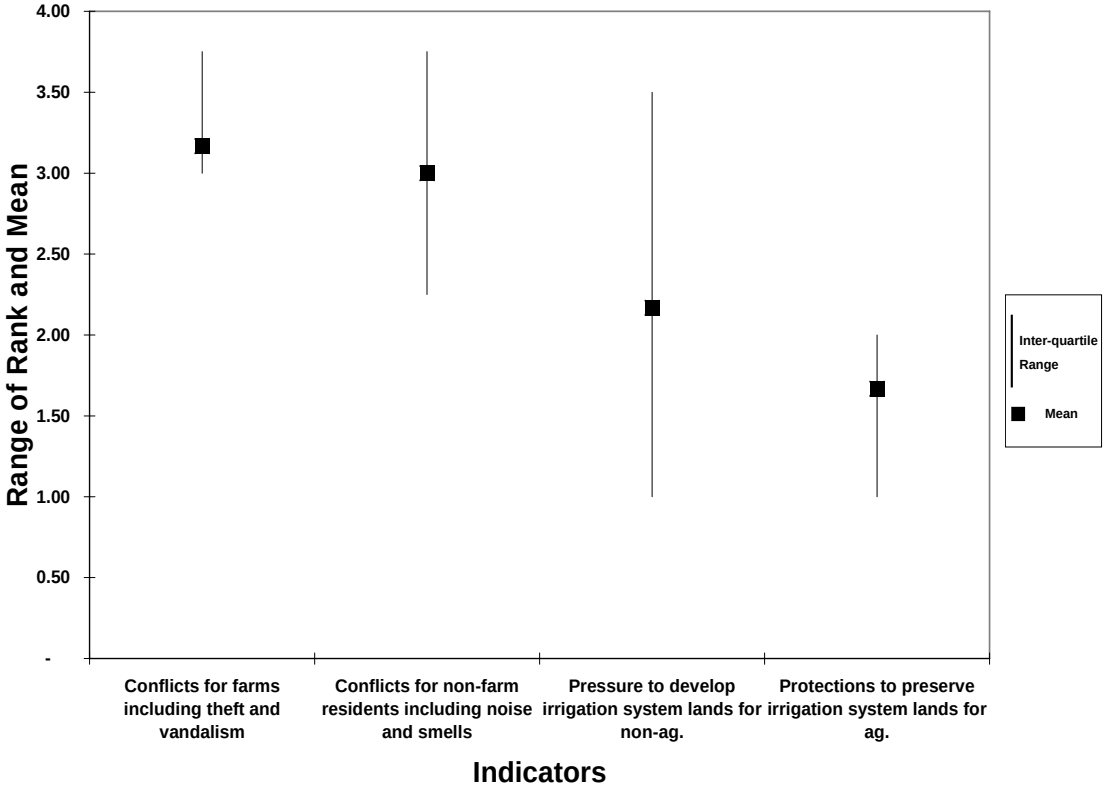

To see panelists' comments for this component from round one, please click here.

***5.0 Farm Infrastructure and Institutions:*** Non-water facilities and conditions affecting farm viability and profitability:

| **Conceptual Indicators** | **Empirical Indicator(s)**<br>**Problem(s) reported by System or by Farmers** | **Round 1 Mean Rank** | **Re-Rank 1-5** |
|---|---|---|---|
| a/d. agricultural property development including farm lots, field boundaries, farm infrastructure including fences/other security measures | % system area with farm lots and field boundaries | 3.7 | |
| | % farmers taking security measures relative to reported theft and invasive animal problems. | | |
| b. security of farm land tenure | % farmers with owned land, government lease or long-term private lease | 2.8 | |
| | % system area in Hawaiian Homes land | | |
| | Problems reported by system managers and farmers involving land deeds or lease claims | | |
| c. public infrastructure including roads, electricity | Farmer assessments on quality of transportation services in community | 4.2 | |
| | Farmer assessments on quality of road conditions | | |
| e. farm production costs, particularly purchased inputs | Farmer reported problems in procuring farm inputs | 2.2 | |
| f. farm revenues, particularly marketing outlets and sales | % farm output exported outside of Hawaii | 2.2 | |
| | Farmer reported problems in marketing farm outputs | | |

*Comments:*

The figure below shows the inter-quartile range and mean for each conceptual indicator for component 6.0.



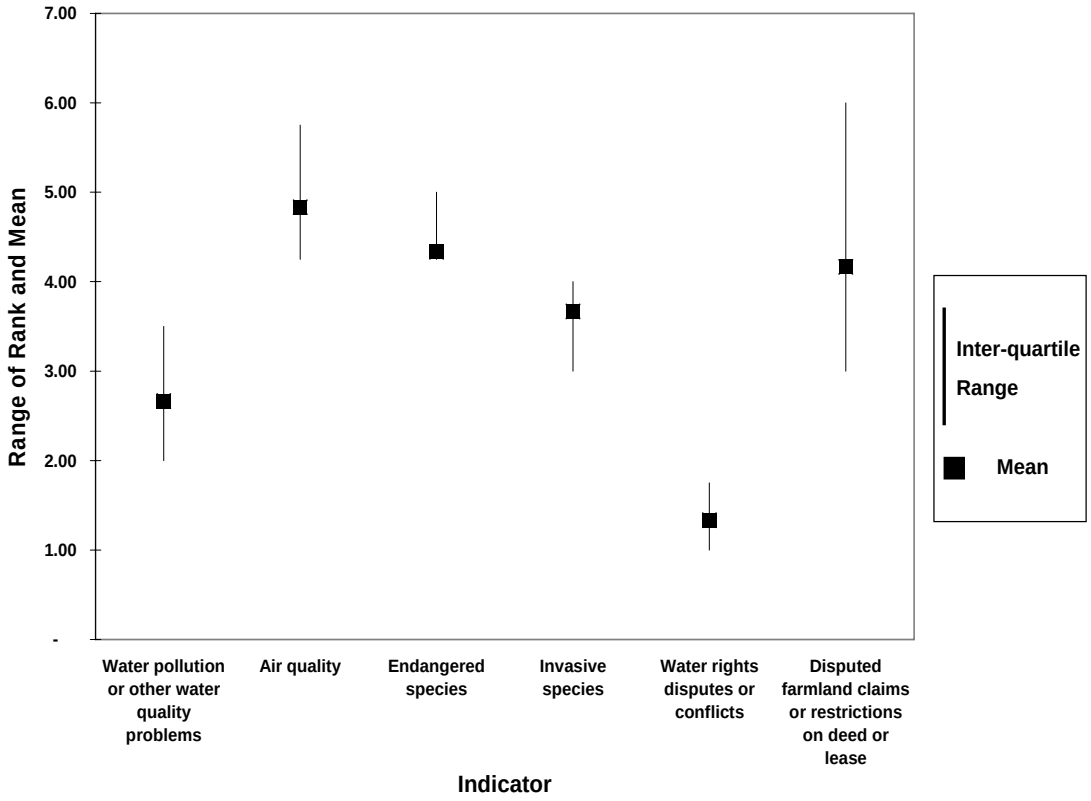

To see panelists' comments for this component from round one, please click here.

***6.0 Non-Agricultural Community:*** Relations between the irrigation system/farmers and non-farm residents in the surrounding area:

| **Conceptual Indicator** | **Empirical Indicator(s)**<br>**Problem(s) reported by System or by Farmers** | **Round 1 Mean Rank** | **Re-Rank 1-4** |
|---|---|---|---|
| a. conflicts for farms including theft and vandalism | *Problems reported by system managers and farmers:*<br>- farm thefts<br>- farm vandalism<br>- trespassing on farmlands<br>- lack of communication, awareness, involvement by non-ag community | 3.2 | |
| b. conflicts for non-farm residents including noise and smells | Problems with neighbor complaints reported by system managers and farmers | 3.0 | |
| c. pressure to develop irrigation system lands for non-agricultural uses | System managers and farmer assessments on likelihood of continued irrigated ag in area through 2030<br>System managers assessment on percentage system area remaining in ag for next 25 years | 2.2 | |
| d. protections to preserve irrigation system lands for agricultural use | Farmer assessments on percentage of own farmed area remaining in ag for next 25 years<br>Farmer assessments on strength of community commitment to maintaining ag | 1.7 | |

*Comments:*

The figure below shows the inter-quartile range and mean for each conceptual indicator for component 7.0.




To see panelists' comments for this component from round one, please click here.

***7.0 Environmental Problems and Limitations:*** Water, land and other biophysical conditions negatively impacting irrigated agriculture:

| **Conceptual Indicators** | **Empirical Indicator(s)**<br>**Problem(s) reported by System or by Farmers** | **Round 1 Mean Rank** | **Re-Rank 1-6** |
|---|---|---|---|
| a. water pollution or other water quality problems | System managers and farmer reported problems with water quality or water pollution | 2.7 | |
| b. air quality | System managers and farmer reported problems with air quality | 4.8 | |
| c. endangered species | System managers and farmer reported problems with endangered species | 4.3 | |
| d. invasive species | System managers and farmer reported problems with invasive species | 3.7 | |
| e. water rights disputes or conflicts | System managers and farmer reported problems with pre-existing water rights | 1.3 | |
| f. disputed farmland claims or restrictions on deed or lease | System managers and farmer reported problems with environmental restrictions on land deeds or leases | 4.2 | |

*Comments:*

***3) Questions on Aggregating Data***

*a) Multiple Responses by System Managers and Farmers*

The project has collected data on selected irrigation systems from official statistics, other reports, system records, and interviews with system manager(s) and selected farmers. Some interview questions were asked of both system managers and farmers. There are several ways that these data could be aggregated. Or the manager and farmer responses could be left as separate indicators.

Instructions: In this exercise, we ask your opinion about how multiple responses from system managers and farmers should be aggregated. In the table below, put an X in the column showing the strength of your agreement with using a given aggregation method. For option c and option d, type comments in the box explaining numerical quantification.

***How should data with responses by both system managers and farmers be aggregated?***

| **Aggregation Methods** | **Strongly Agree** | **Agree** | **Disagree** | **Neither Agree nor Disagree** |
|---|---|---|---|---|
| a. Separate indicators for managers and for farmers | | | | |
| b. Simple average of all responses | | | | |
| c. Weighted average of responses | | | | |
| Comment on appropriate weighting scheme for option c: | | | | |
| d. Other aggregation method: | | | | |
| Comment on specific method and computations to quantify option d: | | | | |

*b) Irrigation Conditions Measured by Problem Statements*

In interviews of system managers and farmers, irrigation conditions were often addressed by asking about various problems experienced at that system. When a problem was reported,

follow-up questions asked about how widespread the problem is, how frequently it is experienced, and how severe the problem is. We would like to aggregate these data to derive a composite indicator for how big a particular problem is at a given system.

Instructions: For this exercise, we ask your opinion about how to aggregate different aspects (widespread, frequency, severity) of a problem so as to measure the overall degree of the problem. Assuming an additive scoring system, should all aspects of a problem be given equal weight (i.e., same average weight used for all aspects)? Or should some aspects be given more or less weight? In the table below, put an X in the column showing how much weight should be given to a particular aspect of a problem.

***How should different aspects of a problem be weighted to derive a composite indicator on the degree of a problem?***

| **Problem Aspect** | **Above Average Weight** | **Average Weight** | **Below Average Weight** | **Undecided** |
|---|---|---|---|---|
| Widespread | | | | |
| Frequency | | | | |
| Severity | | | | |

Comments: Please type your comments in the box section on aggregating different aspects of a problem.

| |
|---|
| *Comments:* |

*With this we have come to the end of Round 2. Please send your responses to the following address: (rchesler@hawaii.edu) by or before Monday, July 3. Mahalo for your participation*

Fig. 4.B-3 Round 3 Questionnaire

The Round 3 questionnaire is in spreadsheet format, because calculations were performed on values inputted by the survey respondents. The spreadsheet format does not lend itself well to static presentation here. To see the Round 3 questionnaire, please open the file, “Irrigation Delphi Round 3.xls” on the accompanying CD-ROM.

Fig. 4.B-4 Round 4 Questionnaire

The Round 4 questionnaire is in spreadsheet format, because calculations were performed on values inputted by the survey respondents. The spreadsheet format does not lend itself well to static presentation here. To see the Round 3 questionnaire, please open the file, “Irrigation Delphi Round 4.xls” on the accompanying CD-ROM.

**4-C Table 4-C Indicator Descriptors**

| No. | Indicator Name | Definition | Rationale | Conceptual and References | Geog. Scale | Data Source | Limitations |
|---|---|---|---|---|---|---|---|
| **WATER SUPPLY** | | | | | | | |
| 1.1 | Avg. water diverted per cultivated acre | Ratio of average water in million gallons per day that is diverted by all intakes for the irrigation system to the cultivated acreage for the entire system. | This indicator is important because it measures water supply and availability as well as growth potential within water constraints. | Indicator is the average water supplied by the system during wet and dry years in terms of precipitation. Cultivated acres are defined as areas that are currently growing and/or harvesting a crop. 5, 14 | S | SI.I.1.a, G | Spatial and temporal distribution of resources is not identified and might not be representative of future ag. potential since land can be transitioning from sugar to diversified ag. |
| 1.2 | Water diversion capacity per irrigable acre | Ratio of maximum water in million gallons per day that is diverted by all intakes for the irrigation system to the irrigable acreage for the entire system. | The importance of this indicator stems from how much growth can occur while operating within water constraints and indicates if water supply is sufficient to meet the needs of irrigation users. | Indicator is a measure of water productivity and defined by max. water diversion capacity. Irrigable acreage is the physical land unit that has and is currently irrigating crops with ag. irrigation water. 14 | S | P, G | Irrigable acres in the service area are dynamic and based off of many factors that might not represent the true potential for ag. productivity. |
| 1.3 | % water diverted to water diversion capacity | Percent of water that is being diverted by all intakes to the maximum that the system can divert. | Indicator of present water availability and the future ability to meet water demands. | Indicator is a measure of potential growth and a measure of how much water is available for the system. Diversion is defined by the amount of water that flows into the system infrastructure and is the sum of all water flows at each intake for the system. 3, 4 | S | SI.I.1.a, P | Water diverted is based on average since no measurements are recorded at intakes or within system infrastructure. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.4 | Ratio of wet to dry season water diversions | Ratio of average water delivery in a wet year to that delivered in a dry year. | Indicator is a measure of relative water supply and shows variability or fluctuations experienced in water supplied by system. | A wet year is defined as above normal precipitation and a dry year is defined below normal precipitation for that region.<br>3, 4, 18 | S | SI.I.2.a | The effect of seasonality on production was not quantified. |
| 1.5 | Historical dry year record water diversion | The amount diverted by all intakes in million gallons per day during a drought. | Indicator is a measure of reliability since the variation in regards to seasonality was asked. | Under extreme events, such as a drought, indicator specifies the minimum water delivered by the system.<br>3 | S | SI.I.2.b | Variations in water supply were not defined by scale: seasonal, year to year, or other. |
| **IRRIGATION INFRASTRUCTURE AND WATER DELIVERY** | | | | | | | |
| 2.1 | % water diverted actually delivered | Percent of water in mgd diverted by all intakes that is available on-farm to irrigation. | Indicator is a measure of water use efficiency as well as system design efficiency. | Indicator denotes loss of water from system that is not used for agricultural purposes. These losses occur due to cracks, leaks, or environmental processes such as evapotranspiration.<br>6 | S | SI.I.1.b | Data is approximate and sometimes limited. Source and effects of inefficiency is not identified. Percent is based off of average water diverted. |
| 2.2 | System storage capacity per irrigable acre | The amount of storage in mg for irrigation system per irrigable acre. | Measures capacity of water stored on site. | Storage is defined by storage reservoirs for the system and do not include on farm infrastructure such as ponds or damns. Irrigable acreage is the physical land unit that has and is currently irrigating crops with ag. irrigation water.<br>1, 12 | S | P, G | There is no information provided that assesses the capability of water storage to capture water quantity. Furthermore, the condition of the storage system was not assessed. |
| 2.3 | % Irrigable acre within 0.25 miles | Percent irrigable acres in service area within a | Indicator identifies the ease of | Spatial identification of irrigable acreage that is | I | G | Information on topography not taken |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | from conveyance | | distance of 0.25 miles of conveyance irrigation infrastructure. | distribution to water consumers of irrigation system. | irrigating crops with ag. irrigation water with 0.25 mile from main system conveyance infrastructure, which includes earthen ditches, tunnels, or pipes. 8 | | | into account and could be part of a larger conveyance problem. |
| 2.4 | Water Capture, Diversion, and System Storage | Intake clogging | Composite: number of intakes that are blocked to total intakes, based on spatial extent, severity and frequency of intake clogging that could be caused by debris or rock falls | Indicator can signify problems with distribution uniformity or management and represents water capture problems. | 7, 14 | S | SI.II.1.a | |
| 2.5 | | Inadequate storage | Composite: mentioned as a problem by superintendent and described based on spatial extent, severity, and frequency | Indicator water capture for system based on the quantity and quality of system infrastructure. | 7, 14 | S | SI.II.1.a | |
| 2.6 | | Access difficulty | Composite: mentioned as a problem by superintendent and described based on spatial extent, severity, and frequency | Difficult access to intakes can causes problems in maintenance and operations. | 7, 14 | S | SI.II.1.a | |
| 2.7 | | Inadequate control structures | Composite: mentioned as a problem by superintendent and described based on spatial extent, severity, and frequency. | Indicator represents the degree of control in system. | Problems include broken or old infrastructure. 7, 14 | S | SI.II.1.a SI.II.2.b | |

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| 2.8 | Water Conveyance | Cracked or leaking infrastructure | Composite: mentioned as a problem by superintendent and described based on spatial extent, severity, and frequency. | Indicator can prevent water transport within the irrigation system. | 8 | S | SI.II.2.b | Indicator does not taken into account the affect of rehabilitation. Replacement of system infrastructure could improve conveyance problems. |
| 2.9 | | Siltation/Rocks | Composite: mentioned as a problem by superintendent and described based on spatial extent, severity, and frequency. | | 8 | S | SI.II.2.b | |
| 2.10 | | Blockages | Composite: mentioned as a problem by superintendent and described based on spatial extent, severity, and frequency. | | 8 | S | SI.II.2.b | |
| 2.11 | | Inadequate control structures | Composite: mentioned as a problem by superintendent and described based on spatial extent, severity, and frequency. | | 8 | S | SI.II.2.b | |
| 2.12 | | Inadequate head or pressure | Composite: mentioned as a problem by superintendent and described based on spatial extent, severity, and frequency. | Indicator can represent problems with distribution uniformity or management. | 14 | S | SI.II.3.ii | The level of impact of farming operations that resulted from problems was not identified or quantified. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2.13 | Field Distribution and Application | Water quality | Composite: mentioned as a problem by superintendent and described based on spatial extent, severity, and frequency. | | 14 | S | SI.II.3.ii | |
| 2.14 | | Leaks | Composite: mentioned as a problem by superintendent and described based on spatial extent, severity, and frequency. | | 14 | S | SI.II.3.ii | |
| 2.15 | | Inadequate control of water flows | Composite: mentioned as a problem by superintendent and described based on spatial extent, severity, and frequency. | Indicator measures water transport through system and to the farm. | 14 | S | SI.II.3.ii | |
| 2.16 | | Inadequate water storage | Composite: mentioned as a problem by superintendent and described based on spatial extent, severity, and frequency. | | 14 | S | SI.II.3.ii | |
| 2.17 | Accuracy of farm water supply | | Percent of time farmer receive adequate water to farm for crops. | Indicator is a measure of effective water control and the ability to control water delivery within system. | Time is expressed annually and adequate water can be defined as no water deficits for on-farm needs.<br>6 | I | F.I.1 | Indicator is based on individual farmers needs and might not be reflective of the systems ability to deliver water. Indicator did not taken into account adequate water pressure for on-farm delivery. |
| **LAND RESOURCES** | | | | | | | | |
| 3.1 | % Irrigable area | | Percent of land in | Measures the | Percent of land is defined in | I | G | Climatic conditions |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | rate prime ag. land | irrigable area that is classified under LCC as prime ag. land, being classes I or class II under nonirrigated conditions. | capacity of the soil to produce a specific crop as well as indicator of good soil health and fertility. | acres only within the irrigable area or that which is currently using ag. irrigation water. Prime ag. land is considered any land that is classified class I or II under LCC (see below). 5, 10, 12, 13 | | | are not taken into account and might affect type of crops produced. Also, management practices were not incorporated into indicator measure. |
| 3.2 | % Irrigable acres by LCC | Percent of land in irrigable area that is ranked class I, II, III, or IV under nonirrigated conditions. | Indication of current land that is suitable for cultivation. | Percent of land is defined in acres only within the irrigable area or land currently using ag. irrigation water. LCC is defined by the NRCS as follows: class I- soils having few limitations for cultivation, class II-soils having some limitations, class III-soil has severe limitations, and class IV-soils having very severe limitations for cultivation. 5, 10, 13 | I | G | LCC is the broadest category in land capability classification system. Class codes can be used to assess both irrigated and nonirrigated land. Indicator is only relevant to present conditions since farm management can alter classification. |
| 3.3 | Ratio LCC for irrigated: nonirrigated conditions (where available) | Ratio of LCC by class under irrigated and nonirrigated conditions. | Indicator denotes the level of improvement in soil fertility from irrigation. | Indicator assumes under irrigation conditions there will be a change in class structure, which is described above. | I | G | Data is severely limited for Hawaii's LCC under irrigated conditions and reliability of data is questionable. |
| 3.4 | Crop demand for irrigation water | Estimated water requirement for a reference crop averaged over one year. | Indicator measures potential benefits from irrigation and evaluates water management for system. | Computation of irrigated demand for crop is based upon a water balance and is specific to that crop. | S | O | Value is estimated and will vary among crops. |
| 3.5 | Erosion | Composite: level of soil | A level of erosion | Identification of a problem | S | SI.III.1 | Impacts of erosion |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | erodiblity based on spatial extent, severity, and frequency. | experience on the farm that is above normal. Erosion is problematic for farmers because too much erosion can cause increase stream sediment loads, fill reservoirs and reduce storage capacity, and reduce soil fertility. | area such as that described in the definition can enable farmers and managers to react to rectify the situation. 13 | | F.II.1 | can be mitigated by farmer practice and through BMP implementation. |
| 3.6 | Drainage | | Composite: problems with natural or artificial removal water from a given area and described based on spatial extent, severity, and frequency. | Many agricultural soils need drainage to improve production or to manage water supplies. | Identification of a problem area such as that described in the definition can enable farmers and managers to react to rectify the situation. | S | SI.III.1<br>F.II.1 | The degree of impact of the indicator is related to seasonal and climatic factors. |
| **NON-AG. RELATIONSHIPS** | | | | | | | | |
| 4.1 | Site Location: System | Farm thefts | Composite: thefts were rated by system superintendent based on spatial extent, severity and frequency. | Problem could hinder crop production. | Identification of a problem area such as that described in the definition can enable farmers and managers to react to rectify the situation. | S | SI.VII.1 | Indicator is dynamic and based on present conditions. |
| 4.2 | | Vandalism | Composite: rated by system superintendent based on spatial extent | Losses from theft and vandalism can lead to decline in farm land and desire to farm. | | S | SI.VII.1 | |
| 4.3 | | Trespassing | Composite: rated by system superintendent based on spatial extent | | | S | SI.VII.1 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 4.4 | | Neighbor complaints | Composite: rated by system superintendent based on spatial extent | | | S | SI.VII.1 | |
| 4.5 | | Lack of Communicatio n | Composite: rated by system superintendent based on spatial extent | | | S | SI.VII.1 | |
| 4.6 | Prospect for Ag. in future | | Average rating on the likelihood of agriculture to continue for the next 25 years | Indicator of encroachment into agricultural lands. | Likelihood is the hypothetical probability that agriculture would exist in a specific area in 2030 and was denoted qualitatively. Typically likelihood is a function that predicts a future specific outcome. 1, 12, 13 | F | SI.VII.2.b F.IV.1.c | Likelihood is a mathematical function that is commonly expressed quantitatively. |
| 4.7 | Future Irrigated Area | | Rating based on percent service area in ag. at 2030 | Indicator of development pressure | Service area is the area shaded pink on maps and is a physical land unit in acres that water from the irrigation system can be delivered. 13 | S | SI.VII.2.c | Indicator is dynamic and based on present conditions. |
| 4.8 | Future Farm Area | | Average farmer rating based on percent of individual farm area remaining in ag. by the year 2030. | The presence of viable farms has an effect on the demographics and economy of the local community. | Farm area is expressed as land that is used for crop production and includes cultivated or uncultivated land. 13 | F | F.IV.1.d | Farm area is estimated from farmers' views. |
| 4.9 | Community commitment to ag. | | Average farmer rating on strength of commitment. | Indicator relates to the role and perception of farming in the wider community and can place significant pressure on the farming community. | 3, 16 | N | F.III.6 | Sample size of farmers differs among systems and is relatively small. |

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|---|---|---|---|---|---|---|---|---|
| | | | | Indicator denotes common interest and/or dedication to continuing agriculture in the future. | | | | |
| 4.10 | Farm Site Problems | Farm thefts | Composite: % farmers reporting widespread, average rating for severity and frequency. | Losses from theft and vandalism can lead to decline in farm land and desire to farm. | | N | F.IV.1.a | |
| 4.11 | | Vandalism | Composite: % farmers reporting widespread, average rating for severity and frequency. | Losses from theft and vandalism can lead to decline in farm land and desire to farm. | | N | F.IV.1.a | |
| 4.12 | | Trespassing | Composite: % farmers reporting widespread, average rating for severity and frequency. | | | N | F.IV.1.a | |
| 4.13 | | Neighbor Complaints | Composite: % farmers reporting widespread, average rating for severity and frequency. | If complaints are received by the government, an abatement notice can be issued to the farm and operations may cease. Conditions imposed by these constraints reflect public concerns. | | N | F.IV.1.a | The number of formal complaints made by community members was not counted. |
| 4.14 | | Lack of communicatio n and awareness | Composite: % farmers reporting widespread, average rating for severity and frequency. | | | N | F.IV.1.a | |
| **CURRENT SYSTEM MGT. & SYSTEM PERFORMANCE** | | | | | | | | |
| 5.1 | Quantitative | | Water quantity in | Indicator allows for | Water could be measured at | F | SI.II.3.iii | Indicator does not |

| | | | | | | | | |
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| | | recorded water measures at farm level | million gallons per day delivered on-farm and measured by gauge or valve. | increase in operational efficiency and for optimizing the allocation of water among crops. | individual farm, at the intake, at the pump, or at a cross section of irrigation system.<br>12, 16 | | | measure benefits obtained from any reallocation or fulfilling water requirements. |
| 5.2 | | Written seasonal plan for water allocation and delivery | A positive or negative response to a formal documented water plan with a given timeframe. | Indicator of system organization and preparedness as well as water resource planning. | Timeframes could be daily, weekly, monthly, or seasonal but must be recorded and documented. The plan must be more than oral communication between farmers and superintendent. | S | SI.IV.3 | Accurate records and data was not kept and no formal plans existed. |
| 5.3 | | Degree of involvement by farmer advisory group | Average farmer positive or negative response for active involvement in an advisory group | Indicator of communication between levels and management responsibilities. | The degree of involvement denotes the amount of water advice available to farmers and whether involvement is irregular, or formal.<br>3 | F | F.I.6 | Indicator is dynamic and only reflect present conditions. |
| 5.4 | System Mgt. Problems (excludes financial) | Staff turnover | Composite: superintendent response based on spatial extent, severity, and frequency | Labor is a resource that is associated with ag. and is one of the major inputs into the system. If problems exist, then operation can be limited or even stop completely. | 7, 15 | S | SI.V.1 | System management problems have intensified in recent years and could only become worse. |
| 5.5 | | Inadequate skilled staff | Composite: superintendent response based on spatial extent, severity, and frequency | | 7, 15 | S | SI.V.1 | |
| 5.6 | | Inadequate equipment | Composite: superintendent response based on spatial extent, severity, and frequency | | | | | |

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| 5.7 | Lack of cooperation by irrigators | Composite: superintendent response based on spatial extent, severity, and frequency | | 7, 15 | S | SI.V.1 | |
| 5.8 | Fair equitable water distribution | Average farmer response that all rights of all water users are being met | Indicator a measure of competition for surface water rights. | Water rights can be defined by law.<br>6, 16, 18 | S | F.I.2 | Indicator based on farmer's views of equity. Indicator remains qualitative due to small farmer sample size. |
| 5.9 | Response mgt. | Average farmer response that managers react quickly to system problems or farmer's needs | Indicator shows flexibility and if system is able to adjust to problems. | Indicator reflects current management of system.<br>3 | S | F.I.3 | No accountability in response was identified. |
| 5.10 | Customer service | Average farmer rating for satisfaction | Indicator of efficiency and reliability and explains how management of system deals with inquiries and complaints | Customer service was rated as very good, good, fairly good, not so good and bad.<br>3 | S | F.I.4 | Customer service never defined and response subjective. |
| 5.8 | Water user org. and membership in org. | Average farmer response for an organization existence and presence in community. | Indicator is a measure of farmer organization and structure and communication facilitation at all system levels. | Existence of organization is denoted by a farmer positive response on survey.<br>1 | F | F.I.5<br>F.I.6 | Level of involvement addressed by separate indicator. |
| 5.9 | Other org. for irrigations | Average farmer response that an alternative organization that represents farmers to the irrigation system management and help solve irrigation | Indicator is a measure of farmer organization and structure and communication facilitation at all system levels. | Organizations such as farmer co-operatives would be included in this indicator. | F | F.I.7 | |

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| | | problems exists. | | | | | |
| 5.10 | O&M budget/cultivated area | Average annual amount of money ($) that is spent for operation and maintenance per cultivate system acres | Indicator reflects that following factors economic growth, the availability and quality of services, and the infrastructure of the wider community. | Indicator measures the progress towards maximizing net profit over the long term and is a proxy for economic viability for crop production.<br>1, 12 | S | SI.IV.6.a, G | No budget was stated that would be required for preventative management |
| 5.11 | O&M budget/irrigable area | Average amount of money ($) that is spent for operation and maintenance per irrigable system acres | Indicator reflects that following factors economic growth, the availability and quality of services, and the infrastructure of the wider community. | Indicator measures the progress towards maximizing net profit over the long term and is a proxy for economic viability for the entire irrigation service area.<br>1, 12 | I | SI.IV.6a, G | No budget was stated that would be required for optimal efficiency. |
| 5.12 | System Improvement | Major capital improvements implemented in recent (5-10) yrs. | Indicator denotes level of investment and priority of management. | Major capital improvements include large structures, budget, contractor or replacement of infrastructure or improvements outside O&M budget.<br>14 | S | SI.IV.6.b<br>SI.VI.2 | Indicator not defined in monetary terms due to scale of system and incomplete answers. |
| 5.13 | Financial Security | Composite: adequacy of financial resources for system for spatial extent, severity, frequency. | Indicator is a measure of investment into system operations and O&M. | Adequacy of funds is meeting selected or all priority budget items. It includes anything that exceeds meeting only major capital improvements. Problems were described based on spatial extent, | S | SI.V. | Biases may be present since asked superintendent of system. |

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| | | | | severity, and frequency.<br>2, 11 | | | |
| **CURRENT FARM INFRASTRUCTURE AND INSTITUTIONS** | | | | | | | |
| 6.1 | Farmstead Development | % service area with lots & boundaries. | Indicator shows the amount invested into land resources. | Indicator denotes how much the land has been subdivided. | S | SI.VI.1 | |
| 6.2 | Security of Land Tenure | % of farmers that owns farm or have long term private leases or a government lease. | If problems exist with capturing secure land, then the future of agriculture for that area is questionable. | Long-term means greater than 10 years and government agencies include HDOA, ADC, DLNR, Maui Co., HI homelands.<br>2, 9 | F | F.III.1 | Small sample size. |
| 6.3 | Transportation | Average farmer rating for transportation services and road availability, accessibility, and condition. | Measures the ease in shipping inter-island as well as the ease in exporting.<br>Indicator that travel to and from market and shipping ports is adequate for farmers' needs. | An improved highway system can reduce the farmers' cost of acquiring production inputs and of transporting outputs to the market<br>9, 12 | S | F.III.2<br>F.III.3 | |
| 6.4 | Degree or extent of farm security for the irrigation system | Average rating for farmers based on area in percent that is secure | Losses from theft and vandalism can lead to decline in farm land and desire to farm. | Indicator describes fencing and other security measures including community measures taken that were described from the farmer questionnaire. | S | F.III.4<br>F.III.5 | Significant loss and economic viability not quantified. |
| 6.5 | Export Sales | Average rating for farmers that export from HI | Indicator of market potential and expansions since the HI market is limited. | Average rating is based on a percent and exports include international as well as shipments made to the mainland. | F | F.IV.2.a | |
| 6.6 | Input marketing problems | Composite: lack of nearby stores, reliability of input supplies, high | Problems with procuring farm inputs that relate to | Identification of a problem area such as that described in the definition can enable | F | F.IV.2.b | |

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|---|---|---|---|---|---|---|---|
| | | costs, and few dealers ratings | fertilizer and equipment or other supplies | farmers and managers to react to rectify the situation. | | | |
| 6.7 | Output marketing problems | Composite: inadequate road transportation to main hub, shipping facilities/service from hub, high costs for transport, lack of local outlets/buyers, and poor telecommunication or infrastructure services ratings | | Identification of a problem area such as that described in the definition can enable farmers and managers to react to rectify the situation. | F | F.IV.2.c | |
| 6.8 | Alternative water supply | Average number of farmers with other water sources that can provide water to crops in service area. | Indicator denotes the ability of farmer to supply excess water to crops to continue production. | Location of water supply has to be available in the area and can be accessed by individual farm, such as groundwater wells or non-system county water supply. | S | | Self-reporting, information was not specifically collected. |
| 6.9 | Native HI Farmsteads | % Service area in HI home land | Indicator is a proxy for security of land tenure and fulfills policy requirements for indigenous ag. development. | | S | G | |
| 6.10 | Land claims, deeds, or restrictions | Composite: superintendent response on spatial extent, severity, and frequency | | 2 | F | SI.III.2 | |
| **ENVIRONMENTAL PROBLEMS AND LIMITATIONS** | | | | | | | |
| 7.1 | System: Water quality or pollution | Composite: superintendent's response on spatial extent, severity, and frequency. | | Identification of a problem area such as that described in the definition can enable farmers and managers to react to rectify the situation. 16 | S | SI.III.1 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 7.2 | | Pre-existing water rights | Composite: superintendent's response on spatial extent, severity, and frequency. | | 16 | S | SI.III.1 | |
| 7.3 | System Farm Related Problems | Air quality | Composite: superintendent's response on spatial extent, severity, and frequency. | | Identification of a problem area such as that described in the definition can enable farmers and managers to react to rectify the situation. 16 | S | SI.III.2 | |
| 7.4 | | Endangered species | Composite: superintendent's response on spatial extent, severity, and frequency. | | 16 | S | SI.III.2 | |
| 7.5 | | Invasive species | Composite: superintendent's response on spatial extent, severity, and frequency. | | 16 | S | SI.III.2 | |
| 7.6 | | Land claim limitations | Composite: superintendent's response on spatial extent, severity, and frequency. | | 16 | S | SI.III.2 | |
| 7.7 | Farmer (Perceived) Environ. | Water quality or pollution | Composite: % farmers reporting widespread, average rating for severity and frequency. | | Identification of a problem area such as that described in the definition can enable farmers and managers to react to rectify the situation. 16 | F | F.II.1 | |
| 7.8 | | Pre-existing water rights | Composite: % farmers reporting widespread, average rating for severity and frequency. | | 16 | F | F.II.1 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 7.9 | Farmer Farm Related problems | Air quality | Composite: % farmers reporting widespread, average rating for severity and frequency. | | 5, 16 | F | F.II.2 | |
| 7.10 | | Endangered species | Composite: % farmers reporting widespread, average rating for severity and frequency. | | 5, 16 | F | F.II.2 | |
| 7.11 | | Invasive species | Composite: % farmers reporting widespread, average rating for severity and frequency. | | 5, 16 | F | F.II.2 | |
| 7.12 | | Land claim limitations | Composite: % farmers reporting widespread, average rating for severity and frequency. | | 5, 16 | F | F.II.2 | |

**Legends:**

**Geographic Scale**

S-entire irrigation system can include physical and nonphysical (such as number of intakes) scales
I-physical land unit relating to irrigable acres in service area
F-physical unit for an individual farm and includes financial units and farming community social scale
N-nonagricultural community social scale

**Data Source**

G-information derived from GIS or other type of map
F-information derived from farmer survey questionnaire
SI-information derived from superintendent survey questionnaire
P-information derived from Agriculture Water Use Development Plan-Phase I
O-information derived from other source such as EIA/EIS, Watershed Plans, and Community Development Plans
P-information derived from Agriculture Water Use Development Plan-Phase I
O-information derived from other source such as EIA/EIS, Watershed Plans, and Community Development Plans

## 5-A Macroeconomic Delphi Survey

Panelists' names:

1. Paul H. Brewbaker (BOH)
2. Byron Gangnes (UHM)
3. Dr. Khem Sharma (DBEDT)
4. Dr. James Moncur (UHM)
5. Dr. Ilan Noy (UHM)
6. Dr. Marcia Sakai (UHH)

Fig. 5.A-1 Round 1 Questionnaire

# Developing Macroeconomic Scenarios for Hawaii's Agricultural Future Using the Delphi Survey Method: Round 1

**Introduction**

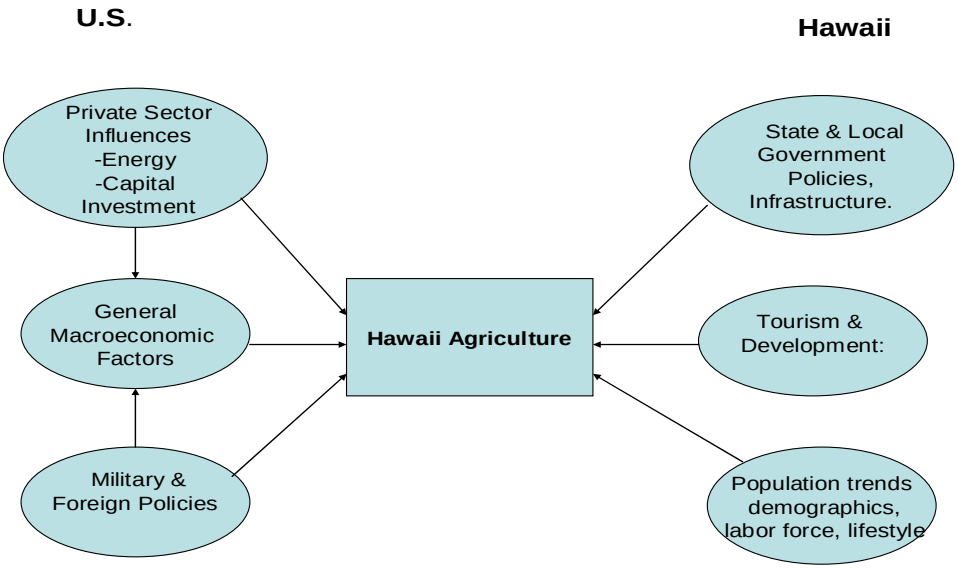
Thank you for your willingness to participate. The goal of this survey is to eventually arrive at different scenarios of agricultural growth rates that will influence the future demand for irrigation water. To begin we will determine the most important macroeconomic factors that impact the performance of Hawaii's agricultural economy. We will be using the Delphi technique to accomplish this goal. The Delphi survey will be conducted entirely via e-mail and will take about 15-20 minutes per round to answer. Depending on how quickly we get to a consensus, the Delphi exercise will consist of about five rounds. Instructions will be provided at the beginning of each round as to how to go about completing each exercise. Since the Delphi methodology involves a number of iterations with feedback of all responses, Round 1 is to get you to identify what the important economic drivers are that will influence Hawaii's agricultural future. Lastly, in regard to your responses, complete anonymity will be maintained with only the summary of the responses fed-back to the panelists.

We ask that you please return your completed Round 1 survey by or before **Thursday, June 8**, by e-mailing the attached .doc file to: rchesler@hawaii.edu. Mahalo!

**Round 1:**

The figure below shows the relationships between important macroeconomic factors that affect Hawaii's agricultural economy. Please review the diagram below and provide any feedback you have in the comment box below.

**Figure 1: Relationship between Important Macroeconomic Factors that Affect the Future Supply and Demand of Hawaii Agricultural Products**




Comments for Figure 1:

The following exercise attempts to identify the key macroeconomic factors and how they impact Hawaii's agriculture. There are six major categories of factors, and for each category there are various factors which we consider important. The factors and a description of how they may affect the economy are provided. Please rate the importance of these factors by typing an '**X**' in the box which corresponds to your choice. A comment box has been provided at the end of each category. Please address any factors that may have been omitted under each category or describe how the factors affect the economy in a way you regard as more appropriate. Please indicate your comments for each factor by matching them with the same numbering in the comment box provided. For example if you disagree with the factor, "Distribution/equality of income" as being a very important factor then please provide your comment next to the space provided for "I.1 Distribution/equality of income."

## I. U.S. Macroeconomic Indicators Affecting Hawaii's Agriculture

| **Factors** | | **Very Important** | **Important** | **Somewhat Important** | **Not Important** | **Undecided** |
|---|---|---|---|---|---|---|
| | | **Please type an 'X' in the box corresponding to your choice** | | | | |
| | *Distribution/ equality of income*: Widening or narrowing gap between the upper and lower **income** groups and a concentration of wealth will affect the consumption and expenditure trend. | | | | | |
| | *GDP*: GDP growth rate will impact the State's economy. | | | | | |
| | *Per-capita income*: Changes in the **per-capita income** will affect tourist dollars spent in Hawaii, resulting in a higher ***per-capita income*** for Hawaii. | | | | | |
| | *Interest rates:* Level of Interest **rates** set by the Federal Reserve will impact banks' lending policy. | | | | | |
| | *Value of U.S. dollar*: Strength of the **U.S. dollar** versus foreign currencies, such as the yen, will influence Hawaii's economic growth. | | | | | |
| | *Federal government fiscal policy*: Expansionary and contractionary **fiscal policy** may impact the rate of inflation, employment etc. | | | | | |

## II. US Military and Foreign Policy

| **Comment:** |
|---|
| **I.1** *Distribution/ equality of income:* |
| **I.2** *GDP:* |
| **I.3** *Per-capita:* |
| **I.4** *Interest rates:* |
| **I.5** *U.S. dollar value:* |
| **I.6** *Fiscal policy:* |

| **Factors** | **Very Important** | **Important** | **Somewhat Important** | **Not Important** | **Undecided** |
|---|---|---|---|---|---|
| | **Please type an 'X' in the box corresponding to your choice** | | | | |
| **1.** *Military presence in the Pacific Basin and Asia:* Changing **military presence in the Pacific Basin and Asia** will impact Hawaii's economy. | | | | | |
| **2.** *Military expansion*: **Military expansion** would impact government expenditure and employment opportunities. | | | | | |
| **3.** *Ally relationships*: Strategic ***a*lly relationships** with Japan, South Korea and others will influence trade flow and stabilize national security. | | | | | |
| **4.** *Terrorist attack (I):* A **terrorist attack** on a U.S. military base in Hawaii might lead to an increase in defense spending for Hawaii. | | | | | |
| **5.** *Terrorist attack (II):* A **terrorist attack** would also have negative implications for the tourism industry in Hawaii. | | | | | |

| **Comment:** |
|---|
| **II.1** *Military presence in Pacific Basin***:** |
| **II.2** *Military expansion:* |
| **II.3** *Ally relationship:* |
| **II.4** *Terrorist attack I:* |
| **II.5** *Terrorist attack II:* |

### III. Rest of (U.S.) Private Economy (including energy and capital)

| **Factors** | **Very Important** | **Important** | **Somewhat Important** | **Not Important** | **Undecided** |
|---|---|---|---|---|---|
| | **Please type an 'X' in the box corresponding to your choice** | | | | |
| **1.** *Capital Investment*: Changes in capital **investment** inflows will affect Hawaii's economy. | | | | | |
| **2.** *Price of oil:* The **price of oil** will continue to impact the economy. | | | | | |
| **3.** *Renewable energy technology, government policies*: Introduction of new policies encouraging **renewable energy** supply will enhance economic growth and development. | | | | | |
| **4.** *Outsourcing**:*** **Outsourcing** of service business enterprises will affect employment opportunities in Hawaii. | | | | | |

| |
|---|
| **Comment:** |
| **III.1** *Capital investment*: |
| **III.2** *Price of oil:* |
| **III.3** *Renewable energy:* |
| **III.4** *Outsourcing:* |

## IV. Hawaii Population, Demographics, Labor Force, Lifestyle

| **Factors** | **Very Important** | **Important** | **Somewhat Important** | **Not Important** | **Undecided** |
|---|---|---|---|---|---|
| | **Please type an 'X' in the box corresponding to your choice** | | | | |
| **1.** *Population Growth*: Changes in **population growth** in Hawaii will affect employment and consumption. | | | | | |
| **2.** *Aging resident population/emigration*: **Emigration** of young population and increase in the aging population will impact labor availability. | | | | | |
| **3.** *Labor Force:* Greater need for skilled **labor** might increase demand for mainland and foreign labor. | | | | | |
| **4.** *Cost of Living & Housing*: **The cost of housing** will impact the **cost of living**. | | | | | |
| **5.** *Part-time vs. full-time labor*: Changes in part–time **labor vs. full-time labor** will affect productivity. | | | | | |
| **6.** *Social Security*: Increased age limit for **social security** could impact labor supply and quality. | | | | | |
| **7.** *Unions:* Strength of the **unions** will play an important role in the productivity of the labor force. | | | | | |

| **Comment:** |
|---|
| **IV.1** *Population growth*: |
| **IV.2** *Aging resident population/emigration*: |
| **IV.3** *Labor force:* |
| **IV.4** *Cost of living and housing:* |
| **IV.5** *Part-time vs. full-time labor:* |
| **IV.6** *Social security:* |
| **IV.7** *Unions:* |

## V. Hawaii Tourism and Development

| **Factors** | **Very Important** | **Important** | **Somewhat Important** | **Not Important** | **Undecided** |
|---|---|---|---|---|---|
| | **Please type an 'X' in the box corresponding to your choice** | | | | |
| **1.** *Visitors:* Changes in number of **visitors** to Hawaii will impact the economy. | | | | | |
| **2.** *Air service*: Improved **air service** will bring about a boom in the tourism industry causing a positive impact on the economy. | | | | | |
| **3.** *Sun-and-fun tourism*: Changes in demand for other **types of tourism** will impact Hawaii's economy. | | | | | |
| **4.** *Cruise lines:* **Cruise lines** will play a crucial role in the tourism industry. | | | | | |
| ***5.*** *Aloha spirit:* Change in **aloha spirit** will impact the tourism industry in Hawaii. | | | | | |
| **6.** *Development regulations and costs (price of land, zoning, impact fees):* Changing **development regulations** and zoning laws may make Hawaii either less or more desirable for developers. | | | | | |
| **7.** *Development of high-tech industries (e.g. computer-related, ocean technology, health/medical, and biotechnology):* Development of **high-tech industries** will impact the economy. | | | | | |

| |
|---|
| **Comment:** |
| **V.1** *Visitors:* |
| **V.2** *Air service*: |

| |
|---|
| **V.3** *Sun-and-fun tourism*: |
| **V.4** *Cruise lines:* |
| **V.5** *Aloha spirit:* |
| **V.6** *Development regulations and costs (price of land, zoning, impact fees):* |
| **V.7** *Development of high-tech industries (e.g. computer-related, ocean technology, health/medical, and biotechnology):* |

**VI) State & Local Government, Policies, Infrastructure**

| **Factors** | **Very Important** | **Important** | **Somewhat Important** | **Not Important** | **Undecided** |
|---|---|---|---|---|---|
| | **Please type an 'X' in the box corresponding to your choice** | | | | |
| **1.** *Roads, seaports, airports and monorail:* Future investments on transportation infrastructure such as **roads, airports, ports and monorail** will enhance economic growth. | | | | | |
| **2.** *Water delivery system, sewage system:* Better infrastructure facilities such as | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| improved **water delivery systems, sewage systems,** will enhance economic growth. | | | | | |
| **3.** *Taxes and revenues:* Changes in **income, sales, property, corporate taxes, and revenues** will impact economic growth. | | | | | |
| **4.** *Electricity:* Low dependency on **electricity** due to technological advances will impact the economy. | | | | | |
| ***5.*** *Communication infrastructure:* Improvements in **communication infrastructure** would improve efficiency and impact Hawaii's economic growth. | | | | | |
| **6.** *Overall government spending and debt:* Changes in spending and deficit would impact inflation rate. | | | | | |
| **7.** *Native Hawaiian sovereignty:* Passing of the Akaka Bill will have an impact on the economy. | | | | | |
| **8.** *Political culture/climate:* Change in political party leadership will impact government policy which in turn will impact the economy. | | | | | |

| **Comment:** |
|---|
| **VI.1** *Roads, seaports, airports and monorail:* |
| **VI.2** *Water delivery systems, sewage systems:* |
| **VI.3** *Taxes and revenues:* |
| **VI.4** *Electricity:* |
| **VI.5** *Communication infrastructure:* |
| **VI.6** *Overall government spending and debt:* |
| **VI.7** *Native Hawaiian sovereignty:* |
| **VI.8** *Political culture/climate:* |

This concludes Round 1. Please send your completed survey to Rick Chesler at the following e-mail address: rchesler@hawaii.edu.

**Round 2 will begin on Friday, June 9.**

# Mahalo for your participation!

Fig. 5.A-2 Round 2 Questionnaire

NOTE: The Round 2 Appendix is not included here for the sake of brevity. The complete Round 2 questionnaire, including its appendix is available on the CD-ROM accompanying this report ("Macro Delphi Round 2.doc").

**DEVELOPING MACROECONOMIC SCENARIOS FOR HAWAII'S AGRICULTURAL FUTURE: ROUND 2**

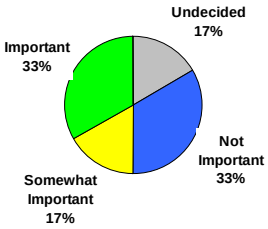
Thank you for your prompt response to Round 1. The purpose of Round 2 is for you to reassess your responses based on the panel results from Round 1. The results from Round 1 are summarized below as pie-charts showing the frequency distribution in terms of the percentage of panelists who selected Very Important, Important, etc. for each factor.

Note: Selected comments from panelists are presented in the appendix at the end of this document. Click the provided links to jump directly to comments for a specific factor. (To use the links it's necessary to hold down the Ctrl key and then left mouse-click). Some comments have been edited or paraphrased for clarity. After reading any comments from the other panelists and viewing the panel results (pie-charts), please re-vote for that factor by typing an 'X' in the box corresponding to your choice. Use View→Zoom to increase font size for easier viewing if necessary.

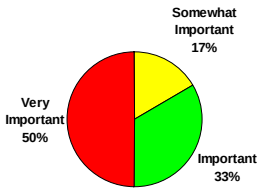
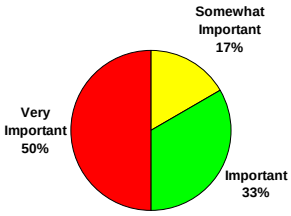
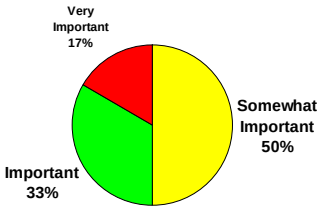
Please return your completed Round 2 survey to rchesler@hawaii.edu by or before Tuesday, June 20. (The sooner they are completed, the sooner we are able to advance to the next round).

**Results from Round 1 of Delphi Survey:**

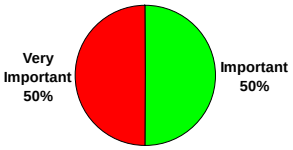
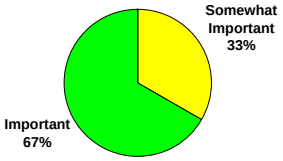
**I) U.S. Macroeconomic Indicators Affecting Hawaii's Agriculture**

| **Panel Response for Round 1** | **Factors** | **Very Important** | **Important** | **Somewhat Important** | **Not Important** | **Undecided** |
|---|---|---|---|---|---|---|
| | | **Please type an 'X' in the box corresponding to your choice** | | | | |
|  | **DISTRIBUTION/ EQUALITY OF INCOME**: Widening or narrowing gap between the upper and lower **income** groups and a concentration of wealth will affect the consumption and expenditure trend. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |

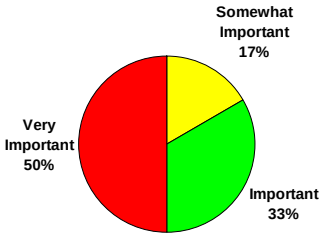
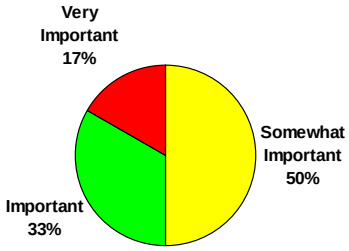
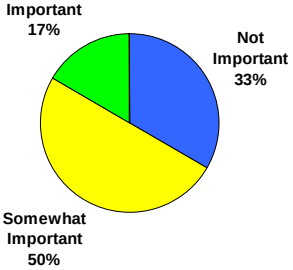
**I) US Macroeconomic Indicators Affecting Hawaii's Agriculture (Continued)**

| **Panel Response for Round 1** | **Factors** | **Very Important** | **Important** | **Somewhat Important** | **Not Important** | **Undecided** |
|---|---|---|---|---|---|---|
|  | *GDP*: GDP growth rate will impact the State's economy. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |
|  | *Per-capita income*: Changes in the **per capita income**, will affect tourist dollars spent in Hawaii, resulting in a higher ***per capita income*** for Hawaii. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |
|  | *Interest rates: Level of Interest* **rates** set by the Federal Reserve will impact banks' lending policy. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |

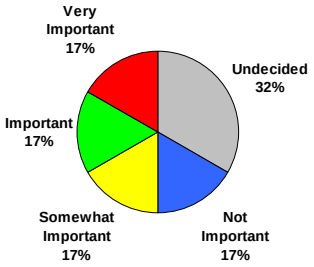
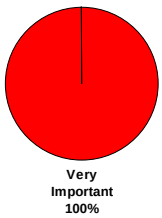
## I) US Macroeconomic Indicators Affecting Hawaii's Agriculture (Continued)

| Panel Response for Round 1 | Factors | Very Important | Important | Somewhat Important | Not Important | Undecided |
|---|---|---|---|---|---|---|
|  | *Value of U.S. dollar*: Strength of the **U.S. dollar** versus foreign currencies, such as the yen, will influence Hawaii's economic growth. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |
|  | *Federal government fiscal policy*: Expansionary and contractionary **fiscal policy** may impact the rate of inflation, employment etc. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |

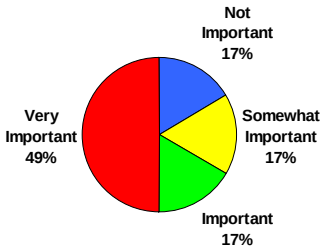
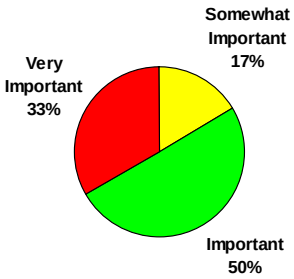
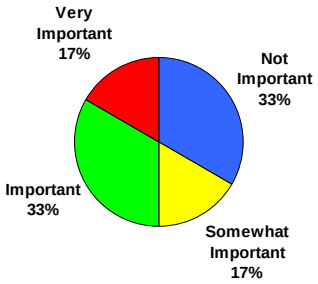
## II. US Military and Foreign Policy

| Panel Response from Round 1 | Factors | Very Important | Important | Somewhat Important | Not Important | Undecided |
|---|---|---|---|---|---|---|
| | | Please type an 'X' in the box corresponding to your choice | | | | |
|  | *Military presence in the Pacific Basin and Asia: Changing* **Military presence in the Pacific Basin and Asia** will impact Hawaii's economy. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |
|  | *Military expansion*: **Military expansion** would impact government expenses and employment opportunities. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |
|  | *Ally relationships: Strategic* ***a*lly relationships** with Japan, South Korea and others will influence trade flow and stabilize national security. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |

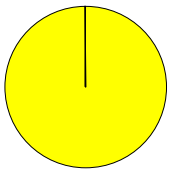
**II. US Military and Foreign Policy (Continued)**

| Panel Response from Round 1 | Factors | Very Important | Important | Somewhat Important | Not Important | Undecided |
|---|---|---|---|---|---|---|
|  | *Terrorist attack (I):* A **terrorist attack** on a U.S. military base in Hawaii, would lead to an increase in defense spending for Hawaii. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |
|  | *Terrorist attack (II):* A **terrorist attack** would also have negative implications for the tourism industry in Hawaii. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |

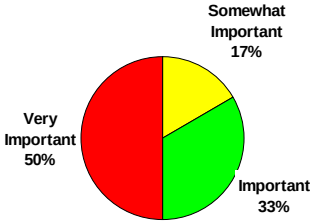
**III. Rest of (US) Private Economy (including construction, energy)**

| Panel Response from Round 1 | Factors | Very Important | Important | Somewhat Important | Not Important | Undecided |
|---|---|---|---|---|---|---|
|  | *Capital Investment*: Changes in capital **investment** inflows will affect Hawaii's economy. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |
|  | *Price of Oil:* The **price of oil** will continue to impact the economy. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |
|  | *Renewable energy technology, government policies*: Introduction of new policies encouraging **renewable energy** supply will result in better economic growth and development. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |

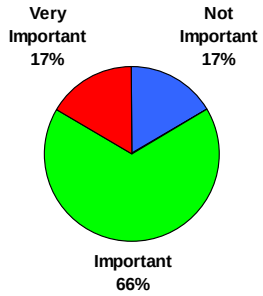
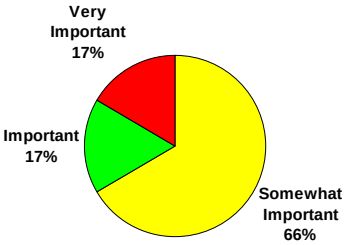
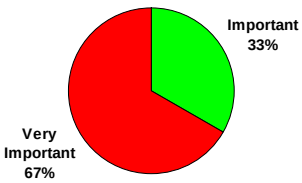
**III. Rest of (US) Private Economy (including construction, energy) (Continued)**

| Panel Response from Round 1 | Factors | Very Important | Important | Somewhat Important | Not Important | Undecided |
|---|---|---|---|---|---|---|
|   | *Outsourcing*: **Outsourcing** of service business enterprises will affect the types of employment opportunities in Hawaii. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |

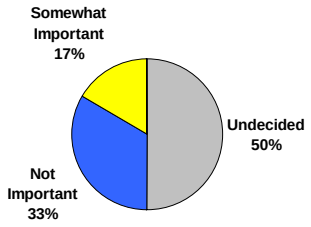
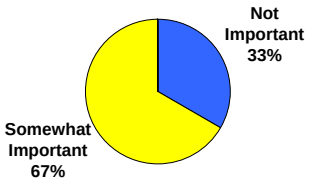
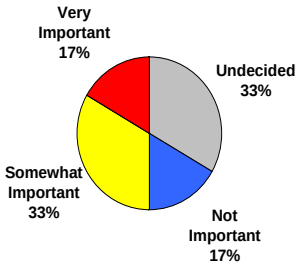
**IV. Hawaii Population, Demographics, Labor Force, Lifestyle**

| Panel Response from Round 1 | Factors | Very Important | Important | Somewhat Important | Not Important | Undecided |
|---|---|---|---|---|---|---|
| | | Please type an 'X' in the box corresponding to your choice | | | | |
|   | *Population Growth*: Changes in p**opulation growth** in Hawaii will affect employment and consumption. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |

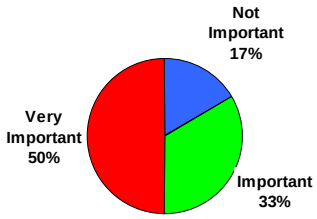
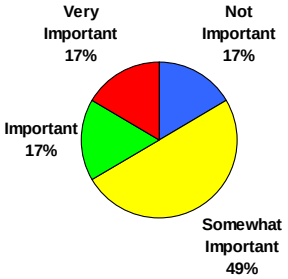
**IV. Hawaii Population, Demographics, Labor Force, Lifestyle (continued)**

| Panel Response from Round 1 | Factors | Very Important | Important | Somewhat Important | Not Important | Undecided |
|---|---|---|---|---|---|---|
|  | *Aging resident Population/ Emigration*: **Emigration** of young population will cause increase in the aging population which will impact labor availability. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |
|  | *Labor Force:* Greater need for skilled **labor** will put an increased demand on importing labor. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |
|  | *Cost of Living & Housing*: **The cost of housing** will impact the **cost of living**. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |

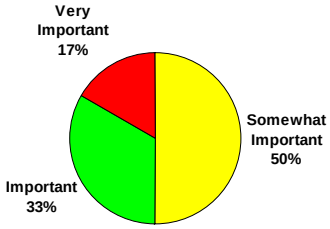
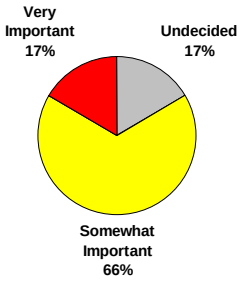
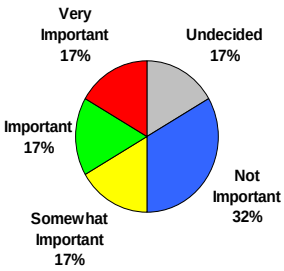
**IV. Hawaii Population, Demographics, Labor Force, Lifestyle (Continued)**

| Panel Response from Round 1 | Factors | Very Important | Important | Somewhat Important | Not Important | Undecided |
|---|---|---|---|---|---|---|
|  | *Part-time vs. full-time labor*: Changes in part–time **labor vs. full-time labor** will affect productivity. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |
|  | *Social Security*: Increased age limit for **social security** could impact labor supply and quality. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |
|  | *Unions**: Strength of the** Unions* will play an important role in the productivity of the labor force. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |

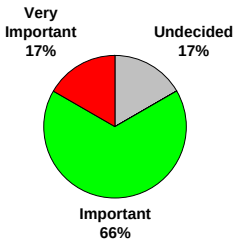
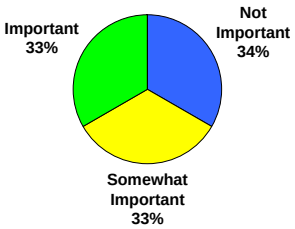
## V. Hawaii Tourism and Development

| Panel Response for Round 1 | Factors | Very Important | Important | Somewhat Important | Not Important | Undecided |
|---|---|---|---|---|---|---|
| | | Please type an 'X' in the box corresponding to your choice | | | | |
|  | *Visitors:* Changes in number of **visitors** to Hawaii will impact the economy. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |
|  | *Air service*: Improved **air service** will bring about a boom in the tourism industry causing a positive impact on the economy. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |

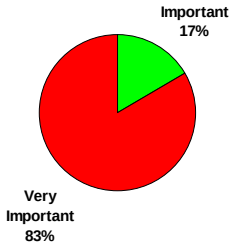
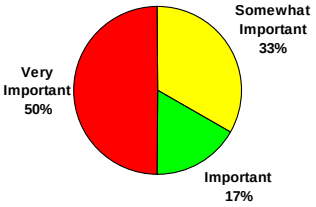
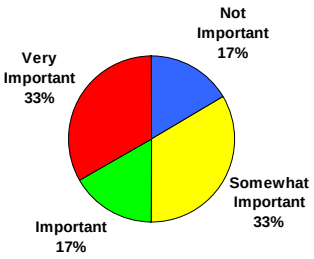
## V. Hawaii Tourism and Development (Continued)

| Panel Response for Round 1 | Factors | Very Important | Important | Somewhat Important | Not Important | Undecided |
|---|---|---|---|---|---|---|
|  | *Sun-and-fun tourism*: Changes in demand trend for **type of tourism** will impact Hawaii's economy. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |
|  | *Cruise lines:* **Cruise lines** will play a crucial role in the tourism industry. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |
|  | *Aloha spirit:* Change in **aloha spirit** will impact the tourism industry in Hawaii. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |

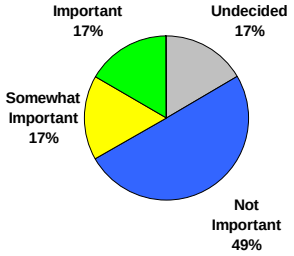
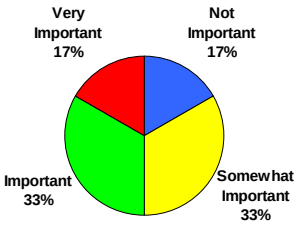
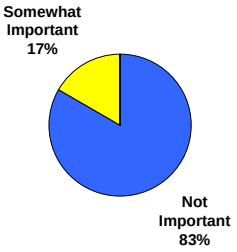
## V. Hawaii Tourism and Development (Continued)

| Panel Response for Round 1 | Factors | Very Important | Important | Somewhat Important | Not Important | Undecided |
|---|---|---|---|---|---|---|
|  | *Development regulations and costs (price of land, zoning, impact fees):* Changing **development regulations** and zoning laws may make Hawaii either less or more desirable for developers. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |
|  | *Development of high-tech industries (e.g. computer-related, ocean technology, health/medical, and biotechnology):* Development of **high-tech industries** will have an effect the strength of economy. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |

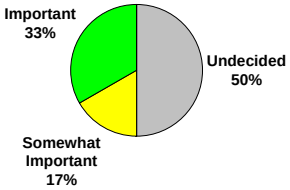
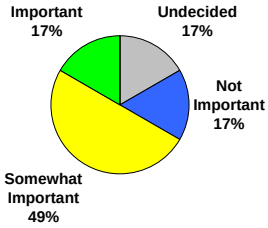
**VI. State & Local Government, Policies, Infrastructure**

| Panel Response for Round 1 | Factors | Very Important | Important | Somewhat Important | Not Important | Undecided |
|---|---|---|---|---|---|---|
|  | *Roads, seaports, airports and monorail:* Future investments on transportation infrastructure such as **roads, airports, ports and monorail** will enhance economic growth. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |
|  | *Water delivery system, sewage system:* Better infrastructure facilities such as improved **water delivery systems, sewage systems,** will enhance economic growth. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |
|  | *Taxes and revenues:* Changes in **income, sales, property, corporate taxes, and revenues** will impact economic growth. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |

**VI. State & Local Government, Policies, Infrastructure (Continued)**

| Panel Response for Round 1 | Factors | Very Important | Important | Somewhat Important | Not Important | Undecided |
|---|---|---|---|---|---|---|
|  | *Electricity:* Low dependency on **electricity** due to technological advances will impact economy. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |
|  | *Communication infrastructure:* Improvements in **communication infrastructure** would improve efficiency and impact Hawaii's economic growth. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |
|  | *Overall government spending and debt:* Changes in spending and deficit would impact inflation rate. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |

**VI. State & Local Government, Policies, Infrastructure (Continued)**

| Panel Response for Round 1 | Factors | Very Important | Important | Somewhat Important | Not Important | Undecided |
|---|---|---|---|---|---|---|
|  | *Native Hawaiian sovereignty:* Passing of the Akaka Bill will have an impact on the economy. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |
|  | *Political culture/climate:* Change in political party leadership will have an impact on the government policy which will impact the economy. | | | | | |
| | To see panelists' comments for this factor from round one, please click here | | | | | |
| | Comment space for this factor: | | | | | |

*With this we have come to the end of Round 2. Please send your responses to the following address: (rchesler@hawaii.edu) by or before Tuesday, June 20. Mahalo for your participation in the second round.*

Fig. 5.A-3 Round 3 Questionnaire
NOTE: The Round 3 Appendix is not included here for the sake of brevity. The complete Round 3 questionnaire, including its appendix is available on the CD-ROM accompanying this report ("Macro Delphi Round 3.doc").

**DEVELOPING SCENARIOS FOR HAWAII'S AGRICULTURAL FUTURE: ROUND 3**

Thank you for your prompt response to Round 2. The top ten most important macroeconomic factors, as voted by the panel in Rounds 1 and 2, have been determined. The purpose of Round 3 is for you to take these top ten factors and come up with linkages among the various factors that you think will affect the growth of Hawaii's agricultural sector. To get to the end point, there are three sequential steps we would like you to do: (I) determine whether each factor is a trend or an uncertainty (definitions below); (II) identify key descriptors for each factor and (III) express linkages, if any, among the various factors.

Please return your completed Round 3 survey to rchesler@hawaii.edu by or before **Thursday, July 6**. (The sooner they are completed, the sooner we are able to advance to the next round).

**Step I**: **Determine Whether a Factor is either a Trend or an Uncertainty**

**To create scenarios one determines the selected factors either as a trend or an uncertainty variable. A trend may be thought of as the most likely, or expected case, while an uncertainty is some thing or event that is inherently difficult to predict. In the table below we present the top ten macroeconomic factors selected by the panel from Rounds 1 and 2. Please indicate whether each factor should be considered either a trend or an uncertainty, both in the medium- and long-term (you will indicate your answers by typing two X's for each factor—one for medium-term and one for long-term). If a factor is a trend variable, please indicate whether the trend goes up, down, or stays the same (flat). If a factor is determined as an uncertainty, please indicate the degree of the uncertainty (low, medium, or high). Note that in some cases, the same factor may be a trend variable in the medium-term period and an uncertainty variable in the long-term period.**

If you wish to review the description for each factor (from Round 1), it is presented in the appendix at the end of this document. Click the provided hyperlinks to jump directly to the description for each specific factor. (To use the links it is necessary to hold down the Ctrl key and then left mouse-click).

A comment box has been placed below the table for you to write any comments associated with this exercise. For example, if you think that factor A in the long-term has a net upward trend, you might want to state in the comment box that the trend will first decline and then rise. In completing the table, however, we are interested only in the net result of the trend at the end of a given period (up, down, or flat).

:

Please place an "**X**" in the box that corresponds to your answer for both the medium- and long-term timeframes

| **Factor** | **Medium Term (Next 10 Years)** | | | | | | | **Long Term (next 25 years)** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Trend** | | | **Uncertainty** | | | | **Trend** | | | **Uncertainty** | | |
| | | | Down | Low | Medium | High | | Flat | Up | Down | Low | Medium | High |
| 1.a.* GDP | | | | | | | | | | | | | |
| 1.b.* Per-capita Income | | | | | | | | | | | | | |
| 2. US Dollar Values | | | | | | | | | | | | | |
| 3. Terrorist Attack | | | | | | | | | | | | | |
| 4. Capital Investment | | | | | | | | | | | | | |
| 5. Price of Oil | | | | | | | | | | | | | |
| 6. Population Growth | | | | | | | | | | | | | |
| 7. Cost Living & Housing | | | | | | | | | | | | | |
| 8. Visitors | | | | | | | | | | | | | |
| 9. Road, Seaport, Airport, and Monorail | | | | | | | | | | | | | |

* Because GDP and per capita income are highly correlated, we have combined them into a single factor.

*Comments:*

Factor 1:
Factor 2:
Factor 3:
Factor 4:
Factor 5:
Factor 6:
Factor 7:
Factor 8:
Factor 9:

**Step II**: **Development of Descriptors for 3 Scenarios of Hawaii Agricultural Growth**

**For each of the boxes below we are asking you to write brief descriptors for three forecasting scenarios (most likely, optimistic, and pessimistic) for each of the top ten macroeconomic factors selected by the panel from Rounds 1 and 2. Descriptors may be thought of as keywords or definitive characteristics, and may be expressed as words or phrases. Please type your descriptor(s) which best correspond to the most likely, optimistic, and pessimistic scenario for each factor.**

Using factor *Interest rate* (which was not selected as one of the top 10 factors) as an example, one might come up with the following descriptors:

**Box *x*: Interest rates**
Descriptor(s):
Most likely: stable

Optimistic: borrower's market

Pessimistic: almost prohibitively high

We suggest that you to begin with Box 10 (Hawaii Agriculture) from the table below—you would first determine what Hawaii agriculture would be like under a most likely, optimistic, and pessimistic scenario. Then, write the descriptors for each of the scenarios and think about the linkages among the factors as you develop the descriptors.

A comment box has been placed below the factor boxes for you to write any comments associated with this exercise. We are also interested in your opinion as to whether certain boxes should be combined or modified in some way. Also, if you believe there are significant differences for the same factor (Box) between long- and medium-term timeframes, please indicate this in the space provided below for comments.

**Development of Descriptors for 3 Scenarios of Hawaii Agricultural Growth**

**Box 1: GDP and Per-capita Income**
Descriptor(s):
Most likely:

Optimistic:

Pessimistic:

(For Step III: return to Linkages table below)

**Box 2: US Dollar Value**
Descriptor(s)
Most likely:

Optimistic::

Pessimistic:

**Box 10: Hawaii Agriculture**
Descriptor(s)
Most likely:

Optimistic::

Pessimistic:

**Box 6: Population Growth**
Descriptor(s)
Most likely:

Optimistic::

Pessimistic:

**Box 3: Terrorist Attack**
Descriptor(s):
Most likely:

Optimistic:

Pessimistic:

**Box 7: Cost of Living & Housing**
Descriptor(s)
Most likely:

Optimistic::

Pessimistic:

**Box 4: Capital Investment**
Descriptor(s)
Most likely:

Optimistic:

Pessimistic:

**Box 8: Visitors**
Descriptor(s)
Most likely:

Optimistic::

Pessimistic:

**Box 5: Price of Oil**
Descriptor(s)
Most likely:

Optimistic:

Pessimistic:

**Box 9: Road, Seaport, Airports, and Monorail**
Descriptor(s)
Most likely:

Optimistic::

Pessimistic:

*Comments:*
Box 1:
Box 2:
Box 3:
Box 4:
Box 5:
Box 6:
Box 7:
Box 8:
Box 9:
Box 10:
Other comments:

**Step III*: Determine Linkages Among the Factors***
To better understand how each factor affects the future of Hawaii's agriculture, the linkages between each factor or cluster of factors (if any), need to be determined. In this step you are being asked to review the factors presented in the boxes in the previous section and determine if there are linkages between the factors. In addition, you are asked to describe the economic relationships between the factors that you indicate. If you wish to review the boxes containing the factors, a hyperlink has been provided for you in the table below.
Instructions: **In the first column, indicate whether there are linkages between the factors by typing the numbers that correspond to the boxes containing the specific factors that you think are linked. (e.g. if you think boxes 1 and 7 are linked you would type in "1-7"). In the second column, you are asked to describe the economic relationship between the linked factors using the descriptors determined in the previous exercise. (e.g. if you typed "1-7" in the first column, then in the second column you might describe that relationship such as "U.S. per capita income growth affects the number of visitors from the mainland who are a major market for Hawaii agricultural products"). A comment box has been provided below the table for you to provide any comments you have related to this exercise.**

| Linkages among factors (e.g. 1-7) | Describe economic relationship |
|---|---|
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |

| *Comments*: |
| --- |
| |

*With this we have come to the end of Round 3. Please send your responses to the following address: (rchesler@hawaii.edu) by or before* **Thursday, July 6**. *Mahalo for your participation in the Round 3.*

Fig. 5.A-4 Round 4 Questionnaire
NOTE: The Round 2 Appendix is not included here for the sake of brevity. The complete Round 4 questionnaire,
including its appendix is available on the CD-ROM accompanying this report ("Macro Delphi Round 4.doc").

**DEVELOPING SCENARIOS FOR HAWAII'S AGRICULTURAL FUTURE:**
**ROUND 4**

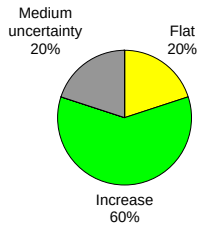
Thank you for your prompt response to Round 3. The purpose of Round 4 is for you to reassess your responses from Round 3 and revote on whether each factor is a trend or uncertainty. In addition, review the linkages that were determined in Round 3 and comment on the dynamics affecting Hawaii's agricultural sector. To get to the end point, there are three sequential steps we would like you to do: (I) revote on whether each factor is a trend or an uncertainty (definitions below); (II) review key descriptors for each factor and review linkages, and (III) validate the most likely scenario developed from Round 3 responses.

Please return your completed Round 4 survey to rsm@hawaii.edu by or before Friday, 7/28/06.

**Step I**: **Revote Whether a Factor is either a Trend or an Uncertainty**

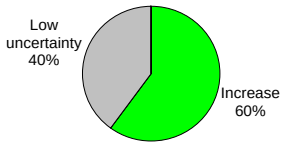
**To create scenarios one determines the selected factors either as a trend or an uncertainty. A trend may be thought of as a best educated guess about a direction of movement in a variable, while an uncertainty is some thing or event that is inherently difficult to predict. In the table below we present the top ten macroeconomic factors selected by the panel from Rounds 1 and 2 with feedback from Round 3 votes on trends and uncertainties. Because of the lack of consensus, we ask you to review the results and revote. You will indicate your answers by typing two X's in the yellow cells for each factor—one for medium-term and one for long-term. If a factor is a trend variable, please indicate whether the trend goes up, down, or stays the same (flat). If a factor is determined as an uncertainty, please indicate the degree of the uncertainty (medium or high). Note that in some cases, the same factor may be a trend variable in the medium-term period and an uncertainty in the long-term period.**
If you wish to review the description for each factor (from Round 1), it is presented in the appendix at the end of this document. Click the provided hyperlinks to jump directly to the description for each specific factor. (To use the links it is necessary to hold down the Ctrl key and then left mouse-click).

## 1.a. US GDP




**Midterm (Next 10 years)**

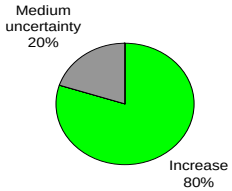
| Trend | | VOTE OR | Uncertainty | |
|---|---|---|---|---|
| Up | | | Medium | |
| Flat | | | High | |
| Down | | | | |




**Long-term (Next 25 years)**

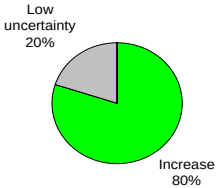
| Trend | | VOTE OR | Uncertainty | |
|---|---|---|---|---|
| Up | | | Medium | |
| Flat | | | High | |
| Down | | | | |

## 1.b.US Per-capita Income




**Midterm (Next 10 years)**

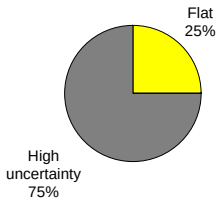
| Trend | | VOTE OR | Uncertainty | |
|---|---|---|---|---|
| Up | | | Medium | |
| Flat | | | High | |
| Down | | | | |




**Long-term (Next 25 years)**

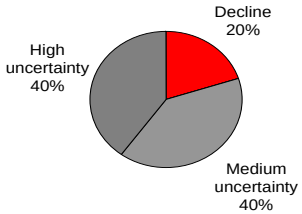
| Trend | | VOTE OR | Uncertainty | |
|---|---|---|---|---|
| Up | | | Medium | |
| Flat | | | High | |

## 2. US Dollar Values




**Midterm (Next 10 years)**

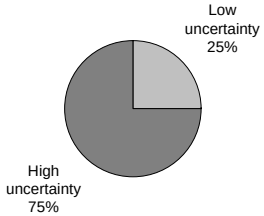
| Trend | | VOTE OR | Uncertainty | |
|---|---|---|---|---|
| Up | | | Medium | |
| Flat | | | High | |
| Down | | | | |




**Long-term (Next 25 years)**

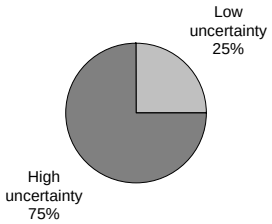
| Trend | | VOTE OR | Uncertainty | |
|---|---|---|---|---|
| Up | | | Medium | |
| Flat | | | High | |
| Down | | | | |

## 3. HI Terrorist Attack




**Midterm (Next 10 years)**

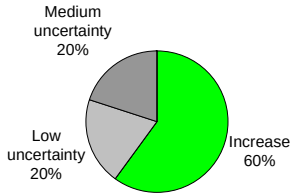
| Trend | | VOTE OR | Uncertainty | |
|---|---|---|---|---|
| Up | | | Medium | |
| Flat | | | High | |
| Down | | | | |




**Long-term (Next 25 years)**

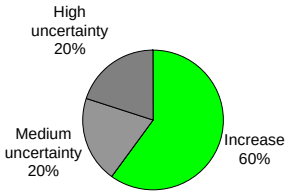
| Trend | | VOTE OR | Uncertainty | |
|---|---|---|---|---|
| Up | | | Medium | |
| Flat | | | High | |
| Down | | | | |

## 4. US Capital Investment




**Midterm (Next 10 years)**

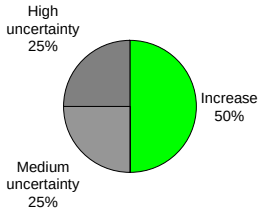
| Trend | | VOTE OR | Uncertainty | |
|---|---|---|---|---|
| Up | | | Medium | |
| Flat | | | High | |
| Down | | | | |




**Long-term (Next 25 years)**

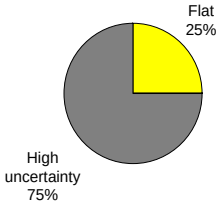
| Trend | | VOTE OR | Uncertainty | |
|---|---|---|---|---|
| Up | | | Medium | |
| Flat | | | High | |
| Down | | | | |

## 5. Price of Oil




**Midterm (Next 10 years)**

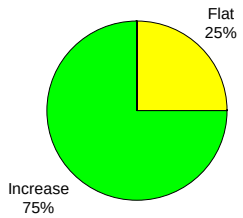
| Trend | | VOTE OR | Uncertaty | |
|---|---|---|---|---|
| Up | | | Medium | |
| Flat | | | High | |




**Long-term (Next 25 years)**

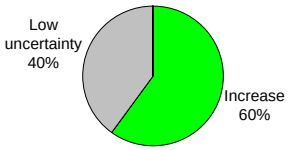
| Trend | | VOTE OR | Uncertainty | |
|---|---|---|---|---|
| Up | | | Medium | |
| Flat | | | High | |

## 6. HI Population Growth




**Midterm (Next 10 years)**

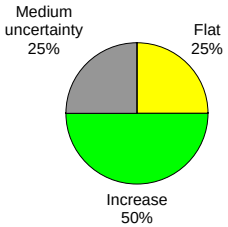
| Trend | | VOTE OR | Uncertainty | |
|---|---|---|---|---|
| Up | | | Medium | |
| Flat | | | High | |
| Down | | | | |




**Long-term (Next 25 years)**

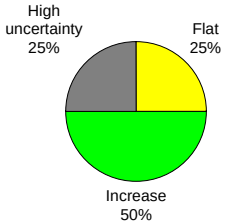
| Trend | | VOTE OR | Uncertainty | |
|---|---|---|---|---|
| Up | | | Medium | |
| Flat | | | High | |
| Down | | | | |

## 7. HI Cost Living & Housing




**Midterm (Next 10 years)**

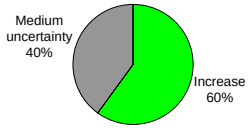
| Trend | | VOTE OR | Uncertainty | |
|---|---|---|---|---|
| Up | | | Medium | |
| Flat | | | High | |




**Long-term (Next 25 years)**

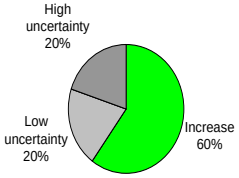
| Trend | | VOTE OR | Uncertainty | |
|---|---|---|---|---|
| Up | | | Medium | |
| Flat | | | High | |

## 8. HI Visitors




**Midterm (Next 10 years)**

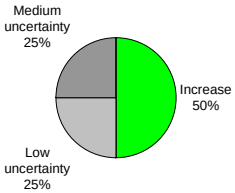
| Trend | | VOTE OR | Uncertainty | |
|---|---|---|---|---|
| Up | | | Medium | |
| Flat | | | High | |
| Down | | | | |




**Long-term (Next 25 years)**

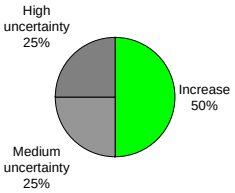
| Trend | | VOTE OR | Uncertainty | |
|---|---|---|---|---|
| Up | | | Medium | |
| Flat | | | High | |
| Down | | | | |

## 9. HI Road, Seaport, Airport, and Monorail




**Midterm (Next 10 years)**

| Trend | | VOTE OR | Uncertainty | |
|---|---|---|---|---|
| Up | | | Medium | |
| Flat | | | High | |
| Down | | | | |

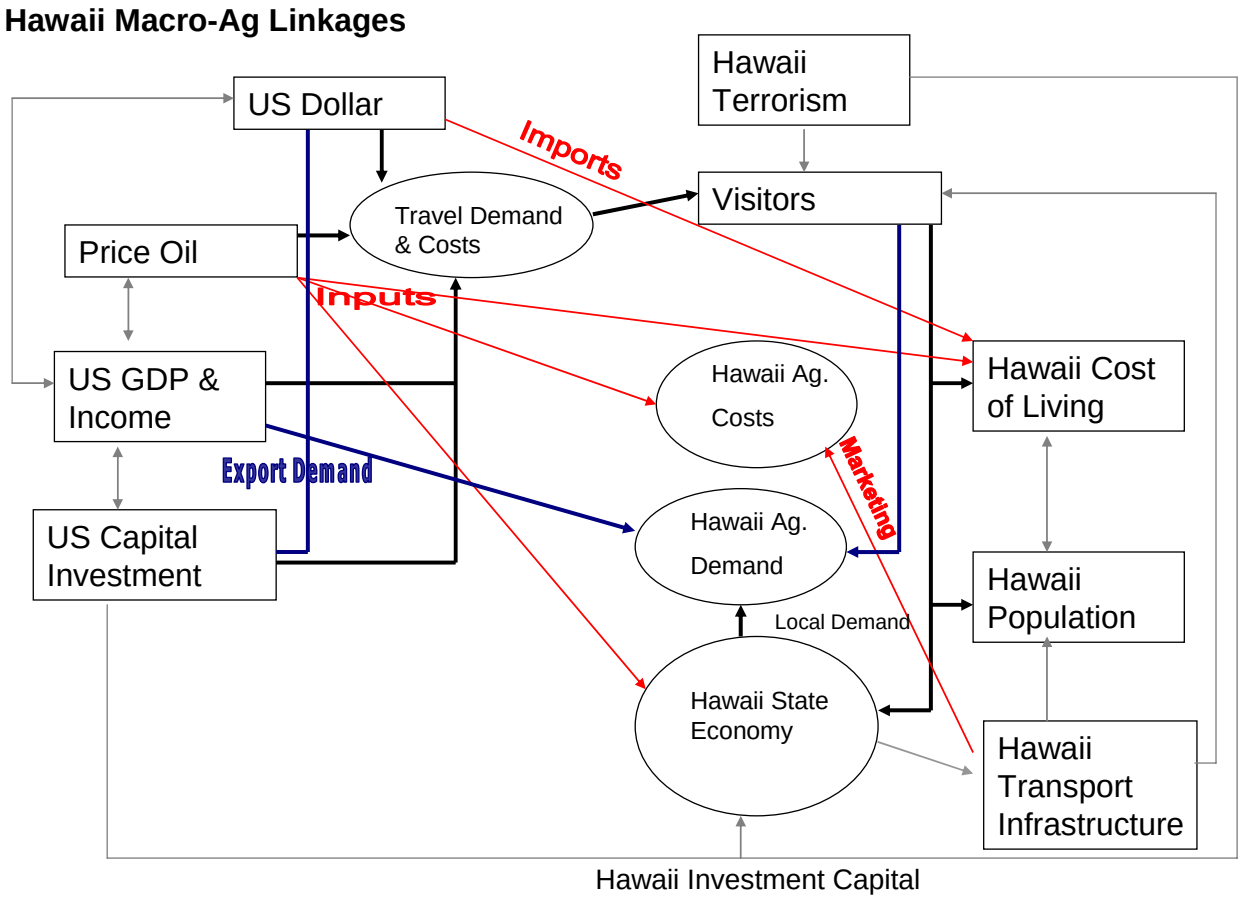



**Long-term (Next 25 years)**

| Trend | | VOTE OR | Uncertainty | |
|---|---|---|---|---|
| Up | | | Medium | |
| Flat | | | High | |
| Down | | | | |

**Step II: Linkages among the Factors**

The following flow diagram was developed from Round 3 responses and illustrates linkages between the macroeconomy and the Hawaii agricultural sector. Please review it and then follow the instructions below.




From the above diagram and scenario descriptors, eleven important linkages were identified. These are described below. Please review these and add comments if you disagree with any of the linkages or would like to qualify them. For example, you might comment if you feel a specific linkage is not important in a particular scenario or does not accurately account for the dynamics of our economy.

Please place an "X" in the column corresponding to your answer.

| Linkages | *Comments* |
|---|---|
| **1. Value of U.S. dollar affects travel demand by foreign visitors and travel costs to Hawaii. This impacts total visitor spending in Hawaii and sales of agricultural products to visitors. There could also be some indirect effects through exposure of Hawaii's agricultural products to foreign consumers, which can affect export sales.** | |
| **2. Value of U.S. dollar affects competitiveness of Hawaii agriculture relative to foreign producers. This impacts Hawaii agricultural sales to foreign markets and to mainland markets for imported products.** | |
| **3. Hawaii is an import-dependent economy, where foreign imports will play an increasing role. The value of the U.S. dollar will thus become a significant factor in Hawaii's cost of living. The latter has broad economic ramifications on growth in the resident population and income, which impact local demand for agricultural products.** | |
| **4. Strength of the U.S. economy impacts the demand for agricultural exports from Hawaii to the mainland.** | |
| **5. U.S. per capita income affects demand by mainland travelers to Hawaii. The number of mainland visitors impacts export demand for Hawaii agriculture, both in direct sales to visitors and indirectly through exposing mainlanders to Hawaii products.** | |
| **6. Growth in the U.S. economy affects American capital investment, including net capital flows into Hawaii. This impacts overall growth in state economy, which determines local demand for Hawaii agricultural products.** | |
| **7. A terrorism event in Hawaii could decrease the number of visitors and capital investment. This would result in slower** | |

| | |
|---|---|
| **growth or even decline in the state's economy. Hawaii's agriculture would then experience lower export sales and reduced local demand.** | |
| **8. The price of oil is an important factor in the U.S. economy. It affects consumer expenditures including the number and spending by mainland visitors to Hawaii. This would affect exports and local demand for Hawaii agricultural products.** | |
| **9. Hawaii currently depends heavily on oil for its energy supply. Thus, the price of oil has a large impact on Hawaii's economy including the costs of living, consumer demand for agricultural products, agricultural production and marketing costs. This affects local and export sales of Hawaii agricultural products.** | |
| **10. Hawaii population growth affects local demand for housing, where housing prices are a major factor in the cost of living and thus growth in Hawaii's economy. Net migration flows can feedback to population growth and dampen this effect. Local demand for agricultural products depends on resident population and state income.** | |
| **11. Development of transportation infrastructure is important to sustaining growth in Hawaii's visitor industry, and to marketing Hawaii agricultural products in local and export markets.** | |
| **12. Other linkage: explain** | |

**Step III**: **Most Likely Scenario**

In Round 3, you provided descriptors for important macroeconomic factors and agricultural sector impacts under three scenarios – most likely, optimistic, pessimistic. The descriptors (numbered for responding panelists) for the most likely scenario are given in the table below.

| |
|---|
| **U.S. GDP & Per Capita Income:** (i) moderate growth (ii) moderate growth (iii) continue trend of last 20 years (iv) follow historical trend. |
| **U.S. Dollar Value:** (i) stable (ii) gradual depreciation of the dollar (iii) will go down significantly (iv) will be fairly stable |
| **HI Terrorist Attack:** (i) nothing local (ii) risk of infrequent moderate events (iii) uncertain (iv) uncertain |
| **US Capital Investment:** (i) moderate long run growth (ii) continued moderate growth (iii) uncertain (iv) to follow historical trend |
| **Price of Oil:** (i) beats CPI (ii) Moderate decline in oil prices (iii) will go up (iv) Between $60-$80 a barrel |
| **HI Population Growth:** (i) sable growth rate (ii) moderate growth (iii) will continue at moderate rates (iv) growth to slow but will remain positive |
| **HI Cost of Living & Housing:** (i) continued upward trend (ii) stable housing prices and cost of living (iii) will remain stable when compared to salaries (iv) continue to increase but inconsistent with historical trend |
| **HI Visitors:** (i) moderate growth (ii) most likely: moderately slow growth in visitor arrivals, with moderate growth in visitor spending |
| **HI Road, Seaport, Airports, and Monorail:** (i) continued congestion, high taxes, (ii) infrastructure continues to act as a modest growth constraint (iii) there will be some investment (iv) new development at part with population growth |
| **Hawaii Agriculture:** (i) moderate growth (ii) additional gradual decline (iii) will continue increasing as now (iv) its share in total economy will continue to shrink, although it will expand |

Based on panelists' Round 3 responses, the following paragraph was developed describing the most likely scenario for Hawaii agriculture.

Most Likely Macroeconomic Scenario:

*The U.S. economy and consumer incomes expand at a moderate rate. This sustains average growth in Hawaii's visitor industry and in exports of Hawaii's agricultural products. It also fuels capital investment in Hawaii, which further stimulates the state economy and growth in the resident population. But such growth also pushes up housing prices and Hawaii's cost of living, which dampens the increase in agricultural demands. Investment in transportation infrastructure lags growth in the local economy such that capacity constraints and congestion raise the costs of marketing farm products. On the international scene, downward pressures on the U.S. dollar and, in the medium term, higher oil prices slow growth in the national and Hawaii economies. Dollar and oil price shocks increase local farm production and marketing costs, and lower sales to external markets. Overall, Hawaii agriculture still grows at a modest rate but its share of the state's economy continues to shrink.*

We now ask you to evaluate the above scenario with respect to:

(a) credible story of the most likely future for Hawaii agriculture

(b) internal consistency and coherence in explaining the important macroeconomic influences on Hawaii agriculture.
In the table below, please place an "X" in the cells indicating whether you agree or disagree that the scenario meets these criteria. If you feel that the scenario is not credible or coherent, please type a comment in the space provided to explain your opinion.

| **Evaluation Criteria** | **Agree** | **Disagree** | **Type comment for disagreement** |
|---|---|---|---|
| a. Credibility | | | |
| b. Coherence | | | |

*With this we have come to the end of Round 4. Please send your responses to the following address: (rsm@hawaii.edu) by or before* **Friday, July 28**. *Mahalo for participating in Round 4.*

Fig. 5.A-5 Round 5 Questionnaire
NOTE: The Round 5 Appendix is not included here for the sake of brevity. The complete Round 5 questionnaire,
including its appendix is available on the CD-ROM accompanying this report ("Macro Delphi Round 5.doc").

**DEVELOPING SCENARIOS FOR HAWAII'S AGRICULTURAL FUTURE:**
**ROUND 5**

Thank you for your prompt response to Round 4. This fifth and final round of the survey will present you with Round 4 results and then ask you to assess three macroeconomic scenarios concerning future growth in Hawaii agriculture. Finally, there's also a concluding question about reporting participation in the survey.

**Please return your completed Round 5 survey to rchesler@hawaii.edu by or before Wednesday, 8/16/06.**

### *Feedback from Round 4*

In Round 4, the panel re-voted whether important drivers were a trend (up, flat, down) or an uncertainty (medium, high). We also asked for comments on eleven important macroeconomic linkages with agriculture which were incorporated into the scenarios where they were useful. The results are reported in an appendix. Click here to review them. These responses were taken

into account with other input from panelists in developing the scenarios presented in the next sections.

Based on the responses and comments from each macro Delphi round, descriptors for the most likely, pessimistic and optimistic scenarios have been developed. The scenarios employing these descriptors are focused mainly on the macroeconomic drivers provided by the panel, as there is another group focusing on the microeconomic aspects of agriculture in Hawaii. The final scenarios are non-technical in nature because they are intended for an audience of laypeople. They will be provided to agriculturalists from the private and public sector. These agriculturalists will use the three different scenarios when projecting future agricultural acreages.

***Most Likely Scenario***

Round 4 presented a most likely macroeconomic scenario for future growth in Hawaii agriculture. Click here to review the original description and panelist rewrite of the most likely scenario introduced in Round 4.

Based on the panel's input, the most likely scenario has been revised to the following:

*The U.S. economy and consumer incomes expand at a moderate rate. This increases the domestic demand for vacations to Hawaii. However, in the medium term, capacity constraints slow growth in the number of visitors. Additional investment is expected to relieve these constraints and sustain moderate growth in domestic visitors over the long run. Demand by foreign tourists is more uncertain due to volatility in the value of the U.S. dollar. Also, higher oil prices in the medium term raise the costs of travel, holding down growth in foreign visitors. Hawaii continues to benefit from global mobility in capital, and capital investment stimulates growth in the state's economy. But such growth also leads to continuing increases in housing prices and the local cost of living. For Hawaii's agriculture, downward pressures on the dollar increase exports to foreign countries, particularly emerging economies. Moderate growth in the mainland economy, Hawaii visitors and resident population increases domestic demands for ag-based products. But higher oil prices raise local farm production and agricultural marketing costs. Inadequate transportation facilities and congestion in shipping limit market expansion for the next ten years. Overall, Hawaii agriculture grows at a modest rate but its share of the state's economy continues to shrink as emerging sectors come to dominate future economic growth.*

We now ask you to evaluate the scenario as to whether it's a:

(a) Credible story of the most likely future for Hawaii agriculture, and

(b) Internally consistent and coherent in explaining the important macroeconomic influences on Hawaii agriculture

In the table below, please place an "X" in the cells indicating whether you agree or disagree that the scenario meets these criteria. If you feel that the scenario is not credible or coherent, please type a comment in the space provided to explain your opinion.

| **Evaluation Criteria** | **Agree** | **Disagree** | **Type comment for disagreement** |
|---|---|---|---|
| a. Credibility | | | |
| b. Coherence | | | |
| **Editorial Comments:** | | | |

***Optimistic and Pessimistic Scenarios***

In Round 3, you provided descriptors for Optimistic and Pessimistic scenarios for Hawaii agriculture. Click here to review the descriptors.

Based on these responses plus other panel input, we've drafted text descriptions for these scenarios. Please review the scenario descriptions below, and evaluate the credibility and coherence of each scenario. There's also a box for you to type editorial comments or suggest revisions in the scenario description to make it more consistent with your understanding of the Hawaii macroeconomy and its impact on growth in Hawaii agriculture.

**Optimistic Scenario:**
***Optimistic***

*Hawaii agriculture flourishes with the establishment of a bioenergy industry and development of new tropical specialty crops. Rational planning and upgrades of local infrastructure, including new modes of transportation, improve transport of goods and the overall efficiency of marketing agricultural products. The renaissance in Hawaii agriculture feeds on strengths in the global economy. As the price of oil levels off and concerns about terrorism fade, the American economy experiences accelerating growth, charged by high-tech investment and cyclical booms. Gradual depreciation in the U.S. dollar stimulates growth in exports including high-value agricultural products from Hawaii. It also spurs growth in Hawaii's visitor industry, especially an influx of upscale tourists. This fuels the demand for niche agricultural products. The local population grows at a moderate rate, enough to keep pace with labor demands. Increases in the cost of living in Hawaii slow and, given the strong economy, locals enjoy higher personal incomes. This sustains steady expansion in local sales for ag-based products. Farm revenues rise faster than production costs, the latter held down by moderating prices for energy and other inputs. As a result, the expansion of Hawaii's agricultural sector outpaces the rest of the state's economy.*

| **Evaluation Criteria**<br>X for agree or disagree | **Agree** | **Disagree** | **Type comment for disagreement** |
|---|---|---|---|
| a. Credibility | | | |
| b. Coherence | | | |

**Editorial Comments:**

**Pessimistic Scenario:** *Hawaii faces its worst economic outlook in recent memory. The mainland economy endures long periods of little or no growth with sharp cyclical downturns. Volatility in the U.S. dollar hinders economic expansion through exports. Capital investment slows, further depressing the economy of the U.S. mainland and Hawaii. The price of oil trends up in the near-term period, with occasional spikes above $100 per barrel due to unpredictable supply and high costs of alternative energy sources.. The global demand for vacation travel wavers with energy prices. Hawaii's image suffers a severe blow after a terrorist attack on a local target, and eliminates Hawaii as a top tourist destination for many years. For Hawaii residents, increases in the cost of living outpace growth in earnings. Movements in the resident population are fluid, with periods of outmigration leading to labor shortages. Local lifestyles deteriorate from overcrowding and inadequate public investment to address transportation problems. In this dismal economic environment, Hawaii's farmers face insurmountable challenges. Agricultural production and marketing costs rise due to higher prices for energy, labor, and other inputs. This is compounded by problems finding adequate water and farm workers. Competition from low-cost producers squeeze the profitability of local agribusiness. Export markets for high-value agricultural products dry up, while local sales falter and imports increase. Hawaii agriculture is driven into a permanent decline and virtually disappears by the year 2030.*

| **Evaluation Criteria**<br>X for agree or disagree | **Agree** | **Disagree** | **Type comment for disagreement** |
|---|---|---|---|
| a. Credibility | | | |
| b. Coherence | | | |

**Editorial Comments:**

At this point we are asking you to consider all three scenarios (Most Likely, Optimistic and Pessimistic) together. **When taken together**, do the three scenarios represent a reasonable range of uncertainty, as well as a reasonable degree of plausibility?

| **Evaluation Criteria** X for agree or disagree | **Agree** | **Disagree** | **Type comment for disagreement** |
|---|---|---|---|
| a. Reasonable range of uncertainty | | | |
| b. Reasonable degree of plausibility | | | |

| **Editorial comments:** |
|---|
| |

***Final Questions***

1. This survey is part of a study being conducted for the Hawaii Dept. of Agriculture and state Commission on Water Resource Management. In the final report for the study, we would like to list your name as a participant in the survey, along with your position and the organization that you work for. (Note: The answers to the survey are completely confidential and will not be associated with your name.) Please answer "**yes**" or "**no**" in the box below if you will or will not allow your name to be listed in our report:

| List you in report? Enter yes or no: |
|---|

2. How many years have you worked in Hawaii in areas related to this survey? [ ]

*With this we have come to the end of Round 5, and the end of our macroeconomic Delphi survey. Thank you very much for your participation in this survey. We will notify you of the results when our study is completed and available for public release.* **Please return your completed Round 5 survey to rchesler@hawaii.edu by or before Wednesday, 8/16/06. Mahalo!**

# 5-B Crop Projections Delphi Survey

Panelists' names:

1. Lance Santo (HARC)
2. Sally Rice
3. Bob Foerster (Kona Coffee Council)
4. Dan Clegg (Monsanto)
5. Myra Ikeda (HI Forest Industry Association)
6. Harold and Eric Tanouye (Green Point Nurseries, Inc.)
7. [name withheld]
8. Paula Helfrich (Economic Development Alliance of Hawaii)
9. Ken Love (12 Trees Project)
10. Wesley Nohara and Jeff Pearson (Maui Land and Pineapple)
11. HC Bittenbender (UH)
12. Mike Conway (Dole)
13. Hilary Brown (Macfarms of Hawaii, LLC)
14. Judy Schilling, (HI Export Nursery Association)
15. Dr. Kent Fleming (UH)
16. [name withheld]
17. Steven Fukuda (UH)
18. Steve Bowles (Waimea Water Services)
19. Lorie Farrell
20. Monty Richards (Kahua Cattle Ranch)
21. Dayday Hopkins (County of Hawaii-Research and Development)
22. Robin Shimabuku (UH/CTAHR)
23. Mae Nakahata (HC&S)
24. Leng Chian (UH)

Fig. 5.B-1 Round 1 Questionnaire

# Developing Crop Projections for Hawaii's Agricultural Future Using the Delphi Technique: Round 1

**Introduction**

Thank you for your willingness to participate. The goal of this survey is to project Hawaii acreages by crop group (jump to descriptions in Appendix) in order to predict future irrigation water demand. To begin, we will determine the most important economic drivers for different crops in the state of Hawaii, as well as the expected agriculture growth rate for two time periods, 2006-2015 and 2016-2030. Please note that this survey is not meant to account for crops that would be grown strictly for bioenergy uses (e.g. growing sorghum for ethanol production).

We will be using the Delphi technique to accomplish this goal. The Delphi survey will be conducted entirely via e-mail and will take about 20-30 minutes per round to answer. Depending on how quickly we get a consensus, the Delphi exercise will consist of about five rounds. Instructions will be provided at the beginning of each round on how to complete each exercise. The Delphi methodology involves a number of iterations with feedback of all responses. With regard to your responses, complete anonymity will be maintained with only a summary of the groups' responses fedback to the panelists. If you think that responding to a particular question represents a breach of confidentiality for your organization, please feel free to skip that question and proceed to the next question.

We ask that you please return your completed Round 1 survey by or before **Friday, July 28th, 2006**, by e-mailing the attached .doc file to: rsm@hawaii.edu. Mahalo!

## Round 1

**Drivers of Agricultural Growth**

Many factors may affect the performance of Hawaii's agricultural production through the year 2030 and the increase or decrease in the amount of acreage devoted to each of Hawaii's current crops. In the table on the next page, potential drivers of Hawaii agriculture's future are listed for seven crop groups.

Please indicate where a driver will be important for a given crop group by placing an "**X**" in the respective cell of the table. A comment box has been provided at the end of the table.

| **Driver for Growth/ Decline in Ag. Acreage** | | **Pineapple** | | **Veg. & Melons** | **Fruit & Nut Trees** | **Nursery & Flowers** | **Pasture** |
|---|---|---|---|---|---|---|---|
| Land: availability & cost | | | | | | | |
| Water: availability & cost | | | | | | | |
| Other production inputs including technology | | | | | | | |
| Transportation: industry structure, modes, routes incl. transhipment, cost | | | | | | | |
| Development of ag-based products & processing technology | | | | | | | |
| Hawaii Markets: consumer demand & competition | | | | | | | |
| Mainland & Foreign Markets: consumer demand & competition | | | | | | | |

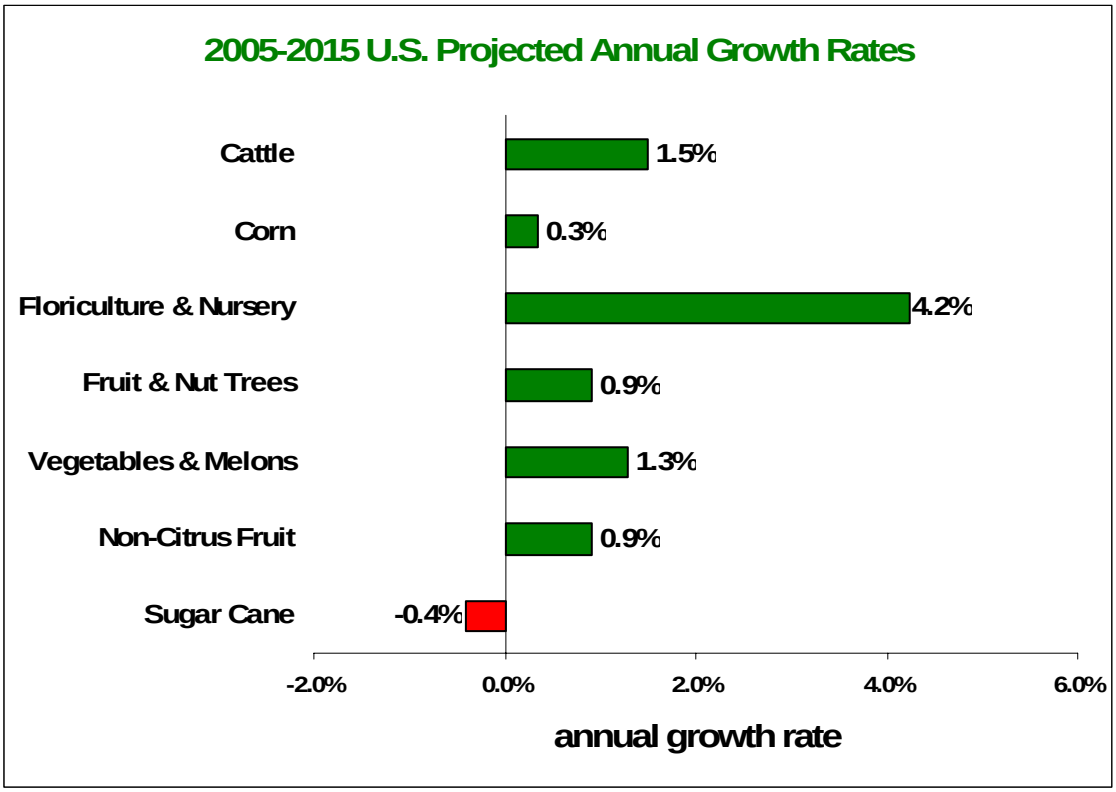
Comments:
Please type any comments you have regarding this section into the box below. Address any concerns or additional drivers that you feel should be included in this table. This space can also be used to explain or qualify your choice of drivers.

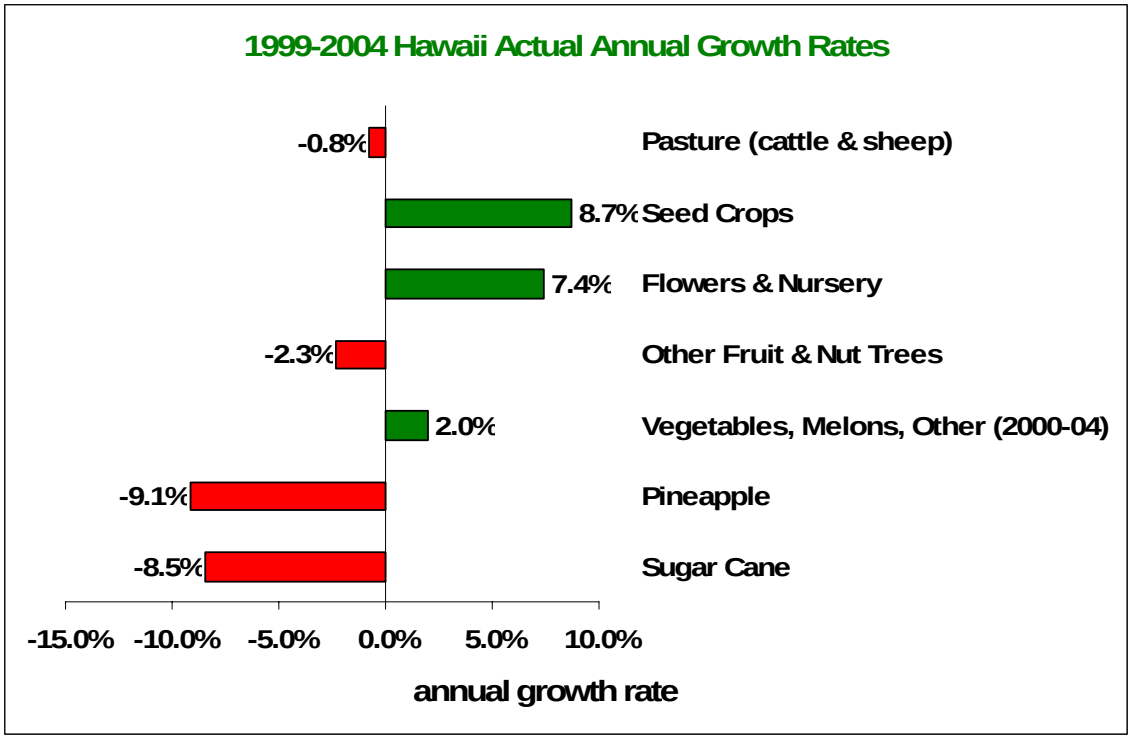
*Comments:*

**Agricultural Growth Rates**

This section examines agricultural growth rates for two time periods: 2005-2015 and 2016-2030. Background information is provided from DBEDT projections (jump to description), USDA projections (jump to descriptions), and agricultural statistics on crop acreage from HASS.

DBEDT projects state agricultural growth output will average 1.6% for 2005-2015 and 1.5% for 2016-2030. The USDA projections for selected crops extend only to 2015. The following graphs show Hawaii's recent growth in agriculture acreage and U.S. predicted agricultural trends.




1999-2004 Hawaii Actual Annual Growth Rates
-0.8%
Pasture (cattle & sheep)
8.7%
Seed Crops
7.4%
Flowers & Nursery
-2.3%
Other Fruit & Nut Trees
2.0%
Vegetables, Melons, Other (2000-04)
-9.1%
Pineapple
-8.5%
Sugar Cane
-15.0%
-10.0%
-5.0%
0.0%
5.0%
10.0%
annual growth rate

Using the information above as reference, please complete the following table by placing an "**X**" in the table cells that reflect your thoughts for expected 2005-2015 acreage growth for and how crop growth during 2016-2030 will compare to 2005-2015 growth for each of the seven crop groups.

| **Crop Group** | **2005-2015 Expected Growth in Hawaii Crop Acreage** | | | | | **2016-2030 Growth Relative to 2005-2015 Growth** | | |
|---|---|---|---|---|---|---|---|---|
| | **Above average** | **Average** | **Below average** | **Flat (no growth)** | **Decline** | | | |
| Sugar | | | | | | | | |
| Pineapple | | | | | | | | |
| Seed Crops | | | | | | | | |
| Veg. & Melons | | | | | | | | |
| Fruit & Nut Trees | | | | | | | | |
| Nursery & Flowers | | | | | | | | |
| Pasture | | | | | | | | |

Comments:

Please type any comments you have regarding this section into the box below. In particular, feel free to explain or qualify expected growth rates in the above table.

*Comments:*

**Location of Hawaii Agriculture**

Since each of the five main islands (Kauai, Oahu, Molokai, Maui, and Hawaii) have different resources, opportunities, and unique constraints, the location of crop production in 2030 may shift. In the following table, put a (+) sign under the relevant island(s) where the listed driver might lead to a stronger than average growth in agricultural acreage to 2030 and a (-) sign where the listed driver is expected to cause lower than average growth or decline. For example, if you feel that lower land costs on a particular island might lead to significant growth in acreage, then a (+) sign should be placed in table cell.

| **Driver for Growth/Decline in Ag. Acreage** | **Kauai** | **Oahu** | **Molokai** | **Maui** | **Big Island** |
|---|---|---|---|---|---|
| Land: availability & cost | | | | | |
| Water: availability & cost | | | | | |
| Other production inputs including technology | | | | | |
| Transportation: industry structure, modes, routes incl. transhipment, cost | | | | | |
| Development of ag-based products & processing technology | | | | | |
| Hawaii Markets: consumer demand & competition | | | | | |
| Mainland & Foreign Markets: consumer demand & competition | | | | | |

Comments:

Please type any comments you have regarding this section into the box below. Please use this space to explain or qualify factors affecting different islands.

| *Comments:* |
|---|
| |

*With this we have come to the end of Round 1. Please send your responses to the following address: (rsm@hawaii.edu) by or before Friday, July 28th. Mahalo for your participation!*

# Appendix
# Descriptions for Crops Delphi Round 1

**Hawaii Crop Groups**

The following grouping of crops takes into account availability of data, importance to Hawaii's agricultural sector, similarity in crop water requirements, and the use of irrigation. The main data sources are the Hawaii Agricultural Statistics Service (HASS) annual reports and the USDA's 2002 Census of Agriculture (COA). The table below provides definitional information for the seven crop groups used in this survey.

| Crop Group | Area Measure | Data, Estimation Methods |
|---|---|---|
| 1. Sugarcane | ac. in crop | HASS |
| 2. Pineapple | ac. used | HASS |
| 3. Seed Crops | total ac. | HASS for state. Varied info. sources for distribution by island. |
| 4. Vegetables & Melons with other crops including taro, feed & forage crops | harvested ac. | Sum of HASS Veg. & Melons and All Other Crops categories, minus Seed Crops (group 3) and Nursery & Flowers (group 6). |
| 5. Fruit & Nut Trees | total ac. | Sum of HASS Fruits (excluding Pineapple), Coffee, and Macadamia Nuts area. COA and other info. used for distribution on some islands. |
| 6. Nursery & Flowers | total ac. | Total including Greenhouse, Artificial Shade, Natural Shade, and Open Field area. |
| 7. Pasture for cattle and sheep | total ac. | COA total pastureland (all types) taken as ratio to HASS livestock inventory by county. Kauai sheep estimated from COA farm sizes. |

References

HASS *Statistics of Hawaii Agriculture 2004*, www.nass.usda.gov/hi/stats/t_of_c.htm

USDA *2002 Census of Agriculture Volume 1 Chapter 2: Hawaii County Level Data*, www.nass.usda.gov/census/census02/volume1/hi/index2.htm

**Back to Introduction**

**DBEDT Economic Projections**

County input-output (I-O models) were developed from a statewide model using a 131-industry specification, later aggregated into 20 sectors including Agriculture. Although many industries lack county-level information, county data on agriculture and trade were available and directly

incorporated into the I-O matrices. Estimates of industry input purchases from other counties were developed from available data on waterborne commerce, Hawaii Dept. of Agriculture (DOA) data on agricultural shipments from the neighbor islands to Honolulu, and DBEDT judgments. County-level final demands for resident consumption and visitor expenditures were estimated using various methods. Since only statewide data are available for exports, state totals on exported outputs were allocated proportionally based on total industry output in a county.

DBEDT developed the county I-O models to make economic projections to the year 2030. Model accuracy may be better than average for the agricultural sector because DOA production and trade data were incorporated into county matrices. County projections are for five-year periods over 2000-2030. The forecasting model is largely sequential with population and external factors determining economic performance. The main feedback is migration, where it is assumed that labor will flow in/out of Hawaii so that projected labor supply equals demand. The model was "benchmarked" to the year 2000 using sectoral job and income data, then "calibrated" for actual 2001-2003 jobs. The model forecasts are driven by estimates for final demand, typically applying a growth rate to 2000 demands. DBEDT considers the projections "are neither targets nor goals" but instead their "best estimate of likely trends ... based on currently available information ... for use as baselines for long-term infrastructure planning."

References

DBEDT *Input Output Study: 1997 Benchmark Report*, www.hawaii.gov/dbedt/info/economic/data_reports/input-output/
DBEDT *Population and Economic Projections for the State of Hawaii to 2030*, www.hawaii.gov/dbedt/info/economic/data_reports/population-projections/

**Back to Ag. Growth Rates**

**USDA Agricultural Projections**

The U.S. Dept. of Agriculture (USDA) publishes annual reports with 10-year projections for major field crops and livestock industries. The projections are a composite of results from USDA models and consensus judgments by several USDA committees. The reports provide a comprehensive outlook for U.S. agriculture, and include macroeconomic assumptions for the U.S. and world regions. Some projections cover commodities of particular relevance to Hawaii including sugarcane, horticultural crops, ornamentals, and cattle. The USDA does not provide a specific purpose for these projections. The reports do state that it is "not a USDA forecast about the future" but "a conditional, longrun scenario" based on continuing current policy and assumed external conditions. Most assumptions appear to follow recent trends and/or are middle-of-the road values, with external shocks explicitly excluded.

References

USDA *Briefing Room: Agricultural Baseline Projections*, www.ers.usda.gov/briefing/Baseline/
USDA *Agricultural Baseline Projections to 2015*, www.ers.usda.gov/publications/oce061/

**Back to Ag. Growth Rates**

Fig. 5.B-2 Round 2 Questionnaire
NOTE: The Round 2 Appendix is not included here for the sake of brevity. The complete Round 2 questionnaire,
including its appendix is available on the CD-ROM accompanying this report ("Crops Delphi Round 2.doc").

# Delphi Survey on Crop Projections for Hawaii's Agricultural Future: Round 2

## *Introduction*

Thank you for your prompt response to Round 1. The purpose of Round 2 is for you to quantify growth rates in crop acreages based on the panel results from Round 1. The results from Round 1 will be summarized in the following sections, along with new questions on agricultural growth.

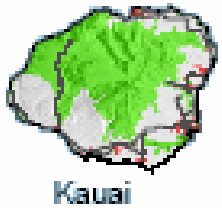
Please return your completed Round 2 survey to rchesler@hawaii.edu by or before Monday, **August 14th, 2006**. (The sooner they are completed, the sooner we are able to advance to the next round).

## *Drivers for Future Agricultural Growth*

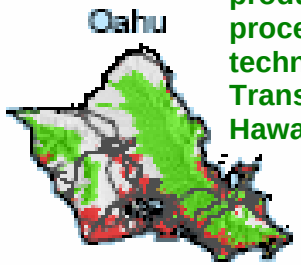
In Round 1, panelists were asked to select the important drivers for growth in Hawaii crop acreages to the year 2030. The table on the next page reports the results based on the number of times a particular driver was identified as important.

The next page also contains a map of Hawaii. The map has labels next to the five main islands. These labels show which drivers the panel felt would lead to stronger than average growth (positive drivers in green) or lower than average growth/decline (negative drivers in pink) in agriculture. Drivers were determined to be positive or negative based on a 2:1 ratio of Round 1 responses. Mixed results occurred for some drivers and are not shown. Please review the table and map on the next page, and comment on the results in the box at the top of page 3.

Round 1 responses also included selected comments. These comments are summarized in the appendix (click here to view). A reader can jump to the comments by clicking the link provided. (You may have to hold down the Ctrl key and then left mouse-click to activate a link.) Some comments have been edited or paraphrased for clarity. Besides the drivers presented in the round 1 questionnaire, some panelists commented on other important factors like labor availability and cost, and public policy. Consider all factors that you feel are important when answering the rest of this survey.



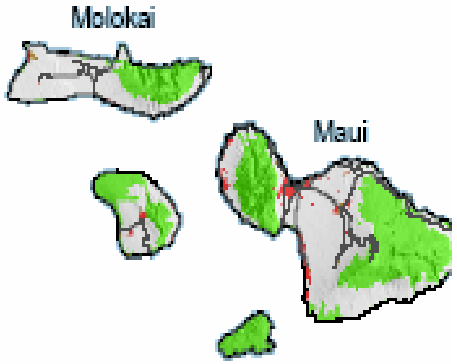

**Mainland & Foreign Markets, Land**
**Other inputs, Ag-based products &**




**Other inputs, Ag-based products & processing technology, Transportation, Hawaii markets,**

**Mainland & Foreign Markets, Land**

*Maps show state agricultural district in grey, conservation district in green, and urban district in red.*




**Land, Other inputs, Ag-based products & processing technology, Hawaii markets, Mainland & Foreign**

## ROUND 1 DRIVERS FOR FUTURE AGRICULTURAL GROWTH

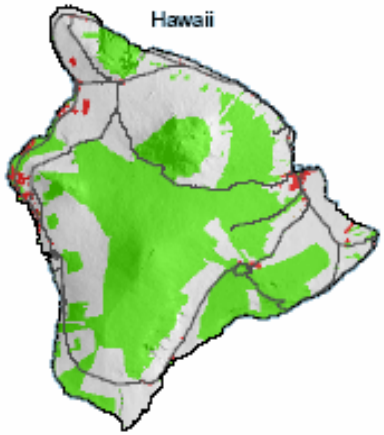
*Map labels show drivers for five main islands. Positive drivers in **green**, negative drivers in **pink**.*

***Important Drivers for Hawaii Crop Groups***

legend: XXX for very important, X for important, s for somewhat important.

| Driver for Growth/ Decline in Ag. Acreage | Sugar | Pineapple | Seed Crops | Veg. & Melons | Fruit & Nut Trees | Nursery & Flowers | Pasture |
|---|---|---|---|---|---|---|---|
| Land | s | s | X | X | X | X | X |
| Water | X | s | X | X | X | X | s |
| Other inputs | | s | X | s | s | s | s |
| Transportation | s | s | s | X | XXX | XXX | XXX |
| Ag-based products & processing technology | X | | s | | X | | |
| Hawaii Markets | | | | XXX | X | s | X |
| Mainland & Foreign Markets | X | X | s | s | XXX | XXX | X |

**Land, Other inputs, Ag-based products & processing technology, Transportation, Hawaii markets, Mainland & Foreign Markets**



Comments:
Please type comments in the following box where you disagree with the panel's assessment on important agriculture drivers or you would like to qualify the results. (To review panelist's comments again, please click here.)

| *Comments:* |
|---|
| |

### *Expected Growth in Hawaii Crop Acreages*

In Round 1, you voted on expected growth rates in crop acreage for two time periods, 2005-2015 and 2016-2030. To review the Round 1 responses, click here. Your qualitative assessments on growth were translated into quantitative estimates based on DBEDT's projected average (1.6%) growth for Hawaii agriculture. The table below shows the relationships between the qualitative answers and quantified growth rates.

| | **2005-2015 Expected Growth in Hawaii Crop Acreage** | | | | |
|---|---|---|---|---|---|
| | Above average | Average | Below Average | Flat (no growth) | Decline |
| **2016-2030 Growth Relative to 2005-2015 Growth:** | | | | | |
| Higher | 3.6% | 2.4% | 1.2% | 0.8% | -0.2% |
| Same | 2.4% | 1.6% | 0.8% | 0.0% | -0.4% |
| Lower | 1.2% | 0.8% | 0.4% | -0.4% | -0.6% |

Now we would like you to re-estimate quantitative growth rates for Hawaii crop acreages in two time periods, 2005-2015 and 2016-2030, under the "most likely" macroeconomic scenario given below in italics. This scenario has been developed by a panel of local economists in a separate Delphi survey.

***Most Likely***: *The U.S. economy and consumer incomes expand at a moderate rate. This increases the domestic demand for vacations to Hawaii. However, in the medium term, capacity constraints slow growth in the number of visitors. Additional investment is expected to relieve these constraints and sustain moderate growth in domestic visitors over the long run. Demand by foreign tourists is more uncertainty due to volatility in the value of the U.S. dollar. Also, higher oil prices in the medium term raise the costs of travel, holding down growth in foreign visitors. Hawaii continues to benefit from global mobility in capital, and capital investment stimulates growth in the state's economy. But such growth also leads to continuing increases in housing prices and the local cost of living. For Hawaii's agriculture, downward pressures on the dollar increase exports to foreign countries, particularly emerging economies. Moderate growth in the mainland economy, Hawaii visitors and resident population increases domestic demands for ag-*

*based products. But higher oil prices raise local farm production and agricultural marketing costs. Inadequate transportation facilities and congestion in shipping limit market expansion for the next ten years. Overall, Hawaii agriculture grows at a modest rate but its share of the state's economy continues to shrink as emerging sectors come to dominate future economic growth.*

Keeping this scenario in mind, please enter percentage numbers in the table below (yellow cells) with your estimate of growth in acreage for seven Hawaii crop groups. The average (statistical mean) growth rates, quantified from your Round 1 assessments, are given in the table for your reference.

| **Crop Group** | **2005-2015 Annual Growth** | | **2016-2030 Annual Growth** | |
|---|---|---|---|---|
| | Round 1 average rate | Enter revised rate | Round 1 average rate | Enter revised rate |
| Sugar | 0.5% | | 0.3% | |
| Pineapple | 0.1% | | -0.3% | |
| Seed Crops | 1.9% | | 2.5% | |
| Veg. & Melons | 1.7% | | 1.9% | |
| Fruit & Nut Trees | 1.3% | | 1.2% | |
| Nursery & Flowers | 1.6% | | 1.6% | |
| Pasture | 0.6% | | 0.4% | |

Comments:
Please type any comments you have on estimating crop growth rates or related issues in the following box. (To see panelist comments on growth rates from round 1, click here.)

*Comments:*

### *Location of Hawaii Agriculture*

In the following pages, we'll go through each of the seven crop groups. We present graphs showing crop acreage in the year 2004 (latest available data) and projected acreage in 2015 and 2030. The projections are based on the Round 1 average growth rates. There are also pie charts showing the estimated 2004 crop acres by island (jump to appendix description for specifics on estimation methods). We also list the important drivers for a given crop and individual islands, identified in Round 1.

Given all this information, we ask you to consider the likely locations for the growth or decline in acreage by the year 2030. For each crop group, there's a table where we ask you to vote (yellow cells) which islands will be:

G =major location for growth in crop acreage (35% of state or more)
m =minor location for growth in crop acreage (10% to 34% of state)
s =relatively stable acreage (-10% to +10% of state)
d =minor location for decline in crop acreage (-11% to -34% of state)
F =major location for decline in crop acreage (-35% of state or more)

If you think that the acreage changes will go in opposite directions on different islands, you can identify locations of growth and of decline for the same crop. For example, the Big Island could be a major location for growth in vegetable acreage (vote G) while Oahu might experience a minor decline in acreage (vote d).

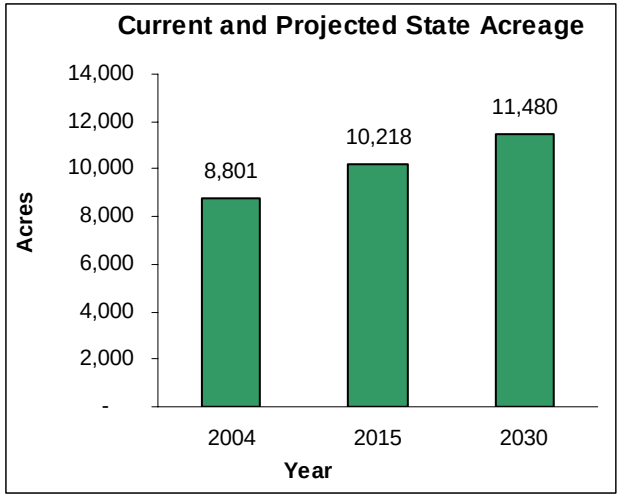
You can now proceed through the crop group pages and vote in the yellow cells on the future location of Hawaii agriculture. Please use only one letter per table cell. When you've finished, please return the completed survey form to rchesler@hawaii.edu.

## VEGETABLES AND MELONS

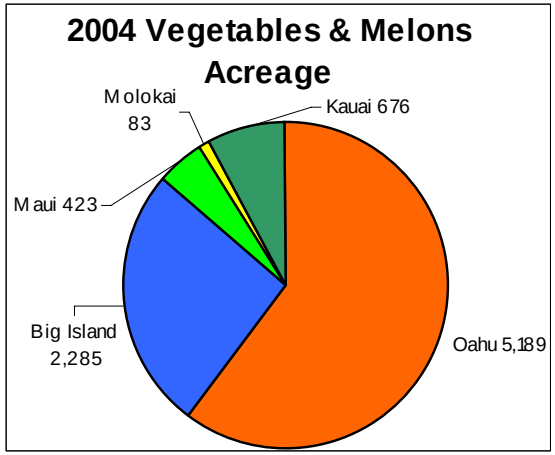
***Important Drivers for Vegetables & Melons***

Land, water, transportation, and Hawaii markets

| **Island** | **Positive and Negative Agricultural Drivers** | **2030 Area*** |
|---|---|---|
| Kauai | Other inputs,<br>Ag-based products & processing technology,<br>Hawaii markets,<br>Mainland and Foreign Markets,<br>Lands | |
| Oahu | Other inputs,<br>Ag-based products & Processing technology,<br>Transportation,<br>Hawaii markets,<br>Mainland and Foreign Markets,<br>Lands | |
| Molokai | Land,<br>Mainland and Foreign markets | |
| Maui | Other inputs,<br>Ag-based products & processing technology,<br>Transportation,<br>Hawaii markets,<br>Mainland and Foreign Markets,<br>Lands | |
| Big Island | Land, | |



| | | |
|---|---|---|
| | Others inputs<br>Ag-based products &<br>Processing technology,<br>Transportation,<br>Hawaii markets,<br>Mainland and Foreign Markets, | |

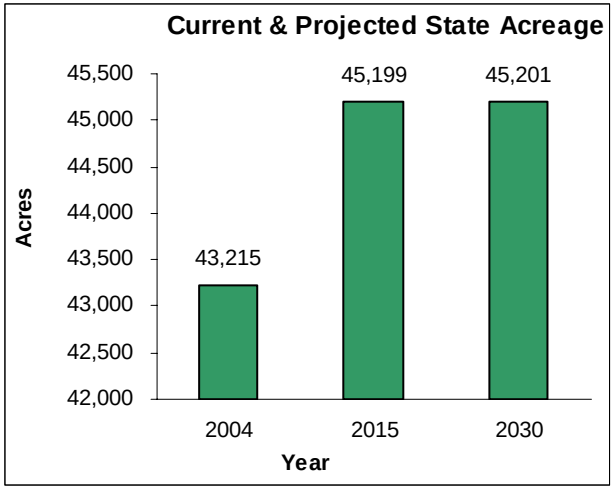



*Vote one letter in each yellow cell, either: G=major growth, m=minor growth, s=stable, d=minor decline, F=major decline

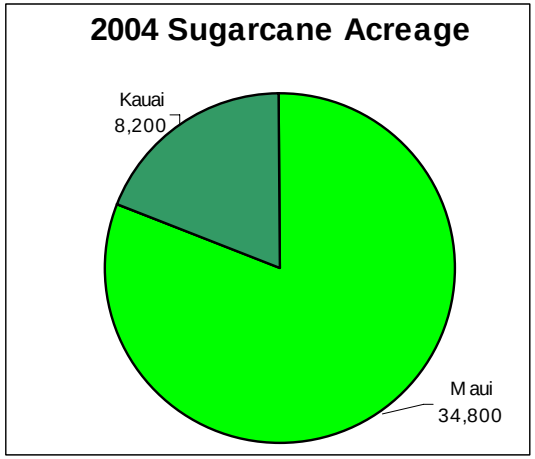
## SUGARCANE

***Important Drivers for Sugarcane***
Water, Ag.-Based products & processing technology, and Mainland & Foreign Markets

| **Island** | **Positive and Negative Agricultural Drivers** | **2030 Area*** |
|---|---|---|
| Kauai | Other inputs,<br>Ag-based products & processing technology,<br>Hawaii markets,<br>Mainland and Foreign Markets,<br>Lands | |
| Oahu | Other inputs,<br>Ag-based products & Processing technology,<br>Transportation,<br>Hawaii markets,<br>Mainland and Foreign Markets,<br>Lands | |
| Molokai | Land,<br>Mainland and Foreign markets | |
| Maui | Other inputs,<br>Ag-based products & processing technology,<br>Transportation,<br>Hawaii markets,<br>Mainland and Foreign Markets,<br>Lands | |
| Big Island | Land, | |



| | | |
|---|---|---|
| | Others inputs<br>Ag-based products &<br>Processing technology,<br>Transportation,<br>Hawaii markets,<br>Mainland and Foreign Markets, | |



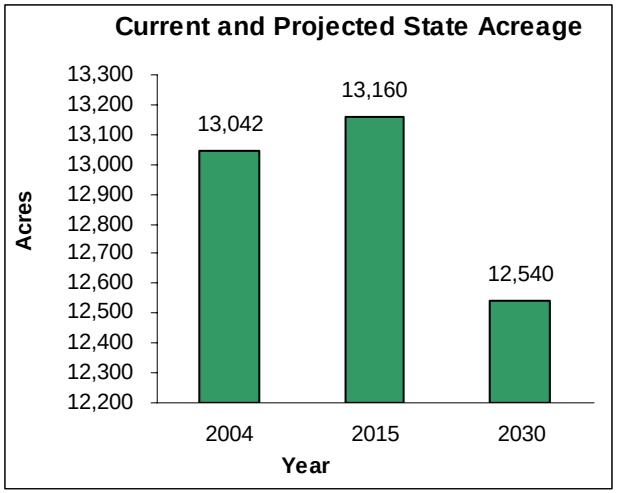

*Vote one letter in each yellow cell, either: G=major growth, m=minor growth, s=stable, d=minor decline, F=major decline

# PINEAPPLE

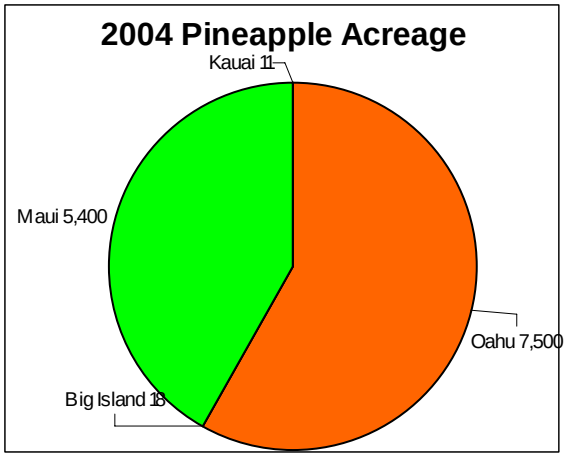
***Important Drivers for Pineapple***

Mainland & Foreign Markets

| **Island** | **Positive and Negative Agricultural Drivers** | **2030 Area*** |
|---|---|---|
| Kauai | Other inputs,<br>Ag-based products & processing technology,<br>Hawaii markets,<br>Mainland and Foreign Markets,<br>Lands | |
| Oahu | Other inputs,<br>Ag-based products & Processing technology,<br>Transportation,<br>Hawaii markets,<br>Mainland and Foreign Markets,<br>Lands | |
| Molokai | Land,<br>Mainland and Foreign markets | |
| Maui | Other inputs,<br>Ag-based products & processing technology,<br>Transportation,<br>Hawaii markets,<br>Mainland and Foreign Markets, | |



| | | |
|---|---|---|
| | Lands | |
| Big Island | Land,<br>Others inputs<br>Ag-based products &<br>Processing technology,<br>Transportation,<br>Hawaii markets,<br>Mainland and Foreign Markets, | |



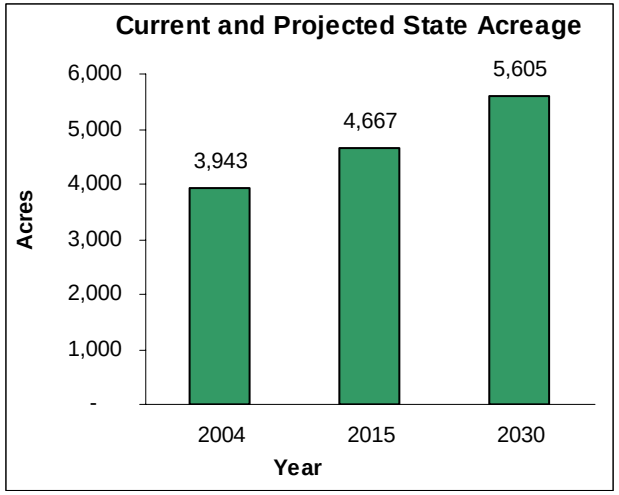

*Vote one letter in each yellow cell, either: G=major growth, m=minor growth, s=stable, d=minor decline, F=major decline

## SEED CROPS

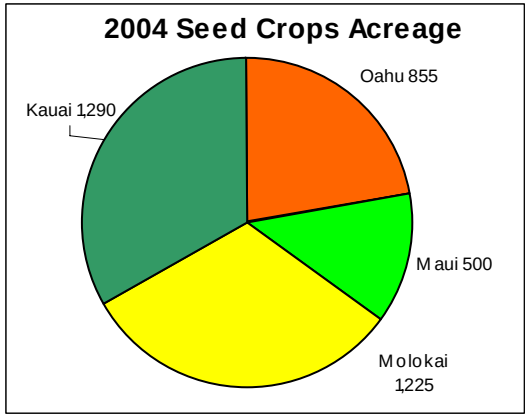
***Important Drivers for Seed Crops***

Land, Water, and Other inputs

| **Island** | **Positive and Negative Agricultural Drivers** | **2030 Area*** |
|---|---|---|
| Kauai | Other inputs,<br>Ag-based products &<br>processing technology,<br>Hawaii markets,<br>Mainland and Foreign Markets,<br>Lands | |
| Oahu | Other inputs,<br>Ag-based products &<br>Processing technology,<br>Transportation,<br>Hawaii markets,<br>Mainland and Foreign Markets,<br>Lands | |
| Molokai | Land,<br>Mainland and Foreign markets | |
| Maui | Other inputs,<br>Ag-based products &<br>processing technology,<br>Transportation,<br>Hawaii markets,<br>Mainland and Foreign Markets,<br>Lands | |
| Big Island | Land,<br>Others inputs<br>Ag-based products & | |



| | | |
|---|---|---|
| | Processing technology,<br>Transportation,<br>Hawaii markets,<br>Mainland and Foreign Markets, | |



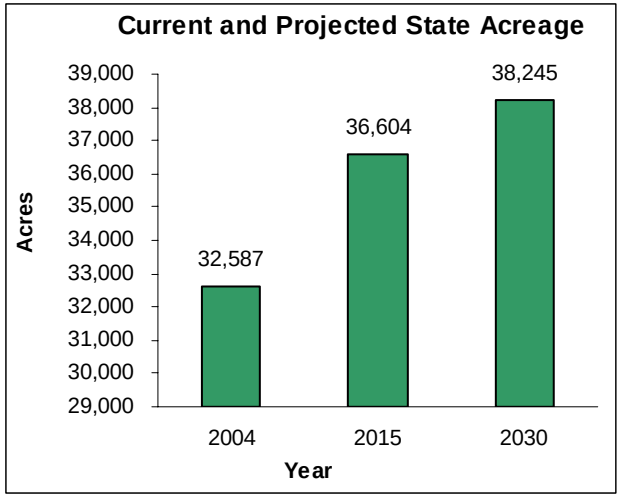

*Vote one letter in each yellow cell, either: G=major growth, m=minor growth, s=stable, d=minor decline, F=major decline

## FRUIT AND NUT TREE

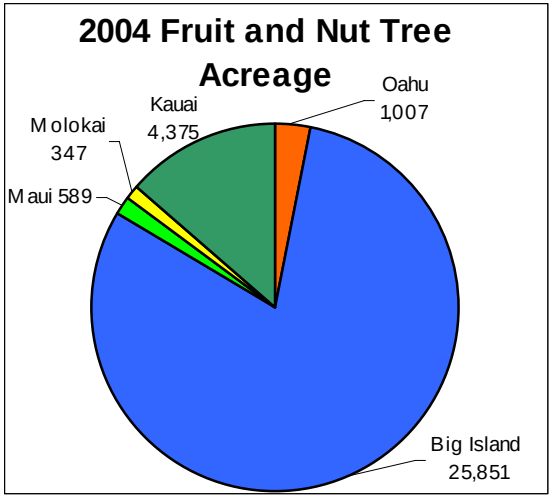
***Important Drivers for Fruit and Nut Trees***

Land, Water, Transportation, Ag.-Based products & processing technology, Hawaii Markets, and Mainland & Foreign Markets.

| **Island** | **Positive and Negative Agricultural Drivers** | **2030 Area*** |
|---|---|---|
| Kauai | Other inputs,<br>Ag-based products & processing technology,<br>Hawaii markets,<br>Mainland and Foreign Markets,<br>Lands | |
| Oahu | Other inputs,<br>Ag-based products & Processing technology,<br>Transportation,<br>Hawaii markets,<br>Mainland and Foreign Markets,<br>Lands | |
| Molokai | Land,<br>Mainland and Foreign markets | |
| Maui | Other inputs,<br>Ag-based products & processing technology,<br>Transportation,<br>Hawaii markets,<br>Mainland and Foreign Markets,<br>Lands | |
| Big Island | Land, | |



| | | |
|---|---|---|
| | Others inputs<br>Ag-based products &<br>Processing technology,<br>Transportation,<br>Hawaii markets,<br>Mainland and Foreign Markets, | |



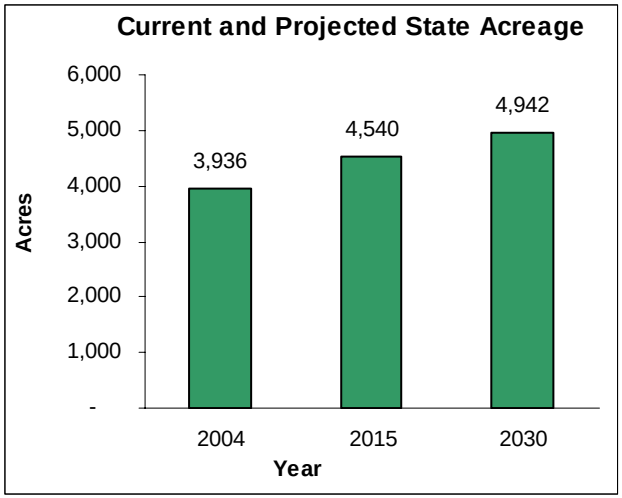

*Vote one letter in each yellow cell, either: G=major growth, m=minor growth, s=stable, d=minor decline, F=major decline

## FLORICULTURE & NURSERY

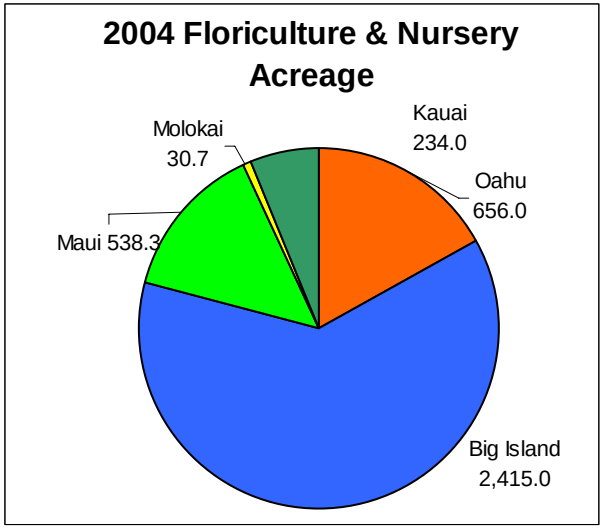
***Important Drivers for Floriculture & Nursery***

Land, Water, Transportation, and Mainland &Foreign Markets

| **Island** | **Positive and Negative Agricultural Drivers** | **2030 Area*** |
|---|---|---|
| Kauai | Other inputs,<br>Ag-based products & processing technology,<br>Hawaii markets,<br>Mainland and Foreign Markets,<br>Lands | |
| Oahu | Other inputs,<br>Ag-based products & Processing technology,<br>Transportation,<br>Hawaii markets,<br>Mainland and Foreign Markets,<br>Lands | |
| Molokai | Land,<br>Mainland and Foreign markets | |
| Maui | Other inputs,<br>Ag-based products & processing technology,<br>Transportation,<br>Hawaii markets,<br>Mainland and Foreign Markets,<br>Lands | |
| Big Island | Land,<br>Others inputs | |



| | | |
|---|---|---|
| | Ag-based products &<br>Processing technology,<br>Transportation,<br>Hawaii markets,<br>Mainland and Foreign Markets, | |



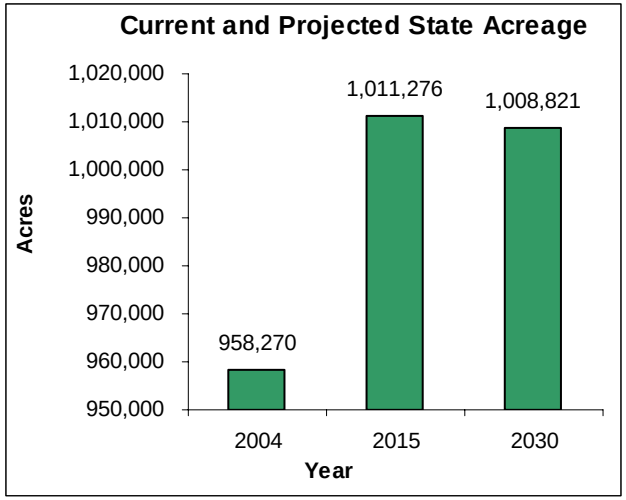

*Vote one letter in each yellow cell, either: G=major growth, m=minor growth, s=stable, d=minor decline, F=major decline

## PASTURE

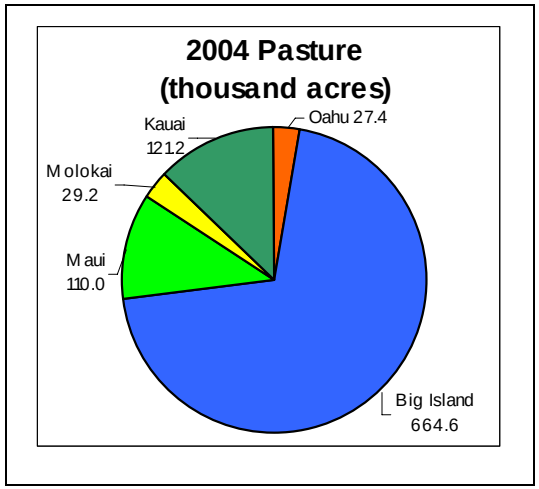
***Important Drivers for Pasture***

Land, Transportation, Hawaii Markets, and Mainland & Foreign Markets

| Island | Positive and Negative Agricultural Drivers | 2030 Area* |
|---|---|---|
| Kauai | Other inputs,<br>Ag-based products & processing technology,<br>Hawaii markets,<br>Mainland and Foreign Markets,<br>Lands | |
| Oahu | Other inputs,<br>Ag-based products & Processing technology,<br>Transportation,<br>Hawaii markets,<br>Mainland and Foreign Markets,<br>Lands | |
| Molokai | Land,<br>Mainland and Foreign markets | |
| Maui | Other inputs,<br>Ag-based products & processing technology,<br>Transportation,<br>Hawaii markets,<br>Mainland and Foreign Markets,<br>Lands | |
| Big Island | Land,<br>Others inputs<br>Ag-based products & | |



| | | |
|---|---|---|
| | Processing technology,<br>Transportation,<br>Hawaii markets,<br>Mainland and Foreign Markets, | |




* Vote one letter in each yellow cell, either: G=major growth, m=minor growth, s=stable, d=minor decline, F=major decline

*With this we have come to the end of Round 2. Please send your responses to the following address: (rchesler@hawaii.edu) by or before* **Monday, August 14th**. *Mahalo for your participation in Round 2.*

Fig. 5.B-3 Round 3 Questionnaire
NOTE: The Round 3 Appendix is not included here for the sake of brevity. The complete Round 3 questionnaire,
including its appendix is available on the CD-ROM accompanying this report ("Crops Delphi Round 3.doc").

# Crop Projections Delphi Survey for Hawaii's Agricultural Future: Round 3

## *Introduction*

Thank you for your prompt response to Round 2. The purpose of Round 3 is to project 2030 island crop acreages based on Round 2 quantitative growth rates. The results from Round 2 are summarized below.

Please return your completed Round 3 survey to rchesler@hawii.edu by or before **Thursday**, **September 7, 2006**. (The sooner they are completed, the sooner we are able to advance to the next round).

## *Expected Growth Rates*

In Round 2, you voted quantitative growth rates for two time periods, 2005-2015 and 2016-2030, for seven crop groups excluding crops grown exclusively for bioenergy. To review the distribution of Round 2 panelists' responses, click here. Round 2 responses include selected comments from Delphi panelists, presented in an appendix to this document. (You may have to hold down the Ctrl key and then left mouse-click to activate a link.) Some comments have been edited or paraphrased for clarity. After reading the comments and other results, please answer the questions posed in the following sections.

A different Delphi panel created three different macroeconomic scenarios for Hawaii agriculture to the year 2030: a most likely scenario, a pessimistic scenario, and an optimistic scenario. In Round 2, the mostly likely macroeconomic scenario was provided to assist in estimating average growth rates for Hawaii crop acreages. Click here to review a revised version of the most likely scenario. The average growth rates (excluding highest and lowest extreme values) for crop acreages are presented in the table on the next page.

To develop a better consensus by the panel, now we would like you to revote growth rates in Hawaii crop acreages under the mostly likely scenario by entering new rates in the yellow cells of the table on the next page. After that, we'll give you the pessimistic and optimistic macroeconomic scenarios. Then we'll ask you to assess the impact of estimated growth in crop acreages.

| Crop Group | Most Likely Scenario | | | |
|---|---|---|---|---|
| | Round 2 average growth rate 2005-2015 | Round 2 average growth rate 2016-2030 | Enter revised growth rate 2005-2015 | Enter revised growth rate 2016-2030 |
| Sugar | 0.9% | -0.1% | | |
| Pineapple | 0.1% | -0.4% | | |
| Seed Crops | 1.4% | 2.2% | | |
| Veg. & Melons | 1.5% | 1.8% | | |
| Fruit & Nut Trees | 1.3% | 1.1% | | |
| Nursery & Flowers | 1.4% | 1.1% | | |
| Pasture | 0.5% | 0.1% | | |

Please write any comments on estimating state average growth rates for the above crop groups in the box below.

## Other Macroeconomic Scenarios

In this section, we present alternative macroeconomic scenarios below in italics. These scenarios were developed by a separate Delphi group and represent optimistic and pessimistic views on the macroeconomic conditions for agricultural growth. Please read these passages and complete the table on page 4.

**Optimistic Scenario**: *Hawaii agriculture prospers with the establishment of a bioenergy industry and continued development of new tropical specialty crops. Rational planning and upgrades of local infrastructure, including new modes of transportation, improve transport of goods and the overall efficiency of marketing agricultural products. This revitalization of Hawaii agriculture feeds on strengths in the global economy. As the price of oil levels off and concerns about terrorist attacks fade, the American economy experiences accelerating growth, charged by high-tech investment and cyclical booms. Gradual depreciation in the U.S. dollar stimulates growth in exports including high-value agricultural products from Hawaii. It also spurs growth in Hawaii's visitor industry, especially an influx of upscale tourists. This fuels the demand for niche agricultural products. The local population grows at a moderate rate, enough to keep pace with labor demands. Increases in the cost of living in Hawaii slow and, given the strong economy, locals enjoy higher personal incomes. This sustains steady expansion in demand for locally produced agricultural products. Moderating prices for energy and other inputs are offset by rising wages. Overall, the expansion of Hawaii's agricultural sector outpaces the rest of the state's economy.*

**Pessimistic Scenario**: *The mainland economy endures long periods of little or no growth with sharp cyclical downturns. Volatility in the U.S. dollar creates uncertainty and hinders economic expansion through exports. Capital investment slows, further depressing the economy of the U.S. mainland and Hawaii. The price of oil continues its upward trend in the near-term period, with occasional spikes above $100 per barrel due to unpredictable supply and slow development of cheaper alternative energy sources. The global demand for vacation travel wavers with energy prices. Credible terrorist threats to high-profile tourism sites in Hawaii damage our image as a vacation destination. For Hawaii residents, increases in the cost of living outpace growth in earnings. Local lifestyles deteriorate from overcrowding and poor transportation due to inadequate public investment in infrastructure projects. In this depressed economic environment, Hawaii's farmers face serious challenges. Agricultural production and marketing costs rise due to higher prices for energy, and other inputs. This is compounded by problems of finding adequate water and farm workers. Competition from low-cost producers squeeze the profitability of local agribusiness. Growth in export markets for high-value agricultural products slows. Local sales of agricultural products falter and food imports increase. Hawaii's total agricultural output experiences a gradual decline through the year 2030.*

Now consider how much the optimistic scenario would increase the growth in acreage for different crops over the 2005-2030 period, and how much the pessimistic scenario would decrease growth in crop acreages. In the table on the next page (p. 4), enter a letter in the yellow cells to indicate that you would expect these alternative scenarios would cause:

S = minor change in the annual growth rate (less than half a percentage point)
M = moderate change in the annual growth rate (one-half to one percentage point)
L = large change in the annual growth rate (more than one percentage point).

| **Crop Group** | **Change in Acreage Growth Rate with Alternative Scenarios** (Please enter S, M or L) |
|---|---|
| Sugar | |
| Pineapple | |
| Seed Crops | |
| Veg. & Melons | |
| Fruit & Nut Trees | |
| Nursery & Flowers | |
| Pasture | |

In the box below we would like you to type any comments on the impact to acreage growth from the alternative macroeconomic scenarios. For example, do you feel that the upside effect from the Optimistic scenario is greater than the downside from the Pessimistic scenario? Do you expect differences between the near-term (next 10 years) and long-term (next 25 years) periods? Would particular islands be more affected by the Optimistic or Pessimistic outcomes?

**Comments**:

## *Location of Hawaii Agriculture*

In Round 2, the panel voted on the likely locations for growth or decline in state crop acreages by island. Your qualitative responses were used to estimate the change in state acreage attributed to different islands. Click here to read more about the estimation method.

In the following pages, we'll go through each of the seven crop groups again. We present graphs with Round 2 results on the projected statewide acreage to 2030, and the likely islands for projected growth/decline in area. After that, there's a table showing the percentage distribution of the growth/decline in acreage by island, estimated from your Round 2 responses. We ask you to revote the percentages in the yellow cells of the table. Do not enter a "%" sign—use the numbers only. If you think that acreage changes will go in opposite directions on different islands, you can enter both positive and negative values.

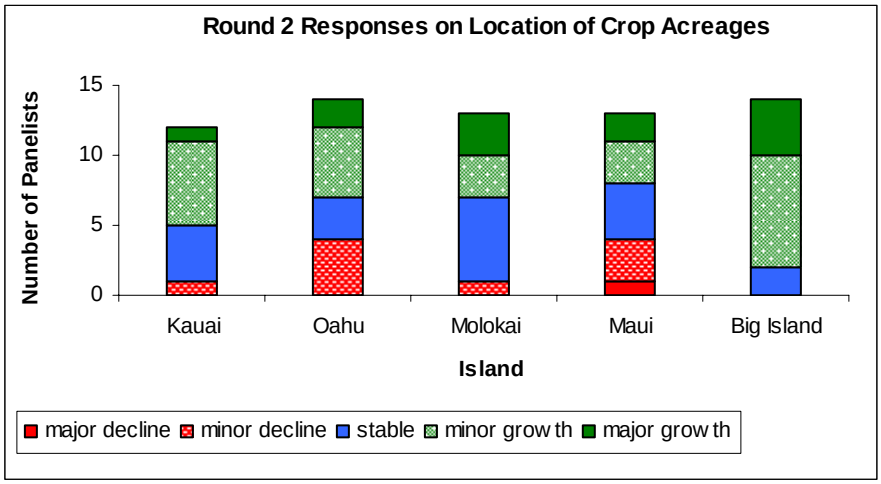
The island percentages should sum to 100% for a given crop, thus accounting for total change in state acreage. The lower right-most cell of the table (red cell) computes the total of the percentage values you enter into the yellow cells. After entering your percentage values in the yellow cells, you can activate the total function by:

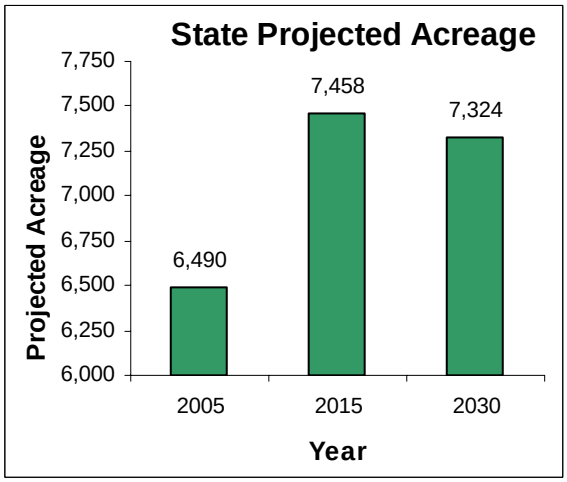
- clicking the "0.00" within the red cell to access the automated field, and then
- pressing the F9 function key (or right-click and select "Update Field") to recompute percentage total.

You do not have to use this feature if you don't want to. The total is to assist you in assigning percentages which add up to 100%.

After voting the island location of 2030 acreage for the seven crop groups, there's a comment box for you to enter any thoughts you might have about this exercise. When you've finished, please return the completed survey to **rchesler@hawaii.edu** by **Thursday**, **September 7**, **2006**. Thank you for your continued participation.

## VEGETABLES AND MELONS

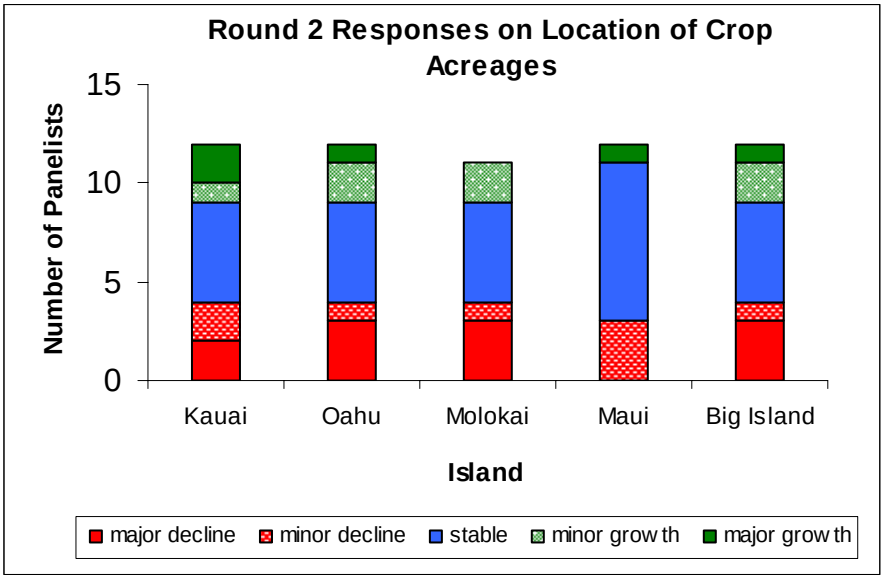


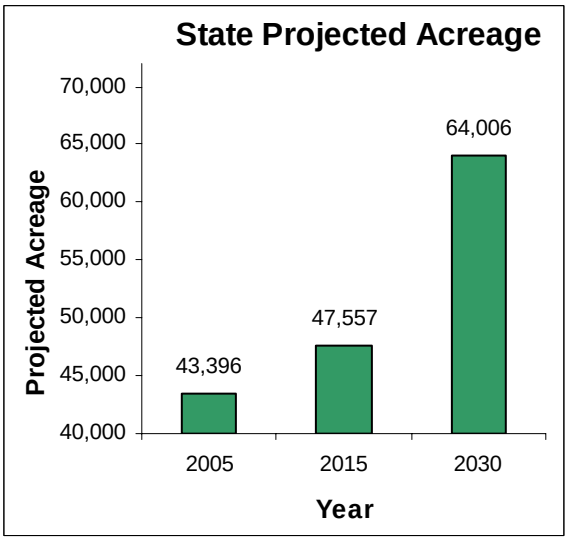




Please revote on a revised average of future acreage distribution by island for this crop group in the yellow cells.

| **Island** | **Round 2 Average Allocation of Growth/Decline in State Acreage** | **Revote Allocation** Note: Enter numbers only—do not enter a "%" sign. |
|---|---|---|
| Kauai | 20% | |
| Oahu | 13% | |
| Molokai | 22% | |
| Maui | 5% | |
| Big Island | 40% | |
| Updated red cell should sum to 100 | | |

## SUGARCANE

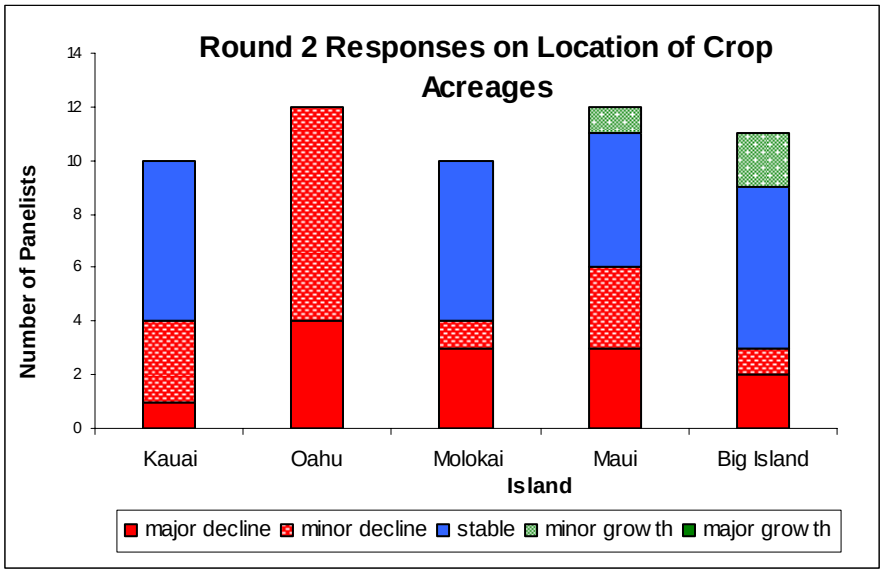


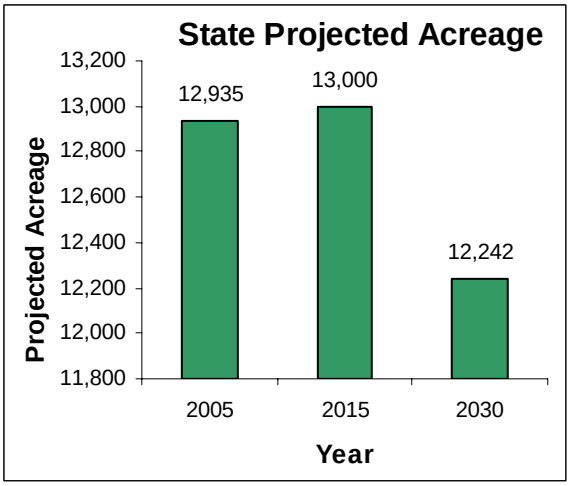




Please revote on a revised average of future acreage distribution by island for this crop group in the yellow cells.

| **Island** | **Round 2 Average Allocation of Growth/Decline in State Acreage** | **Revote Allocation** Note: Do not use a "%" sign.. |
|---|---|---|
| Kauai | 7% | |
| Oahu | 22% | |
| Molokai | 41% | |
| Maui | 7% | |
| Big Island | 22% | |
| Updated red cell should sum to 100 | | |

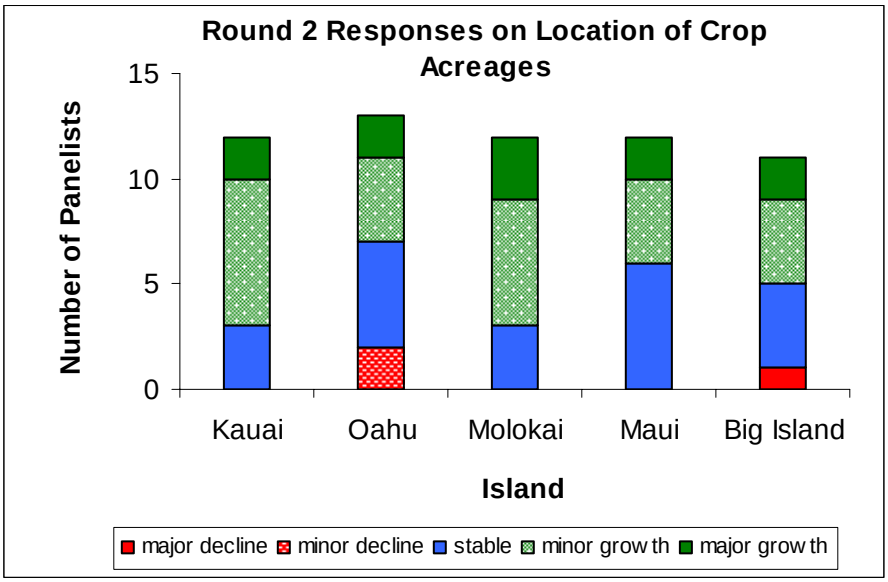
## PINEAPPLE

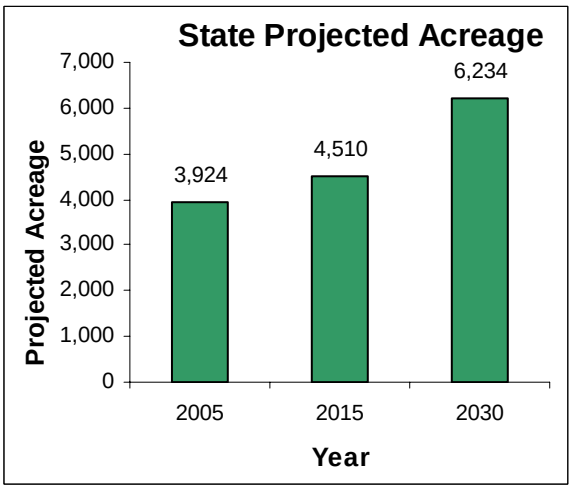



| Island | Round 2 Average Allocation of Growth/Decline in State Acreage | Revote Allocation<br>Note: Enter numbers only—do not enter a "%" sign. |
|---|---|---|
| Kauai | 14% | |
| Oahu | 38% | |
| Molokai | 20% | |
| Maui | 19% | |
| Big Island | 8% | |
| Updated red cell should sum to 100: | | 0.00 |

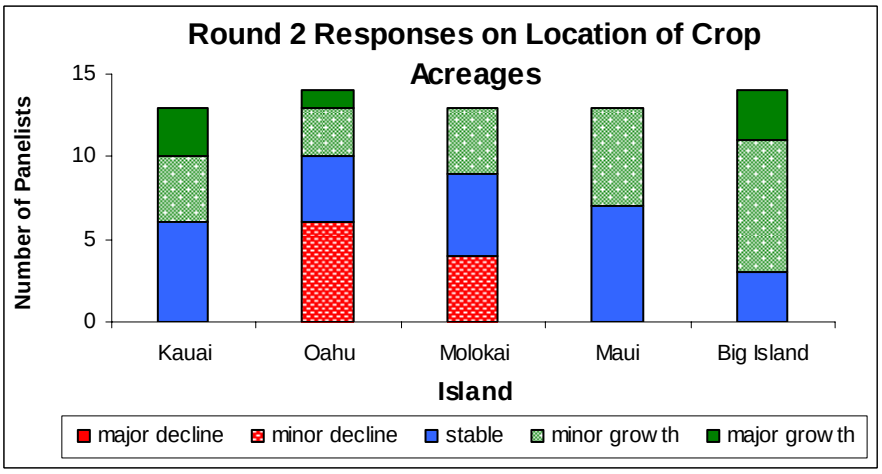
## SEED CROPS

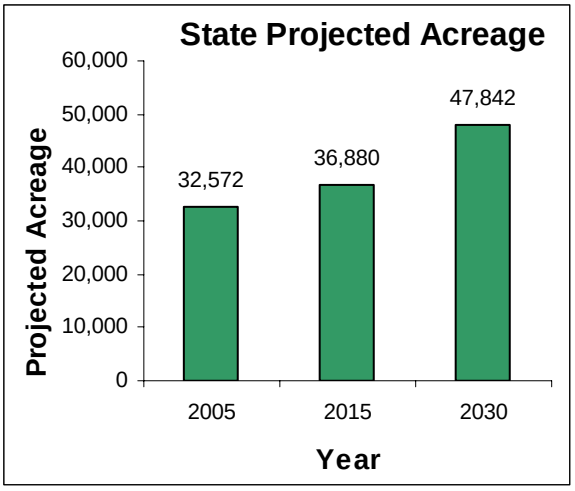



| Island | Round 2 Average Allocation of Growth/Decline in State Acreage | Revote Allocation<br>Note: Enter numbers only—do not enter a "%" sign. |
|---|---|---|
| Kauai | 26% | |
| Oahu | 13% | |
| Molokai | 28% | |
| Maui | 19% | |
| Big Island | 15% | |
| Updated red cell should sum to 100: | | 0.00 |

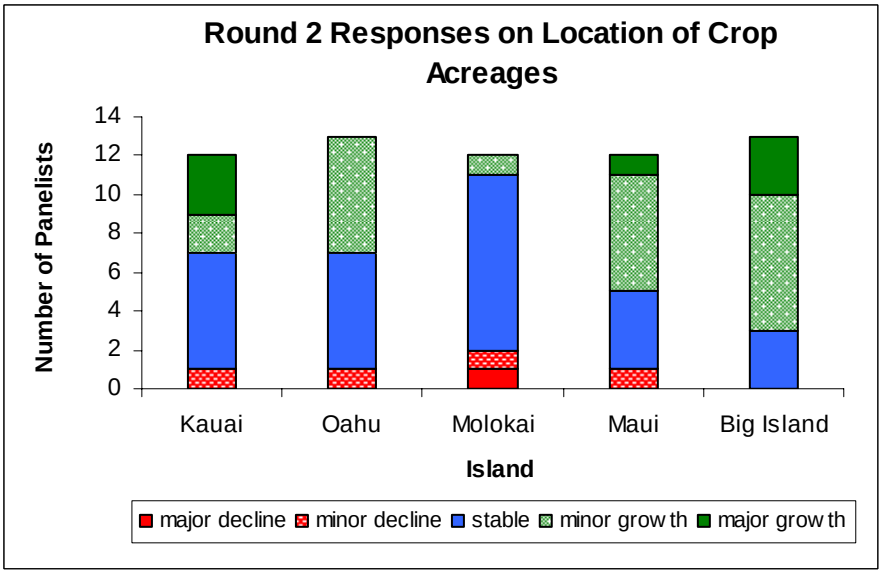
## FRUIT AND NUT TREE

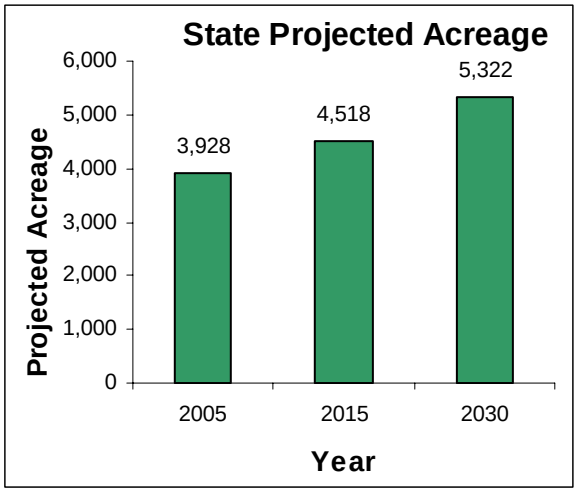



| Island | Round 2 Average Allocation of Growth/Decline in State Acreage | Revote Allocation<br>Note: Enter numbers only—do not enter a "%" sign. |
|---|---|---|
| Kauai | 36% | |
| Oahu | -3% | |
| Molokai | 0% | |
| Maui | 21% | |
| Big Island | 46% | |
| Updated red cell should sum to 100 | | |

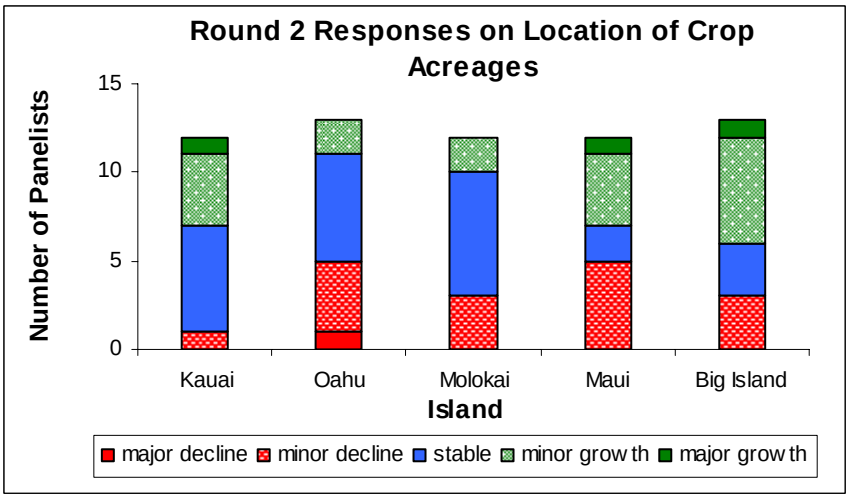
## FLORICULTURE & NURSERY

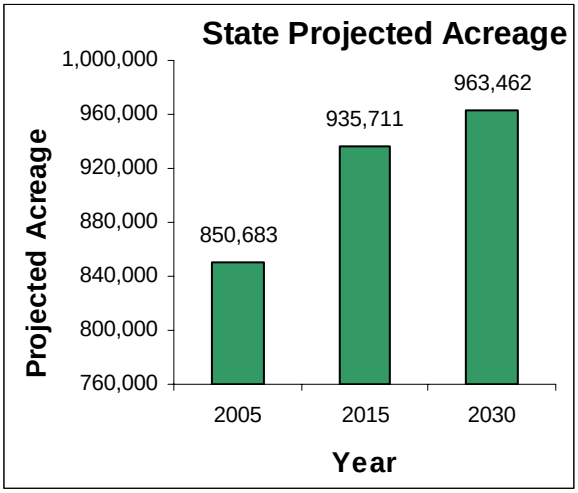



| Island | Round 2 Average Allocation of Growth/Decline in State Acreage | Revote Allocation<br>Note: Enter numbers only—do not enter a "%" sign. |
|---|---|---|
| Kauai | 25% | |
| Oahu | 16% | |
| Molokai | -7% | |
| Maui | 25% | |
| Big Island | 42% | |
| Updated red cell should sum to 100 | | |

## PASTURE




| Island | Round 2 Average Allocation of Growth/Decline in State Acreage | Revote Allocation<br>Note: Enter numbers only—do not enter a "%" sign. |
|---|---|---|
| Kauai | 84% | |
| Oahu | -62% | |
| Molokai | -17% | |
| Maui | 17% | |
| Big Island | 78% | |
| Updated red cell should sum to 100: | | 0.00 |

Please write any comments you have regarding estimating the allocation of future acreage to different islands in the box below.

| **Comments:** |
| --- |
| |

*With this we have come to the end of Round 3. Please send your responses to rchesler@hawaii.edu by or before* **Thursday, September 7, 2006**. *Mahalo for your participation in Round 3.*

Fig. 5.B-4 Round 4 Questionnaire
NOTE: The Round 4 Appendix is not included here for the sake of brevity. The complete Round 2 questionnaire,
including its appendix is available on the CD-ROM accompanying this report ("Crops Delphi_Round4.doc").

## Crop Projections Delphi Survey for Hawaii's Agricultural Future: Round 4

### Introduction

Thank you for your prompt response to Round 3. Following up on the last round's results, we will ask for input on the crop average growth rates, the projected acreage according to our macro-scenarios, and the crop acreage distribution by island and selected irrigation systems. Where there has been significant convergence, we will ask for a validation vote. Where there hasn't been significant convergence, we will ask for a revised vote. Please return your completed Round 4 survey to rchesler@hawii.edu by or before Monday, **January 29, 2007**.

### *1. Validation of Expected Growth Rates for State Acreages*

In Round 3, you were asked to revote quantitative growth rates in agricultural acreages for seven crop groups (excluding any crops grown exclusively for bioenergy) over two time periods (2005-2015 and 2016-2030) under a most likely macroeconomic scenario. The averages of your responses were used to project state crop acreages to the year 2030. Review appendix graphs of the acreage projections by clicking here. (You may have to hold down the Ctrl key and then left mouse-click to activate a link). Selected panelist comments from Round 3 are also presented in the appendix.

In this section, we ask you to validate the Round 3 average growth rates. Review the results in the table below and vote in the yellow cells by placing an "R" if the growth rates for a given crop group are about right, an "H" if they are too high, or an "L" if they are too low. If you think the rates are too high or too low, please type a comment in the far right column of the table explaining your reasons.

| **Crop Type** | **Average Growth Rate** | | **Validation Vote (R,H,L)** | **Comment:** If you indicated that the growth was too high or too low, please explain**.** |
|---|---|---|---|---|
| | **2005-2015** | **2016-2030** | | |
| **Sugar** | 0.9% | 0.1% | | |
| **Pineapple** | -0.1% | -0.3% | | |
| **Vegetables & Melons** | 1.9% | 2.3% | | |
| **Seed Crops** | 1.7% | 1.8% | | |
| **Fruit & Nut trees** | 1.7% | 1.4% | | |
| **Floriculture & Nursery** | 1.6% | 1.3% | | |
| **Pasture** | 0.4% | 0.4% | | |

### *2. Macroeconomic Scenarios*

In Round 3, we presented alternative (optimistic and pessimistic) macroeconomic scenarios for Hawaii agriculture and asked you to assess the impact on acreage growth rates for the seven crop groups. A graph of panel responses is given in the appendix. The median Round 3 responses were used to estimate a range in projected 2030 crop acreages under the different scenarios.

In this section, we ask you to validate the projected crop acreage ranges. Review the results in the table below and vote in the yellow cells by placing an "R" if the acreage range for a given crop group is about right, an "L" if it's too large, or an "S" if it's too small. If you think a range is too large or too small, please type a comment in the far right column of the table explaining your reasons.

| **Crop Type** | **Projected 2030 Acreage** | | | **Validation Vote (R,L,S)** | **Comment:**If you indicated that the growth was too high or too low, please explain**.** |
|---|---|---|---|---|---|
| | **Pessimistic** | **Most Likely** | **Optimistic** | | |
| **Sugar** | 42,119 | 47,956 | 54,566 | | |
| **Pineapple** | 10,816 | 12,325 | 14,035 | | |
| **Vegetable & Melons** | 8,879 | 10,092 | 11,464 | | |
| **Seed Crops** | 5,877 | 6,677 | 7,581 | | |

| | | | | | |
|---|---|---|---|---|---|
| **Fruit & Nut Trees** | 41,666 | 47,374 | 53,831 | | |
| **Floriculture & Nursery** | 4,865 | 5,532 | 6,287 | | |
| **Pastures** | 928,951 | 1,057,704 | 1,203,527 | | |

### *3. Acreage Projections and Allocation Shares by Island*

Due to a lack of convergence in the preceding rounds for sugar, pineapple and pasture acreage, this section asks you to revote on the crop share allocation by island for these groups. See Graphs 4, 5, 6 in the Appendix for acreage projections by island. The *Low* and *High* values are the boundaries demarcating the middle half. The *Mean* has been calculated excluding extreme values.

| Crop | | Kauai | Maui | Molokai | Oahu | Big Island | Comment |
|---|---|---|---|---|---|---|---|
| **Sugar** | *Low* | 10% | 5% | 0% | 10% | 0% | |
| | *High* | 20% | 20% | 40% | 22% | 22% | |
| | *Mean* | 19% | 20% | 27% | 19% | 16% | |
| **Revote on Share Allocation** | | | | | | | |
| **Pineapple** | *Low* | 6% | 19% | 10% | 23% | 4% | |
| | *High* | 14% | 44% | 20% | 40% | 10% | |
| | *Mean* | 11% | 32% | 14% | 34% | 8% | |
| **Revote on Share Allocation** | | | | | | | |
| **Pasture** | *Low* | 10% | 0% | -4% | -14% | 45% | |
| | *High* | 57% | 15% | 10% | 10% | 75% | |
| | *Mean* | 33% | 9% | 4% | -2% | 56% | |
| **Revote on Share Allocation** | | | | | | | |

Since there was greater consensus for the crop groups below, we would like you to validate the mean share by placing an "R" in the yellow cell if they are about right, "H" if they are too high, or "L" if they are too low. If you think a range is too large or too small, please type a comment in the far right column of the table explaining your reasons.

| Crop | Kauai | Maui | Molokai | Oahu | Big Island | Comment |
|---|---|---|---|---|---|---|
| **Veg. and Melons** | 19% | 7% | 20% | 17% | 37% | |
| **Validate (R,H,L)** | | | | | | |
| **Seed Crops** | 26% | 18% | 25% | 16% | 15% | |
| **Validate (R,H,L)** | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Fruit and Nuts** | 28% | 16% | 4% | 4% | 49% | |
| **Validate (R,H,L)** | | | | | | |
| **Flor. and Nursery** | 22% | 18% | 3% | 14% | 43% | |
| **Validate (R,H,L)** | | | | | | |

### *4. Estimating Distribution of Crop Acreages for Selected Irrigation Systems*

This phase of the state agricultural water plan focuses on ten irrigation systems, public and private. They are spread across five of the state's islands and vary in size, cultivation, and operational maintenance. You can view the systems, their scores and the methods used to formulate the scores in the appendix.

On the following pages, we provide:
1. Island Maps,
2. Projected Crop Acreages by Island (using Round 3 means),
3. Studied Irrigation Systems and their Scores.

We are asking you to vote on the crop acreage distribution in order to project island acreages by the irrigation systems in this study.

Please use this information to vote on the crop acreage distribution among the irrigation systems (yellow cells). Please use the following qualitative voting key:

G =major location for growth in crop acreage (35% of island or more)
m =minor location for growth in crop acreage (10% to 34% of island)
d =minor location for decline in crop acreage (-11% to -34% of island)
F =major location for decline in crop acreage (-35% of island or more)
Leave blank for relatively stable acreage (-10% to +10% of island)

The maximum score for an irrigation system is 100. The minimum is 0.

## PROJECTED CROP ACRES

| Kauai | 2004 | 2030 |
|---|---|---|
| Pasture | 121,200 | 157,872 |
| Sugar | 8,200 | 8,886 |
| Pineapple | 11 | -51* |
| Fruit and Nut Trees | 4,375 | 8,654 |
| Vegetables and Melons | 300 | 992 |
| Seed Crops | 1,290 | 2,006 |
| Floriculture and Nursery | 234 | 594 |

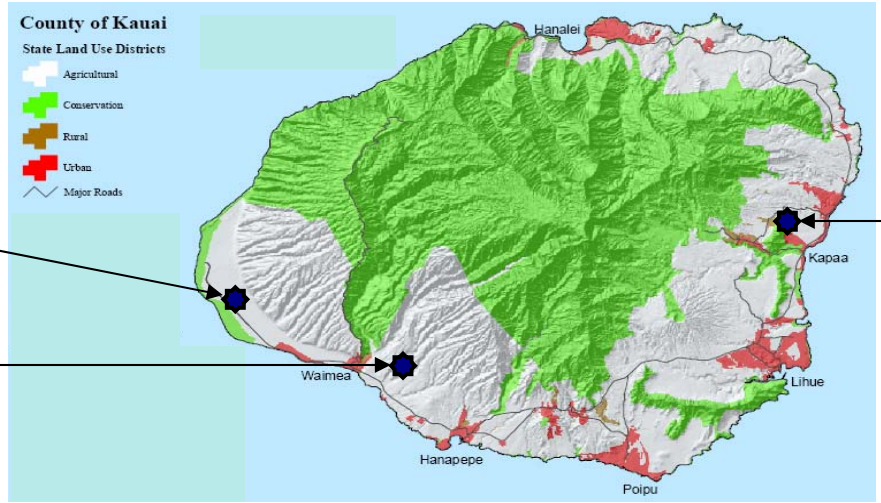
* Projected negative acreage reflects Round 3 acreage and island share responses.

| Irr. System (Score) | Pasture | Sugar | Pineapple | Fruit and Nut Trees | Veg. and Melons | Seed Crops | Flor. and Nursery |
|---|---|---|---|---|---|---|---|
| **Kekaha (69)** | | | | | | | |
| **Kauai Coffee (69)** | | | | | | | |
| **East Kauai (63)** | | | | | | | |

Vote one letter in each yellow cell, either: G=major growth, m=minor growth, d=minor decline, F=major decline. Leave blank if you project stable growth.

**KEKAHA**
Irrigable Acres: 6,517
Current Cultivated Acres: 6,517
Main Crops: seed corn, sugar

**KAUAI COFFEE**
Irrigable Acres: 4,384
Current Cultivated Acres: 3,896
Main Crops: Coffee




**EAST KAUAI**
Irrigable Acres: 5,907
Current Cultivated Acres: 1,530
Main Crops: nursery

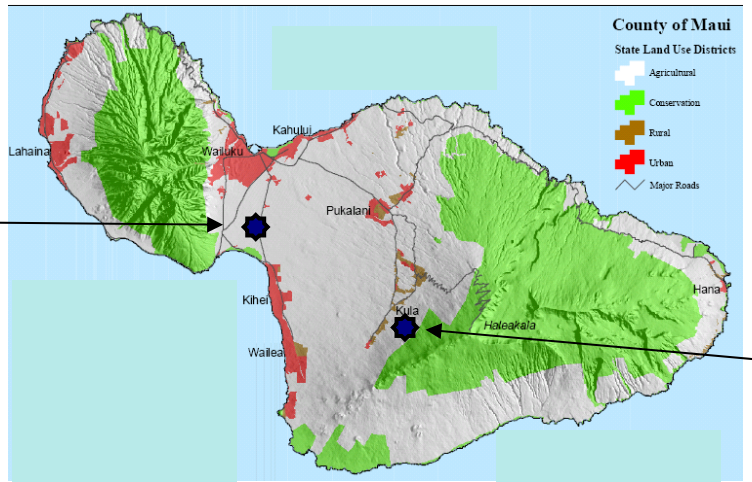
## PROJECTED CROP ACREAGE

| Maui | 2004 | 2030 |
|---|---|---|
| Pasture | 110,000 | 118,599 |
| Sugar | 34,800 | 35,494 |
| Pineapple | 5,400 | 5,187 |
| Fruit and Nut Trees | 589 | 2,956 |
| Vegetables and Melons | 900 | 1,174 |
| Seed Crops | 500 | 1,011 |
| Floriculture and Nursery | 538 | 841 |

| Irr. System (Score) | Pasture | Sugar | Pineapple | Fruit and Nut Trees | Veg. and Melons | Seed Crops | Flor. and Nursery |
|---|---|---|---|---|---|---|---|
| **West Maui (68)** | | | | | | | |
| **Upcountry Maui (61)** | | | | | | | |

Vote one letter in each yellow cell, either: G=major growth, m=minor growth, d=minor decline, F=major decline. Leave blank if you project stable growth.

**WEST MAUI**
Irrigable Acres: 6,341
Current Cultivated Acres: 6,322
Main Crops: sugar




**UPCOUNTRY MAUI**
Irrigable Acres: 1,473
Current Cultivated Acres: 402
Main Crops: nursery, vegetables and melons

## PROJECTED CROP ACRES

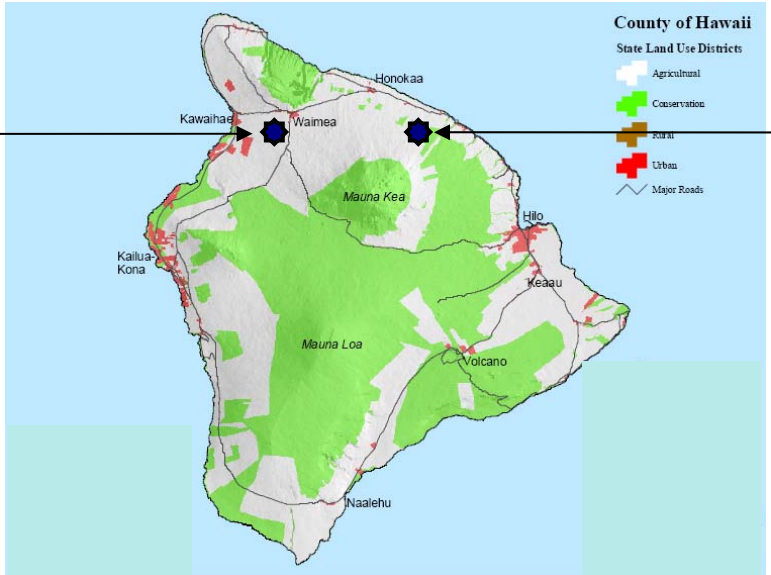
| Big Island | 2004 | 2030 |
|---|---|---|
| Pasture | 664,600 | 724,648 |
| Sugar | 0 | -232* |
| Pineapple | 18 | -36* |
| Fruit and Nut Trees | 25,852 | 33,226 |
| Vegetables and Melons | 1,600 | 2,972 |
| Seed Crops | 0 | 423 |
| Floriculture and Nursery | 2,415 | 3,139 |

* Projected negative acreage reflects Round 3 acreage and island share responses.

| Irr. System (Score) | Pasture | Sugar | Pineapple | Fruit and Nut Trees | Veg. and Melons | Seed Crops | Flor. and Nursery |
|---|---|---|---|---|---|---|---|
| **Waimea (77)** | | | | | | | |
| **Lower Hamakua (64)** | | | | | | | |

Vote one letter in each yellow cell, either: G=major growth, m=minor growth, d=minor decline, F=major decline. Leave blank if you project stable growth.

**WAIMEA**
Irrigable Acres: 1,312
Current Cultivated Acres: 739
Main Crops: nursery, vegetables and melons




**LOWER HAMAKUA**
Irrigable Acres: 4,215
Current Cultivated Acres: 307
Main Crops: pasture, fruits and nuts, vegetables and melons

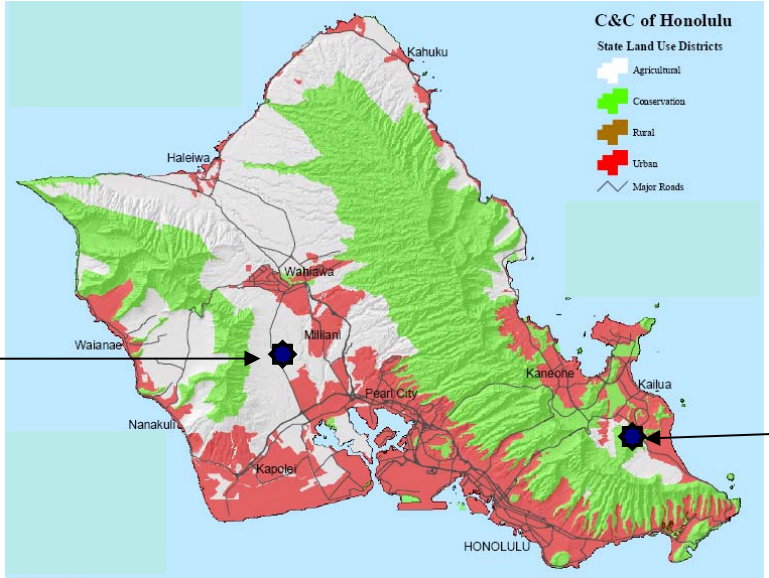
## PROJECTED CROP ACREAGE

| Oahu | 2004 | 2030 |
|---|---|---|
| Pasture | 27,400 | 23,019 |
| Sugar | 0 | 1,655 |
| Pineapple | 7,500 | 7,311 |
| Fruit and Nut Trees | 1,007 | 1,648 |
| Vegetables and Melons | 3,400 | 4,031 |
| Seed Crops | 855 | 1,304 |
| Floriculture and Nursery | 656 | 894 |

| Irr. System (Score) | Pasture | Sugar | Pineapple | Fruit and Nut Trees | Veg. and Melons | Seed Crops | Flor. and Nursery |
|---|---|---|---|---|---|---|---|
| **Waiahole (71)** | | | | | | | |
| **Waimanalo (56)** | | | | | | | |

Vote one letter in each yellow cell, either: G=major growth, m=minor growth, d=minor decline, F=major decline. Leave blank if you project stable growth.

**WAIAHOLE**
Irrigable Acres: 5,927
Current Cultivated Acres: 4,004
Main Crops: seed corn, vegetables and melons, pineapple




**WAIMANALO**
Irrigable Acres: 1,455
Current Cultivated Acres: 806
Main Crops: nursery, vegetables and melons

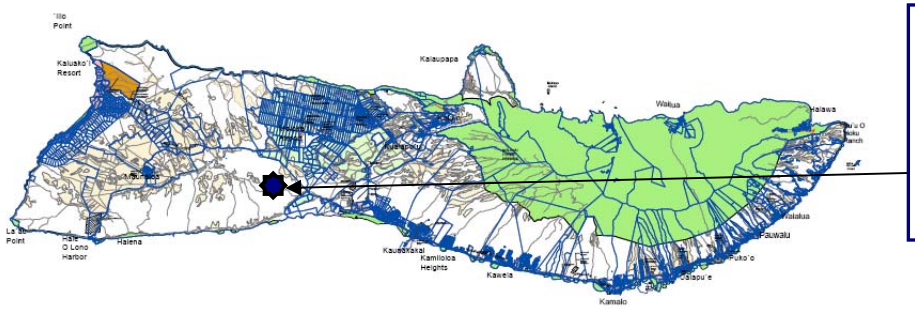
**PROJECTED CROP ACREAGE**

| Molokai | 2004 | 2030 |
|---|---|---|
| Pasture | 29,200 | 33,566 |
| Sugar | 0 | 2,152 |
| Pineapple | 0 | -85* |
| Fruit and Nut Trees | 347 | 890 |
| Vegetables and Melons | 200 | 923 |
| Seed Crops | 1,225 | 1,933 |
| Floriculture and Nursery | 31 | 74 |

* Projected negative acreage reflects Round 3 acreage and island share responses.

| Irr. System (Score) | Pasture | Sugar | Pineapple | Fruit and Nut Trees | Veg. and Melons | Seed Crops | Flor. and Nursery |
|---|---|---|---|---|---|---|---|
| Molokai (65) | | | | | | | |

Vote one letter in each yellow cell, either: G=major growth, m=minor growth, d=minor decline, F=major decline. Leave blank if you project stable growth.



**MOLOKAI IRRIGATION SYSTEM**
Irrigable Acres: 9,725
Current Cultivated Acres: 3212
Main Crops: coffee, seed crops

Thank you very much for your participation! Please return your completed Round 4 survey to rchesler@hawii.edu by or before Monday, **January 29, 2007**.

Fig. 5.B-5 Round 5 Questionnaire
NOTE: The Round 5 Appendix is not included here for the sake of brevity. The complete Round 5 questionnaire, including its appendix is available on the CD-ROM accompanying this report ("Crops_Delphi_Round_5.doc").

# Crop Projections Delphi Survey for Hawaii's Agricultural Future: Round 5

## Introduction

Thank you for your prompt response to Round 4. This is the final round of the Hawaii Crops Delphi Survey. The first section requests background information from the panelists which will be kept confidential. Then, following up on Round 4's results, we will ask for input on the completed sections, the crop acreage distribution by island and irrigation system, and the expected change if the irrigation systems were rehabilitated.

Please return your completed Round 5 survey to rchesler@hawii.edu by or before **March 16, 2007**.

## *1. Questions to Conclude the Crops Delphi Survey*

1. This survey is part of a study being conducted for the Hawaii Dept. of Agriculture and the state Commission on Water Resource Management. In the final report for the study, we would like to list your name as a participant in the survey, along with your position and the organization that you work for. (Note: Your answers to the survey are completely confidential and will not be associated with your name.) Please answer "**yes**" or "**no**" in the box below if you will or will not allow your name to be listed in our report:

| List you in report? Enter yes or no: |
|---|

2. How many years have you worked in Hawaii in areas related to this survey? [ ]

3. In these years in Hawaii, type an **X** in the boxes below for all the crops you have worked with and type the exact crop where appropriate on the line provided:

| | | |
|---|---|---|
| Sugar: | | |
| Pineapple: | | |
| Fruits: | | |
| Nuts: | | |
| Veg. and Melons: | | |
| Seed Crops: | | |
| Floriculture: | | |
| Nursery: | | |
| Animal: | | |
| Other: | | |

4. Throughout your time in Hawaii working in agriculture and related areas, in the boxes below place a ***C*** for all that applies to your current agribusiness capacity and a ***P*** for past agribusiness capacities:

| | |
|---|---|
| Executive | |
| Finance | |
| Accounting | |
| Marketing and Sales | |
| Development | |
| Research | |
| Extension and Outreach | |
| Agricultural Industry/Association | |
| Government | |
| Planning and Development Organization | |
| Non-Profit | |
| Farm Production and Operations | |
| Processing | |
| Other | |

4. Final Comments on this Delphi Survey:
5.

### *2. Comments on Completed Sections*

In the past rounds, particularly Round 4, you were asked to vote on and validate expected growth rates, growth rate changes under different macroeconomic scenarios, and crop allocation shares by island. In this section, we ask you to make any final comments on the accuracy, validity or other aspects of the survey outcome summary. Selected panelist comments from Round 4 are presented in the appendix. Results from Round 4 for each of the questions are also available in the appendix, which you can reach by clicking on the links in the table below.

| **Question** | **Survey Outcome Summary** | **Comments:** Please comment on the accuracy, validity, or other aspects of the survey outcome summary. |
|---|---|---|
| **Expected Growth Rates (Growth Rates)** | There has been significant convergence among the Delphi panelists for the expected growth rates. There is still some spread of opinion for sugar growth. Various respondents think that the expected growth rates for vegetables and melons, and for floriculture and nursery to be too small. | |
| **Growth Rates Under Macroeconomic Scenarios (Macro Scenarios)** | There has been significant convergence among the Delphi panelists for the changes in growth rates under the different macroeconomic scenarios. There is still some spread of opinion for sugar and seed crop. | |
| **Crop Allocation Shares by Island (Crop Share)** | There has been significant convergence among the Delphi panelists for crop allocation shares by island. There still some spread of opinion for seed crop allocation on the Big Island. | |

### *3. Validation on Share Allocation for Sugar, Pineapple and Pasture*

In Round 4, we asked you to revote on the crop allocation shares for sugar, pineapple and pasture. We have taken the average of these allocation share votes to project the acreage for each of the islands in the box below. We ask in this section for you to validate the projected acreage by island by placing an "R" in the yellow cell if they are about right, "H" if they are too high, or "L" if they are too low. If you think a projected acreage is too large or too small, please type a comment in the far right column of the table explaining your reasons.

| **Crop** | **Island** | **2005*** | **2015*** | **2030*** | **Validate (R,H,L)** | **Comments:** If you indicated that the allocation share was too high or too low, please explain**.** |
|---|---|---|---|---|---|---|
| **Sugar** | Kauai | 8,290 | 9,239 | 9,340 | | |
| | Oahu | 39 | 452 | 496 | | |
| | Molokai | 31 | 361 | 396 | | |
| | Maui | 34,992 | 37,014 | 37,228 | | |
| | Big Island | 39 | 452 | 496 | | |
| **Pineapple** | Kauai | 10 | 0 | 0 | | |
| | Oahu | 7,497 | 7,464 | 7,337 | | |
| | Molokai | 0 | 0 | 0 | | |
| | Maui | 5,394 | 5,338 | 5,116 | | |
| | Big Island | 17 | 10 | 0 | | |
| **Pasture** | Kauai | 122,090 | 131,206 | 144,367 | | |
| | Oahu | 27,683 | 30,584 | 34,771 | | |
| | Molokai | 29,524 | 32,839 | 37,624 | | |
| | Maui | 110,526 | 115,913 | 123,690 | | |
| | Big Island | 666,624 | 687,342 | 717,252 | | |

* "0" represents small projected negative acreage, which reflects Rounds 3 and 4 acreage and island share responses.

### *4. Validating the Distribution of Crop Acreages for Selected Irrigation Systems*

Your qualitative assessments of crop acreage growth from Round 4 were translated into quantitative projected acreage based on the following conversion system:

Major Decline = - 44%
Minor Decline = - 22%
Stable= 0%
Minor Growth = 22%
Major Growth = 44%

We took the average for each system and projected acreage for the year 2030, using the projected acreage by respective island. (We took the liberty to remove those votes that projected negative growth for currently non-existing acreage.) In this section we ask you to validate these projected acreages for each of the studied irrigation systems without rehabilitation. You can view the systems, their scores and the methods used to formulate the scores in the appendix. A map of the systems is also available in the appendix.

We ask in this section for you to validate the acreage projections by placing an “R” in the yellow cell if they are about right, “H” if they are too high, or “L” if they are too low. If you think a range is too large or too small, please type a comment in the far right column of the table explaining your reasons.

# Kauai

*Change in Acreage from 2005 to 2030*

| Irrigation System | Crops | 2005* | 2015* | 2030* | Validate (R,H,L) | **Comments:** If you indicated that the change in acreage was too high or too low, please explain. |
|---|---|---|---|---|---|---|
| **Kekaha** | Pasture | 157 | 1,604 | 2,316 | | |
| | Sugar | -4 | -42 | -4 | | |
| | Pineapple | 0 | 1 | 6 | | |
| | Fruit and Nut | 33 | 368 | 540 | | |
| | Veg. and Melons | 1 | 10 | 19 | | |
| | Seed Crops | 6 | 63 | 152 | | |
| | Flor. and Nursery | 0 | 0 | 0 | | |
| | **Total Acreage** | 193 | 2,005 | 3,029 | | |
| **Kauai Coffee** | Pasture | 0 | 0 | -2 | | |
| | Sugar | 20 | 221 | 324 | | |
| | Pineapple | 1 | 10 | 19 | | |
| | Fruit and Nut | 3 | 36 | 87 | | |
| | Veg. and Melons | 1 | 12 | 18 | | |
| | Seed Crops | 156 | 1,624 | 2,220 | | |
| | Flor. and Nursery | 14 | 141 | 204 | | |
| | **Total Acreage** | 195 | 2,044 | 2,870 | | |
| **East Kauai** | Pasture | 0 | 0 | -2 | | |
| | Sugar | 20 | 221 | 324 | | |
| | Pineapple | 0 | 0 | 0 | | |
| | Fruit and Nut | 3 | 36 | 87 | | |
| | Veg. and Melons | 2 | 25 | 36 | | |
| | Seed Crops | 52 | 541 | 740 | | |
| | Flor. and Nursery | 34 | 353 | 510 | | |
| | **Total Acreage** | 112 | 1,175 | 1,695 | | |

* Projected negative acreage reflects Rounds 3 and 4 acreage and island share responses.

# Oahu

*Change in Acreage from 2005 to 2030*

| Irrigation System | Crops | 2005 | 2015* | 2030* | Validate (R,H,L) | **Comments:** If you indicated that the change in acreage was too high or too low, please explain. |
|---|---|---|---|---|---|---|
| **Waiahole** | Pasture | 37 | 383 | 553 | | |
| | Sugar | -2 | -18 | -2 | | |
| | Pineapple | 0 | 0 | 0 | | |
| | Fruit and Nut | 1 | 11 | 16 | | |
| | Veg. and Melons | 6 | 64 | 124 | | |
| | Seed Crops | 3 | 34 | 81 | | |
| | Flor. and Nursery | 0 | 4 | 6 | | |
| | **Total Acreage** | 46 | 478 | 778 | | |
| **Waimanalo** | Pasture | 0 | -3 | -11 | | |
| | Sugar | 0 | 0 | 0 | | |
| | Pineapple | 0 | 0 | 0 | | |
| | Fruit and Nut | 2 | 17 | 41 | | |
| | Veg. and Melons | 2 | 16 | 24 | | |
| | Seed Crops | 17 | 174 | 234 | | |
| | Flor. and Nursery | 7 | 67 | 97 | | |
| | **Total Acreage** | 26 | 272 | 385 | | |

* Projected negative acreage reflects Rounds 3 and 4 acreage and island share responses.

# Molokai

*Change in Acreage from 2005 to 2030*

| Irrigation System | Crops | 2005 | 2015* | 2030* | Validate (R,H,L) | **Comments:** If you indicated that the change in acreage was too high or too low, please explain**.** |
|---|---|---|---|---|---|---|
| **Molokai** | Pasture | 57 | 583 | 842 | | |
| | Sugar | 0 | 0 | 0 | | |
| | Pineapple | 0 | 2 | 9 | | |
| | Fruit and Nut | 2 | 19 | 27 | | |
| | Veg. and Melons | 3 | 32 | 61 | | |
| | Seed Crops | 1 | 9 | 21 | | |
| | Flor. and Nursery | 0 | 1 | 2 | | |
| | **Total Acreage** | 63 | 646 | 963 | | |

* Projected negative acreage reflects Rounds 3 and 4 acreage and island share responses.

# Maui

*Change in Acreage from 2005 to 2030*

| Irrigation System | Crops | 2005 | 2015* | 2030* | Validate (R,H,L) | **Comments:** If you indicated that the change in acreage was too high or too low, please explain**.** |
|---|---|---|---|---|---|---|
| **West Maui** | Pasture | 23 | 237 | 342 | | |
| | Sugar | 8 | 89 | 9 | | |
| | Pineapple | -1 | -5 | -20 | | |
| | Fruit and Nut | 15 | 163 | 239 | | |
| | Veg. and Melons | 1 | 8 | 15 | | |
| | Seed Crops | 2 | 26 | 62 | | |
| | Flor. and Nursery | 1 | 10 | 15 | | |
| | **Total Acreage** | 50 | 528 | 664 | | |
| **Upcountry Maui** | Pasture | -1 | -5 | -20 | | |
| | Sugar | 0 | 0 | 0 | | |
| | Pineapple | 0 | -4 | -8 | | |
| | Fruit and Nut | 2 | 19 | 46 | | |
| | Veg. and Melons | 2 | 26 | 38 | | |
| | Seed Crops | 36 | 380 | 432 | | |
| | Flor. and Nursery | 4 | 42 | 60 | | |
| | **Total Acreage** | 44 | 458 | 550 | | |

* Projected negative acreage reflects Rounds 3 and 4 acreage and island share responses.

# Big Island

| Irrigation System | Crops | 2005 | 2015* | 2030* | Validate (R,H,L) | **Comments:** If you indicated that the change in acreage was too high or too low, please explain**.** |
|---|---|---|---|---|---|---|
| **Waimea** | Pasture | 89 | 912 | 1,316 | | |
| | Sugar | 0 | 0 | 0 | | |
| | Pineapple | 0 | 1 | 2 | | |
| | Fruit and Nut | 58 | 633 | 931 | | |
| | Veg. and Melons | 9 | 100 | 193 | | |
| | Seed Crops | 0 | 5 | 13 | | |
| | Flor. and Nursery | 5 | 50 | 73 | | |
| | **Total Acreage** | 161 | 1,701 | 2,528 | | |
| **Lower Hamakua** | Pasture | 0 | -1 | -5 | | |
| | Sugar | 0 | 0 | 0 | | |
| | Pineapple | 0 | 0 | 0 | | |
| | Fruit and Nut | 3 | 32 | 77 | | |
| | Veg. and Melons | 7 | 75 | 109 | | |
| | Seed Crops | 0 | 0 | 0 | | |
| | Flor. and Nursery | 31 | 321 | 463 | | |
| | **Total Acreage** | 41 | 427 | 644 | | |

* Projected negative acreage reflects Rounds 3 and 4 acreage and island share responses.

### *5. The Impact of Rehabilitation on Irrigation Systems Voting*

The rating for future agricultural potential of the ten studied irrigation systems with proposed rehabilitation uses the same methods for rating the systems in their current state (without rehabilitation). You can view the systems, their scores and the methods used to formulate the scores in the appendix. We ask that you vote on the qualitative impact on total agricultural acreage that rehabilitation would bring about for each of the studied irrigation systems by the year 2030. Please use the following qualitative voting key:

0 =no increase (0%)
1 =little increase (1-10%)
2 =some increase (11-25%)
3 =major increase (>25%)

| **Irrigation System** | **System Rating*** | | **Vote (0,1,2,3)** | **Comment:** If you vote for an increase where the rehabilitation scores do not increase, or if you vote for a decrease where the rehabilitation score increases or remains the same, please explain your reasons here. |
|---|---|---|---|---|
| | **WITHOUT Rehabilitation** | **WITH Rehabilitation** | | |
| Waimea | 77 | 82 | | |
| East Kauai | 63 | 72 | | |
| West Maui | 68 | 68 | | |
| Molokai | 64 | 76 | | |
| Waiahole | 71 | 71 | | |
| Hamakua | 64 | 66 | | |
| Upcountry Maui | 63 | 74 | | |
| Kauai Coffee | 69 | 69 | | |
| Waimanalo | 56 | 68 | | |
| Kekaha | 69 | 76 | | |

* The scores represent long-run agricultural potential.

*With this we have come to the end of Round 5, and the end of our Hawaii Crops Delphi Survey. Thank you for your participation in this survey! We will notify you of the results when our study is completed and available for public release.* **Please return your completed Round 5 survey to rchesler@hawaii.edu by or before March 16. Mahalo!**

## 5-C Bioenergy

Fig. 5.C-1 Bioenergy Survey

# BIOENERGY IN HAWAII SURVEY

University of Hawaii at Manoa, College of Tropical Agriculture and Human Resources

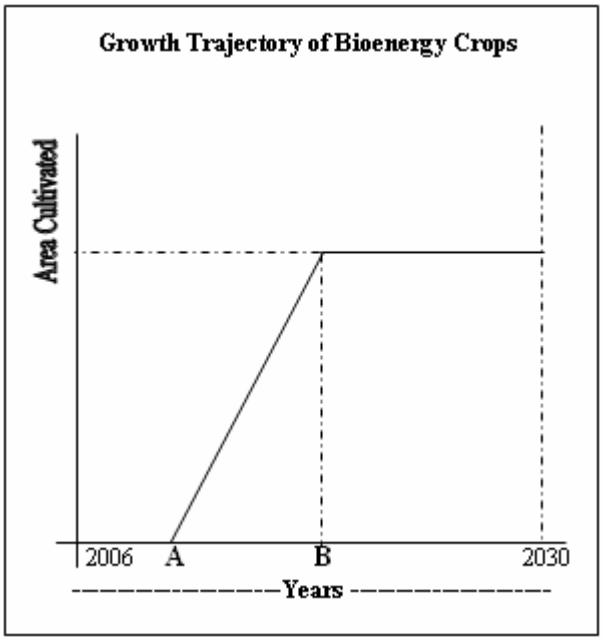
*The University of Hawaii at Manoa is carrying out a study to project agricultural acreages in order to predict future irrigation water demands up to the year 2030. One crop category is bioenergy, which includes both biofuel crops used to produce ethanol for cars and biomass crops for generating electricity.*

*We are surveying people in Hawaii who are knowledgeable in the fields of agriculture, energy and irrigation in order to develop a range of scenarios for the potential for bioenergy crops. There is tremendous uncertainty about what is going to happen in this industry. All we are asking is that you provide your best guesses for these questions.*

1. **What is your assessment of the likelihood that bioenergy crops will be developed in Hawaii over the next 25 years (until the year 2030)?**

   _____ Highly likely
   _____ Somewhat likely
   _____ Unlikely

   *(Note: If your assessment is "Unlikely" then you may or may not wish to complete the rest of the questionnaire.)*




2. **What is the earliest year for which you think there will be significant planting of bioenergy crops (point A in graph) in Hawaii?**

   ____ 2007 ____ 2010 ____ 2013
   ____ 2008 ____ 2011 ____ 2014
   ____ 2009 ____ 2012 ____ 2015 or later

3. **From that earliest year you selected above, how many years do you think it will take for Hawaii to reach its maximum potential (point A to point B in graph)?**

   ____ 5 years
   ____ 10 years
   ____ 15 years
   ____ 20 years
   ____ more than 25 years

**Please return the completed survey to Richard Bowen or Caleb O'Kray**

**4. The areas below are current or former sugarcane producing regions and have irrigation systems that can be used for bioenergy crops. What is your best guess as to the probability that bioenergy crops are going to develop in each of these general areas?**

**a. Kauai (north and west of Lihue):**

**Unlikely ----------Very Likely**

____ 0 - 25% ____ 25 – 50% ____ 50 – 75% ____ 75 - 100%

**b. North Shore Oahu (Waialua lands):**

____ 0 - 25% ____ 25 – 50% ____ 50 – 75% ____ 75 - 100%

**c. West Maui (Ka`anapali side):**

____ 0 - 25% ____ 25 – 50% ____ 50 – 75% ____ 75 - 100%

**d. Central Maui: (HC&S plus Wailuku lands):**

____ 0 - 25% ____ 25 – 50% ____ 50 – 75% ____ 75 - 100%

**e. Hilo Coast: (Hilo to Waipio Valley):**

____ 0 - 25% ____ 25 – 50% ____ 50 – 75% ____ 75 - 100%

**6. Are there any other areas not mentioned above that you believe will be important for future bioenergy production?**

Areas:
_____

**7. Bioenergy Crop Type:**

**Which crops do you project will be important for bioenergy production in Hawaii?**

***Sugarcane:*** ____ Very Important____ Somewhat Important____ Not Important

***Corn:*** ____ Very Important____ Somewhat Important____ Not Important

***Banagrass:*** ____ Very Important____ Somewhat Important____ Not Important

***Leucaena:*** ____ Very Important____ Somewhat Important____ Not Important

**8. Comments or questions:**

**Occupation**(*Please circle one)*

Government Energy private sector Corporate Farmer Non-corporate Farmer

Consultant Trader Public Student Other: _____

**Rate Your Knowledge in**: *Not knowledgeable* ----------*Very Knowledgeable*

- ***Agriculture***— 1 2 3 4
- ***Irrigation***— 1 2 3 4
- ***Bioenergy***— 1 2 3 4

Fig. 5.C-2 Description of Methods Used to Produce GIS Maps for Bioenergy Section

The objective was to identify large plots of former sugar and pineapple lands that remain in the Agricultural District. Large land plots are defined as being greater than one thousand acres.
The data was provided by Joan Delos Santos, of the Office of Planning for the State of Hawaii. Ms. Santos can be contacted at (808) 587-2895, or by email: JDelos_Santos@dbedt.hawaii.gov.
This analysis uses four basic layers to identify the agricultural lands. Those layers all use polygon layer type with a Universal Trans Mercator, Zone 4 (Meters) projection and NAD 83 datum. The four layers are Agricultural Land Use Maps (ALUM), State Land Use District Boundaries (SLUD), Large Landowners (large landowners) and Coastline (COAST).
Agricultural Land Use Maps (ALUM) were used to identify lands formerly in sugarcane or pineapple. The source is the State Department of Agriculture 1:24,000 hand drafted stabiline maps; compiled and drafted during 1978-80 from information from State DOA Planning and Development Section, and the US Soil Conservation Service. The attributes used where P for Pineapple and S for Sugarcane.
State Land Use District Boundaries (SLUD) was created by the State Land Use Commission 1:24,000 mylar maps. State Land Use District Boundaries were compiled by the State Land Use Commission using the State of Hawaii's Geographic Information System (GIS). The State Land Use Districts depicted in these files are not official and are merely representations for presentation purposes only. A determination of the official State Land Use District Boundaries should be obtained through the State Land Use Commission. Duplication of these files or the information therein is prohibited unless authorized by the State Land Use Commission. Attributes used where A Agricultural Land Use District. The SLUD layer was created in 2006.

The Large Landowners (large_landowners) dataset was created using the TMK Parcel shapefiles from the counties of Honolulu, Kauai, Maui and Hawaii. For Kauai, Maui and Hawaii Counties, the "MajorOwner" field was queried to include all public lands along with private landowners with a cumulative of at least 1000 acres per island. All land owners with "MajorOwner" = "other" were excluded. For Oahu, since there was no "MajorOwner" field, the "Owner" field was queried to select the Public Lands and Private owners of at least 1000 acres. Attributes used where MajorOwner, Tax Acreage, GIS_Acres. The Large Landowners layer was created in 2006.

Coastline (COAST) was extracted by OSP staff from the 1983 1:24,000 USGS Digital Line Graphs. Attribute used where COAST-ID.

**Methods**

Step one: Download zip files from Hawaii State GIS data website

Step two: Create a file hierarchy system for the five Hawaiian Islands

Step three: Extract zipped files into hierarchy

Step four: Use ArcGIS 9.0 to open each island's file and delete unrelated information
Step five: Using the intercept tool, enter files large landowners and SLUD to produce large agricultural owners. Then enter that new shapefile and ALUM back into the intercept tool. Repeat this process for all five islands.

Step six: Open attribute tables and recalculate acres by

1. Start an edit session in Arcmap. Editor > **Start editing**
2. Open the layers attribute table by right clicking the layer and choosing> **Open Attribute Table**
3. Right click on the field heading for Area and choose **Calculate Values**
4. In the Field Calculator window, check the **Advanced** option
5. Type the following Visual Basic code into the text box:

```
Dim dblArea as Double
Dim pArea as IArea
Set pArea = [shape]
dblArea = pArea.area
```

6. Type the variable dblArea in the text box directly under the area field name.
7. Click **OK**

Finally delete all plots smaller then one thousand acres. Then end result produces the potential plots for the water project.
Step seven: Create map layout and legend to specifications