Water consumption, yield and water use efficiency of table and wine grapes in Western Cape, South Africa

Annemarie Klaasse
WaterWatch

- Scientific advisory firm (12 employees)
- founded in 2000 by Prof. Bastiaanssen

Remote sensing services for quantifying water management

Diagnose historic and current water management practices across large irrigated river basins by means of satellite measurements
Background

- Western Cape, South Africa is approaching physical water scarcity
- Agricultural sector is responsible for 43% of total water use

Optimal use of limited water resources is essential.
Project objective

The **challenge** is to maintain an economically sustainable grape industry whilst making optimum use of the limited water resources

Understanding the spatial and temporal variation of water use efficiency in table and wine grape vineyards

- 3 grape seasons:
  September – April 2004-5, 2005-6 and 2006-7

- 6 areas (Western Cape winelands):
  Hex Valley, Worcester, Paarl, Franschhoek, Somerset West, Stellenbosch
Project methodology

- **Meteorological point data**
  - MeteoLook
  - Gridded meteorological data

- **Satellite data (Landsat)**
  - Temperature
  - Vegetation index
  - Albedo

- **SEBAL**
  - Water consumption ($ET_{act}$)
  - Biomass production

- **Yield modeling**
  - Wine and table grape yield

- **Grape classification**
  - Water use efficiency (water productivity)
Location of vineyards

Grape classification

Wine grapes

Table grapes
SEBAL
Surface Energy Balance Algorithm for Land

SEBAL calculates on a pixel by pixel basis:
- Actual evapotranspiration (\( \text{ET}_{\text{act}} \)) = water consumption
- Biomass production
- Soil moisture in the root zone
SEBAL calculates the **energy balance**, not the **water balance**!

The energy balance includes all major sources ($R_n$) and consumers (ET, G, H) of energy.
SEBAL

Surface energy balance

Dry surface

Wet surface
SEBAL

Surface temperature in Hex Valley
Water consumption (ET\textsubscript{act}) of table grapes in Hex Valley
Table grape vineyards in Hex Valley, Worcester and Paarl

Wine grape vineyards in Worcester
Validation of results

Validation of water consumption (ET) with water balance measurements in the Hex Valley (charts) and Worcester
Yield modeling

A complex empirical function of
- soil moisture in November/December, and
- water deficit in February
- biomass production between September and April

Calibrated with yield data of Hex Valley (Sunred, Dauphine, Crimson) and Worcester (Colombard)
Yield modeling

Yield of table grapes in Hex Valley
Yield of table grapes in Hex Valley, Worcester and Paarl

Yield of Colombard wine grapes in Worcester
Water use efficiency

\[ WUE = \frac{Y}{10 \times ET} \]
Water use efficiency

Table grapes in Hex Valley, 2004-5

![Graph showing water use efficiency](image.png)

- **High WUE**: WUE = 5.8 kg/m³
- **Low WUE**: WUE = 1.7 kg/m³
Hex River Valley: water availability

Water shortage in 2004-5 had a strong effect on water consumption, but the effect on table grape yield was only small.
Stellenbosch: rainfall

Water consumption

Biomass production

Biomass water use efficiency

Rainfall

2004-5

Rainfall

W: 328 mm
S: 213 mm

Rainfall

W: 393 mm
S: 105 mm

Rainfall

W: 322 mm
S: 157 mm
Stellenbosch: rainfall

Wine vineyards in Stellenbosch are rainfed or are irrigated at low frequency. Low rainfall in the summer of 2005-6 resulted in very low water consumption but also strongly affected the biomass produced.
Worcester: irrigation water availability

Worcester wine grapes:
Hex River area : 287 ha
Nuy area : 497 ha
Southern part : 840 ha

Less water available in Southern part
### Water availability

#### Worcester wine grapes

<table>
<thead>
<tr>
<th></th>
<th>2004-5</th>
<th>2005-6</th>
<th>2006-7</th>
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</thead>
<tbody>
<tr>
<td><strong>ET (mm)</strong></td>
<td></td>
<td></td>
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<tr>
<td>Hex River area</td>
<td>766</td>
<td>833</td>
<td>800</td>
</tr>
<tr>
<td>Nuy area</td>
<td>718</td>
<td>722</td>
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<tr>
<td>Southern part</td>
<td>610</td>
<td>627</td>
<td>694</td>
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<table>
<thead>
<tr>
<th><strong>Yield (tons/ha)</strong></th>
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<th>2006-7</th>
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<tbody>
<tr>
<td>Hex River area</td>
<td>22.3</td>
<td>29.7</td>
<td>27.1</td>
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<tr>
<td>Nuy area</td>
<td>21.6</td>
<td>25.8</td>
<td>26.6</td>
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<tr>
<td>Southern part</td>
<td>24.1</td>
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<table>
<thead>
<tr>
<th><strong>WUE (kg/m$^3$)</strong></th>
<th>2004-5</th>
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<tbody>
<tr>
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<td>3.9</td>
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<tr>
<td>Nuy area</td>
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<tr>
<td>Southern part</td>
<td>4.1</td>
<td>5.1</td>
<td>4.1</td>
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</table>
Soil type and water table

Table grapes in Hex Valley

- Hex Valley upstream: 762 ha
- Hex Valley Groothoek: 996 ha
- Hex Valley downstream: 1361 ha
- Hex Valley Drierivierenkloof: 630 ha

- Groothoek: rocky soils
- Drierivierenkloof: sandy soils
## Soil type and water table

### Hex Valley table grapes

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<tr>
<td>downstream</td>
<td>639</td>
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<tr>
<td>Groothoek</td>
<td>725</td>
<td>877</td>
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<tr>
<td>upstream</td>
<td>676</td>
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<td><strong>Yield (tons/ha)</strong></td>
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<td>2.4</td>
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Cultivar

Vineyard in Stellenbosch area

- Cabernet Sauvignon
- Pinotage
Management

2004-5: Dry year
2005-6: Drastic change in management
2006-7: Management improved

550 mm
405 mm
825 mm
Plant stress

Water logging early in season

Biomass production in 2005-6

Water consumption in 2005-6
Conclusions

- High variation in water consumption, yield and water use efficiency between fields, areas, and between years.
- Crop water consumptive use can be spatially mapped with 90% accuracy.
- Some fields perform similarly over years, indicating e.g. low performance can be related to local conditions.
- Table grapes consume on average more water than wine grapes.
- Reduced irrigation in table grape areas resulted in lower water consumption but similar yields -> high WUE!
- A dry summer in wine grape areas in Stellenbosch did reduce water consumption and yield, resulting in low WUE!
- There is scope for improvement.
- RS can be used to help farmers in optimizing irrigation water resources.
- Google Earth applications are emerging now.
For more information:

Email:
A.Klaasse@waterwatch.nl

Results in Google Maps and Google Earth:
www.WaterWatch.nl/grapes (soon)

Operational product for farmers in the Netherlands:
www.MijnAkker.nl