Crop yield estimation using remote sensing: A comparison between two methods

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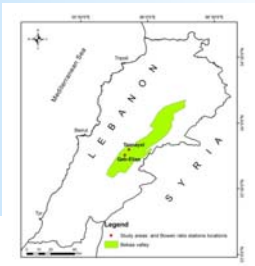
Objectives

Developing countries need reliable techniques
1-To predict ahead the crop outcome in order to increase production,
2- to meet the demand for food and to reduce the import of crops.
In this research, remote sensing and METRIC are used
1-to estimate crop yield.
2-to find the most robust technique based on two different Known ones
A-The energy balance equation and
B- the other is based on Scott's equation.

Area of studies



The selected areas have different sizes one is a small area about 1000 m² and the other is more than 50 ha.
The Selected areas are at the same time the location of the Bowen ratio stations.

The small area is located in an agricultural research institute while the other is owned by a potato chips manufacturer.

The distance between both is about 12 km and one is located in the middle of the valley while the other in the south.

Data and Methods

The most famous model for estimating crop yield is the Monteith's model (1972). The accumulation of biomass is according to the Monteith model proportional to accumulated APAR.

$$Bio_{act}^{tot} = \varepsilon \sum (APAR(t)(t)(Kgm^{-2}) \quad (1)$$

Where Bio_{act}^{tot} (kg/m²) is the accumulated biomass in period t, ε (g M/J) the light use efficiency and t describes the period over which accumulation takes place.
A more comprehensive global ecology model for computing net production was created by Field *et al.* (1995) in which they have used the following formula of ε.

$$\varepsilon = \varepsilon' T_1 T_2 W \ (gMJ^{-1}) \quad (2)$$

Where ε' is the maximum conversion element for above ground biomass when the environmental conditions are optimal. During the growing season the actual light use efficiency varies and will be lower than the maximum ε' value.

$$T_1 = 0.8 + 0.02T_{opt} - 0.0005T_{opt}^2 \ (T_2 = \frac{1}{1+\exp(0.2T_{opt}-10-T_{mon})} \times \frac{1}{\exp(0.3(-T_{opt}-10+T_{mon}))} \quad (3)$$

T_{opt} (◦C) is the mean air temperature in the month with maximum leaf area index, and T_{mon} (◦C) is the mean monthly air temperature.

W is a function of the effective fraction of the available soil moisture. Computed based on energy balance equation:

$$W = \frac{\lambda E}{R_n - G_0} \quad (4)$$

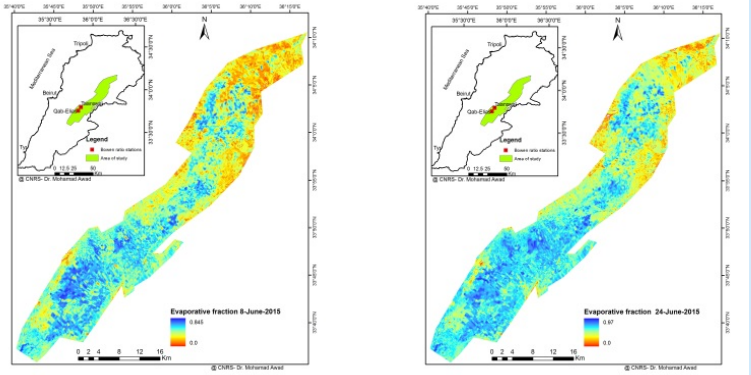
Where λE latent heat flux, R_n is the net radiation, and G_0 is the soil heat flux.

Or according to Scott *et al.* model (2003). The model computes W using a function of actual surface temperature T_s ,hot pixels T_{smax}, and cold pixel T_{sminx}

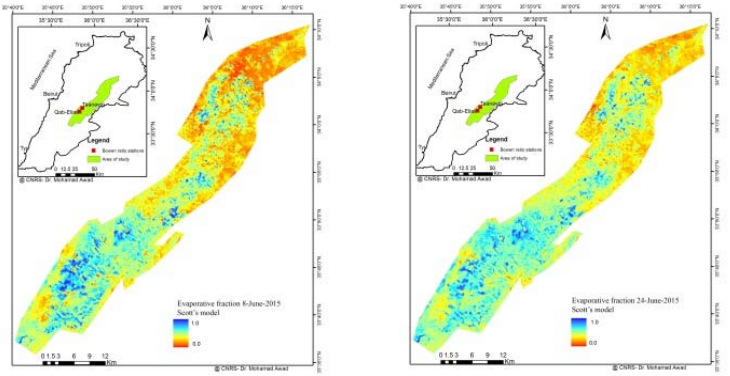
$$W = \frac{T_{smax} - T_s}{T_{smax} - T_{smin}} \quad (5)$$

Results

The acquired Landsat images are related to the date the potato was planted and to the date that was harvested. The potato leafs appears almost 20 days after seeding. The weather in Lebanon during winter and spring is mostly rainy and cloudy. It was very hard to get images during the months of March (the date potato was planted) and April. Seven images are collected between the months of April, May, June, and July.



Examples of Evaporative fraction maps using Energy balance equation and METRIC



Examples of Evaporative fraction maps using Scott's Model

Time	Rn W/m2	G W/m2	Latent Heat Flux W/m2	Evaporative fraction
9:00	323	18.72	220.083	0.72329
10:00	725	46.08	515.380	0.75912
11:00	1007	91.22	718.760	0.78486
12:00	724	116.88	482.840	0.79530
13:00	889	112.4	621.720	0.80057

Examples of Bowen Ratio Data and computed parameters

Conclusions

Taking the value of the predicted W computed by METRIC model for The 8th and 24th of June Landsat images and comparing them it to the computed ones from Bowen ratio station at time 11:00. The results show that the error ranges between 0.5% to 5 % for METRIC results, while it ranges between 9% and 13% for the Scott's model.

The above result showed that energy balance is more reliable to estimate crop yield. In turn the estimation of potato crop yield and the actual production from the two study areas showed about 98% agreement. The estimation is based on using the evaporative fraction W based on METRIC model.

Acknowledgment

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References

Monteith J., (1972). "Solar radiation and productivity in tropical ecosystems." *Journal of Applied Ecology*, 9: 747-766.

Scott C., W. Bastiaanssen, and M. ud-Din Ahmad, (2003). "Mapping root zone soil moisture using remotely sensed optical imagery." *ASCE Irrigation and Drainage Engineering*, 129(5): 326-335.