INTEGRATING REMOTE SENSING DATA AND ENERGY BALANCE MODELING FOR DETECTION OF DROUGHT (Case Study of Karawang District, West Java)

Adi Witono

Indonesian National Institute of Aeronautic and Space (LAPAN)

Center for Application of Atmosphere Science and Climate

OUTLINE

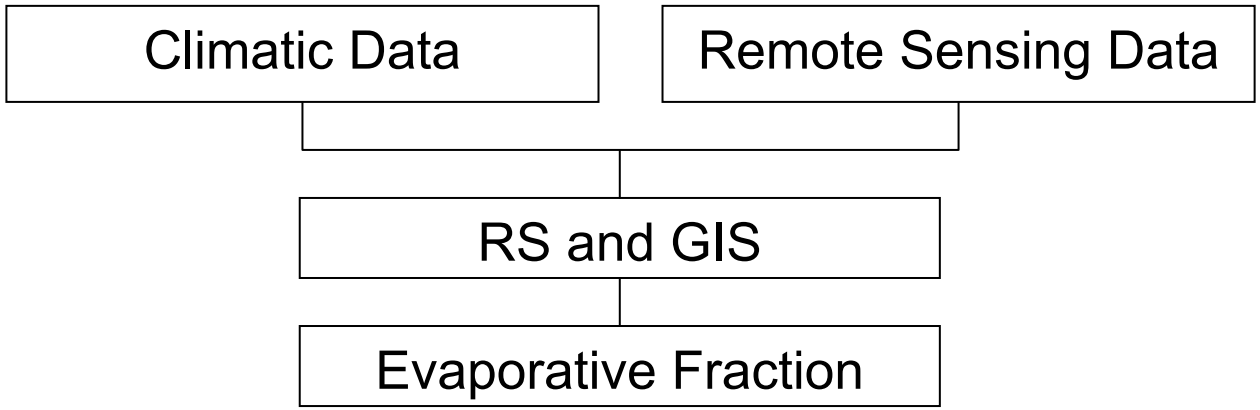
- ☒ Introductions
- ☒ Background Theory
- ☒ Methodology
- ☒ Results and Discussions
- ☒ Conclusions and Recommendations

INTRODUCTION

- **Drought is climatic phenomena that vary in space, time and intensity,** a consequence of a reduction over an extended period of time in the amount of precipitation that is received, usually over a season or more in length.
- **Traditional methods** of drought monitoring rely on rainfall data.
- **New methods** of drought monitoring using remote sensing technology.

INTRODUCTION

- **In the present study, the moisture status of the land surface is monitored using the daily evolution of the evaporative fraction (EF).**



- **Water irrigation for agriculture in Karawang is mainly from Jatiluhur dam, and have problem of water distribution during dry season.**

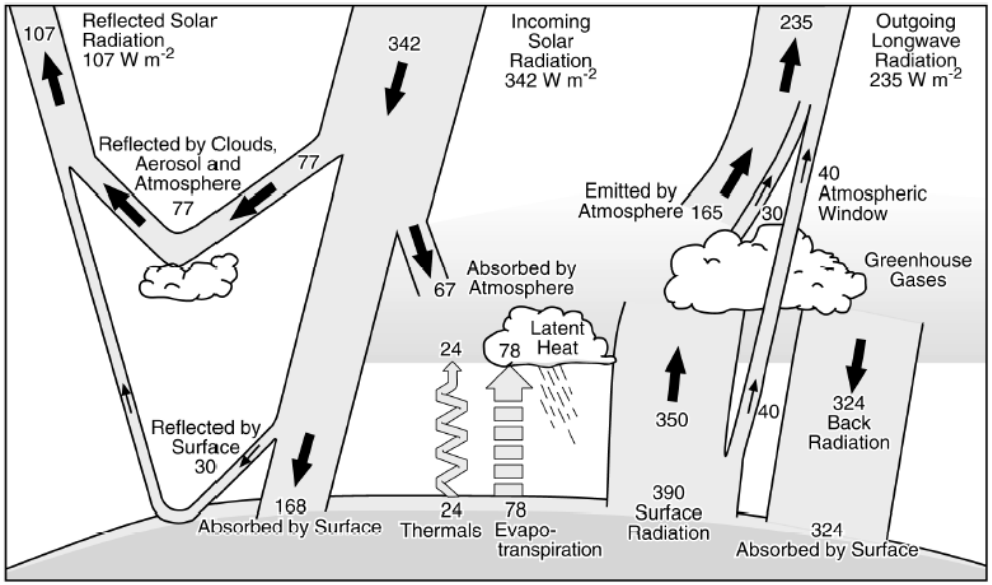
Objectives

The objectives in this research are:

- ☒ **To analyze energy balance and evaporative fraction such as drought indicator in Karawang district.**
- ☒ **To asses the potential use of remote sensing capability in identifying the surface cover parameter of image and visualization using Remote Sensing and Geographic Information System**

BACKGROUND THEORY

- Energy balance refers to the physical fact that energy cannot be created nor destroyed so that the solar and long wave radiation energy received by a land cover layer during any time interval must exactly equal, or 'balance,' the energy gained by that layer minus that lost from the layer during the same time interval.
- The balance between the energy absorbed, reflected and emitted by the earth's surface



$$Rn = G + H + \lambda E$$

- *Rn* is the net radiation emitted from the Earth surface *(W/m2),*
- *G* is energy for heating the soil *(W/m2),*
- *H* is energy for sensible heat flux *(W/m2),*
- *λE* is the latent heat flux, being the energy necessary to vaporize water (*W/m2*)

BACKGROUND THEORY

☒ Finally, the evaporative fraction (EF) is expressed as:

$$EF = \frac{\lambda E}{Rn - G}$$

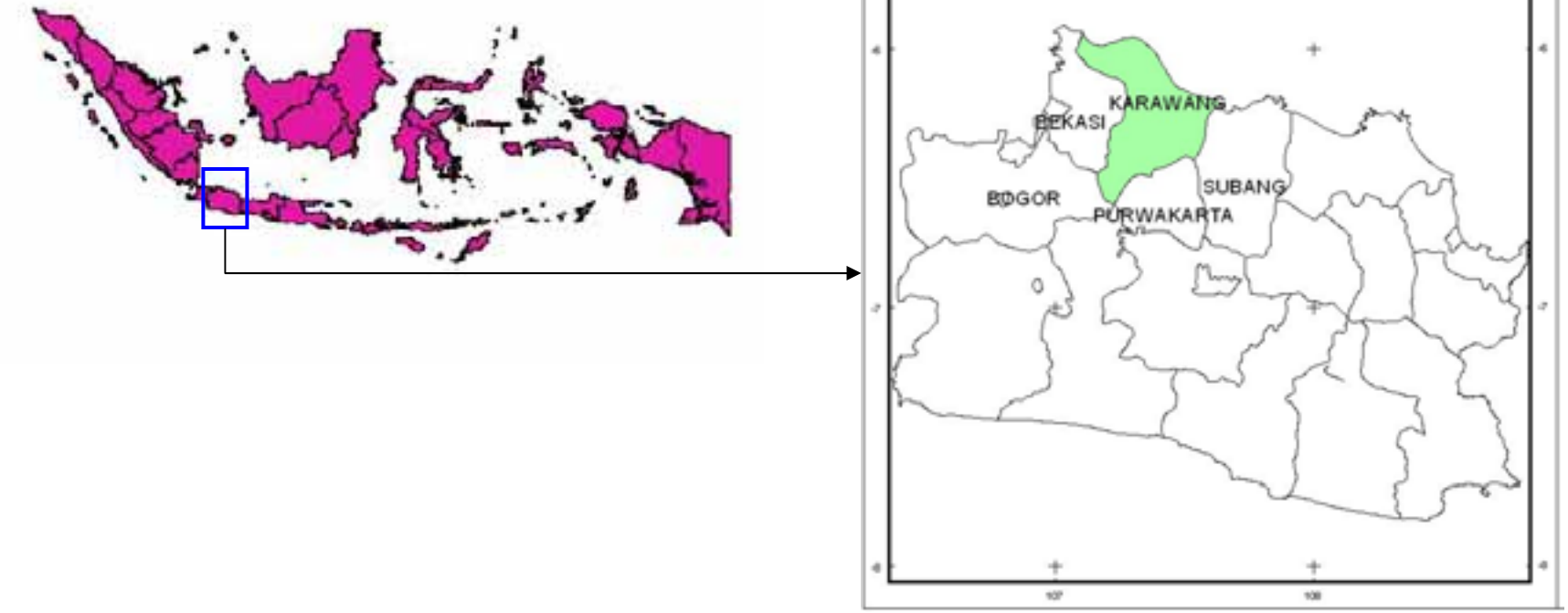
EF indicates how much of the available energy is used for evapotranspiration, that is, for transpiration of the vegetation and evaporation of the soil and EF will be close to one (no water stress). As long as moisture is available, energy will be used for its evaporation.

With little or no moisture left, all available energy will be directed into the sensible heat flux and EF will approach zero (serious water stress).

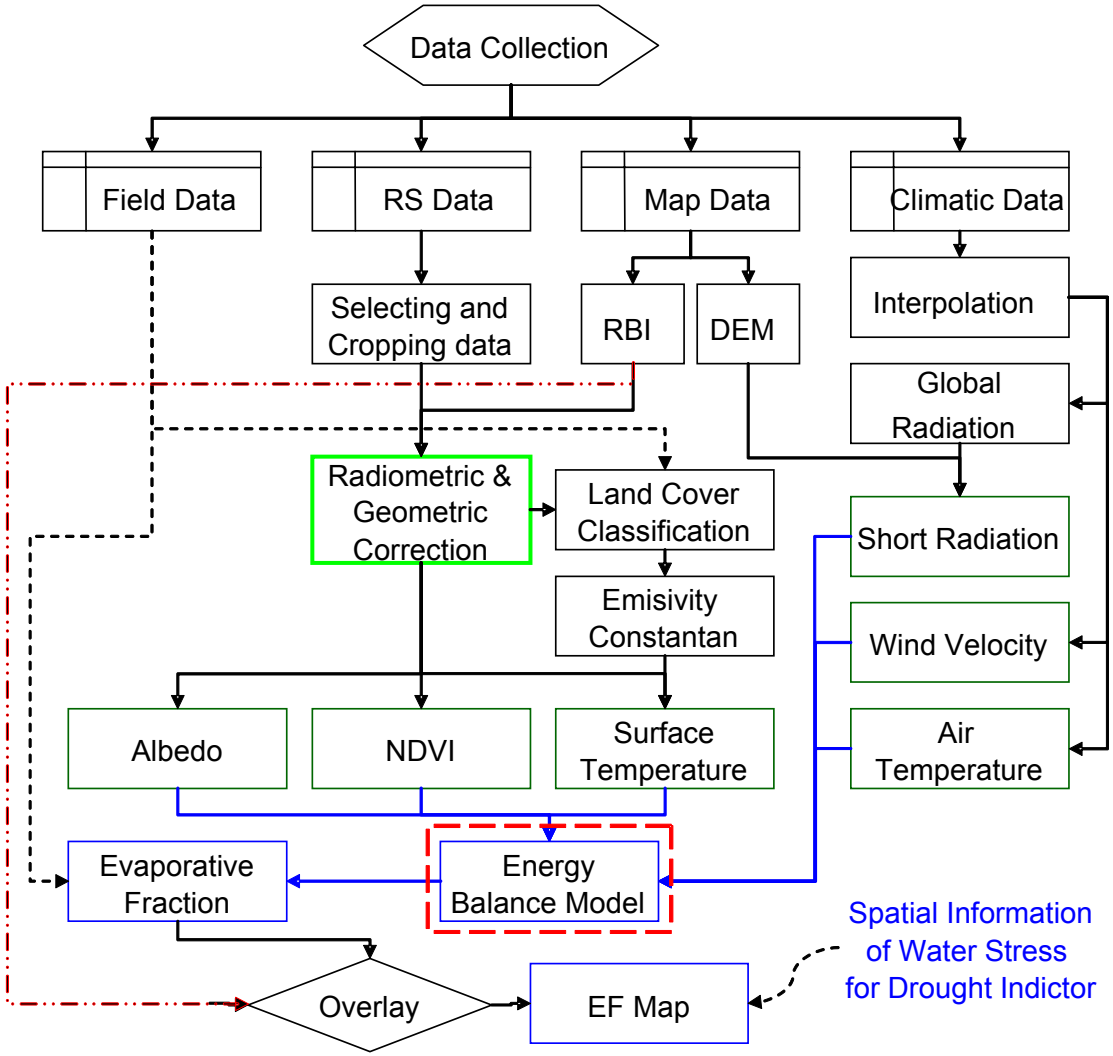
METHODOLOGY

Time and location :

- Research site is Karawang district, which is geographically located between 107° 05' 11'' - 107° 38' 32'' East and 05° 55' 58'' - 06° 38' 28'' South. Image processing and analysis conducted from March to May 2007.

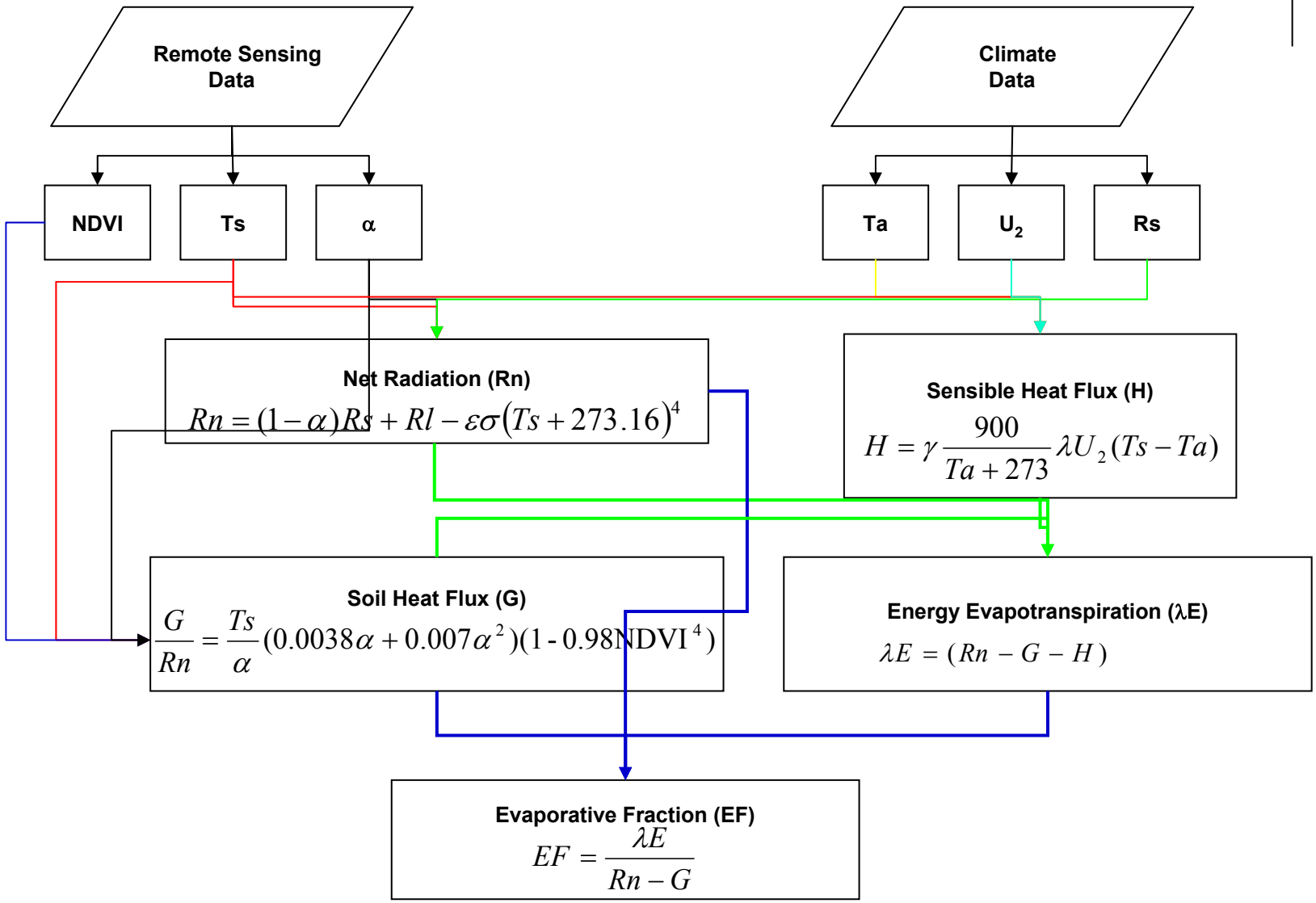


METHODOLOGY

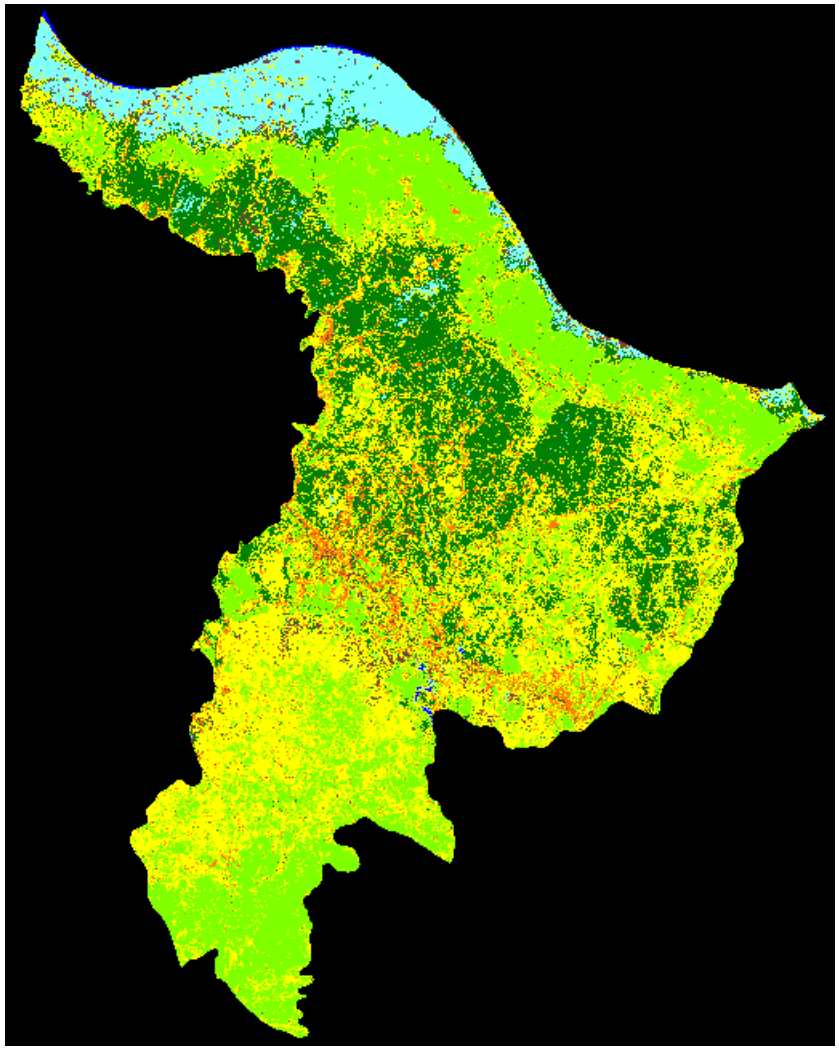


- ☒ Data collection from any institution
- ☒ Image pre-processing
- ☒ Data processing and Analysis
- ☒ Energy balance modeling

Energy Balance Modeling



RESULTS AND DISCUSSIONS

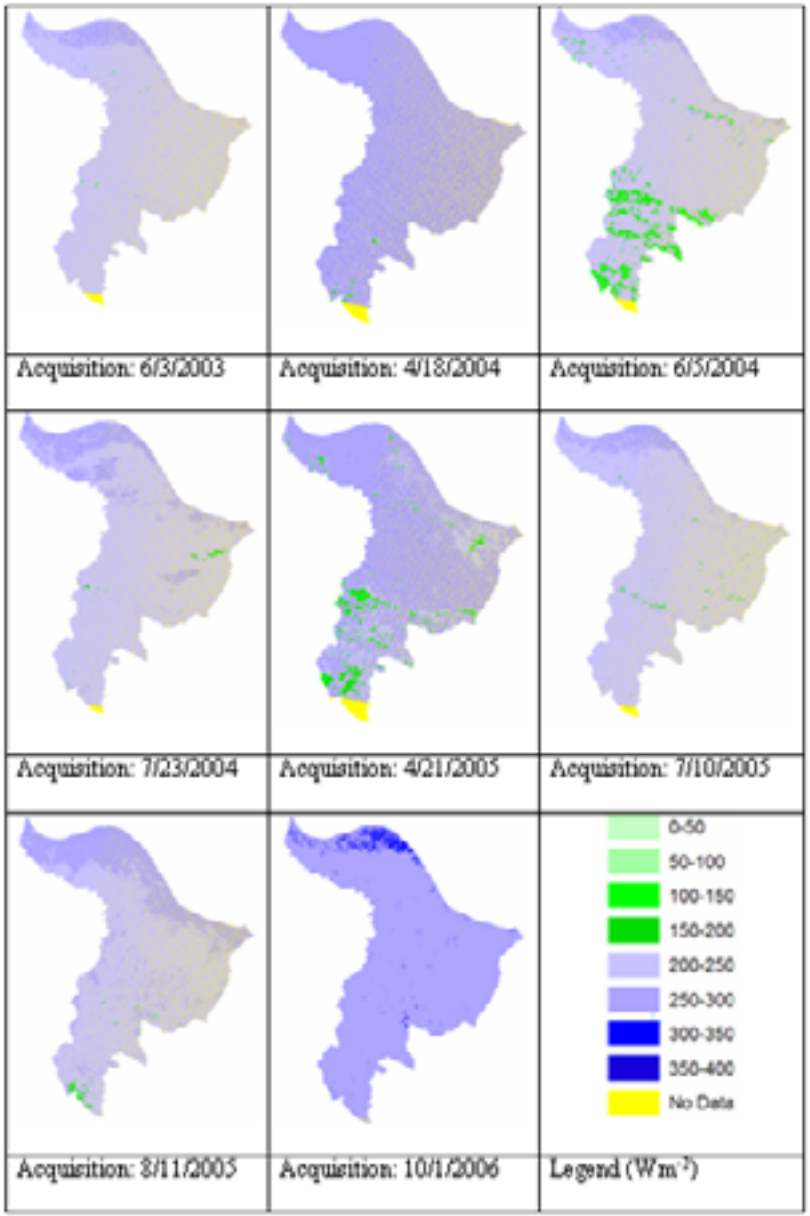


Existing Landuse

- ☑ EL is obtained by interpreting of Landsat-7 ETM+ image in October 1, 2006.
- ☑ The land use consists of:

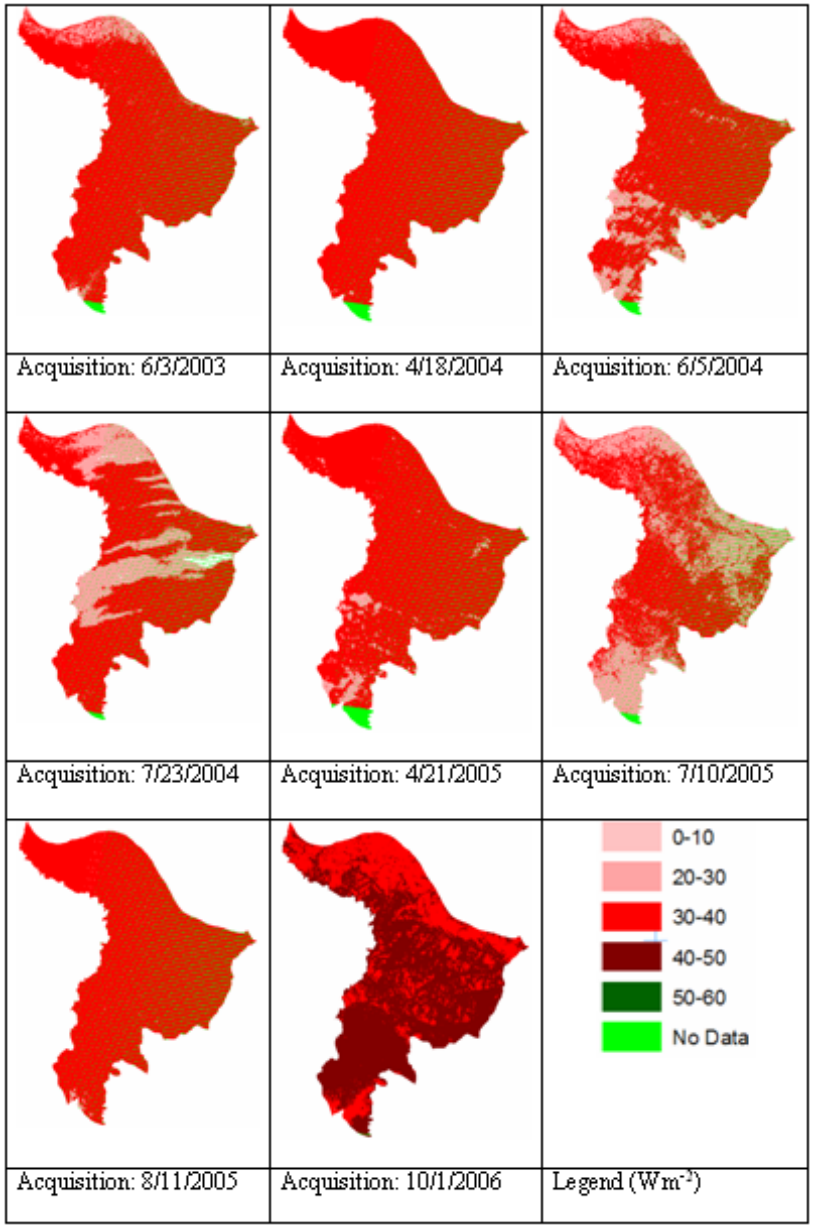
No	Land Use	Area (ha)	Area (%)
1	Paddy Field	42424.4	22.0
2	Industry	3476.3	1.8
3	Residential	10282.1	5.3
4	Fish Pond	14776.9	7.7
5	Vegetation	51889.2	26.9
6	Unirrigated Land	69891.1	36.2
7	Water	357.4	0.2
	Total	193097.34	100

Net Radiation



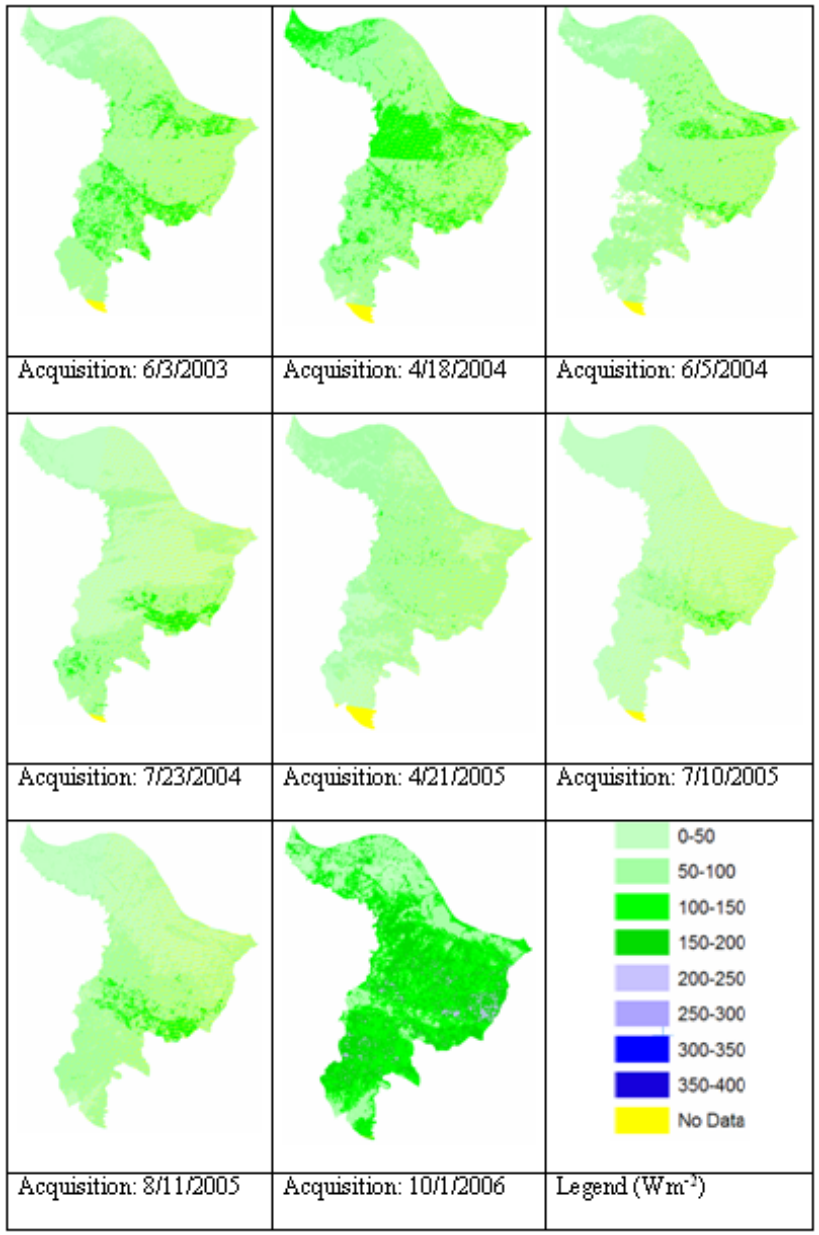
- In April Karawang district has net radiation between 250-300 Wm^{-2}, in May-August 200-250 Wm^{-2} and October 250-300 Wm^{-2}.
- In October almost all area receive net radiation around 250-300 Wm^{-2}, or 187,000 hectare from total area of Karawang (193000 hectare).
- Geographically in Karawang district the influence on amount of the net radiation which reaches the land surface is not significant.

Soil Heat Flux



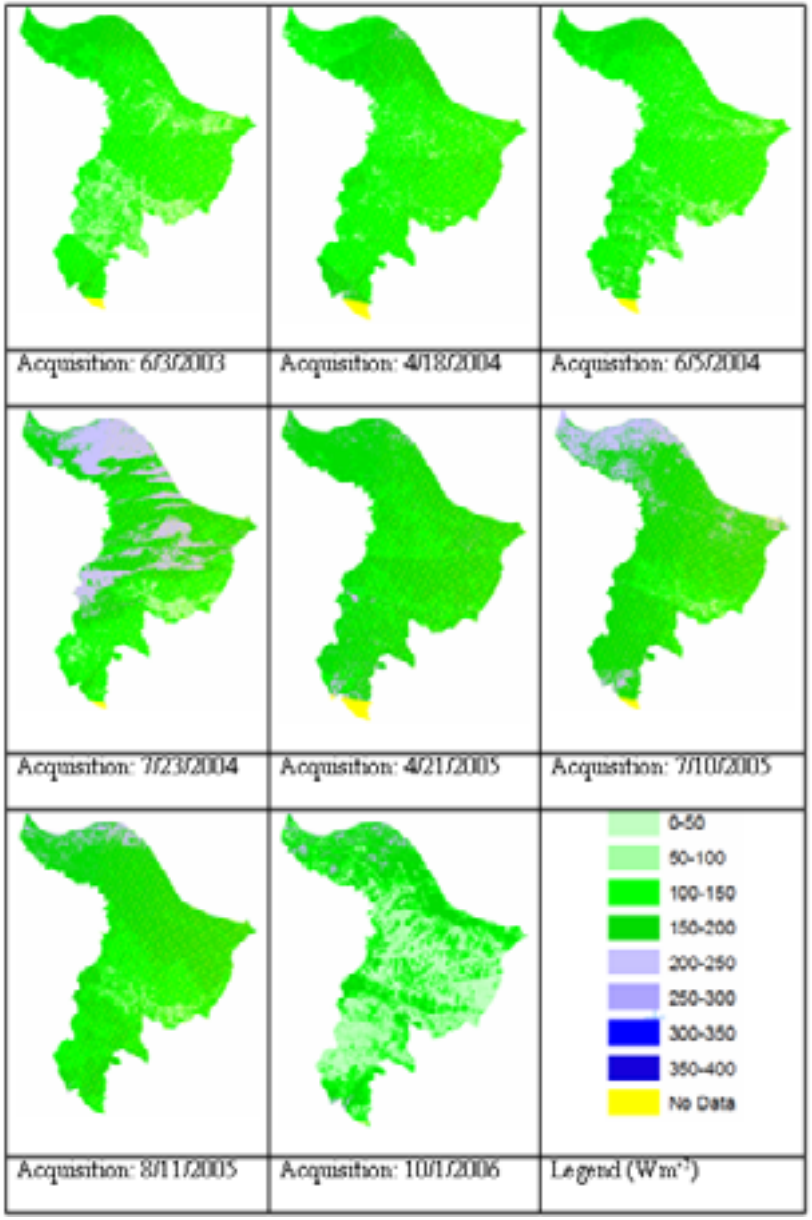
- In Karawang district potential energy for soil heating is 30-40 Wm^{-2}.
- Except for the data of October 1, 2006 when total energy used to heat soil is about 40-50 Wm^{-2} for areas near water body or fish pond and for water body and fish pond it is about 30-40 Wm^{-2}.

Sensible Heat Flux



- ☒ Sensible heat flux ranges from 50-100 Wm^{-2} and for several areas are about 100-150 Wm^{-2}.
- ☒ Except data in October 1, 2006 where total energy used is higher than the other data about 100-200 Wm^{-2}.
- ☒ The dry months before October 2006 is long i.e. about 4-5 months, therefore the total energy used to heat air is high.

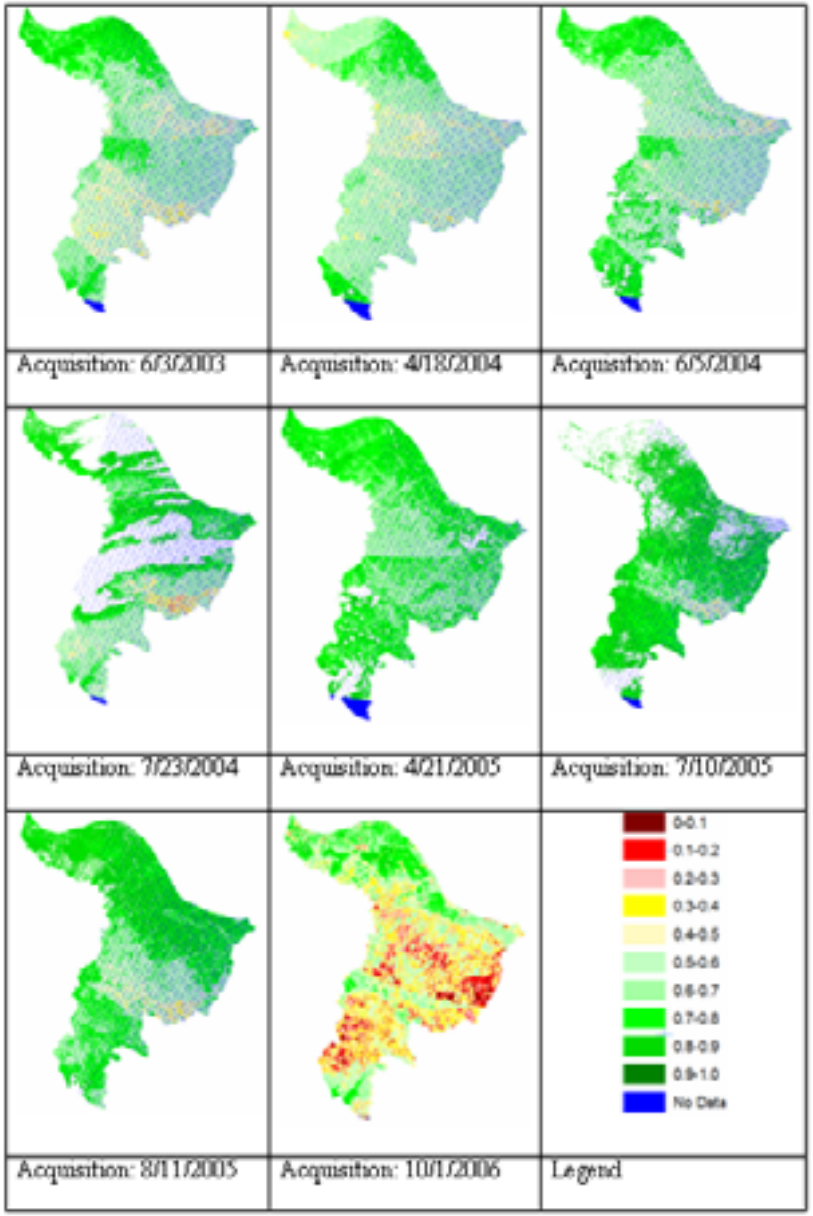
Evapotranspiration



- Based on October 2006 data, the distribution is different from other data, because part of Karawang area uses energy about 50-100 Wm^{-2}.
- It shows that amount of water content in soil or vegetation is low than total energy needed for evaporation.
- Land cover such as water body, fish pond and cloud needs higher energy about 200-250 Wm^{-2}. It indicates that an area covers with water or cloud needs more energy for evaporation.
- Furthermore, it will decrease total energy used for soil and air heating.

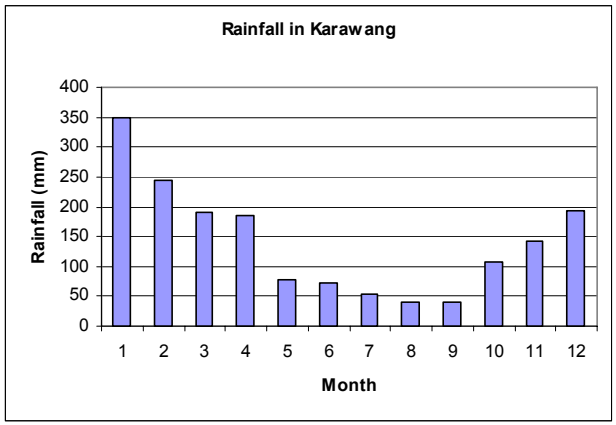
LAPAN

DROUGHT DETECTION

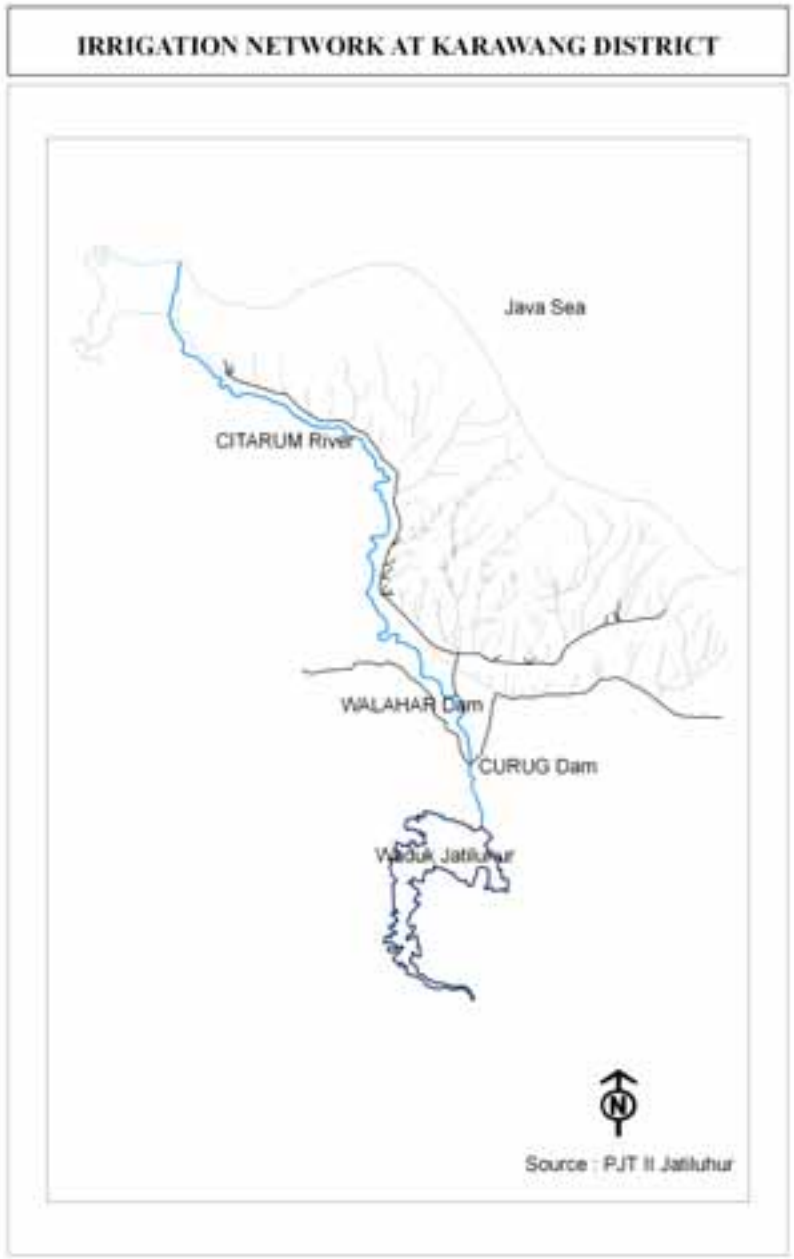


- ☒ EF value is near or equal one indicating this area is not potential of drought.
- ☒ EF value is near or equal zero indicating this area is potential of drought.
- ☒ The dry or wet seasons in 2003-2005 have low potential of drought, because there is enough water for evapotranspiration. Water source can be supplied by rain and irrigation.
- ☒ On the contrary in 2006 there is a potential for drought in several locations of Karawang.

Rainfall



- Monthly average rainfall data for 30 years indicate that the dry season in Karawang district occurs from May to September and rainy season from October to April. .



RESULT ANALYSIS

- Relatively wider areas of drought potential is detected at the beginning of rain season i.e. acquisition Landsat image in October 1, 2006.
- Evaporative fraction (EF) values used to determine area of drought vulnerability range from 0 – 0.4.
- Landsat data June 3, 2003 analysis indicates potential of drought vulnerability is 2,746 Ha. Water availability in soil for June is adequate. Indicator of water availability can be seen by land cover condition with relatively green vegetation index and high energy used for evaporation that indicates water for evapotranspiration from soil and crop is available in the soil, only a small area in Karawang is potential of drought, which means most energy is used for sensible heat flux.
- The same result is shown from Landsat image analysis for 2004 and 2005. In 2004 there is increase of drought vulnerability from 1,074 Ha in June to 2,965 Ha in July. The same trend is observed for analysis in 2005 where increased area of drought is from 322 Ha in July to 1,229 Ha in August.
- Similar increase of drought vulnerability area is shown for result analysis in 2006. The analysis is based on data acquisition at the start of the rainy season, but climate conditions i.e. delay of the start of rainy season i.e. October is still the dry season. About 77,057 Ha areas in Karawang indicated drought vulnerability.

Conclusion and Recommendations

Conclusions

- ☒ The drought potential from 2003 to 2005 at Karawang district is low either in the wet season or dry season. For rainy season data is taken in April and for dry season from June to October. The dominant drought indicated is 0.5-0.8, especially in paddy field areas. Based on drought indicators in Karawang district water is supplied by rainfall and irrigation available during dry or rainy season.
- ☒ In October 2006, the drought level is moderate until very dry as indicated by evaporative fraction which is about 0-0.4. In September 2006, all irrigated areas in Karawang already harvested their crop so many paddy field areas are bare and intentionally let dry waiting for the next planting session. October is usually the start of the rainy season, but in October 2006 there was no rainfall observed. Hence, wider drought vulnerability was detected.

Conclusion and Recommendations

Recommendations

- ☒ To prevent drought vulnerability efficient use of water especially in the upper course near the main irrigation channel should be based on planting time, watering, and classification of paddy field.

LAPAN

THANKS FOR YOU ATTENTION