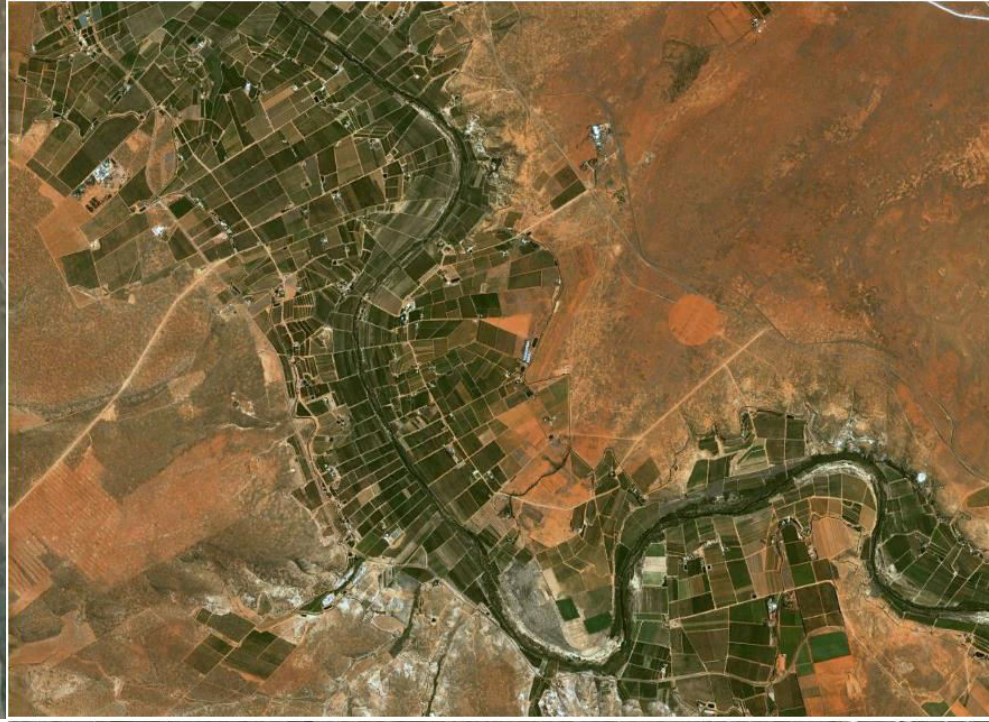
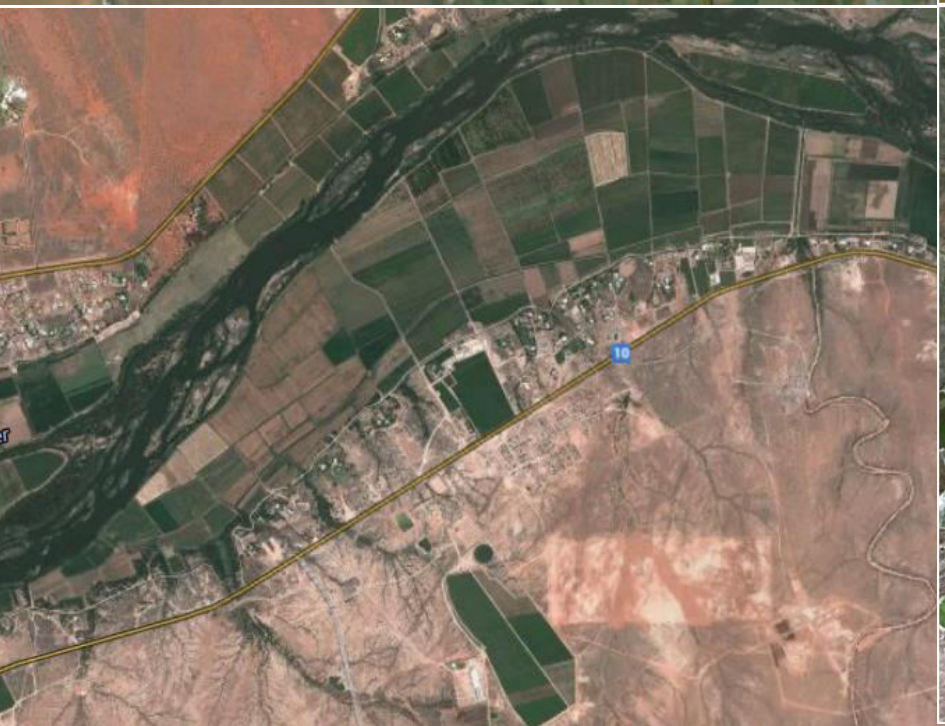

Hartswater
PAMPIERSTAD
18

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WATER USED BY IRRIGATED AGRICULTURE IN SOUTH AFRICA: APPROACH FOR AN UPDATE

Ferreira F[1], Goudriaan R[2], Gibson LA[3], Jarmain C[4], Kemp JN[6], Mashimbye E[5], Münch Z[6], Pauw T[6], Stephenson G[6], Van Niekerk A[6]

[1] GeoTerra Image
[2] eLeaf Competence Center
[3] CapeNature
[4] Independent consultant (cjarmain@gmail.com)
[5] Agricultural Research Council
[6] Centre for Geographical Analysis, Geography & Environmental Studies, Stellenbosch University (avn@sun.ac.za)

SANCID SYMPOSIUM 2014, 18 – 20 November 2014,
Glenburn Lodge, Muldersdrift

WIDE-SCALE MODELLING OF WATER AND WATER AVAILABILITY WITH EARTH OBSERVATION/SATELLITE IMAGERY

Ferreira F[1], Goudriaan R[2], Gibson LA[3], *Jarmain C*[4], Kemp JN[6], Mashimbye E[5], Münch Z[6], Pauw T[6], Stephenson G[6], *Van Niekerk A*[6]

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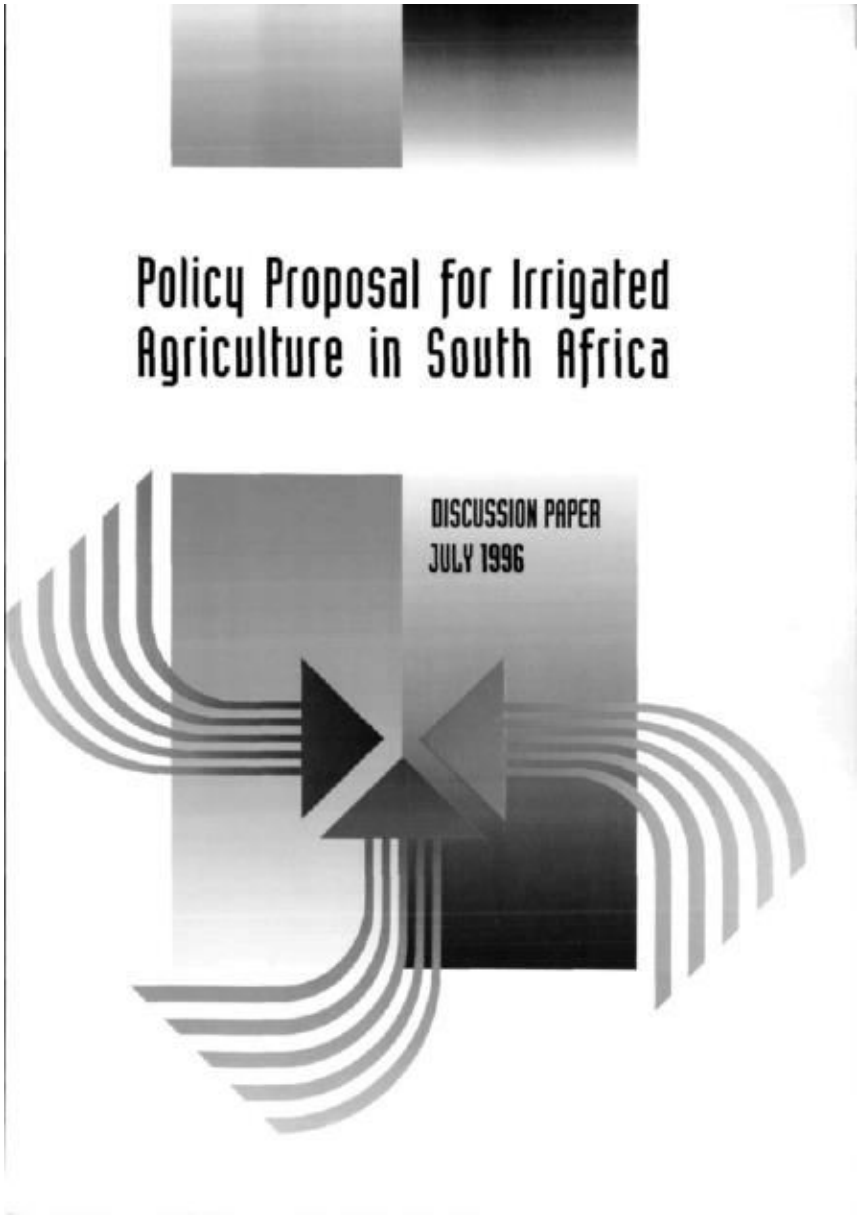
Research questions

- Update area under irrigated agricultural crops
  - How much land is used for irrigated crops?
- Update amount of water used by irrigated agriculture
  - How much water is being used for irrigated agriculture?
  - How much water is being used by specific irrigated crops? What is the variance?
- How can water accounting be used to guide new water allocations?

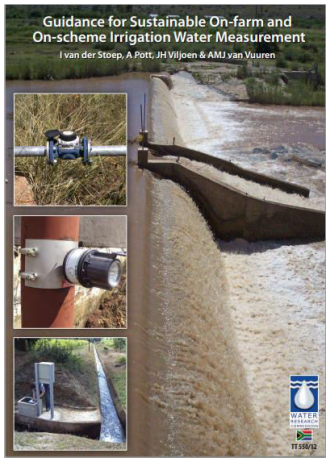
Knowledge gaps

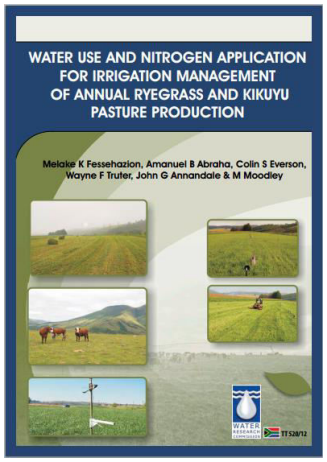
- Importance of knowledge for water management is clear
  - Within context of pressure on resources
  - New developments and allocation
- Estimates on area under irrigated agriculture & water used by agriculture outdated
- Policy proposal, 1996:
  - 1.3m ha under irrigation; 280 000 ha suitable for expansion; but water available for 178 000 ha
- Backeberg, 2005:
  - 1.5m ha under irrigation; 66700 ha expansion of schemes; Additional expansion of 200 000 ha
- Other estimates e.g.
  - Van der Stoep et al.(2008): 1.68m ha registered but only 1.399m ha irrigated

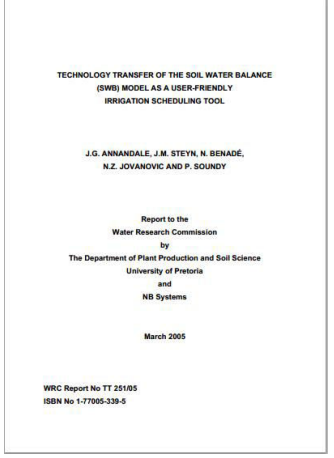


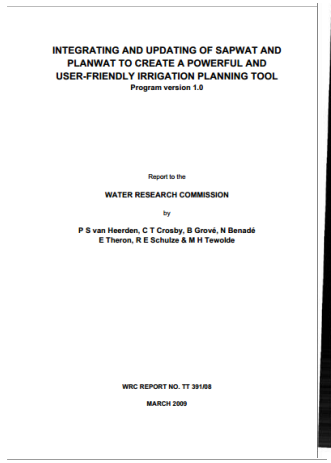
Knowledge exist

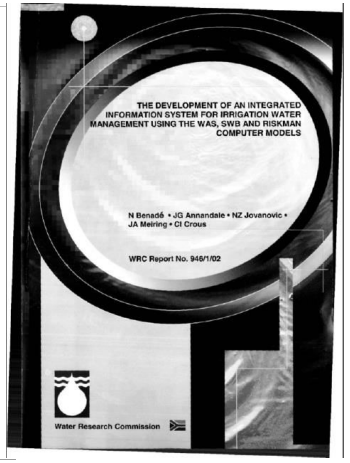
- Water use, irrigation requirements
- Irrigation scheduling, measurement
- Measurement, modelling
- Datasets:
  - WARMS data basis
  - Water resources assessments









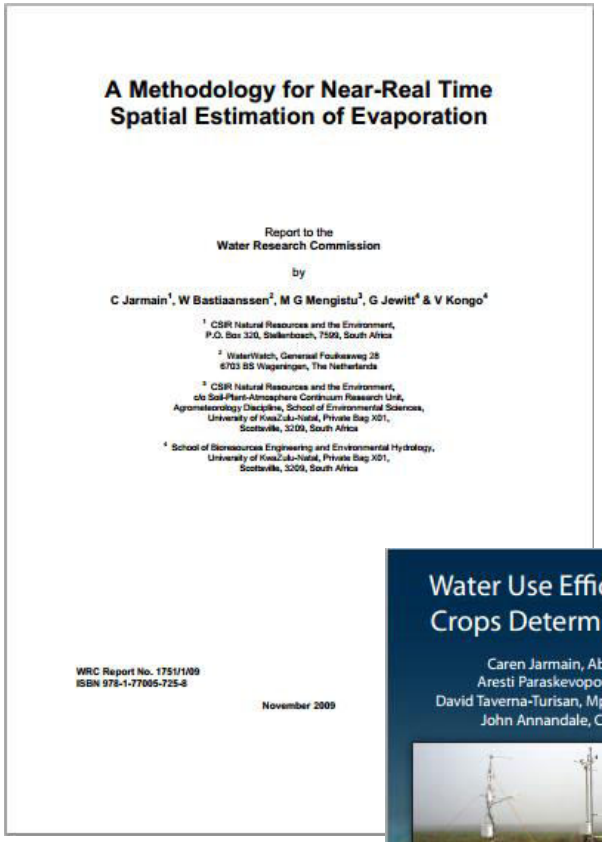


Value of available information, research related to irrigation illustrated – much funded by WRC

But, no recent…. complete (spatial) picture…

2014 Update….

- Wide scale modelling… water use and water availability.. earth observation, satellite imagery
- Build on from past WRC funded research
- Use novel approach



A Methodology for Near-Real Time Spatial Estimation of Evaporation

Report to the
Water Research Commission

by

C Jarmain[1], W Bastiaanssen[2], M G Mengistu[3], G Jewitt[4] & V Kongo[4]

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WRC Report No. 1751/1/09
ISBN 978-1-77005-725-8

November 2009

Water Use Efficiency of Selected Irrigated Crops Determined with Satellite Imagery

Caren Jarmain, Abraham Singels, Ernesto Bastidas-Obando, Aresti Paraskevopoulos, Francois Olivier, Michael van der Laan, David Taverna-Turisan, Mpendulo Dlamini, Zahn Munch, Wim Bastiaanssen, John Annandale, Colin Everson, Michael Savage & Sue Walker

WATER RESEARCH COMMISSION
TT 602/14

Aims (primary)

1. Update the *total area* used for irrigated agriculture in South Africa;
2. Update the estimated *total amount of water used* by irrigated agriculture in South Africa;
3. Quantify the *water used by selected irrigated crops* in selected areas;
4. Demonstrate how *water accounting* can be employed to determine water use and water availability over large catchments;

Aims (secondary)

- Develop capacity in EO and other geospatial techniques, specifically those relating to water use estimations, land cover and crop type mapping, as well as water accounting; and
- Engage with industry to stimulate participation, increase awareness of crop water use and availability and encourage adoption of new technologies and datasets.

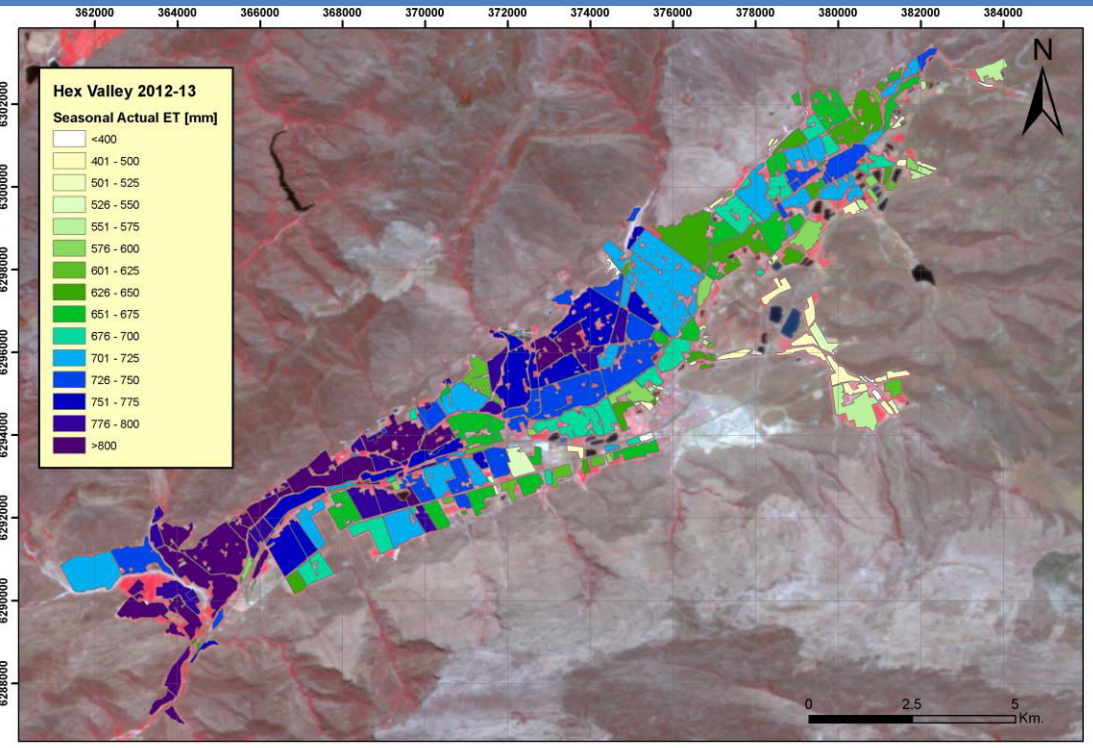
Definitions

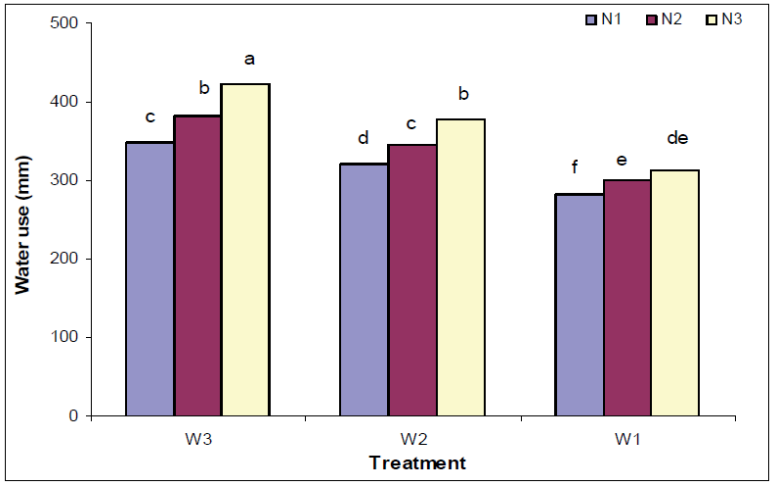
- Water used = ET = E+T
- ET = Water used ≠ Irrigation applied
- ET ≠ Irrigation water used or water abstraction
- Actual ET ≠ crop potential ET

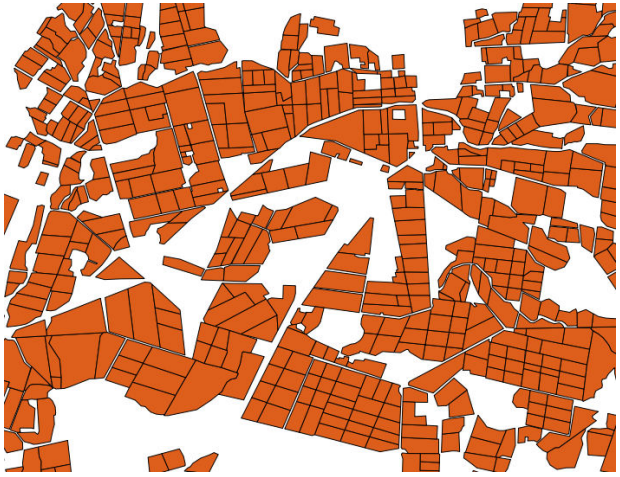
- ET from surface and groundwater
- ET not according to assurance of supply

- Irrigated area = total area irrigated under irrigation schemes, privately irrigated and small scale farms
- Actual estimated area, not predicted areas

Build on from existing data sets & data basis







water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

WATER IS LIFE, SANITATION IS DIGNITY

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WELCOME TO THE WARMS WEBPAGE

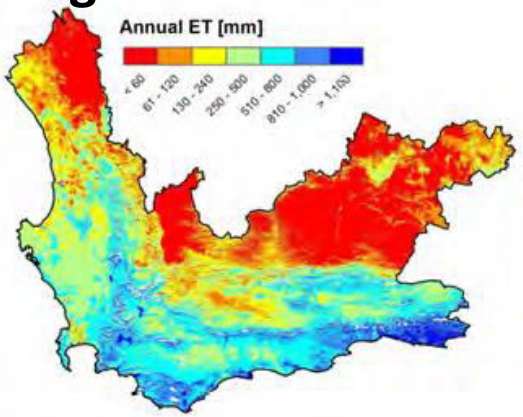
South Africa's scarce water resources are under increasing pressure. We will have to use them efficiently, effectively and wisely if we wish to build a sustainable future. In order to do this, we need to know how much water is used, by whom, and where. Once we know this, we will be able to measure it against how much water is actually available for use. In some areas we will then find that there is still extra water that can be made available for use. In other areas we will find that there is already more water being used than the water resources can provide without considerable damage to the aquatic ecosystems.

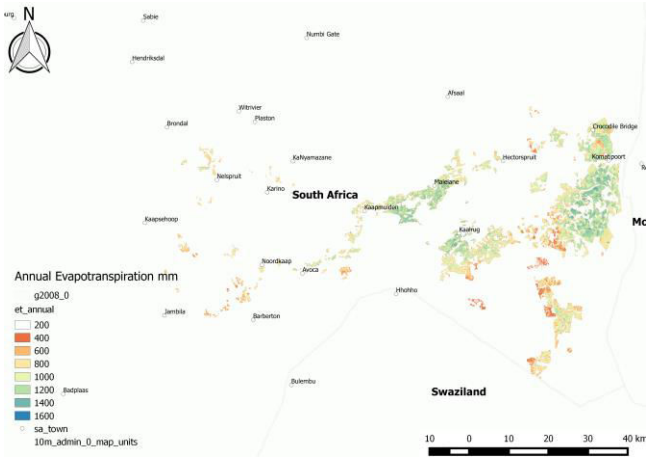
The National Water Act (Act 36 of 1998) gives the Department of Water Affairs the tools to gather the information that we need for the optimal management of our water resources. The registration of water use is one of these tools.

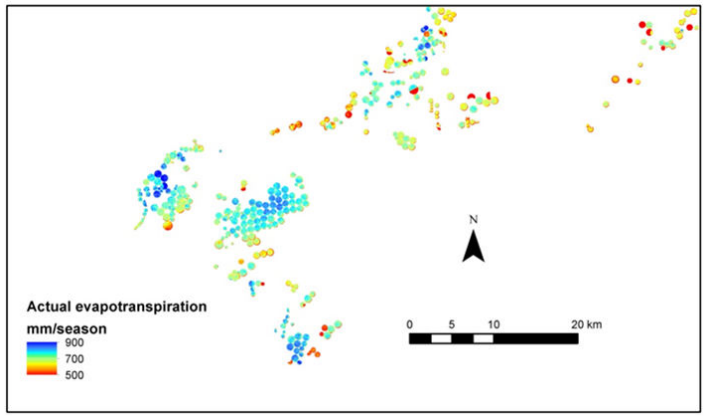
where available

Generate new country wide data sets related to ET, land cover / land use and others

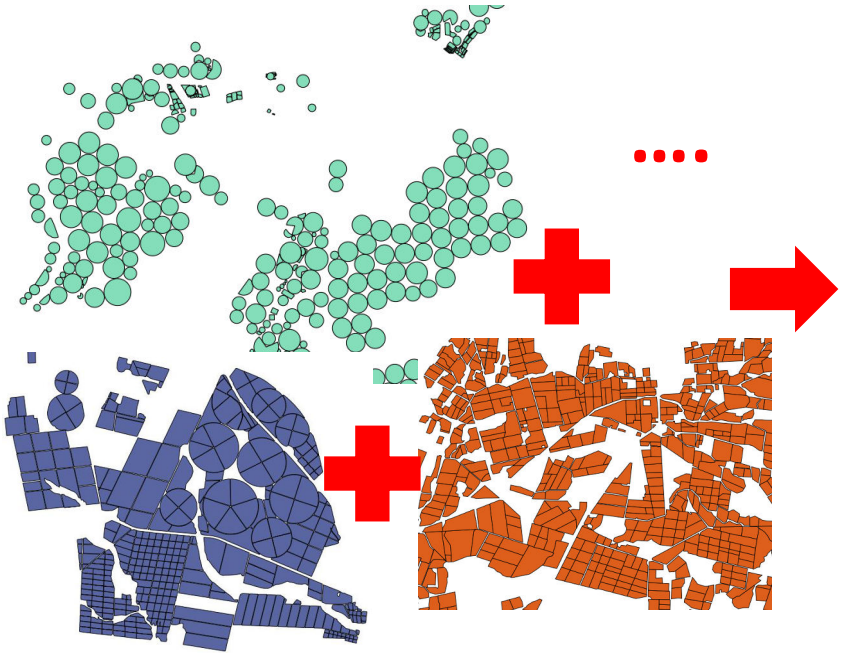
Vegetation water use

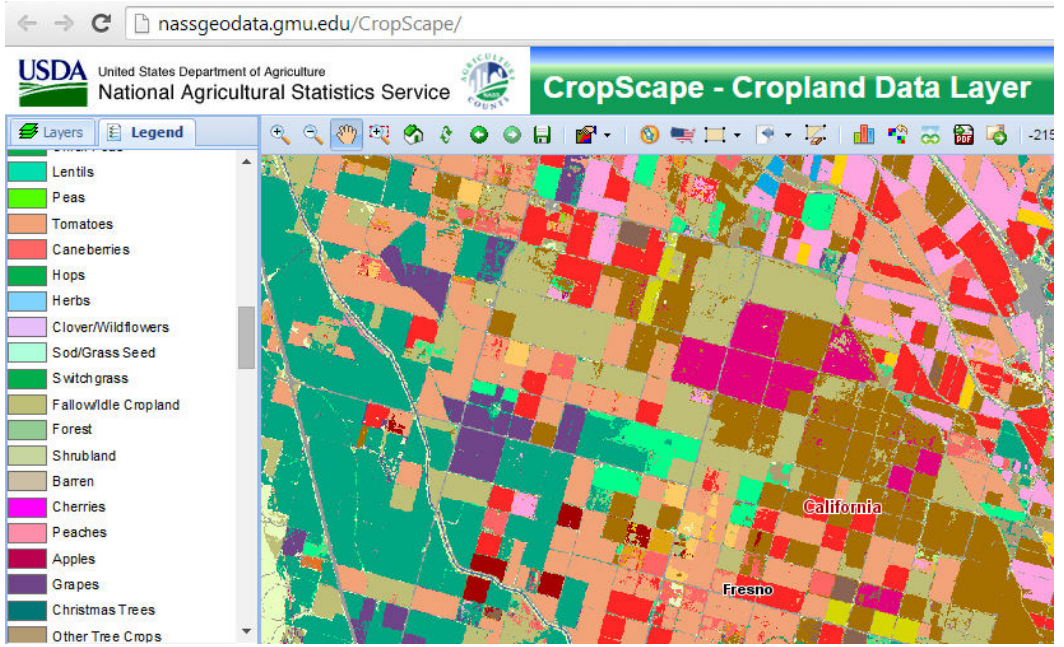






Land cover / land use





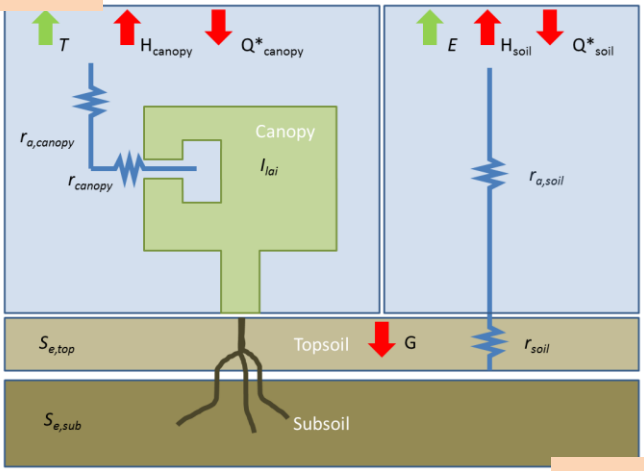
Use Innovative ways

Remote sensing datasets

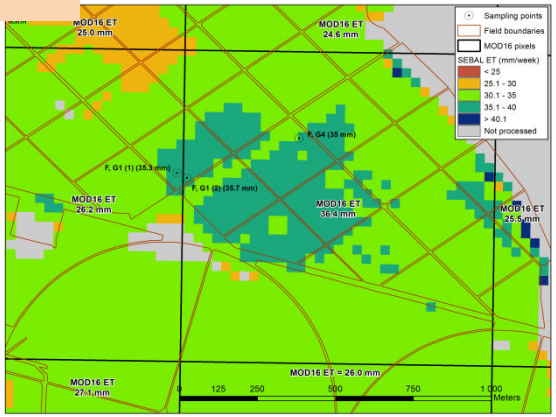
- MODIS / VIIRS
- ASCAT/MODIS-LST
- FEWS/TRMM
- Optical
- Thermal
- Active (microwave)
- Image classification methods

Data, models and frameworks

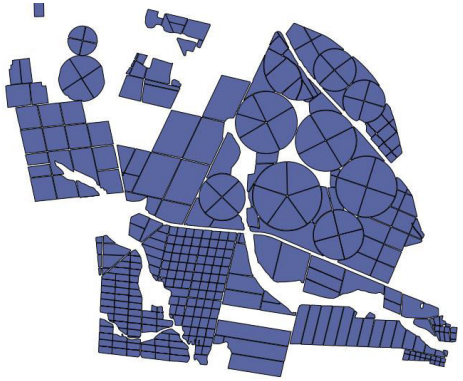
ETLook



MOD16

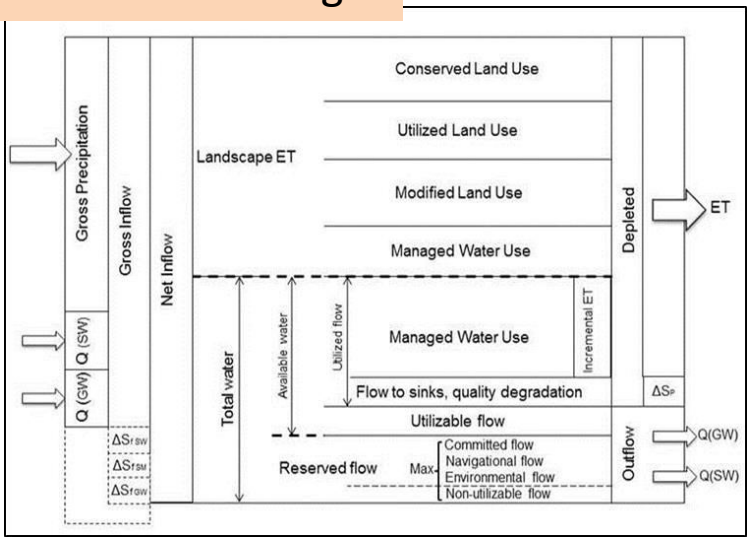


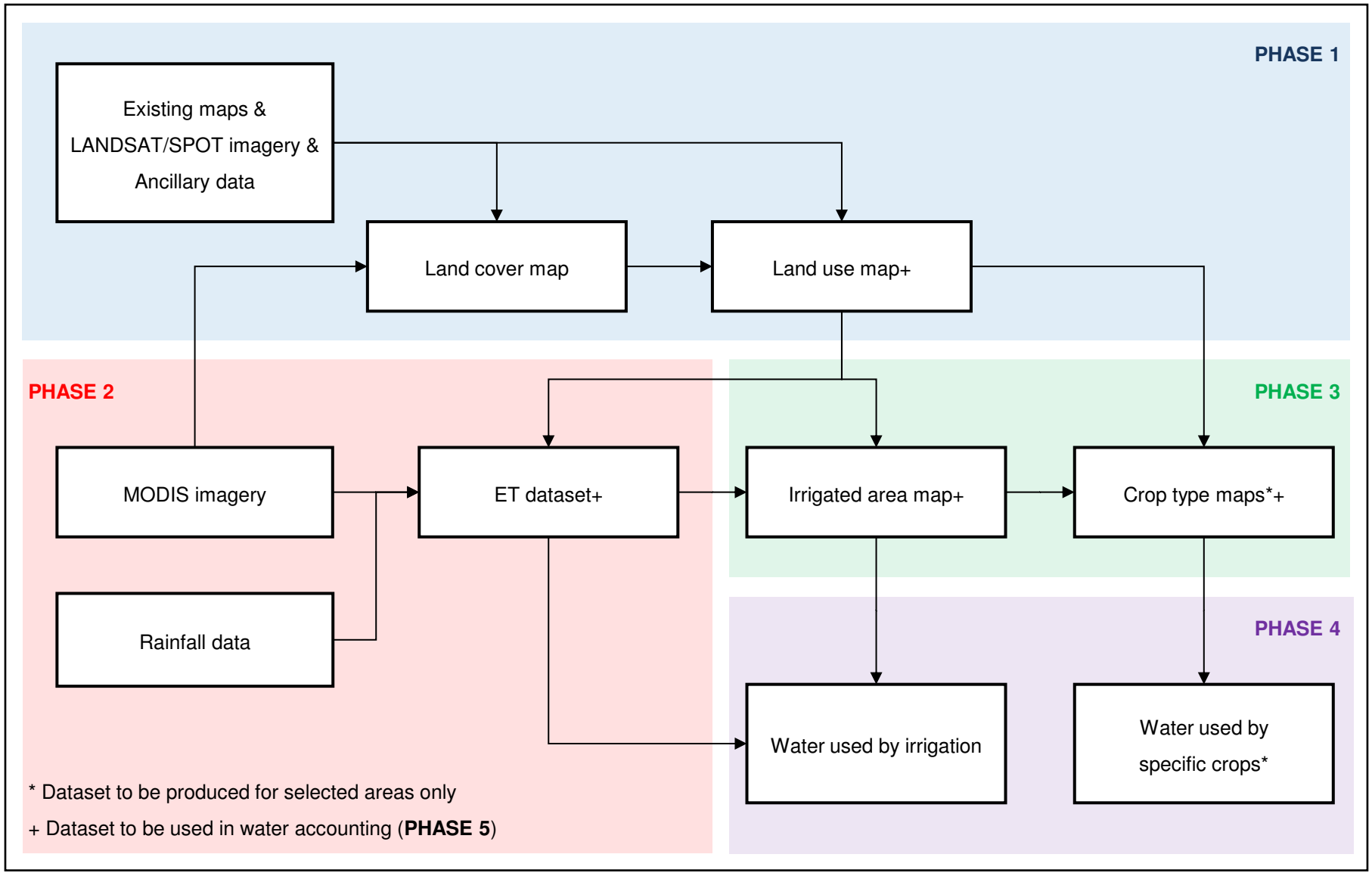
GIS data sets



- Available land cover / land use

Water accounting +

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Crop type maps*+
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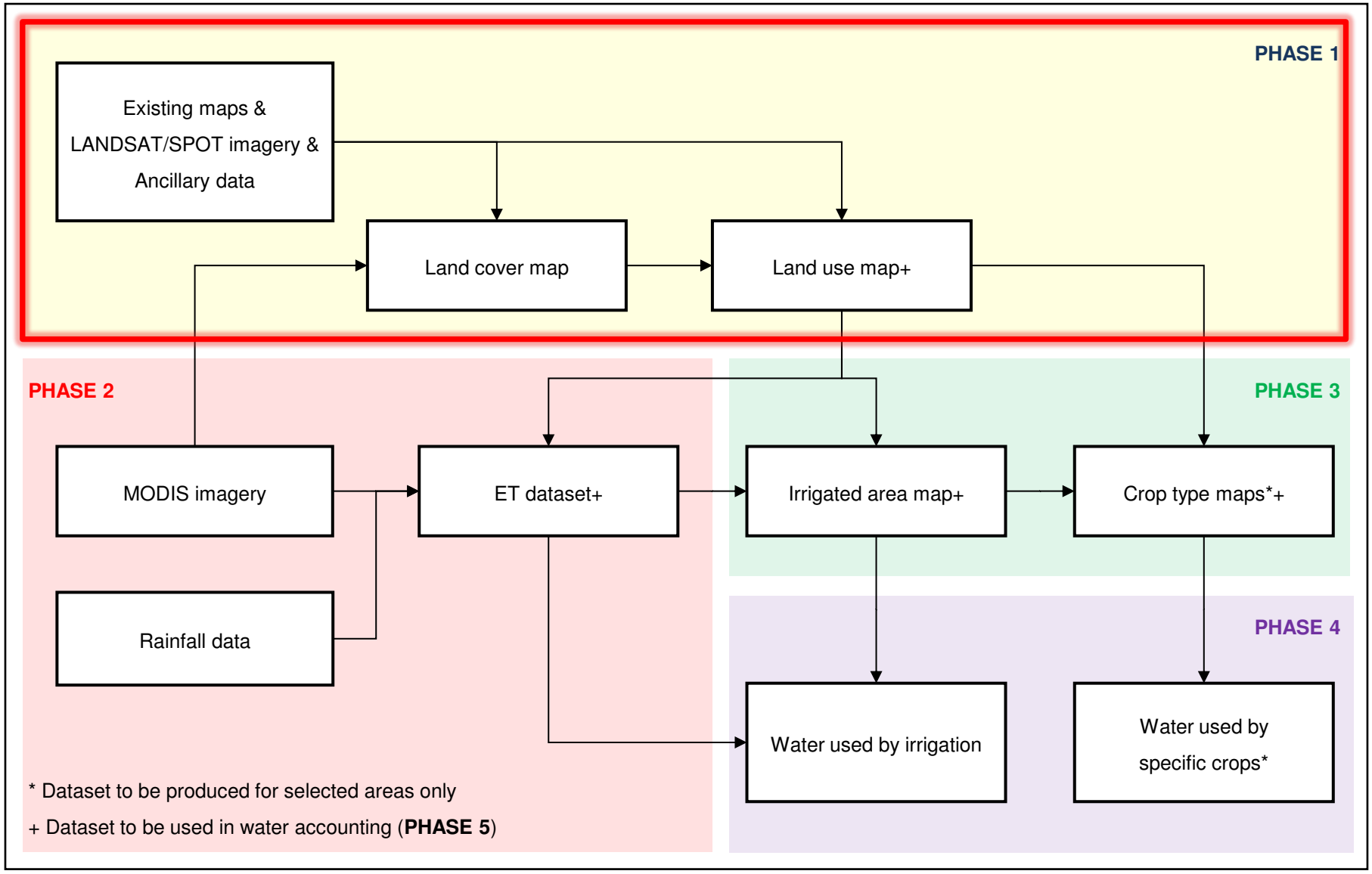
Water used by irrigation
Water used by specific crops*
* Dataset to be produced for selected areas only
+ Dataset to be used in water accounting (PHASE 5)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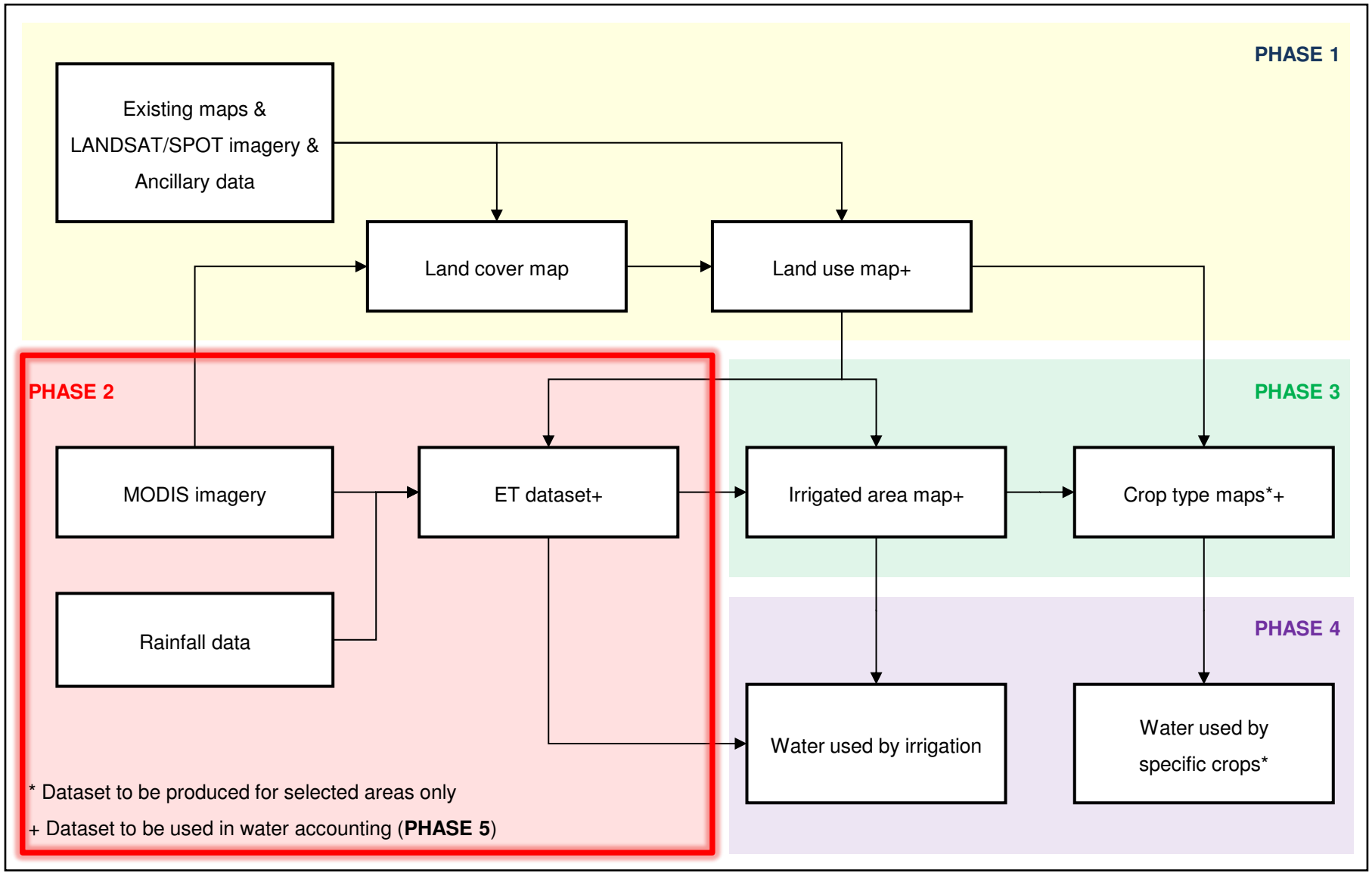
Phase 1: Land cover and land use mapping

- Land cover/use fundamental input to later phases
  - ET modelling (Phase 2)
  - Irrigated area/crop mapping (Phase 3)
  - Water accounting (Phase 5)
- Budget does not allow for the generation of a national, wall-to-wall land cover/use map
- Make use of existing maps; but identify gaps
- Spatial resolution 10m

Phase 1: Land cover/use mapping procedure

- Use NLC2000 as foundation dataset
- Replace NLC2000 data with more recent land cover maps where available:
  - North West (Spot5 2007)
  - Free State (Spot5 2009)
  - Limpopo (Spot5 2010)
  - Inkomati Catchment (Spot5 2010)
  - KZN (Spot5 2011)
  - Mpumalanga (Landsat & Spot 2008)
  - Parts of Western Cape (Spot5 2007 & SIQ 2013)
  - Eastern Cape (2012 – in progress)
  - National field boundaries (2013)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Phase 2.1: Rainfall data

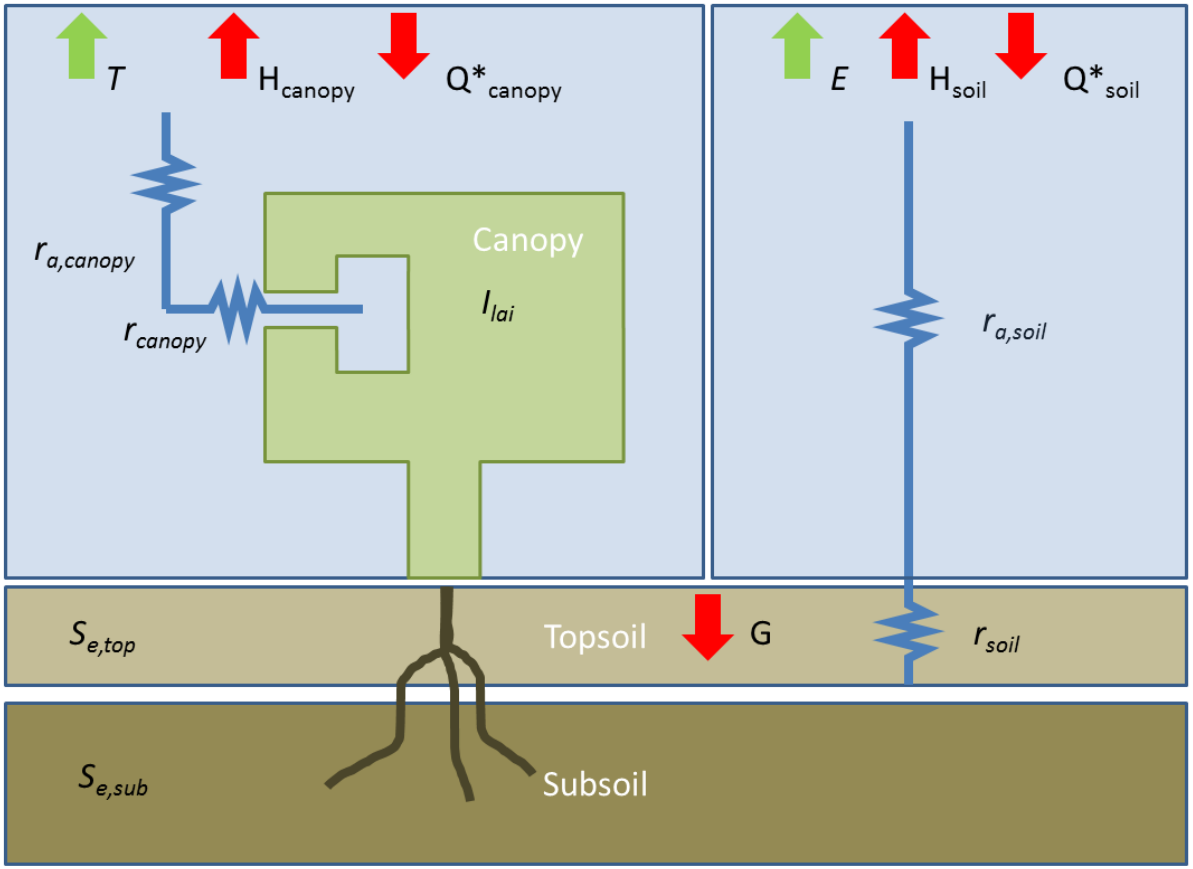
- Rainfall data needed for:
  - distinguishing between ETP (ET from precipitation) and ETirr (ET from irrigation)
  - Determining interception
- Sources of data to be investigated:
  - FEWS
  - TRMM
  - GMOA
  - Other SA data bases

Phase 2.2: ET dataset development

- ETLook will be used to generate actual ET datasets at national level
  - 250m resolution (MODIS or VIRS)
  - Daily and monthly interval
  - From 1 August 2014 to 31 July 2015
- Source data:
  - Land cover/use
  - Rainfall data (Component 2.1)
  - MODIS (or VIRS), MSG, ASCAT
- Sensitivity analysis (Component 2.3)

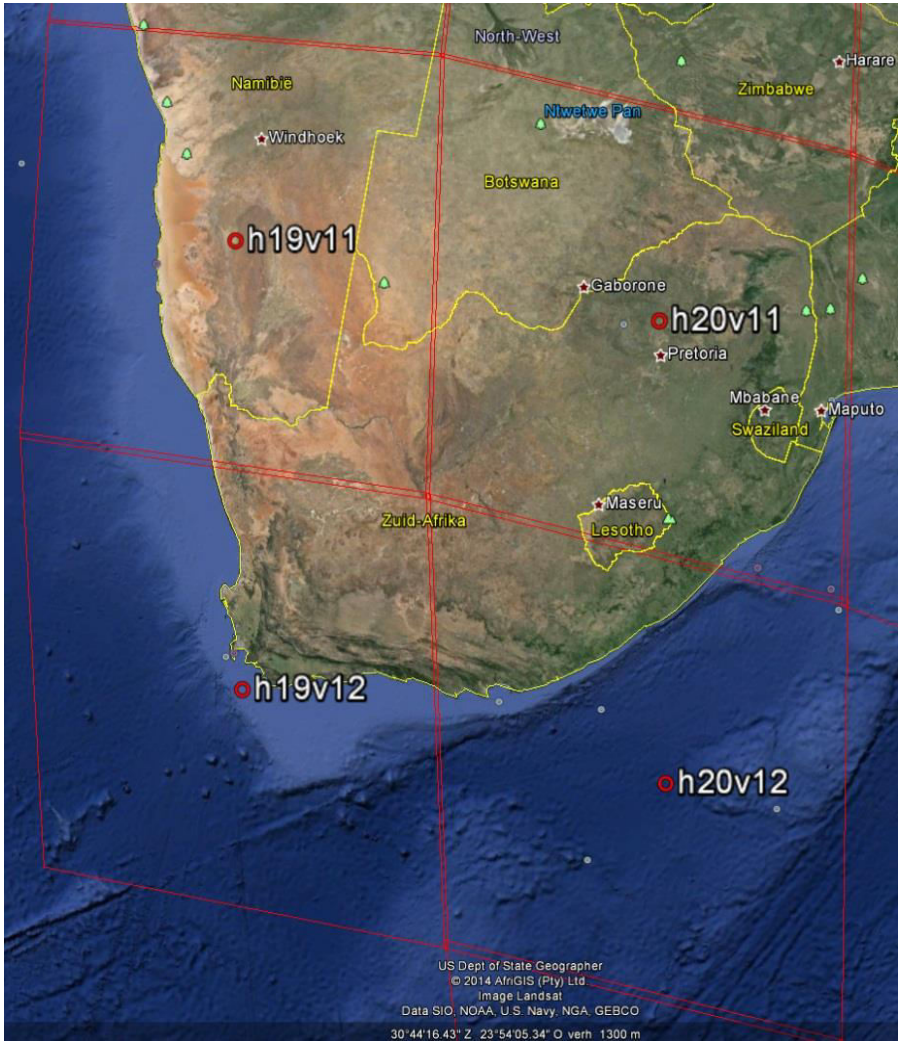
Phase 2.2: ETLook

ETLook (Bastiaanssen et al., 2012) combines estimates of soil moisture in top soil, surface energy balance and Penman-Monteith equation to estimate E and T separately



W. G. M. Bastiaanssen,M. J. M. Cheema, W. W. Immerzeel, I. J. Miltenburg, and H. Pelgrum. 2012. Surface energy balance and actual evapotranspiration of the transboundary Indus Basin estimated from satellite measurements and the ETLook model. WATER RESOURCES RESEARCH, VOL. 48, W11512, doi:10.1029/2011WR010482, 2012.

Phase 2.3: ET sensitivity



Coarse scale Satellite data due to extent of area:

-MODIS (aqua or terra) (250 to 500m) or NPP satellite (VIIRS) from NOAA (375m)

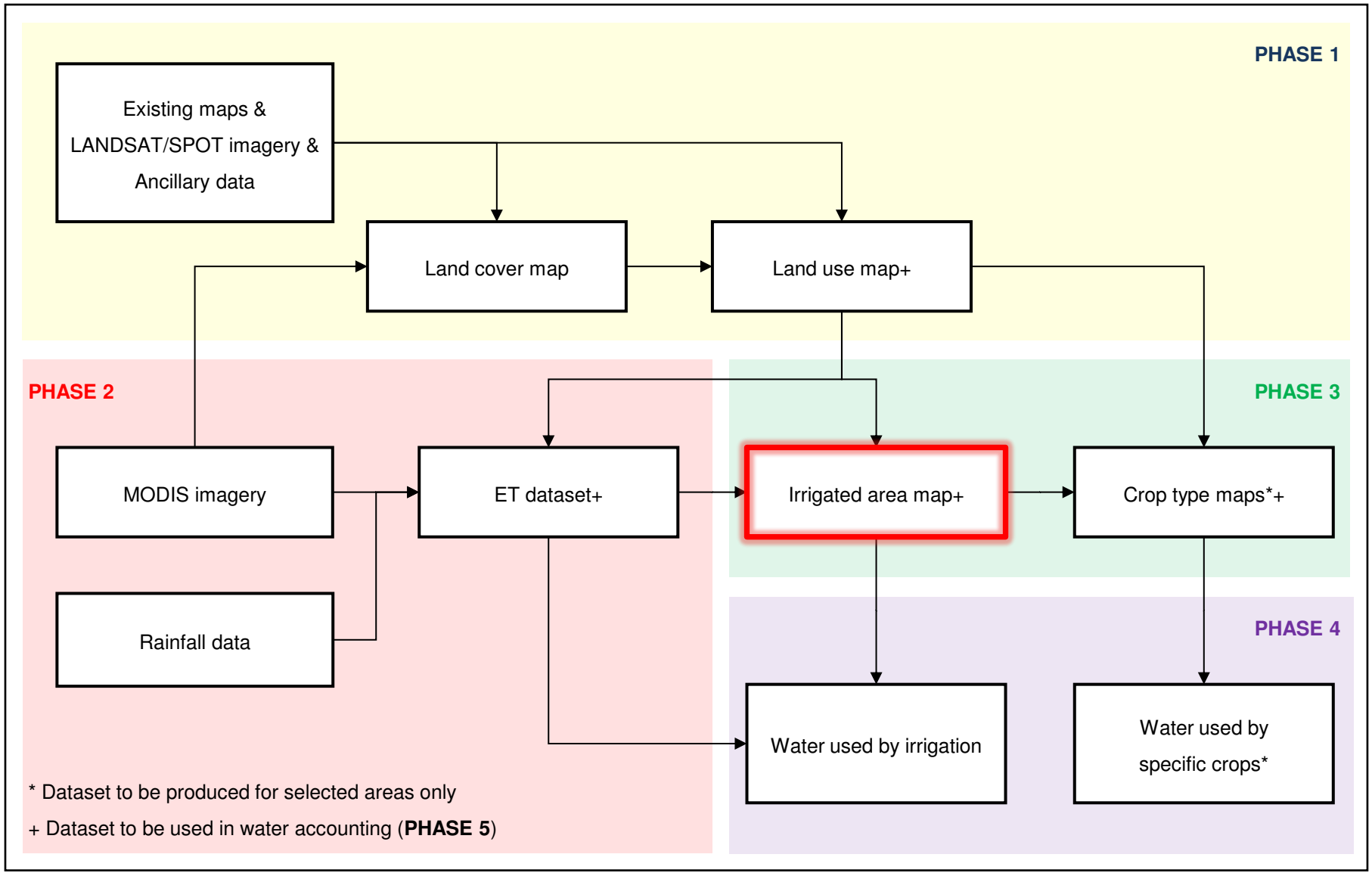
-Advanced Scatterometer (ASCAT) for soil moisture

-Meteosat Second Generation (MSG) for cloud cover

Sensitivity analysis:

-Comparison against existing high resolution data sets

-ET histograms, profiles, etc.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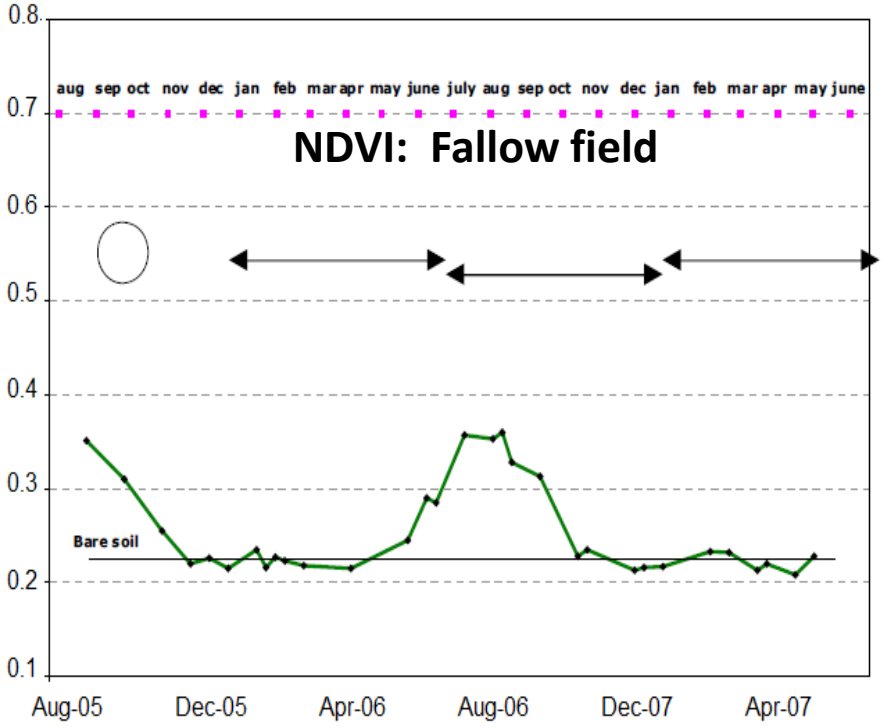
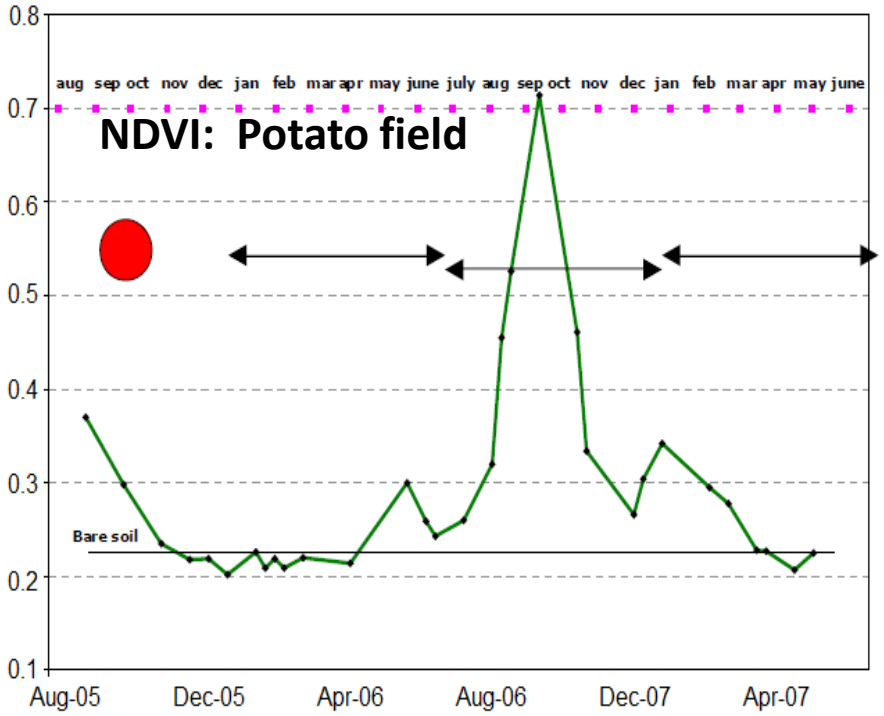
Phase 3.1: Irrigated area mapping

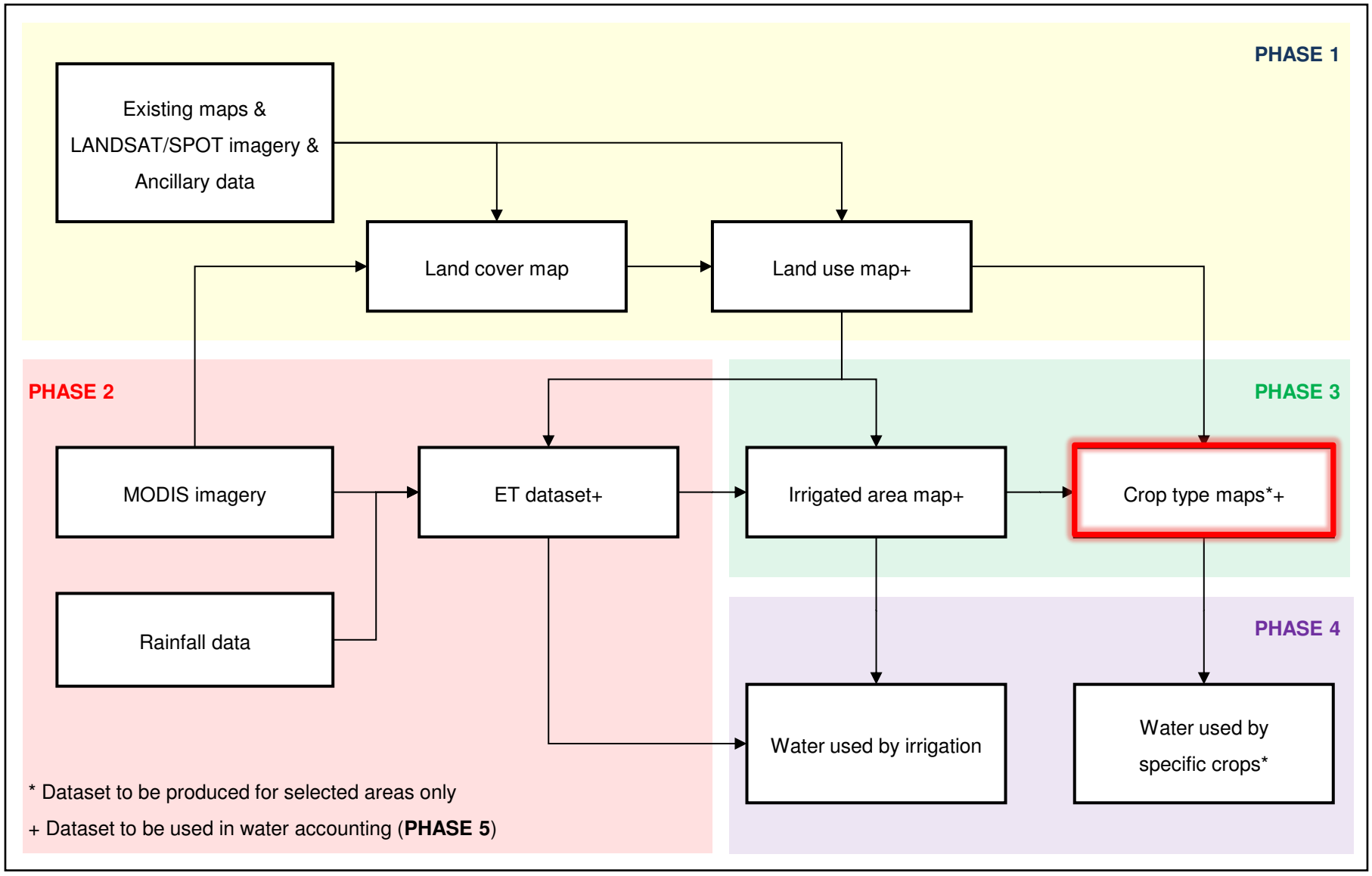
- In order to estimate total water used by irrigated agriculture=area under irrigation during the dry and wet season
- Land cover/use map is used as starting point (e.g. to differentiate agricultural areas from other land uses)
- Irrigation during dry season: Use MODIS 8-day composite NDVI profiles (>6.25ha)





Phase 3.1&3.2: Irrigated area mapping

- Irrigation during wet season more complex:
  - Combine ET and rainfall (P) data
  - Fields where ET > P are most likely irrigated
- Cross-check
  - Against land use/ land cover map (Phase 1)
  - Against existing data sources (AQUASTAT, FAO global irrigated area map, Irrigation scheme data, DWAF)
- Also, alternative remote sensing methods for irrigated area mapping (Phase 3.2)
  - Determine minimum requirements for mapping
  - Investigate freely available data (MOD16, Landsat 8, SPOT5)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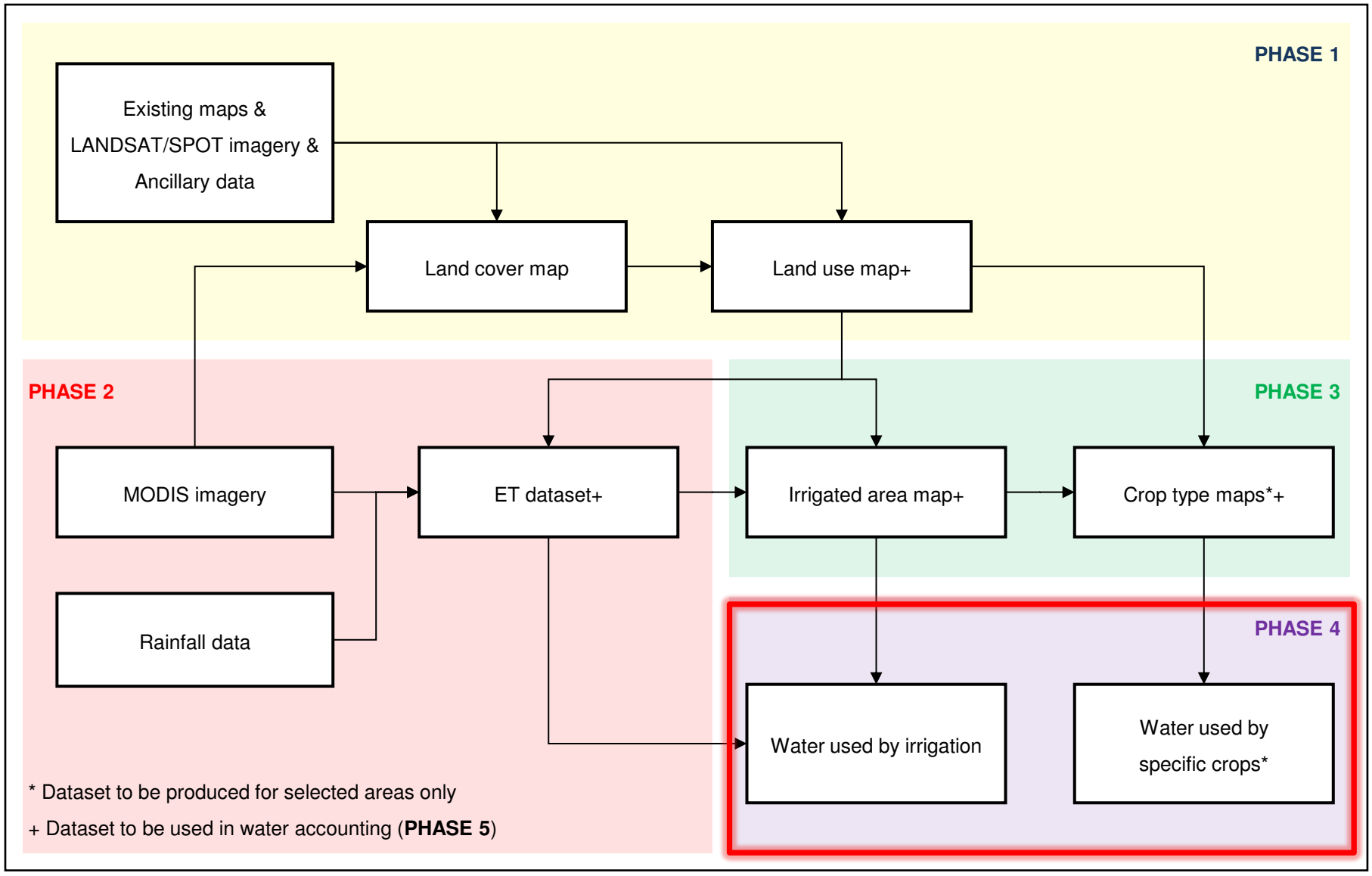
Phase 3.3: Crop type mapping

- Only require maps for representative areas and selected crops
- Make use of existing maps
  - Western Cape (2013)
  - Gauteng (2009)
  - Limpopo (2011)
  - Free State (2007-2010)
  - North West (2011-2013)
  - Others where available
- Investigate remote sensing techniques for crop mapping (e.g. SeasonLook, multi-temporal Landsat 8, Synthetic aperture radar or SAR)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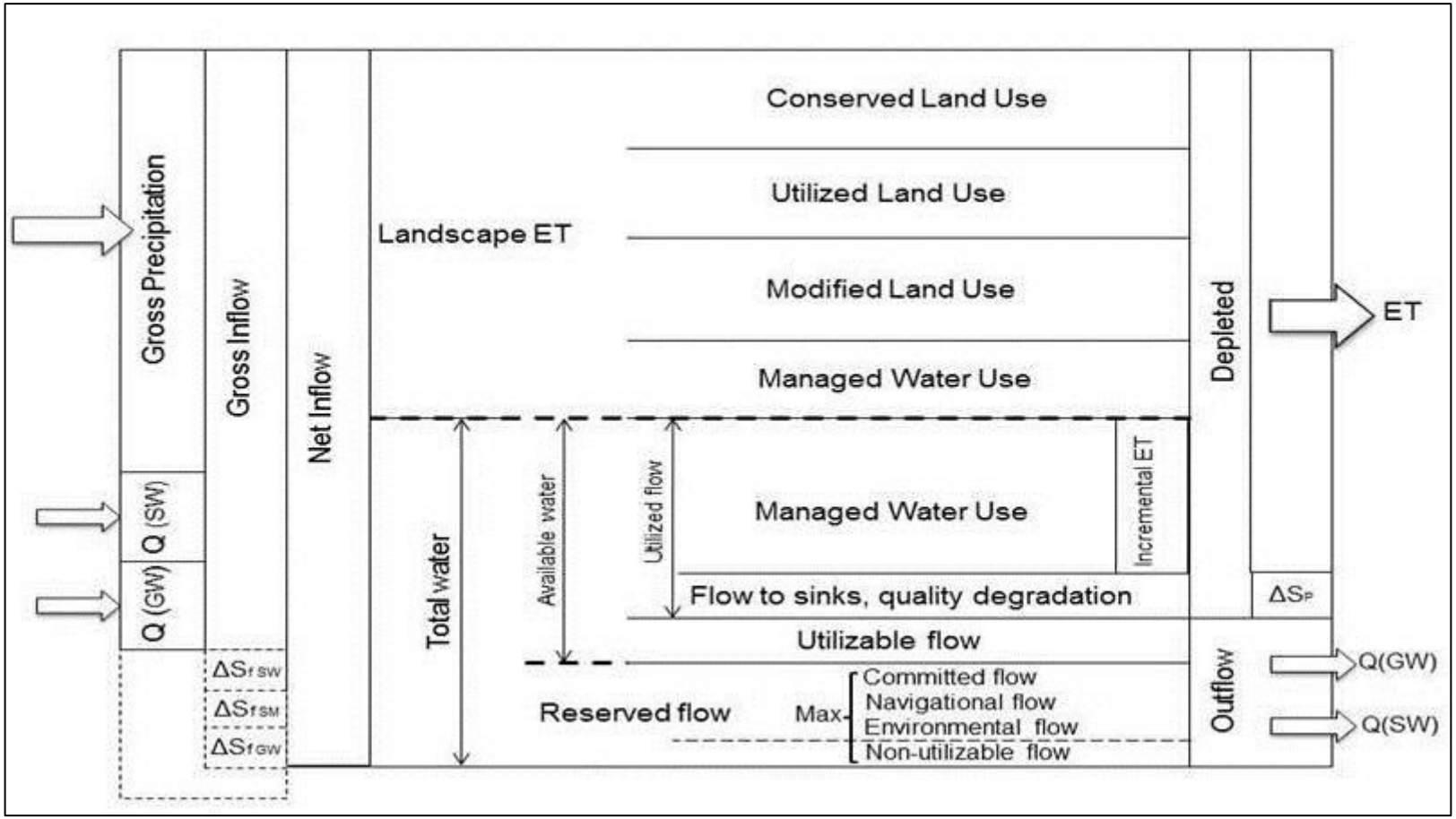
Phase 4: Water used by irrigated agriculture and selected crops

- Relatively simple GIS procedure using products derived in previous phases
  1. Extract ET values occurring within irrigated areas (or selected crops)
  2. Calculate total ET (for entire irrigated area) and mean total ET (per crop)
- Results can be presented at national level or per province, municipality, irrigation scheme or catchment
- Seasonality can also be analysed

Phase 5: Water accounting

- Example application(s) of the Water Accounting + approach
- WA+ sheets will be produced for
  - One hydrological year (Aug 2014 to Jul 2015)
  - Selection of catchments in SA (possibly 10)
- Catchment selection will be based on
  - Climate
  - Level of development
  - Data availability
  - Inputs from reference group and other researchers
- Results will be interpreted and recommendations will be made
- Framework will utilize data outputs from previous phases

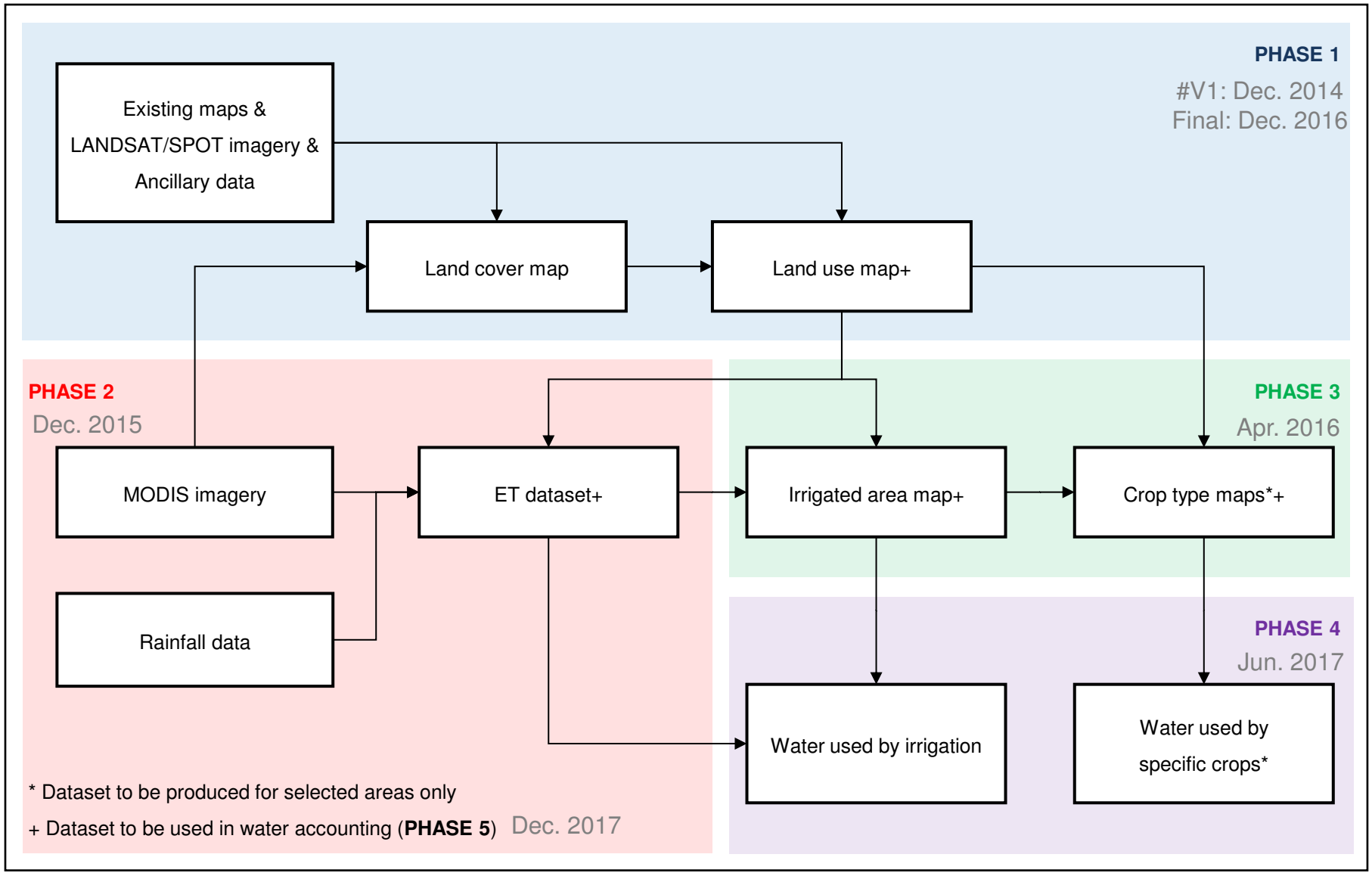
Phase 5: Water accounting



Important outputs and products

- Important outputs:
  1. Updated estimate of area under irrigation
  2. Updated estimate of water used by irrigated agriculture
  3. Updated estimate of ET per main irrigated crop

- Products:
  - Map of areas under irrigated cultivation
  - Monthly ET database at national level
  - Guideline documents
    - Step-by-step instructions and user-friendly guidelines on how water use and availability can be monitored over large areas


PHASE 1
#V1: Dec. 2014
Final: Dec. 2016
Existing maps & LANDSAT/SPOT imagery & Ancillary data
Land cover map
Land use map+
PHASE 2
Dec. 2015
PHASE 3
Apr. 2016
MODIS imagery
ET dataset+
Irrigated area map+
Crop type maps*+
Rainfall data
PHASE 4
Jun. 2017
Water used by irrigation
Water used by specific crops*
* Dataset to be produced for selected areas only
+ Dataset to be used in water accounting (PHASE 5) Dec. 2017

Please complete the questionnaire ☺

Thank you

Project contacts

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SANCID SYMPOSIUM 2014, 18 – 20 November 2014, Glenburn Lodge, Muldersdrift