



ITU Regional Workshop on “Prospects of Smart Water Management (SWM) in Arab Region” Khartoum-Sudan, 12 December 2017

Smart Technologies for Water Management in Support of Agricultural Production and Irrigation

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ITU expert





Outline:

Definitions

Challenges in Water Management for Agricultural and Irrigation

Objective

Smart Agricultural Water Efficiency

- Expansion and Enhancement of Monitoring System
- Development and Rehabilitation of Water Resources
- Enhancement of Water Management Technology
- Development of ICT Applications
- Integrated Water Resources Management (IWRM)

Case Study



Definitions



Definitions

Agricultural Water Efficiency (AWE):
 AWE has been generally defined as the ratio of crop yield to water used to produce the yield; (Ali and Talukder, 2008; Boutraa, 2010; Fan et al., 2012). The term can be used for a wide range of scales from the basin to the farm or to the level of plant part. Different similar terms are in use like **Water Productivity, Irrigation Efficiency, and Water Conservation**

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 OUR VISION: TO CREATE INDUSTRY-LEADING SOLUTIONS FOR...

AGRICULTURAL EFFICIENCY & PRODUCTION

INSTALL COST
 INCREASED YIELD 3-10 YRS

RETURN ON INVESTMENT
 Drainage systems can return the cost of investment in 3-10 years¹ and are one of the most effective methods of increasing agricultural efficiency and productivity.

STANDING WATER
 Standing water directly affects yield and interrupts traffic patterns by creating non-uniform field conditions.

TOTAL FIELD ACCESS
 Prinsco Drainage: Wet Field, Optimal Planting, Short Season
 Inadequate Drainage: Wet Field, Optimal Planting, Short Season

HIGHER YIELDS
 Subsurface drainage systems can significantly improve crop yields on poorly drained soil. Typical increases might be 10-30 bushels/acre for corn and 5-10 bushels/acre for soybeans.¹

DEMANDS OF POPULATION GROWTH
 As the global population grows from 7 billion to almost 9 billion by 2040, the demand for resources will rise exponentially. By 2030, the world will need at least 50 percent more food, 45 percent more energy and 30 percent more water.¹

PROTEIN CONSUMPTION
 World consumption of animal protein is on the rise, and about 35% of the world's grain harvest is used to produce animal protein. It takes 7 lbs of grain for 1 lb of gain in grain-fed beef.¹

CONTROLLED DRAINAGE
 The emerging trend towards controlled drainage allows farmers to manage water tables while reducing nitrate loss.

SOIL COMPACTION
 Vehicle traffic on wet soil can cause soil compaction, limiting root growth and adding to plant stress.

SATURATED ROOTS
 Over saturated soil condition limits oxygen to the root zone resulting in shallow root growth. Crops with shallow roots are less durable, less productive and have trouble reaching water tables in the dry season.

PEAK FLOW RATES
 Surface drainage increases peak surface runoff flow rates, which is what causes flooding. Because tile drainage tends to decrease peak runoff rates, it should not increase, and may even decrease, the incidence of flooding.¹

HEALTHY ROOTS
 Subsurface drainage promotes deeper, healthier root systems by decreasing plant stress and allowing for more oxygen in the root zone.

WATER QUALITY
 Subsurface drainage can decrease surface runoff thereby reducing sediment losses by 16-65% and phosphorus losses by up to 45%.¹

SEDIMENT
 Uncontrolled surface runoff can increase the loss of nutrients and sediment and negatively impact water quality.

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Definitions

- A. Water Productivity:** This represents the ratio of the aboveground biomass per unit of water transpired by the crop (Steduto, 2007; Levidow et al., 2014).
- B. Irrigation Efficiency:** Irrigation engineers have another term for AWE which is “Irrigation Efficiency”. This is expressed as the ratio of water beneficially used to the total water applied (Sinclair et al., 1984). There are more than 30 different definitions of irrigation efficiency currently used (Edkins, 2006; Jensen, 2007; Halsema and Vincent, 2012).
- C. Water Conservation:** California DWR (2012) used the term “Water Conservation”, defined as the efficient management of water resources for beneficial uses, preventing waste or accomplishing additional benefits with the same amount of water.



Challenges in Water Management for Agricultural and Irrigation



Challenges in Water Management for Agricultural and Irrigation

WORLD POPULATION DATA

TOP WORLD POPULATION RANKINGS IN 2050 WILL STACK UP DIFFERENTLY THAN IN 2017

2017		2050	
CHINA	1,387 MILLION	INDIA	1,676 MILLION
INDIA	1,353 MILLION	CHINA	1,343 MILLION
UNITED STATES	325 MILLION	NIGERIA	411 MILLION
INDONESIA	264 MILLION	UNITED STATES	397 MILLION
BRAZIL	208 MILLION	INDONESIA	322 MILLION
PAKISTAN	199 MILLION	PAKISTAN	311 MILLION
NIGERIA	191 MILLION	BRAZIL	231 MILLION

SOURCE: POPULATION REFERENCE BUREAU • WORLDPOPDATA.ORG • #WORLDPOPDATA

The world population reached **7.5** billion in **2017** and is expected to increase to about **9.8** billion by **2050**.

Food, Choice, Sustainability



In the year
2050
World
population
will require



70%
More **food**, and



70%
Of this food must come
from efficiency-improving
technology³

Sources:
1. Green, R., et al. January 2005. "Farming and the Fate of Wild Nature." Science 307: 550-555.
2. Tilman, D., et al. August 2002. "Agricultural sustainability and intensive production practices." Nature 418: 671-677.
3. "World agriculture: toward 2015/2030." 2002. United Nations Food and Agriculture Organization, Rome. Accessed December 2, 2008. <<http://ftp.fao.org/docrep/ao/004/y3557e/y3557e.pdf>>.

2017 to 2050...

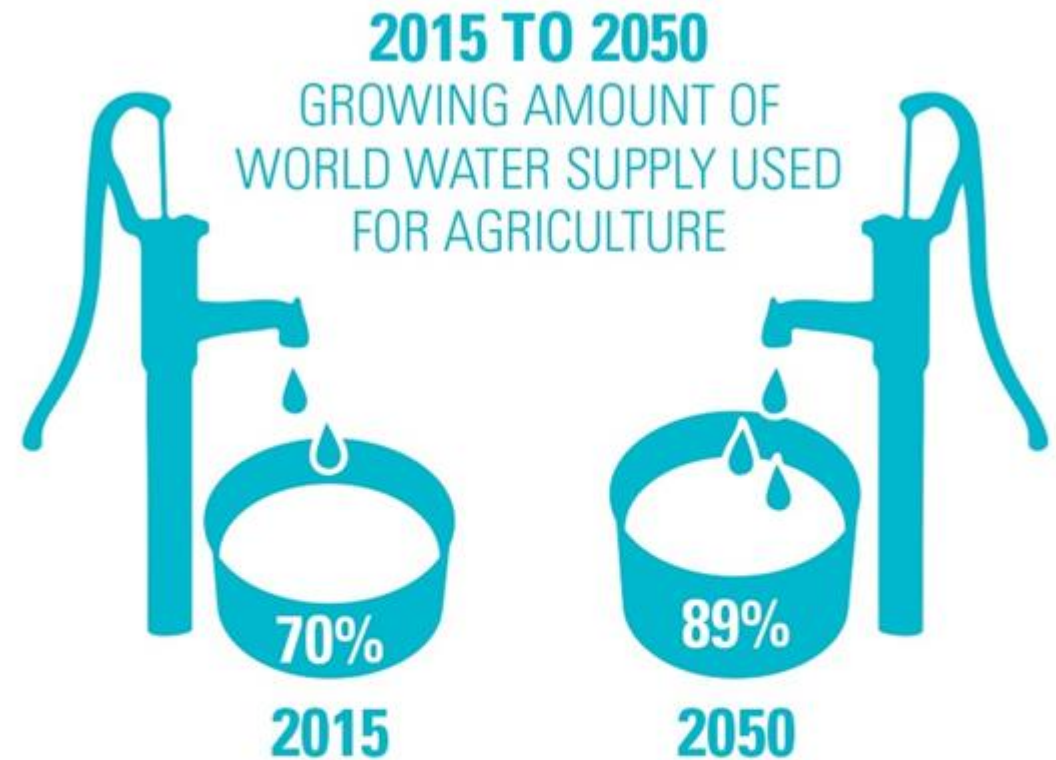
70% more food is required (OECD, 2015).

Challenges in Water Management for Agricultural and Irrigation

The world's cultivated area has grown by **12%** over the past **50** years, and the global irrigated area has doubled from **139** million hectares in **1961** to **357** million hectares in **2016**.

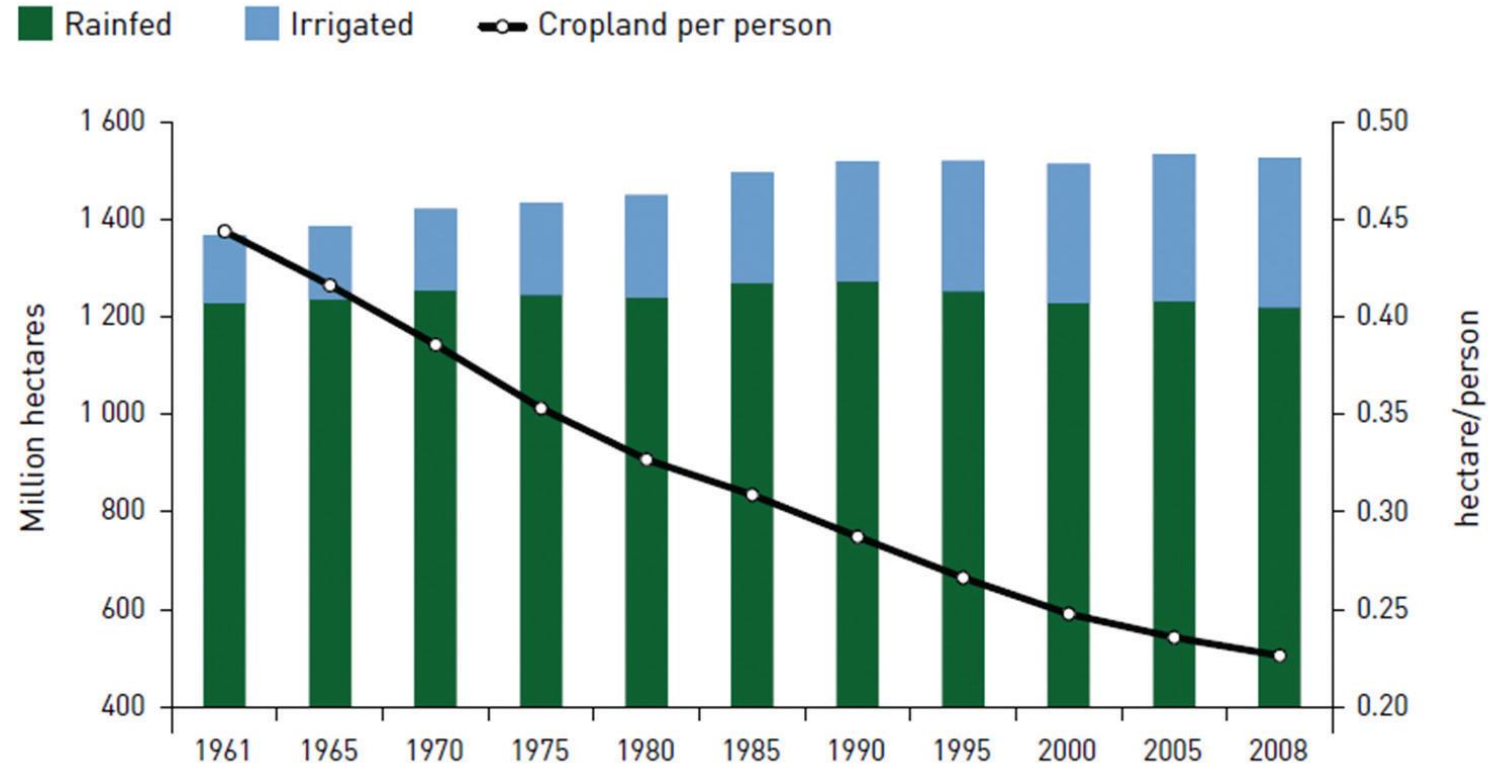
Agricultural water is estimated to account for **70%** of all water withdrawn from aquifers, streams and lakes, and more than **90%** of the agricultural water intake is for irrigation (FAO, 2007, 2011).

Existing water resources are already fully exploited. Agriculture therefore faces a great challenge in coping with growing water scarcity and increasing demands for food production.



Water: 70% of the water extracted from the world's rivers, lakes and aquifers is used for agriculture and this will rise to **89%** by 2050. In developing countries, irrigation **already uses 85%** of extracted water.⁹

Challenges in Water Management for Agricultural and Irrigation



Source: FAO (2010b)

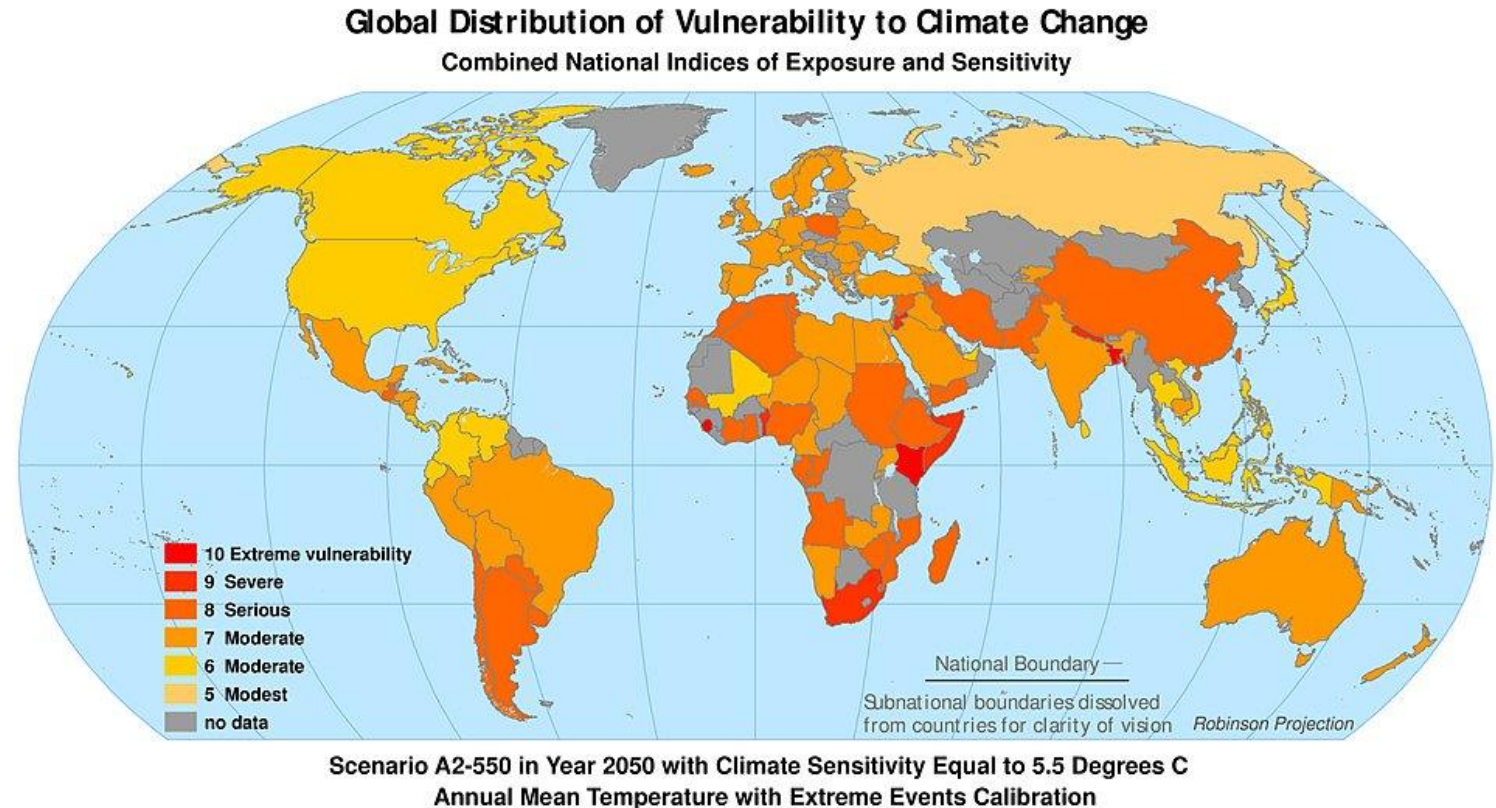
Evolution of land under irrigated and rainfed cropping (1961-2008)
(FAO, 2010b)

Challenges in Water Management for Agricultural and Irrigation

Climate change is expected to alter the patterns of temperature, precipitation, and river flows upon which agricultural systems depend.

In the future, weather patterns will become more uncertain and the frequency of extreme climate events, such as twister and droughts, will increase (Benito et al., 2009; FAO, 2011).

The percentage of global land classified as 'Very Dry' has doubled since 1970s, and natural water storage capacity and long-term annual river flows are declining (Morrison et al., 2009).



<http://ciesin.columbia.edu/data/climate/>

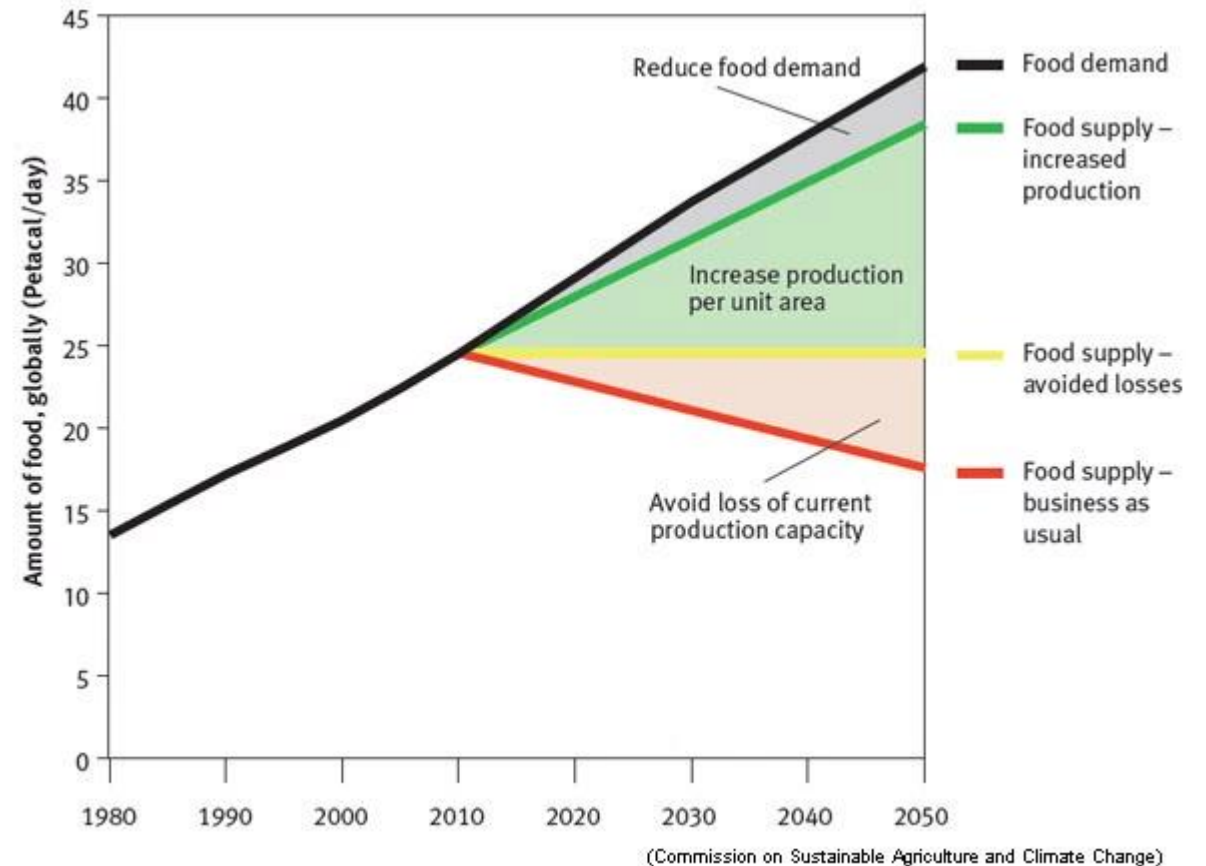
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Challenges in Water Management for Agricultural and Irrigation

- ❑ Agricultural Water Efficiency (AWE) is still very low in most of the developing countries owing poor irrigation management and lack of investment in infrastructure (Fan et al., 2012).

- ❑ Even in the developed countries, most irrigation systems perform below their original capacity and are not adapted to the needs of today's agriculture.





Objective

-  Specific
-  Measurable
-  Achievable
-  Rewarding
-  Timely



wiki How to Write an Educational Objective

Objective

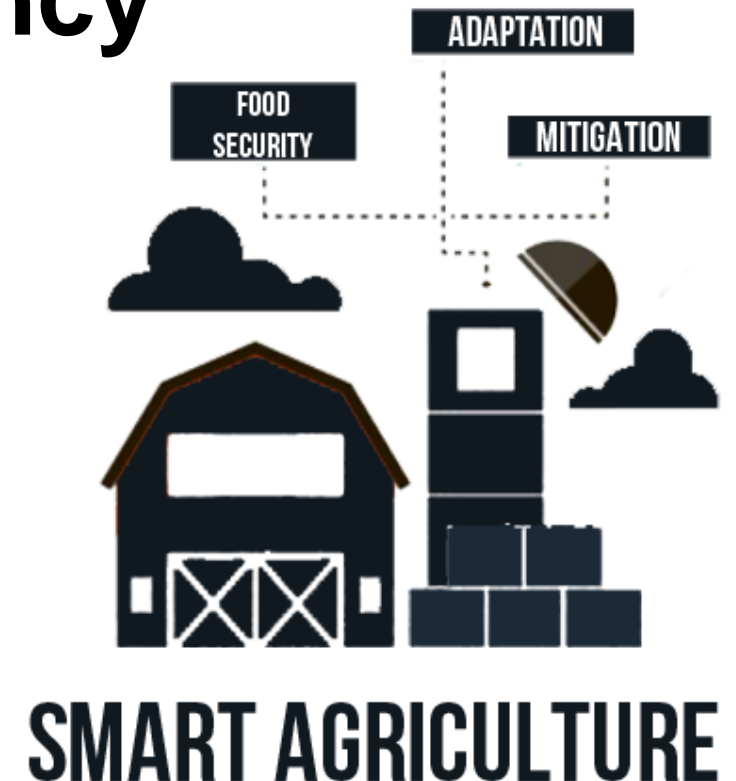
Smart irrigation and agriculture systems are must. With the concept of Internet of Things (IOT) and the power of the cloud, it is possible to real time monitor/control different processes of irrigation and agriculture.

Smart irrigation and agriculture is made up of sensors which monitor different types of data such as; weather forecasting (air humidity, air temperature, sun exposure ...etc), soil moisture (water content of the soil), soil's specified composition/type, crop quantity and quality,etc. Theses data are transmitted, processed, and the farmer is then informed (by a web app or mobile app) about when to irrigate, duration/amount of irrigation,etc. Furthermore, farmer can monitor/control over the air (OTA) a lot of the aspects relating to optimized irrigation and agriculture.



Smart Agricultural Water Efficiency

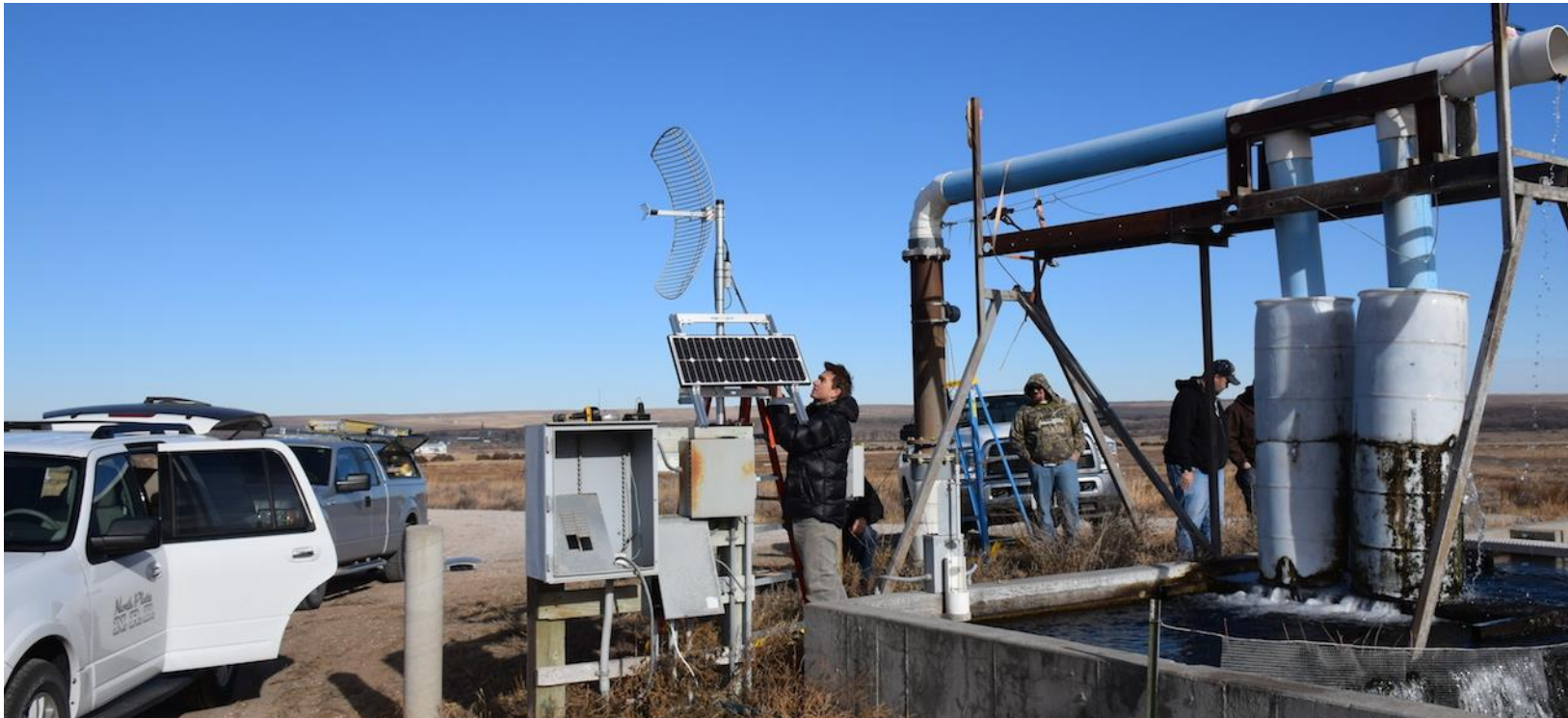
- Expansion and Enhancement of Monitoring System
- Development and Rehabilitation of Water Resources
- Enhancement of Water Management Technology
- Development of ICT Applications
- Integrated Water Resources Management (IWRM)



Smart Agricultural Water Efficiency

- Expansion and Enhancement of Monitoring System

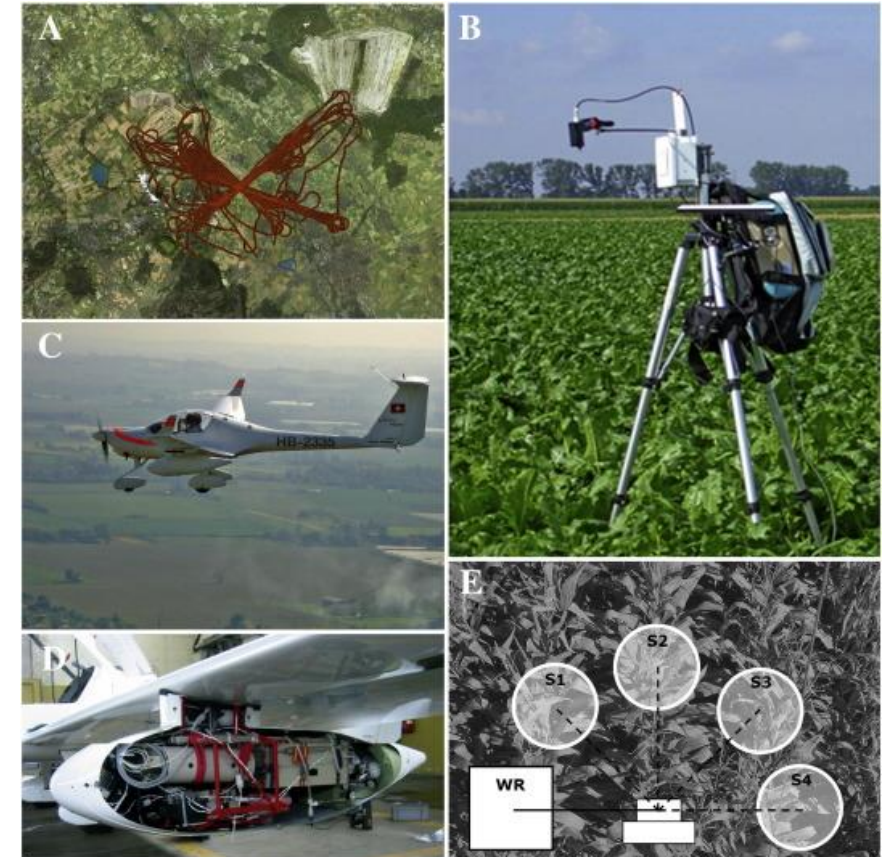
Accurate monitoring of water used is an essential part of reasonable water management and helps reach optimal performance in saving water while enhancing yields (Levidow et al., 2014). Knowledge on water usage and flow in a region is a first step for raising water efficiency in agriculture.



Smart Agricultural Water Efficiency

- Expansion and Enhancement of Monitoring System

Monitoring different factors affecting crop yield should be observed as well, such as fertility, crop variety, pest management, sowing date, soil water content, planting density,and so on (Bouttraa, 2010; Levidow et al., 2014). The monitoring can be obtained through different direct and indirect methods including on-ground and over-ground sensor systems, and can be interpreted with the support of ICT technologies.



Smart Agricultural Water Efficiency

- Expansion and Enhancement of Monitoring System

The Korean Rural Community Corporation (KRC) has invested since 2001 in a “Comprehensive Water Management System” to more effectively secure water resources for agricultural. The project monitors in real time (24/7) reservoir flow, alert flood, and control storage water for drought. The project targets 1,570 agricultural reservoirs having effective storage above 0.1 million m³. (<https://rawris.ekr.or.kr>).



Water management control room at the headquarters of the Korea Rural Community Corp. (KRC) in Naju, South Jeolla Province.

Smart Agricultural Water Efficiency

- Development and Rehabilitation of Water Resources

Various initiatives are being made to increase the water storage capacity of soil under agricultural land or to utilize ineffective waste flow in terms of crop consumption. The modernization of irrigation systems has steadily progressed and water productivity has improved considerably (COPA-COGECA, 2007; Levidow et al., 2014).

In South Korea, the agricultural reservoir rehabilitation project secured flood and drought prevention including stream management flow (2009-2015, total 11 agricultural reservoirs, US\$2.7 billion) . The KRC secured total of 0.28 billion tons of additional water.



Smart Agricultural Water Efficiency

- Enhancement of Water Management Technology

Enhancement of Water Management Technology
Comprises;

- Suitable crop selection,
- Proper irrigation scheduling,
- Effective irrigation techniques, and
- Using alternative sources of water for irrigation.

Highly-efficient irrigation involves technologies for;

- Fine-tuning the time and amount of water applied to crops based on the water content in the crop root zone,
- The amount of water consumed by the crop since it was last irrigated,
- The stage of crop development.



Smart Agricultural Water Efficiency

- Enhancement of Water Management Technology

New technologies/sensors are emerged in the market such as;

- Air temperature
- Air humidity
- Soil temperature
- Soil moisture
- Atmospheric pressure
- Wind speed/direction
- Rainfall
- Solar radiation
- Soil fertility
- Water retention capacity, and
- Irrigation management to reduce losses

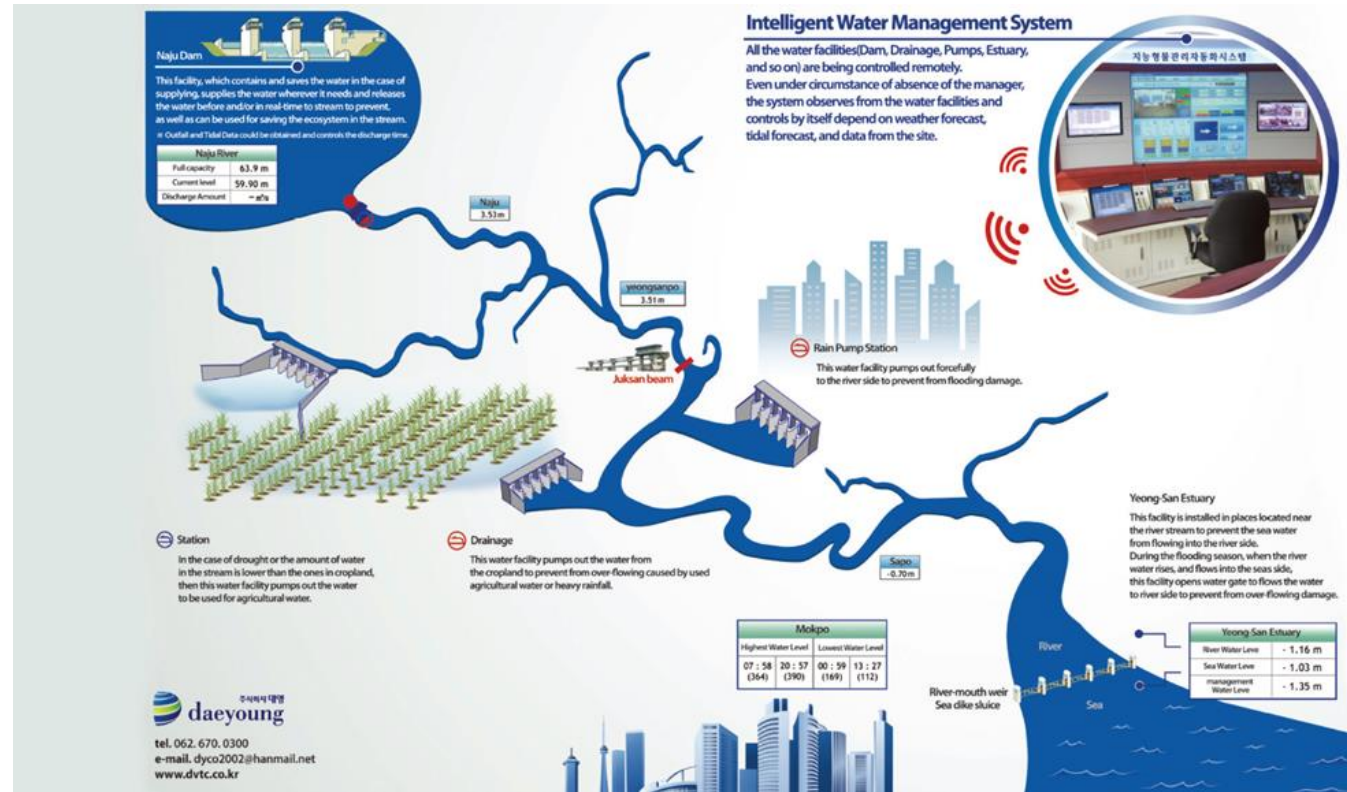


The potential of water saving from smart irrigation is up to 43% of the current volume (Benito et al., 2009). Benefits including improved water quality, energy savings and emission reduction of greenhouse gases.

Smart Agricultural Water Efficiency

- Enhancement of Water Management Technology

The Korean government has made progress in updating and modernizing irrigation practices and technology through ICT development. A TM/TC (tele-metering and tele-control) project has been realized since 2001 to watch floods and manage drought in irrigation districts. The project will be continue until 2021 with a total spend of US\$0.5 billion. So far, it has been completed in 37 irrigation districts.



Intelligent water management system (TM/TC) applied to Yeong-San River, South Korea

Smart Agricultural Water Efficiency

- Development of ICT Applications

ITC plays a significant role in smart irrigation and agricultural by connecting and integrating different spatial and temporal scales and multiple stakeholders with varying goals.

ITC enterprise system encompass integration between in-field sensors, geographic information systems (GIS), remote sensing, crop and water simulation models, prediction of climate, advanced information processing, big data analytics, and wire/wireless communications.





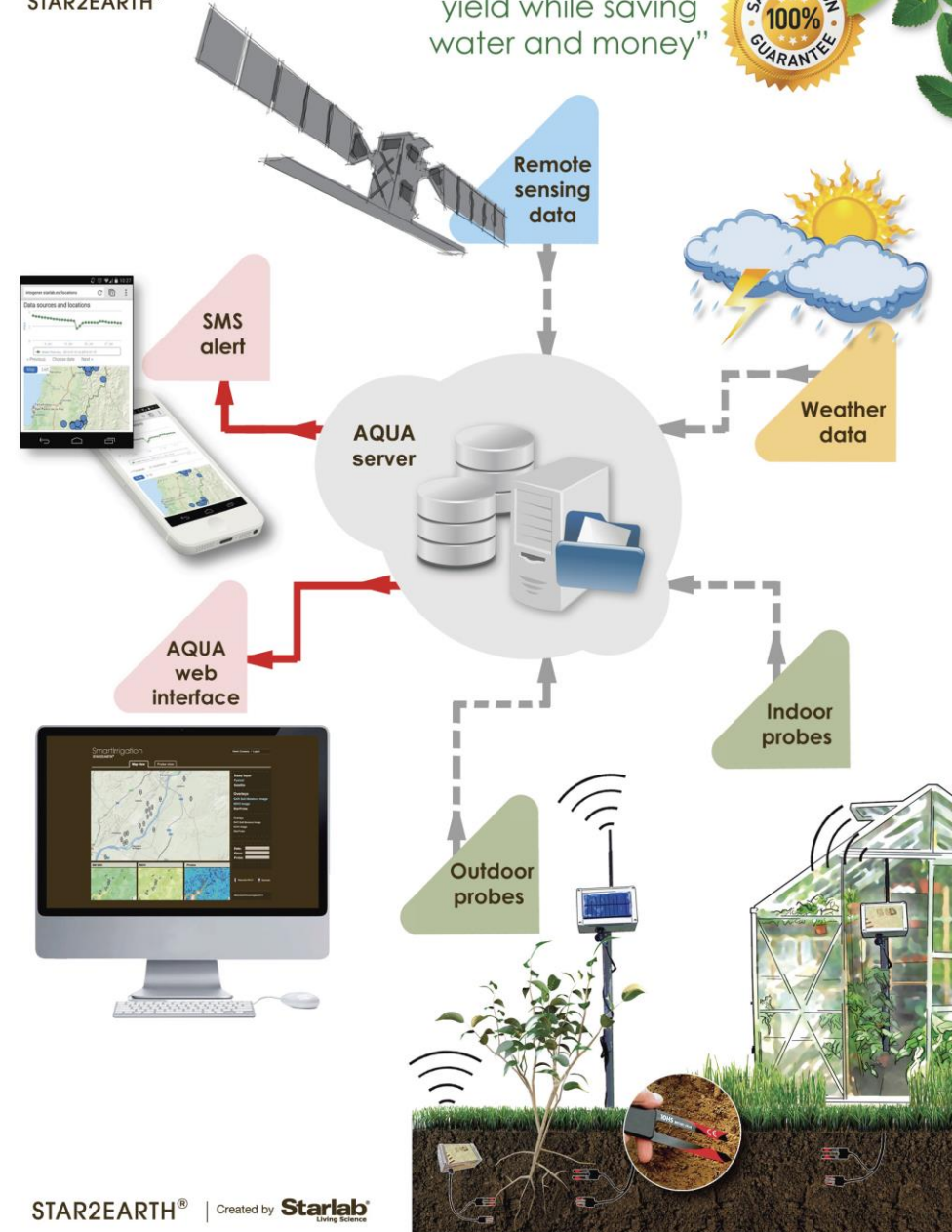
Smart Agricultural Water Efficiency

- Development of ICT Applications

ITC contributes effectively in the optimization of the operation, decision making, and strategic planning.

SmartIrrigation
STAR2EARTH®

"Increase your crop yield while saving water and money"



Smart Agricultural Water Efficiency

- Integrated Water Resources Management (IWRM)

IWRM integrate interactively surface water and groundwater, coastal and fluvial systems, hydrological and meteorology, smart irrigation and agriculture

IWRM considers different factors about the ecosystem as well as crop production (increase and intensify production, reduce crop failure risk, diversify production, increase efficiency, and sustain natural resources). IWRM apply the right depth of water in the right place and at the right time which further improve the efficiency by 5-20% (Benito et al., 2014).

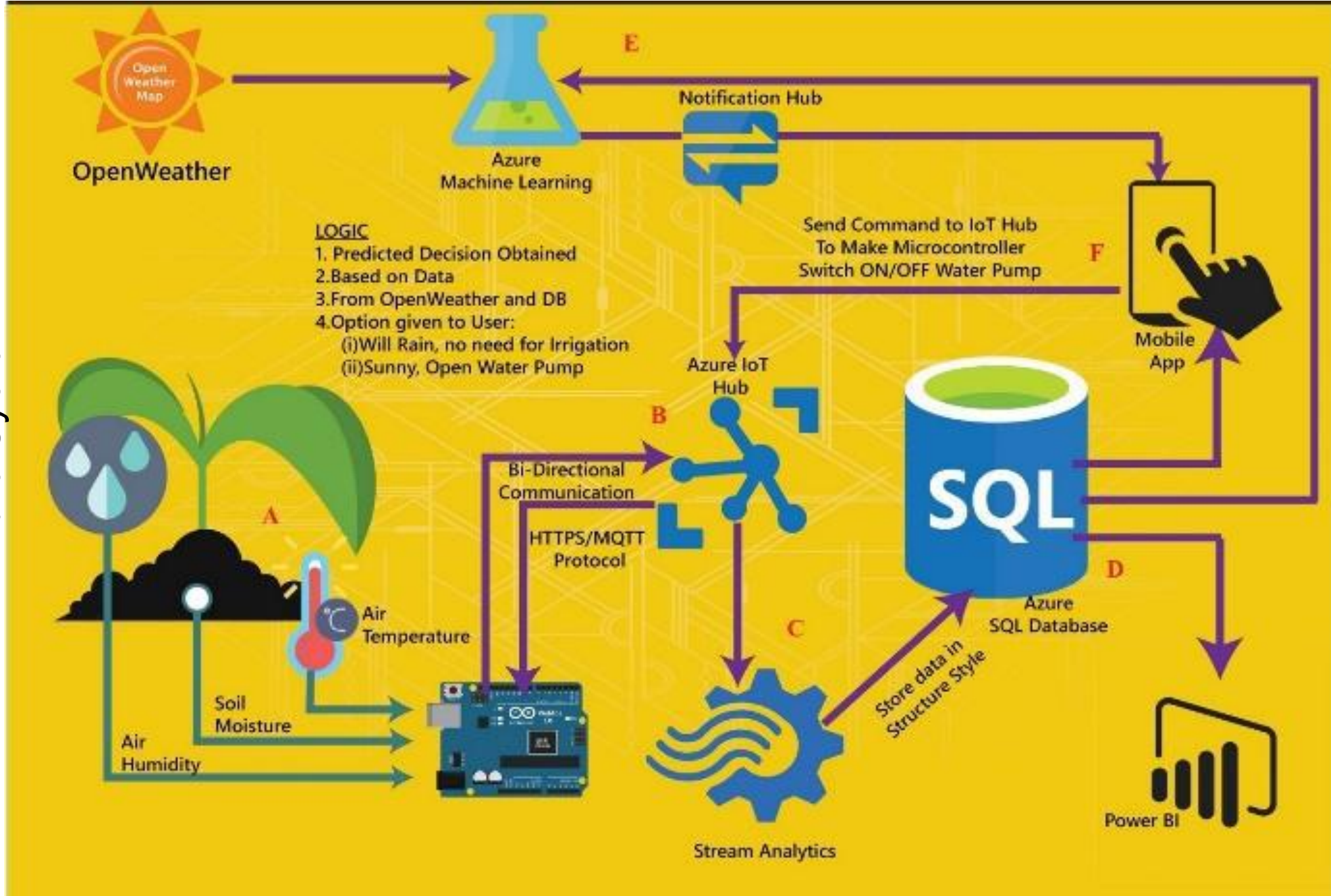




Case Study 1

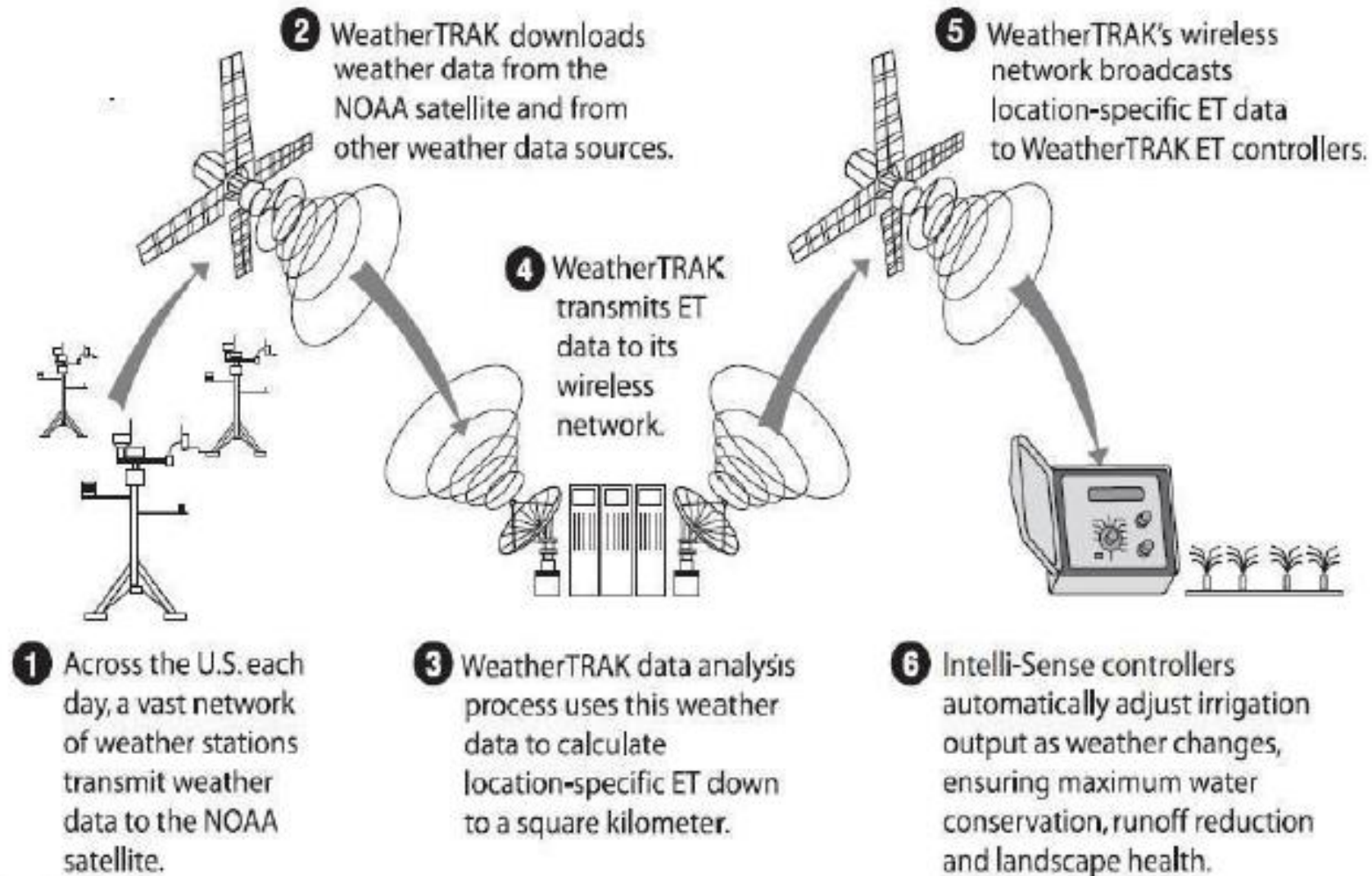


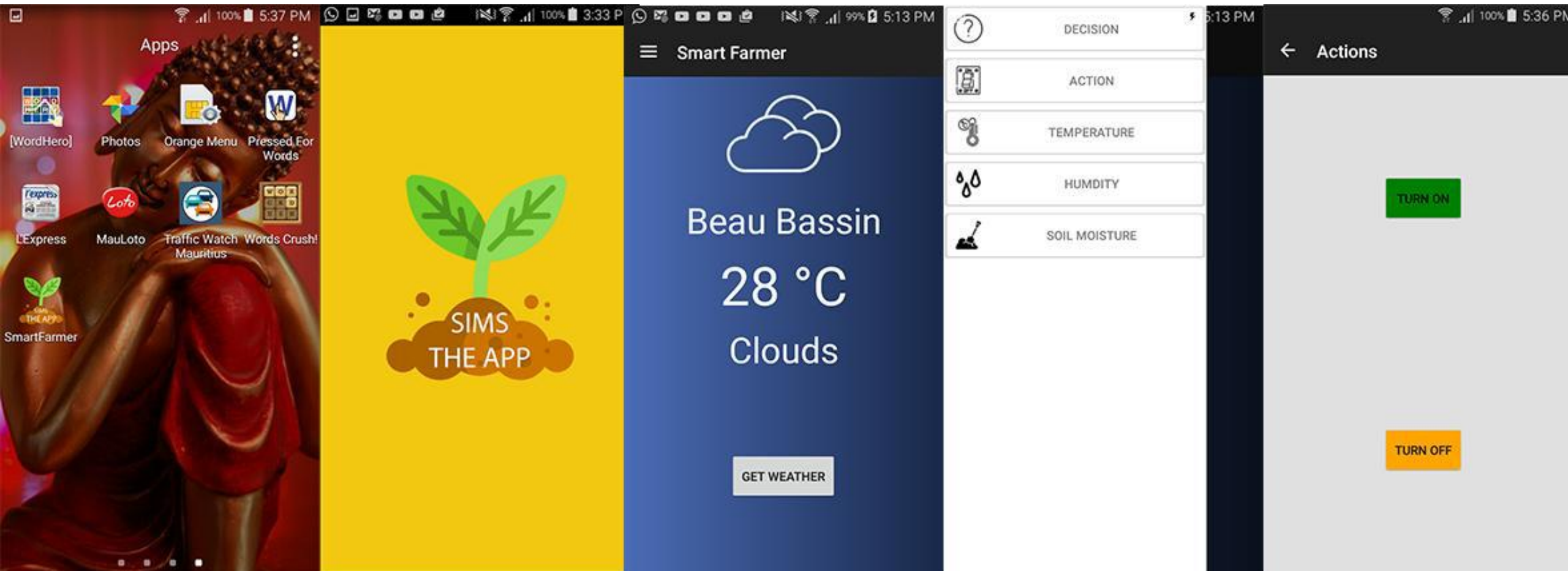
Azure System



Azure Smart Irrigation Architecture

ET system schematic





Interface of Mobile Application

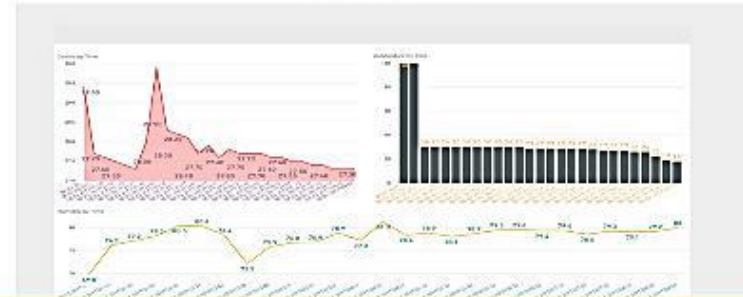


Screen Interface of the Web App



UWTDC
BUENOS AIRES 2017
October

POWER BI



SENSORS



Name:

Email:

Subject:

Message:

SEND MESSAGE

CELEBRATING
25 YEARS
OF ACHIEVEMENTS



Sensor Reading

Device Explorer

Configuration Management **Data** Messages To Device

Monitoring

Event Hub: SmartFarmingIoT Hub

Device ID: WeMosD1

Start Time: 03/18/2017 17:54:57

Consumer Group: \$Default Enable

Monitor Cancel Clear

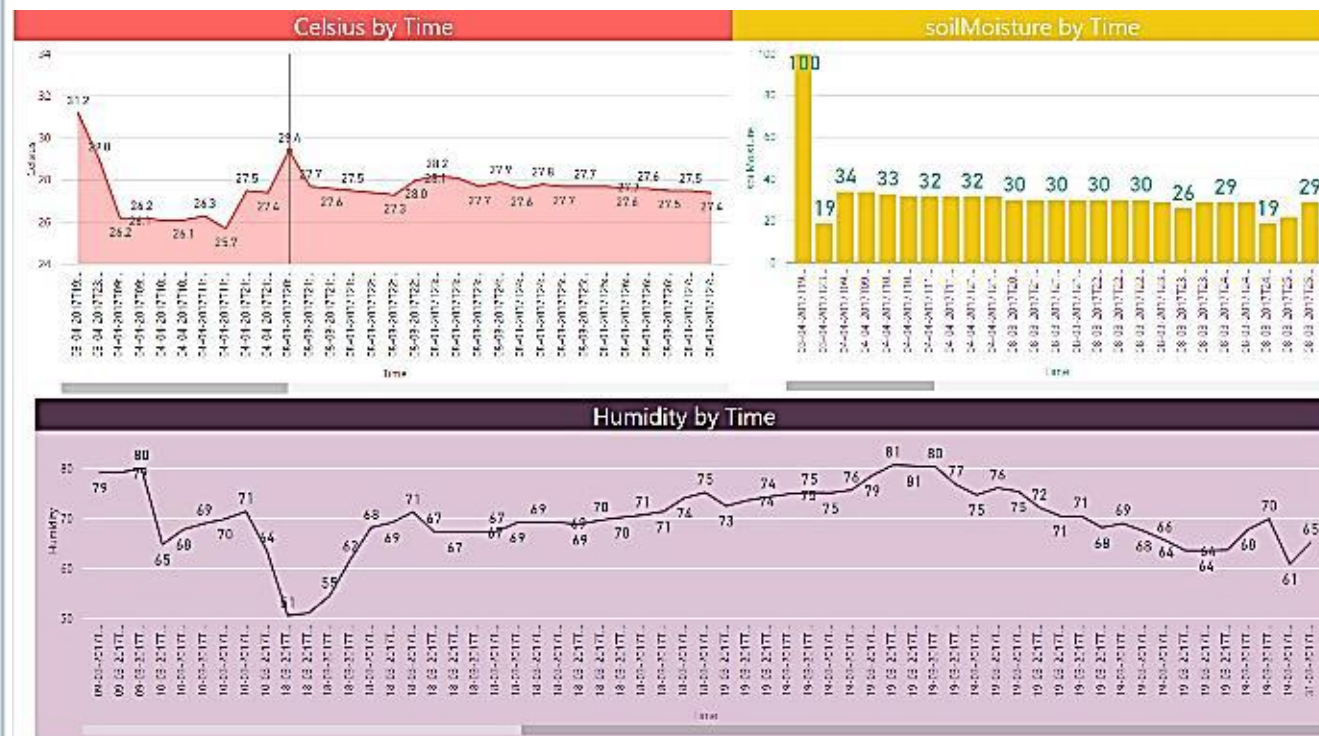
Event Hub Data

```
Receiving events...
3/18/2017 17:56:20> Device: [WeMosD1], Data:{"DeviceId":"WeMosD1","Time":"18-03-2017T13:56","Celsius":30.40,"Humidity":67.40,"soilMoisture":73,"Geo":"Coromandel"}
3/18/2017 18:00:06> Device: [WeMosD1], Data:{"DeviceId":"WeMosD1","Time":"18-03-2017T14:00","Celsius":30.30,"Humidity":67.20,"soilMoisture":74,"Geo":"Coromandel"}
3/18/2017 18:01:25> Device: [WeMosD1], Data:{"DeviceId":"WeMosD1","Time":"18-03-2017T14:01","Celsius":30.30,"Humidity":67.10,"soilMoisture":76,"Geo":"Coromandel"}
3/18/2017 18:02:36> Device: [WeMosD1], Data:{"DeviceId":"WeMosD1","Time":"18-03-2017T14:02","Celsius":30.10,"Humidity":66.90,"soilMoisture":76,"Geo":"Coromandel"}
```

rows 60
columns 6

view as

Air Temperature	Air Humidity	Soil Moisture	Irrigate	Scored Labels	Scored Probabilities
29.63	67.58	20	yes	yes	0.978723
29.7	67.32	29	no	no	0.010417
27.89	74.76	26	no	no	0.010417
31.29	61.46	38	no	no	0.010417
26.87	79.41	31	no	no	0.010417
28.57	71.88	28	no	no	0.010417
27.08	78.39	36	no	no	0.010417
27.84	75.01	27	no	no	0.010417
27.58	76.14	25	no	no	0.010417
30.96	62.66	39	no	no	0.010417
28.45	72.37	16	yes	yes	0.978723
27.91	74.69	30	no	no	0.010417
31.08	62.22	37	no	no	0.010417



Results from Azure Machine Learning

Graphs Representing the Sensor Values



Case Study 2



A Basic raindancer Set-Up



GPS Transmitter
solar power supply directly
attached to the irrigating device



App
selected functionalities
on your smartphone

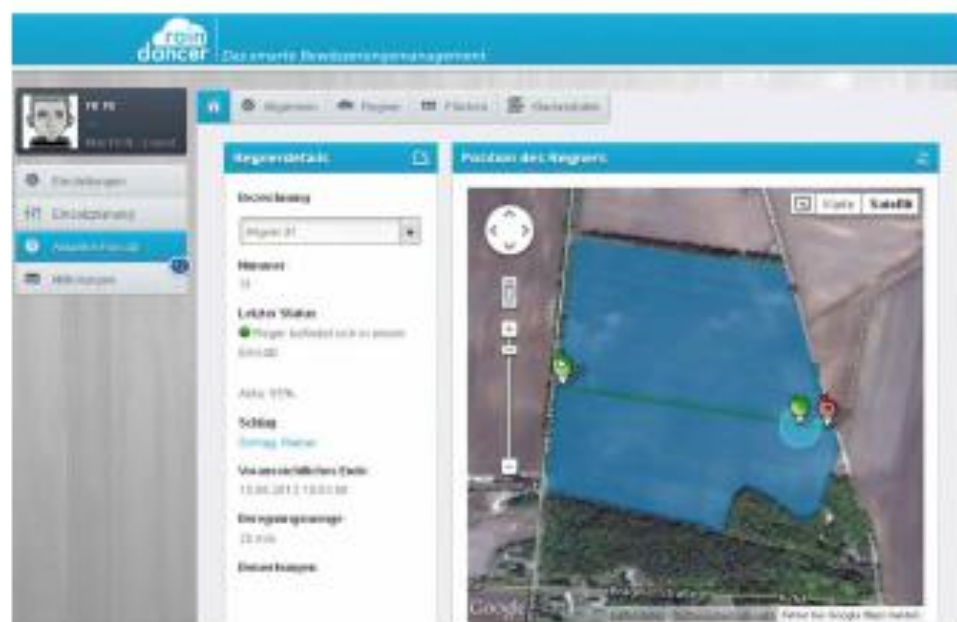


TDR Probe
measuring soil moisture

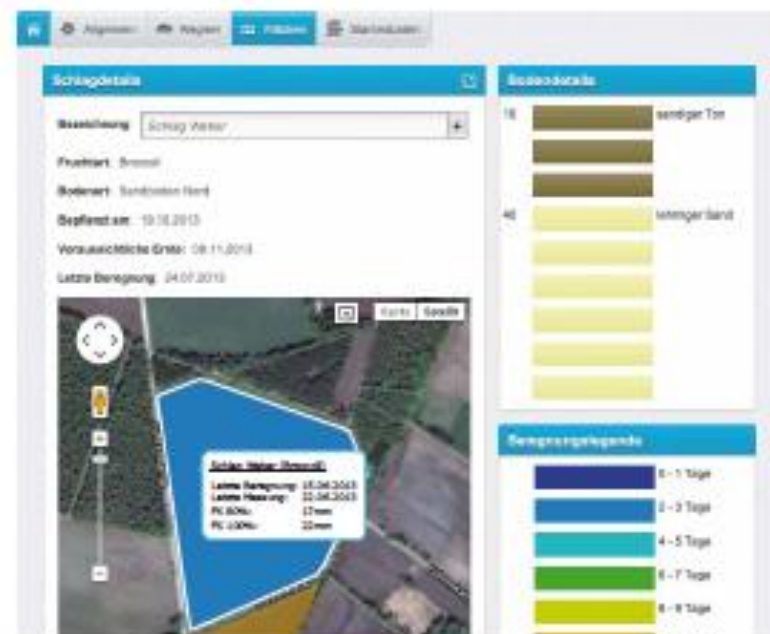


web platform raindancer
direct access from every PC or tablet
with an internet connection

raindancer - Basic Settings



Sprinkler



Fields



as well as:

- soil types
- soil composition
- crop types
- wells / water reservoirs

Starting an Irrigation with your smartphone

mobile Overview – always and everywhere



Which device finishes when and where?
Which devices already finished and are still not repositioned yet?



Where to relocate to?
Colors show when your fields have been irrigated the last time.

raindancer sends notifications via SMS ...

... when an irrigation completes



... if a malfunction occurs



Monitoring



Irrigation completed.
Relocation already organized?

Irrigation completed in 35 min.
Let's schedule its relocation!



Springler idle for 5 hours!

Results:

- Where are the sprinklers currently located?
- Which ones are completing soon – relocations have to be planned!
- Which ones are idle?
- Are there any malfunctions?

Scheduling

Where to relocate to?
What amount to irrigate?



Example Results:

- **Sprinkler 8** completes soon, to be relocated onto field »Weber«, irrigation amount 20mm.
- **Sprinkler 11** to be relocated onto field »South-East«, there, moisture has to be measured and an amount to be irrigated will be determined!



Measuring & Calculating the Need of Irrigation

... basic setup

Übersicht der Substrate

Substratkennz.	Substratbezeichnung	NK	PK	AK	DK 90%
0	Sand	14,8	0,3	0,0	13,1
1	leimiger Sand	16,0	0,1	0,0	14,3
2	leimiger Lehm	11,0	0,3	11,8	10,9
3	leimig-schluffiger Lehm	16,4	0,4	15,4	16,2
4	Lehm	11,1	14,2	16,9	11,7
5	leimiger Ton	15,4	15,7	11,1	14
6	schluffiger Lehm	11,0	15	16,0	11,4
7	leimiger Ton	15,7	16,9	16,8	11,0
8	Schluff	16,4	11,2	11,0	14,2
9	leimig-schluffiger Lehm	16,9	16,7	11,1	16,0
10	schluffiger Ton	16,9	16,2	10,7	16,8
11	Ton	14,0	11,7	11,9	16,1

Definition of soil types

Böden im Betrieb

0-10cm	leimiger Ton
10-20cm	leimiger Ton
20-30cm	leimiger Ton
30-40cm	leimiger Sand
40-50cm	leimiger Sand
50-60cm	leimiger Sand
60-70cm	leimiger Sand
70-80cm	leimiger Sand
80-90cm	leimiger Sand
90-100cm	leimiger Sand
100-110cm	leimiger Sand
110-120cm	leimiger Sand
120-130cm	leimiger Sand
130-140cm	leimiger Sand
140-150cm	leimiger Sand
150-160cm	leimiger Sand
160-170cm	leimiger Sand
170-180cm	leimiger Sand
180-190cm	leimiger Sand
190-200cm	leimiger Sand

Definition of soil composition

Schlagdetails

Bezeichnung: Schlag Wasser

Fruchtart: Brombeere

Bodenart: Sandboden Nord

Bepflanz am: 10.10.2010

Voraussichtliche Ernte: 08.11.2010

Letzte Bewässerung: 24.07.2010

Bodenprofile

- 0-10cm: leimiger Ton
- 10-20cm: leimiger Ton
- 20-30cm: leimiger Ton
- 30-40cm: leimiger Sand
- 40-50cm: leimiger Sand
- 50-60cm: leimiger Sand
- 60-70cm: leimiger Sand
- 70-80cm: leimiger Sand
- 80-90cm: leimiger Sand
- 90-100cm: leimiger Sand
- 100-110cm: leimiger Sand
- 110-120cm: leimiger Sand
- 120-130cm: leimiger Sand
- 130-140cm: leimiger Sand
- 140-150cm: leimiger Sand
- 150-160cm: leimiger Sand
- 160-170cm: leimiger Sand
- 170-180cm: leimiger Sand
- 180-190cm: leimiger Sand
- 190-200cm: leimiger Sand

Bewässerungslegende

- 0-1 Tage
- 1-2 Tage
- 3-4 Tage
- 4-5 Tage
- 5-7 Tage
- 6-9 Tage
- 10-12 Tage
- 13-15 Tage
- 16-18 Tage
- 19-21 Tage
- 22-24 Tage
- 25-27 Tage
- 28-30 Tage
- 31-33 Tage
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- 271-273 Tage
- 274-276 Tage
- 277-279 Tage
- 280-282 Tage
- 283-285 Tage
- 286-288 Tage
- 289-291 Tage
- 292-294 Tage
- 295-297 Tage
- 298-300 Tage

Fields and their corresponding soils



Measuring & Calculating the Need of Irrigation



Enter and transfer measured values.



Receive calculated required amount of irrigation.





Thank You

