

Workshop with Water User Associations of Southeast Anatolian Project (Turkey)

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Research group Irrigation, Agronomy and the Environment



Mediterranean Agronomic Institute
Zaragoza, 8 and 15 April 2013

Aula Dei Campus (Zaragoza, España)



- CITA (DGA)
- E. E. Aula Dei (CSIC)
- IAMZ (CIHEAM)
- Leading Spanish Campus in agricultural sciences

RESEARCH GROUP “IRRIGATION, AGRONOMY AND THE ENVIRONMENT”

- CITA and EEAD staff
- Largest national group in the area
- One of group leaders in Europe



Personnel in 2013

- 12 staff researchers
- 4 temporary researchers
- 11 students
- 9 staff technicians
- 9 temporary technicians
- Total: 45

Objective

Generate scientific and technological information in the “soil-water-crop-atmosphere” interface leading to more competitive, efficient and sustainable agricultural systems with emphasis on **irrigation, agronomy and the environment**, and with an applied-research focus.

Priority lines:

- 1- Sustainable use of water and soil resources
- 2- Environmental impact of agricultural activities
- 3- Crop agronomy

Irrigated Agriculture in the Ebro Valley



Enrique Playán

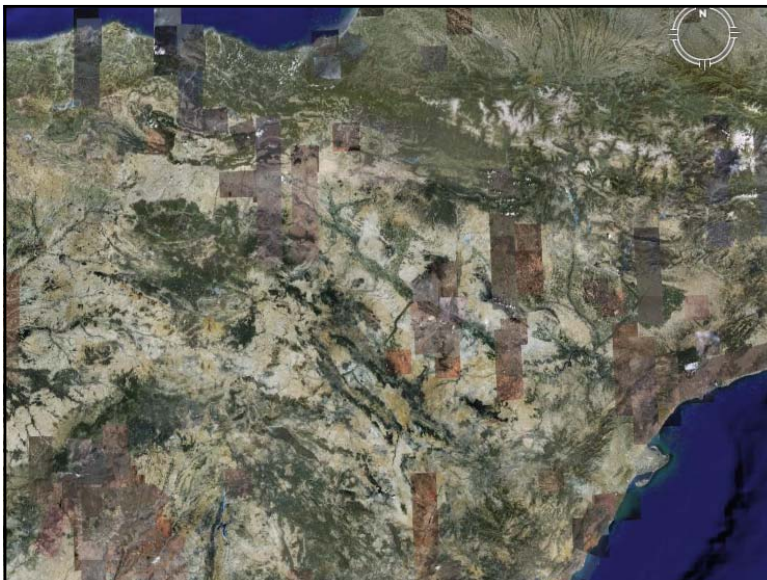
Where are we?

A slide show on dryfarming and irrigated agriculture

1

Where are we today?

- The central Ebro valley depression
- Precipitation: 250 – 400 mm
- Reference evapotranspiration of about 1,100 mm per year
- Shallow, poorly developed soils
- Salinity resulting from lake like evaporation
- Rivers and wind have modeled the landscape





Dryfarming in Monegros

- Rich agricultural tradition
- Barbecho system
- Deforestation boosted by diesel power
- Linked to the 20th century history
- Now a days:
 - Poor yields
 - Harvest only a fraction of the years







A bit of irrigation history, XIX and XX

- Regeneracionism
- Looking inside
- Water for rural development
- Strong governmental intervention
- A popular policy





Irrigation systems

2

Identifying limiting factors to sustainable Mediterranean agriculture

Sustainable Mediterranean Agriculture

- Mediterranean climate is naturally characterized by variability
- Pending issues on water quality, derived from the WFD: irrigation return flows
- Need to adjust inputs to improve energy, pollutant and economic budgets
- Soil protection: key issue in an extremely vulnerable area
 - Erosion
 - Salinity

Sustainable Mediterranean Agriculture

- Our best farmers are using resources rather well... what can we do for the rest?
 - Part-time farmers
 - Poorly educated farmers
 - **To what extent can technology alleviate deficits in dedication or training?**

Surface irrigation

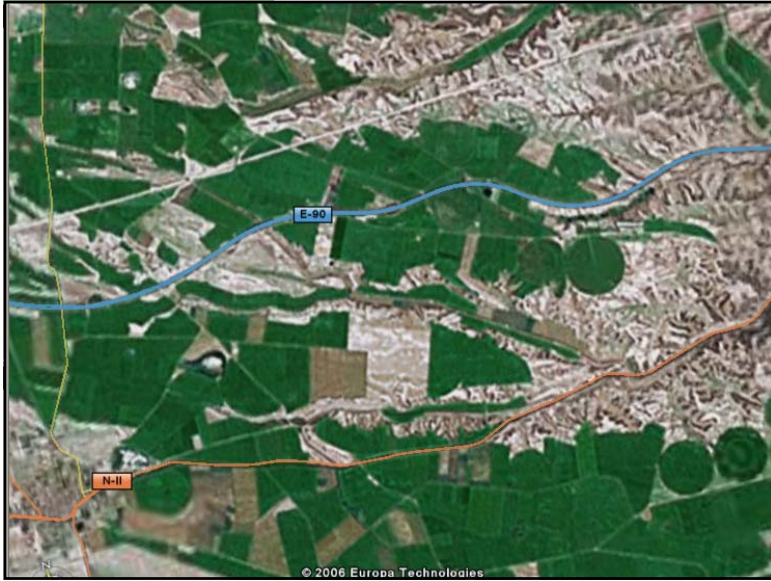
- Initial irrigation system
- The only one available
- Applied to all soils and conditions
- Successes and failures
- In clear regression





Sprinkler irrigation (1970+)

- Started as individual fields
- Continued with collective networks
- Today we are in the middle of rebuilding about half of the surface irrigated area, switching to collective sprinkler (and drip) irrigation networks





Drip irrigation

- Relevant in some areas: fruit production
- Warm climate
- Large properties: industrial
- Aggregated supply
- Associated to labor intensive crops





Collective Water Management

3

Specific challenges
derived from
collective structures

Collective water management

- Difficult access to water, surface water developments
- Large initial investments required
- Strong initial public intervention
- Mandatory “irrigation districts”
 - Not only irrigation now
 - Long tradition in overland water
 - Accounting efforts
- Districts + Basin authorities
 - Public-private interaction
 - Embryo of some WFD concepts
 - 80 years old here

Challenges for the 21st century

- Inspiring the National Irrigation Plan:
 - Improve irrigation efficiency
 - Improve irrigation structures
 - Sustainable, profitable irrigated farming
 - Protect water quality
 - Improve water management
- The Plan has been in operation for about 10 years now
 - Projects in about 1 Mha
 - Large public-private investments
 - From surface to sprinkler/drip irrigation
 - Collective networks

Two paths to improve irrigation efficiency:

- Structures
 - 99 % of the Spanish National Irrigation Plan
- Management
 - 1 % of the Spanish National Irrigation Plan (26 M€)
 - Advantages:
 - Bottom - up
 - Slow and endogenous
 - Much cheaper (€/m³ of conserved water)
- Need to combine both approaches for optimum results (Styles, 1999; Vidal et al., 2001)

Irrigation management principles

- Transparency
- Participation
- Traceability
- Effectiveness
- Standardization
- Certification

...These are the ingredients we used to build **Ador**, an irrigation district water management software

Ador: a tool for collective water management

4

And also a Trojan horse...

Ador: Strength gained at the districts

- Cooperation between:
 - researchers,
 - farmers,
 - companies,
 - public administration and
 - water managers.
- Half of the Aragonese irrigated land is managed with Ador (about 180,000 ha)
- The project has boosted water management utilities nationwide
- Currently released version: 1.2.9 (free download)

Water pricing: a matrix

Las unidades del precio del Agua introducido son € por 1000 m3

Cod.	Tipoagua	Tipo Agua	Coste Agrícola	Coste Ganadero	Coste Urbano	Coste Industrial	
5	Alta presión		23,00 €	12,00 €	43,00 €	23,00 €	<input type="button" value="Cambiar Precio"/>
6	Baja presión		12,00 €	12,00 €	12,00 €	12,00 €	<input type="button" value="Cambiar Precio"/>
7	Sin presión		5,00 €	5,00 €	12,00 €	1,20 €	<input type="button" value="Cambiar Precio"/>
{AutoNumber}							<input type="button" value="Cambiar Precio"/>

Aceptar Eliminar Tipo Agua Ayuda

Registro 3 de 3

Water users

Consultar Datos Usuarios

Campos Obligatorios de Rellenar Campos de Uso de la Aplicación

Usuarios

Datos Personales	Contacto
Identificador Usuario: 423	Teléfono Principal: 974-555-666
Identificador contable: 4300000001	Segundo Teléfono:
Primer apellido: ABADIAS	Calle y n.º: Mayor, 3
Segundo apellido: RALUY	Población: SELGUA
Nombre: ALVARO	Provincia: Huesca
NIF: 18191275P	C. P.: 22415
N.º de votos: 22	Código Usuario: 423

[Seleccionar Conj. Usuario](#) [Seleccionar Todos Usuario](#) [Cerrar Formulario](#) [Ayuda](#)

Datos Bancarios

Nombre Banco: IBERCAJA	Código Entidad: 2085	Sucursal: 2409	Cuenta Corriente: 090000365088
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Nuevo Banco Modificar Datos Banco Eliminar Banco

Registro: 1 de 413

Cadastral plots and water uses

Modificar Parcelas Catastrales

Campos Obligatorios de Rellenar Campos de Uso de la Aplicación

Parcelas Catastrales

Identificadores Parcela

Código de Parcela Catastral: 5667 Código Catastro: 22218044000670000

Datos Parcela

Polígono: 044	Municipio: Monzón
Parcela: 00067	Paraje: ARMENTER
Subparcela: 0000	Suelo: <no asignado>
Superficie catastral (Hectareas): 4.37	Superficie de riego (Hectareas): 4.37
Riego en Precario:	Propietario: ALLUE PUY, CARLOS

Usos

- Usos Agrícolas
- Usos Industriales
- Usos Ganaderos
- Usos Urbanos

[Buscar Parcela](#) [Restaurar Modificaciones](#) [Graba y Cierra Formulario](#) [Ayuda](#)

Registro: 3 de 2222

Relación de Usos de la Parcela

Usos Agrícolas Parcela	Usos Industriales:		
Cultivo	Sup. Uso	Tipo Riego	Descripción
<no asignado>	4.37	<no asignado>	

Usos Ganaderos:	Usos Urbanos:
Descripción	Descripción
Granja porcino	

Water uses

Modificar Uso Agrícola

Campos Obligatorios de Rellenar Campos de Uso de la Aplicación

Uso Agrícola

Identificadores Uso:

Código de Parcela: 5667 Parcela: Polígono Parcela Subparcela Sup. Riego: 044 00067 0000 4.37

Código Uso: 2477

Tipo de Uso: Agrícola

Datos Uso:

Superficie: 4.3700 Cultivo: Alfalfa

Cuel. Amortización: 0 Valiedad: <no asignado>

Usuarios Uso Parcela:

Usuario Arrendatario: ALLUE - ALLUE PUY, CARLOS - Arrendatario

Usuario Pagador Agua: ALLUE - ALLUE PUY, CARLOS - Pagador Agua

Usuario Pagador Gastos: ALLUE - ALLUE PUY, CARLOS - Pagador Gastos

Datos Riego:

Tipo de Riego: Aspersión

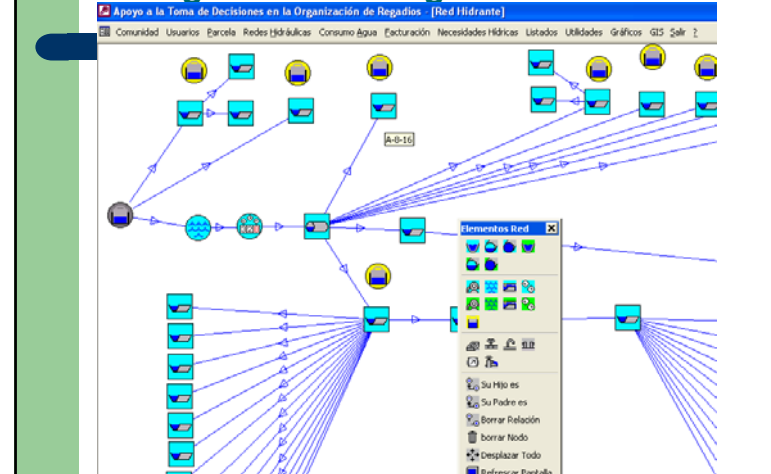
Plta Hidrante que Riega el Uso: C. Allue-1

[Agregar Uso](#) [Restaurar Modificaciones](#) [Grabar Uso](#) [Cerrar Formulario](#) [Ayuda](#)

Cultivos Asignados:

Cultivo	Sup. Uso	Hidrante	Línea
Alfalfa	4.37	C. Allue-1	A-84-30-01

A diagram of the irrigation network



Secondary network elements

Elementos Secundarios de Red Modificar

Características Secundarias Campos Obligatorios de Rellenar Campos de Uso de la Aplicación

Identificador de Elemento Secundario

Código Elemento: 48
 Código Línea: 25
 Elemento Secundario: Hidrante
 Nombre Elemento: T3

Características de Elemento Secundario

Material: No asignado
 Orden en Línea: 1

Características Punto Hidrante

Código Hidrante: 31
 ¿Contador? ¿Regulador de Presión?
 ¿Limitador de Caudal?
 Tipo Hidrante:
 Presión (atm) Max: 0,000 Nominal: 0,000
 Caudal: 12, l/s 1037 m3/24h

Descripción:

Relacionar Hidrante con Parcelas

Restaurar Modificaciones
 Grabar y Cerrar Formulario
 Ayuda
 Orden Línea
 Mantenimiento

Registering and allocating water orders

Generar Petición Concesión

Generar Petición Concesión Campos Obligatorios de Rellenar Campos de Uso de la Aplicación

Generar Petición Concesión:

Pagador Agua: ABADIAS TESA, GONZALO
 Info U. Gestión: Nombre: Tipo: Horas Inicio: Fin: m3/24h l/s
 A-8-10: 24 8:00 75000 868.1

U. Gestión: A-8-10
 Info Línea: Línea: Descripción Elemento: m3/24h l/s
 A-8-10-11: Canal: 20000 231.5

Linea Hidrante: A-8-10-11
 parcelas: Tipo Uso: Sup. Us: Hectares: Hectares: Hectares: Cubivos: Línea

Usos-Pagador Agua:

Usos Seleccionados: Reparto Usos Automático Manual Todos los Usos

Tipo Uso	Cubivo	Sup. Us	Hectares	Hectares	Hectares	Línea	Nombre	Días	Horas	Consumo	Uso
Agrícola	0,53					A-8-10-11	G. Abadías-1	0	6:30	5247,5	
Agrícola	0,3					A-8-10-11	G. Abadías-2	0	3:56	2970,3	
Agrícola	1,19					A-8-10-11	G. Abadías-3	0	14:14	11782,2	

Caudal Concesión: 5000 m3/24h 331,48 l/s Para Día: 24/10/2003 Días: 1 Hora Inicio: 8:00 Hora Fin: 8:00
 Cod Vale: Consumos: 20000 Finalizar: 25/10/2003 Horas: Observaciones: Aceptar Concesión

Generar Concesiones:

usuario	Fecha Concesión	Fecha Inicio	Hora Inicio	Fecha Fin	Hora Fin	m3/24h	l/s	Consumo
ABADIAS RALLIV, ALVARO	24/10/2003	24/10/2003	8:00	25/10/2003	8:00	20000	231,48	20000
ABADIAS RALLIV, GONZALO	24/10/2003	24/10/2003	8:00	25/10/2003	8:00	2000	23,15	2000

Registrar: Línea: Unidad: A-8-10 Análisis Red
 Modificar Concesión
 Vale Agrupado
 Vale Unitario
 24/10/2003
 Borrar Concesión
 Observaciones

Cerrar Formulario Ayuda

Registering water meter readings

Lechura de Contadores

Introducir Lecturas Puntos Hidrantes Campos Obligatorios de Rellenar Campos de Uso de la Aplicación

Filtros: Recorrido: RECORRIDO 2A Nombre Línea: Hidrante:

Línea	Nombre	Lechura Anterior	Fecha Lechura	Lechura Hidrante	Fecha Nueva Lechura	Nueva Lechura
1	TPN-1-1(300)b	1144	555555	23/10/03	555555	666.666.0
2	TPN-1-4(300)	1412	60000	07/05/03	75000	29/10/2003 85.000.0
3	TPN-1(1100)	14106	0	01/06/03	0	29/10/2003 2.000.0
4	TPN-1(1200)	14109	0	06/05/03	6000	29/10/2003 8.000.0
5	TPN-2-6-3(250)	2411	0	03/05/03	5000	29/10/2003
6	TPN-2-6-3(110)	2415	0	03/05/03	3000	29/10/2003
7	TPN-2-6-1(180)	2417	0	03/05/03	5000	29/10/2003
8	TPN-2-6-1-1(110)	2416	0	03/05/03	2000	29/10/2003
9	TPN-2-6-5(110)	2423	0	03/05/03	15000	29/10/2003
10	TPN-1-16 B(5(110)	14106	0	03/05/03	5000	29/10/2003
11	TPN-1(1100)	14199	0	03/05/03	6300	29/10/2003
12	TPN-1-13-2(200)	14183	0	03/05/03	6000	29/10/2003
13	TPN-1-13-4(200)	14162	0	01/06/03	0	29/10/2003

Eliminar Lectura Cerrar Sin Guardar
 Mostrar Todas Lecturas Cerrar

Billing for general costs: by the hectare

Introducir Introducir Gastos Especiales

Derramas Campos Obligatorios de Rellenar Campos de Uso de la Aplicación

Código Gastos Especial: 1
 Nombre Gasto Especial: Mejoras en la estación de bombeo
 Descripción Gasto Especial: Se aplica a los usos que se riegan de la estación Cuenta Contabilidad:

Aplicar el Gasto: Por hectarea Cantidad Fija

Asignar el Gasto: Pagador Gastos Pagador Agua Arrendatario Propietario

Grupo de Selección de Usos: Unidades de Gestión Líneas Hidrantes Parcelas Usos

Cantidad x Hectarea: 12,00 €

seleccionar
 Total usos Seleccionados: 0

Grabar Gasto Especial Buscar Gasto Especial
 Nuevo Gasto Especial Cerrar Formulario sin Grabar
 Cerrar Formulario Ayuda

Registro 1/4 1

Billing for water use: by the m³

Facturación

Facturación Campos Obligatorios de Rellenar Campos de Uso de la Aplicación

Construir Facturación:

Cod. Facturación: 35 Nombre Facturación: _____

Periodo desde: 10/08/2004 hasta: 16/05/2006 Fecha Emisión: 16/05/2006 Fecha Vencimiento: 23/05/2006

Conceptos Facturar: Facturar Consumos Facturar Gastos Especiales

Opciones Numeración: Numeración Automática Elegir Numero Primera Factura

Num. 1ª Factura: _____

Gestionar Facturaciones:

Nombre Facturación	Fecha Inicio	Fecha Fin	Enviado a Contaplus	Fecha vencimiento	Norma19
AGUA JUNIO 2004	31/10/2002	25/06/2004	No	30/07/2004	Yes

Configuración Imprimir Facturas:

Hoja Resumen Logotipo Comunidad Detalle Acequias Sin Gráfico

Detalle Contadores Listado Peticiones Detalle Gastos Especiales Detalle Gastos Especiales Usuarios

Estilo Facturas: Detallada Reducida

Información Hoja Resumen: Consumos Gastos Especiales Ambos

Orden Facturas: Criterio 1: Número Factura Criterio 2: Texto Particular Facturas

The educational water bill

Los pedales

La Iglesia, s/n
Tel: 976-346 623 22265 Abreva Bajo
Huesca C.I.F. Z44444444

Datos del Cliente:
Titular: Álvaro Milla, Mera
NIF: 360165703
Dirección: Gost, 34
Población: Huesca Provincia: ARZOBISPA

Consumo:

Tipo Uso	Consumo	ha	Consumo m ³ /ha	Importe Total
Acequia	48.000,00 m ³	4,2	11428,57	194,80 €

Gastos Especiales de Usos:

Nombre	Tipo	Ha-Parceles	Cantidad	Total
Otros gastos	Rebajas	11,3	24,00 €	267,50 €
Reparación acequia	Rebajas	11,3	3,42 €	62,38 €

Gastos Especiales de Usuarios:

Concepto	Cantidad	Precio	Total
Ocupación	5	12,0000 €	60,00 €

Totales:

Total Consumo:	194,80 €
Total Gastos:	49,23 €
Total Factura:	604,23 €

Consumo Medio:

Legenda: Acequias (Azul), Con Acequias (Verde), Contador (Rojo), Con Contador (Amarillo)

Drought management: water restrictions

Listado de Consumos

Listado de Consumos (Cupos)

Ejercicio: _____

Cupo: 4000 m³/ha

Usuario: _____

Tipo Usuarios: Propietario Pagador Agua Arrendatario Pagador Gastos

Presentación de resultados: Exportar a Excel Vista preliminar Imprimir en impresora predeterminada

Opciones de configuración de informe:

% Aviso Prox. Cupo: 20 %

Fecha Inicial: 01/01/2004

Fecha Final: 17/05/2004

Incluir Parcelas Precario Ordenado alfabéticamente Ordenado por cupo

GIS support: plot identification

Visualizador Gis Comunidad

Capa Activas Capa Parcelas Capa Red Hidráulica

Parcela: 005-00048-0000

Sup. Catastral: 20,1600

Sup. Pliego: 20,1600

Precoato:

Municipio: Castiella del Puente

Paraje: (No asignado)

Suelo: _____

Propietario: _____

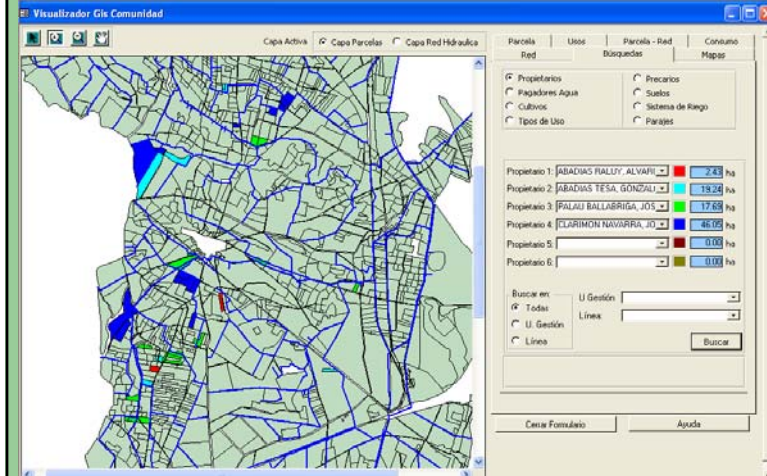
ESTALI CAMPOJUNIO

Teléfono: 974415743

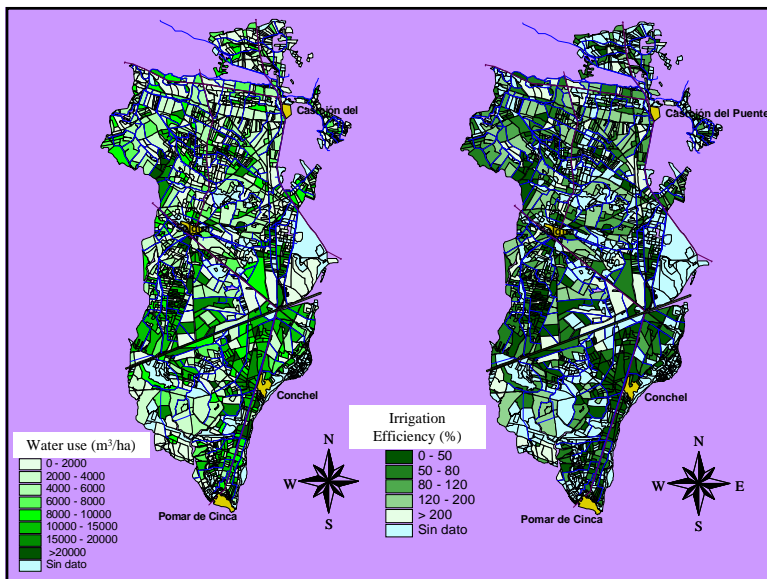
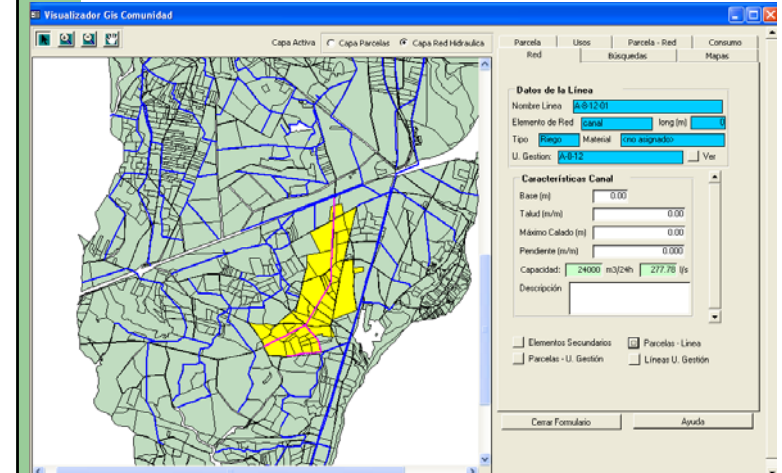
Código Catastro: 221200500480000

Datos Parcela Datos Propietario Datos Suelo

GIS support: searches and queries



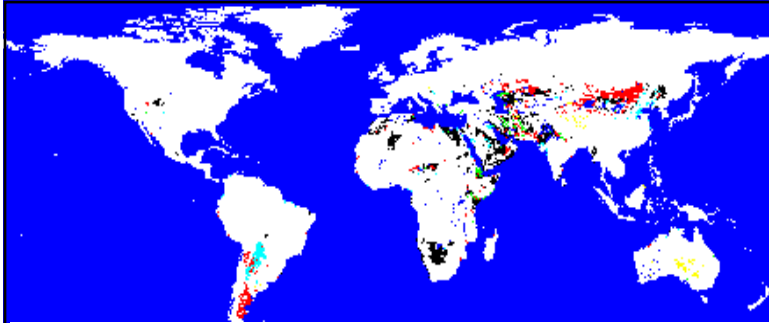
GIS support: supply lines and cadastral plots



Irrigation and salinity of waters and soils



Ramón Aragón



- Salinity is one of the most important problems in agriculture (around 1000 m ha worldwide).
- Of the 230 ha irrigated land, about 10% is seriously affected and 30% is moderately affected. Each year, about 0.25-0.50 m ha are lost due to salinization.
- Areas affected by salinity: USA (28%), China (23%), Pakistan (21%), India (11%), Ebro river (20%)...

Irrigated agriculture and salinity

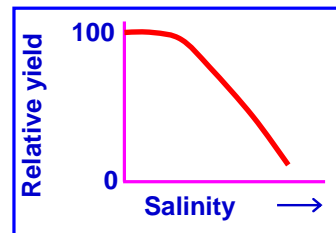
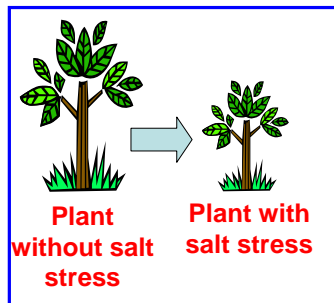
¿Why is there salinity?

Because both the irrigation water and the soil water dissolve salt minerals

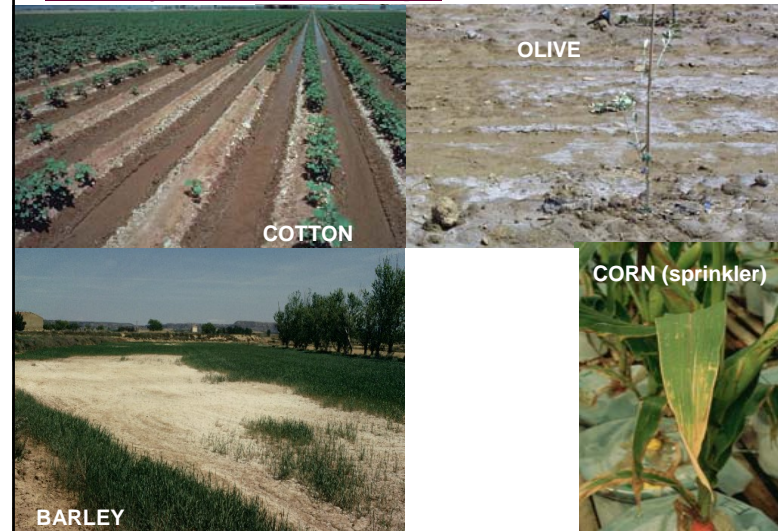


• Why is salinity a problem?

- Because it affects negatively crop yield



Salinity effects on crops



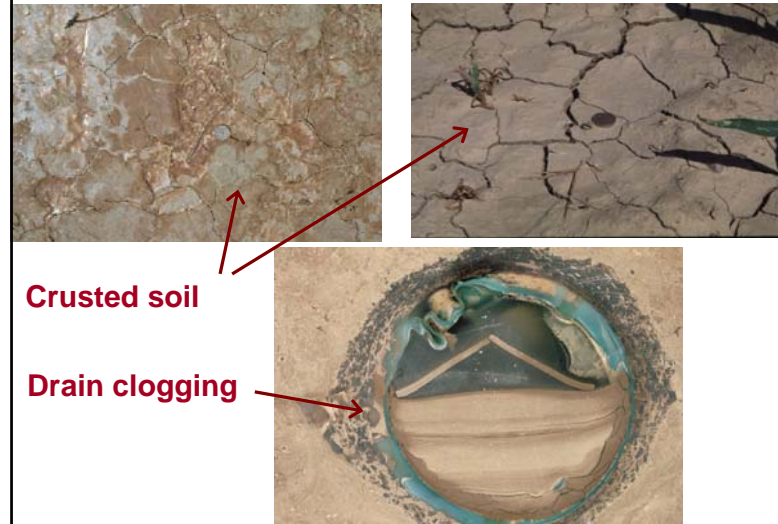
• Why is salinity a problem?

Because if sodium is preponderant (“sodicity”) it may affect negatively soil’s structural stability.



Pakistan:
saline, sodic,
alkaline soil,
impermeable

Effects of sodicity on soils



Crusted soil

Drain clogging

• Why soil salinity increases in irrigated agriculture?

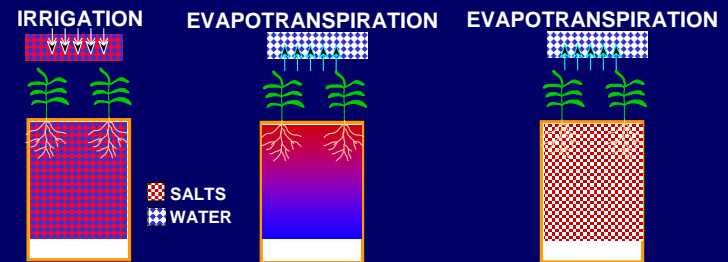
- Because plants extract water from the soil, but not the salts that accumulate in the soil.

- Because water evaporates from the soil as vapor, leaving the salts in the soil.

- Thus, soil evaporation (E) and plant transpiration (Tc), in other words ETC, is one main reason for salinity increases in irrigated agriculture.

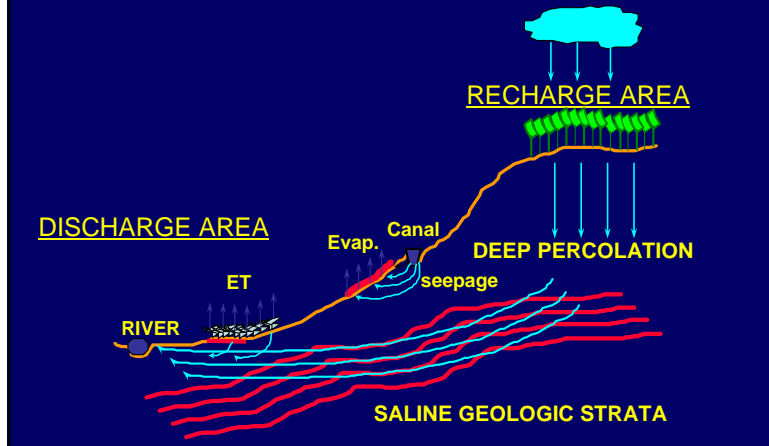
SOIL SALINIZATION IN IRRIGATION

● Evapotranspiration effect: soil water evapo-concentration



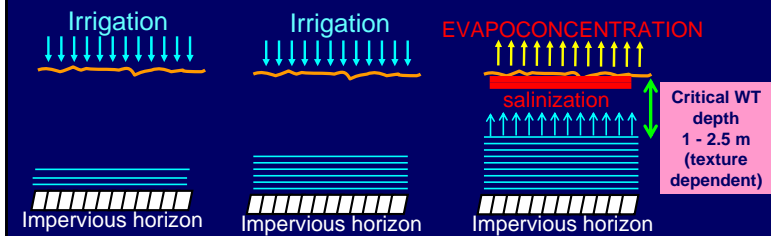
ROOT ZONE SOIL SALINIZATION

- **Weathering effect:** dissolution of mineral/salt deposits due to deep-percolation waters.

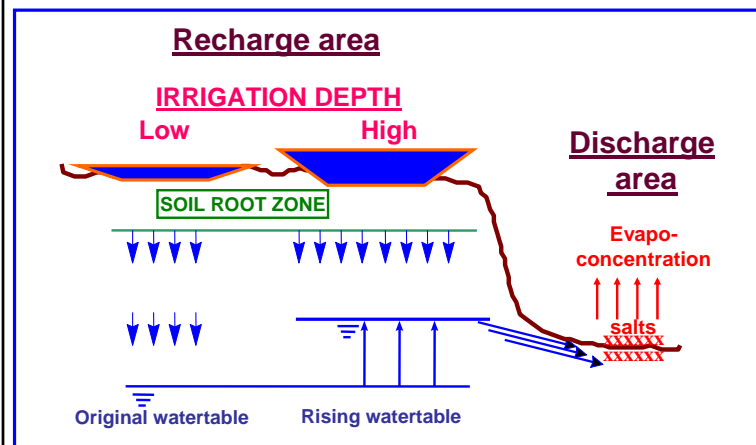


SOIL SALINIZATION IN IRRIGATION

- Excessive application of irrigation water in soils with limited drainage.
- Creation of shallow watertables that:
 - (1) prevent the leaching of salts
 - (2) induce the capillary rise of water and salts and the subsequent evapoconcentration at the soil surface.



Irrigation and soil salinization: the inefficiency of irrigation in the recharge areas provokes soil salinization in the discharge areas

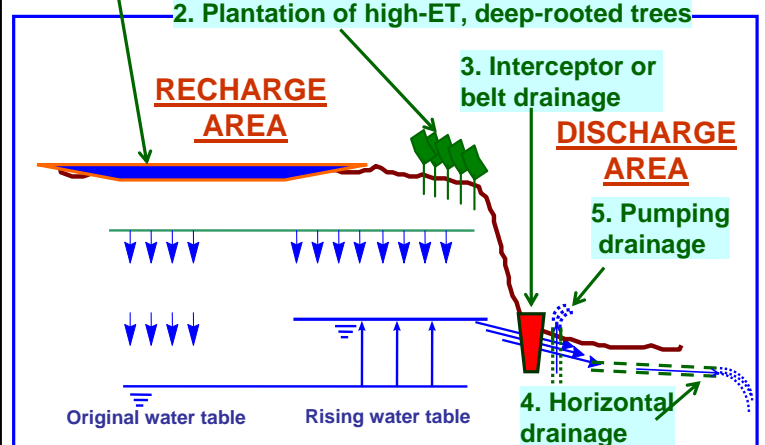


¿How to avoid soil salinization in the discharge areas?

1. Increase efficiency/uniformity of irrigation

2. Plantation of high-ET, deep-rooted trees

3. Interceptor or belt drainage



THE APPROPRIATE MANAGEMENT OF IRRIGATION AND DRAINAGE ARE THE TWO KEY STRATEGIES FOR CONTROLLING SALINITY IN IRRIGATED AGRICULTURE

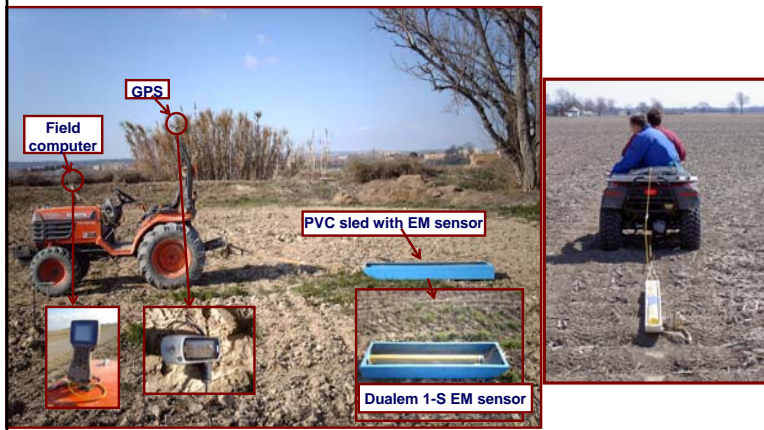
- Soil salinity must be measured in space and time.
- Today, we have remote sensors that are able to estimate salinity of large-scale irrigation districts:

1- Terrestrial vehicles with electromagnetic sensor

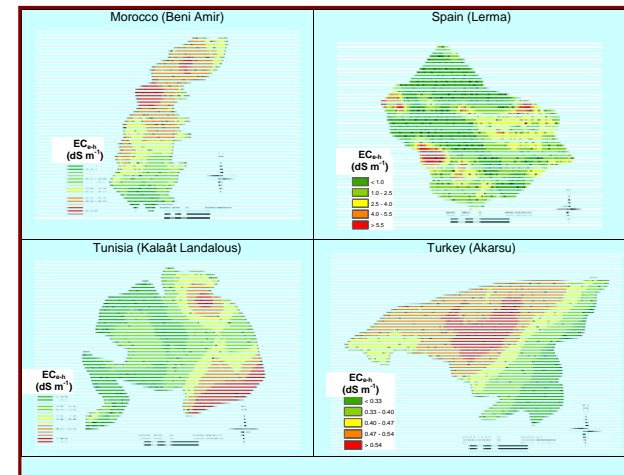
2- Aerial vehicles with electromagnetic sensor

3- Image satellites as Landsat

Terrestrial vehicles: mobile and geo-referenced electromagnetic sensor. Prototype designed at CITA



Salinity maps performed with the terrestrial EM sensor in Spain, Morocco, Tunisia and Turkey (INCO project)

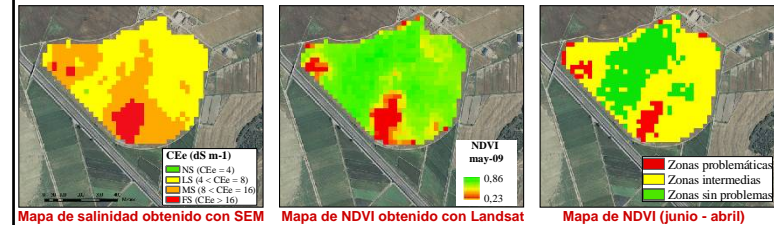


Aerial vehicles: helicopter with RESOLVE EM sensor



Landsat satellite images

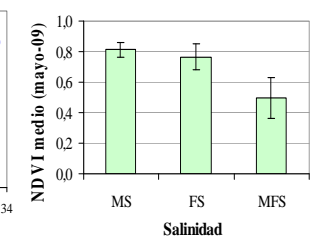
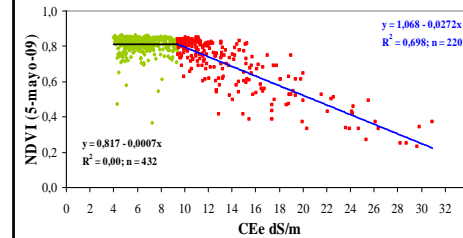
Barley, Pompenillo farm (Huesca, España)



Mapa de salinidad obtenido con SEM

Mapa de NDVI obtenido con Landsat

Mapa de NDVI (junio - abril)

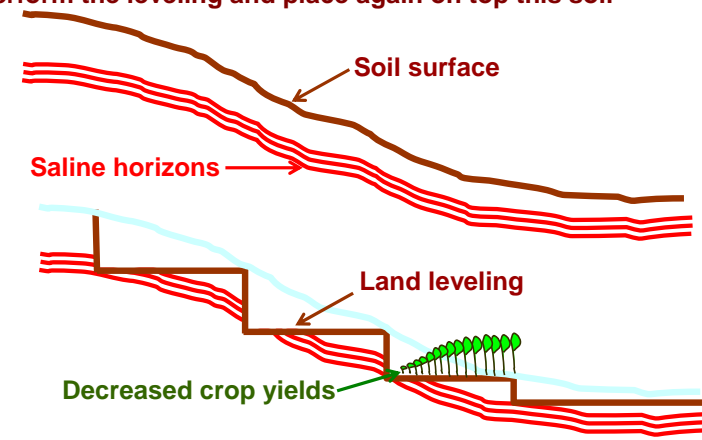


Irrigation systems and salinity: synthesis of potential problems and corrective measures

System	Potential problem	Corrective measures
Flood	Low distribution uniformity \Rightarrow differential leaching of salts	Reshape of plot/laser leveling
Furrow	Evaporation of water \Rightarrow salt accumulation in the upper part of ridges	Soil mulching
Sprinkler	Wetting of leaves and foliar absorption of ions \Rightarrow specific ion toxicity (Na, Cl, B)	Avoid wetting of leaves; irrigate at times of low evaporation
Drip	Salt accumulation at soil surface and edges of wetted areas	Increase drip density

Plot's configuration for basin irrigation

✓ An excessive land leveling may outcrop deep saline horizons. It is recommended to take out the surface soil, perform the leveling and place again on top this soil



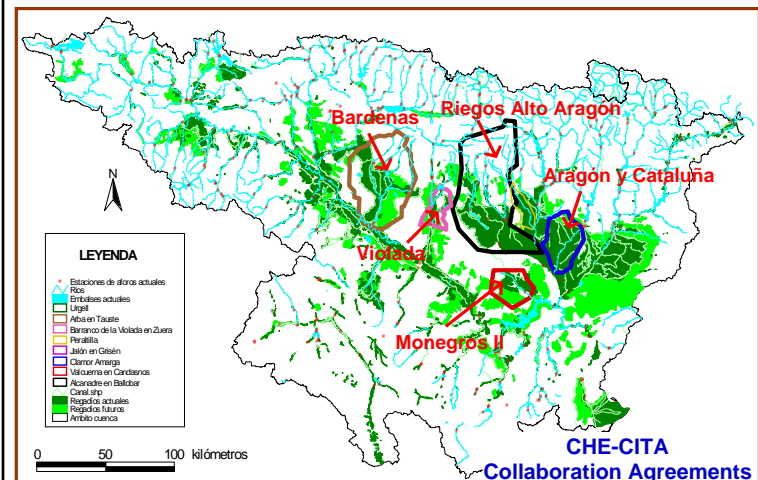
The European Water Framework Directive and the National Hydrologic Plan

- Objective of the WFD: Framework for the protection of water quality in Europe.
- All water bodies must attain a good chemical and ecological status in year 2015.
- “Polluters pay”... A difficult task when pollution is diffuse (as in agriculture). Role of WUA...
- Increasing pressure towards agricultural systems that guaranty the quality of waters: increasing need to quantify pollution induced by irrigation.

The Spanish Environmental Monitoring Program

- Monitoring of environmental impacts.
- Research of “cause-effects”.
- Elaboration of codes of good agricultural practices.
- Establishment of agro-environmental indicators.
- Network of environmental monitoring stations in each Spanish hydrological basin.

RECOREBRO: Ebro River Basin Network for the assessment of irrigation-induced pollution



Measurement of flows and water quality at the exit of an irrigation district



Measurement of flows and water quality at the exit of an irrigation district

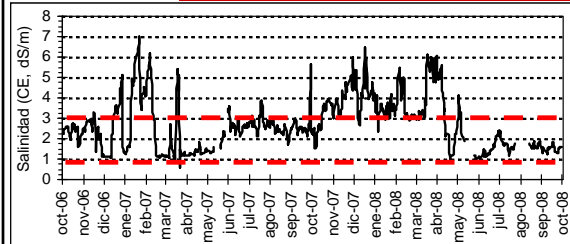


Flow and quality station in Lerma (Bardenas)

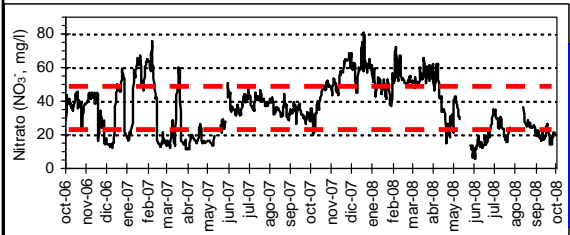
Measurement of flow in Akarsu irrigation district (Adana, Turkey)



Bardenas: Arba in Tauste



Mean 07+08
2,7 dS/m
6,0 T/ha-year



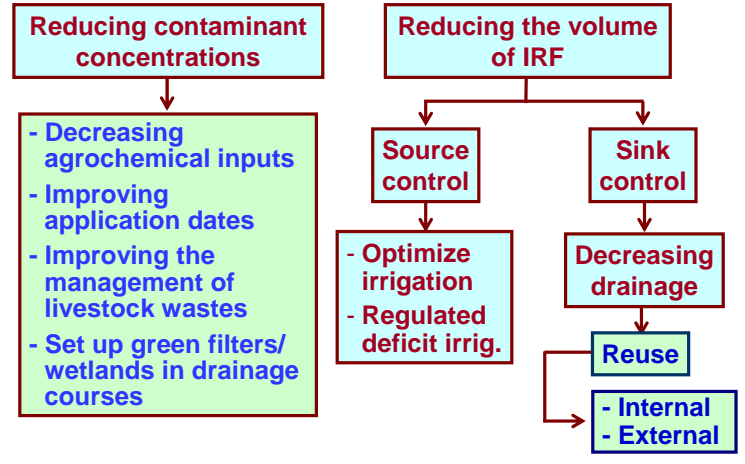
Mean 07+08
37 mg/l
114 Kg NO₃/ha-year
= 26 Kg N/ha-year
24% with NO₃ > 50
68% with NO₃ > 25

Why IRF are important within the European WFD?

Because the load of contaminants (i.e., volume of IRF and contaminant concentrations) largely determine the quality (i.e. the concentration of contaminants) in the receiving water bodies (rivers)

Hence, salt and nitrate concentrations is a relevant and increasing problem in many rivers of the Ebro Basin...

How to minimize contaminant loads in IRF?
(Load = Concentration x Volume)



In all these activities, Water User Associations play a major role for:

- 1- Environmental monitoring of irrigation**
- 2- Establishment of good agricultural practices for pollution control**
- 3- Training and dissemination activities**
- 4- Interaction with research**