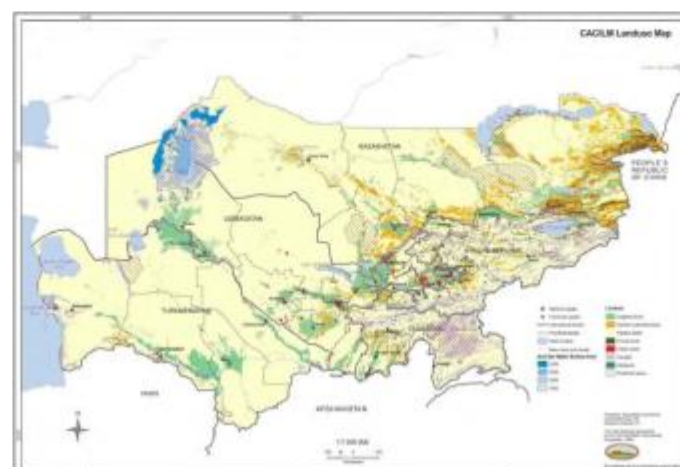
Soil salinity assessment – from point to field scales

Akmal Akramkhanov

Qarshi, August 17, 2021



Context

- Low irrigation and water use efficiency
- Shallow groundwater table
- Deteriorating drainage network
- Secondary soil salinity requiring leaching
- Inadequate soil salinity monitoring

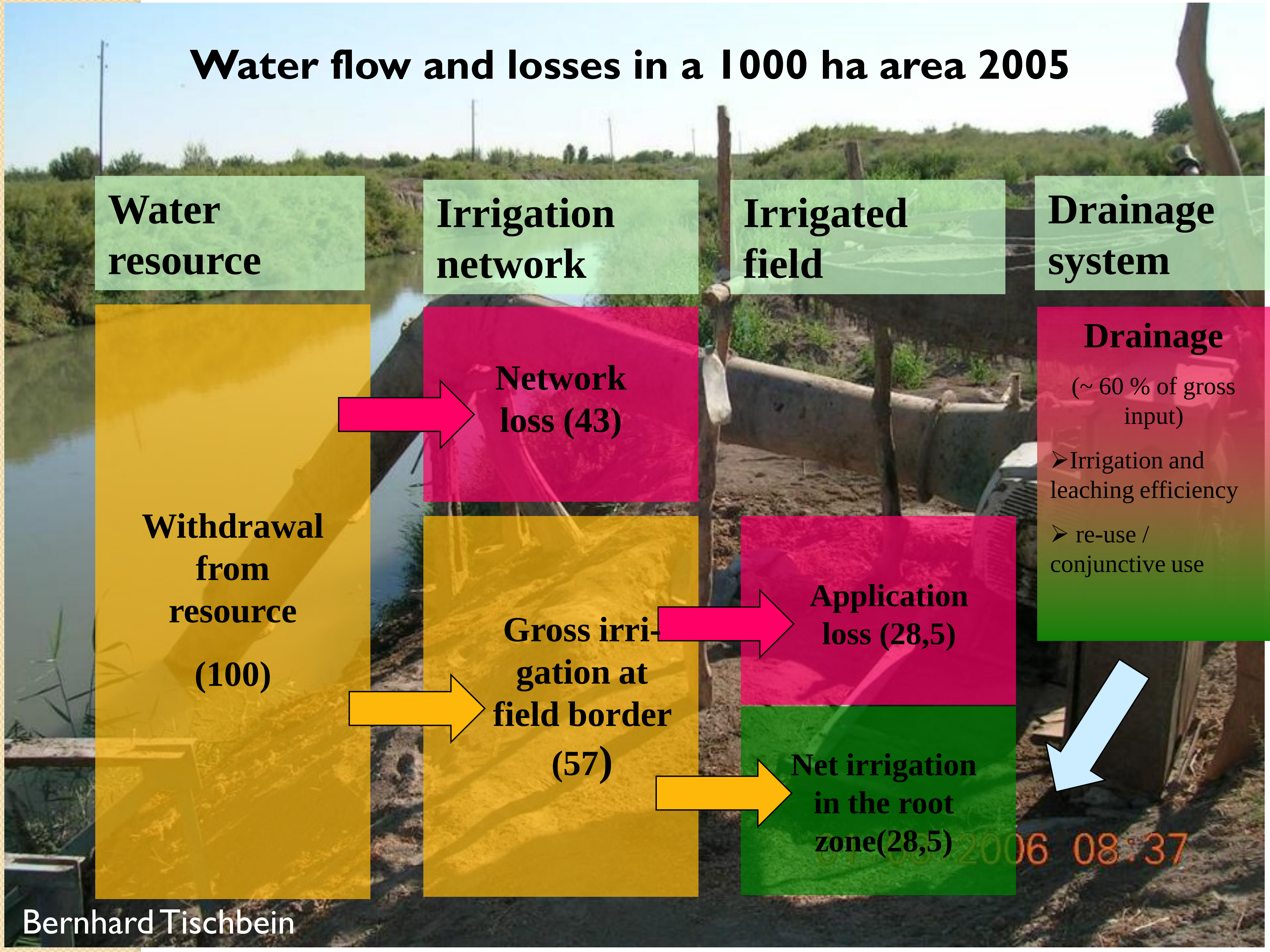
Soil salinity in irrigated areas





Photos: ZEF/UNESCO Khorezm project

Irrigation (and leaching)


Water flow and losses in a 1000 ha area 2005
Water resource
Irrigation network
Irrigated field
Drainage system
Withdrawal from resource (100)
Network loss (43)
Gross irri-gation at field border (57)
Application loss (28,5)
Net irrigation in the root zone(28,5)
Drainage
(~ 60 % of gross input)
➢Irrigation and leaching efficiency
➢ re-use / conjunctive use
Bernhard Tischbein

Assessment and Monitoring of Salt-Affected Soils

- Soil salinization is one of the most important factors of land degradation
- Soil salinity is often quoted factor for remedial actions (leaching practices, land rehabilitation projects, I&D network improvement, etc.)
- Subsequently used as a common indicator for various actions


Photo by G. Ruecker

- To assess the effectiveness of irrigation, drainage, and soil management practices
- To inventory the extent of salt-affected soils

Constraints

- Assessment and monitoring is often poorly addressed
- Conventional measuring techniques are laborious and compromise representativity
- Takes long time before analyses and maps are ready to react (i.e. water amount for leaching)

Objectives

- Demonstrate simplified measurements and proxy instruments to estimate TDS and ECe
- Compare EC meters
- Present conversion factors to estimate soil salinity with different EC methods

Salinity studies area

МАСШТАБНЫЙ ПОДХОД ОЦЕНКИ ЗАСОЛЕНИЯ ПОЧВ ОТ ТОЧЕЧНЫХ ДО ОБЛАСТНЫХ УРОВНЕЙ

А. Акрамханов, ЗЕФ-ЮНЕСКО Проект*

GERMAN-UZBEK KHOREZM PROJECT

ZEF Bonn

Традиционный

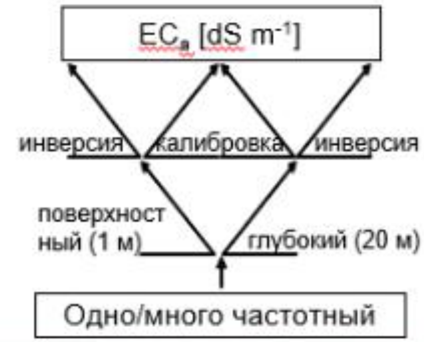
ТОЧЕЧНАЯ ОЦЕНКА ПРОБ

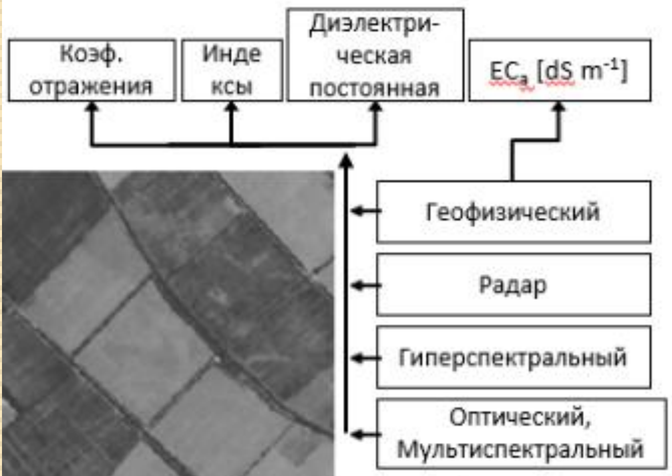
+ точные значения
- маленький объем
+ несколько слоев
- большой разброс
+ отдельные ионы
- трудоемкий
+ универсален
- медленный
- высокая стоимость

ЕС штырь, электрокондуктометр

ТОЧЕЧНЫЙ/ПОЛЕВОЙ

+ точные значения
- маленький объем
+ несколько слоев
- большой разброс
- зависит от влажности
+ легко использовать
- требует калибровки
+ быстрый
+ дешевый





ХОЗЯЙСТВА/ОБЛАСТЬ

- относительные значения
+ сплошное покрытие
- поверхностный слой
+ маленький разброс
- интерпретация
- наземная проверка
- навыки обработки снимков
+ быстр и дешев /га
- начальные расходы

ПОЛЯ/ХОЗЯЙСТВА

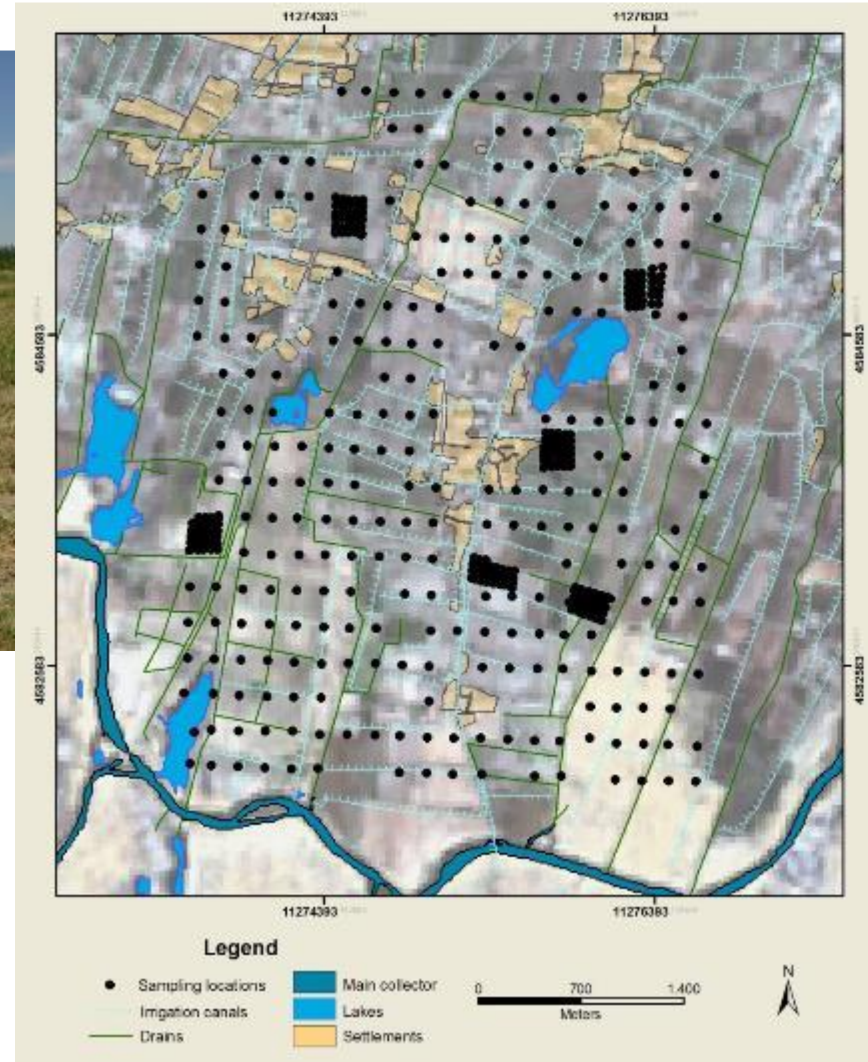
+ точные значения
+ большой объем
+ разные слои почвы
+ маленький разброс
+ недеструктивный
+ непрерывный замер
- требует калибровки
- зависит от местных условий
+ быстр и дешев /га

Аэрокосмические методы

Электромагнитная индукция

*Экономическая и Экологическая Реструктуризация Земле- и Водопользования в Хорезмской области

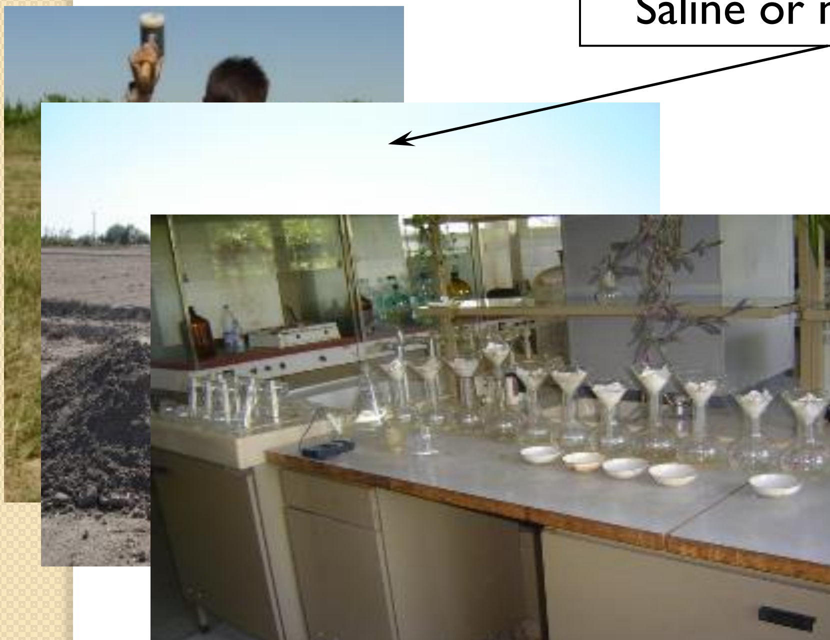
Field survey



Field survey

Soil salinity assessment

Saline or not saline?



Sample	Location	Salinity level
1	Area 1	Saline
2	Area 2	Not saline
…	…	…

Table 4: Soil classification based on salinity level (Kovda et al. 1960)

Salinity level	Salinity type, total dissolved solids, %							
	chloride-sodium	sulphate-sodium	sodium-chloride	sodium-sulphate	sulphate-chloride	chloride-sulphate	chloride	sulphate
Not saline	<0.15	<0.15	<0.15	<0.15	<0.2	<0.25	<0.15	<0.3
Low	0.15-0.25	0.15-0.3	0.15-0.25	0.15-0.25	0.2-0.3	0.25-0.4	0.15-0.3	0.3-0.6
Moderate	0.25-0.4	0.3-0.5	0.25-0.4	0.3-0.5	0.3-0.6	0.4-0.7	0.3-0.5	0.6-1.0
High	0.4-0.6	0.5-0.7	0.4-0.6	0.5-0.7	0.6-1.0	0.7-1.2	0.5-0.8	1.0-2.0
Solonchak	>0.6	>0.7	>0.6	>0.7	>1	>1.2	>0.8	>2.0

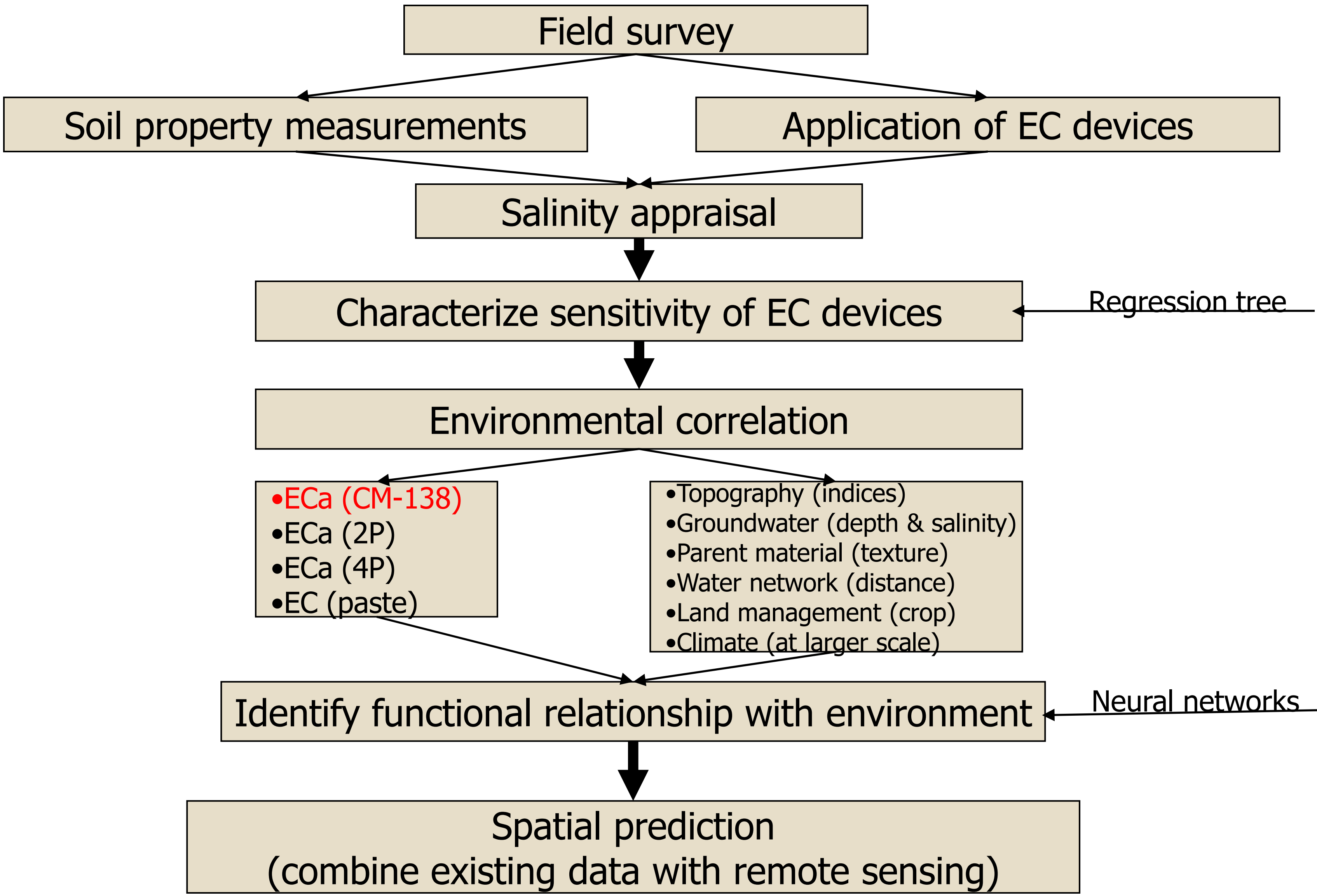
Soil salinity assessment

Saline or not saline?

Sample	Location	Salinity level
1	Area 1	Saline
2	Area 2	Not saline
…	…	…

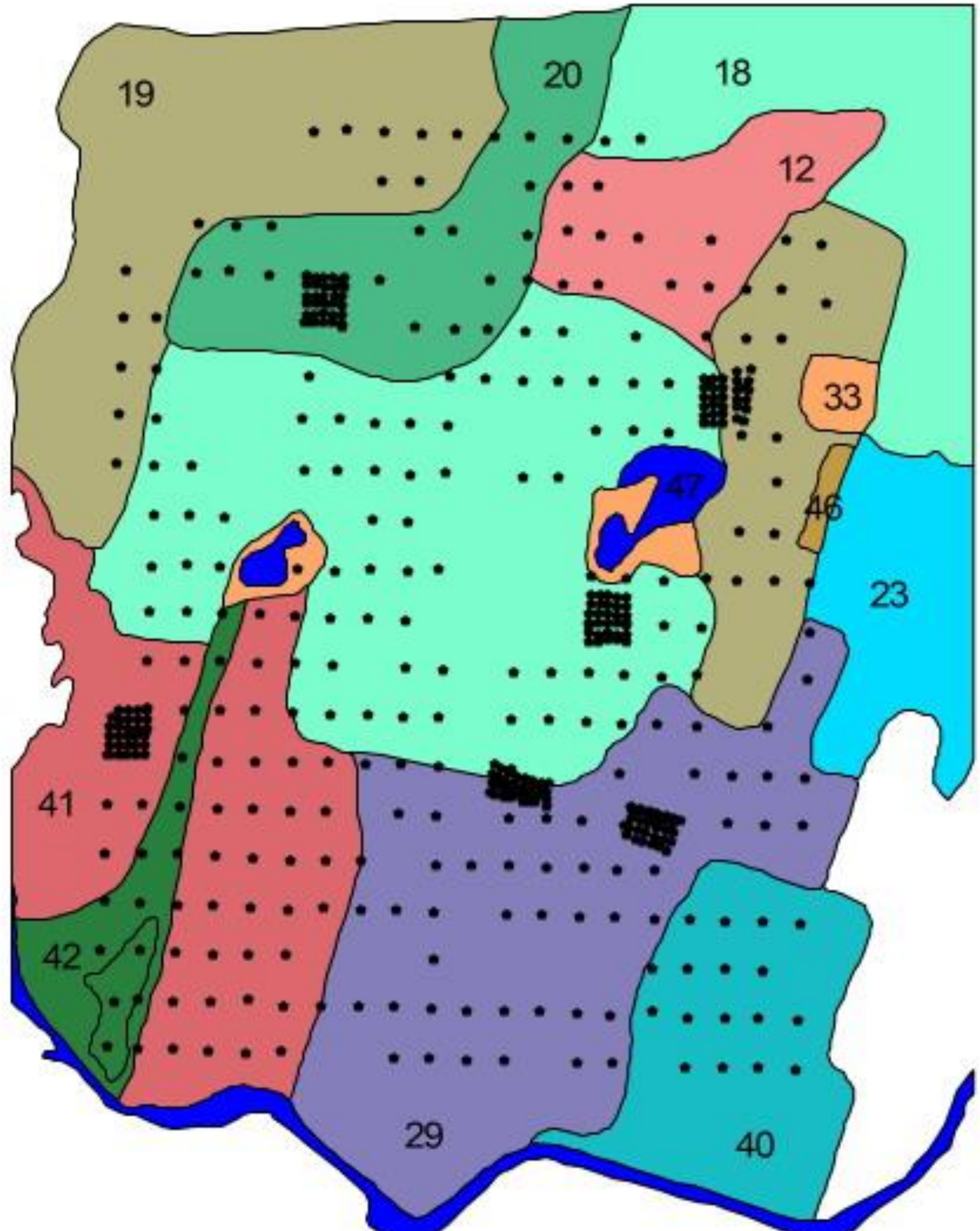
Approach

- relatively new equipment
- no experience in the region
- complexity of the device
- data extraction and analysis


Field survey
Soil property measurements
Application of EC devices
Salinity appraisal
Characterize sensitivity of EC devices
Regression tree
Environmental correlation
•ECa (CM-138)
•ECa (2P)
•ECa (4P)
•EC (paste)
•Topography (indices)
•Groundwater (depth & salinity)
•Parent material (texture)
•Water network (distance)
•Land management (crop)
•Climate (at larger scale)
Identify functional relationship with environment
Neural networks
Spatial prediction
(combine existing data with remote sensing)

Study area

1,000 ha farm community



Study area

80 ha research farm

Measurements and laboratory analyses

TDS total dissolved solids, determined by evaporating water from soil solution (1:5) extract

EC_e electrical conductivity of saturation paste extract

EC_p EC of soil solution (1:1), measured in the soil solution ***before water extraction***

$EC_{1:1}$ EC of soil solution (1:1) extract

$EC_{1:5}$ EC of soil solution (1:5) extract

EM_v EC_a of bulk soil layer up to 1.5 m depth measured by EM38 in vertical mode

EM_h EC_a of bulk soil layer up to 0.75 m depth measured by EM38 in horizontal mode

Aral Sea water salinity

- Eijkelkamp 18.21 could measure extremely high salinity levels compared to Hanna Instruments HI 98312
- Example of Aral Sea water EC (13.06.2009)

Soil sampling

- Before and after leaching
- Samples collected from 5 layers at 30 cm intervals (0-30, 30-60, 60-90, 90-120, 120-150 cm)

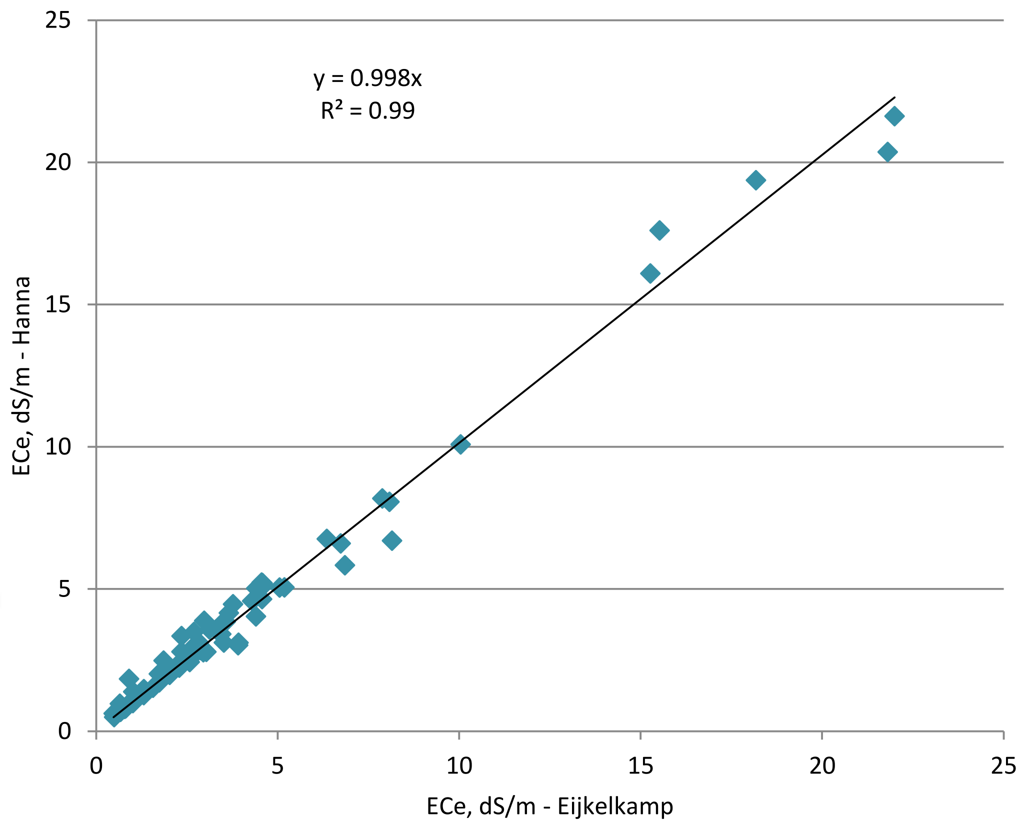
Analysis

Steps	ECe (250 grams)	EC 1:1 (40 grams)	EC 1:5 (20 grams)
1	Add **measured amount of distilled water** to a sample of soil while stirring with a spatula until saturation, at saturation the soil paste: a. Does not have free standing water on the surface of the paste b. Slides freely and cleanly of a spatula c. Will flow slightly when the container is tipped to a 45 degree d. Soil surface glistens as it reflects light e. Consolidates easily by tapping after a trench is formed in the paste with the flat side of spatula (may not apply to sandy soils >70% sand)	Add 40 ml of distilled water, mix intensively.	Add 100 ml of distilled water, mix intensively.
2		Cover and leave the sample. Mix again in 30, 60, and 90 min. Total number of mixing is minimum 4 times.	
3	Record amount of added distilled water. Cover container and let it stay for four (4) hours. Check saturation characteristics again and add soil or water as needed to obtain the desired characteristics. **If additional soil or water is added, then record the mass of the soil (g) and total water (g) added.**	Calibrate conductivity probe. Rinse. Measure T'C and conductivity of the **EC paste**. Record.	
4	After equilibrium, thoroughly remix soil paste, transfer soil saturation paste to (Buchner) funnel and spread evenly over the surface. Apply -60 to -80 kPa vacuum and collect filtrate in measuring container for 30 min. Discontinue vacuum when cracks appear in soil paste. Refilter if filtrate is turbid. *Approximately ¼ to ⅓ of the water added in making the saturated paste can be recovered as extract.*	Transfer the solution to a filter funnel. Wait till water extract is collected in the containers. Refilter if filtrate is turbid.	
5	Calibrate conductivity probe. Rinse with distilled water the measuring containers and the conductivity probe. Measure temperature and conductivity. Record the values.		

EC meters

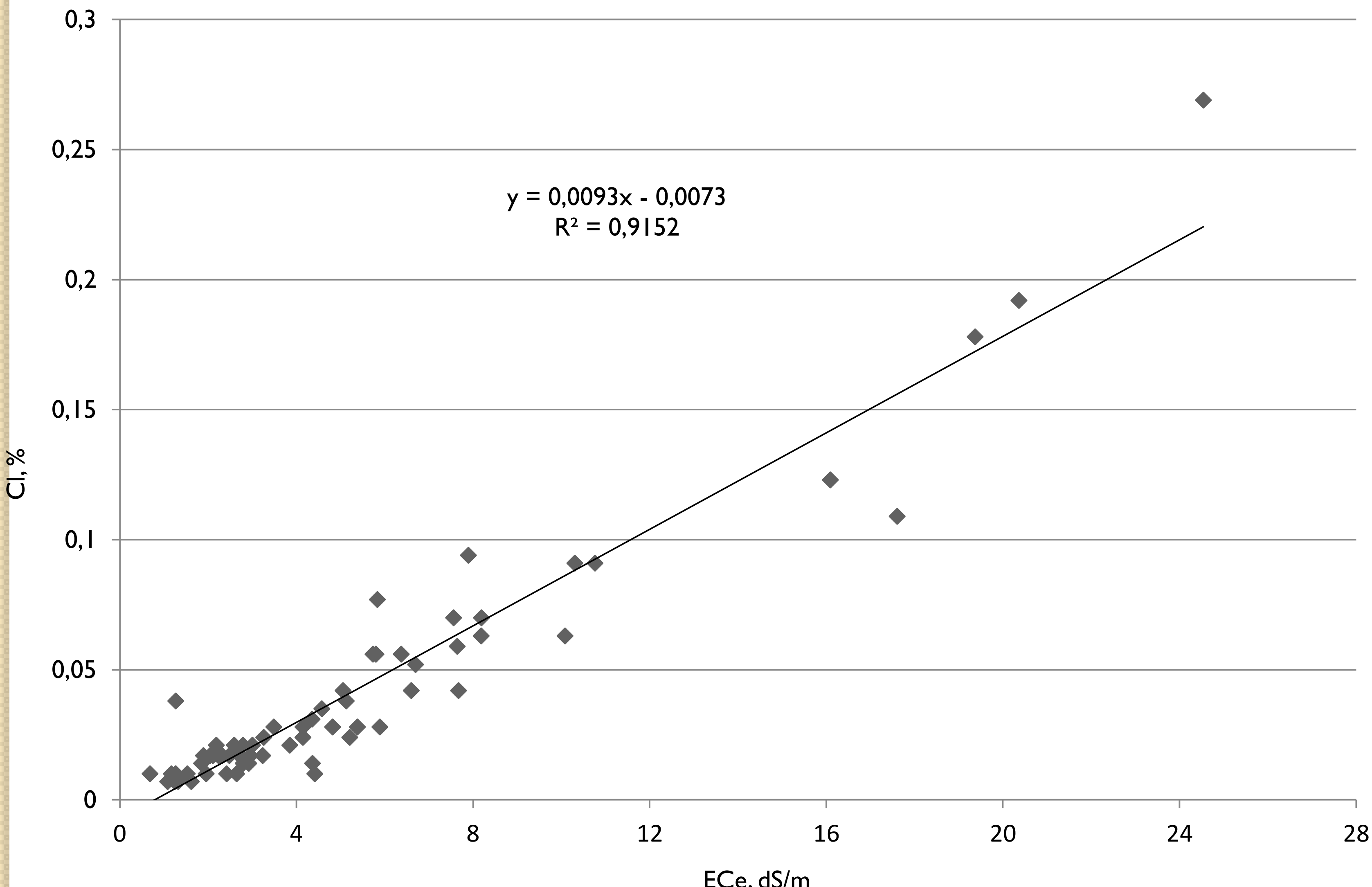
EC meters

- Eijkelkamp 18.21 and Hanna Instruments HI 98312
- Foreign and locally made EC meters are available
- Measuring principles are identical
- Accuracy is satisfactory



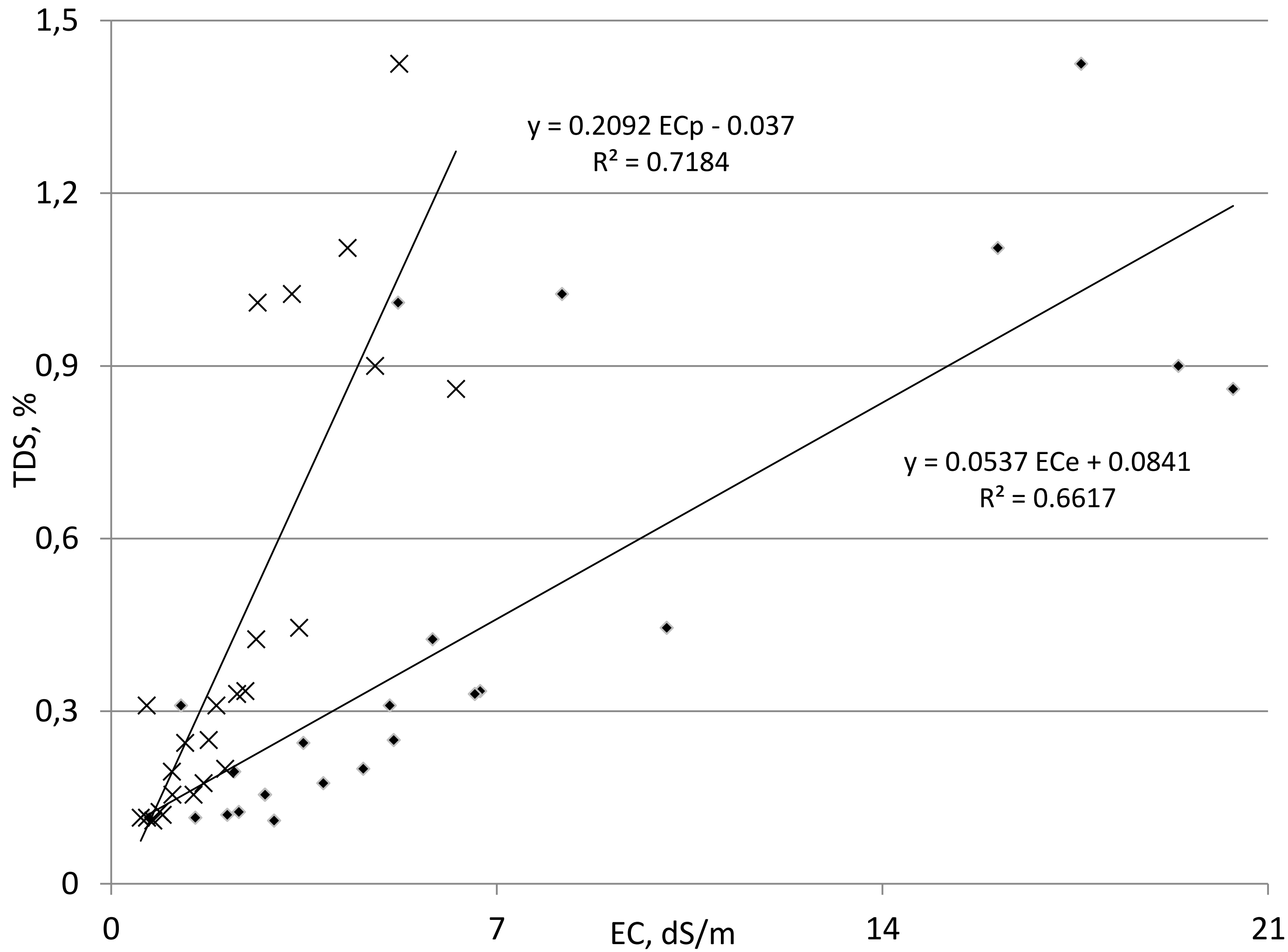
Correlation factors ECe vs. Cl

- High accuracy

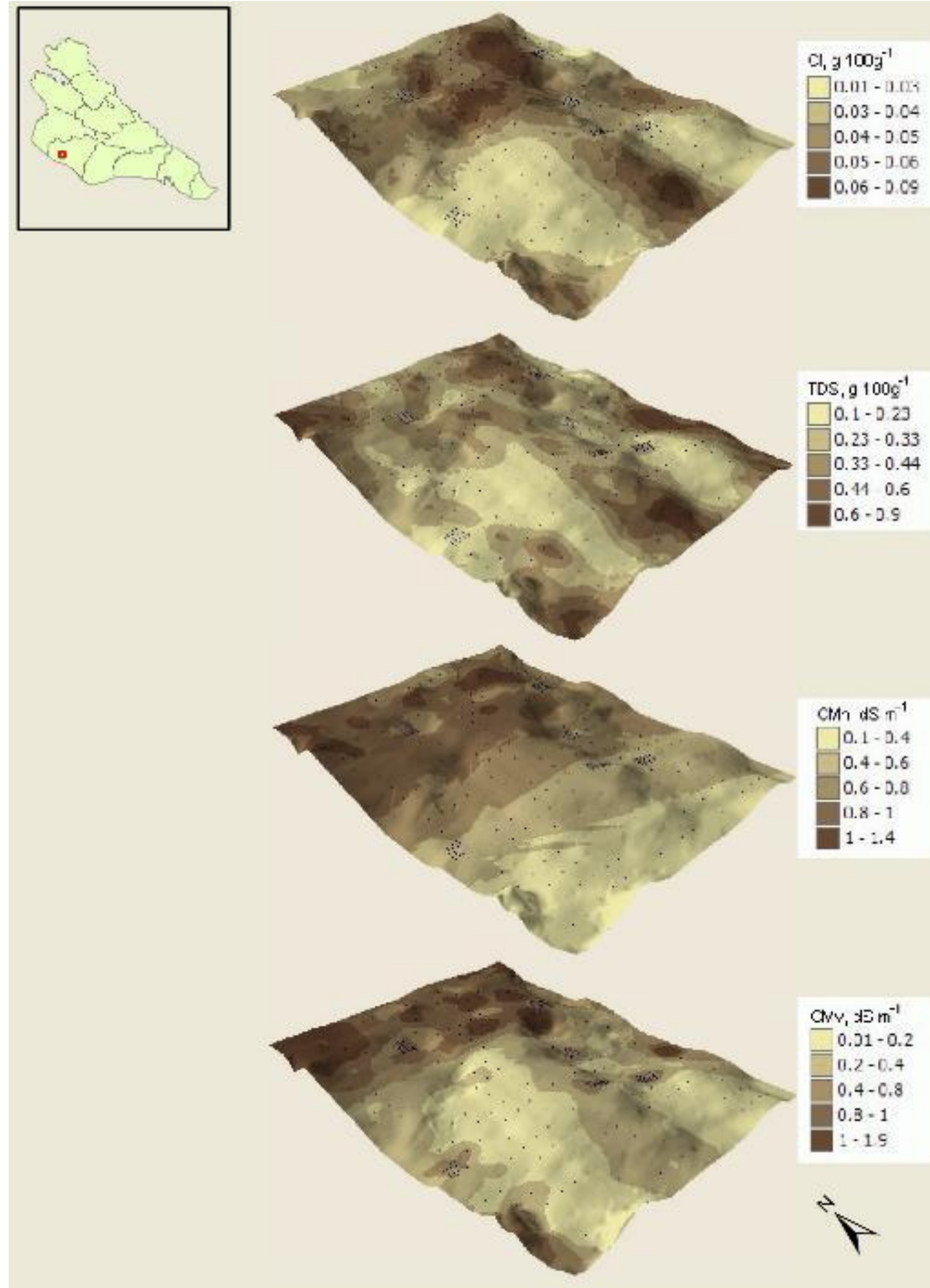


Correlation factors EC vs. TDS

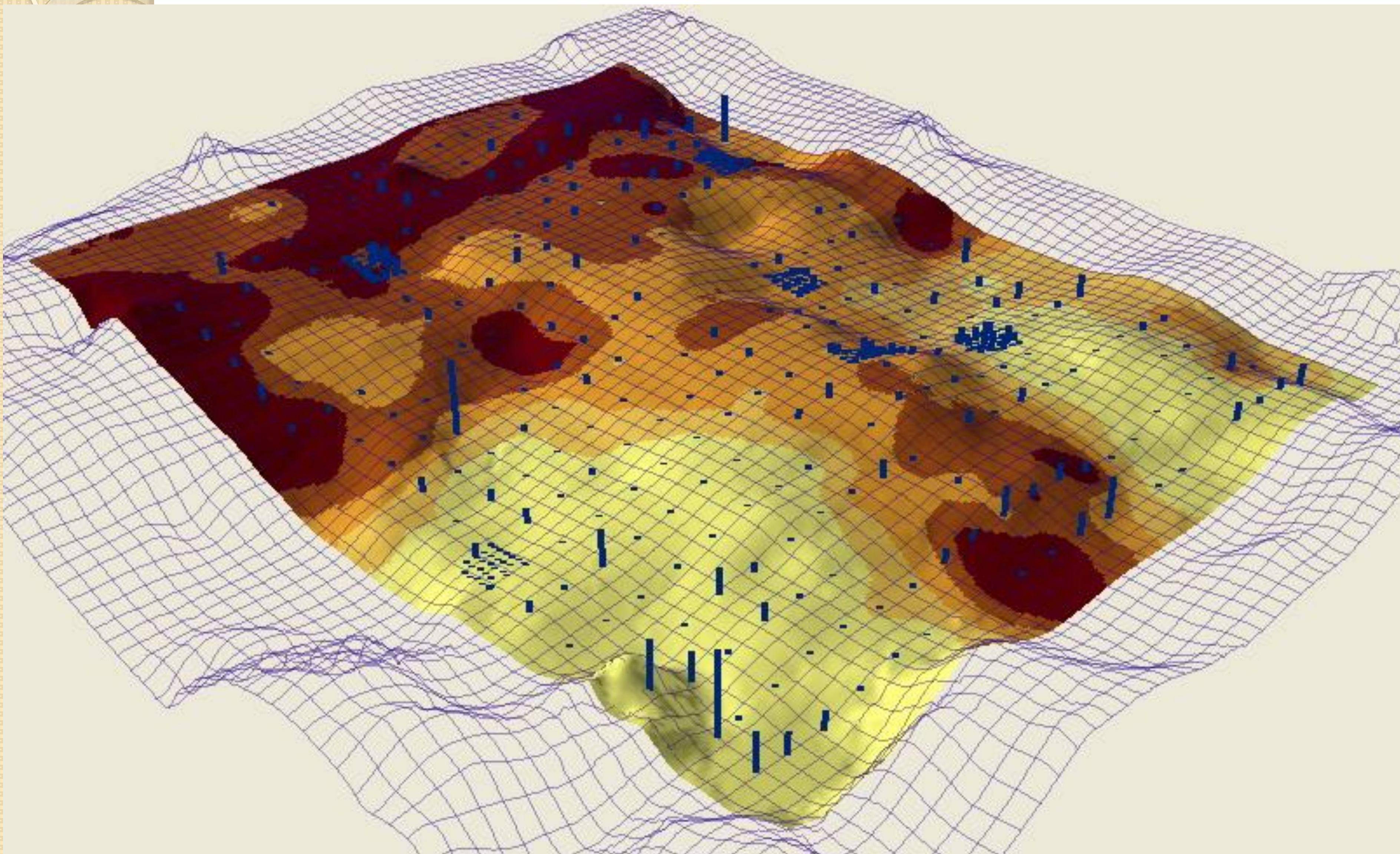
- Possible, high variation



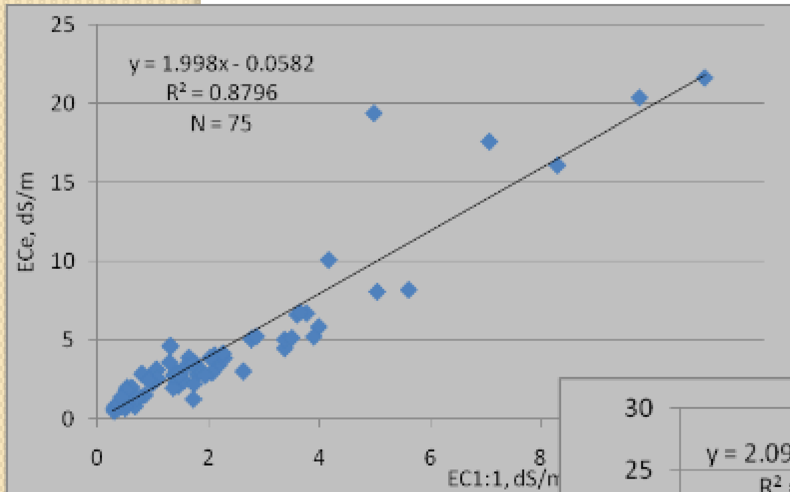
Spatial distribution of soil salinity



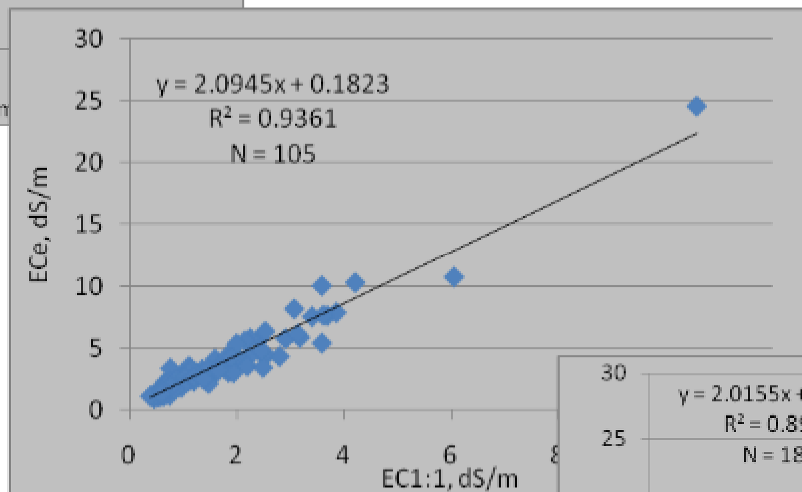
Overlay map of elevation (mesh), clay content (colored), extruded columns (TDS)

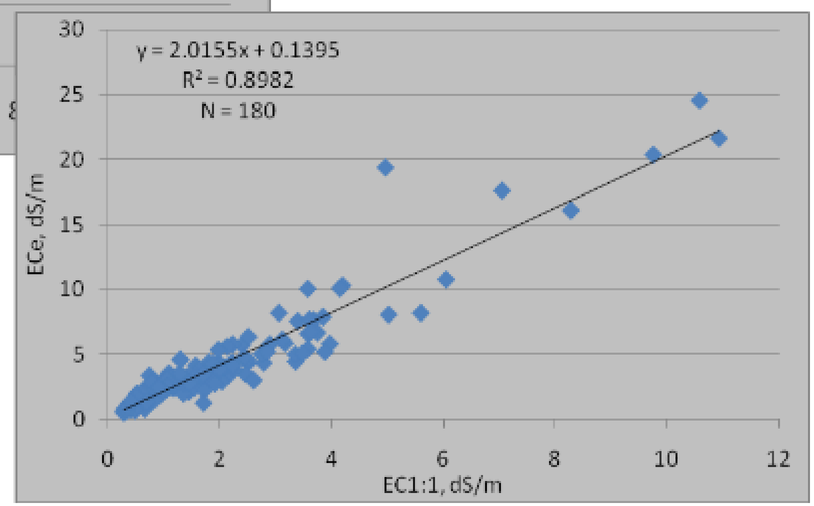


Correlation factors EC_e vs. $EC_{1:1}$

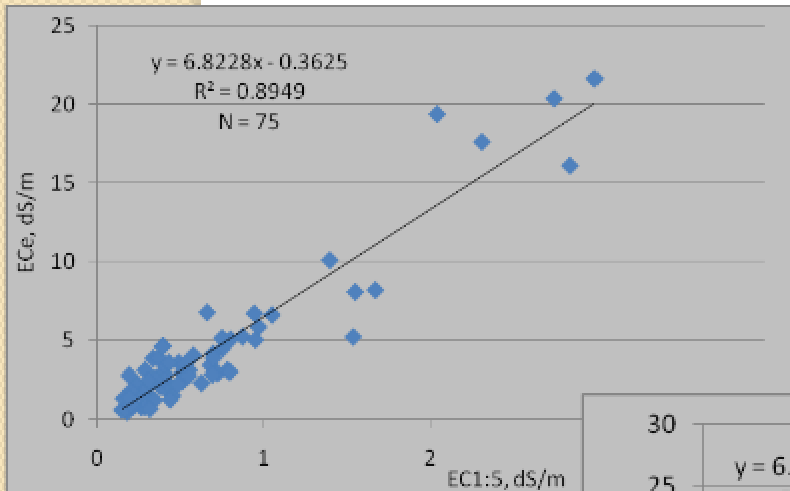


EC_e	Equation	R^2
Pre-leaching	$=1.98 \times EC_{1:1}$	0.88
Post-leaching	$=2.16 \times EC_{1:1}$	0.93
Combined	$=2.06 \times EC_{1:1}$	0.90

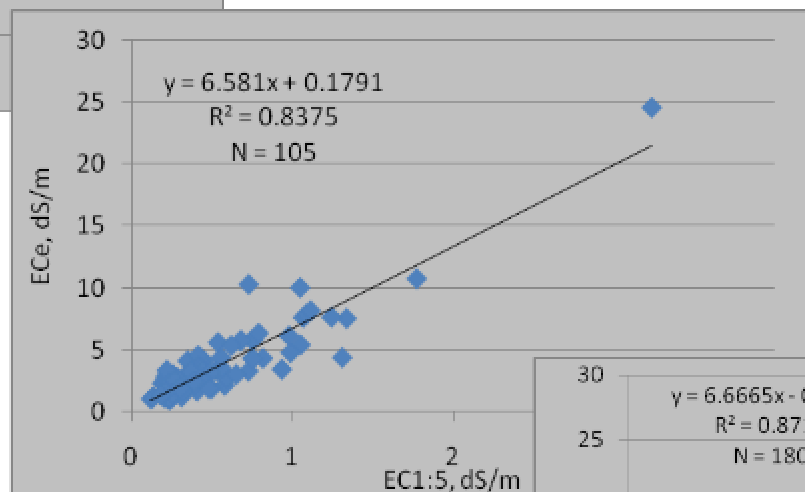


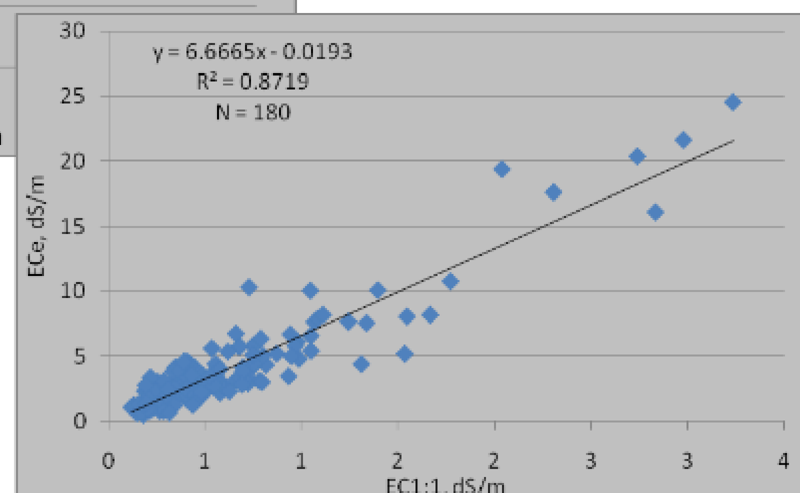


Correlation factors EC_e vs. $EC_{1:5}$



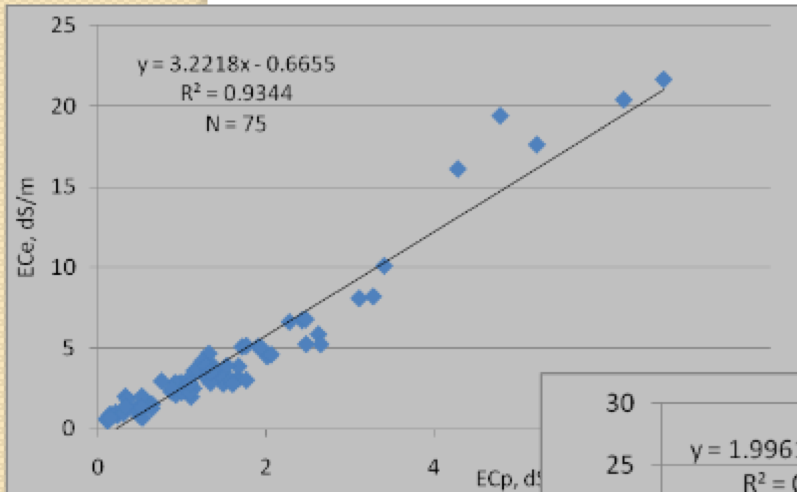
EC_e	Equation	R^2
Pre-leaching	$=6.53 \times EC_{1:5}$	0.89
Post-leaching	$=6.80 \times EC_{1:5}$	0.84
Combined	$=6.65 \times EC_{1:5}$	0.87

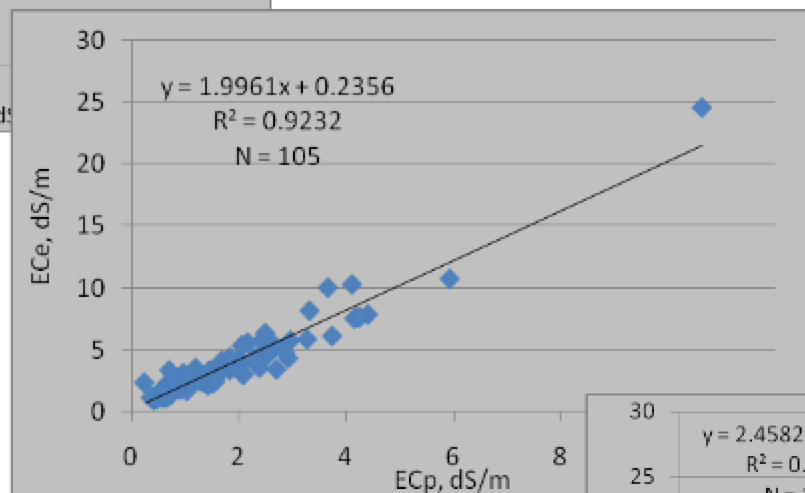


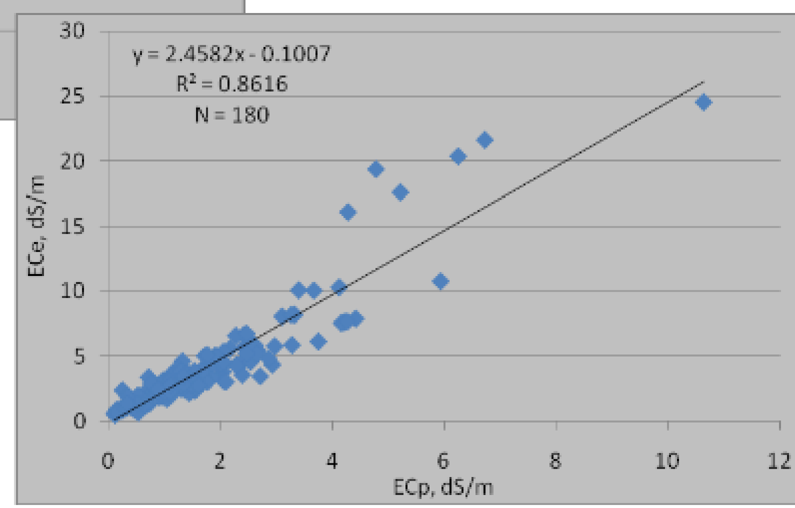


Correlation factors EC_e vs. EC_p

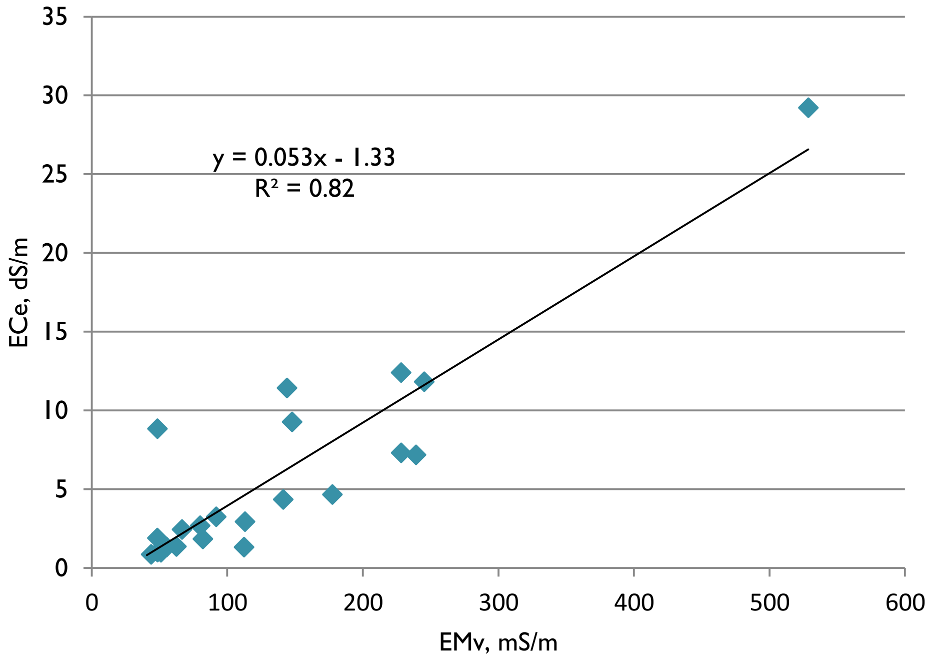
EC_e	Relationship equation	R^2
Pre-leaching	$=2.97 \times EC_p$	0.92
Post-leaching	$=2.08 \times EC_p$	0.92
Combined	$=2.42 \times EC_p$	0.86

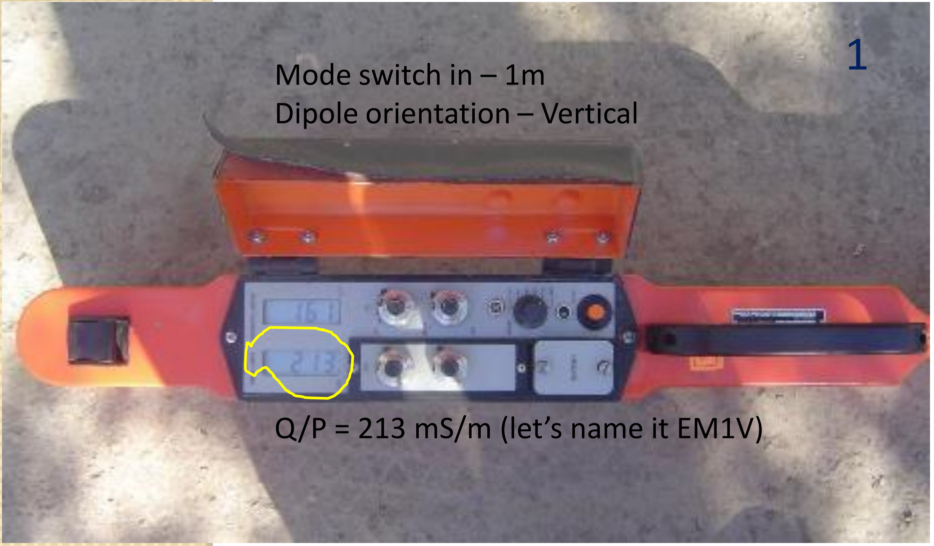


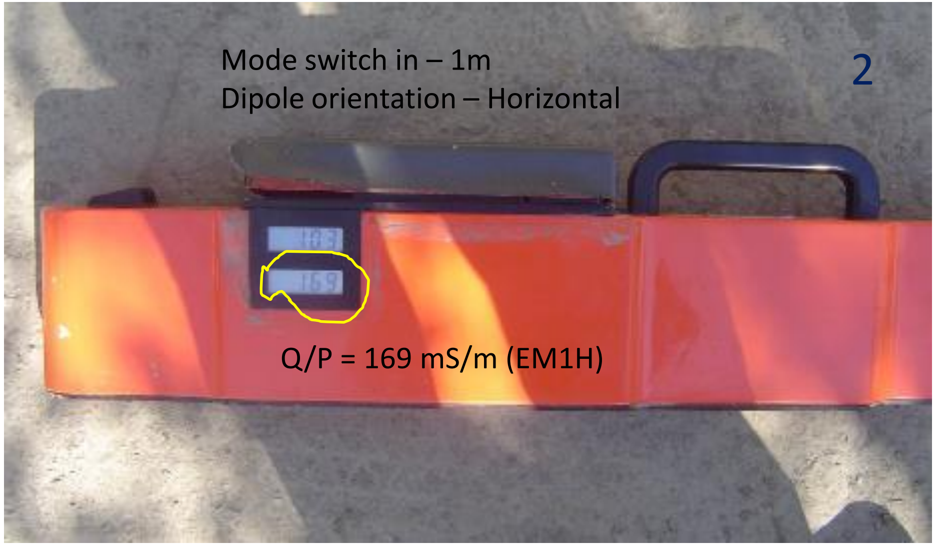




Electromagnetic induction (EM38)

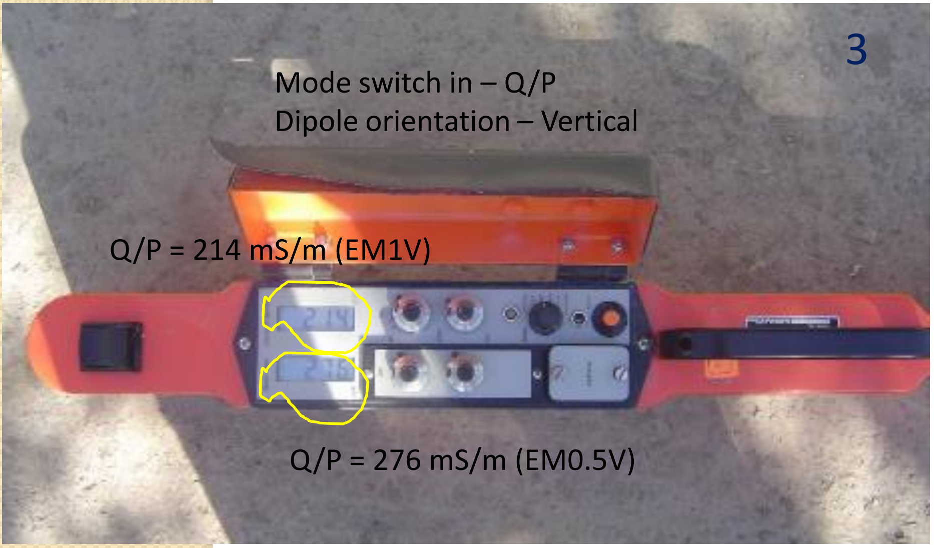


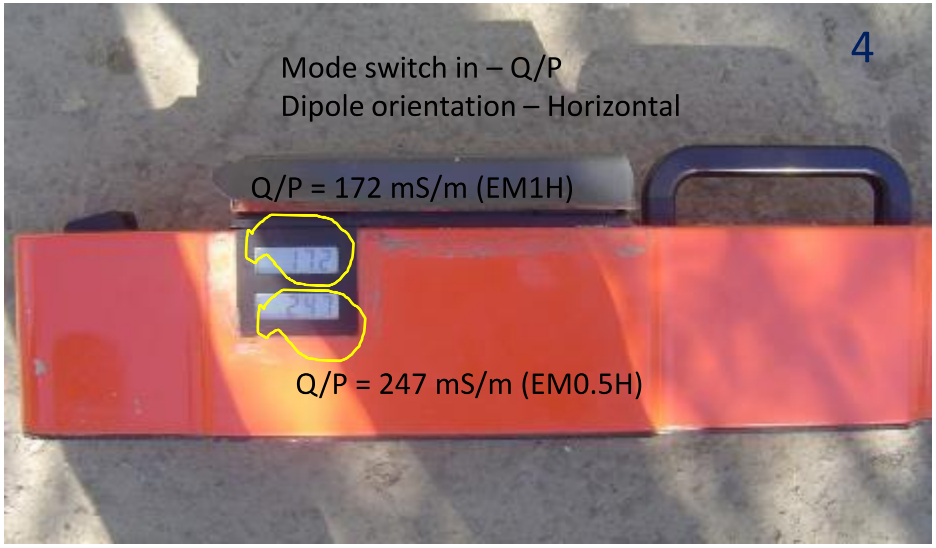




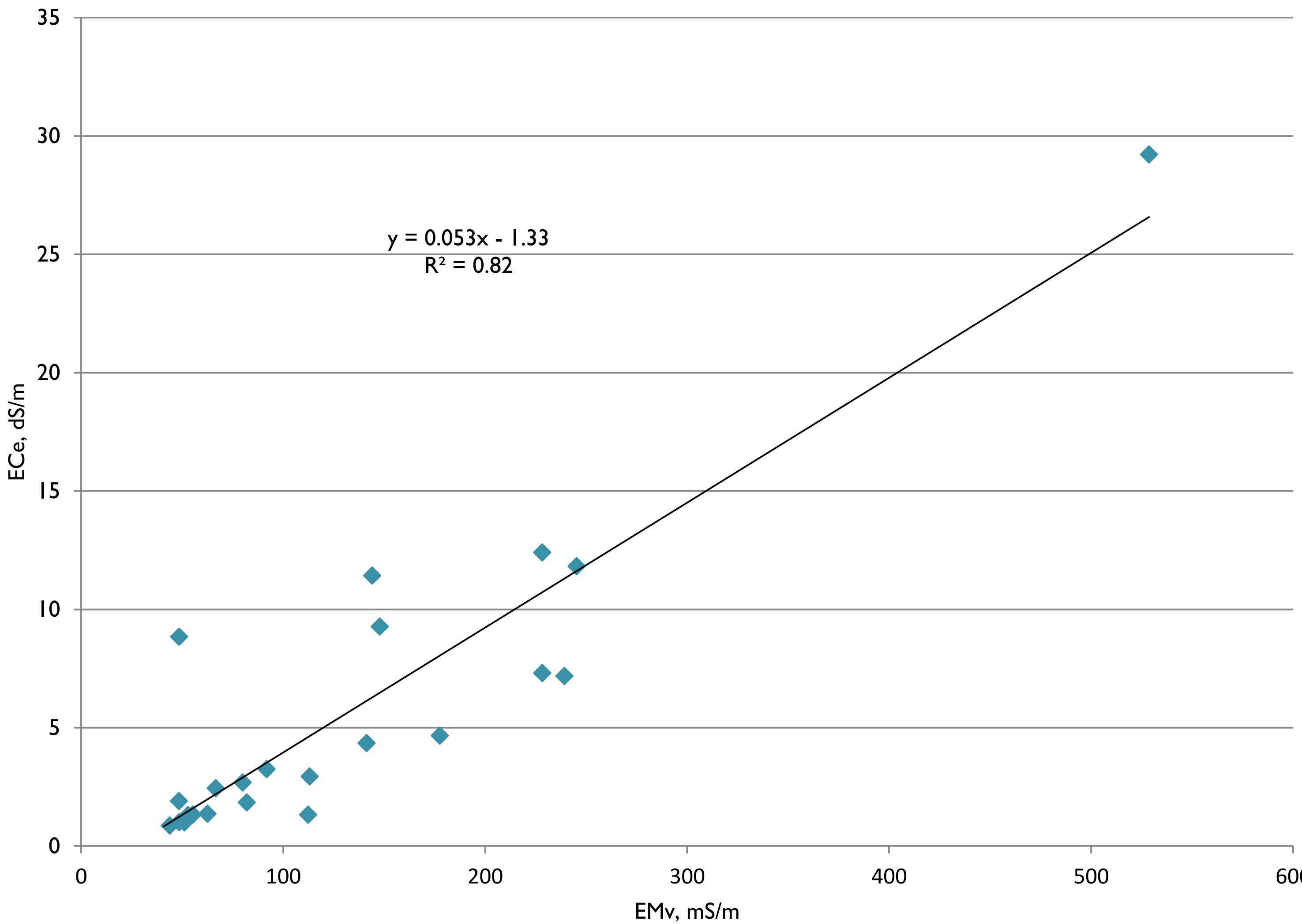
EM1V (pic1) = EM1V (pic3) – ground conductivity of 1.50 m depth (213 mS/m ≈ 214 mS/m)
EM1H (pic2) = EM1H (pic4) – ground conductivity of 0.75 m (169 mS/m ≈ 172 mS/m)

EM1H (pic2) ≠ EM0.5V (pic3) – ground conductivity of 0.75 m (169 mS/m ≠ 276 mS/m) – **Because of different response functions. But the difference is 107 mS/m. Most of data I collected with EM38-MK2-2 with**

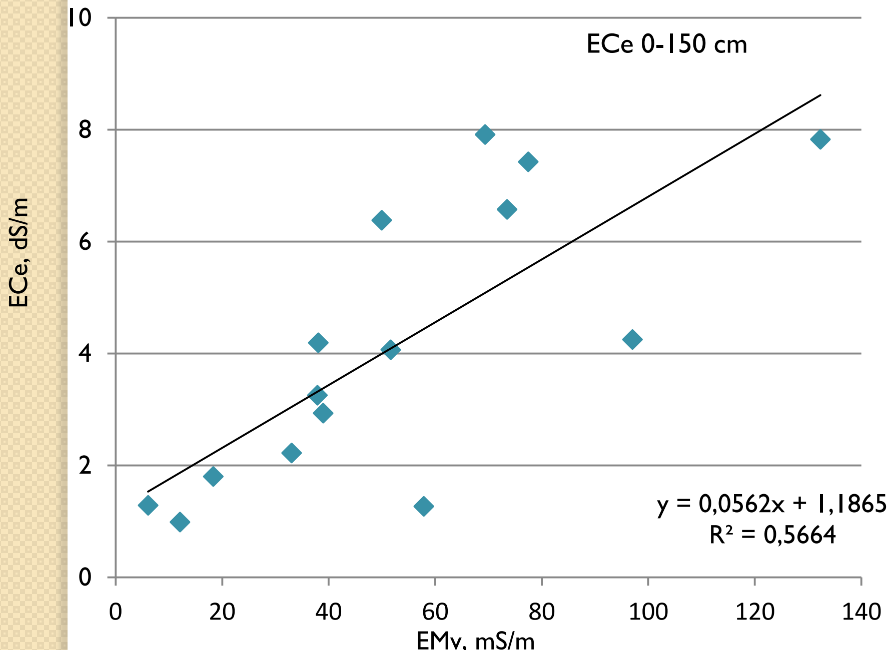




Calibration is needed to interpret values

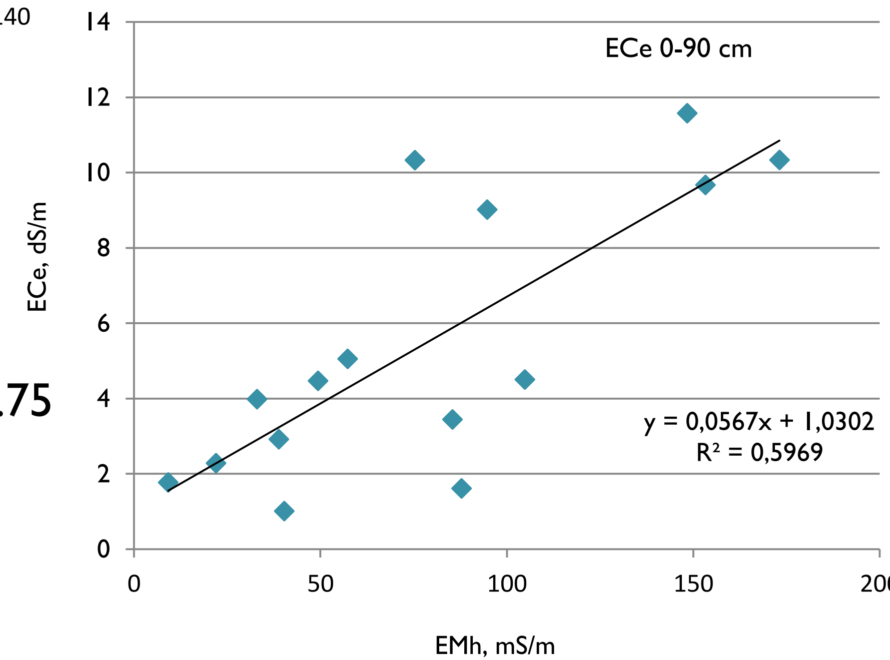


EM38 and ECe relationship

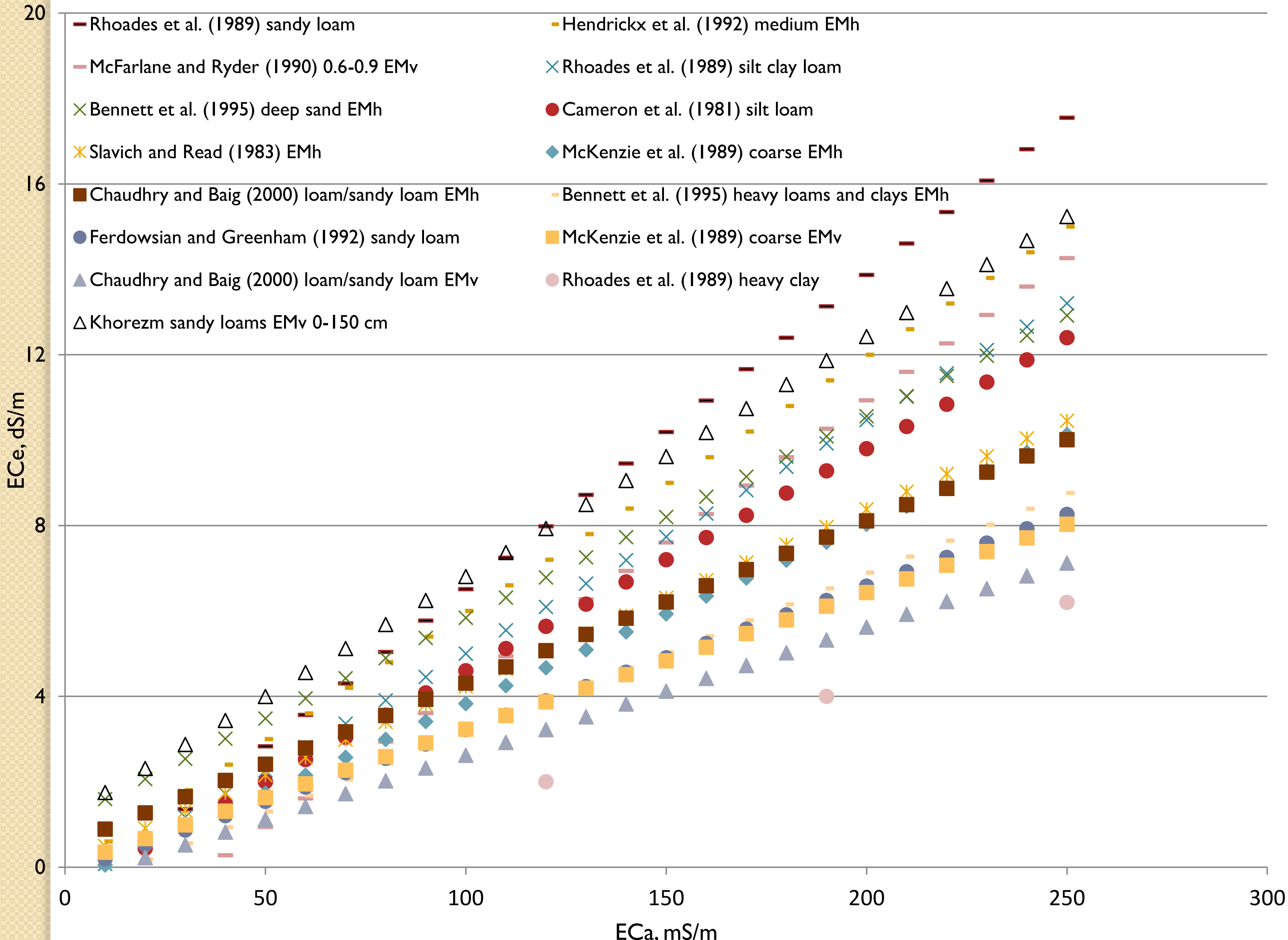


❑ECe and EM38 in vertical mode (1.5 depth)

❑ECe and EM38 in horizontal mode (0.75 depth)



EM38 calibrations

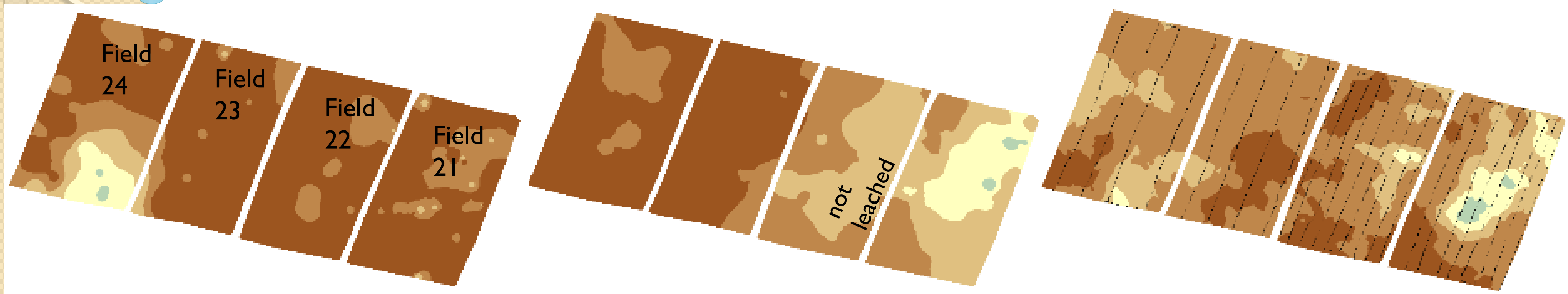


EM38 survey of a research station (~80 ha)

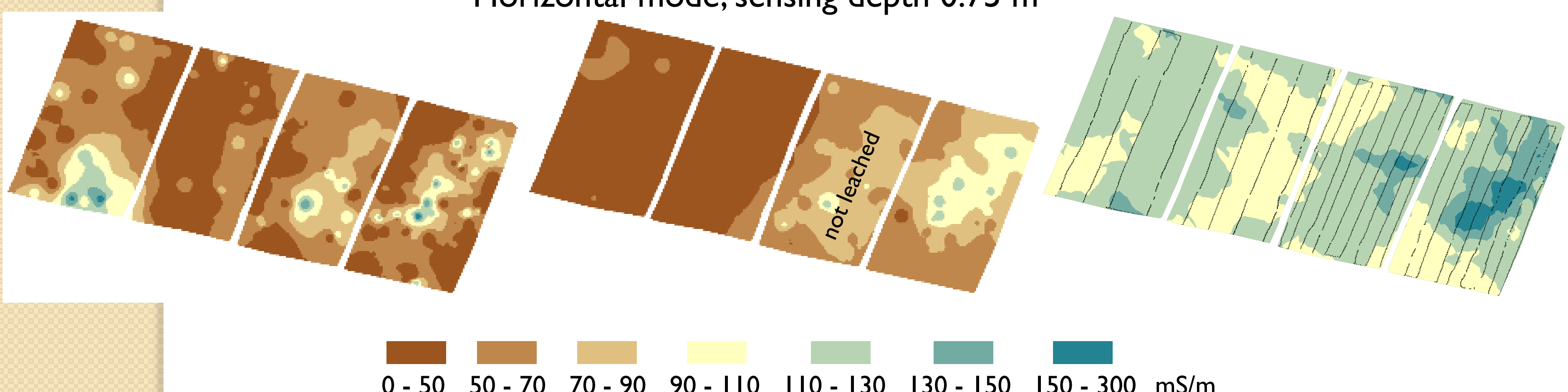
Soil salinity before- (March), after-leaching (April), towards the end of vegetation (August) based on point measurements EM38

March **April** **August**

Vertical mode, sensing depth 1.5 m



Horizontal mode, sensing depth 0.75 m



https://community.emlid.com/t/atv-survey-setup/14874

https://www.mdpi.com/1424-8220/17/11/2540#

Conclusions

- EC meters can be used interchangeably
- Conversion factors between various EC methods offer accurate transformations
- EM38 is a good reconnaissance tool and provides continuous measurements
- EM38 readings can be used to classify salinity level with sufficient accuracy
- Most suitable for frequent monitoring purposes
- Maps can be generated right after survey

Water saving technologies:

E.g.

Systems level >

Plastic lining of channels

Field level>

Laser guided land-leveling

Double sited furrow-irrigation

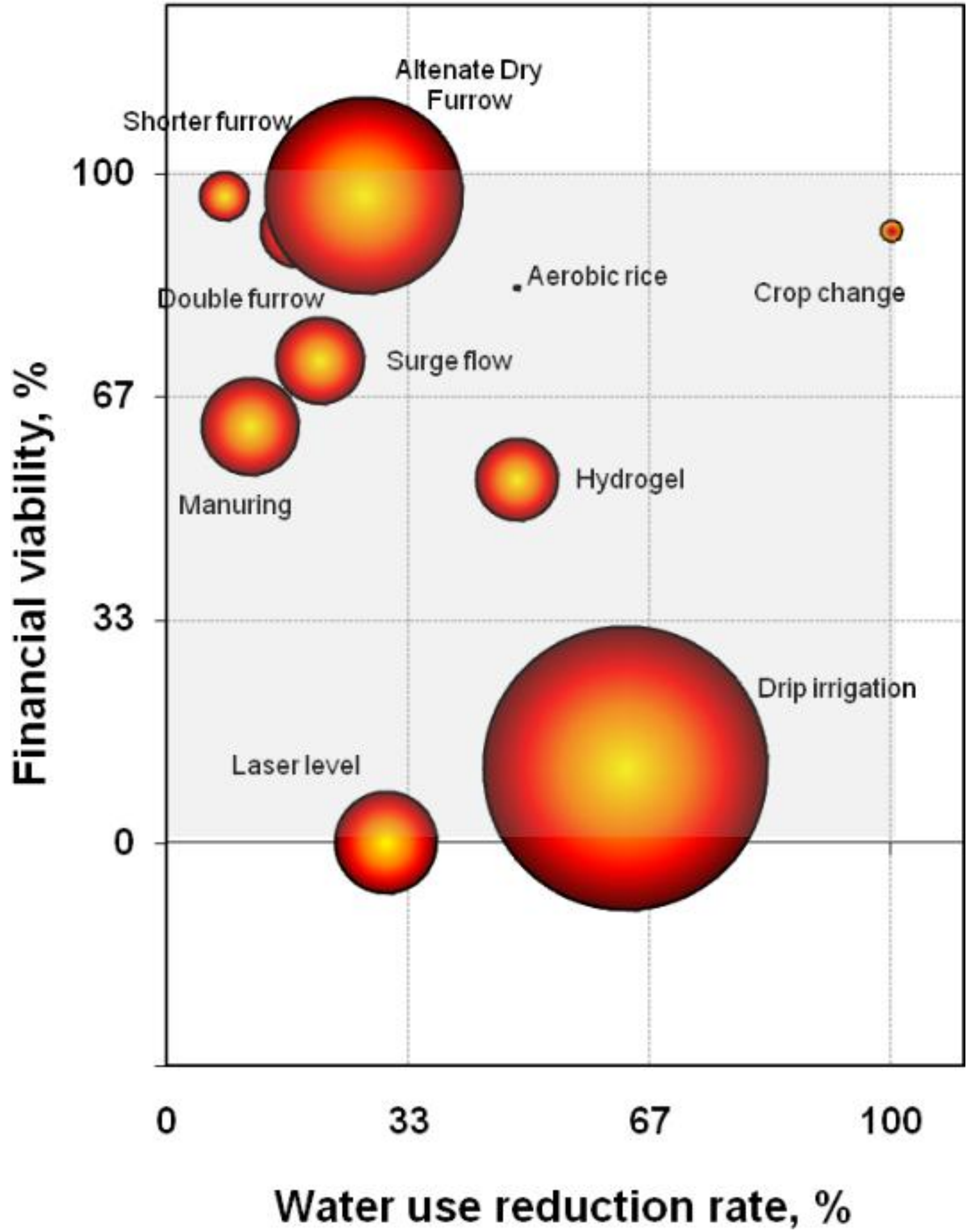
Conservation agriculture

Drip irrigation

Bio-drainage

Hydrogel

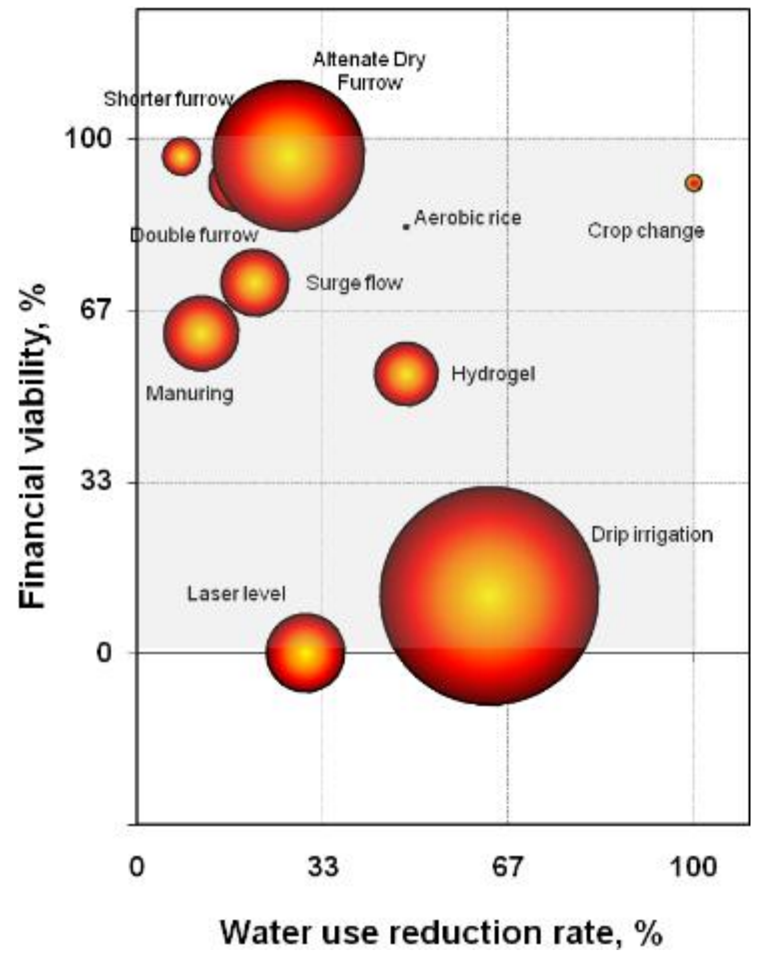
Options for water use reduction



Source: Bekchanov, M.; Lamers, J.P.; Martius, C. Pros and Cons of Adopting Water-Wise Approaches in the Lower Reaches of the Amu Darya: A Socio-Economic View. *Water* 2010, 2, 200-216.

Options for water use reduction

- **More water-efficient technology is more expensive**
- **Low capital intensive but less water efficient measures (double flow, short and alternate dry furrow techniques) are financially attractive**
- **Capital intensive options could at present be initialized in home gardens, greenhouses, and private household plots**



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