GW·MATE THE WORLD BANK Global Water Partnership

AGRICULTURAL IRRIGATION – the Critical Nexus for Groundwater Resources in More Arid Climates

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WATER PARTNERSHIP PROGRAM

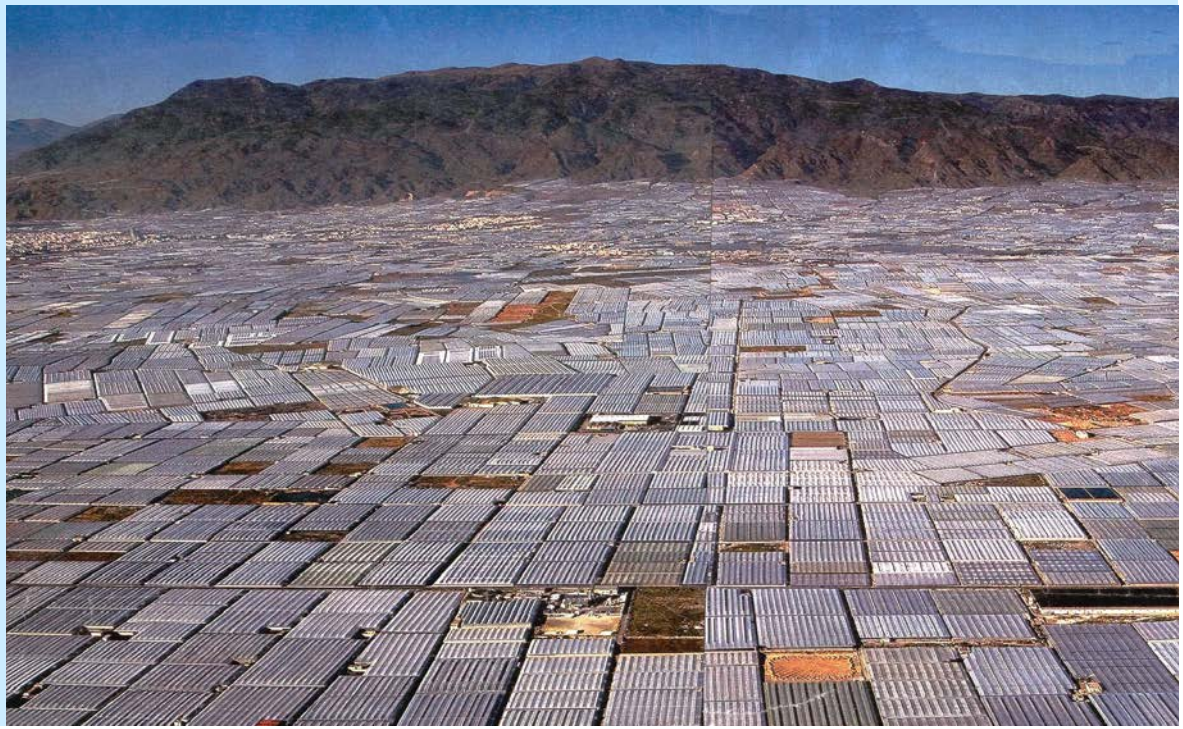
AGRICULTURE IRRIGATION & GROUNDWATER
an intimate but complex relationship

- agricultural land occupies large proportion of many aquifer recharge areas
- often predominant influence on groundwater quality

- greatly affects aquifer recharge (mechanisms/rates)
- irrigation is the major consumer of water resources

CONSEQUENCE

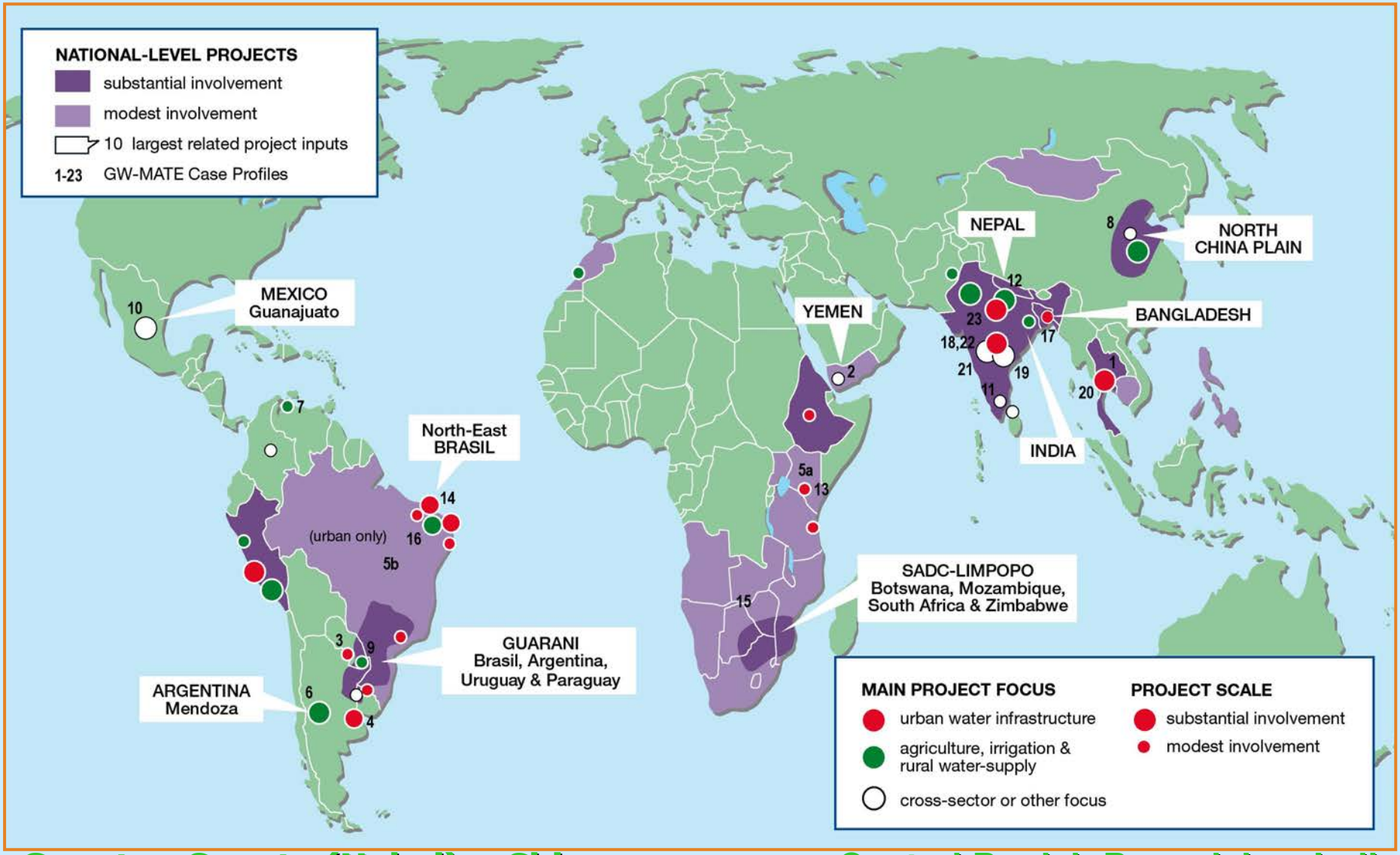
must understand and manage the relationship to conserve and protect groundwater



THE GROUNDWATER IRRIGATION BOOM
scale, drivers, benefits and issues

- **massive growth of irrigation waterwells (~40% total use)**
  mainly private investment stimulated by government
- **groundwater very 'popular' with farmers**
  if energy-supply reliable and affordable – because of
  direct access, near point-of-use, well-suited to pressurised irrigation
- **large groundwater economies with major social benefits**
  NOTABLY drought water-supply security avoiding crop yields impacts
- **BUT unconstrained use tends to generate excessive resource demand, with sustainability and social concerns**
  given population pressure on the land above most aquifers – since initially groundwater minor component of overall agro-input costs
- **resource base not generally in imminent 'danger of collapse' – but certainly in need of some 'loving care'**

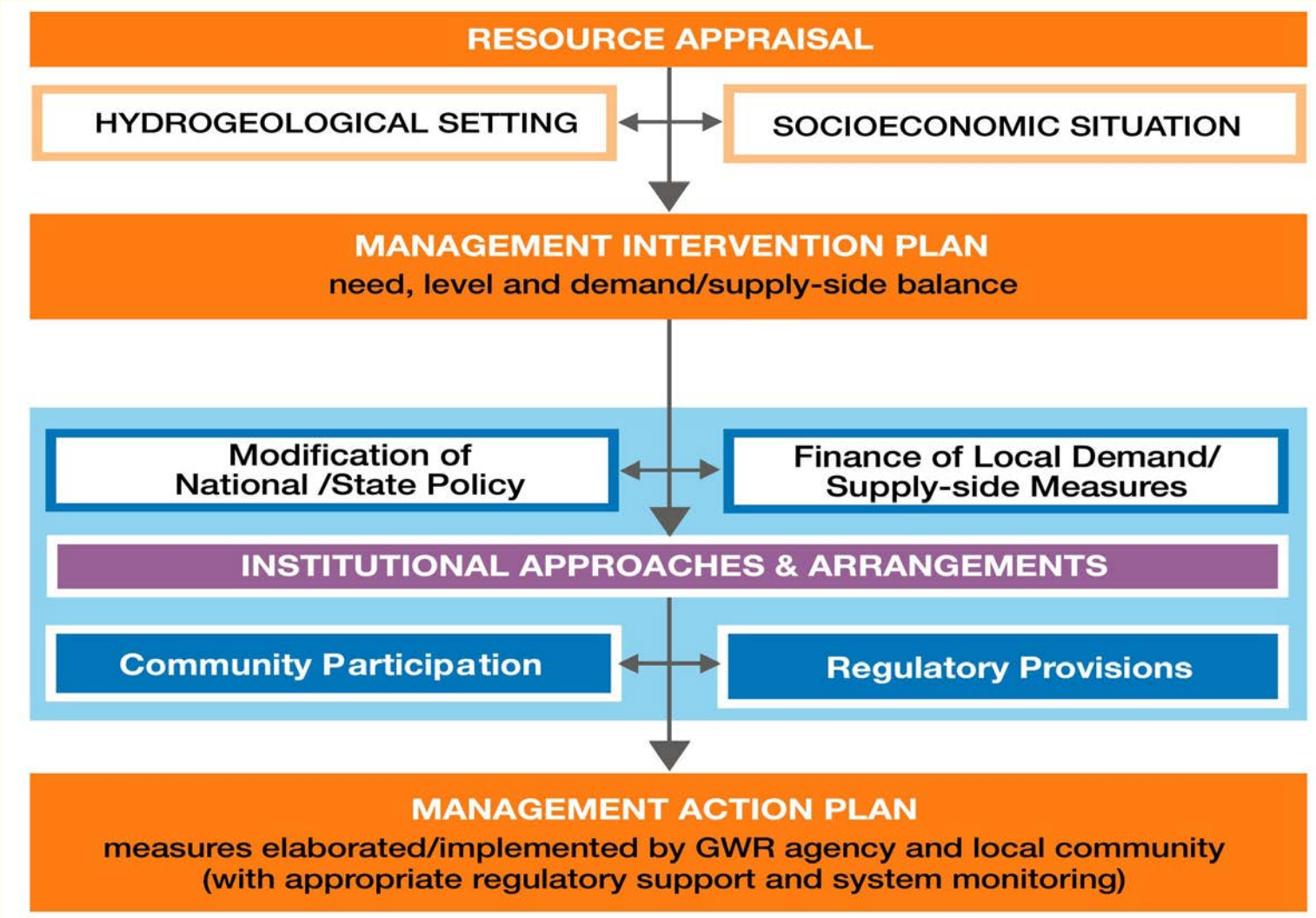
GW•MATE Activities in World Bank Projects : 2001-11



Guantao County (Hebei) – China,
Ica District – Peru, Apodi Plateau – Brasil,
Silao (Guadalajara) - Mexico

Central Punjab Peneplain – India,
Hivre Bazaar (Maharashtra) – India,
Carrizal (Mendoza) - Argentina

PRAGMATIC FRAMEWORK FOR GROUNDWATER RESOURCE MANAGEMENT IN HEAVILY-EXPLOITED AQUIFERS



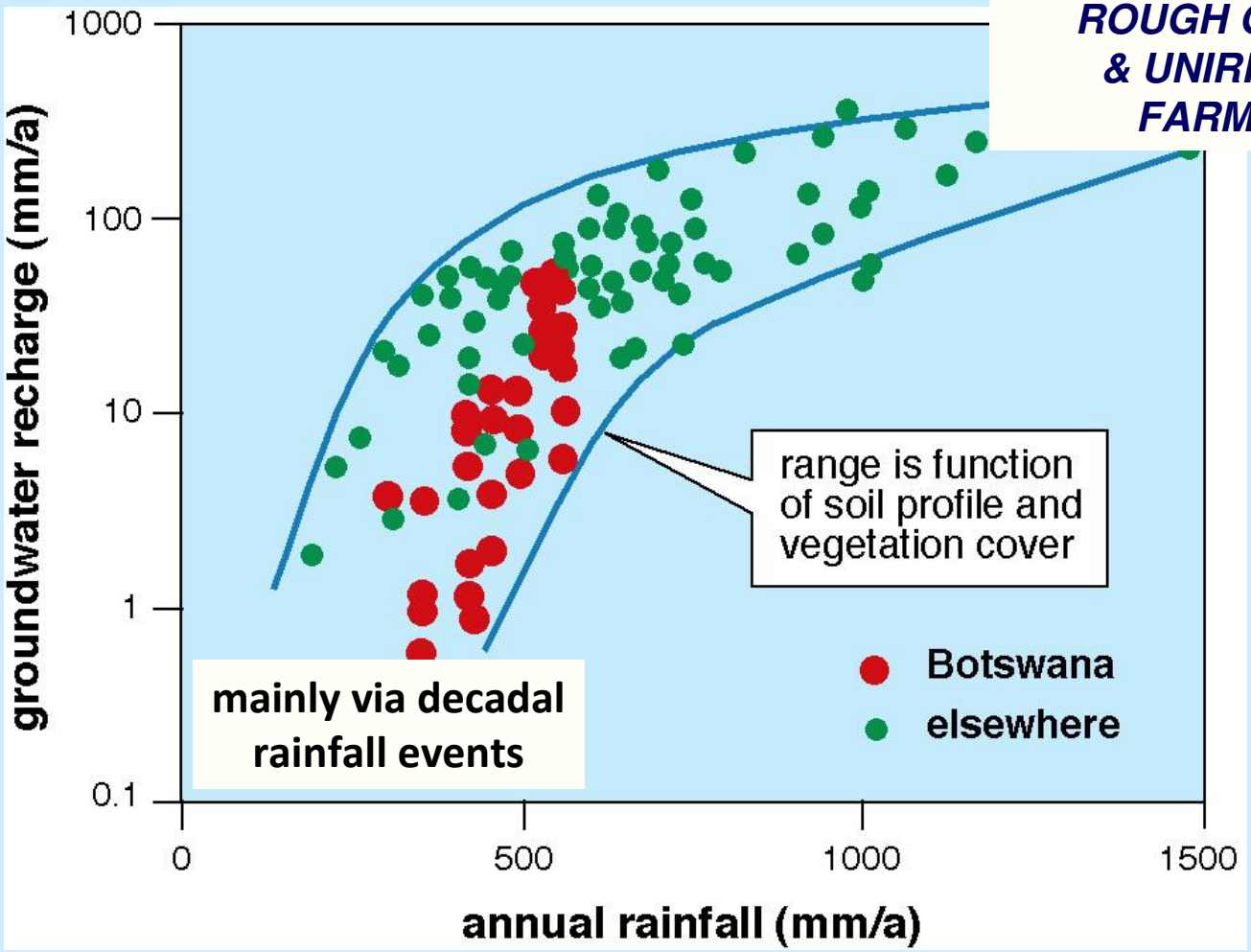
GROUNDWATER RESOURCES & IRRIGATION WATER MANAGEMENT

Key Concepts & Practical Concerns

GROUNDWATER IRRIGATION USE
measurement for management

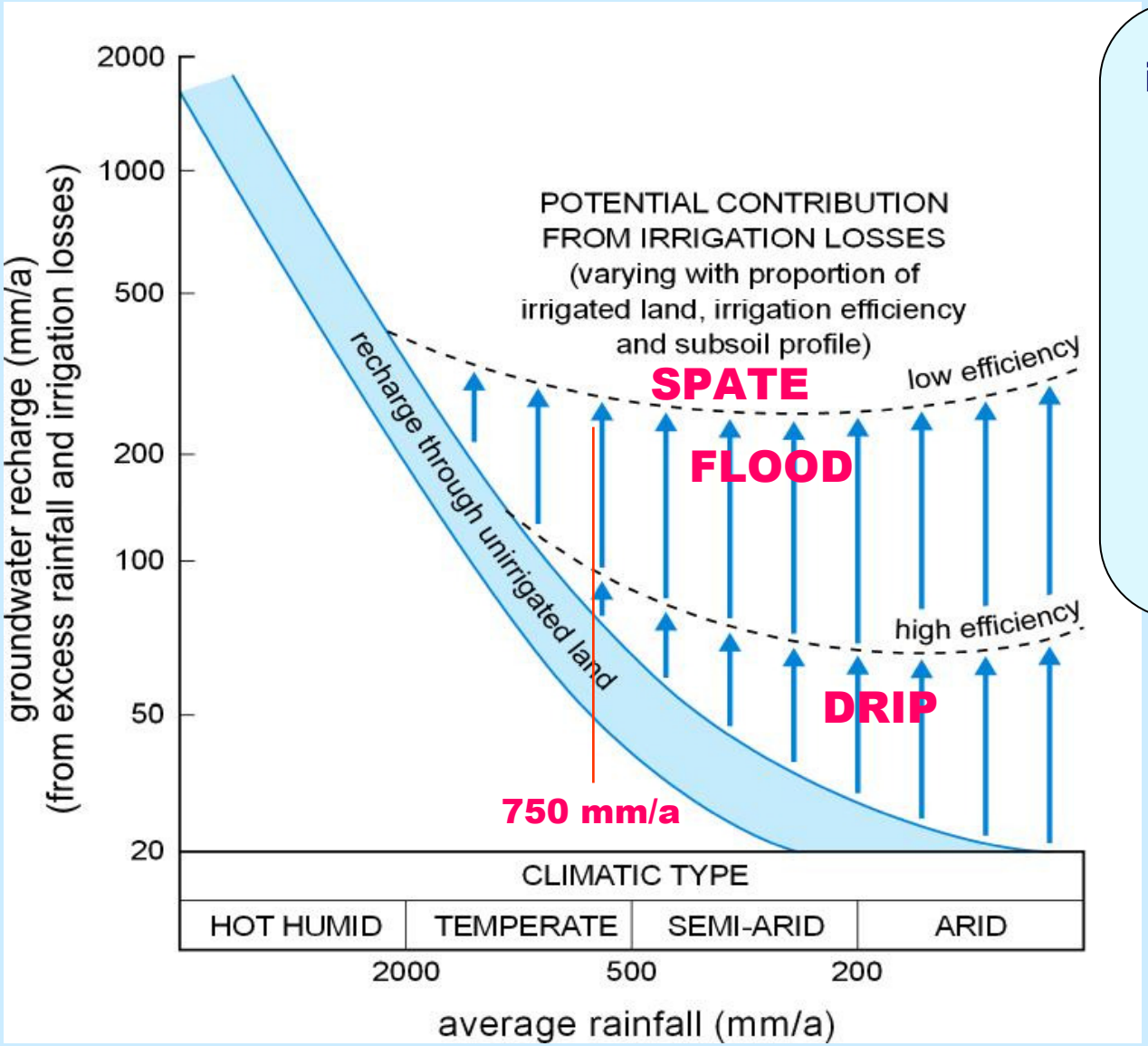
- waterwell metering still 'exception not rule' – surrogates widely have to be used (pump capacity/hours, crop-water requirement, licensed abstraction, etc)
- GIS-based inventory of irrigation wells/land and electricity supply – with groundwater abstraction estimated from electrical energy metering and joint charging established
- consumptive use of groundwater major interest – often increasing even where licensed abstraction fixed because of conversion from flood to drip irrigation and increasing waterwell use factors (not to mention illegal waterwells and abstraction rates above permitted)
- pressing need for improving use estimates and quantifying use fractions (thermal and other satellite imagery, isotope applications, instrumented plots, integrated land-atmosphere and land-energy/water budget modelling, etc)

GROUNDWATER RECHARGE – RAINFALL CORRELATION
composite research data from Southern Africa



IRRIGATION WATER MANAGEMENT

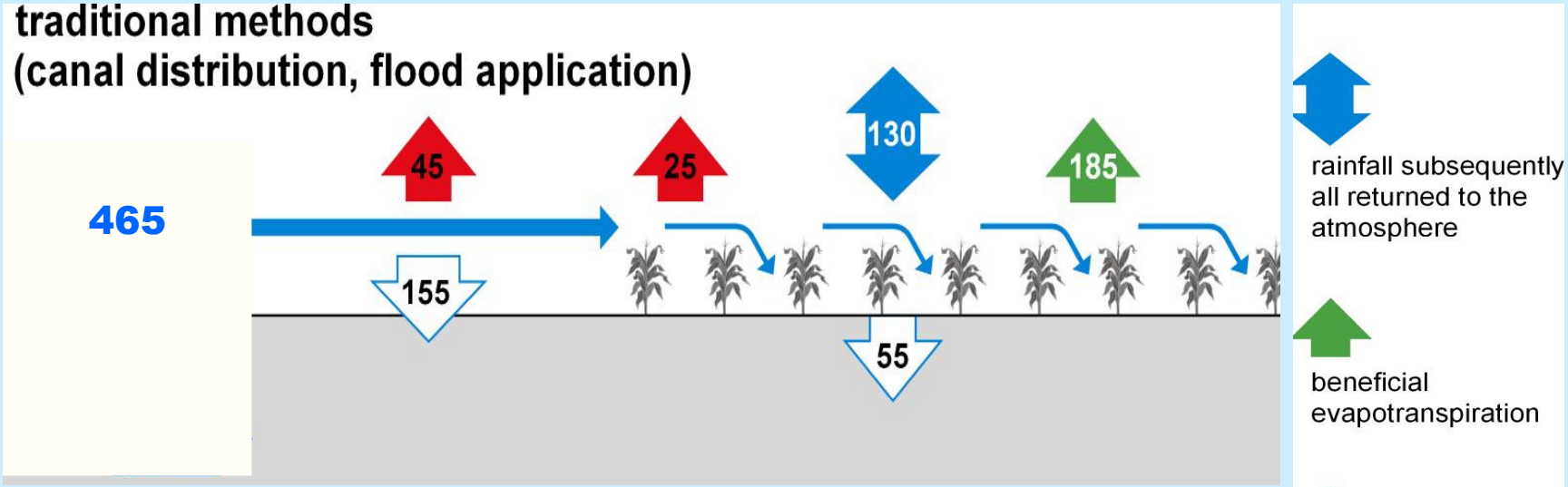
major influence on groundwater recharge



influence of irrigated agricultural practice on groundwater recharge rates and frequency (from episodic to annual)

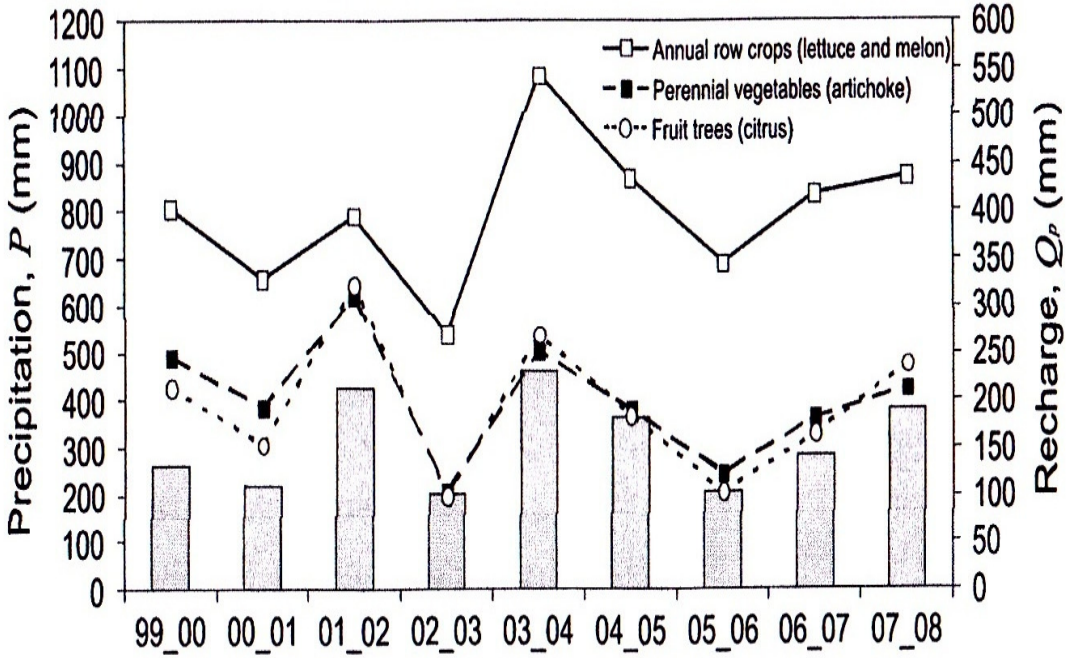
must distinguish between case of surface-water and groundwater irrigation

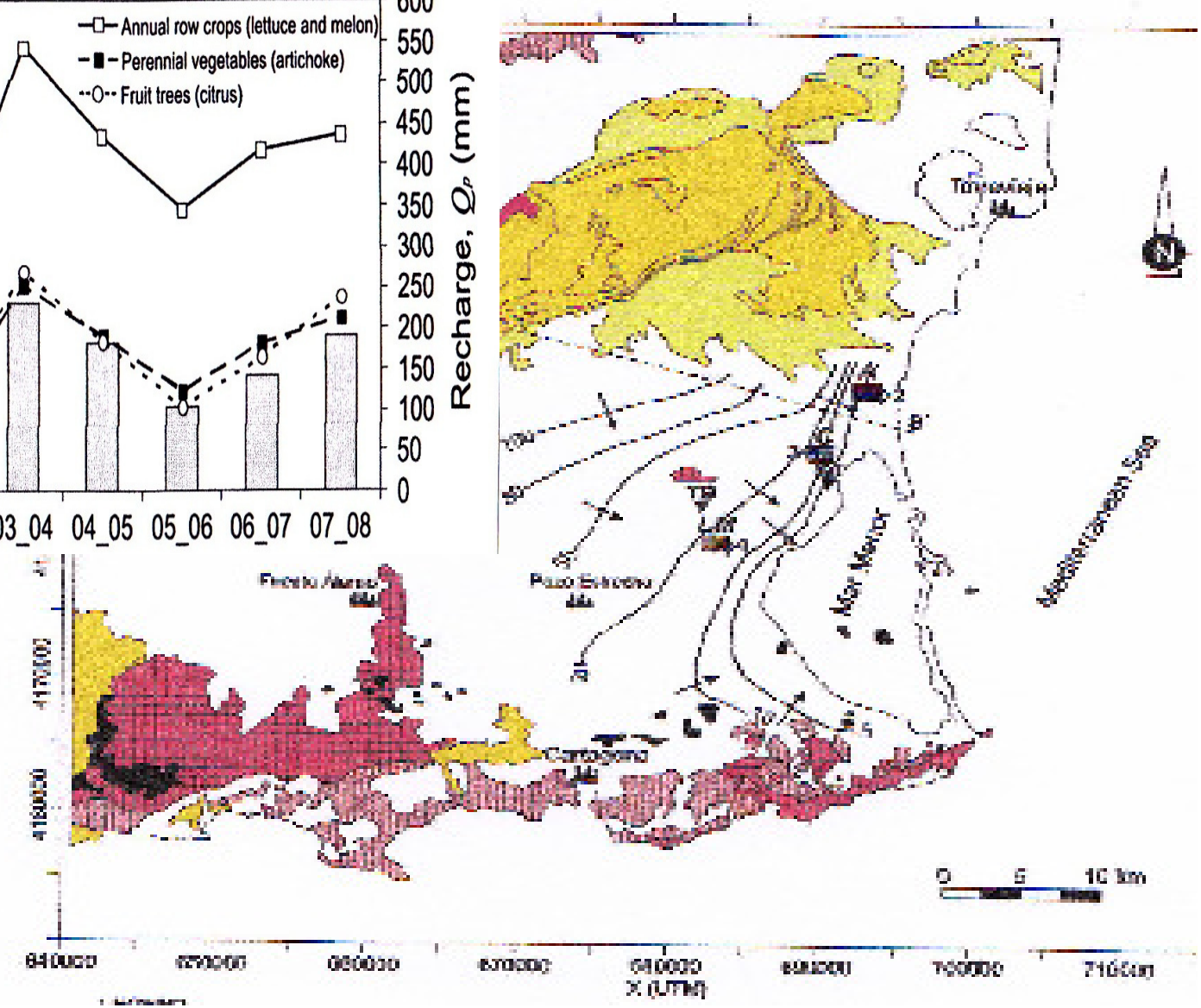
GRAVITY IRRIGATION ON PERMEABLE SOILS
quantifying consumed and non-consumed fractions



- **irrigation water efficiency = 40%**
- **irrigation return to groundwater = 45%**
- **non-recovered irrigation-water losses = 15%**

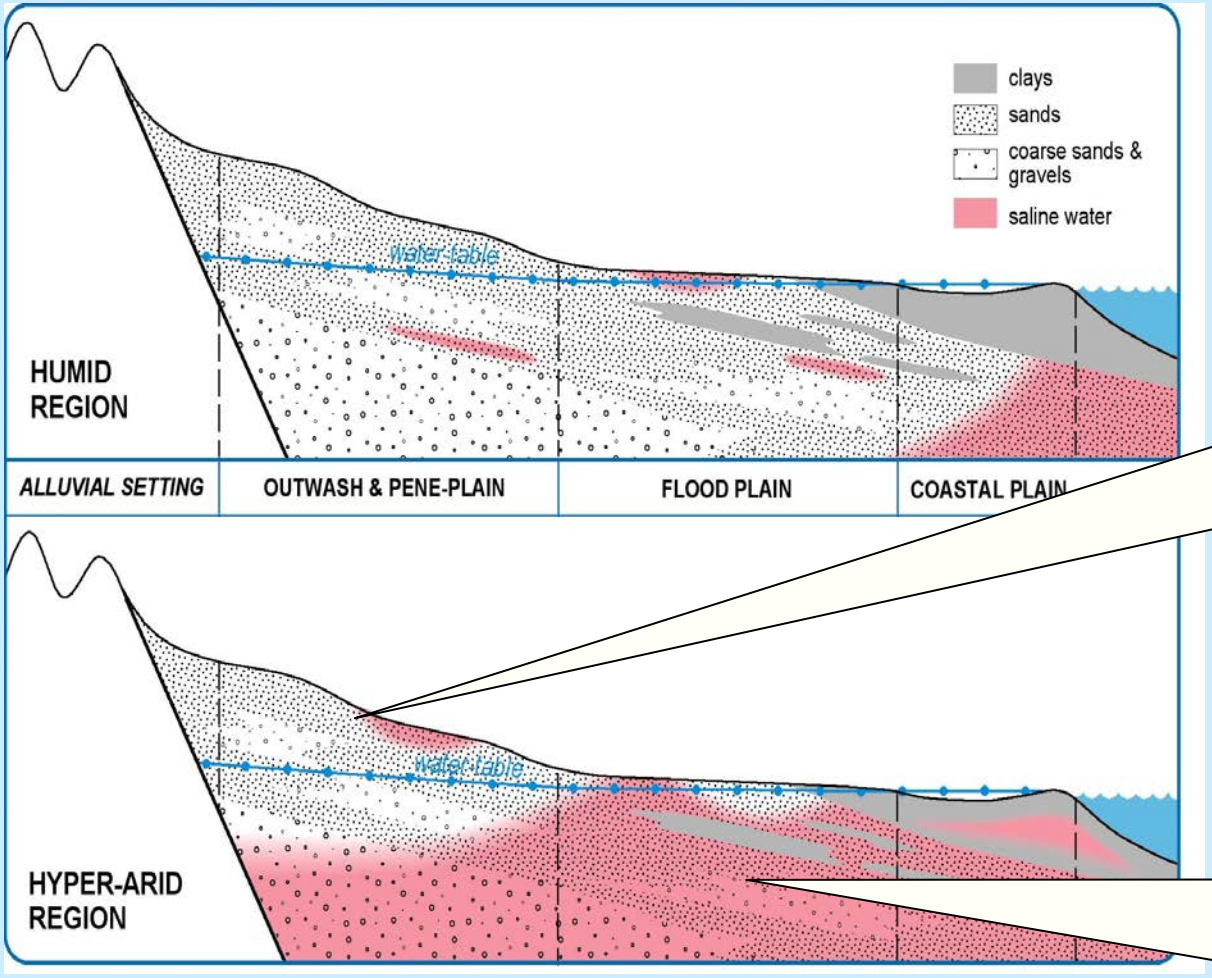
IRRIGATED CROP-TYPE : EFFECT ON RECHARGE
Campo de Cartagena (Murcia) – Spain

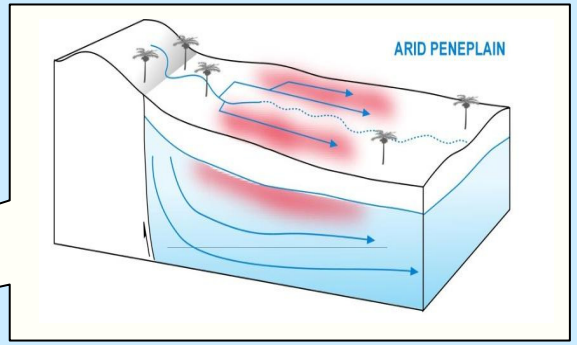


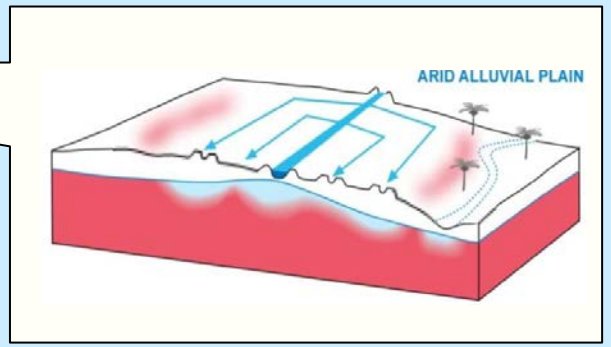


Candela et al, 2010

GROUNDWATER SALINITY & SALINISATION
characterisation in major alluvial aquifers







- insidious salinisation threats widely exist
- groundwater/surface water relations critical

GROUNDWATER IRRIGATION USE IN ARID REGIONS

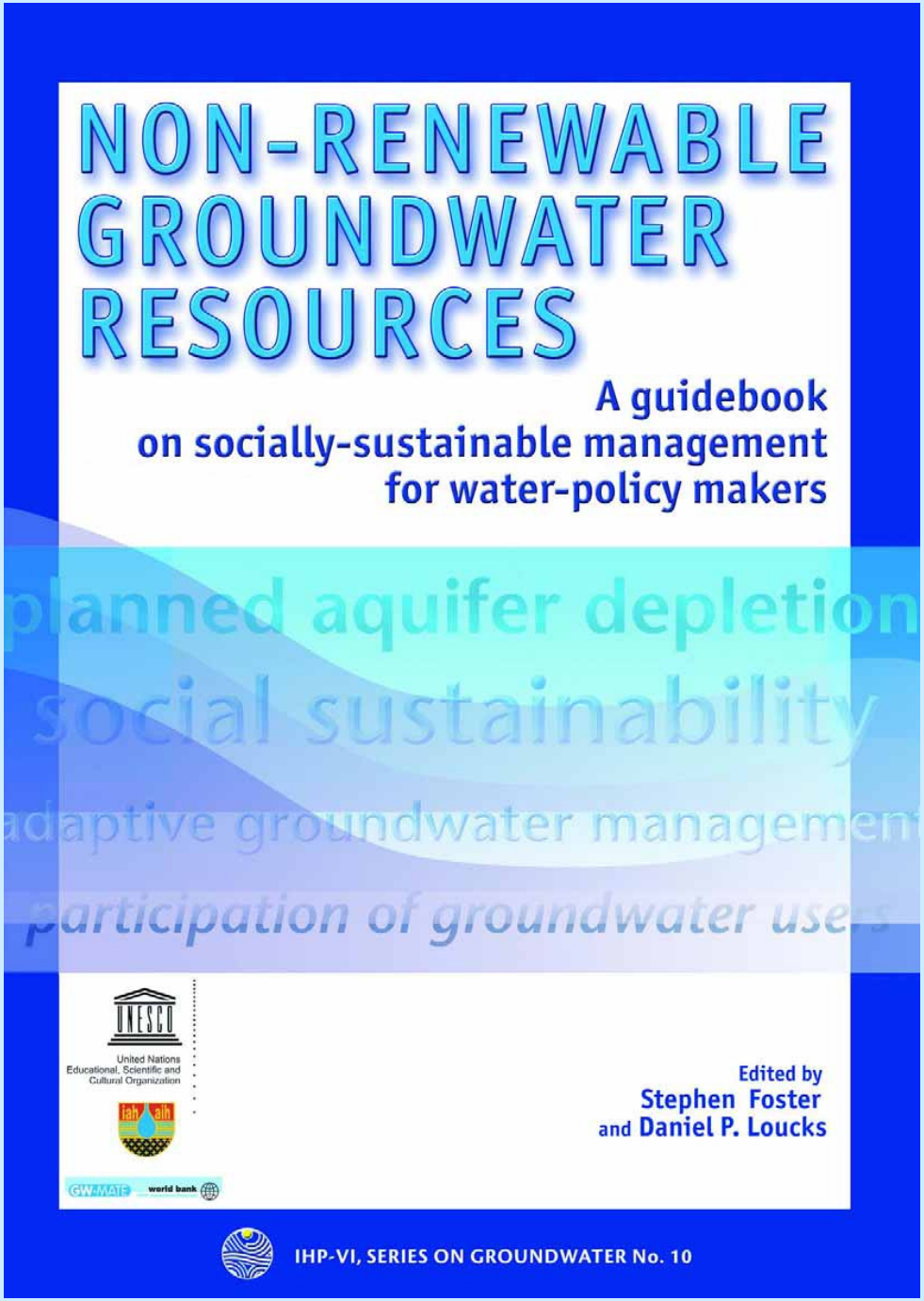
Common Policy Misunderstandings

GROUNDWATER RESOURCE MANAGEMENT
fantasy of 'simple panacea' or 'quick fix' for excessive irrigation abstraction

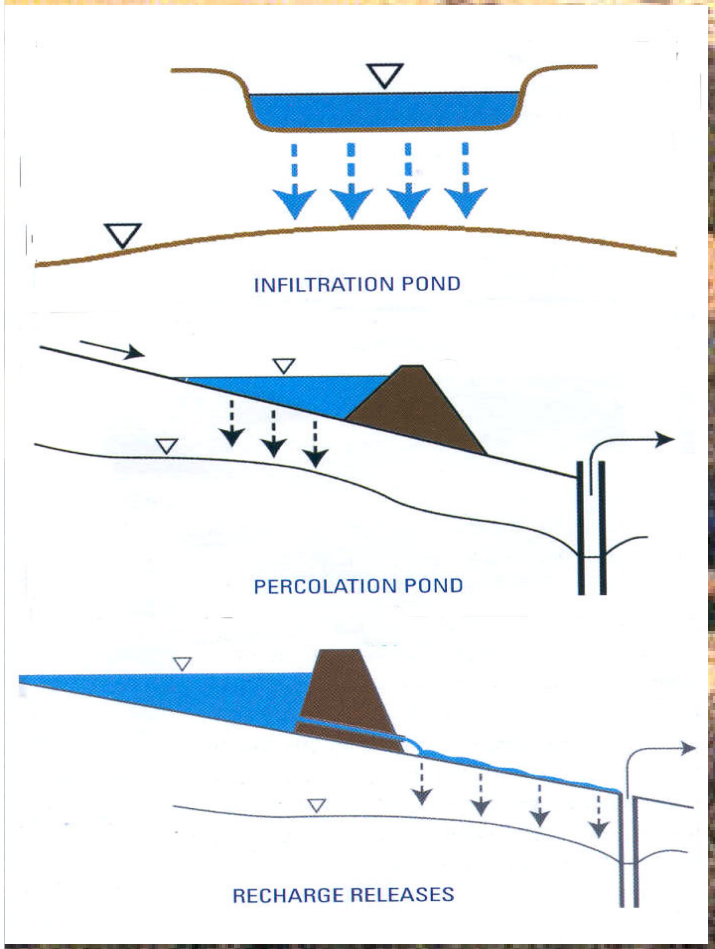
- first reaction of governments often is to propose major stand-alone investments in :
  - aquifer recharge enhancement and/or
  - 'efficient' irrigation technology rather than :

> focusing on 'underlying core issue' of reducing consumptive water-use (preferably 'non-beneficial') with parallel need to raise water-use productivity and to maintain/improve farmer incomes

> confronting the harsh reality of weakly-recharged aquifers sometimes trying to support inappropriate agricultural economies


NON-RENEWABLE GROUNDWATER RESOURCES
A guidebook on socially-sustainable management for water-policy makers
planned aquifer depletion
social sustainability
adaptive groundwater management
participation of groundwater users
United Nations Educational, Scientific and Cultural Organization
GW-MATE
world bank
Edited by
Stephen Foster
and Daniel P. Loucks
IHP-VI, SERIES ON GROUNDWATER No. 10

GROUNDWATER SUPPLY-SIDE INTERVENTIONS
scope and limits of recharge enhancement



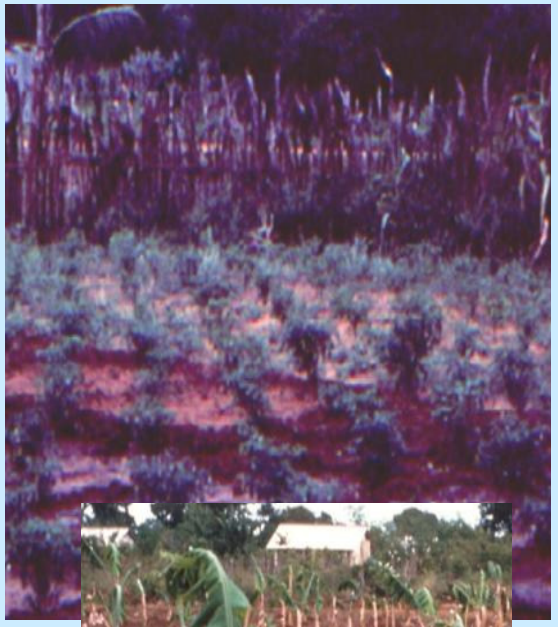
valuable for specific water-supply problems –
not universal panacea for resource deficit

IRRIGATION TECHNOLOGY

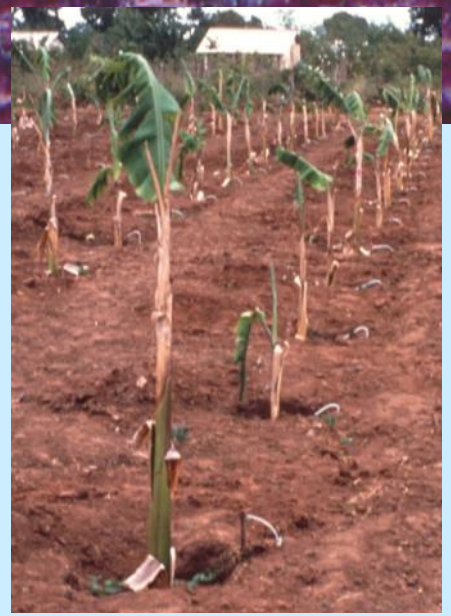
greatly influences groundwater recharge/ consumptive use and scope for 'real water resource saving'

GROUNDWATER RESOURCE MANAGEMENT
investments in irrigation technology

improving 'irrigation water-use efficiency' often advocated by agricultural sector as universal panacea for groundwater problems

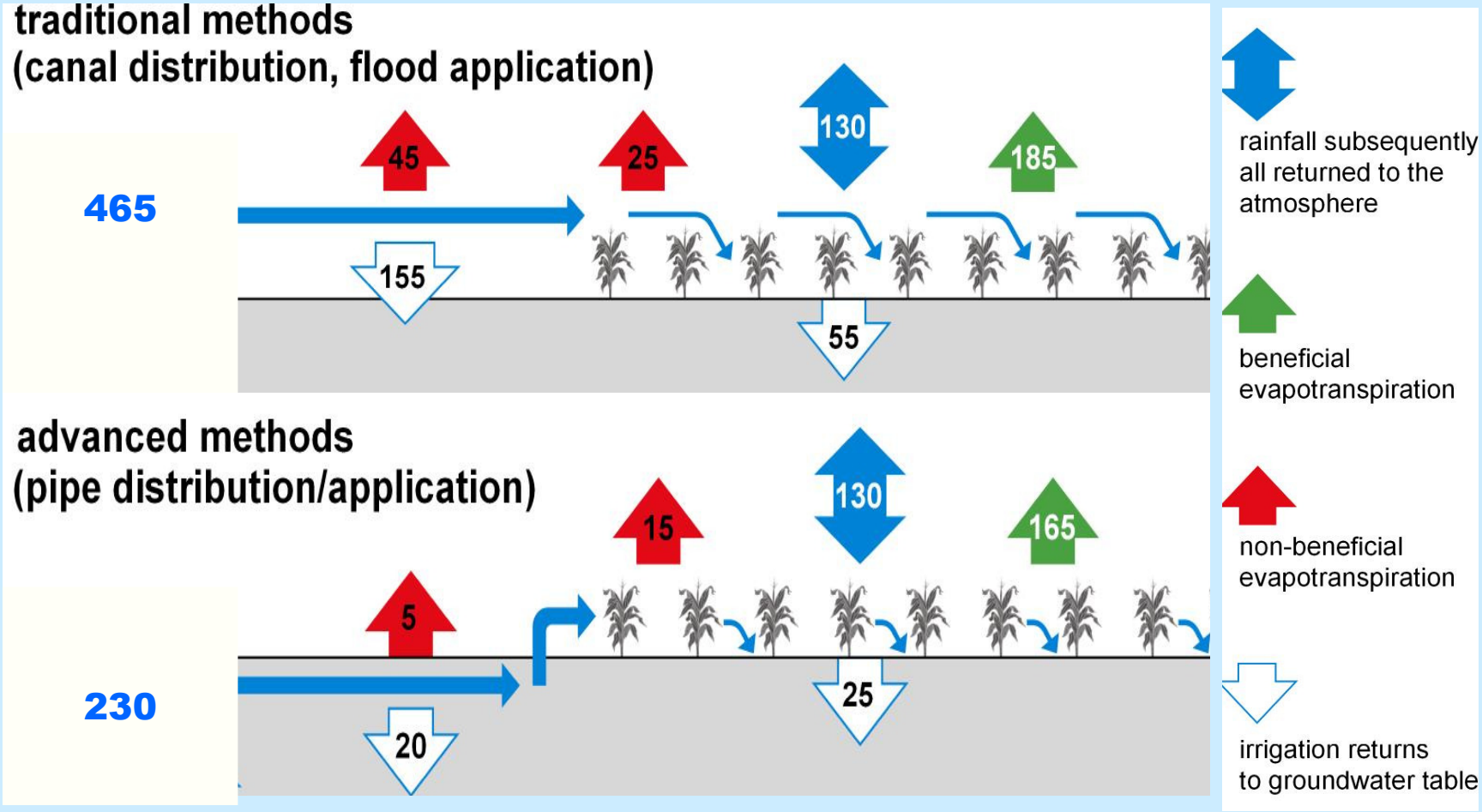


- **improved irrigation technology is effective for energy saving and enhancing water productivity – *BUT* improving 'irrigation efficiency' alone does not necessarily mean real groundwater resource saving (and often results in the reverse)**



- **but to achieve *'real water saving'* essential to :**
  - **ensure that water-saving measures are targeted at reducing non-beneficial evaporation (rather than irrigation returns to fresh groundwater)**
  - **constrain irrigated area and reduce consumptive groundwater use rights**

REAL GROUNDWATER RESOURCE SAVINGS from improved irrigation techniques

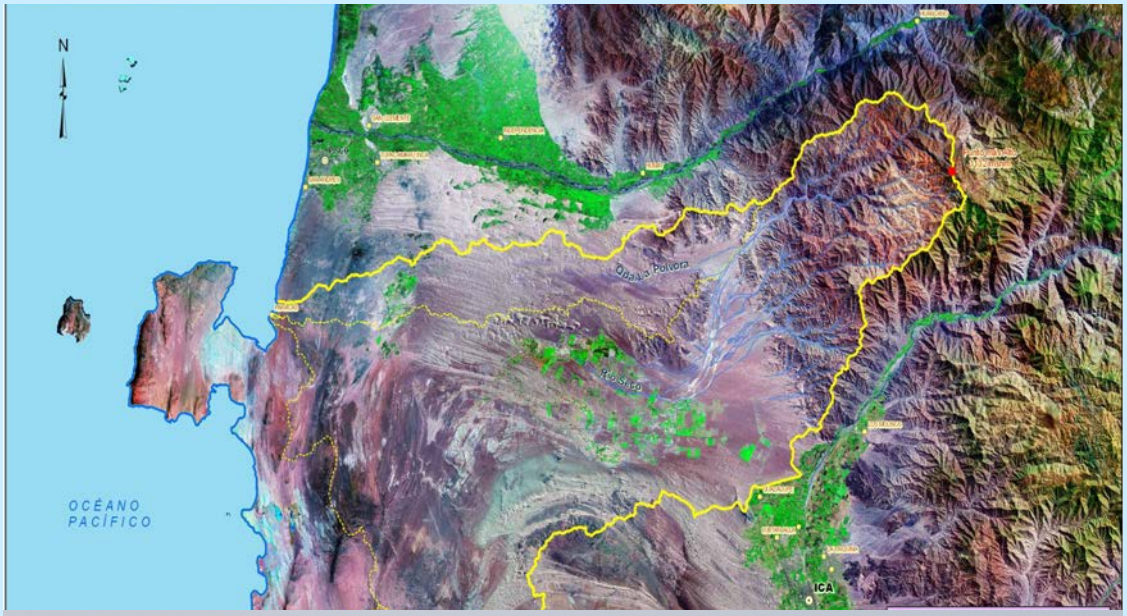


'irrigation water-efficiency' improves from 40% to 72%
- but only reductions in non-beneficial evaporation are real water savings (=50 mm for crop or 11%)

GROUNDWATER IRRIGATION MANAGEMENT CASE HISTORIES

Inspiration & Frustration

ICA (VILLACURI) - PERU
little progress despite initial institutional reforms



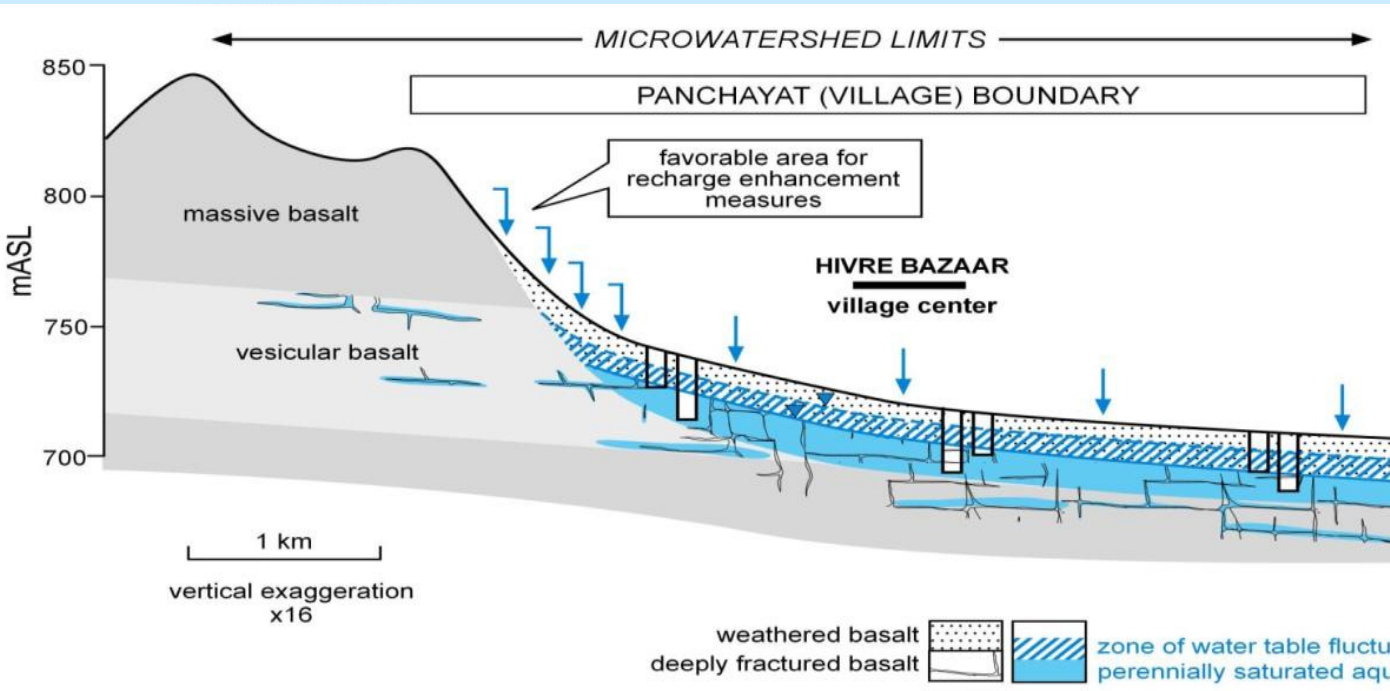
- major investment in export asparagus based largely on non-renewable groundwater
- aquifer underlain by 'marine formation' causing major salinity complication
- groundwater use/ irrigated area requires major reduction and deeper waterwells plugged to reduce pumping saline water
- finance of surface water transfer/aquifer recharge may alleviate situation

GUANTAO COUNTY – CHINA
successful application of improved irrigation technology

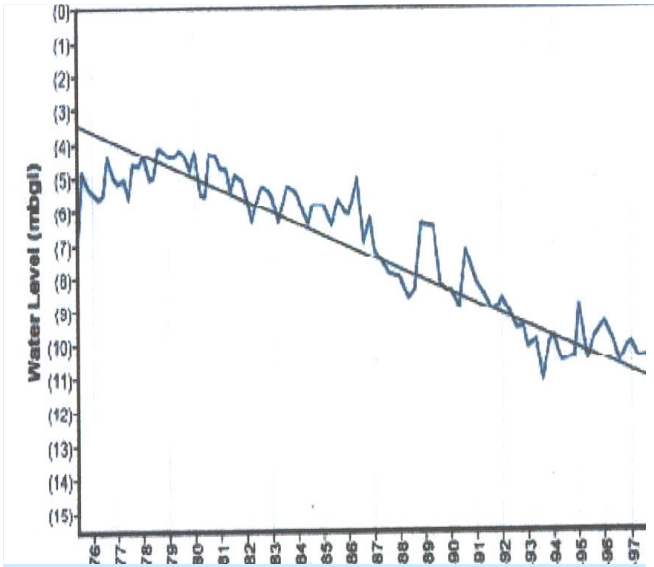
- extensive winter-wheat and summer-maize cultivation – mainly with waterwell irrigation
- widespread excess groundwater abstraction of 80-100 mm/a – continuous water-table decline and aquifer salinity threat
- national ministry promoting 'real water resource savings' through :
  - thermal satellite imagery to identify areas with high total evaporation and low water productivity
  - irrigation technology used to reduce NBET – evidence of real water savings of ~50 mm/a with change from flood to pipe irrigation of winter wheat
- county water resource bureau under excessive developmental pressure (from both industrial and agricultural sectors) and reluctant to reduce groundwater abstraction permits in line with estimates of resource availability

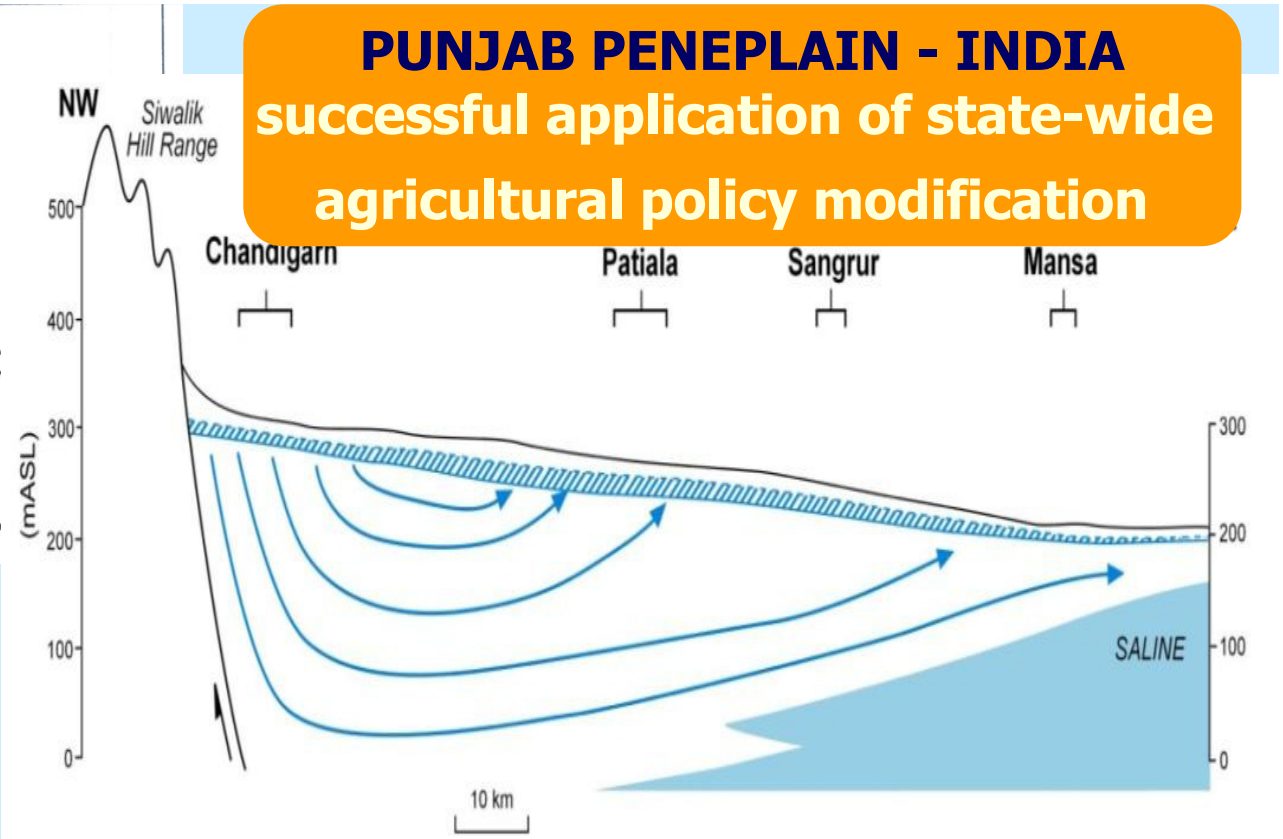
MAHARASHTRA-INDIA Hivre Bazaar
successful communuity self-regulation

- **effective recharge enhancement in favourable hill-foot setting**
- **inspired community decision on 'dugwell only use' for irrigation – eliminating divisive competition for limited groundwater storage and focusing farmers' attention on 'irrigation water productivity'**
- **crop-water budgeting based on antecedent conditions, ban on sugar-cane cultivation and intelligent crop diversification**
- **excellent outcomes on groundwater sustainability, higher-value crops/products, family incomes and eliminated water-supply tankers**



PUNJAB PENEPLAIN - INDIA
successful application of state-wide agricultural policy modification

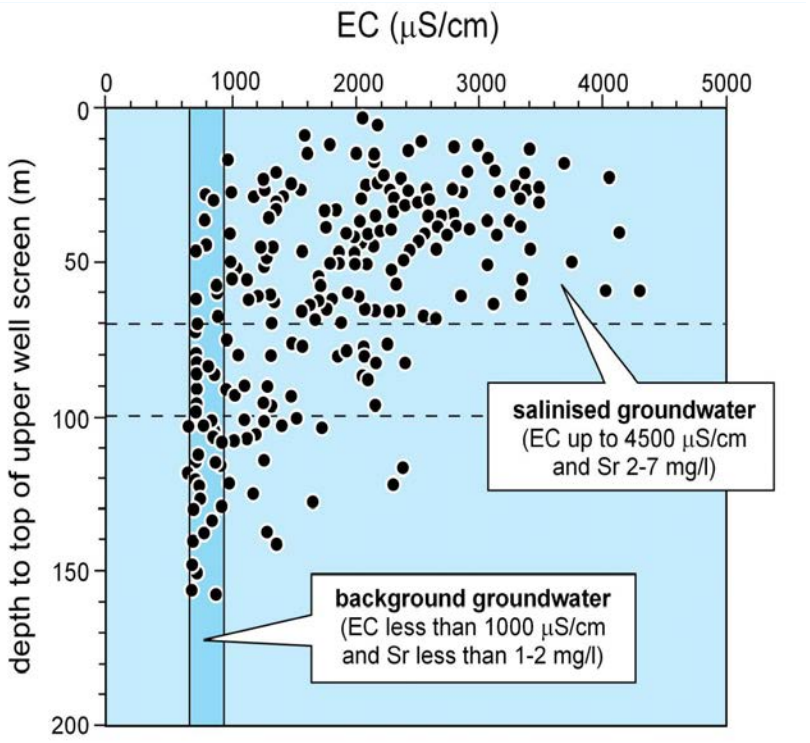


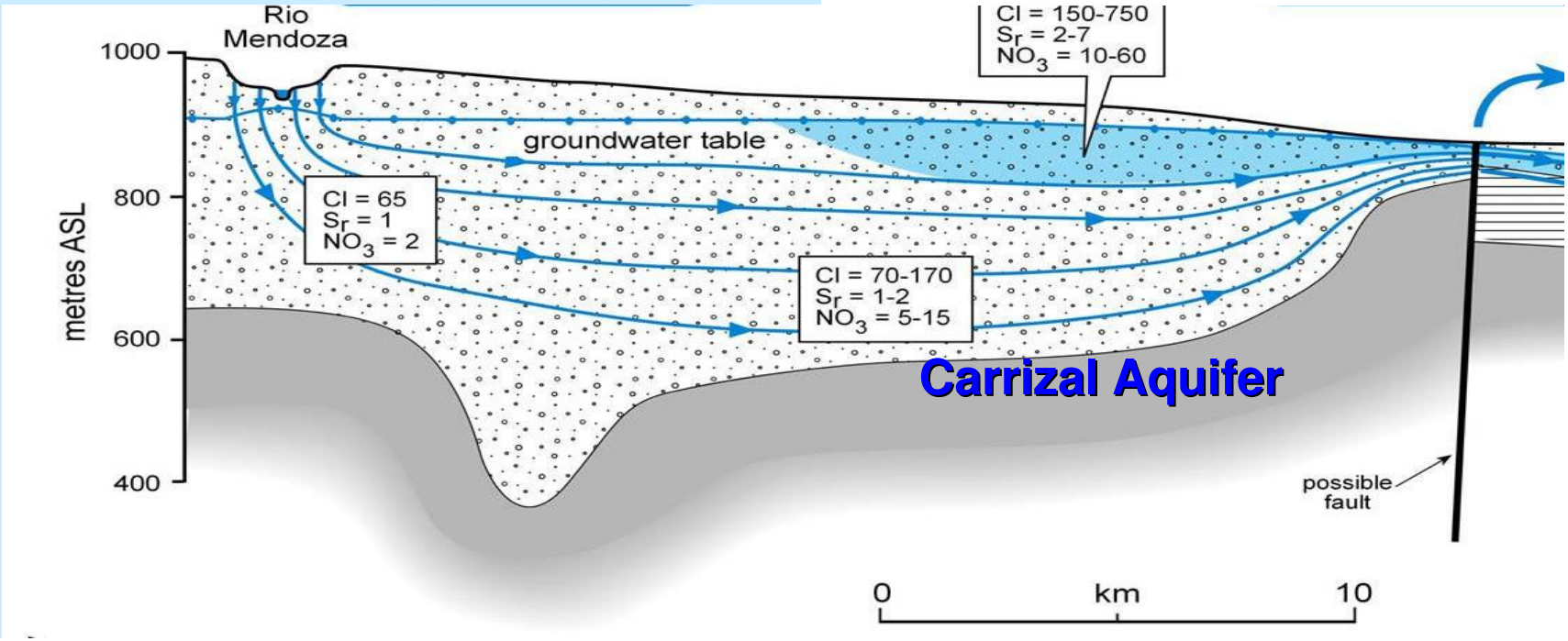


- 'national grain basket' with almost entire land area cropped for rabi wheat/kharib rice – some 70% with waterwell irrigation
- resultant excessive groundwater abstraction equivalent to 120-150 mm/a – water-table continuously declining at 0.5-0.8 m/a
- but about 35-40% of recharge by irrigation canal seepage
- salinisation down-gradient and severe depletion around all towns
- since 2008 statutory deferral of paddy planting to June (by up to 35 days) estimated to have reduced by NBET by 80-100 mm/a ?

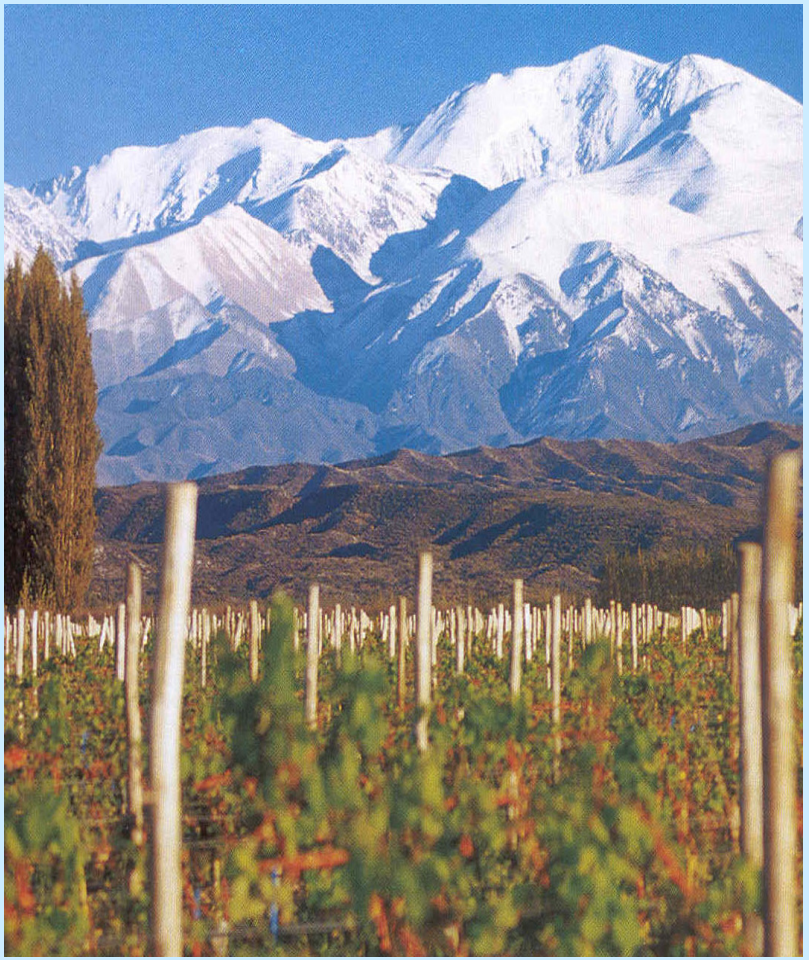
MENDOZA-ARGENTINA
successful application of use regulation and charging

- high-productivity waterwell irrigation for wine/fruit production threatened by groundwater salinisation
- 'waterwell drilling restriction zone' declared in 2000 with constraints on both spatial transfer and reactivation of groundwater use rights





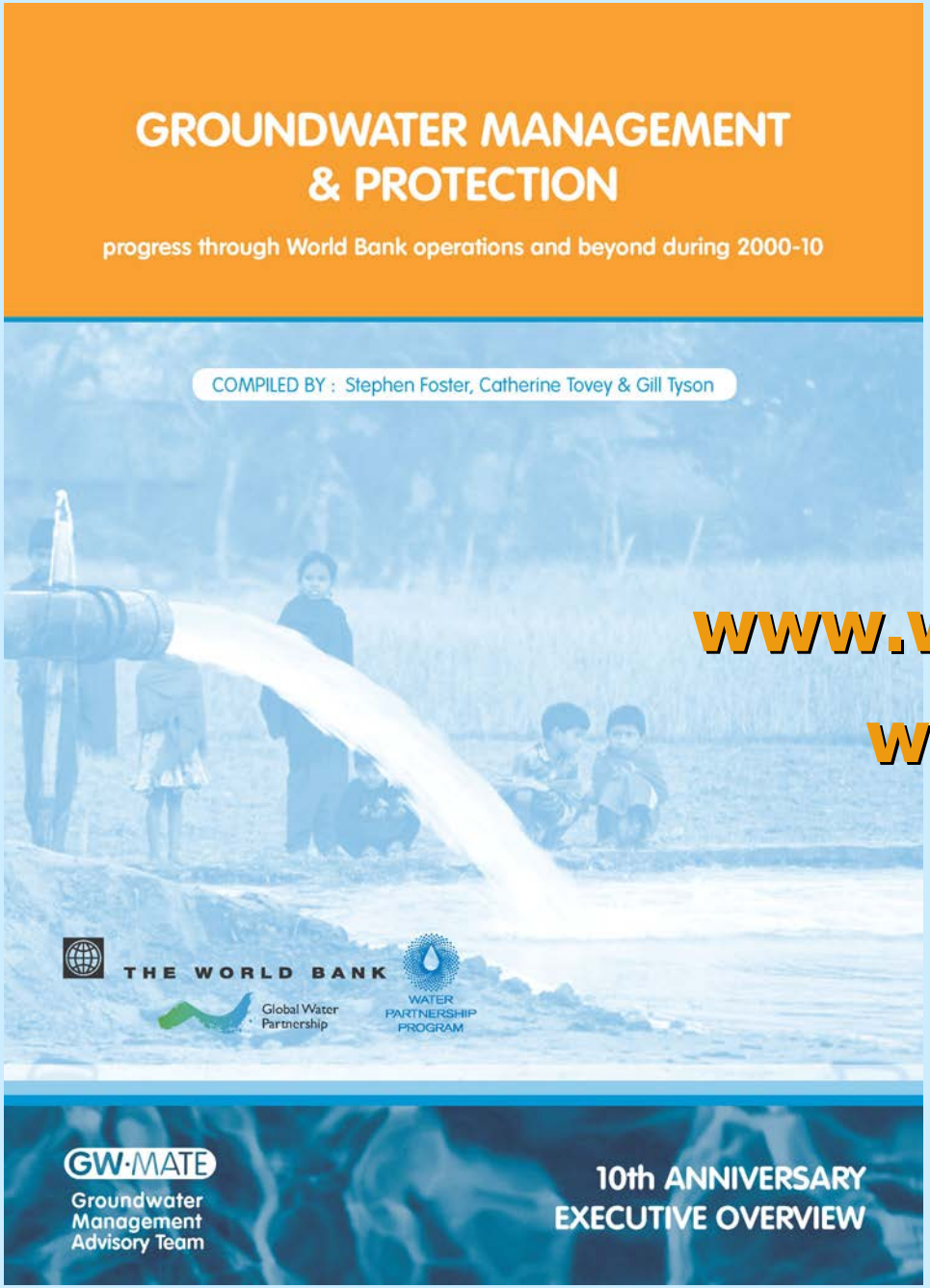
MENDOZA-ARGENTINA
successful application of use regulation and charging



- satellite mapping of waterwell use and groundwater abstraction estimated from electricity metering with joint charging
- groundwater use, level and salinity monitoring intensified
- consumptive use of groundwater increasing even while licensed abstraction fixed – because of both increasing waterwell use factor and conversion from flood to drip irrigation
- by 2008 indications of water-table recovery and reducing shallow groundwater salinity – but upstream modifications to Mendoza River flow-regime argue for continuing caution

GROUNDWATER & IRRIGATED AGRICULTURE
general conclusions

- more unified vision and integrated management of irrigation-water and groundwater widely required
- focus on reducing consumptive water-use (especially 'non-beneficial') whilst raising water-use productivity
- confront harsh reality of weakly-recharged aquifers trying to support inappropriate agricultural economies
- where surface water also available great scope to move from 'spontaneous'conjunctive use' to 'science-based conjunctive management'



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