Knowledge transfer project on technologies and techniques for improved irrigation efficiency

WRC project nr K8/1059//4

Isobel van der Stoep

WATER RESEARCH COMMISSION

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
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Overview

- Project background
- The water balance framework and implementation manual
- Irrigation measurement guidelines
- Dissemination process and way forward

PROJECT BACKGROUND

Irrigation efficiency background

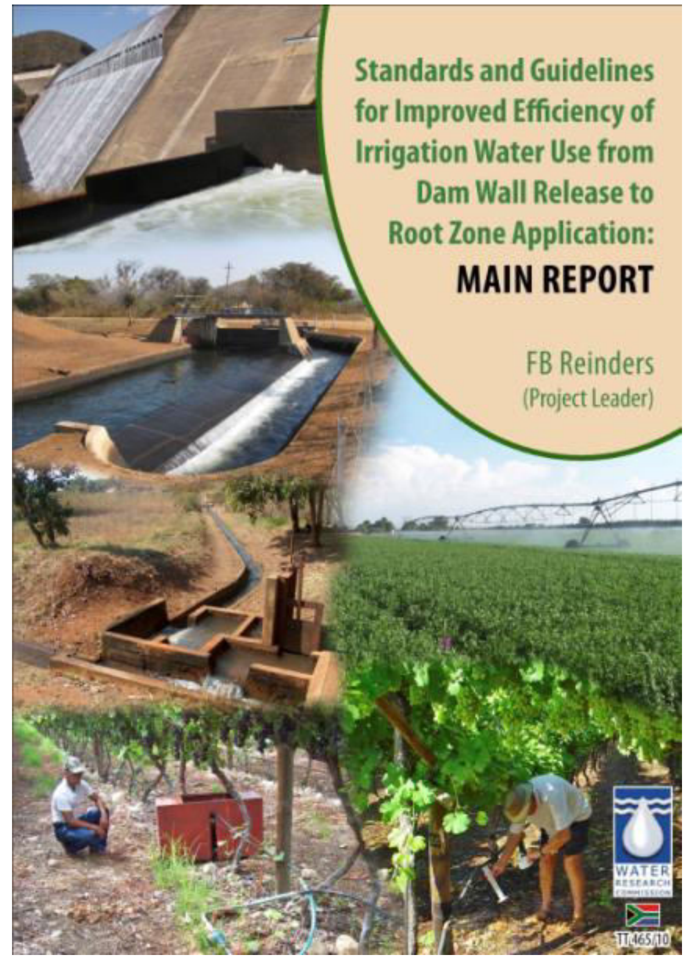
- WRC Project K5/1482/4 (2004-2010):
  - "Standards and guidelines for improved efficiency of irrigation water use from dam wall release to root zone application"
- Overall objective:
  - To evaluate appropriate measurement tools, propose best management practices and formulate guidelines to improve conveyance, distribution, on-farm surface storage, field application, soil storage and return-flow efficiency of irrigation water use

Irrigation efficiency background

- Issues raised:
  - Confusion regarding the definition of “efficiency”
  - Inconsistent application of existing definitions
  - Lack of data to quantify existing definitions
  - Lack of benchmarks to compare recorded data with
- Improved efficiency ≠ reduced consumption
  - This is still not fully understood by many
  - Improved efficiency often = increased consumption!

Irrigation efficiency background

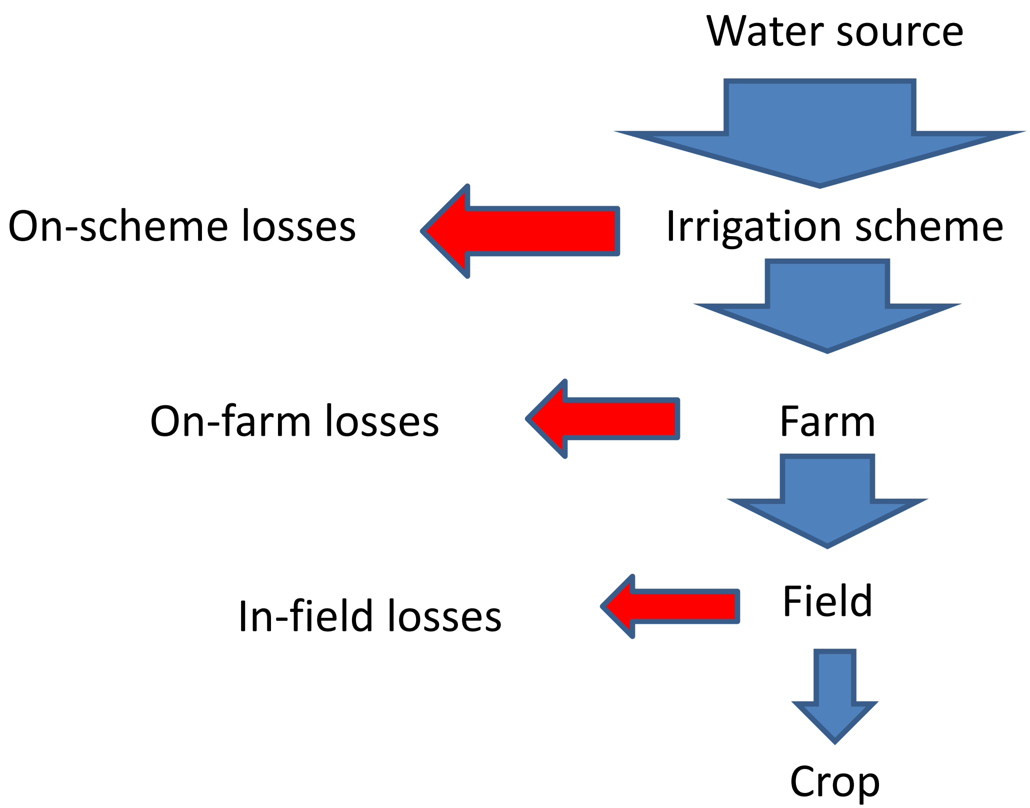
- Guidelines have been developed for improving irrigation water management, taking a water balance approach
- The structure and content of the guidelines are based on the lessons learnt locally and internationally



THE WATER BALANCE FRAMEWORK

Water balance approach

- Defining efficient use of irrigation water:



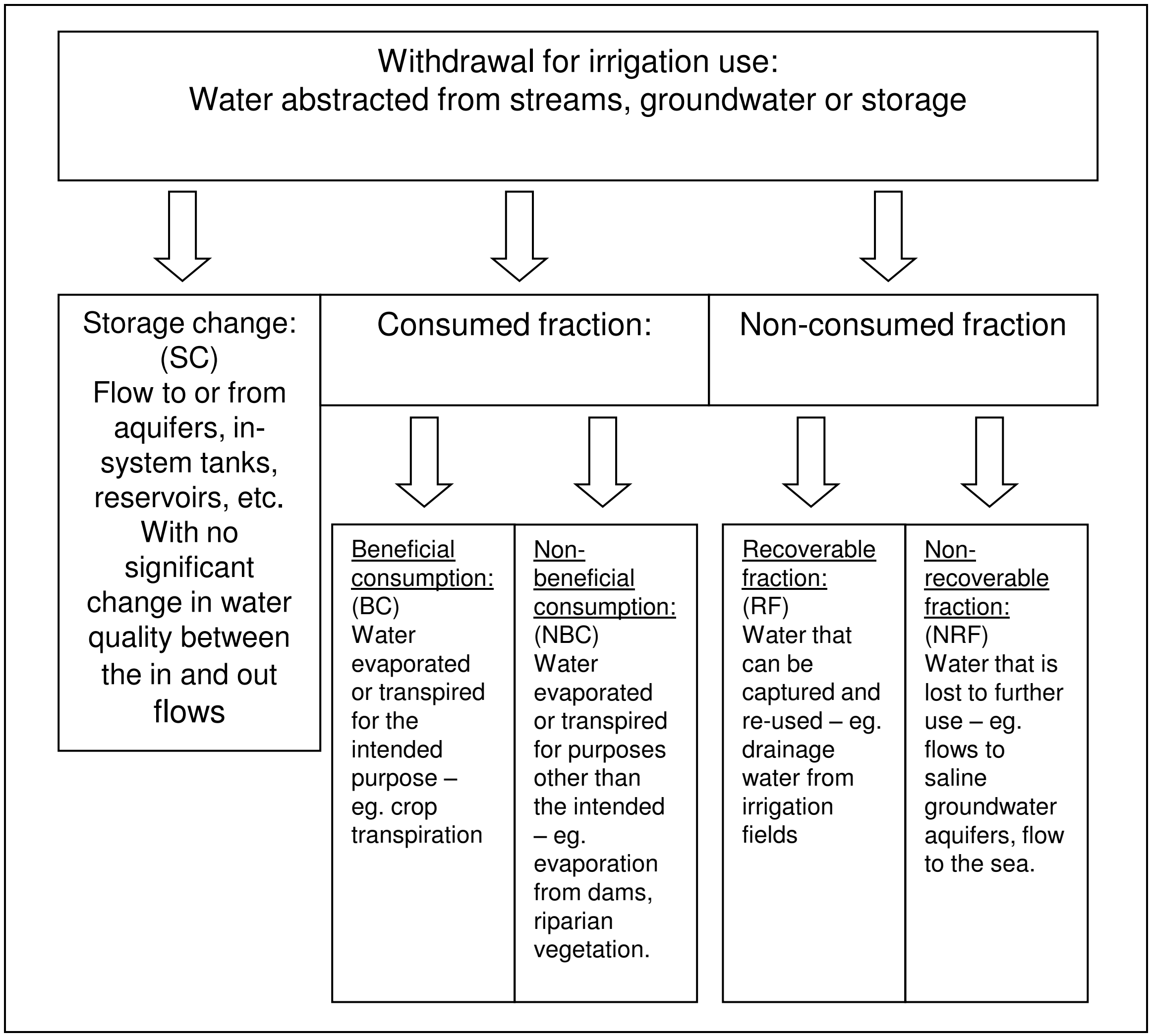
Ensuring that most of the water taken from the source reach the intended target – the crop – by minimising losses along the way.

Irrigation efficiency framework

- Consider a water balance approach rather than calculating ratios,
- Taking into account the destination of applied water, and
- Including factors such as infiltration, deep percolation, surface runoff, evaporation from the soil surface, spray evaporation, wind drift, plant interception and transpiration.

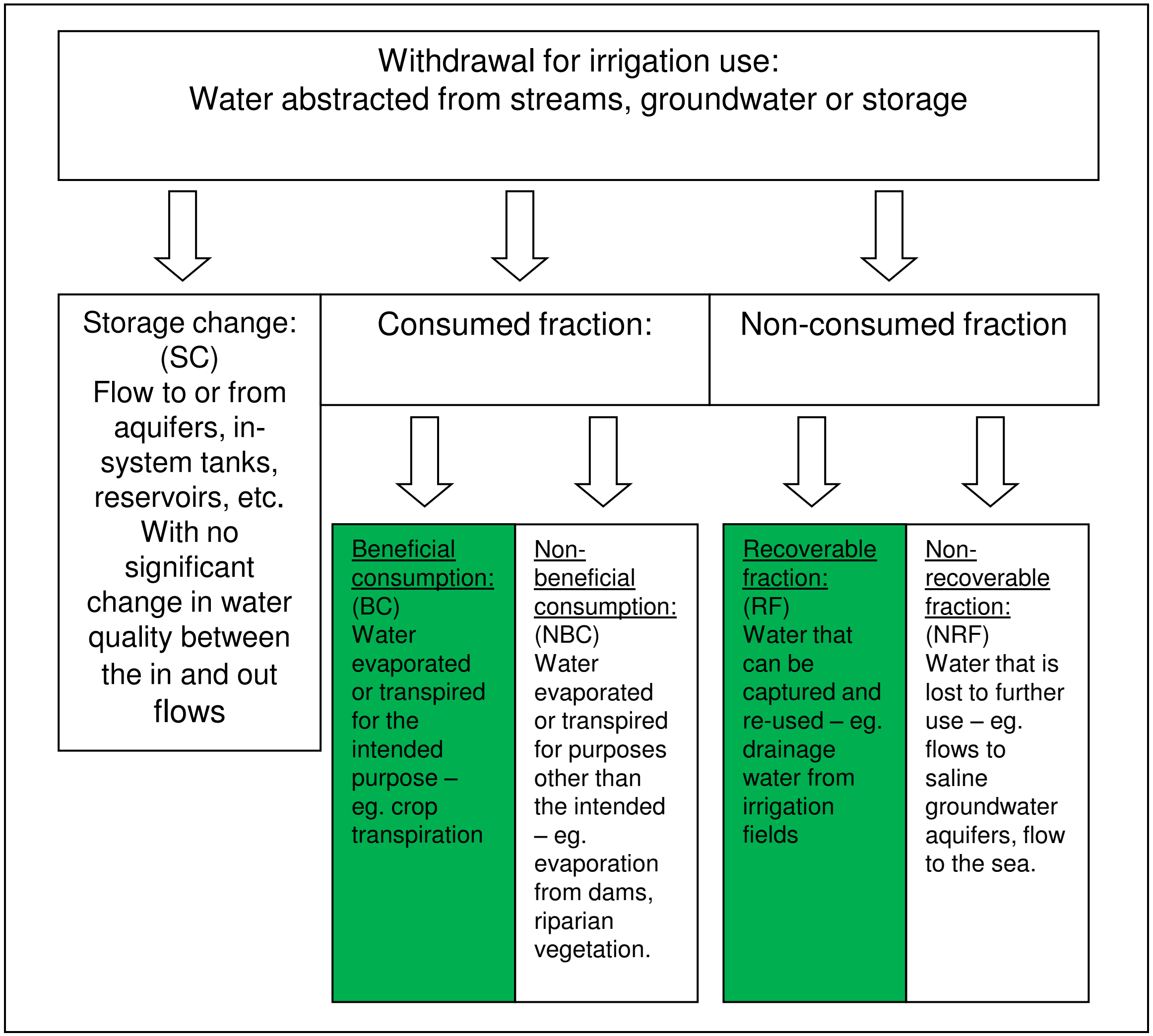
?????

Water balance framework



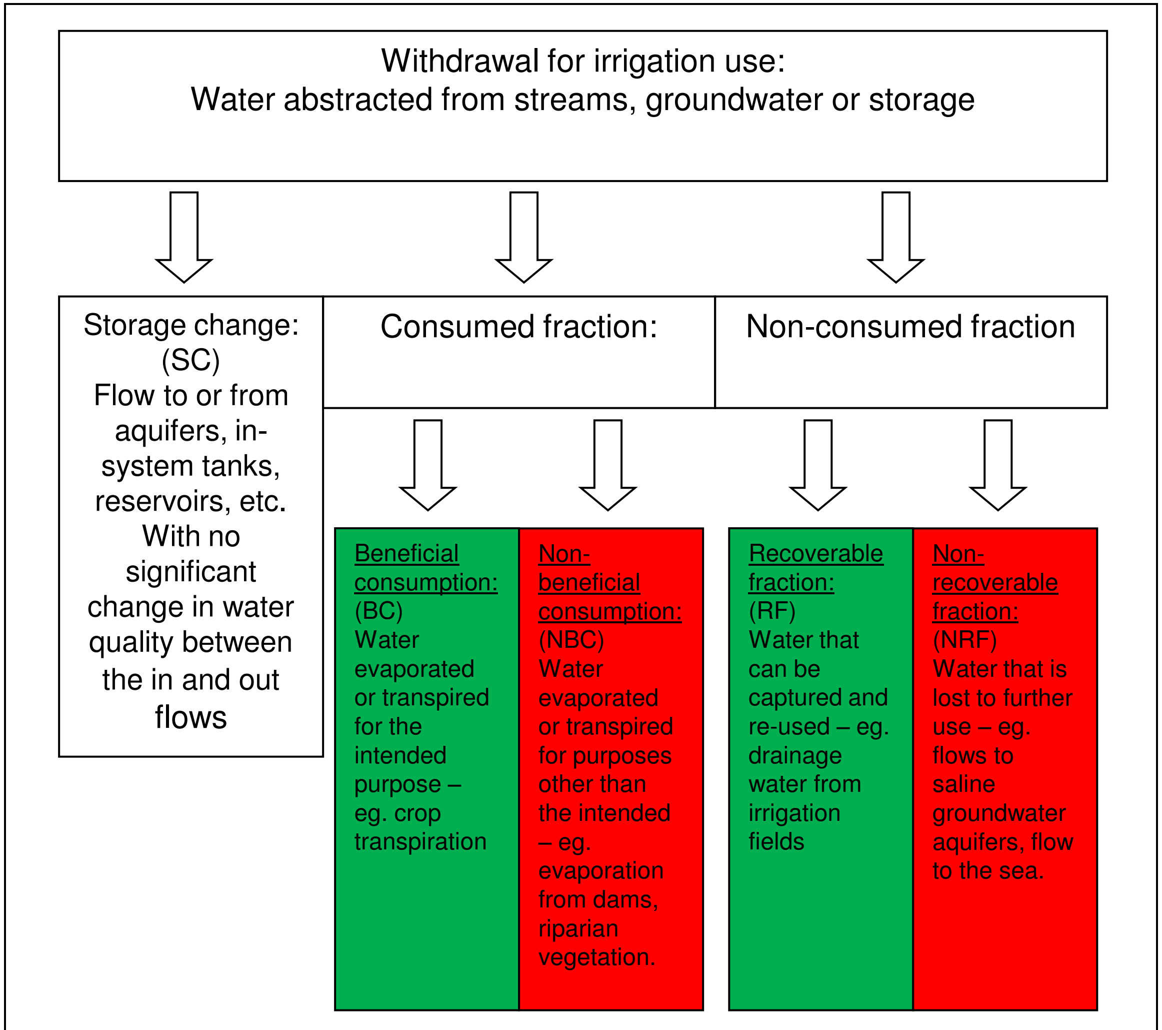
(Perry, 2007)

Water balance framework



(Perry, 2007)

Water balance framework



(Perry, 2007)

Optimising water use

- We have to find ways of reducing the non-beneficial consumptive and non-recoverable fractions of water use within the areas that we control
- How?

Improvement process

Process:

Quantify water balance components for current situation

↓

Assess WBCs and identify system components to change

↓

Assess feasibility of changing
(Technical, environmental, economic)

↓

Implement changes,
using proven methodologies

Requirements:

Water balance framework and
Measurement/Estimation methods

Benchmarks for comparison / assessment

Information on options available
(captured into models)

Guidelines and plans for implementation

Water balance implementation

Implementation of the proposed efficiency improvement process requires reliable data, which in turn will require -

- Standardised measurements,
- Realistic benchmarks,
- Practical models,
- Effective implementation plans, and
- Skilled persons

WATER BALANCE IMPLEMENTATION MANUAL

WATER BALANCE IMPLEMENTATION MANUAL

PREPARATION

- Background on water use efficiency
- Understanding the water balance principle and its terminology
- The structure of the water balance framework

APPLICATION

- Customising the water balance framework
- & Setting the range or threshold values
- Collecting the data (measurements)
- Taking action to improve efficiency

Material promoting measurement:

Planning an irrigation water measurement system:

- On-scheme / On-farm

Selection, installation, operation and maintenance of flow measuring devices:

- Canals / Rivers / Pipes

Managing measurement implementation projects

Environmental measurements:

- Rainfall
- Evaporation / Transpiration / Evapotranspiration
- Soil water content
- Drainage water
- Seepage losses

In-field irrigation measurements:

- Run-off
- Irrigation applications
- Distribution uniformities

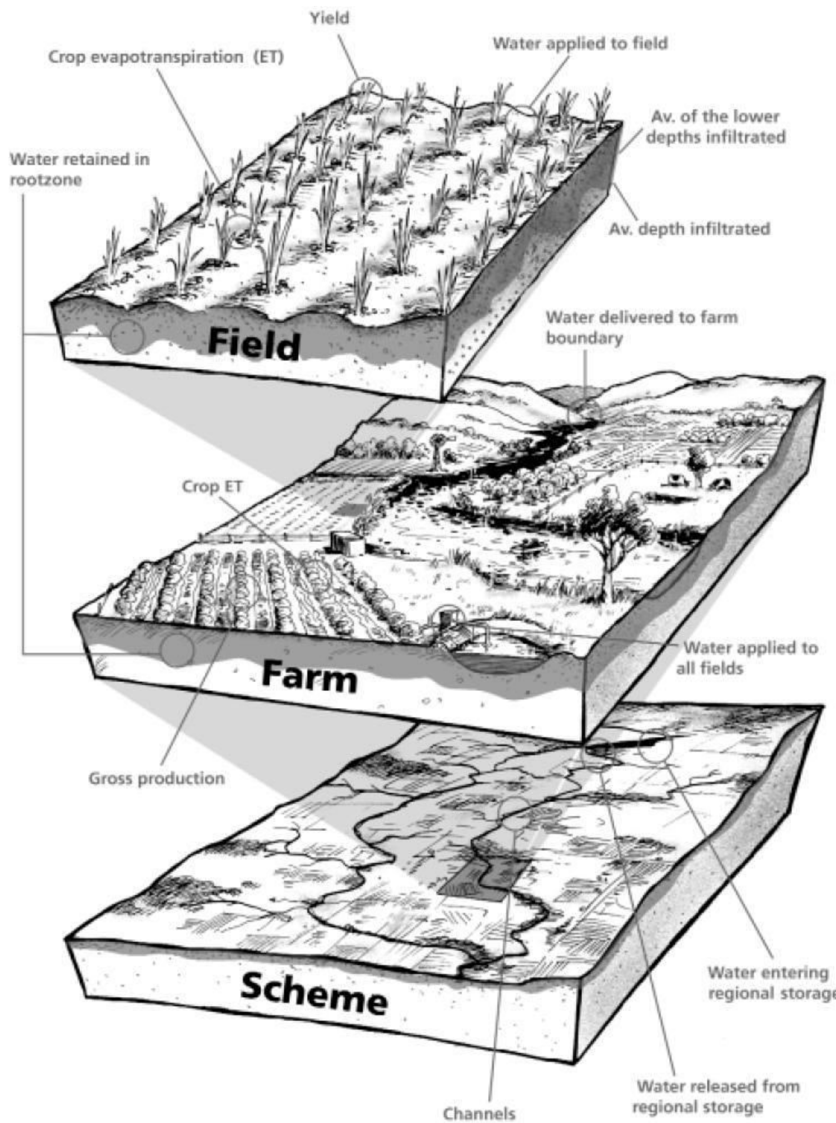
EVALUATION

- Reporting of results
- Assessing the impact of the actions taken
- Recordkeeping

Customising the framework

1. Identify the appropriate level of application
   – On-scheme / On-farm / In-field?

Application level



Customising the framework

1. Identify the appropriate level of application
   – On-scheme / On-farm / In-field?
2. Identify the applicable system component/s and their boundaries
   – Canal / river / pipe / irrigation system?

Management levels

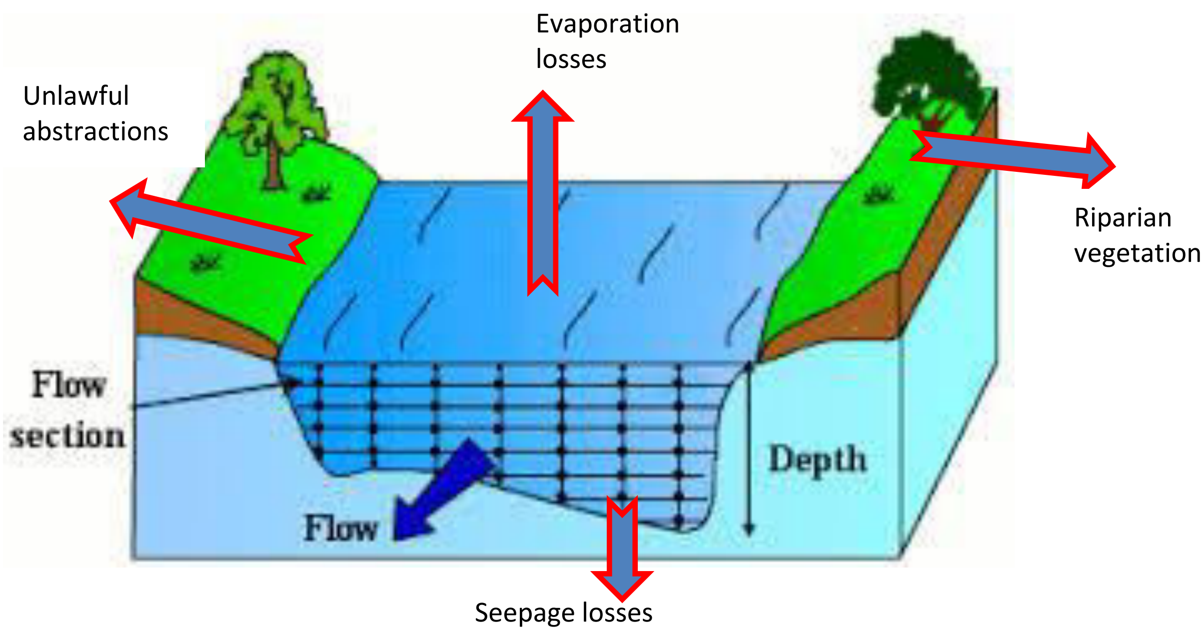
<table>
<tr><th>Water management level</th><th colspan="3">Infrastructure system component</th></tr>
<tr><td>Water Source</td><td colspan="2">Dam/Reservoir</td><td rowspan="5">Aquifer</td></tr>
<tr><td>Bulk conveyance system</td><td>River</td><td>Canal</td></tr>
<tr><td rowspan="3">Irrigation scheme</td><td colspan="2">On-scheme dam</td></tr>
<tr><td colspan="2">On-scheme canal</td></tr>
<tr><td colspan="2">On-scheme pipe</td></tr>
<tr><td rowspan="3">Irrigation farm</td><td colspan="3">On-farm dam</td></tr>
<tr><td colspan="3">On-farm pipe / canal</td></tr>
<tr><td colspan="3">Irrigation system</td></tr>
</table>

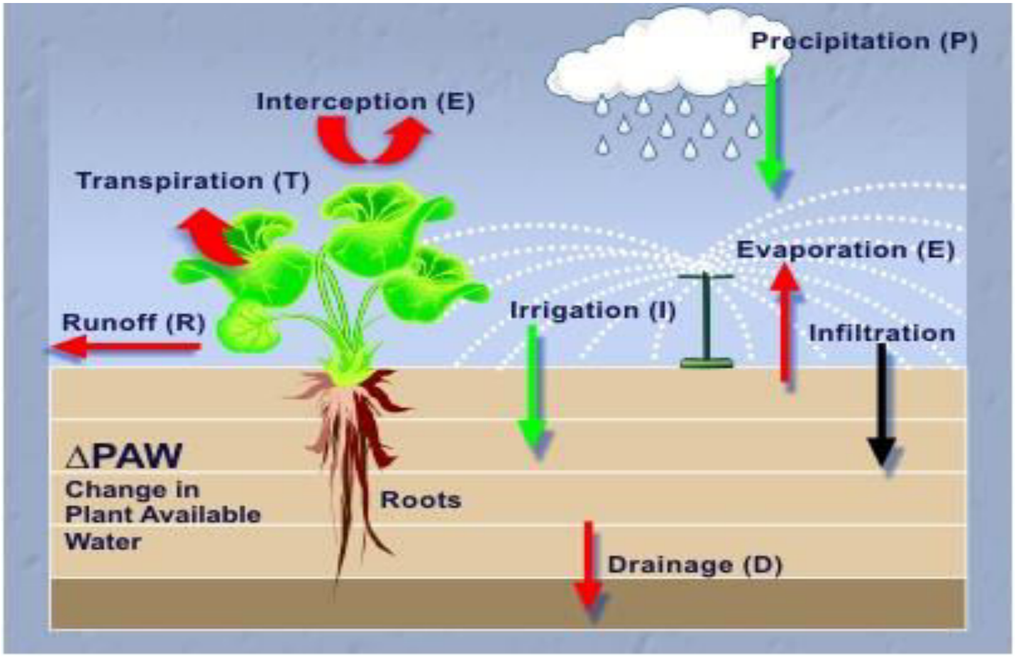
Spatial boundaries

Area	Upper boundary	Lower boundary	Horizontal boundary
River system (from on-river dam to scheme / farm edge)	Water surface	Bottom of river	All river inflows and outflows
On- scheme conveyance system	Water surface / pipe inlet	Bottom of canals / pipe walls	Scheme edges
On-farm distribution system (from farm edge to field edge)	Water surface / pipe inlet	Bottom of canal / pipe walls / drainage system	Farm edges
In-field application systems (from field edge to root zone)	Crop canopy	Bottom of root zone	Field edges

Customising the framework

1. Identify the appropriate level of application
   – On-scheme / On-farm / In-field?
2. Identify the applicable system component/s and their boundaries
   – Canal / river / pipe / irrigation system?
3. Finalise the list of possible destinations
   – Where can the water go?


Evaporation losses
Unlawful abstractions
Riparian vegetation
Flow section
Depth
Flow
Seepage losses


Precipitation (P)
Interception (E)
Transpiration (T)
Evaporation (E)
Irrigation (I)
Runoff (R)
Infiltration
ΔPAW
Change in Plant Available Water
Roots
Drainage (D)

Customising the framework

1. Identify the appropriate level of application
   – On-scheme / On-farm / In-field?
2. Identify the applicable system component/s and their boundaries
   – Canal / river / pipe / irrigation system?
3. Finalise the list of possible destinations
   – Where can the water go?
4. Set the range or threshold values
   – Are they fair yet achievable?

Actual data collected

Irrigation Scheme	Bulk Conveyance	On-scheme distribution	On-scheme return flow	Irrigation system (application)	Irrigation management (Soil storage)
Breede River	X	X	X	X	
Dzindi	X			X	
Gamtoos	X			X	X
Hartbeespoort	X			X	
Hex River				X	
KZN scheme	X	X		X	X
Loskop	X			X	
Nkwalini	X			X	
ORWUA	X	X	X	X	X
Steenkoppies					X
Vaalharts	X		X	X	
Worcester East				X	

Customising the framework

Water balance framework system component (based on infrastructure)	Inflow of water into system component	Possible water destinations within the system component	Framework classification	Desired Range, % of inflow
Canal bulk conveyance system (from on-river dam to scheme / farm edge) (if applicable)	Total amount of water entering the main canal	On-scheme surface storage	BC	
		On-scheme distribution system	BC	
		Farm edge (on-farm surface storage, distribution system or irrigation system)	BC	
		Evaporation from canal	NBC	<1
		Seepage in canal	NRF	<5
		Unlawful abstractions	NRF	0
		Operational losses (unavoidable, eg filling canal, tailends)	RF	<10
		Operational losses (inaccurate releases, spills, breaks, etc.)	NRF	0

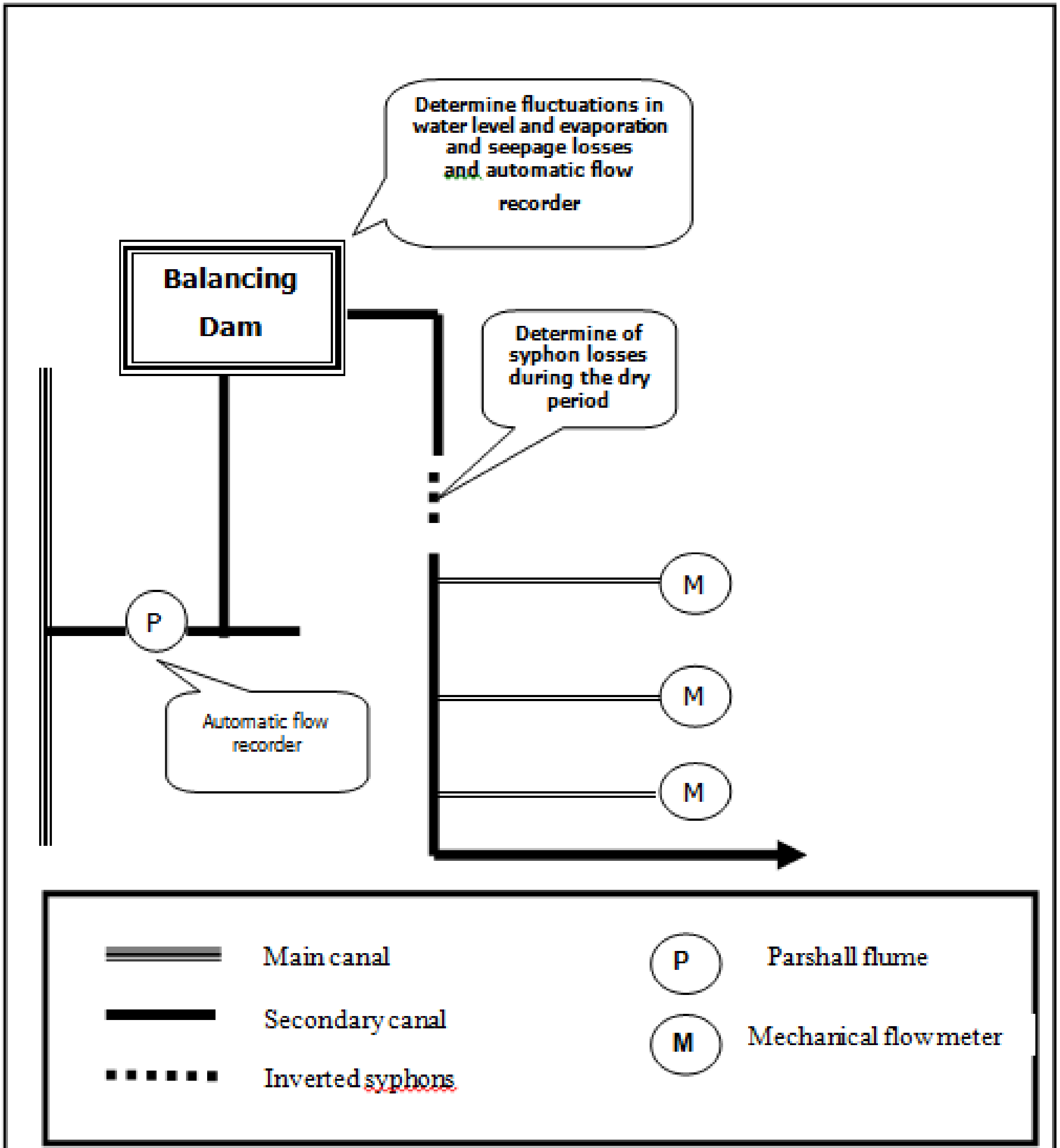
Customising the framework

Water balance framework system component (based on infrastructure)	Inflow of water into system component	Possible water destinations within the system component	Framework classification	Desired Range, % of inflow
On-farm surface storage	Total amount of water entering a farm dam	Increase volume of water stored	SC	
		On-farm distribution system (release from dam)	BC	
		Irrigation system (abstraction from dam)	BC	
		Evaporation from dam	NBC	<1
		Seepage from dam	NRF	<1
		Operational losses (spills, leaks)	NRF	<1
On-farm distribution system	Total amount of water entering the on-farm pipelines or canals	Irrigation system	BC	
		On-farm distribution system leaks	NRF	0
		Operational losses (unavoidable)	RF	<5

Customising the framework

Water balance framework system component (based on infrastructure)	Inflow of water into system component	Possible water destinations within the system component	Framework classification	Desired Range, % of inflow
In-field system (from field edge to root zone) **Intended destination of the water released.**	Total amount of water entering the irrigation system (Gross Irrigation Requirement (GIR) plus precipitation)	Increase soil water content	SC	
		Transpiration by crop	BC	
		In-field evaporation (beneficial)	BC	
		Frost protection irrigation water	BC	
		Leaching (intended, beneficial but non-recoverable)	BC	
		Interception (unavoidable)	NBC	<1
		In-field evaporation (non-beneficial, excessive)	NBC	0
		In-field deep percolation (non-intended, non-recoverable)	NRF	0
		In-field run-off (uncontrolled)	NRF	0
		Drainage water (surface & subsurface, recoverable)	RF	
		Operational losses (unavoidable)	NRF	<5

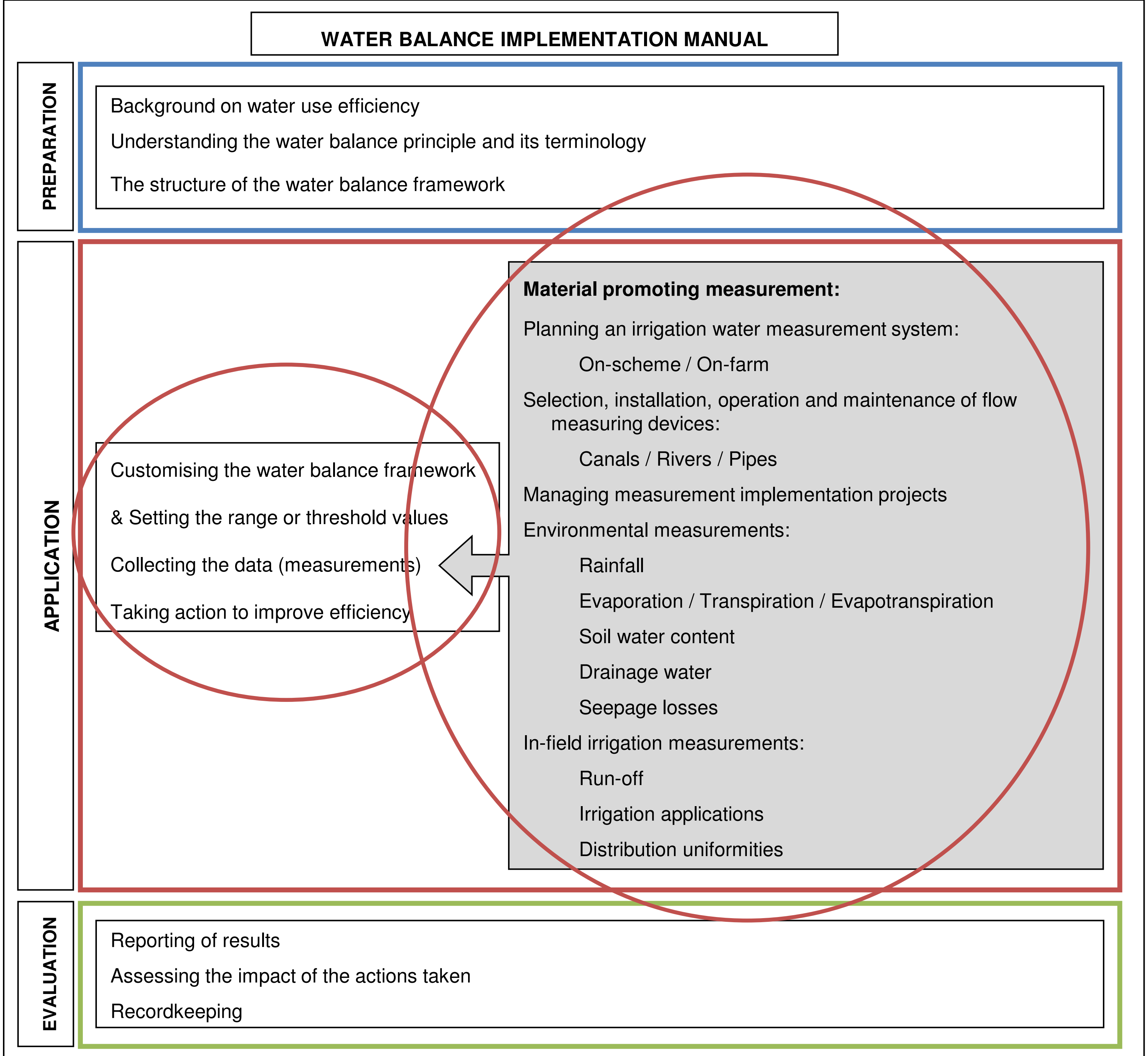
ON-FARM CASE STUDY



Determine fluctuations in water level and evaporation and seepage losses and automatic flow recorder
Balancing Dam
Determine of syphon losses during the dry period
P
Automatic flow recorder
M
M
M
Main canal
Secondary canal
Inverted syphons
P
Parshall flume
M
Mechanical flowmeter

Example – customised framework

System component	Water use	Framework component	
		Comp.	Target % of GIR
Irrigation water release	Increase flow in canal system	SC	121%
Bulk conveyance system (from on-river dam to scheme edge)	Not applicable)		
On-scheme conveyance system	Evaporation from canal	NBC	<1
	Seepage in canal	NRF	<5
	Leakages in pipes	NBC	0
	Unlawful abstractions	NBC	0
	Operational losses (unutilised)	NRF	<10
	Return flows (unutilised)	RF	<5
On-farm conveyance system (from farm edge to field edge)	On-farm system leaks	NRF	0



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PREPARATION
Background on water use efficiency
Understanding the water balance principle and its terminology
The structure of the water balance framework
APPLICATION
Customising the water balance framework
& Setting the range or threshold values
Collecting the data (measurements)
Taking action to improve efficiency
Material promoting measurement:
Planning an irrigation water measurement system:
On-scheme / On-farm
Selection, installation, operation and maintenance of flow measuring devices:
Canals / Rivers / Pipes
Managing measurement implementation projects
Environmental measurements:
Rainfall
Evaporation / Transpiration / Evapotranspiration
Soil water content
Drainage water
Seepage losses
In-field irrigation measurements:
Run-off
Irrigation applications
Distribution uniformities
EVALUATION
Reporting of results
Assessing the impact of the actions taken
Recordkeeping

Collecting the data

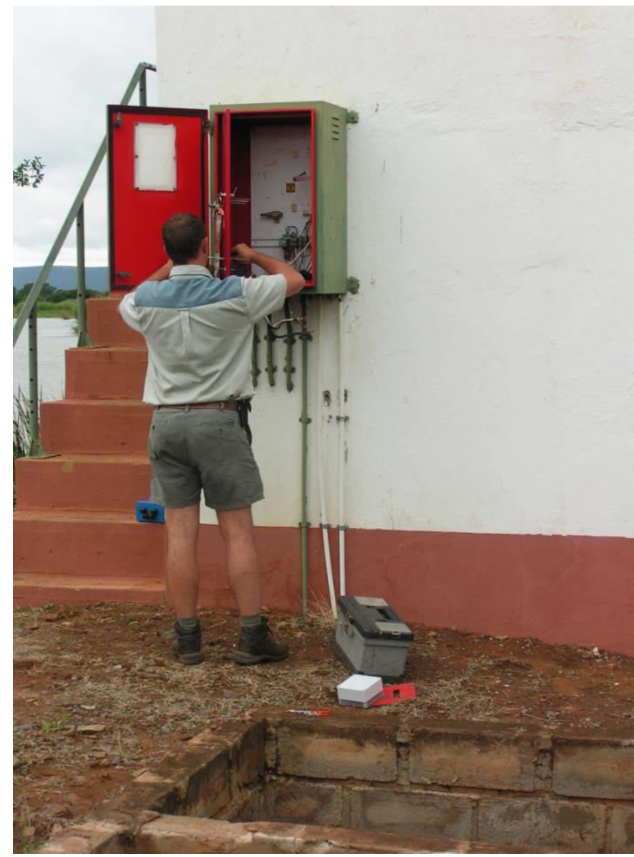
- Planning the irrigation water measurement system:
  - On-scheme / On-farm?
  - What do you want to measure where? (see framework)
- Selection, installation, operation and maintenance of flow measuring devices:
  - Canals / Rivers / Pipes
  - What measuring device / method to use?
- Environmental measurements:
  - Rainfall, Evaporation / Transpiration / Evapotranspiration
  - Soil water content, Drainage water, Seepage losses
- In-field irrigation measurements:
  - Run-off / Irrigation applications / Distribution uniformities
- Managing measurement implementation projects

Managing measurement projects

- Assign the responsibility for implementation to a skilled person
- Preparation is key
- Commit to an implementation plan
- Install the most appropriate technology that can be afforded

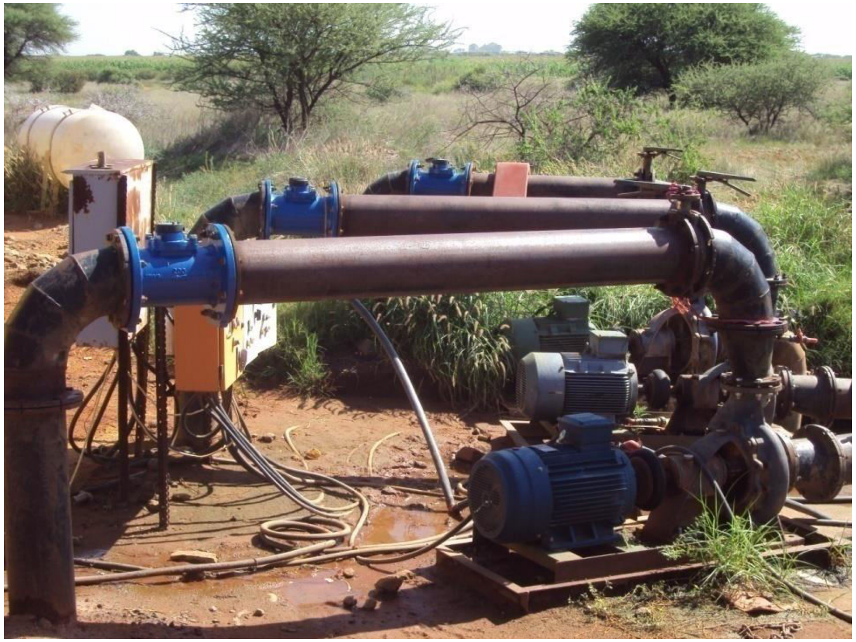
Appoint/train a responsible person

- A knowledgeable and skilled person employed by the WUA/IB is required if water measurement is to be implemented successfully
- Case studies:
  - Komati/Lomati /Crocodile River Ibs
  - ORWUA
  - Breede River



Preparation is key

- Try out as many technologies as possible
- Case study:
  - Orange-Riet WUA
  - 1998-2014
  - Meters:
    - Mechanical
    - Electromagnetic
    - Electronic
    - Ultrasonic



Commit to an implementation plan

- WRC report TT248/05
- Guidelines for irrigation water measurement in practice
  - Measurement implementation planning
  - The measurement system
  - Implementing the plan

Commit to an implementation plan

- Measurement implementation planning
  – Background to the implementation area
  – Measurement trigger
  – Purpose of the proposed system
  – Locations for measurement
  – Benefits of measurement
  – Water user support and institutional arrangements

Commit to an implementation plan

- The measurement system
  - Measuring device selection
  - Installation
  - Operation and maintenance
  - Monitoring and evaluation
- Implementing the plan
  - Budget and funding
  - Roleplayers and responsibilities
  - Gantt chart
  - Invitation for inputs

Install the most appropriate technology that can be afforded

- The measurement solution should suit the measurement problem, not the budget

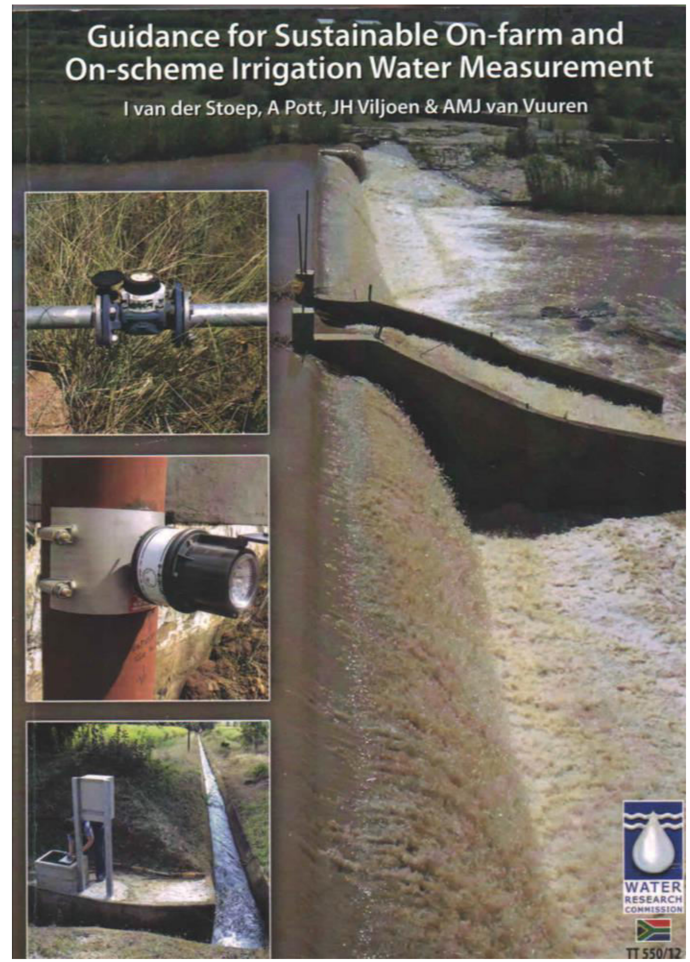
Collecting the data

- 65 045 registered irrigation systems (fields)
  - 53 701 pressurised irrigation systems
  - 11 344 flood irrigation systems
- 70% of irrigation systems not measured (2008)
- Cost of measurement implementation:
  - Piped (pressurised) systems: R21 986 per system
  - Open channel (flood) systems: R29 173 per system
- Cost of managing measurement systems: R23,94/ha

(Costs based on 2014 WARMS data and 2008 WRC survey results, adjusted for inflation to be applicable in 2013)

Water measurement source info

- Guidelines for implementation of water measurement have been developed
- Check that all inputs required by the framework can be measured to an acceptable accuracy



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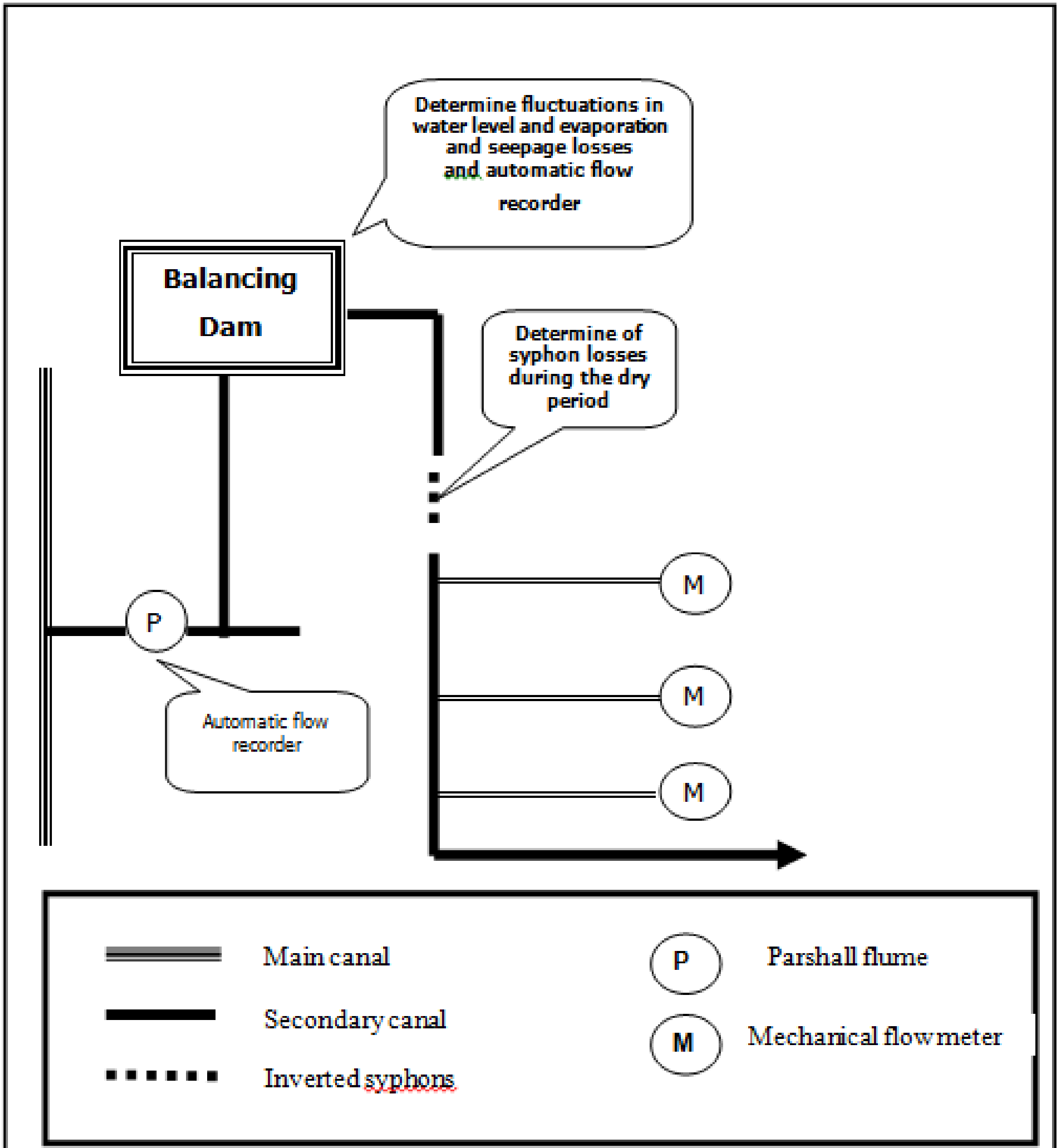
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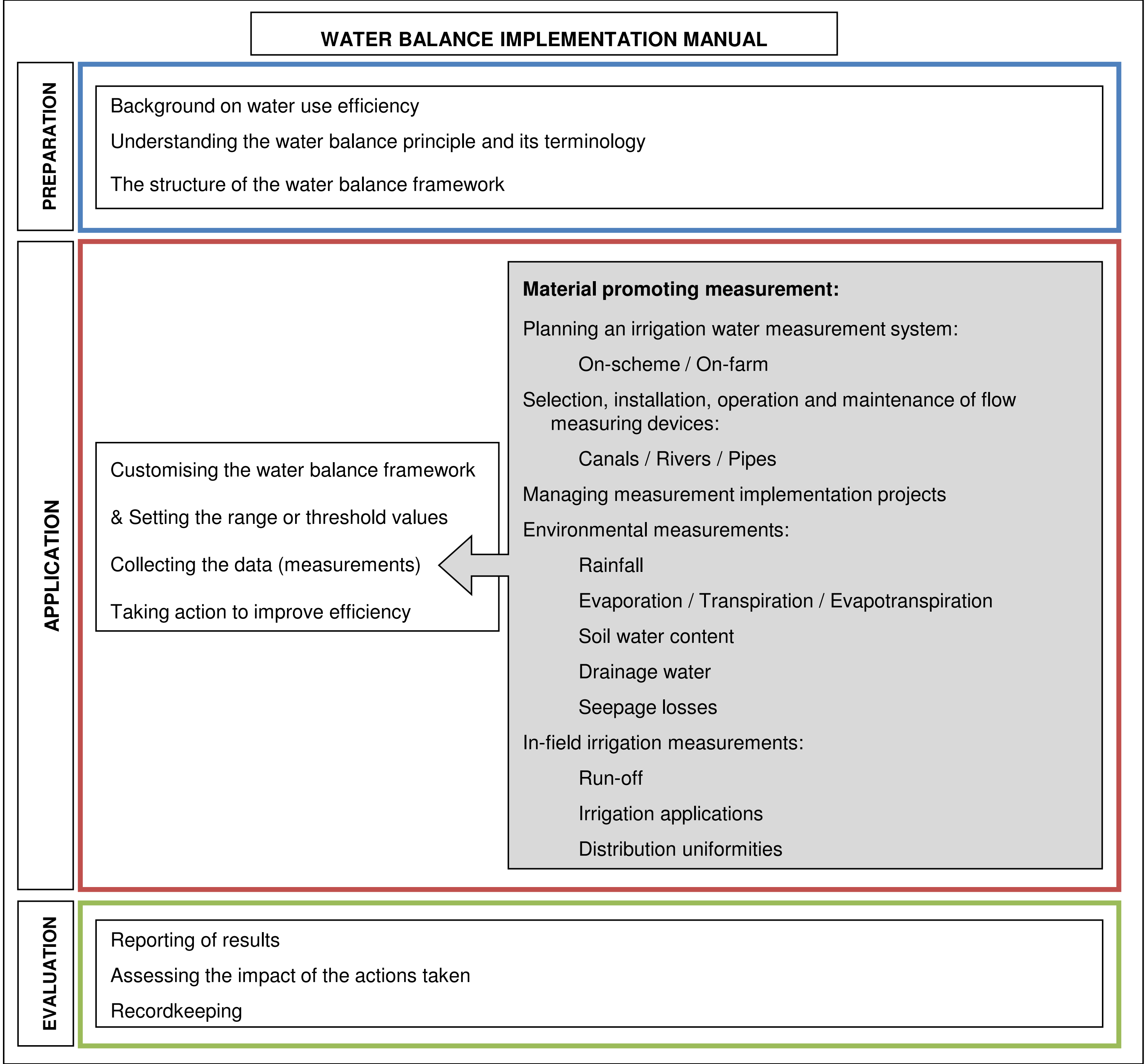
Example – customised framework

System component	Water use	Framework component		
		Comp.	Target % of GIR	Actual % of GIR
Irrigation water release	Increase flow in canal system	SC	121%	167%
Bulk conveyance system (from on-river dam to scheme edge)	Not applicable)			
On-scheme conveyance system	Evaporation from canal	NBC	<1	2%
	Seepage in canal	NRF	<5	10%
	Leakages in pipes	NBC	0	25%
	Unlawful abstractions	NBC	0	15%
	Operational losses (unutilised)	NRF	<10	8%
	Return flows (unutilised)	RF	<5	5%
On-farm conveyance system (from farm edge to field edge)	On-farm system leaks	NRF	0	2%



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Conclusion and way forward

- Who are the main stakeholder group/s of the water balance implementation framework?
- How can they best be made aware of the importance of implementation?
- Which organisation should take ownership of the manual (eg. SABI, SANCID, SAAFWUA, etc.)?

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