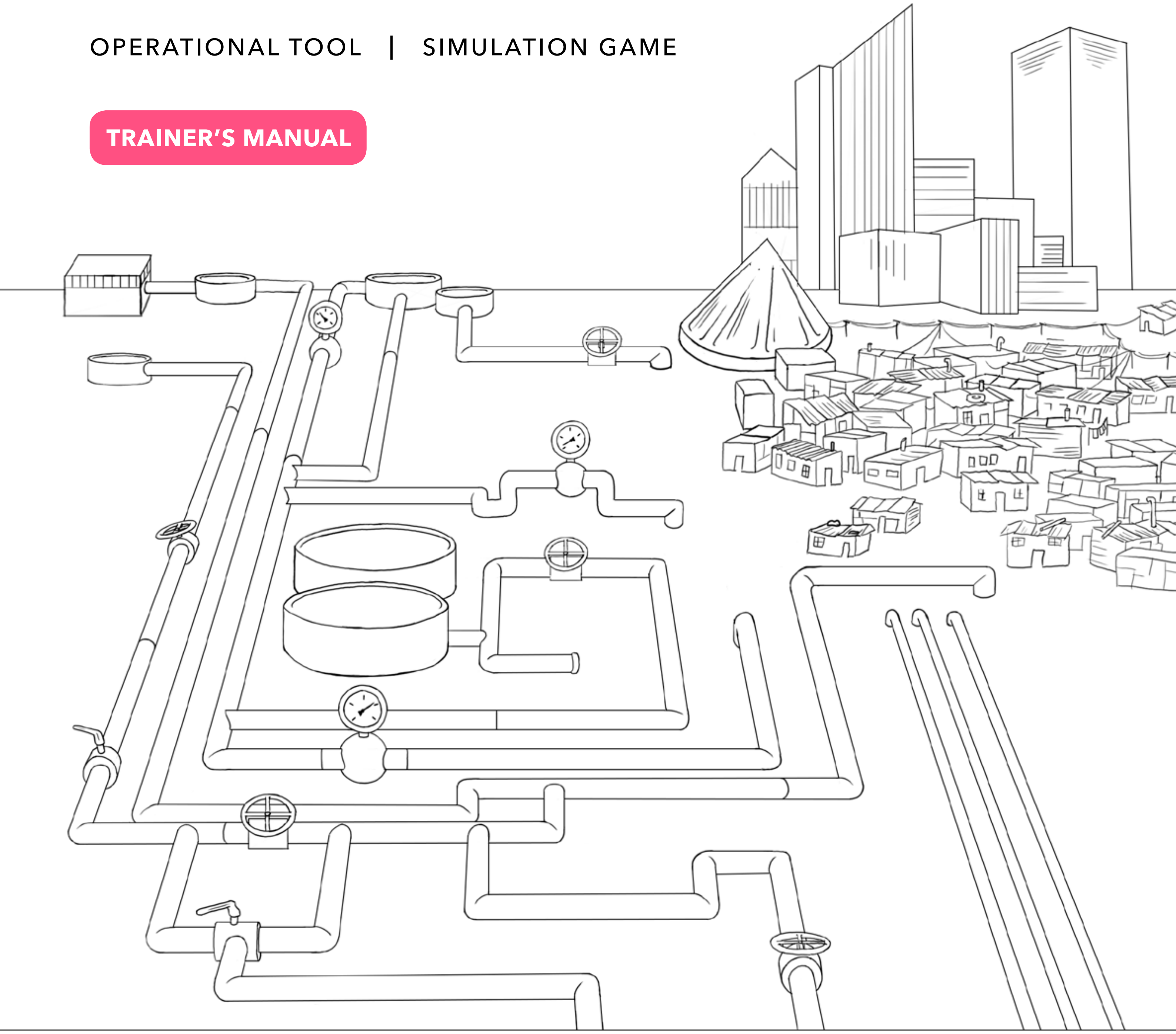
BEWOP

TOOL SERIES

Water Utility Management

OPERATIONAL TOOL | SIMULATION GAME

TRAINER'S MANUAL



GWOPA Global Water Operators' Partnerships Alliance

UN-HABITAT FOR A BETTER URBAN FUTURE

UNESCO IHE DELFT

A joint initiative of GWOPA/ UN-Habitat and IHE Delft Institute for Water Education

Ministry of Foreign Affairs of the Netherlands

Cooperación Española

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Principal Author
Andrés Cabrera Flamini, a.cabrera@un-ihe.org

BEWOP

Water Operators' Partnerships are peer support arrangements between two or more water and sanitation operators, carried out on a not-for-profit basis with the objective of strengthening operator capacity.

The Boosting Effectiveness of Water Operators' Partnerships (BEWOP) initiative is producing a series of guidance materials, tools and games to help WOP partners expertly plan and implement WOP partnerships and effectively learn and share knowledge with one another.

Two types of products feature in the second phase of this BEWOP initiative. Process Tools support WOP participants prepare for, design, implement and follow through with their WOPs. Operational Tools support in the transfer of knowledge on specific operational topics relevant for water utilities.

Find out more

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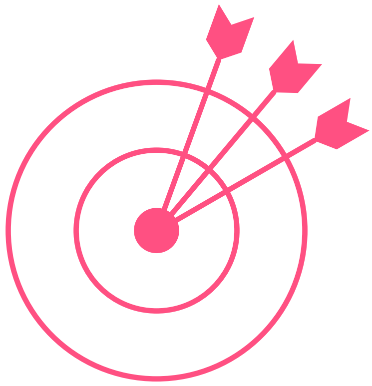


Objectives

This tool has been designed as a learning game to develop awareness and knowledge of the processes of strategic planning within utilities.

The game can be used as a team building or learning exercise for students, utility staff or other water professionals.

The Utility Management Simulation Game is played with a facilitator or trainer who guides discussions on how decisions, trade-offs, and actions play out in everyday business practice, and throws in some surprise elements.

The game draws from real cases and practical experience of experts, which allows participants to experience utilities' decision-making dilemmas in a safe environment.

How this tool works

Within a (water) utility, managers are tasked with achieving numerous, often conflicting objectives: full service coverage, high water quality, service affordability, adequate infrastructure operation and maintenance, HR management, bankability. Achieving these objectives simultaneously is tough and often involved foreseeing potential consequences and making trade-offs on investment and priorities.

The Utility Management Simulation Game groups players into teams of 4, with each player taking on the role of either a General, Financial, Commercial or Operational manager to run a utility for ten years. Based on data from a real utility from a developing country, players must work together to make strategic decisions on the best way forward to improve key performance indicators.

Several teams can play at once to compete (or just explore) how their decisions result in often unexpected outcomes.

Can you keep the utility from going bankrupt? Will service quality bring in more financial resources? What happens when your assumptions change? See how you would cope with this by playing the game.

Access the full Water Utility Management Tool here.

Contents

Introduction

The **UTILITY MANAGEMENT SIMULATION GAME** (UMSG) is a multi-player simulation game for capacity building programs. This simulation game mimics the challenges and uncertainties faced by water utility management teams, and reflects the influence of their decisions in the performance of the water utility company: Macondo, a fictitious utility modeled after a real-life utility. Players' performance is evaluated through the use of typical key performance indicators (KPI) for water utilities such as full cost recovery, non-revenue water (real and apparent), and staff development. Each of the possible decisions players make have a different influence on the different KPI's in terms of operational, financial and commercial performance. The game simulates an operational timespan of 10 years, where players make decisions for a total of 10 turns (1 turn = 1 year).

The objective of the UMSG is to enable players to experience the challenge of managing a water utility from different management positions. Within a water utility, middle-level managers often have to achieve objectives which can be conflicting. Achieving the desired objectives – such as attaining full service coverage, ensuring quality of water supplied, guaranteeing affordability of the service, fostering access to services for the poor, and sufficient cost recovery to mention some – is often difficult as these objectives inherently involve trade-offs. For example, increasing cost recovery may be achieved at the detriment of ensuring affordability of services. Moreover, managers in water utilities have to achieve both short-term objectives, which are often linked to the electoral cycle of the government-owned public utilities, and long-term objectives, which are often linked to the state of the utility infrastructure and services provided. Achieving these objectives simultaneously is difficult as the more political short-term objectives may be at odds with long-term objectives relating to infrastructure investment and asset management. The purpose of the UMSG is to let participants experience this challenge of utility management by simulating decision-making in the areas of customer, operational and financial management within the utility.

The game is best experienced in teams of 4 people and the UMSG can accommodate up to 4 water utilities in a single game. Playing with 2 or more water utilities allows for benchmarking between utilities (teams) and adds a sense of competition to the game. All utilities operate within the same case study, as provided by the facilitator at the start of the session. The challenge for the players is to estimate the implications of their decisions and convince other players in their utility to accept their proposals to improve the performance of the water utility.

How does the game work?

The main goal of the game is for participants to experience the management challenges and trade-offs needed within the utility's various departments, i.e.: General Management, Financial Management, Operational Management, and Costumer Management. This is simulated by having 4 participants per team discuss and decide on the most pertinent investment activities for the utility to implement. These decisions are made on the basis of an initial loan and a 10 year plan presented by the teams to the facilitator. The teams' progress is measured via the changes of the KPI's established within the game, which measure specific aspects of each of the players' management area. For further details on UMSG's game design, assumptions, and steps, please refer to the Participant's Manual section: **Playing the Game**.

N.B.: For the UMSG to run, you must **Enable Content** when the game opens, that is *Enable the Macros* with which the simulation runs. In most Excel versions, when you open the file a warning message should appear under the Formula bar allowing you to enable the necessary content.

Facilitator's role in the game

As the Facilitator for UMSG, there are several tasks you must undertake. These are as follows:

Presentation of UMSG: When implementing UMSG as a capacity development activity, the first step is to present the objectives, dynamics, and time commitment for the game. These will usually be defined on a case to case basis. Generically, you will provide participants with:

- The desired objective of the game, for example: to increase their awareness of the different processes and trade-offs that occur within a utility.
- The expected agenda of the game, namely each team's initial 10-year plan presentation, the amount of playing time/rounds you will do, and each team's presentation on the reflection of playing the game, lessons learned, etc.
- The creation of management teams and definition of roles within the teams. You can pre-assign teams and roles, or let the players choose by themselves.
- Explain the dynamics of the game and run the game as facilitator. This includes distributing decision-making sheets before you begin, running the simulations, and providing teams with feedback on the impact of their decisions. Highlight your role within the game in terms of running the simulation while at the same time be in charge of the overarching government policies the participants will need to adhere to.

Participants' strategies presentation: Before running the first simulation, management teams will be handed information regarding the current state of the utility and the relevant KPI's they will be assessed on. This information is located in the Participant's Manual. If desired by the facilitator, the governmental policy goals (and other relevant game parameters) can be shared with them at this point. Management teams will then need to prepare a presentation on the utility's objectives and how they intend to achieve this (for example: increase coverage to low income areas through network and water kiosks development). They will present their strategy to the facilitator, other teams, and audience (if desired), and receive a round of questions and feedback on their strategy. Following this, they will fill out per team the first year (Turn 1) in the **'Management Decisions Sheet'**, which can be found at the end of the Participant's Manual.

Running UMSG's Excel interface: The first task will be to open the Excel file called *Water Utility Management Simulation Game*. Once the file opens, click on the **PLAY GAME** button in the lower left-hand corner:

Figure 1. Play Game Button

This will lead you to the Yearly Decisions sheet (see *Figure 2*) in Excel, the main interface where you, as facilitator, will input the data provided by the teams, run the simulation, and produce the results that will be given back to the teams so they may make the relevant decisions for the next turn.

Once you have received each management team's "Yearly Decisions sheet", you will input the numbers into the Excel interface's 'Yearly Decisions' tab under the respective column, i.e. input for Turn 1 under the column for Turn 1. For each team, you will have to input their data one team at a time. Once the data has been input, you press the **Play Turn** button (see *Figure 6*); this will run the simulation. Depending on the processing power of your computer, you may see flashes of equations and numbers as the simulation runs, this is normal as long as the UMSG does not crash Excel[1].

1. If Excel continues to crash when running the game, we recommend updating to a computer with higher processing power. Currently, the UMSG is the lightest version of the game available and was tested on an Core i5 vPro processor.

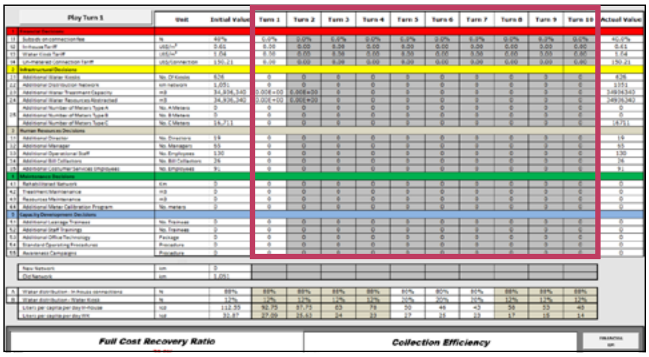


Figure 2. Yearly Decisions Interface

After the simulation has run, we highly recommend you save the team's result by using the **SAVE GAME** button (see *Figure 7*). After pressing the button, you will be prompted with a dialogue box where you can input the team's name and select the location where you want to save the data for that round. For every round, we recommend you save the data, as failure to do so will mean you have to input the data and run the simulation again. Regardless of how "risky" the teams are playing, it will save you, the facilitator, a great amount of time to change the save file name, e.g. Team 2 Year 4, after every turn. If the team goes into bankruptcy, by having an earlier save file they can try different combinations to succeed. This will be extra work for the facilitator, so it remains up to him/her to decide whether to implement this modality. In order to load the previous game, use the **LOAD GAME** button (see *Figure 7*) to open a dialogue box where you can select the appropriate file.

Once the simulation has been run for the respective turn and the data has been saved, you can produce the relevant graphs that will show how the water utility's KPIs have been impacted by the investment decisions taken by each team. You can obtain these by pressing the *SAVE KPIS TO PDF* button (see *Figure 7*). This will create a PDF file that can be printed or emailed. These results can then be communicated to each management team, in order for them to analyze and prepare the next round of management decisions.

If you have more than one team and want to have the teams engage in a quasi-competition, at this point you can implement the benchmarking option by pressing the **BENCHMARKING** button (see *Figure 7*). This will open a dialogue box where you can assign a utility # to each team (see Figure 3). When you click the respective box, the game will ask you to select a saved file, so select the file for the respective team that you have just saved. Once you have loaded all team's saved data for the turn, you can press the 'Bench-Marking Graphs' button to generate the Benchmarking Graphs. Share the graphs (*not* the management decisions sheet) with the teams so that each team can compare their performance so far with that of the others.

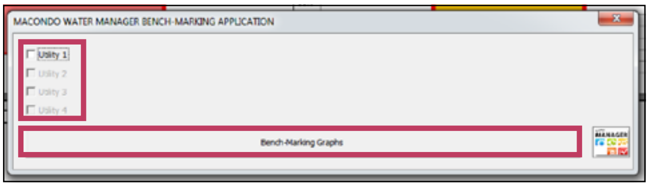


Figure 3. Benchmarking Graphs Interface

It is possible, based on the management decisions made, that participants will lead the utility bankrupt early in the game, or before the allotted playing time is over. As facilitator you will can make four different decisions at this point:

- The management team can no longer participate in the game. This is *not* recommended as it will deprive them of the opportunity to learn from their past decisions, and will leave them without a task.
- You return the "Management Decision Sheet" to the team and tell them their current decisions will lead to bankruptcy. Allow them to reconsider their approach and provide an alternative set of decisions.
- You alter the values given by them and communicate to them that due to external circumstances the management decisions made had to be altered; for example, if a management team has invested too heavily in network expansion that particular year, you can argue that the local government has prioritized equipment and resources necessary for the network expansion to other sectors (energy, mining, etc.) and therefore their proposed decision cannot be

carried out. It is in these decisions that your ability and creativity as facilitator are crucial and tested.

- At the bottom of the 'Yearly Decisions Tab' under the set of graphs you will find the 'Initial Financial Loan' cell (see *Figure 4*). This cell changes the loan received by ALL the teams. Thus, it is recommended **only** to change when all teams are in need. In order to do this, it is recommended that you, the facilitator, mention that a donor/bank has opened an additional line of funding through loans. The teams will then need to present a plan for the remaining years, along with the value of the loan requested. As facilitator, you will decide what the new loan will be. **Avoid at all costs giving different loans to each team** as this will require you to manually change the loan for every round you play per team. The UMSG is designed to a total loan value of $30,000,000; going beyond this value will make the game far too easy and will likely cause issues with the internal coding processes of the simulation. We recommend you do not go beyond this value. Finally, this value **does not return** to its original value once the game is reset, therefore if you change the value for a game, make sure that at the end of the game you return the value back to $15,000,000. This also means that if you are going to run previously saved games that had a different loan, you must change this loan **before** loading or running the next year turn.

Repeat the above steps for 10 turns or until time runs out for all teams.

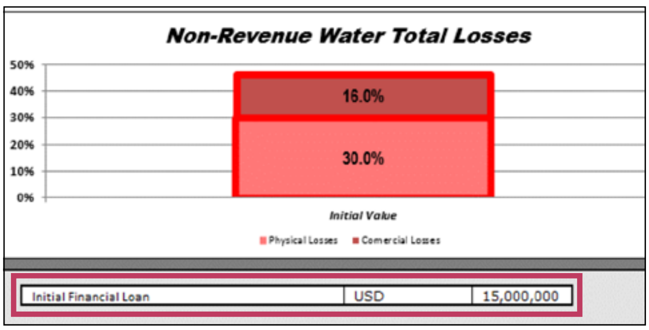


Figure 4. Initial Financial Loan Cell

Drought Scenario: The current version of the UMSG has incorporated a drought-scenario for Years 5 to 7 of the game; this drought effectively cuts access to water resources to 75% of Year 4's resources. As a response to the drought conditions, during Years 5 to 7 management teams will be given the option of directing the available water to either in-house connections, water kiosk, or a combination of both. Management teams will need to ensure that at least the minimum quantity of water per capita is delivered to avoid public health issues (10 liters per capita per day).

As a facilitator, it is recommended that you announce the potential occurrence of a drought prior to the beginning of Year 5 in order for teams to prepare accordingly. The drought has been incorporated into this version of UMSG to further "test" how teams will alter their initial strategies in face of a significant change in their operations. The drought has been placed between Years 5 to 7 to allow time for participants to identify the relations between decisions and impacts on performance, as well as provide a chance in Years 8 to 10, to recover from the drought period.

At the bottom of each teams' 'Management Decision Sheet' there is a space for them to put what percentage (%) is being sent to each connection type. As facilitator, you will only have to input the 'Water distribution – In-house connections" percentage (%) in the current turn (5, 6, or 7). The other cells will fill out automatically.

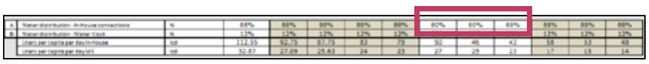


Figure 5. Drought Scenario Input Cells

Scenario creation: As a facilitator, you will find a significant amount of liberty in how you wish to guide the participants through the game by the various scenarios you choose to implement. Issues such as political elections, civil unrest, and potential budget constraints during specific years can be incorporated in the narrative you use as facilitator with your participants. It might also be relevant to incorporate specific issues in your water utility's context that you want participants to discuss or respond to. The more times you experiment with your participants, the greater breadth of possible scenarios you will have available. Just be sure to align your scenarios with the possible decisions in the UMSG to ensure the simulation runs smoothly.

Facilitate participants' reflections: At the end of the game (either Year 10, bankruptcy, or end of allotted time), it is important that you support participants in reflecting on their experience and learning from the game. This can be done in the form of an open discussion with all participants or by having each management team do a follow-up to their initial strategic presentation.

The key elements to reflect upon include:

- Was the management team consistent with their initial strategy? If so, what where the challenges of implementing their strategies, and if not, why did they change their approach?
- What was the process through which teams came to an agreement on management decisions? In each participant's opinion, was the process fair, and how could it be improved?
- What were some of the trade-offs they experienced within management teams and the decision-results produced by UMSG? Can they relate this to how water utilities operate on a day-to-day basis and how they carry out their long-term plans?

Once you have finished the game, if you would like to share your experiences or questions regarding the UMSG, feel free to contact the Water Services Management Group at IHE-Delft.

Main assumptions and Initial values for Macondo case study

As with any simulation or model, several assumptions have been made for the UMSG to run; these assumptions, along with other relevant figures such as initial values for Lilongwe context and for the utility's performance, are fixed within the game. If the facilitator wishes to change them, it will be necessary to 'Unhide' the 'INI-VAL' (initial values) tab in the Excel simulation sheet; doing this requires careful monitoring of the game's outputs as these have been calibrated according to the assumptions and initial values already programmed. For a list with relevant explanations on the assumptions and initial values, please refer to the Participant's Manual sections:

- **Key Performance Indicators** under the **Water Services Sector in Mokum Dollet** section;
- **Game Assumptions** under the **Playing the Game** section; and,
- **Profile of Malawi** under the **Introduction** section.

Button Functions

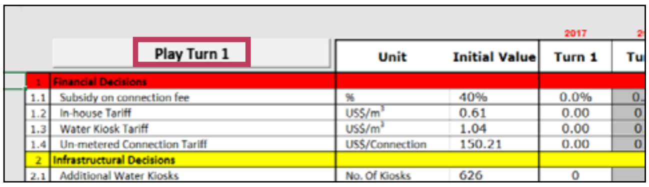
The operation of the UMSG is done through clickable buttons located through the various sheets within the Excel-based simulator. For clarity purposes, these have been grouped into Action Buttons – those that generate changes/calculations in the simulation – and Results Buttons – those the display current results in the ongoing simulation. These are described below:

Action Buttons

PLAY GAME Button: This is the first button that appears in the screen (see previous section, *Figure 1*); its main objective of this button is to delete all previous game-play data, set the decisions sheet blank, and thus ensure older data does not interfere with the current game.

Play Turn Button: This button is located on the top-left corner of the 'Yearly Decision' tab (see *Figure 6*). It is used to run the simulation for the current "Year", once the facilitator has input the data in the relevant Excel cells. For each round or turn, the heading will change indicating which year is being played.

After this button is clicked, the previous decisions are stored and locked and cannot be changed until the end of the game. Some decisions have built-in restrictions, such as negative tariffs or building Public Stand Pipes without sufficient network, which will prevent the simulation from running until they are corrected; a dialogue box will pop-up to warn the facilitator when this is occurring.



	Play Turn 1	Unit	Initial Value	Turn 1 (2017)	Tu
1	Financial Decisions				
1.1	Subsidy on connection fee	%	40%	0.0%	0.
1.2	In-house Tariff	US$/m^3	0.61	0.00	0
1.3	Water Kiosk Tariff	US$/m^3	1.04	0.00	0
1.4	Un-metered Connection Tariff	US$/Connection	150.21	0.00	0
2	Infrastructural Decisions				
2.1	Additional Water Kiosks	No. Of Kiosks	626	0	

Figure 6. Play Turn Button

Results Buttons

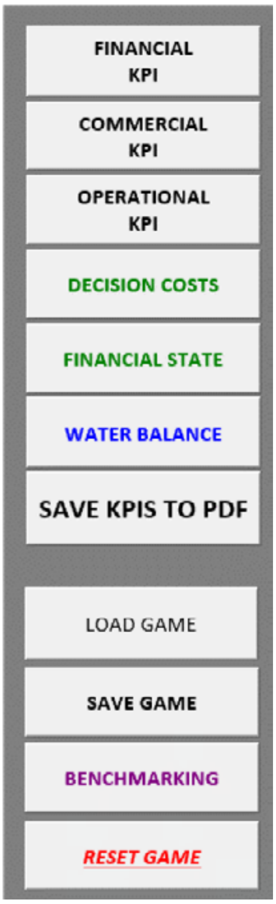


Figure 7. Results Buttons on bottom-right of 'Yearly Decisions' Interface

These buttons are located in the lower-right section of the 'Yearly Decision' tab in the Excel interface, next to the graphs highlighting some of the relevant KPIs. Their description is as follows:

Financial, Commercial, and Operational KPI buttons: These buttons will send the user to the graphs of respective KPIs. In this tab there is also a button that will send back the user to the "Yearly Decision" tab.

Decision Costs: This button will show the costs of each decision taken per round (in dollars). Only direct values are shown and not the overall cost, which can include factors such as the fixed operational costs and asset depreciation.

Financial State: This button will display bar graphs comparing the total running costs and income for the utility per year, as well as the use of the initial loan.

Water Balance: This button will open the bar graph that shows the bar plot of the water balance for the utility. This balance displays amounts of water produced, lost and supplied.

Save KPIs to PDF: This button allows the user to save all the KPIs and the Water Balance results into a single PDF file to facilitate sharing with teams.

Load Game: This button allows the user to load previously saved files.

Save Game: This button allows the user to save the simulation so far, this is required for benchmarking.

Benchmarking: This button will allow the user to load several result saved files in order to compare the performance on the different KPI's.

Reset Game: This button will reset all the decisions and restart the game. Before executing all the resting procedure, a message box will appear in order to confirm the user decision.

Decision variables

The game calculates the different KPI's based on their common theoretical definitions and the possible inputs from the UMSG model. Players can influence the inputs for the KPI's through 25 possible decisions that can be made each turn. Each decision carries monetary costs and investments, which are calculated with fixed unitary prices. These decisions can be seen below in Table 2. For an in-depth explanation of the decision variables rationale, please refer to the Participant's Manual section: **Decisions**.

Utility Efficiency and "Golden" Ratios

In order to simplify the complexity between the various factors that impact a utility's performance, UMSG uses the concept of an overall Utility Efficiency (UE) ratio, which reflects how efficient the processes carried out by the utility are. Within the UMSG, the UE is assumed to be composed of the following two components (expressed in ratios): Staff (50%) and Processes (50%). Each component is further composed by different sub-components with different weights, as shown in Table 1: "Golden" Ratios. The UE ratio works as a factor of efficiency in several processes of the utility, providing a boost or a penalty on the processes carried out. In this version of the UMSG, the UE is capped at 1, and boost have been taken into account individually in each equation deemed relevant. It is worth noting that some of the sub-components also directly relate to certain processes and KPI's, and therefore are incorporated in the simulation's calculations beyond just the UE.

The concept of 'Golden Ratios' assumes that there are optimal ratios between different aspects of the utility's operations that can lead to higher efficiencies. Beyond this optimal ratio, the processes will not significantly improve, thus costing the utility more money while not producing better results. Some of the ratios also have a minimum barrier, meaning that if the balance between components drops below the minimum barrier, the process is rendered completely inefficient and does not provide benefits for the utility. Two examples of how these ratios work are presented after Table 1, followed by the descriptions of the remaining ratios.

It is worth noting that these ratios are based on discussions with experts from the Dutch academic and water service provision sectors, and as such are extremely limited as a guidance for other countries and locations. Each water service provider will have a certain optimal scenario for the ratios considered below that will highly depend on physical and technical characteristics of the system, cultural and organizational practices of the employees, and a number of other factors unique to each context. The purpose of discussing these ratios is to highlight the existence of relations between different aspects of a utility's operation, and the usefulness of considering these when making decisions.

Table 1. "Golden" Ratios

Utility Efficiency (UE): 0.5 * ∑ Staff 'Golden' Ratios + 0.5 * ∑ Process 'Golden' Ratios			
Staff 'Golden' Ratios	*Optimal*	*Initial values*	*Weight*
Director to Manager	0.200	0.292	3.75%
Management to Workers	0.125	0.340	11.25%
Workers to Network Size (km)	0.168	0.124	25%
Workers to Treatment Capacity (m^3)	0.000005	0.000004	20%
Bill Collectors to # of Connections	0.000685	0.000513	20%

Costumer Service to # of Connections	0.0028	0.0018	20%
Process 'Golden' Ratios	*Optimal*	*Initial values*	*Weight*
Leakage Trainees / Operational Staff over a 4 year period	1	0	10%
Trainees / Staff over a 4 year-period	1	0	30%
SOP's over a 3-year-period	5	0	30%
Office packages / year	2	0	20%
Awareness Campaigns / year	1	0	10%

Examples

Director to Manager: This ratio reflects the ideal number of managers a director can effectively and efficiently work with. In the current example, the number of Directors at the beginning of the game is higher than the optimal (0.292 > 0.200), meaning this sub-component adds its full weight (25%) to the Staff 'Golden' Ratios component of the UE factor. However, as more directors beyond the optimal point do not improve performance, the additional directors only represent a "benefit-less" cost to the water utility.

SOP's / year: This ratio reflects the need for utility's to adequately design, implement, evaluate, and re-develop their operating procedures on a regular basis as this ensures that procedures are up to the latest standards, and staff are aware and involved in their implementation. In the current example, the optimal number of SOP related activities is set at 5 SOPs over any 3 year period. As none are being implemented at the beginning of the game, SOP's do not add any value to the Process 'Golden' Ratios component at the start of the game.

Explanation of other ratios

Management to Workers: This ratio reflects the ideal number of workers a manager can effectively and efficiently work with, and considers the sum of all workers (operational, bill collectors, and customer service).

Workers to Network Size (km): This ratio considers that for adequate operation of the distribution system, a certain number of workers per kilometer of network are required; these workers would carry out tasks such as identifying leaks, operating booster pumping stations, and on-the-job maintenance for branched connections.

Workers to Treatment Capacity: This ratio reflects the minimum number of operational workers needed per size of the treatment facility (expressed as treatment capacity) to ensure adequate and efficient processes.

Bill Collectors to # of Connections: This ratio reflects the ideal number of bill collectors needed to cover the existing connections and carry out the necessary collection tasks.

Customer Services to # of Connections: This ratio reflects the ideal number of customer service employees needed to cover the requests and complaints from current customers connected.

Leakage Trainees per Operational Staff: This ratio highlights the importance of NRW for operational staff, and considers the number of operational staff that have received training on detecting leakages over the last 4 years.

Trainees per Staff: This ratio considers that for processes to work adequately, staff must be trained on a regular basis. As such, this takes into account the percentage of staff that has been trained over the past 4 years (including the leakage trainees) over the current staff to reflect how much of the staff has 'recently' received training.

Office packages per year: This ratio considers that for processes to work adequately, staff must have the necessary tools in terms of hardware, software, equipment, and office supplies. As these tools are either consumable or quickly outdated by newer versions, this ratio measures how up-to-date the tools are in order to allow for efficient processes.

Awareness campaigns per year: This ratio considers that for a water utility to operate adequately within its context, it needs to continuously socialize both internally and externally the changes in their processes and activities.

Decisions influence over KPIs and Ratios

Each of the potential decisions management teams make through the "Management Decisions Sheet" impacts the utility's performance and its KPI's in particular ways.

Table 2. Decisions' impact on KPIs and "Golden" Ratios

1	*Financial Decisions*	*This decision impacts*
1.1	Subsidy on connection fee	• the utility's cost (higher subsidy = higher cost) • the number of illegal connections (higher subsidy = lower illegal connections) • the consumers' willingness to connect to new available connections (higher subsidy = higher willingness to connect).
1.2	In-house Tariff	• the number of illegal connections (higher tariff = higher illegal connections) • the utility's total income (higher tariff = higher income based on # of connections and # of illegal connections) • the affordability of the service (higher tariff = lower affordability) • the customer satisfaction (higher tariff with respect to previous year's tariff = lower customer satisfaction)
1.3	Water Kiosks (Wk) Tariff	• the utility's total income (higher tariff = higher income based on # of connections and # of illegal connections)
1.4	Un-metered Connection Tariff	• the utility's total income (higher tariff = higher income based on # of connections and # of illegal connections)
2	*Infrastructural Decisions*	*This decision impacts*
2.1	Additional Water Kiosks	• the utility's coverage (more Kiosks = higher coverage) • the utility's income (more Kiosks = higher income) • the utility's cost for the year (more Kiosks = higher investment cost) • the distribution of available water (more Kiosks = more water sent to Kiosks). This becomes relevant in Years 5-7 during drought.

2.2	Additional Distribution Network	• the number of in-house connections (more network = more connections) • the utility's coverage (more connections = higher coverage) • the utility's income (more connections = higher income) • the utility's cost for the year (more network = higher investment cost) • the distribution of available water (more connections = more water sent to connections). This becomes relevant in Years 5-7 during drought. • the overall value of the asset
2.3	Additional Water Treatment Capacity	• the utility's cost for the year (more capacity = higher investment cost) • the amount of water that can be supplied to the network • the overall value of the asset
2.4	Additional Water Resources Abstracted	• the utility's cost for the year (more abstraction = higher investment cost) • the amount of water that can be supplied to the network • the overall value of the asset
2.5	Additional Number of Meters Type A Additional Number of Meters Type B Additional Number of Meters Type C	• the utility's cost for the year (more meters = higher investment cost) • the water consumption per capita as it reduces the number of un-metered connections (more meters = less water consumed per capita served) • the commercial losses (more meters = less meter errors = less commercial losses). The type of meter chosen impacts the degree to which commercial losses are decreased.
3	*Human Resource Decisions*	*This decision impacts*
3.1	Additional Director	• the utility's cost for the year, even if they are fired for that specific year (more staff = higher investment cost) • the utility's efficiency ratio based on staff efficiency overall and process efficiency with regards to trainees ratio
3.2	Additional Manager	• the utility's cost for the year, even if they are fired for that specific year (more staff = higher investment cost) • the utility's efficiency ratio based on staff efficiency overall and process efficiency with regards to trainees ratio

3.3	Additional Operational Staff	• the utility's cost for the year, even if they are fired for that specific year (more staff = higher investment cost) • the utility's efficiency ratio based on staff efficiency overall and process efficiency with regards to trainees ratio • the utility's (in)efficiency with regards to O&M • the utility's (in)efficiency with regards to physical water losses • the utility's water quality
3.4	Additional Bill Collectors	• the utility's cost for the year, even if they are fired for that specific year (more staff = higher investment cost) • the utility's efficiency ratio based on staff efficiency overall and process efficiency with regards to trainees ratio • the utility's collection efficiency
3.5	Additional Costumer Services Employees	• the utility's cost for the year, even if they are fired for that specific year (more staff = higher investment cost) • the utility's efficiency ratio based on staff efficiency overall and process efficiency with regards to trainees ratio • the utility's collection efficiency • the customer satisfaction
4	*Maintenance Decisions*	*This decision impacts*
4.1	Rehabilitated Network	• the utility's water quality • the physical losses over a 5 year period
4.2	Treatment Maintenance	• the utility's water quality
4.3	Resources Maintenance	• the utility's water quality
4.4	Additional Meter Calibration Program	• the utility's commercial losses
5	*Capacity Development Decisions*	*This decision impacts*
5.1	Additional Leakage Trainees	• the utility's process efficiency ratio • the physical losses • the O&M (in)efficiency, i.e. operating costs
5.2	Additional Customer Management trainees	• the utility's process efficiency ratio • the customer satisfaction
5.3	Additional Office technology and infrastructure	• the utility's process efficiency ratio

5.4	Standard Operating Procedures	• the utility's process efficiency ratio • the O&M (in)efficiency, i.e. operating costs
5.5	Awareness Campaigns	• the utility's process efficiency ratio • the customer satisfaction • the willingness to connect
	Water Distribution	*This decision impacts*
A B	Water distribution between In-house and PSP connections (only applicable during Years 5-7, drought scenario.	• The percentage of water distributed to either in-house or PSP connections and a 'dummy' public health warning.

Equations used in UMSG for KPI estimation

The following section provides an overview of the various equations that have been designed to model the utility's performance and KPI's. These equations are meant for the Facilitator to have a better understanding of how UMSG calculates the outputs produced. Although it may be shared with participants, it is recommended to do so only at the end in order to maintain an atmosphere of uncertainty in their decision-making processes similar to the conditions in which actual utilities operate. Below are the relevant parameters, their initial values at the beginning of the game, and the equations with which these values are calculated throughout the game.

Equations used in UMSG for KPI estimation

The following section provides an overview of the various equations that have been designed to model the utility's performance and KPI's. These equations are meant for the Facilitator to have a better understanding of how UMSG calculates the outputs produced. Although it may be shared with participants, it is recommended to this only at the end in order to maintain an atmosphere of uncertainty in their decision-making processes similar to the conditions in which actual utilities operate. Below are the relevant parameters, their initial values at the beginning of the game, and the equations with which these values are calculated throughout the game.

- **Grant (Utility's funds): 15,000,000 USD**

  $Grant_n(USD) = Grant_{n-1} + Income_{total_n} - Cost_{total_n}$, if this value reaches less than 0, the utility becomes bankrupt.

- **Connections (Cnxs): 50,639**

  $$Cnxs_N = Cnxs_{N-1} + 0.7 * [Network_N * \frac{Connections_{Original}}{Network_{Original}} - Cnxs_{N-1}] + 0.3 * WtC * [Network_N * \frac{Connections_{Original}}{Network_{Original}} - Cnxs_{N-1}]$$

  Note: All new connections are included as un-metered connections.

- **Water Kiosks (Wk): 626**

  $Wk_N = Wk_{N-1} + UserInput$

- **No. of Metered Connections: 16,711**

  $Meter_N = Meter_{N-1} + \sum Meter_{TYPE}(UserInput),$

  Note: Can only have as many meters as connections, once this is capped, facilitator must subtract lower caliber meters for the higher caliber meters by subtracting them in the 'Yearly Decisions' tab, i.e. putting a minus sign in front of the number of lower meter types that are being replaced in that turn.

- **No. of Un-Metered Connections: 33,928**

  $Unmetered_N = Unmetered_{N-1} - Meter_N$

- **Population: 1,077,116 inhabitants**

  $Population_N(Inhab.) = (Population_{N-1}) * (1 + Pop.Growth_{Rate})$

- **GDP per capita: 3,004 USD/capita/year**

$$GDP_{N+1}(Inhab.) = (GDP_N) * (1 + AnnualInflation_{Rate})$$

- **Population Served: 846,442 inhabitants**

$$Population_{served}(Inhab.) = (No.Connections_{In-house}) * \frac{8inhab.}{Connection_{In-house}} + (No.Connection_{Wk}) * \frac{705inhab.}{Connection_{Wk}}$$

- **Illegal Connections: 2,532, around 5% of initial connections**

$$No.Connections_{illegal} = [(0.0994 * Tariff_{In-house} - 0.0118) * 0.5 + (-0.0882 * \%Subsidy + 0.0945) * 0.5] * No.Connections_N$$

Note: Illegal connections are based on a linear regression applicable for this case study. It can be found in EQ tab of the UMSG excel file.

- **Network Size: 1,051 Km**

$$Network_{Actual}(km)_n = Network(km)_{n-1} + UserInput$$

- **Vol. Produced: 34,936,340 m^3 /year**

$Vol\_Produced_N(\frac{m^3}{Year}) = Vol\_Produced_{N-1} + UserInput$; Note: **If** Vol_Produced > Vol_Available **Then** Vol_Available used for supply.

- **Vol. Resource Available: 34,936,340 m^3 /year**

$Vol\_Available_N(\frac{m^3}{Year}) = Vol\_Abstracted_{N-1} + UserInput$; Note: **If** Vol_Produced < Vol_Available **Then** Vol_Produced used for supply.

Note: During Turns 5 to 7 (Years 5 to 7), a drought is simulated by restricting the resource available to 75% of the value of Year 4. This remains constant for the 3 years, so investments on abstractions or treatment are not accounted for until Year 8. The value of the drought can be changed in the Initial Values (INI-VAL) sheet in the UMSG excel file.

- **Initial Vol. Lost: 16,070,751 m^3 / year**

$$Vol.Lost_N(\frac{m^3}{Year}) = Vol_{Produced} * (\%PhysicalLosses_N + \%CommercialLosses_N)$$

- **Vol. Supplied: 18,865,589 m^3 /year**

$$Vol.Supplied(\frac{m^3}{Year}) = Vol\_Produced - Vol.Lost$$

- **Full Cost Recovery Ratio: 0.73**

$$CostRecovery = \frac{Income_{total}}{Cost_{total}}$$

- **Total Income: 8,310,699 USD/year**

$$Income_{total}(\frac{U\$D}{year}) = Consumption(m^3)_{Con.type} * Tariff_{Con.type}(\frac{U\$D}{m^3}) * Eff.Collection_{Con.type};$$

where connection types are metered, PSP, and un-metered. To only count the metered in-house connections (not total in-house consumption) the formula uses a percentage of # of Meters / In-house Connections.

- **Demand: 18,870,866 m^3 / year**

$$Vol_{demanded}(\frac{m^3}{Year}) = (No.Connections_{metered} * 10.85\frac{m^3}{month} + No.Connections_{PSP} * 70\frac{m^3}{month} + No.Connections_{unmetered} * 16.26\frac{m^3}{month}) * 12months$$

- **Collection Efficiency : 0.72 (Initial Value)**

$$Eff.Collection = [-0.464 * Ln(Affordability) - 0.8554] * 0.3 + Cust.Satisf. * 0.3 + \frac{Bill.Coll's}{Ntwk_{size}} Ratio * 0.3 + U.E. * 0.1$$

Note: Collection efficiency for standpipes is set at 100%; and un-metered and metered collection efficiency are equal.

- **Total Cost: 11,447,000 U$D/year**

$$Cost_{total}\left(\frac{U\$D}{year}\right) = Staff_{cost} + Infraestructure_{Investment} + Cost_{O\&M}$$

- **Staff Cost: 4,572,000 U$D/year**

$$Cost_{staff}\left(\frac{U\$D}{year}\right) = Directors * 60000\frac{U\$D}{year} + Managers * 30000\frac{U\$D}{year} + (Workers + BillCollectors + C.S.Employees) * 6000\frac{U\$D}{year} + Personel_{Fired}$$

$$Personel_{fired}\left(\frac{U\$D}{year}\right) = (Directors_{fired} * 60000\frac{U\$D}{year} + Managers_{fired} * 30000\frac{U\$D}{year} + (Workers + BillCollectors + C.S.Employees)_{fired} * 6000\frac{U\$D}{year}) * 0.5$$

- **Total Infrastructure Investment:**

$$Infrastructure_{INV}\left(\frac{U\$D}{year}\right) = Distribution_{INV.} + Production_{INV.} + Resources_{INV.} + Wk_{INV.} + Meters_{INV.}$$

- **Total Operation & Maintenance: 6,875,000 U$D/year ; O&M Inefficiency: 1.3**

$$Cost_{O\&M}\left(\frac{U\$D}{year}\right) = (0.7 * Cost_{O\&Minitial} * Inflation^{year} * Ineff_{O\&M}) + (0.3 * \sum O\&M\ Investments * Ineff_{O\&M})$$

$$Inefficiency_{O\&M} = Inefficiency_{O\&M_{n-1}} + 0{,}1 - [0.4 * SOP's_{RATIO} + 0.3 * \frac{Workers}{Ntwks_{SIZE}}{}_{RATIO} + 0.2 * \frac{LeakageTrainees}{Workers}{}_{RATIO} + 0.1 * U.E.]/4$$

Note: If for the current turn there is no O&M investment or the investment is below the annual inflation increase, the program automatically calculates the initial value of total O&M affected by the inflation rate powered by the number of passed years until the actual round.

- **Asset Value: 68,750,000 U$D**

$$Asset_N(U\$D) = Asset_{N-1} + Inv._{Distribution} + Inv._{Production} + Inv._{Resources} - Depreciation$$

- **Depreciation: 1,375,000 U$D/year** *(2% of the Asset Value)*

$$Depreciation_N(U\$D) = (Asset_{N-1}) * 0.02$$

- **Affordability: 5.0%**

$$Affordability = \frac{\left(Tariff\left(\frac{U\$D}{m^3}\right) * Consumption\left(\frac{m^3}{month}\right) * 12\right)_{Inhouse}}{GDP\frac{U\$D}{Inhab/year_n}}$$; Note: Affordability only calculates based on In-house cxns.

- **Customer Satisfaction: 7.0/10**

$$Customer\_Satisfaction = \Delta Tariff * 0.4 + W.Quality._N * 0.2 + Continuity_N * 0.2 + Awareness * 0.1 + \frac{C.S.employees}{No.Cnxs_N}{}_{RATIO} * 0.1$$

Note: the ΔTariff improves customer satisfaction if it its lower than previous year's tariff and vice versa.

- **Awareness: 7/10**

$$Awareness_N = Awareness_{N-1} + No.ofAwarenessCampaigns$$; If no awareness campaigns are carried out 0.5 is subtracted.

- **Water Quality: 70% (Initial Value)**

$$W.Q. = [\Delta Physical_{LOSSES} + \frac{Distribution_{O\&M}}{Ntwk_{SIZE}} + \frac{Resources_{O\&M}}{Resources_{SIZE}} + \frac{Treatment_{O\&M}}{Treatment_{SIZE}}] * 0.8 + \frac{Workers}{Trmt_{SIZE}}{}_{RATIO} * 0.1 + U.E. * 0.1$$

As conditional value, the function is set to have a maximum of 95%. All O&M factors add the previous 5 years of maintenance investments.

- **Continuity: 71.8% or 17.2 hours**

$$Continuity(\%) = \begin{pmatrix} (-26.952 * Phy_{Loss}{}^2 - 10.56 * Phy._{Loss} + 23.6) * 0.7 + (218.85\frac{No.Cnxs_{Illegal}}{No.Cnxs_N} + 2.33) * 0.15 + \\ (-0.0006 * No.Cnxs_N + 43.47) * 0.15 \end{pmatrix} \frac{Vol_{Supplied_N}}{Vol._{Consumed_N} * 24} + 0.028$$

The equation for Continuity is based on a best-fit line based on potential scenarios which consider Physical Losses, # of Connections, and # of Illegal Connections. The data used for this can be found on the 'EQ' tab, which by default is hidden, in the Excel interface.

- **Physical Losses Percentage: 30%**

$$Ph_{losses}(\%) = \frac{Vol._{lost}}{Vol._{produced}}$$

- **Physical Loss Volume: 10,480,902 m^3**

$$Vol_{lost} = (0.2 * Network_{new} + Network_{old}) * \frac{8718m^3}{Km} * Phy.Loss.Eff_N$$

The program contains a macro routine that updates old network into new network based on the maintenance decisions, and also turns new network into old network after 5 years of being constructed.

- **Physical Losses Efficiency: 1.4**

$$Phy.Loss.Eff_N = Phy.Loss.Eff_{N-1} + 0.1 - [0.1 * UE + 0.2 * \frac{Leak.Trainees}{Op.Workers}_{RATIO} + 0.7 * \frac{Distribution_{O\&M}}{Ntwk.Size_N}_{RATIO}] * 0.2$$

Leakage Trainees over 4 year span, Distribution O&M over 5 year span

- **Commercial Losses Percentage: 15%**

$$Comercial_{losses}(\%) = \%Consumption_{own} + (\%)Error_{metering} + (\%)Connection_{illegal}$$

- **Commercial Loss Volume: 5,240,835 m^3**

$$Vol._{loss}\,Comercial = Comercial_{losses}(\%) * Vol._{produced}$$

- **Illegal Connections Percentage: 5%**

$$Connections_{illegal}(\%) = \frac{No.Connections_{illegal}}{No.Connections_{total}}$$

- **Meter Errors: 10%**

$$(\%)Error_{metering\ N} = \frac{Meter_{TYPE} \cdot ErrorMargin_{TYPE}}{\Sigma Meters_N} - \frac{\Sigma Meter.Calibration}{\Sigma Meters_N}$$

The equation in Excel is constrained to: Errors cannot go above 10%, Calibration investments last 4 years, and if 20% or less of the meters existing are calibrated, then the error margin increases.

- **Own Use: 1% (Constant Value)**
- **Coverage: 79%**

$$\%Coverage = \frac{Population.Served_N}{Population.Actual_N}$$

- **Willingness to Connect: 85%**

$$W.t.C._N = 0.7 + [0.03 * (Awareness_N + 2 * \%Subsidy_N) / 3]\ ;$$

where Awareness and %Subsidy are converted to values between 1-10, and a minimum of 70% of people that can connect, will connect when network is extended, regardless of either Awareness or Subsidy.

Handout for Teams

Print and distribute the following set of tables for each team.

Management Decisions Form		Unit	Initial Value	Turn 1	Turn 2	Turn 3	Turn 4	Turn 5	Turn 6	Turn 7	Turn 8	Turn 9	Turn 10
1 Financial Decisions													
1.1	Subsidy on connection fee	%	40%										
1.2	In-house Tariff	US$/m^3	0.61										
1.3	Water Kiosk Tariff	US$/m^3	1.04										
1.4	Un-metered Connection Tariff	US$/Connection	150.21										
2 Infrastructural Decisions													
2.1	Additional Water Kiosks	No. Of WK	626										
2.2	Additional Distribution Network	km network	1,051										
2.3	Additional Water Treatment Capacity	m^3	34,936,340										
2.4	Additional Water Resources Abstracted	m^3	34,936,340										
2.5	Additional Number of Meters Type A	No. A Meters	0										
	Additional Number of Meters Type B	No. B Meters	0										
	Additional Number of Meters Type C	No. C Meters	16,711										
3 Human Resources Decisions													
3.1	Additional Director	No. Directors	19										
3.2	Additional Manager	No. Managers	65										
3.3	Additional Operational Staff	No. Op Staff	130										
3.4	Additional Bill Collectors	No. Bill. Col	26										
3.5	Additional Costumer Services Staff	No. Cost. Serv.	91										
4 Maintenance Decisions													
4.1	Rehabilitated Network	Km	0										
4.2	Treatment Maintenance	m^3	0										
4.3	Resources Maintenance	m^3	0										
4.4	Additional Meter Calibration Program	No. meters	0										
5 Capacity Development Decisions													
5.1	Additional Leakage Trainees	No. Trainees	0										
5.2	Additional Staff Trainings	No. Trainees	0										
5.3	Additional Office technology	Package	0										
5.4	Standard Operating Procedures	Procedure	0										
5.5	Awareness Campaigns	Procedure	0										

KPIs Initial value			
KPIS	*Value*	*Range*	*Manager*
Collection Efficiency	72%	0-100	Commercial
Commercial Water Losses	16%	0-100	Commercial
Customer Satisfaction	75%	0-100	Commercial
Willingness to Connect	85%	0-100	Commercial
Affordability	5%	0-100	Financial
Full Recovery Cost Ratio	73%	0-100	Financial
Asset Depreciation	101,244	n/a	Financial
Asset Value	5,062,200	n/a	Financial
Physical Losses	30%	0-100	Operational
Coverage	79%	0-100	Operational
Continuity (Hours)	17.2	0-24	Operational
Water Quality	70%	0-100	Operational
Utility Efficiency	45%	0-100	General Manager

Unitary cost of each decision	
	Unitary Cost
Financial	
Subsidy (for connection fee)	150 USD
In-house Tariff	0.61 USD/m^3
Water Kiosk Tariff	1.04 USD/m^3
Un-metered Connection Tariff	150.21 USD/connection
Infrastructure	
Additional Water Kiosk	10,000 USD/Kiosk
Additional Network	22,700 USD/km
Additional Water Treatment Capacity	0.33 USD/m^3
Additional Water Resources Abstracted	0.11 USD/m^3
Additional A-type meters	200 USD/meter
Additional B-type meters	150 USD/meter
Additional C-type meters	100 USD/meter
Staff	
Additional Director	60,000 USD/year/employee
Additional Manager	30,000 USD/year/employee
Additional Workers	6,000 USD/year/employee
Additional Bill Collectors	6,000 USD/year/employee
Additional Costumer Services Employees	6,000 USD/year/employee
Maintenance	
Rehabilitated Network	20,000 USD/km
Treatment Maintenance	0.012 USD/m3
Resources Maintenance	0.0038 USD/m3
Meter Calibration Program	10 USD/meter
Capacity Development	
Additional Leakage Trainees	750 USD/year/employee
Additional Staff Training	1,000 USD/year/employee
Additional Office technology	5,000 USD/year/package
SOPs	10,000 USD/year/procedure
Awareness Campaigns	5,000 USD/year/campaign

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