

THE GROUNDWATER GAME

A Serious Game on Improving Groundwater Management
Through Cooperation and Collective Action

MANUAL FOR FACILITATOR

GW-GAME VERSION: MARCH 2020

Delft, March 2020



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For information about the game or questions regarding the use of it, please contact the International Groundwater Resources Assessment Centre at info@un-igrac.org.

ACKNOWLEDGEMENT

IGRAC would like to all involved in developing the GW-Game and to all who gave their valuable remarks and inputs for improving the game throughout the years. We would also like to thank to those who participated in many game-sessions and for their contributions and feedback aiming to improve the GW-Game experience. And last, our special gratitude to the *GroFutures* project team who brought insights and improvements onto the GW-Game and IDS.

TABLE OF CONTENTS

1.0	<i>INTRODUCTION</i>	5
1.1	About the Game	5
1.2	Project References.....	6
1.3	How to use this manual.....	6
2.0	<i>GAME OVERVIEW</i>	7
2.1	Context of the GW-Game	7
2.2	Game roles.....	7
2.3	The lake.....	8
2.4	The wells.....	8
2.5	Game flow.....	10
3.0	<i>GAME RULES</i>	11
3.1	General rules – All Scenarios	13
3.2	Scenario 1 – “Randomly pumping”	14
3.3	Scenario 2 – “Reaching cooperation”	14
3.4	Scenario 3 – “Advanced management”	15
4.0	<i>FACILITATING A GAME SESSION</i>	16
4.1	Set up.....	16
4.2	Using the Excel file.....	17
4.3	Using the PowerPoint presentation	18
4.4	Using the GW GAME Apps.....	18
4.4.3	Pre-Game Preparation.....	22
4.4.4	Running a Game	23
4.5	Finishing the GAME	26
5.0	<i>REFERENCES</i>	27
6.0	<i>APPENDIXES</i>	28

1.0 INTRODUCTION

1.1 About the Game

1.1.1 Context

The Groundwater Game - A Serious Game¹ on Improving Groundwater Management through Cooperation and Collective Action (GW-Game) is a computer simulation, Excel based, in which each player or team of players is part of a rural community growing crops and irrigating their land with groundwater. Each player/team of players is represented by a well.

The goal of the players is to reach prosperity and well-being. Players are expected to maximize their income by producing as much as possible, which in the beginning means more groundwater exploration. But as the game evolves groundwater table is expected to drawdown which results in environmental consequences directly affecting the community and the players.

During the game different groundwater management scenarios are proposed and players will be driven to take measures to better manage groundwater and still get the best profit out of their crops. Increasing pumping costs lower the profits and environmental costs, associated with a nearby lake, have to be taken into consideration. Players have to deal with these elements while looking for the best way to manage their land and a common resource such as groundwater.

1.1.2 Learning Objectives

The GW-Game can be played by all different kinds of audiences: from students to community representatives and from politicians to scientists. The objectives of the GW-Game are to:

- (i) improve the participants' understanding of the functioning of groundwater systems and introduce technical concepts;
- (ii) foster a deeper appreciation of the collective action choices and challenges for regulating groundwater use by influencing policies and management practices; and
- (iii) open up a discussion on the challenges of sustainable and equitable groundwater resources management.

The learning objective of this serious game aims at improving the player's insight in the social dilemma of tragedy of the commons through different groundwater management scenarios. This dilemma is about abstracting and using goods and/or services from a common pool (groundwater resources in this case). A conflict of interests exists between the individual user and the collective. As it is unclear how much goods are used and thus how longer the common pool will exist, the individual users have an incentive to abstract as much and as soon as possible. Over-abstraction may follow with large consequences to the whole community. All these considerations happen through different development conditions adding or removing elements that influence the player's decisions. In this game players learn relevant concepts like groundwater development, common pool resources, development scenarios, data regulation, transaction costs, groundwater management, and collective action.

¹ Serious Game: computer based simulation platforms designed for a specific learning purpose.

1.1.3 Playing the game

The game is played during a game-session, facilitated by one person (the Game Facilitator), preferably assisted by another person. The game itself is built within a MS-Excel calculation sheet and is supported by a PowerPoint presentation, both managed by the game facilitator. The game is managed using the GW Manager App, which is installed in the game facilitator's computer. The players use the GW Player App to enter their moves for each round and see the outcomes of their plays. With the support of PowerPoint presentation and the GW Manager App the game facilitator guides the game session. For each new game-session, the only necessary modifications to the PowerPoint presentation are to the first slide (date, locations, project name, etc.).

Players' inputs to the game, reflecting their farming decisions (e.g. the area to crop), are made using the GW Player App which can be installed on Android smartphones or Windows computers. The GW Player App transmits the data to the GW Manager App which updates the Excel spreadsheet under the control of the game facilitator. In the Excel spreadsheet a series of hydrogeological and economic results are calculate in different worksheets.

The game consists of three different Groundwater Management Scenarios divided into eight playing rounds:

- Scenario 1 (*Randomly pumping*) - 2 rounds
- Scenario 2 (*Reaching Cooperation*) – 3 rounds
- Scenario 3 (*Advanced Management*) – 3 rounds

In each round independently of the scenario, players have to decide on the area to crop and therefore irrigate. In between scenarios players will have the opportunity to change their strategy by adding new features, as for example buy water saving equipment or communicate with the other players in order to limit groundwater abstraction in response to the overall drawdown of the groundwater resources affecting the players goals.

After each round the game facilitators runs the game (i.e. the Excel calculations) and results are shared with the players in order for them to think the about the following plays. The game ends with an evaluation round to discuss the lessons learned and general comments about the outcomes of the game.

1.2 Project References

The game was designed under the theory and article “The Tragedy of the Commons” published in 1968 by Garret Hardin. In 2008 at IGRAC, Frank van Weert adapted this idea and translated it into a game called “The Tragedy of the Groundwater Commons”. This new version of the game continues Frank van Weerts' work adding new concepts and elements into the existing game.

IGRAC has further developed and adjusted the game since 2014 to be use as a tool for the Social Sciences component of the GroFutures project. The current version (March2020) has been further optimized for the purposes of the GroFutures project and the reality of Sub-Saharan Africa.

1.3 How to use this manual

The manual contains the following structure:

- **1.0 Introduction:**

This chapter introduces the game, explains its context, learning objectives and the main information about the game.

- **2.0 Game overview:**
The elements necessary to setup the game are listed here, the flow of the game and the different roles are explained in this section too.
- **3.0 Game rules:**
This chapter explains the time framework of the game and all the rules.
- **4.0 Facilitating a game session:**
All the instructions on how to play the game are listed in this chapter step by step.
- **6.0 References:**
- **Appendixes**

2.0 GAME OVERVIEW

2.1 Context of the GW-Game

The GW-Game is set up in a rural community and can be played by individuals or groups whereas they assume the role of farmers. Every farming household has a farmland of 5 hectares and owns its own groundwater well (needed for groundwater irrigation). There are nine² wells in the game. Each player or team of players, plays with a well. Only one type of crop is grown. Each game round represents a growing season, producing a harvesting and generating income.

Nearby the rural community there is a lake from which farmers can fish, being a valuable source of nourishment. The lake is also a touristic attraction which influences the community's economy. The water level in the lake and thus its ecological balance is influenced by the groundwater level in the aquifer, that is, pumping in the wells by the farmers.

2.2 Game roles

The people necessary to play the game consists of at least one facilitator (preferably two with big groups) and a minimum of nine to a maximum of thirty players (maximum of 3/4 players per team).

2.2.1 Facilitator

The facilitator or 'Game Manager' is responsible for all aspects of the game session. He/she sets the game environment, placing the players in their roles as farmers and introducing the context and storyline for each scenario with the help of the PowerPoint presentation. The facilitator directs the flow of the game by starting each simulation run and prompting the players to make their decisions regarding how much land they want to farm and other scenario-specific issues. The facilitator enforces the rules and provides motivation and guidance to the players throughout the game. When players have uploaded their decisions using the GW Player App, the facilitator updates the Excel spreadsheet via the Game Manager app, and encourages the players to reflect on the outcome of their decisions.

² The MS-Excel sheet is prepared for up to 9 wells, and has features to extend it to up to 20 wells, which will also increase the number of participants to a maximum of 60 (preferably not more than 3 per well).

By the end of the game, the facilitator(s) explains the outcomes and conclusions coming from the game results and promotes a final discussion around the learning objectives of the game. The role of the facilitator in directing the story and context of the game is essential for the functioning and understanding of the game. The learning objectives of the game rely heavily on how the facilitator(s) leads the game.

The facilitator must know very well the game rules and game setting, for that he/she must: read this manual, study the PowerPoint presentation and the Excel game file and become familiar with the game apps.

2.2.2 Farmers

The players will be participating in the game in the role of farmers who live in a small rural community. The main task of the players is to decide how much land they want to farm in each round. Once every farmer has taken his/her decision, the result will be presented and he/she should evaluate the economic impact of that decision, think about continuing with the same strategy or change it in the next round, in order to accumulate benefits and finish the game with as much income as possible.

2.3 The lake

The lake's role is automatically set up in the Excel calculation sheet. This role is not actively played by anyone. However the lake is affected by the players' actions and in turn also affects their decisions. The groundwater pumping activity for irrigation influences the water level in the lake which might result in negative environmental impacts and financial consequences to the community if it runs dry. The lake is essential for the game storyline and learning objectives representing the environmental impacts of over-exploration of groundwater.

2.4 The wells

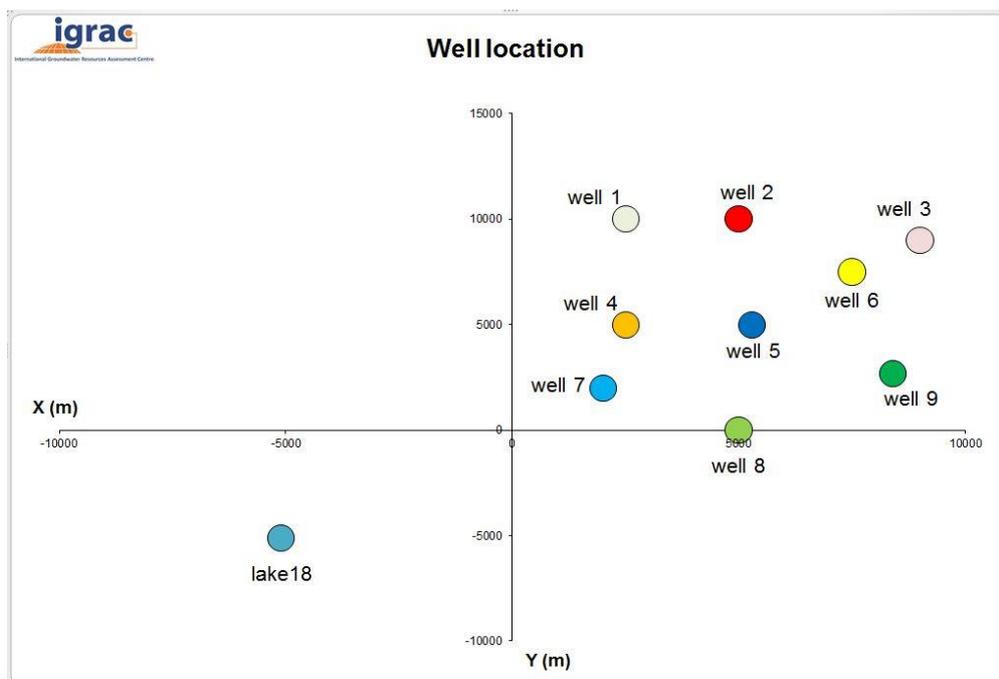


Figure 1: Setting of the wells and the lake in the Groundwater Game.

The GW-Game works around groundwater pumping activities. Pumping for irrigation causes the drawdown of the groundwater table, which will vary according to the pumping rates of each player, i.e. the area each player decides to irrigate in each round (i.e. growing season). The drawdown is cumulative until the last round and in between rounds groundwater levels in the wells and in the lake do not recover completely. The layout of the wells and the lake as it is in the Excel calculation sheet is shown in figure 1. Pumping in each well can influence the neighboring wells and furthermore the drawdown effect of all wells irrigating can bring the lake to dry.

Drawdowns are calculated using the Theis solution: $D = \frac{Q}{4\pi T} W(u)$ and displayed in the Excel file (see chapter 5.1 and appendix 1)

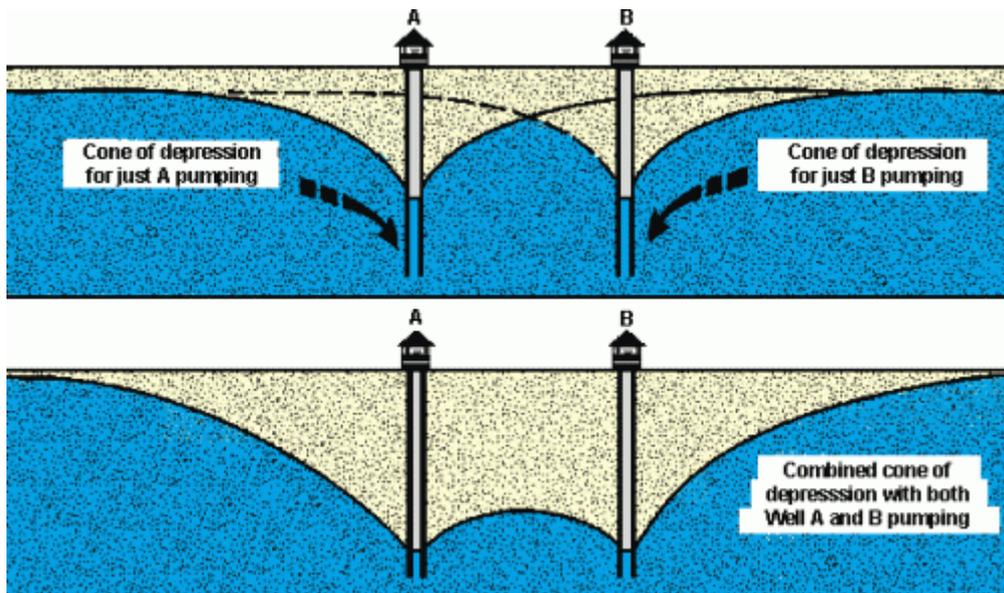


Figure 2: Impact of overlapping drawdown between wells.

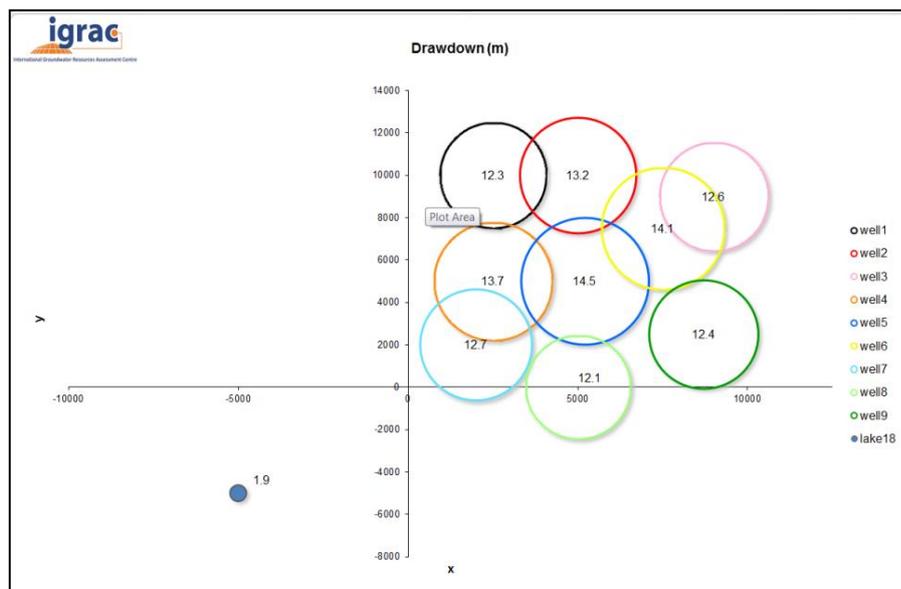


Figure 3: Drawdown illustration on a map, view from above.

2.5 Game flow

The game consists of **three** scenarios divided in a series of **eight** rounds, each one representing one growing season (Figure 4). The scenarios are named: “Randomly Pumping” (2 rounds), “Reaching Cooperation” (3 rounds) and “Advanced Management” (3 rounds). Each scenario has its own context and set of rules and management possibilities. As the game is played, before each scenario the facilitator explains the scenario setting and provides to the players the rules and existing features, if any, that players can use in their strategy. This way in the beginning of the game the players will not have access to the entire set of information on how the game will develop. In scenario 1 players only have limited information regarding their own farmland. Later in the game in Scenarios 2 and 3, more information and features are made available for players to use in their strategies.

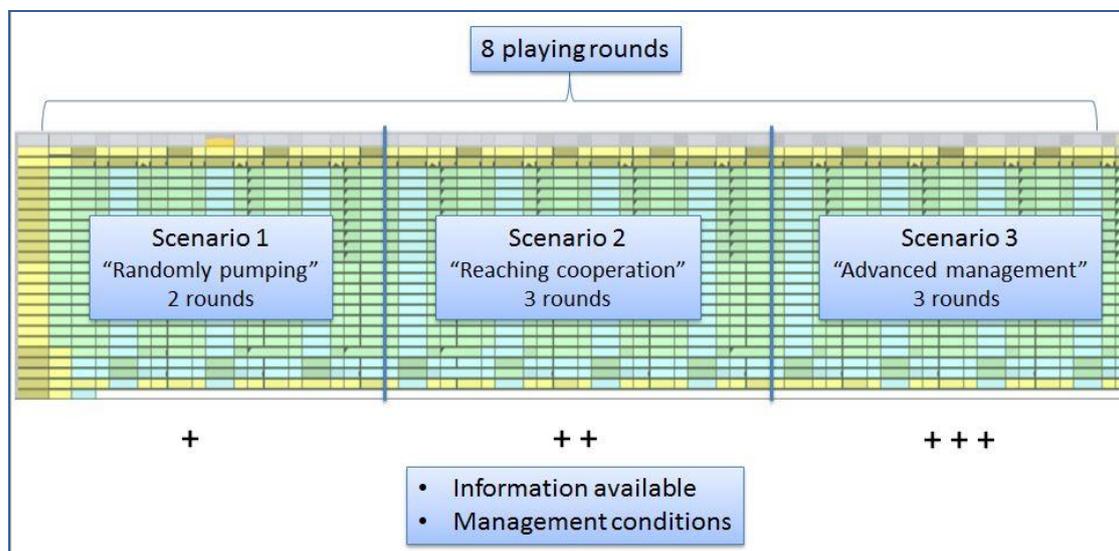


Figure 4: GW-Game scenarios and rounds.

In each round the players upload their decisions to the Game Manager app which, under the control of the facilitator, updates the Excel spreadsheet and sends data on the outcome of the decisions to each player’s app. The players then assess the impact of their decisions and consider their strategy for the next round.

Drawdown

The drop of the water level observed in an aquifer due to groundwater pumping is called drawdown. The total drawdown, measured in meters, and the interference wells can cause on each other’s, depends on location and pumping rate in each well (see Figure 2). Drawdowns are horizontally represented by circles around the wells, which are proportionally represented, according to the influence radius in meters (Figure 3). Depletion is the long-term declination of groundwater levels caused by sustained groundwater pumping which can result in the drying up of wells, reduction of water in

3.0 GAME RULES

And the winner is (are)...

... the farmer (or team) that has accumulated the most profit at the end of the game!

Table 1 resumes the rules of the game.

Table 1: Summary of the GW-Game rules provided to the players at the beginning of the game-session

	Type	Cost	Benefit	Explanation
All scenarios	Starting capital	₺ = 0		Each farmer starts with zero capital.
	Farming profit		₺ 40 /ha	Crop value per hectare.
	Living costs	₺ 25		Payed at each round per well, applied during the entire game!
	Bankrupted			Out of the game when reaches a debt of ₺ 150.
	Abstraction costs	Variable		Costs vary and are a function of (i) volume of groundwater needed (Q), (ii) groundwater level in the well and (iii) price per unit volume: ₺ 0.0015 /m ³ Abs_cost = Q * drawdown * unit price
	Environment costs	₺ 35 / variable		₺ 35 during scenario's 1 & 2 Proportional to Q, during scenario 3
Scenario 1 (2)	Basic irrigation		1000 m ³ /ha	Crops need 1000 m ³ /ha of groundwater for irrigation. Per day? Per season?
Scenario 2 (3 rounds)	Water saving equipment costs	₺ 100	20% water saving	The investment only needs to be done once. Costs payed per well.
	Advanced irrigation		800 m ³ /ha	Crops need 800 m ³ /ha of groundwater if investment in equipment is made.
	Cap rule transaction cost	₺ 100 / well joining the cap rule		At least 5 wells need to join the rule. Players joining it will decide the limit.
	Cap rule penalty	Variable		Penalty = amount of wells joining the rule * ₺ 10.
Scenario 3 (3 rounds)	Social benefit		10% of average cumulative net benefit	Assigned per well to all farmers and fisherman in the subsequent round.
	Cap rule transaction costs	Paid by GW authority		Cap rule will be applied by default. All players will decide the limit.
	Cap rule penalty	Variable		The community (players) decides on height of penalty.

3.1 General rules – All Scenarios

Each player can bring a maximum of 5 hectares of land into production in each round. It is possible to choose a value between 0.1 and 5 (interval of a tenth). Only one type of crop is grown.

The currency of the GW-Game has been chosen to be a fictive one, called *Aqua (A)*.

3.1.1 Starting capital

All households start with an equal capital of A 0.

3.1.2 Farming profit

The benefit of farming profit is equal to A 40 per hectare. This is a fixed value, constant during the entire game. The benefit accumulated in each round is proportional to the hectares brought into production. Each farming household can produce one harvest per simulation run.

3.1.3 Living costs

The living cost for every player is A 25 in every round. It is a constant value during the whole game; not playing (no livelihood activity) will cost money anyhow.

This is the living cost of the farmer and his household. It includes food, water, clothing, farming tools, house maintenance, etc.

3.1.4 Bankrupted

If a household reaches a debt of A 150 the household is out of business for the rest of the game.

3.1.5 Abstraction cost

Groundwater abstraction itself has its costs, due to electricity bills. The abstraction cost is a function of volume of pumped groundwater (Q), groundwater level (drawdown) and a unit price per unit volume (A 0.0015 /m³). The abstraction cost is calculated automatically right after entering the farming area for each player.

$$\text{Abstraction cost} = Q * \text{drawdown} * \text{unit price per unit volume}$$

These are the pumping costs of the farmer. As much water as the farmer decides to abstract, these costs will increase. These costs depend as well on the pumping volumes of his neighbors, as much as they abstract, the drawdown will increase and therefore the costs will rise.

3.1.6 Environmental costs

When the lakes runs dry due to over abstraction of the aquifer caused by the farmers, each player will have extra living costs, plus A 35 per player. The lake is a tourist attraction and if it runs dry the normal flux of tourists in the village decrease as well as the local economy depending on small trades (e.g. handicrafts). This rule applies only to scenarios 1 & 2. During scenario 3, an environmental fee is set and calculated proportionally to the pump water (see section 3.4).

This penalty cost is due to the fact that players, together as a group, pumped so much water that the drawdown reached the lake and therefore the lake dried up. The way this cost is automatically activated in the calculation sheet is when the drawdown at the lake reach a value higher than 2.0 meters.

The story behind the costs: (i) farmers costs for buying fish outside of the village; (ii) lack of tourist income due to less tourism attracted to the dry lake.

3.2 Scenario 1 – “Randomly pumping”

Scenario 1 sets the beginning of the game starting from the principle of the *Tragedy of the Commons*. Farmers pump water independently of what happens in the others farms. Players don't interact and results are not shared, i.e., in the first 2 rounds the players don't know the other players results only their ones.

3.2.1 Basic irrigation

During scenario 1 farmers have only access to basic irrigation. They can grow as much area as they like to a maximum of 5 ha. To grow up their crops, they need 1000 m³ of groundwater to irrigate 1 hectare of land.

3.3 Scenario 2 – “Reaching cooperation”

During scenario 2 the players will be able to choose 2 new features to their strategy: Water saving equipment and agreement in a cap rule to limit water abstraction among farmers. This scenario sets the basis to leverage communication between farmer.

3.3.1 Water saving equipment

This rule offers the players the chance to invest in ‘improved irrigation schemes’, which is available from the first round in Scenario 2. The investment is only done once during the game and it implies 20% water saving of the total discharge Q (groundwater need = 800 m³/ha). Investment in the water saving equipment costs ₺ 100.

Even though is a high cost for a farmer, the investment in water saving equipment will bring its benefits in a long term period. The players will certainly observe its benefits and will start profiting from it as soon as they purchase it. This investment is only available during scenario 2.

3.3.2 Cap rule transaction cost

The *cap rule* is used to set a limit for groundwater abstraction among the players. The South African Groundwater Case Study Report (Pietersen et al. 2011) indicates that a direct management measure to control groundwater abstraction was done by limiting the cropping area among the users. Applying this measure in the game through the *cap rule* sets a limit to the amount of hectares that a player can farm, and therefore a limit or “cap” of the volume abstracted. This might help to avoid the lake to dry out and the environmental impact.

In the game, the players have to organize together and decide on an amount of volume of water to be the maximum used per player. A minimum of 50% of the players have to join this rule in order to be effective. The transaction cost of this rule is ₺ 100, this amount is divided within the players joining the rule. A piece of advice for the players is to try to convince other

players to join; it will make their transaction costs smaller. The rule is only valid for one simulation run. Every time that players want to apply this rule they have to pay again the transaction costs.

3.3.3 Penalty cost for no compliance with cap rule

Players who don't follow the rule and abstract more water than the accorded by the group will receive this penalty cost. The penalty cost is in function of the amount of players that join the rule times a pre-establish value of $\text{€ } 10$. e.g. 6 players joined the rule; penalty costs for those who don't comply is 6×10 , therefore the penalty is $\text{€ } 60$.

3.4 Scenario 3 – “Advanced management”

In this scenario a new figure is added to the Game, The Groundwater Authority, establishing a advanced management scenario where water abstraction, environmental costs and transitional costs associated to a established cap rule are regulated by a water authority. .

3.4.1 Social benefit

In every round an average cumulative net benefit coming from all the players is calculated, 10% of that value (when positive) is assigned to each player in the subsequent round.

The story behind the benefit includes: (i) money coming from the overall benefits from the players, meaning more money circulating in the village and a general “social benefit” is distributed among all, (ii) social welfare coming from the inclusion of the new groundwater authority to the village.

This benefit is used to show the players the advantages of having a sustainable management of the groundwater resources. As long as the keep profiting in their individual households, that benefit will be beneficial as well for the whole community.

3.4.2 Environmental costs

During this last scenario the environmental costs will be assigned to each player according to the proportion of water used pumped (Q) during that simulation run. The allocation of the costs will be considering the same total amount used before but instead of being assigned as a fixed cost, now it will be assigned to the proportion of each player's water consumption.

This new allocation of environmental cost comes due to the inclusion of the new groundwater authority. This is a more “equitable” way to assign the costs in order to protect the environment and penalize those who abstract more.

3.4.3 Penalty cost for no compliance with cap rule

During this scenario the cap rule will be applied by default. This is part of the new elements (groundwater authority) that came along in this scenario. In each of the last rounds from this scenario the players will set a limit for the groundwater abstraction as well as the penalty costs to be paid by the players who don't follow the cap rule.

The new groundwater authority will give the players the right to choose how much they want to sanction those who don't follow the limit established by the group. Also in scenario 3, the calculations are based on the Improved irrigation needs (see 3.3.1).

4.0 FACILITATING A GAME SESSION

4.1 Set up

The GW-Game session is led by a facilitator (two in the case of big groups), prepared in advance for the task. Experience shows that the game-sessions can be very different from each other and surprisingly dynamic. The facilitator needs to be prepared for a very intense and energetic experience.

The following needs to be taken into consideration when setting up a game-session:

- Number of participants: minimum 9, maximum 30;

In the case of more than 9 players, set up teams of up to 3 to 4 players per team (max. of thirty players).

- Game duration: 120 - 160 min (depending on the level of groundwater knowledge)

If it happens that a player or more don't have a computer or a smartphone or the Wi-fi connection fails, then paper base tables (Appendix 4) will be distributed for the players fill with their decisions and strategies. This takes longer and demands patience from the players to wait for the game manager to introduce the players' strategy in the Excel file. In this situation is helpful to have a second person interacting with the players.

To set the local where the game is going to be played the following material needs to be prepared:

- A room with enough capacity for the number of expected players;
- A computer with access to MS Excel and PowerPoint;
- A local Wi-Fi network and a router;
- A Beamer;
- The MS-Excel GW-Game file and PowerPoint presentation;
- The Game Manager and Game Player Apps
- Blank sheets/Note books and pens

Print in advance

- Game Setting and Rules (Appendix 2, one copy per player/team),
- Tables for players moves in all rounds (Appendix 4)¹.
- Well labels (appendix 2);

The 'Game Setting and Rules' must be read before the game-session starts (allow the participants some time to read it). This material contains the general rules for quick review, the layout of the wells and some extra figures to help explaining the groundwater dynamics. This print-out is available in English and French .

¹These table are only used in the case that one or more players do not have a smartphone or laptop or if they have issues with their devices

4.2 Using the Excel file

The latest version of the GW-Game file is from March 2020. The Excel file contains several worksheets that will perform the calculations and outcomes of the game. Some excel worksheets (defined by default) will be embedded in the power point presentation to facilitate the game flow. The Excel file is linked to the power point presentation and all calculations run in the excel file during the game are synchronize in the power-point presentation. The excel file opens automatically once a new game is started in the GW Manager App.

An overview of the Excel worksheets is given bellow:

NOTE: Do not change the names of the worksheets nor the order of the worksheets.

<i>Worksheet</i>	<i>Type</i>	<i>Content</i>
basic_inp	Input	Input of well locations and hydraulic properties
Wells_map	Map/chart	Map showing the location of the wells and the lake
sim_inp	Input	Input of players decisions/moves (e.g.hectares to irrigate, cap rule & investments), costs & benefits
costben_outp	Calculation sheet	Calculation of players' balance (₺) in each round
Scn1_outp	Main output	Summarizes players' balance (₺) in scenario 1
Scn2_outp	Main output	Summarizes players' balance (₺) in scenario 2
Scn3_outp	Main output	Summarizes players' balance (₺) in scenario 3
Cum₺_sum_outp	Main output	Summarizes players' balance (₺) in all rounds
Q_SUMm3 per well	Map/chart	Chart showing the contribution [absolute] of each well in the total discharge per round
Q_%total	Map/chart	Chart showing the contribution [percentage] of each well in the total discharge per round
Down_graph	Map/chart	Chart showing the cumulative drawdown in each well and in the lake
Down_map	Map/chart	Map showing the drawdown in the wells in the on goin round
Down_%well	Map/chart	Chart showing the contribution of all wells to each well and lake drawdown
Costben_chart	Map/chart	Chart showing players' benefits and costs in the on going round
CUM_graph	Map/chart	Chart showing players cumulative balance (₺)
Down_Well1	Calculation sheet	Calculates the drawdown induced by Well 1 in all wells and in the lake
Down_WellX	Calculation sheet	Calculates the drawdown induced by WellX in all wells and in the lake
Breakdown_drawdown	Calculation sheet	Calculates the total drawdown in the wells and in the lake

Note that although there is a pre-defined PowerPoint presentation the facilitator is free to show the outcomes of the players moves, in the Excel file, at any point during Scenarios 2 and 3. At a certain point, there will be several worksheets that can be shared with the players. The facilitator needs to know them very well and adapt his strategy of showing more or less information according to the audience and circumstances (time available, motivation of participants, level

4.3 Using the PowerPoint presentation

The PowerPoint presentation was set up to help the facilitator guiding the players through the game-session. At the end of Scenario 1 and at the end of each round in Scenarios 2 and 3 the results are shown directly in the PowerPoint. In the end of the eight rounds the main graphics generated during the game will be present and discussed with the players. These are embedded in the power point presentation by default. It might happen that the game manager needs to show other graphics not embedded in the PowerPoint. If that is the case then the game manager will have to switch from the PowerPoint presentation to the Excel file. The power point presentation must be located in the Groundwater Game folder created in the *Documents* directory in the facilitator's computer and can only be open after the facilitator starts a new game (see chapter 4.4.3).

Be aware that the game manager might need some time to analyze the final results before the final group discussion. It is recommended to have an interval when the game is finish and before the final discussion so that the facilitator can get acquainted with the final results.

4.4 Using the GW GAME Apps

The GW GAME Apps constitute of two apps: The GW Manager App and The GW Player App. The GW Manager app, which must be installed on the facilitator's computer, is used to manage the input of data from players and sharing of outcomes information with each player. The GW Player App is installed on a computer or Android phone by each player (or one player from each team). This allows the players to upload decisions to the GW Manager app, and also to receive outcome data at the end of each round.

The GW Manager and Player apps communicate on a local Wi-Fi network which should be setup beforehand (see chapter 4.4.3).

4.4.1 The GW Manager App

4.4.1.1 Installation

1. Download the 'GroundwaterMgrInstaller.msi' file from the Groundwater Game web page.
2. Double click 'GroundwaterMgrInstaller.msi' to begin installation.
3. Click through the installation window prompts in to install the GW Manger App. This will create a desktop link and start menu entries for the app.

4.4.1.2 GW Manager App Overview

The Game Manager App consists of 2 tabbed panels labelled 'Admin' and 'Game'.

The Admin panel (Fig 1) contains three control panels:

- Game Setup: this creates new games or restarts existing games.
- Server Control: this starts and stops the server which the players will connect with to upload game data.
- Player Monitor: this monitors players' login status and can be used to log players out and reset passwords.

The lower panel displays an event log for the app.

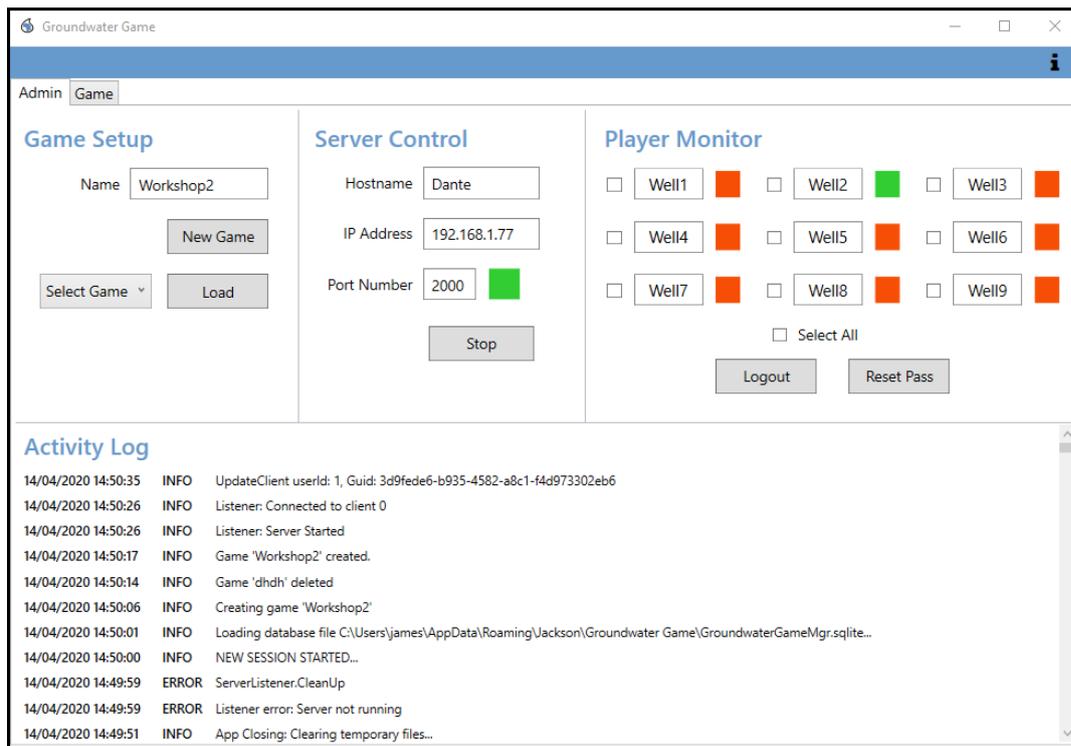


Fig. 1 GW Manager App Admin Panel

The Game panel (Fig. 2) is used to run the game. The upper grid displays the login status of each player and highlights the data input for the current round.

The lower panel displays instructions relevant to the game stage (e.g. at the outset information on getting the participants setup and connected to the server, then instructions for the current round). There are buttons for committing player data (when all well data has been entered), transmitting the cap limit and cap penalty to players and, if required, rolling the game back to the previous round.

Note: Once the GW Manager App is installed and when the first new game is created a folder named *Groundwater Game* is created in the Documents directory in the facilitator's computer. The GW-GAME excel file immediately opens and in the end each game it is saved in the folder *Saved Games* inside the *Groundwater Game* folder.

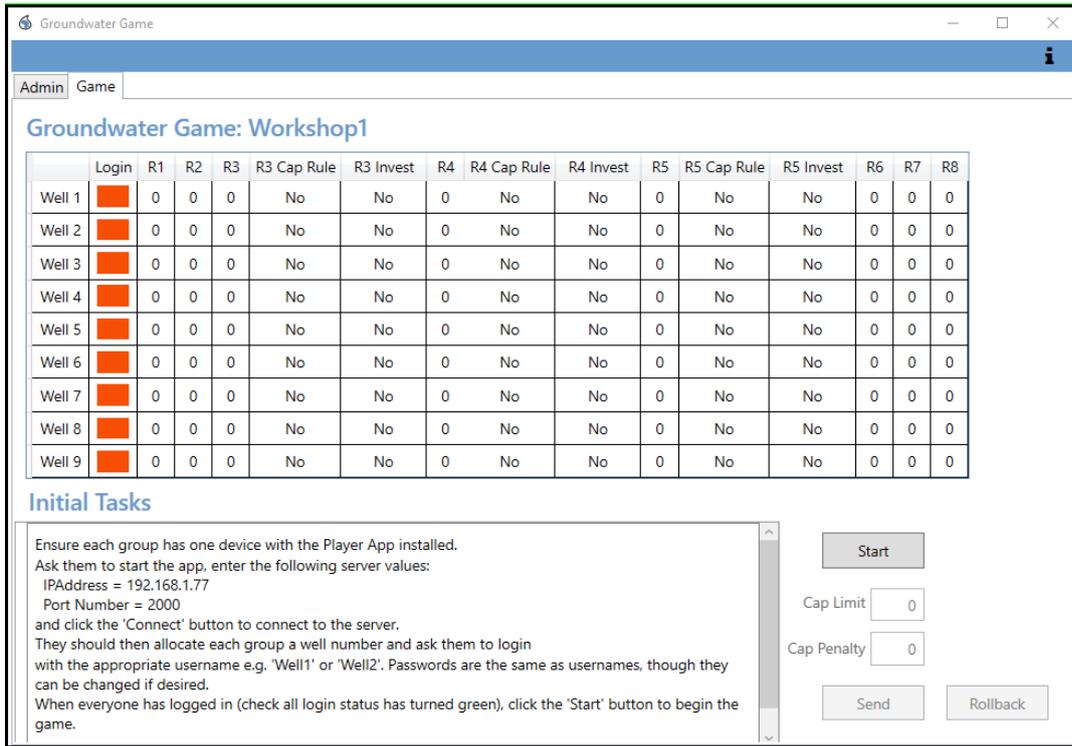


Fig. 2 GW Manager App Game Panel

During each round, as players send data from the GW Player App, the appropriate input cell changes color from amber to green (Fig 3).

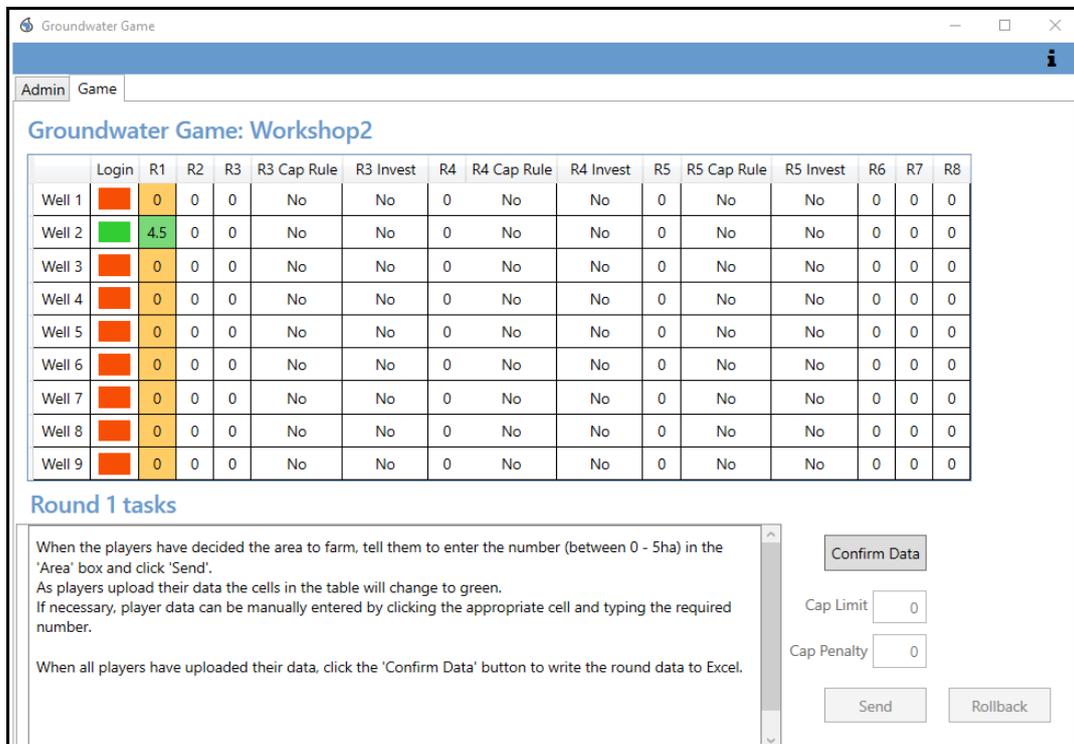


Fig. 3 GW Manager App Game Panel showing data input

Data can also be manually entered by the facilitator, to cover situations where the local Wi-Fi network is interrupted or unavailable for any reason (in this situation use forms in Appendix 4) . To manually add area data, click on the appropriate cell and enter the required number. The 'Cap Rule' and 'Invest' entries are toggled by clicking on the text.

When all data for the round has been entered, click the *Confirm Data* button. This initiates several actions:

1. The data is written to the Excel spreadsheet, triggering the well data calculations.
2. The players' apps are updated with the outcomes of their decisions (see Fig. 7).
3. The game is moved forward to the next round.
4. The instructions in the tasks panel are updated.
5. The excel tables and graphics embedded in the power point presentation are updated.

Note that players can change their data right up until the *Confirm Data* is pressed.

If for any reason the GW Player App is not used or there is a network interruption, the data outcomes can be read directly from the Scn1_outp, Scn2_outp and Scn3_outp worksheets and distributed to the players using the paper forms for Scenario 1 (Appendix 4) or share the results in the power point presentation in Scenarios 1 and 2.

For Scenarios 2 and 3, values for the 'Cap Limit' and 'Cap Penalty' should be entered and the *Send* button clicked to update the GW Player Apps, once these numbers have been agreed by the players.

4.4.2 The GW Player App

4.4.2.1 Installation (Windows)

1. Download the 'GroundwaterPlayerInstaller.msi' files from the Groundwater Game web page.
2. Double click 'GroundwaterPlayerInstaller.msi' to begin installation.
3. Click through the installation window prompts in to install the GW Player App. This will create a desktop link and start menu entries for the app.

4.4.2.2 GW Player App Overview

The Windows version of GW Player App is shown in Fig. 4. The top left hand panel contains controls for connecting to the server, logging in and changing password. The top right hand panel contains the controls for sending well data, cap rule and investment decisions to the server and also displays the player's well number and the current round number. Below this is a panel which displays information on the outcome of the previous round and the overall status. The lower panel displays an event log.

The content of the interface panels will change slightly as the game transitions to different scenarios.

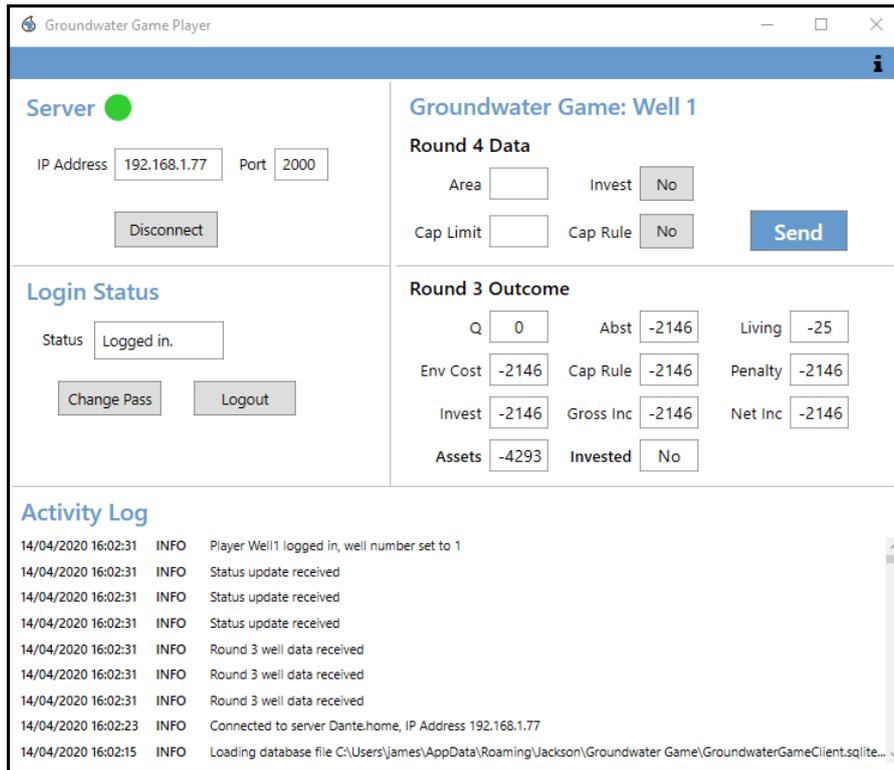


Fig. 4 GW Player App (Windows version, Scenario2)

4.4.3 Pre-Game Preparation

There are several tasks that the game facilitator needs to take care of shortly before starting the game:

1. If not done beforehand, ensure that the GW Manager App is installed on the facilitator's PC and that the GW Player App is installed on the laptops or phones of the players (only one installation per team is required, if more than one player is managing a well)
2. Connect the game manager's computer to the local Wi-Fi network.
3. Ensure that the PowerPoint presentation is located in a folder 'Groundwater Game' in your Documents directory and that it is NOT OPEN at this stage. If you just installed the GW Manager app and it is the first time you are playing the game copy the power point presentation into the folder 'Groundwater Game' in your Documents directory. If you played the game before the power point presentation should be already in the 'Groundwater Game' folder.
4. Start the GW Manager App by double clicking on the Desktop link.
5. Create a new game or load an existing game. To create a new game, enter a name in the box and click *New Game*. If restarting an existing game select the game from the dropdown panel and click *Load*.
A copy of the Excel spreadsheet will be created in the 'Groundwater Game' folder in the Documents directory. The Game Panel will be added to the user interface.
6. Click the *Start* button on the Server Control panel to start the server and then select the 'Game' tab to open the Game panel.
7. Now open the PowerPoint presentation and click *Update Links* in the Security window which will be displayed (Fig 5). This will ensure that the linked data in the presentation will be updated as game data is copied to the Excel spreadsheet as the game progresses.

-
8. Edit the 'Network Connection' slide and add the Wi-Fi network name and password and also the IP Address and Port Number of the server (both can be found in the Server Control panel or task panel). This will give the players the data needed to connect their computers or smartphones to the Wi-Fi network and to connect to the Game Manager server.
 9. **You are now ready to start the game.**

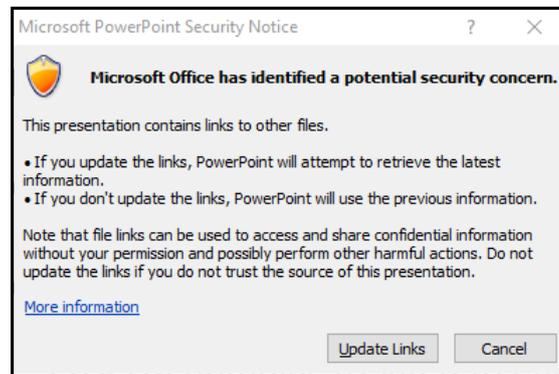


Fig. 5 PowerPoint Security window

4.4.4 Running a Game

After you have completed the pre-game tasks outlined above and the players are assembled:

1. Allocate well numbers (1 – 9) to each player or team (Appendix 3) .
2. Ask the players to connect to the network and server using the data you have entered in the 'Network Connection' slide.
3. Ask the players to login to the server – the usernames are 'Well' followed by the allocated well number e.g. 'Well1', 'Well2' etc. The passwords are the same as the usernames, though can be changed if desired.
4. When all players are logged in (in the GW Manager app check all status icons are green), click *Start* to begin round 1.

Instructions to help you complete the tasks for each round will be displayed in the task panel. For Scenario 1, the players simply upload area information to the server (Fig. 6).

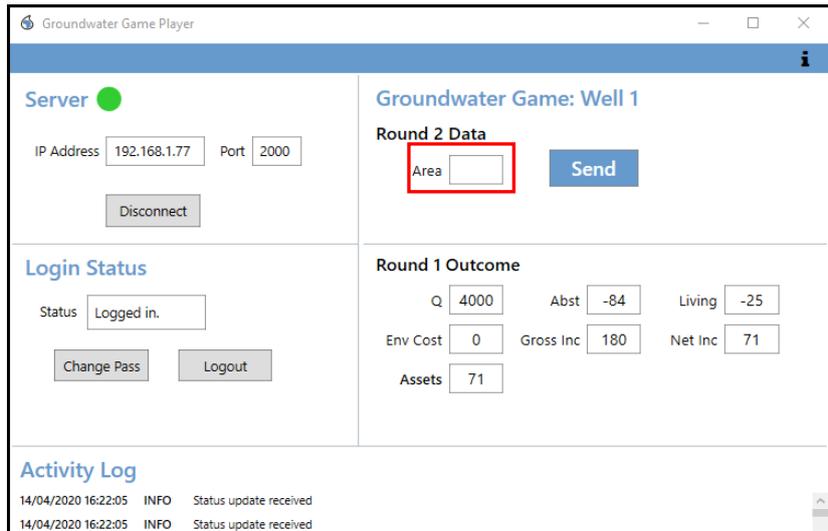


Fig. 6 GW Player App – Scenario 1 data input.

However in Scenario 2 Cap Rule and Investment decisions must also be made (Fig. 7) and the facilitator must send 'Cap Limit' data to players, if they have agreed in a cap value between at least 5 players. . This is done by entering the data in the textbox and clicking *Send* (Fig. 8)

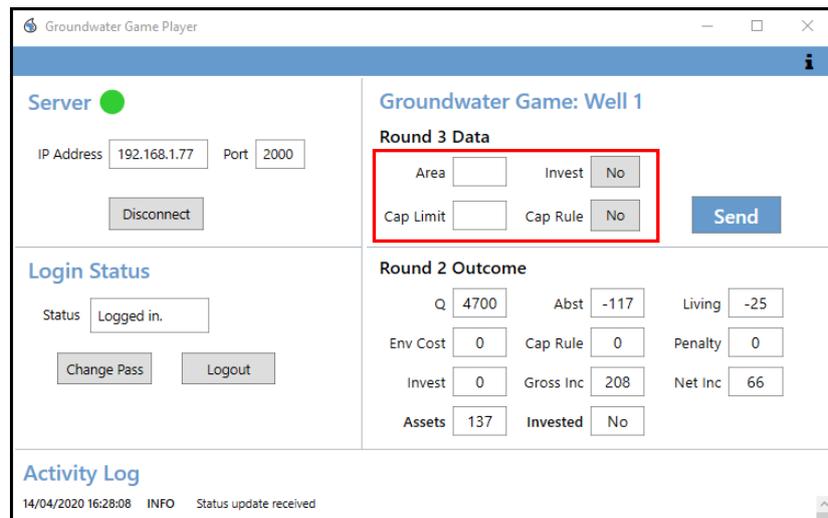


Fig. 7 GW Player App – Scenario 2 data input.

Groundwater Game

Admin Game

Groundwater Game: Workshop3

	Login	R1	R2	R3	R3 Cap Rule	R3 Invest	R4	R4 Cap Rule	R4 Invest	R5	R5 Cap Rule	R5 Invest	R6	R7	R8
Well 1		5	4.6	0	No	No	0	No	No	0	No	No	0	0	0
Well 2		3	4	0	No	No	0	No	No	0	No	No	0	0	0
Well 3		4	5	0	No	No	0	No	No	0	No	No	0	0	0
Well 4		3	4	0	No	No	0	No	No	0	No	No	0	0	0
Well 5		4	3	0	No	No	0	No	No	0	No	No	0	0	0
Well 6		5	5	0	No	No	0	No	No	0	No	No	0	0	0
Well 7		2	5	0	No	No	0	No	No	0	No	No	0	0	0
Well 8		4	3	0	No	No	0	No	No	0	No	No	0	0	0
Well 9		4	3	0	No	No	0	No	No	0	No	No	0	0	0

Round 3 tasks

When the players have received the outcomes of their Round 2 decisions, show the following from the PowerPoint presentation:

- The outputs for scenario 1 in both rounds(worksheet "Scn1_outp" in the excel)
- The Overall cumulative sum in Aquas A by the end of Round 2(worksheet "CumA_sum_outp")

Discuss the results so far:

- Who is the richest farmer? Who is the poorest?
- Ask questions to check that the learning objectives are being met.

Feel free to expand and add more information to the game storyline but be mindful of the available time.

Confirm Data

Cap Limit

Cap Penalty

Send Rollback

Fig. 8 GW Manager App – Cap Limit data input.

In Scenario 3, Cap Penalty data must be sent to players once they have agreed on the amount.

4.5 Finishing the GAME

In the end of the game, show players a general summary of the overall benefits and present the winner(s). Together with the players analyze the generated charts and emphasize the key moments of the game-session. Use the worksheet "CUM_Graph" to show the players the cumulative benefits along the game, if the graph shows an increasing tendency that will mean that the objectives were met and the farmers finalized with a positive income. Make emphasis that this happen due to the addition of the new elements and rules coming from the development of the organization of the village.

Finish the game session with a plenary session on the final outcomes, discuss with the players the lessons learned through the game and hear everyone's conclusions and comments. In the PowerPoint the final slides are specifically prepared to target concepts like drawdown, depletion, groundwater management and governance.

NOTE: When the GW Manager App is closed the game's Excel spreadsheet will be automatically saved as an Excel file with the game name in 'Groundwater Game' directory in a folder 'Saved Games'.

5.0 REFERENCES

FAO, UNESCO-IHP, IAH, GEF & World Bank, 2012: *Regional Diagnostic Report for Sub-Saharan Africa Region*. Groundwater Governance – A Global Framework for Action. Internet < <http://www.groundwatergovernance.org/regional-consultations/sub-saharan-africa/en/> > .

Hardin, G., 1968: *The Tragedy of the Commons*. Science Journal Vol. 162 no. 3859 pp. 1243-1248

Pietersen, K., H.E. Beekman & M. Holland, 2011: *South African Groundwater Governance Case Study*. WRC Report No. KV 273/11 ISBN 978-1-4312-0122-8

Mendler de Suarez, J., P. Suarez & C. Bachofen 2012: *Games for a New Climate: Experiencing the Complexity of Future Risks*. Pardee Center Task Force Report. Boston: The Frederick S. Pardee Center for the Study of the Longer-Range Future, Boston University

6.0 APPENDIXES

APPENDIX 1

Drawdown calculations and Memo.

APPENDIX 2

Game setting and rules (English and French).

GAME SETTING AND RULES – ENGLISH (3PAGES_GW-GAME_summary_EN.pdf)

GAME SETTING AND RULES – FRENCH (3PAGES_GW-GAME_summary_FR.pdf)

APPENDIX 3

Well labels

Remember to print it single sided!

APPENDIX 4

Input and output players decisions.