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Water and Society

Apna Pani - A Project (LWR-036)
of ACIAR-CSU

WELLS APNA FARM

Register A New Well

Check A Well Reading

Report A Well Reading

Owner Name: Bacha Khan

Well Information

Recent Depth To Water: 168

Recent EC Value: 1.44

Owner Name: Drip

Well Information

Owner Name: IRI

Well Information

Recent Depth To Water: NULL

Recent EC Value: NULL

Owner Name: sheraZ Akhter, Indhu

Temperature

Wind Speed

Humidity

Cloud Cover

Visibility

Weather Condition

Improving groundwater management to enhance
agriculture and farming livelihoods: Integrating web and
mobile based applications for groundwater management

Report No. 162

Mobushir Khan
Nabeel Ejaz
Muhammad Amin
Jehangir Punthakey
Michael Mitchell
Catherine Allan
Ghulam Zakir Hassan

Institute for Land, Water and Society

Integrating Web and Mobile-based Applications for Groundwater Management

Mobushir R. Khan, E. Nabeel, Muhammad Amin, Jehangir F. Punthakey, Michael Mitchell, Catherine Allan and Ghulam Zakir Hassan

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Authors

Mobushir R. Khan¹, Nabeel E³., Amin M³., Jehangir F. Punthakey², Michael Mitchell¹, Catherine Allan¹, Ghulam Zakir⁴

¹Charles Sturt University, ILWS, NSW Australia

²Ecoseal Developments Pty Ltd, PO Box 496 Roseville NSW 2069 Australia

³Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan

⁴Punjab Irrigation & Drainage Authority, Lahore Pakistan

Photo Reference

- Mobile application home page and location of applications beings used in the study area of LWR-036 (cover page)

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1 Executive Summary

Groundwater managers, farmers and researchers face challenges regarding the paucity of information and tools for knowledge management. Groundwater problems are characteristically complex and it is not possible to grasp this complexity without the aid of computational analyses. Multiple processes such as groundwater modelling, economic modelling and spatial analyses provide information to address the problems faced by water resources managers. However, because these do not directly address immediate on-ground decision-making needs, there is demand for an easy to use platform to integrate science-based information on groundwater with socio-economic and other physical data and processes. A web-based Decision Support System (DSS) can do this. Web-based DSS are computational systems that use data and models interactively to aid in the formulation, analysis, and selection of management strategies.

This project was undertaken as part of an ACIAR project that aimed to build the capacity of researchers, farmers, farming communities and relevant government and non-government agencies to improve groundwater management in ways that enhance farming family livelihoods in Pakistan. The project developed a web-based DSS to enable the data being generated by the larger ACIAR project to be used. It was developed collaboratively, and iteratively. Initially the larger ACIAR project team members provided direction and feedback, with the goal of recording and visualising groundwater depth and quality, and this resulted in the first Module, Apna Pani (My Water). The development and feedback process then led to the expansion of the DSS to an application that could support decisions about district and on farm water use. Staff from the Agriculture Departments were included in the ongoing iterative design process, and as the prototype developed so too were some individual farmers from the Stakeholder Forums.

In total 10 cycles of design and feedback led to the current two module design, “Apna Pani” (My Water) and “Apna Farm” (My Farm) which, when deployed, can assist users in the calculation of monthly crop water requirements, deficits in surface water supplies, ground water quality and allied information to make decisions on sustainable crop production.

The DSS has four components: client side (where user gives input to the system through mobile or computer); database (interacts with server and the input data through internet); server (hosted on internet and contains algorithms which automatically runs various models for the user); and dynamic web (presents outcomes to the users). The users of this 4-tier web and mobile based system are enabled to estimate their crop water requirements, surface water deficiencies, groundwater quality status and also profitability by comparing available options for alternate crop husbandry. Since this DSS was constructed and applied using integration as a guiding principle, it can advance groundwater management to improve understanding and implementation of real-world integrated groundwater management.

It is anticipated that this DSS will be used and further developed beyond the time of this project. There is the potential to provide organization specific versions to, for example, Punjab Irrigation Department and other Government Departments, and discussion is underway to enable the transfer of the server to the Pakistan Council for Research in Water Resources.

2 Introduction

Water is the most critical resource for sustainable development in arid and semi-arid countries such as Pakistan. It is vital not only for agriculture, industry and society, but it is also an important component of our environmental system. Rapid growth in the population of Pakistan, along with the increasing needs of agriculture and industries, are stressing the quantity and quality of water resources. This is further exacerbated by the effects of climate change. Rainfall contributes less than 15% of the total water requirements for crops and the remaining has to be covered by surface and groundwater irrigation. Surface water resources in Pakistan are limited and supply driven as the major portion of water is supplied in the Indus River System by snow-melt. The difference between crop water requirements and canal supplies are met through extraction of groundwater. In the past, uncontrolled and cheaper access to groundwater contributed enormously towards improving livelihoods for both rural and urban regions. Being a demand driven commodity, groundwater is currently providing more than 50% of the total crop water requirements. Reliance on groundwater for irrigation has increased significantly from a few thousand shallow wells in the 1960s to over 1.4 million tube-wells today (Qureshi, 2020).

This current over-extraction of groundwater is not sustainable; it has caused lowering of the water table and is adversely affecting its quality. This is because salinity in the alluvial aquifer of the Indus Basin increases with depth and intensive pumping results in up-coning and also mobilises lateral movement of groundwater from surrounding areas where groundwater may be of marginal quality (Khan et al., 2008). Future prosperity will depend to a considerable extent on how well we use our surface and groundwater resources. Overuse of water in irrigation is a major issue in Pakistan because farmers are often unaware of actual crop water requirements and there is widespread use of poor irrigation practices. They are also often unaware of the changes in groundwater levels and quality occurring in their area.

The ACIAR project LWR2015036 aims to build the capacity of researchers, farmers, farming communities and relevant government and non-government agencies to improve groundwater management in ways that enhance farming family livelihoods in Pakistan. The behaviour and response of groundwater systems to natural and human influences are best understood through scientific analyses using data and models. Data loggers were installed for monitoring the depth of the water table (DTW), electrical conductivity (EC) and temperature at identified suitable piezometric locations in project areas of Sindh (Naushero Feroze and Shaheed Benazirabad districts) as well as in Punjab (Okara and Sahiwal districts), and in Kuchlak sub-basin in Balochistan. Additionally, government agencies such as the Punjab Irrigation Department (PID) have networks of piezometers and farmers have access to information via their own wells, and government agencies. The technical data from these sources can be used to assist on ground planning decision making, but appropriate non-specialist interfaces are needed. Web based Decision Support Systems (DSS) are one such interface.

Web-based DSS are computational systems that use data and models interactively to aid in the formulation, analysis, and selection of management strategies. At the simplest levels, DSS may provide repositories of data and information in accessible formats and could offer tools to search and discover repository content. At the other end of the spectrum, a DSS may incorporate sophisticated simulations, link with optimization algorithms, or other intelligent systems components to enhance decision making (Mannina et al., 2019). Regardless of the level of sophistication, DSS are well suited for application to integrated groundwater problems because they can provide a set of applications, methodologies, and tools to cope with the inherent complexity and uncertainty.

A DSS links together raw data, empirical calculations, numerical models, and other qualitative factors to analyse decision problems. DSS can help decision-makers conceptualise a problem in

a new way, as well as allowing for the rapid conversion of the vast sets of data typically associated with groundwater problems into understandable reports that can provide guidance and insight.

The research described in the following report aimed to

1. develop a decision support system (DSS) to assist agricultural and irrigation field officials, and farmers
2. explore, together with farmers, the selection of economic crops which use less water, water conservation and enhancing irrigation efficiency

The DSS must be accessible and understandable to users- that is, farmers, their advisers and others who do not necessarily have technical or modelling expertise.

This report introduces the need to develop such DSS applications, then describes the method of development and presents overview of various components of the applications, comprising mobile application - Apna Pani and Web based application – Apna Farm. The use of these applications is discussed, with real time examples from a farm. Information about training sessions undertaken is provided as a case study at the conclusion of the report, followed by the inclusion of the detailed user manual.

3 Methodology

The DSS presented here was developed collaboratively, and iteratively. In the initial stages the design leader worked with LWR2015036 project team members, with the goal of recording and visualising groundwater depth and quality. This resulted in the Apna Pani (My Water) module, which enabled mobile phones to be used to record spatially referenced readings of groundwater depth and quality. The development and feedback process indicated that there was enthusiasm for expanding the scope of the DSS to an application that could support decisions about district and on farm water use. Staff from the Agriculture Departments were included in the ongoing iterative design process, and as the prototype developed so too were some individual farmers from the Stakeholder Forums.

In total 10 cycles of design and feedback led to the current two module design, “Apna Pani” (My Water) and “Apna Farm” (My Farm), which when deployed can assist users in calculation of monthly crop water requirements, deficits in surface water supplies, ground water quality and allied information to make decisions on sustainable crop production. The system overview of the application is shown in Figure 1.

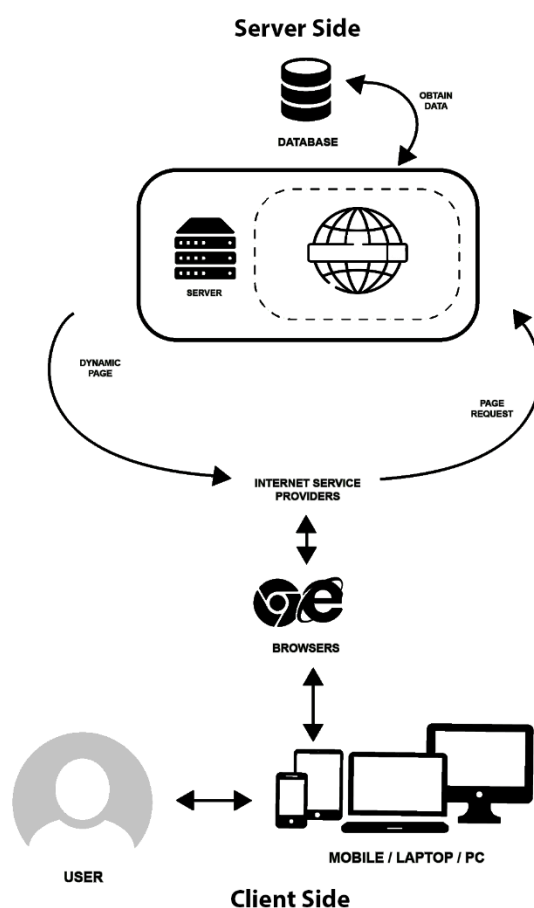


Figure 1: System Overview

The user will interact with the system via a web browser and make a request, the request will be sent to the server. The requested data will be fetched from database and accordingly the dynamic

pages will send the data to the user's web browser. The following subsections discuss the major modules in detail.

3.1 Client side

The user will be able to access the app via a mobile app and web browser. The App takes information as an input and sends it to the server with the help of REST API's then in return the server generates a response and displays the data to the website. Rest API is an architectural style for an application program interface (API) that uses HTTP requests to access and use data. That data can be used to GET, PUT, POST and DELETE data types, which refers to the reading, updating, creating and deleting of operations concerning resources. Figure 2 explains the interaction of modules and components.

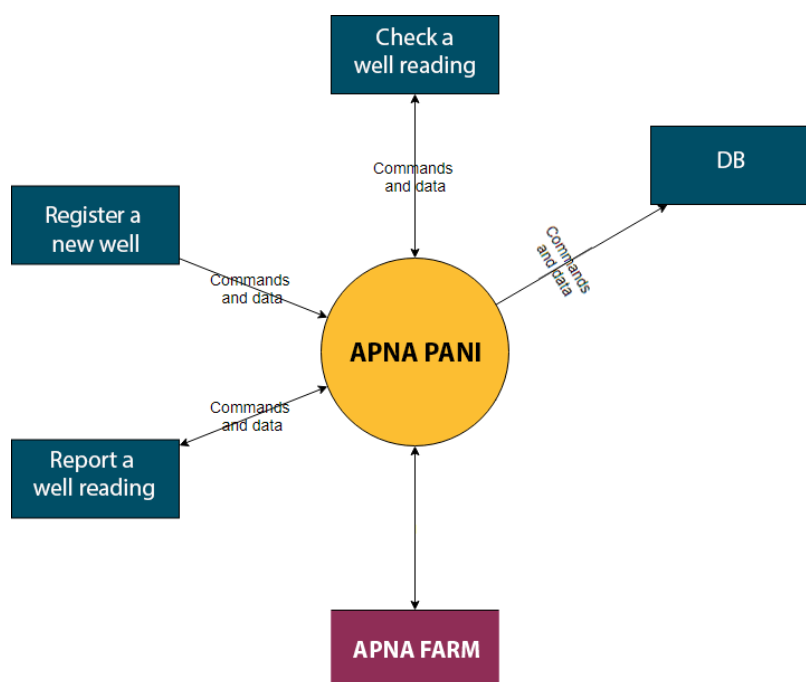


Figure 2: Apna Pani System Diagram

3.2 Server side

The remote side of the architecture helps the user to store data and generate a response for the “APNA FARM” module. During development, the server is hosted by the commercial company DigitalOcean, in New York, US. This provides a secure system with reputable data backup. The database has climate and weather information sourced from the Pakistan Meteorological Department and World Weather On-line. The database also includes the evapotranspiration algorithm of the Food and Agriculture Organisation (FAO) to enable crop water requirements to be estimated (Allen et al., 1998). This is customised with local crop coefficients from the Pakistan Council of Research in Water Resources (PCRWR).

3.3 Apna Pani (the mobile application)

This section discusses the client side, which is accessible via an android mobile. The application is built on Android Studio and the code is written in JAVA using JDK (Java Development Kit). The

mobile app sends data to the server using an internet connection (either broadband or mobile data). In case of unavailability of internet connection, the data will be stored offline and will be transferred once the mobile device is in the range of internet. The “Apna Pani” has three major components: Register a well record, report a well reading and check a well reading (Figure 2).

Register a new well, report a well reading and check a well reading are the main components of the Module “Apna Pani”. The user will make a request to register a new well the system in return will save the data. The user can also update the reading on a daily basis, the system will fetch the well no of the owner from the DB and will display user to update a reading. The third component of the module is all about checking all of the information of a particular well on google maps, the information includes well information, displaying graphs and direction to that particular tube-well.

3.4 Apna Farm (the web application)

Figure 3 shows the second module of the app “Apna Farm” which is the backbone of the farm management and displays information about land on the Map. The Apna Farm app can be used via Mobile App and Web App.

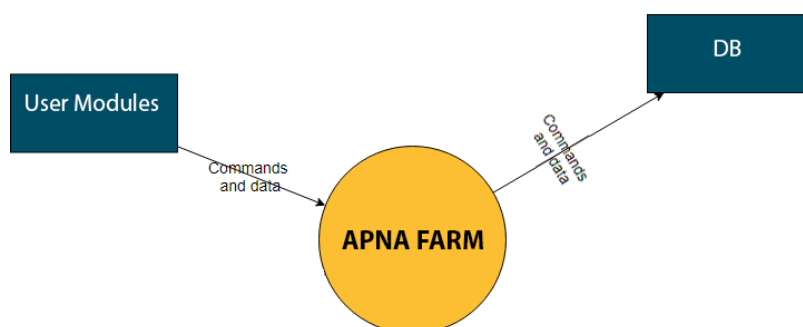


Figure 3: Apna Farm System Diagram

The Mobile version of Apna Farm shows information which includes Weather, Soil Type, Soil Fertility, GW Depth and Profitability. The Web version of Apna Farm shows some additional information which includes crop water requirements estimation, groundwater data (from mobile to web), soil data, crop profitability data, map annotations and custom reports.

3.5 Adopted Methodology

The diagrammatical approach (Figure 4 and 5) helps to explain the approach used while designing the app. To be able to use the app the user must have valid account to login (Figure 4). If the user does not have an account, the user can register the account in a few simple steps. After the successful login the user will be able to access: Register a well record, report a well reading, check a well reading and “Apna Farm”.

Every single record will be saved and if there is a duplicate well record the system is able to generate an appropriate message. The user can also import / export the data in .CSV format.

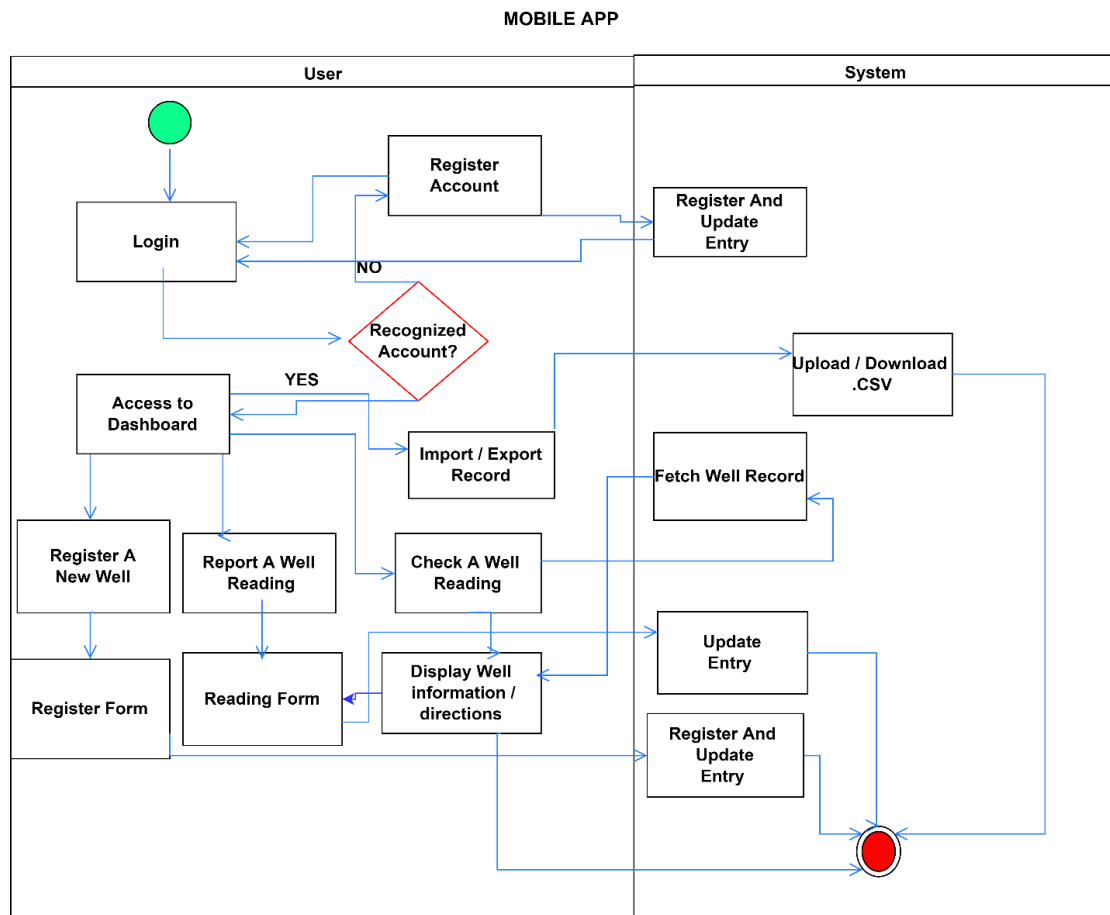


Figure 4: Mobile App (Apna Pani) Flow chart

Figure 5 illustrates the web app, which uses Google Maps to mark the location of the registered tube-well and a search box to search any location on the map to get the weather condition, soil attributes, crop profitability and water requirements graphs on the screen. The user will also be able to generate/download the PDF report of the generated result.

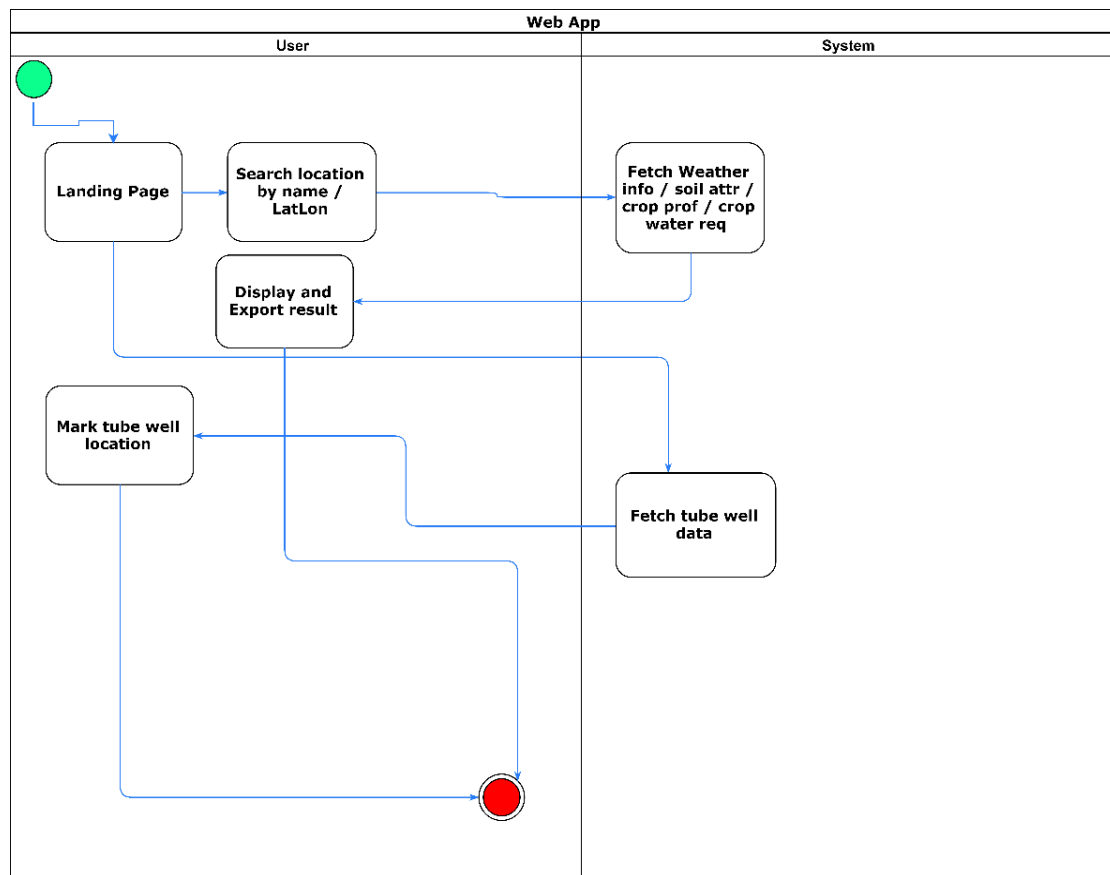


Figure 5: Web App (Apna Farm) Flow chart

3.6 Algorithms

The earlier discussed modules work on the following Algorithms.

Algorithm 1: Register a new well

Input: Well name, Owner name, Well location, Picture of the well, Email Address, Village name, District Name and well alias.

Output: Server Response with unique well ID.

1. HashMap ← (Well name, Owner name, Well location, Picture of the well, Email Address, Village name, District Name and Well alias)
 2. Make HTTP POST REQUEST.
 3. If {Well location is already in the DB
 4. Display "Error Message"
 5. }
 6. Else {
 7. Register and return ID.
 8. }
-

Algorithm 2: Report a well reading

Input: well ID / well name, EC/Depth to water, Date Time.

Output: Success Message.

1. Map ← (well ID / well name, EC/Depth to water, Date Time)
 2. Make HTTP POST REQUEST
 3. Display "Success Message"
-

Algorithm 3: Check a Well Reading

Input: Lat/Long or name of the location.

Output: Show well location with information and reading graphs.

1. Make HTTP GET REQUEST
 2. Fetch information regarding well
 3. Mark them on the map
 4. Generate output for the user.

 5. Display "Success Message"
-

Algorithm 4: APNA FARM

Input: Lat/Long or name of the location.

Output: Weather condition, Soil attributes, Crop profitability graphs and crop water requirement.

1. Location ← Lat/Lon or Name of the place on the Map.
 2. Make HTTP GET REQUEST.
 3. Display Weather condition, Soil attributes, Crop profitability graphs.
 4. Input crop name and cultivated area.
 5. Generate crop water requirement graphs
 6. Generate Report for the user.
-

4 Results and Discussion

4.1 Web application and its functionalities

The graphical user interface (GUI) makes use of Google API for Google maps, which enables users to interactively use, and host google maps on the World Wide Web. The GUI is deployed <http://mriaz-khan.com/aciar/dss/> and can be accessed online (Figure 6). A video demonstration is also provided there to assist the users. To use the app, navigate to the bottom of the page and click on “Launch Application”.

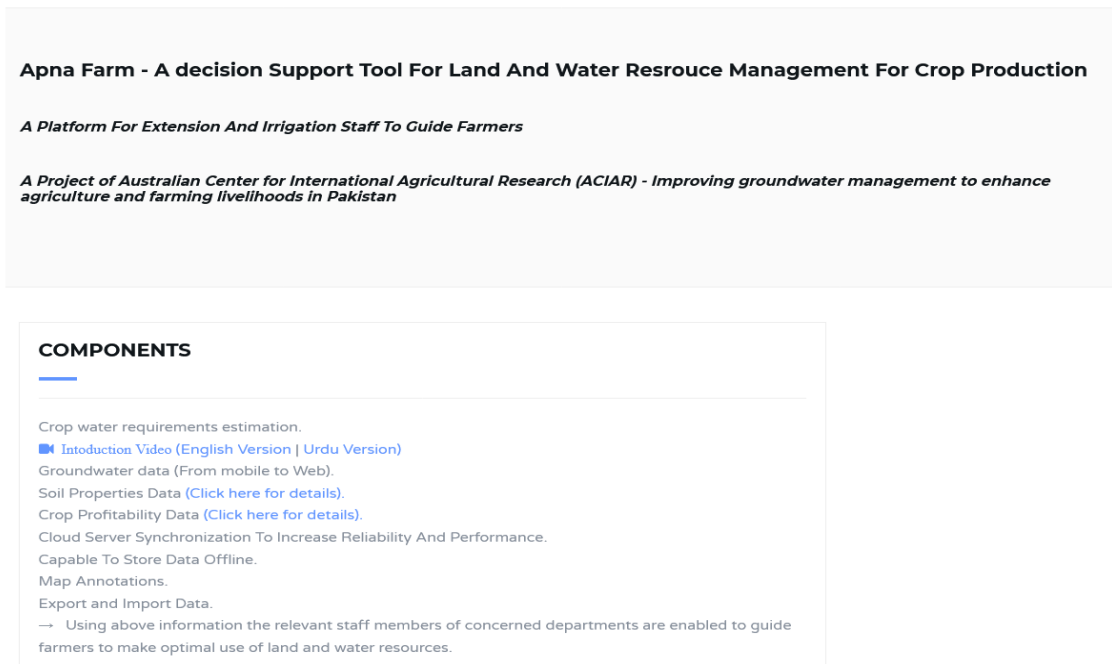


Figure 6: Introductory page

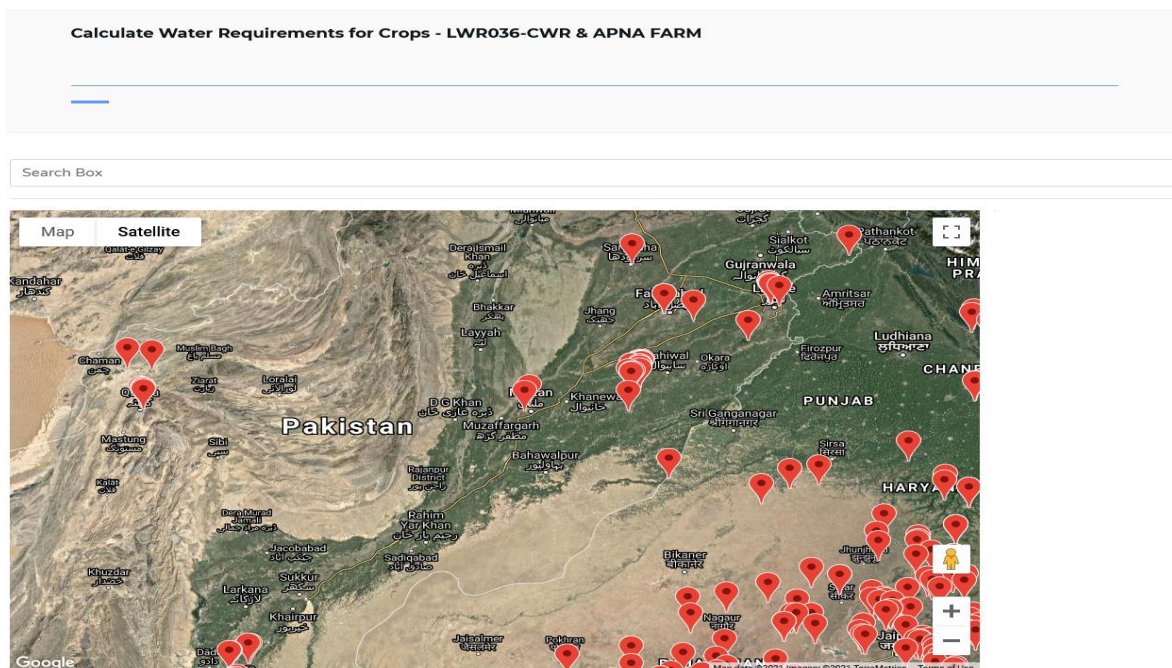



Figure 7: Landing Page

 The icon indicates all of the registered wells in the selected area of Punjab, Balochistan and Sindh. By clicking on them, we can see all of the information of that particular well. The information includes (Figures 8-10):

- a) Latest EC.
- b) Latest Depth to Water.
- c) Weather Condition.
- d) Picture of the well.
- e) Reading Graphs.



Figure 8: Well information (located at the Irrigation Research Institute Lahore, Punjab)

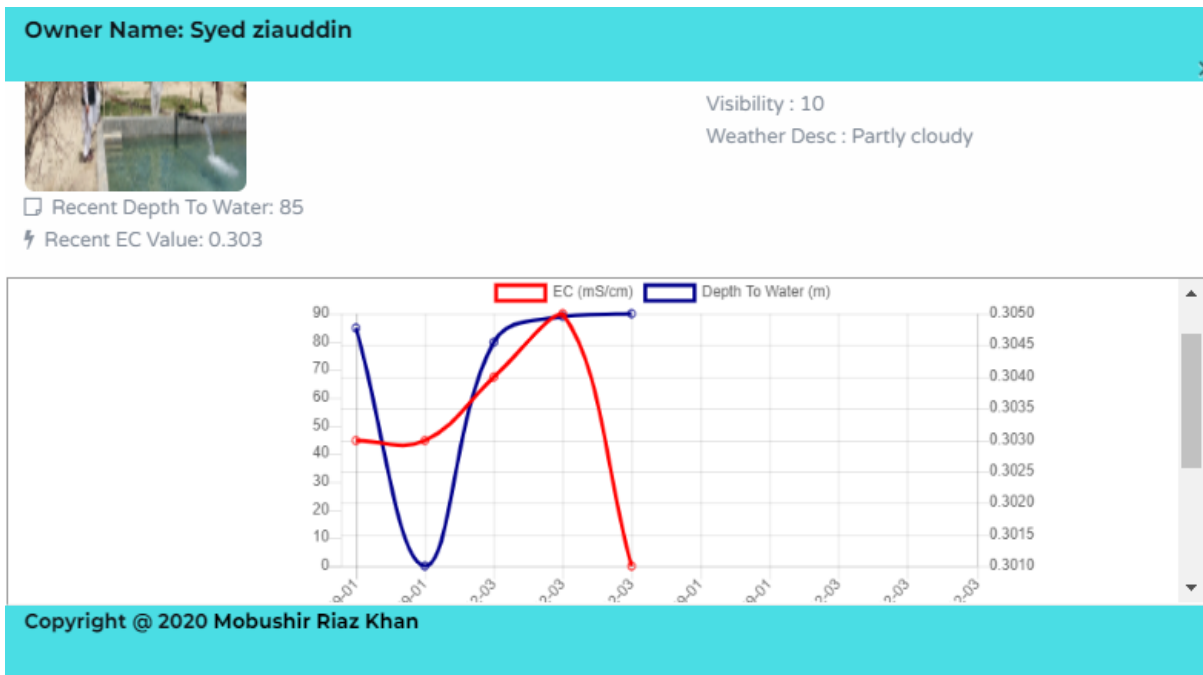


Figure 9: Well information (Quetta, Balochistan)



Figure 10: Well information (Hyderabad, Sindh)

From the search box a user can either search using the name of place or the coordinates and the platform will directly take the user to the place of interest (Figures 11-13). The user can also navigate by dragging the marker to go to a specific field.

Figure 15 shows a high-resolution map and an input field for the user to estimate crop water requirements.



Figure 11: View of search (Chichawatni, Punjab) and nearest weather stations after current weather



Figure 12: View of search (Quetta, Balochistan) and nearest weather stations after current weather

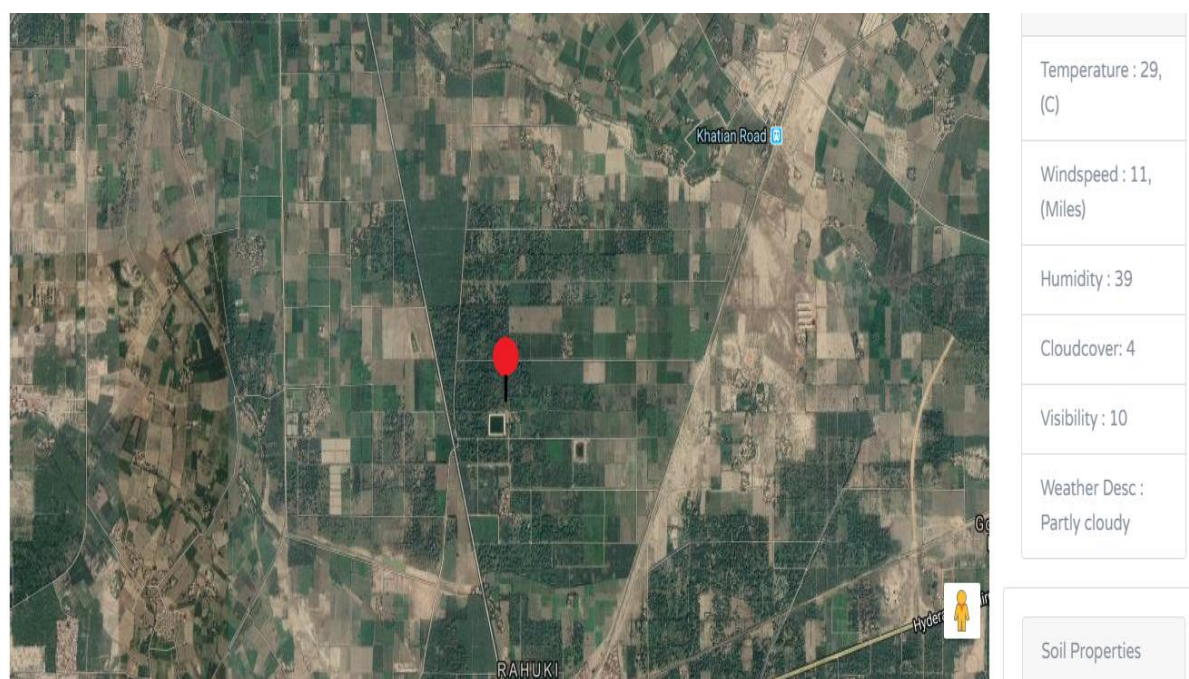


Figure 13: View of search (Hyderabad, Sindh) and nearest weather stations after current weather

After geo-locating a farm, the user will be able to see weather information, soil attributes, crop profitability graph (Figures 11-13).

4.1.1 Electrical Conductivity

Pakistan has considerable areas of land that are salt affected and that affect crop production. Salt affected areas limit options of crop type selection. Therefore, it is very important to map the salt affected areas so that researchers and policy makers can recommend appropriate solutions for salt affected area. The index which is most commonly used to quantify the intensity of salt (concentration) in the soil is Electrical conductivity (EC). In the current mobile application, EC is included as this will be helpful for mapping of salt affected areas. EC is a measure of the amount of salts (minerals) in the soil and it describes the degree to which the soil conducts an electrical current. Figures 8, 9 and 10 show the EC of groundwater at different locations of Pakistan. Figure 8 shows the temporal variation of EC and groundwater depth at a specific location in Lahore. Figures 9 and 10 show the relationship between EC and ground water depth in Quetta and Hyderabad, respectively. The values of EC for these sites are not salty (EC is between 0.8 – 2.5 mS/cm) which shows that water is not bad for irrigation and agriculture purposes (Syed et al., 2021).

4.1.2 Ground water depth (m)

Groundwater fulfils 50% of crop water requirements in Punjab and the remaining 50% is fulfilled by canal and rainwater. There has been a continuous increase in the levels of groundwater extraction over the last two decades which is resulting in declining groundwater levels. Farmers are installing new tube-wells at increasing depths and this increases the risk of saline intrusions and higher pumping costs. The Apna Pani mobile application has the capability to determine the groundwater depth. It would be helpful to identify the hotspots where groundwater extraction areas are resulting in significant water level declines. Figures 8, 9 and 10 show the groundwater depth at different locations.

4.1.3 Current Weather Conditions

Agriculture is directly linked with climatic conditions so much so that climate has an 80-90% role in determining the crop yield in each region. Long term weather conditions represent the climatic conditions. Crop water requirements are completely dependent on climatic conditions and crop evapotranspiration depends on soil moisture availability and climatic conditions. As such, current and future weather data is very important for successful crop production. It helps in real-time decision-making in relation to irrigation scheduling, sowing dates, plant protection measures, fertilizer application and time of crop harvesting. As shown in Figures 8-10, the Apna Pani mobile application has the capacity to show the current weather conditions including relative humidity, visibility, wind speed, temperature and cloud cover.

4.2 Crop Profitability

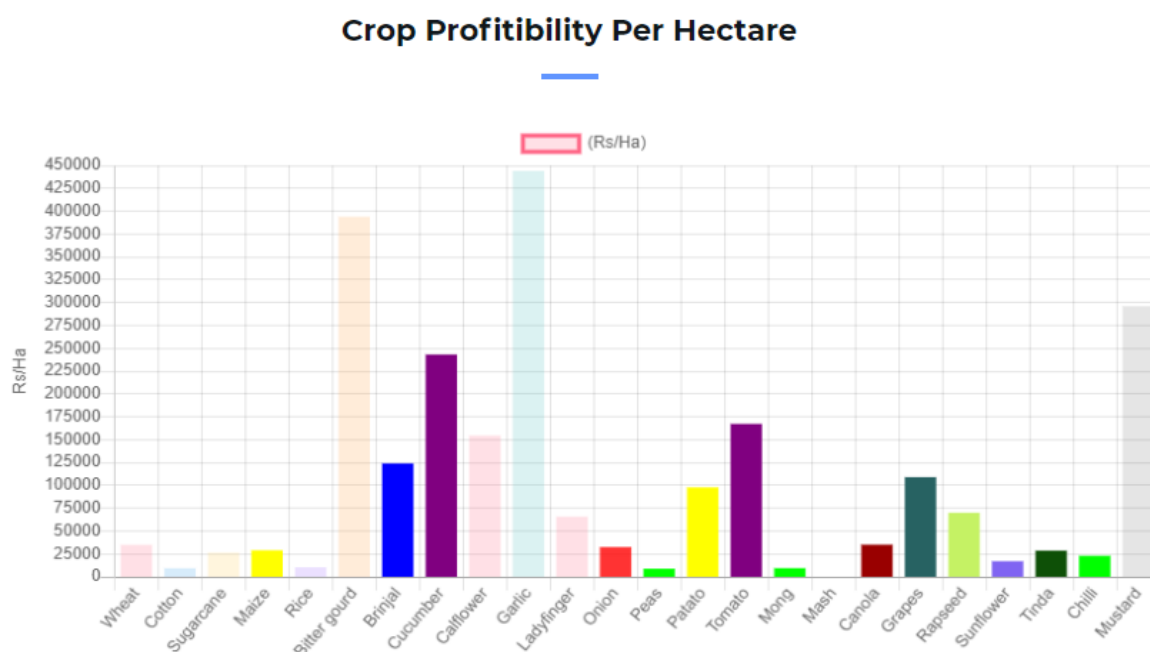


Figure 14: Crop profitability graph

The cost of production per hectare for each crop in each district is estimated by multiplying the per kg cost (calculated at province level by the Crop Reporting Service) by the yield in a specific district. The revenue is generated by taking the product of the yield and its respective product price (Ahmad et al., 2019). The product prices are obtained from the Agricultural Marketing Information Services (AMIS) website. By definition, net revenue (NR) is calculated by subtracting total cost (TC) from total revenue (TR). Hence:

$$NR=TR-TC$$

$$\text{Where, } TR=P * Q; TC=TVC+TFC \text{ and } TVC=\sum(P_{xi} * Q_{xi})$$

TVC = Total Variable Cost

TFC = Total Fixed Cost

P = Price of Crop

Q = Quantity of Crop

P_{xi} = Input price

Q_{xi} = Quantity of Input

4.2.1 Selection of Suitable Districts Based on Minimum Cultivated area for a given Crop

The cost of production data shows that almost all crops are grown across different districts. However, some crops are grown in very small patches for some local need, or on some exceptionally suitable location within otherwise non-suitable land. Using data for districts with very small, cultivated areas for a crop can result in outliers and can be misleading. In order to resolve this issue, a baseline of 20% area under a crop compared to the maximum area under that crop in a district was selected as the criteria for including districts in the economic suitability comparison (i.e. high, medium, low suitability/profitability comparisons).

4.2.2 Economic Suitability Criteria

In order to develop an economic suitability map from the existing crop suitability maps, subjective criteria were developed. The 66th percentile using districts with maximum returns for a crop as criteria was considered highly suitable; the 33rd percentile as moderately suitable and the remaining as a marginal suitable district.

- Highly suitable: > 66th percentile of maximum profit district
- Moderately suitable: > 33rd percentile of maximum profit district
- Marginally suitable: below 33rd percentile of maximum profit district

The user is able to select multiple crops by checking the corresponding box as shown in Figure 15. After selecting the crops, the user will type in the area in acres under cultivation to estimate the crop water requirements for multiple crops.

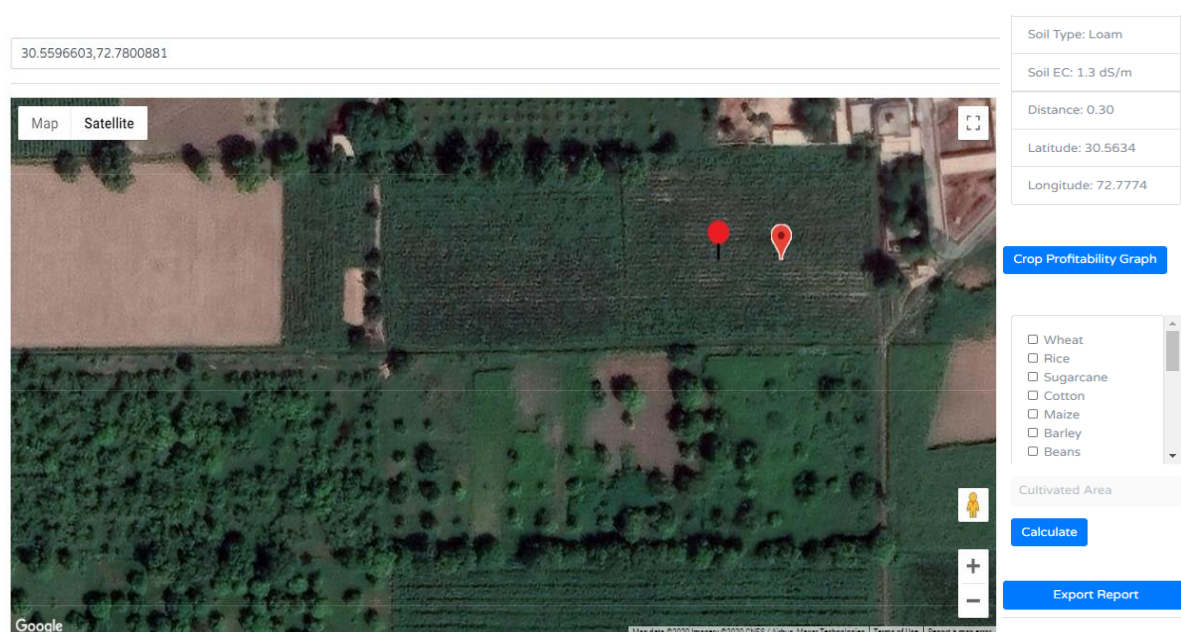


Figure 15: Input parameters from user (crops and area in acres)

The computed crop profitability was compared for Maize and Moong crops at a farmer’s site in Chichawatni. The cost of production was calculated from sowing to harvesting by the farmer and compared with those embedded in Apna Farm. This comparison showed a good agreement

between the crop profitability embedded in the Apna Farm and that of calculated at farmers cite (Figures 16 and 17).

Further, more profitable districts for Moong crop are Layyah and Okara with net returns per hectare of Rs. 16298.72 and Rs. 15983.41 respectively. Moong production also generates significant revenues in district (Ahmad et al., 2019). In the crop profitability module, the district-wise average data was used. The district-wise crop profitability Chichawatni (Sahiwal) net return was calculated as 9966.80 rupees per hectare; while net return was calculated at LWR036 farmer site was 15956.03 rupees as shown in Figure 16. It was observed that the per hectare value 6459.91 rupees per acre was almost same as the value that was calculated by the farmer.

Crop Profitability of Moong Crop						
Total Fixed Cost (TFC)		Total Variable Cost (TVC)		Price of Crop (P)		Quantity of Crop (Q)
Ploughing	1,400.00	Fertilizer	4,300.00	Market Rate	4,000.00	18.00
Bed Preparation	1,400.00	Pesticide	7,670.00			
Seed	3,300.00	Lazer leveling	1,500.00			
Irrigation	2,400.00					
Land Rent	25,000.00					
Harvesting	6,600.00					
Labour	11,970.00					
Total Fixed Cost (TFC)	52,070.00	Total Variable Cost (TVC)	13,470.00	TR= P*Q	72,000.00	18.00
TC= TFC+TVC	65,540.00					
NR= TR-TC	6,460.00					
Net Return Per Acre	6,460.00	NR=TR-TC				
Net Return Per Hectare	15,956.20	Where, TR=P * Q; TC=TVC+TFC and TVC=∑(P _{xi} * Q _{xi})				

Figure 16: Moong crop profitability calculation at farmer’s field in Chichawatni (crops and area in acres)

According to the district-wise calculation of profitability, the net return of a maize crop is very low in northern areas of the province but the net return of district Pakpattan, Okara, Kasur and Bahawalpur Rs. 31623.95, Rs. 30901.73, Rs. 30636.17 and Rs. 30311.11 per hectare. In district-wise crop profitability Chichawatni (Sahiwal) the net return was calculated 29064.14 rupees per hectare; while net return at farmer’s site was 43071.86 rupees as shown in Figure 17. It was observed that per hectare net return difference is due to management practices.

Crop Profitability of Maize Crop						
Total Fixed Cost (TFC)		Total Variable Cost (TVC)		Price of Crop (P)		Quantity of Crop (Q)
Ploughing	2,800.00	Fertilizer	16,900.00	Market Rate	950.00	110.00
Bed Preparation	1,600.00	Pesticide	3,600.00			
Seed	9,300.00	Lazer leveling	1,500.00			
Irrigation	6,000.00					
Land Rent	25,000.00					
Harvesting	7,300.00					
Labour	13,062.00					
Total Fixed Cost (TFC)	65,062.00	Total Variable Cost (TVC)	22,000.00	TR= P*Q	104,500.00	110.00
TC= TFC+TVC	87,062.00					
NR= TR-TC	17,438.00					
Net Return Per Acre	17438	NR=TR-TC				
Net Return Per Hectare	43071.86	Where, TR=P * Q; TC=TVC+TFC and TVC=∑(P _{xi} * Q _{xi})				

Figure 17: Maize crop profitability calculation at farmer’s field in Chichawatni (crops and area in acres)

The web based DSS will produce monthly water requirements for the crops of interest (Figure 18) which are exported to a PDF.

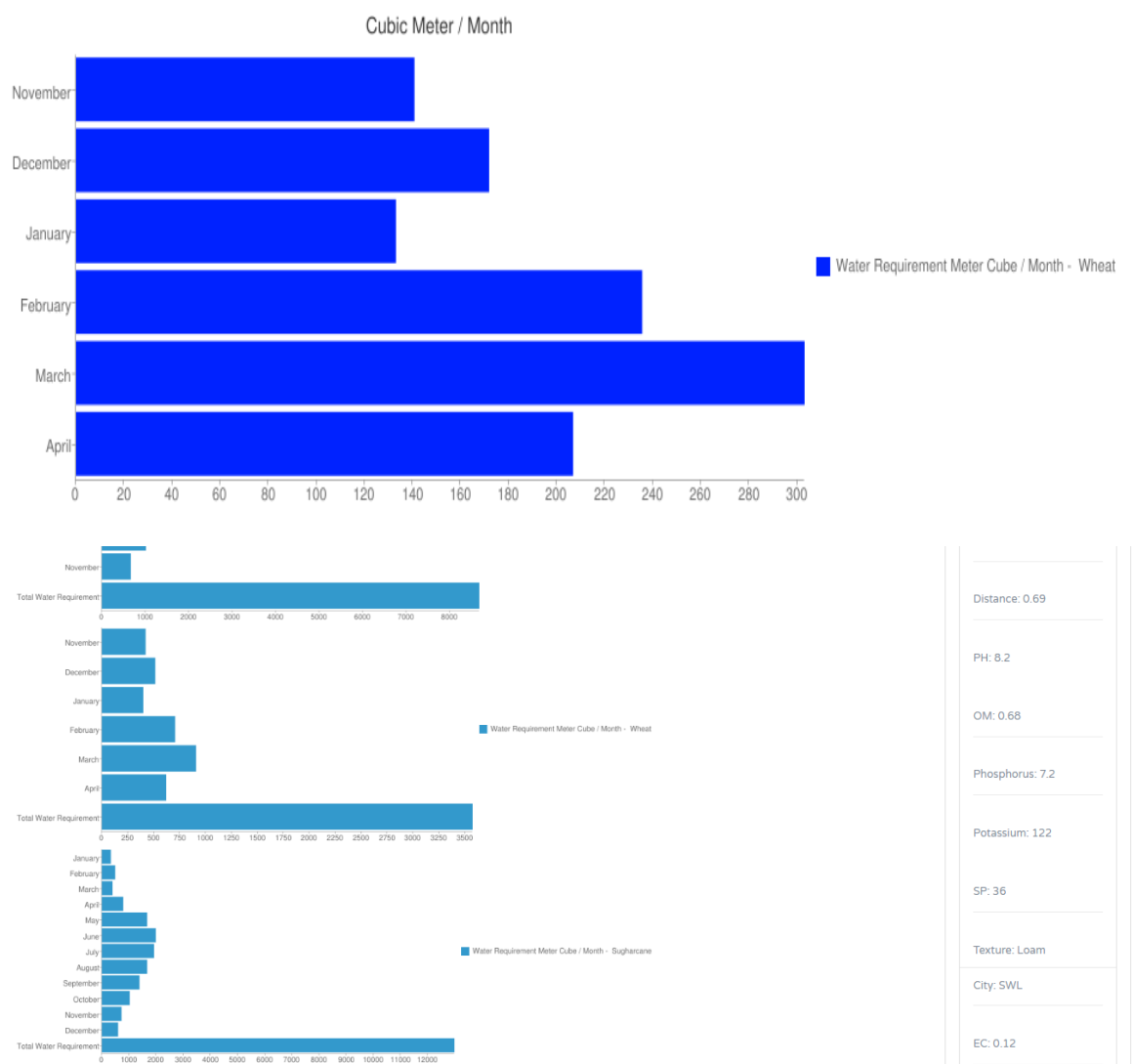
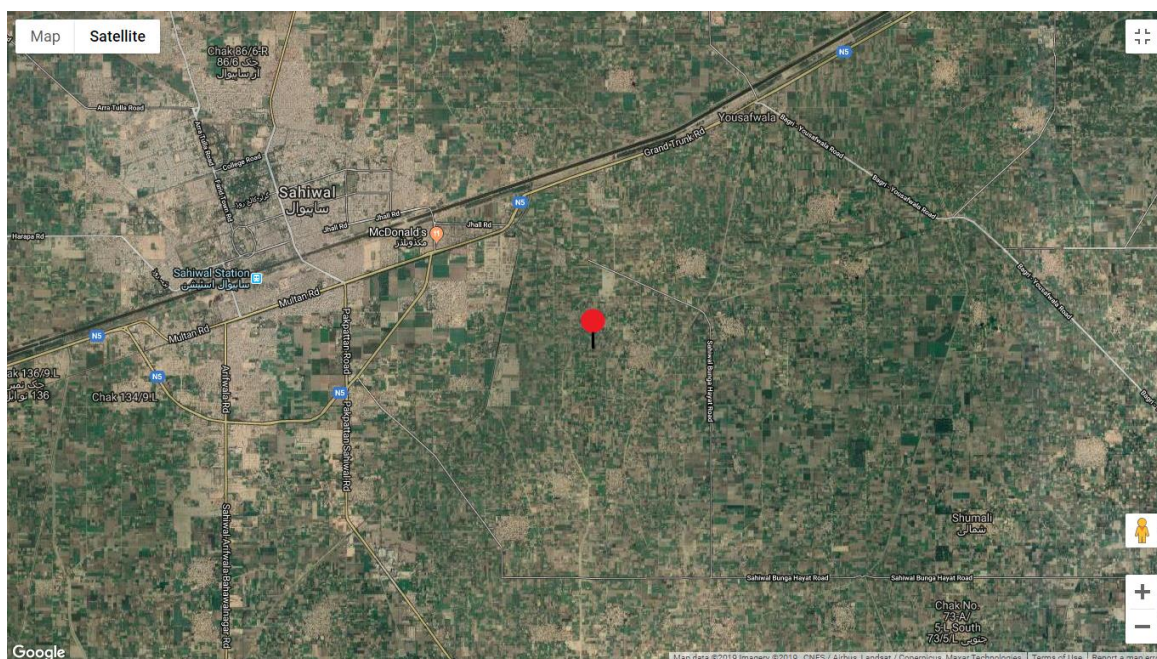


Figure 18: Calculated water requirements of remaining selected crops

4.2.3 Validation of Crop Water Requirements

Crop water requirement is the total requirement of water from sowing to maturity of a crop. Irrigation schedules have an important role for successful crop production especially in water scarce areas. The same crop may have different water requirements in different areas due to climatic difference. The crop water requirement of same crop at same location may also vary from year to year due to differences in climatic conditions. The Apna Pani mobile application can determine the crop water requirement of each crop based on the site-specific climatic conditions. The trend in the outcome of Apna Pani and Apna Farm was validated by using the International Water Management Institute (IWMI) recommended crop water requirements (Ullah et al., 2001). The results showed a close association between the crop water requirement results from the mobile app and the IWMI data. The crop water requirements for two different crops, wheat and maize, at two different locations are presented below. The crop water requirements for both crops planted at Sahiwal as calculated using the mobile app was compared with IWMI data and the error percentage varied from 1 to 18%.



Latitude: 30.6443797822

Longitude: 73.1641401454

Crop: Wheat, Area = 1 Acre

Table 1: Validation of water requirements for wheat

	Application Calculated		IWMI Reported Working Paper 24			Difference	
	CWR (m3)	ETc Depth mm/day)	ETo Depth (mm/day)	Kc	ETc	% Change	Change
Nov	140.8	1.2	1.9	0.38	0.7	60.62	0.4
Dec	171.86	1.4	1.4	0.71	1.0	42.41	0.4
Jan	133.8	1.1	1.5	1	1.5	-26.53	-0.4
Feb	235.5	1.9	2.2	1.15	2.5	-23.33	-0.6
Mar	303.07	2.5	4	0.71	2.8	-12.10	-0.3
Apr	206.83	1.7	5.1	0.53	2.7	-36.97	-1.0

Crop Water Requirement of Wheat Crop calculated by Developed Application.

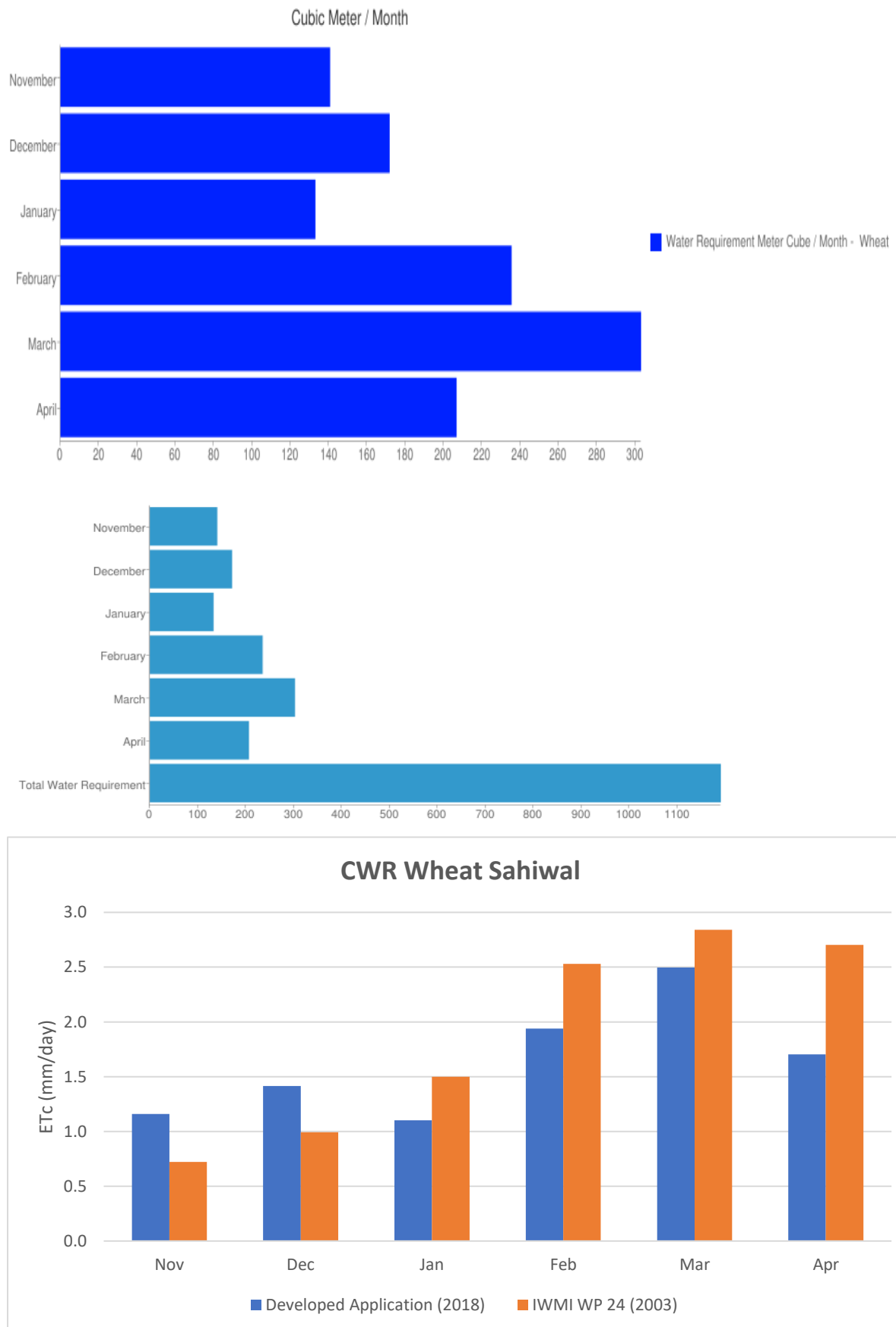


Figure 19: Comparison of ETc of wheat crop calculated through developed application versus IWM report

Description:

Developed application calculate higher crop water requirement as compared to IWMI reported results.

Table 2: Validation of water requirements for Maize

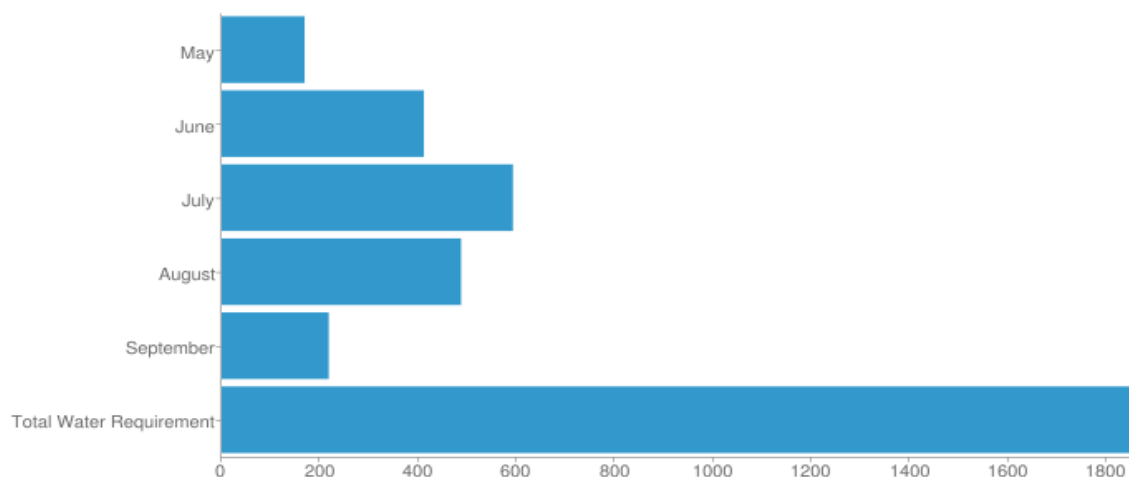
	Application Calculated		IWMI Reported Working Paper 24			Difference	
	CWR (m3)	ETc Depth mm/day)	ETo Depth mm/day)	Kc	ETc	% Change	Change
May	168.74	1.4	6.57	0.15	1.0	41.03	0.4
Jun	411.28	3.4	7.13	0.32	2.3	48.47	1.1
Jul	592.42	4.9	6.03	0.79	4.8	2.43	0.1
Aug	486.89	4.0	5.6	0.82	4.6	-12.67	-0.6
Sep	217.99	1.8	4.9	0.33	1.6	11.04	0.2

Latitude: 30.6443797822

Longitude: 73.1641401454

Crop: Maize, Area = 1 Acre

Crop Water Requirement of Maize Crop calculated by Developed Application



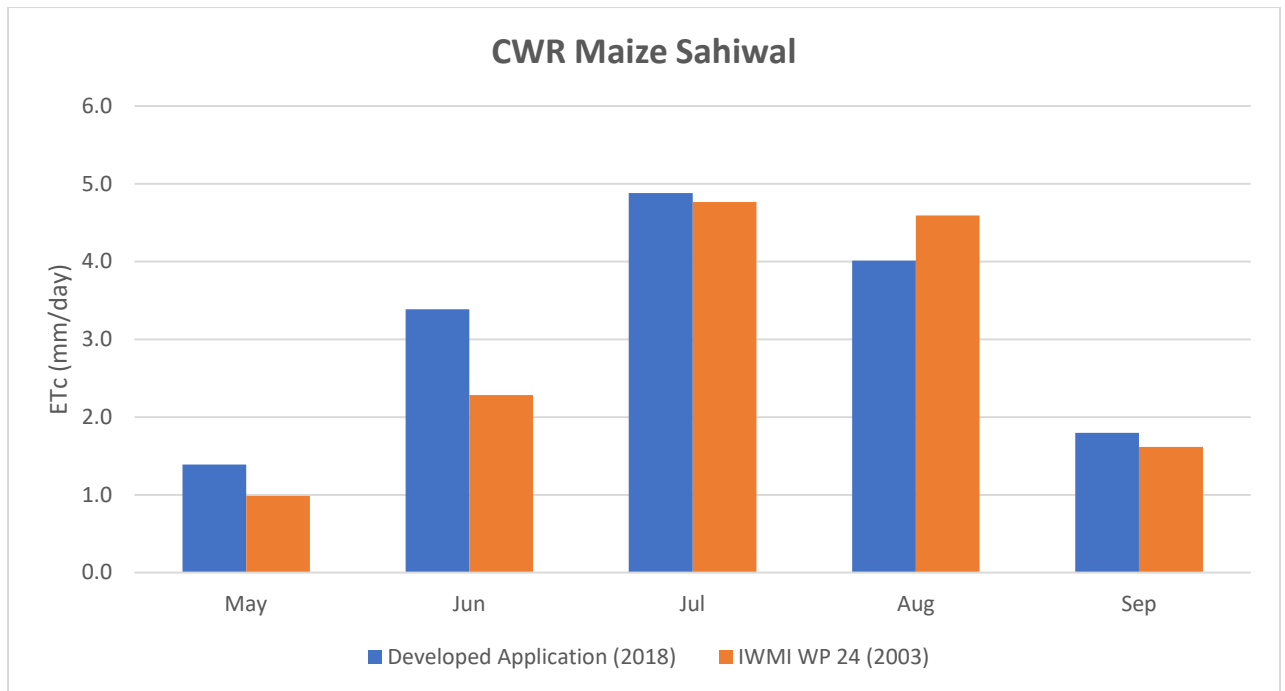


Figure 20: Comparison of ETc of maize crop calculated through developed application versus IWMI report

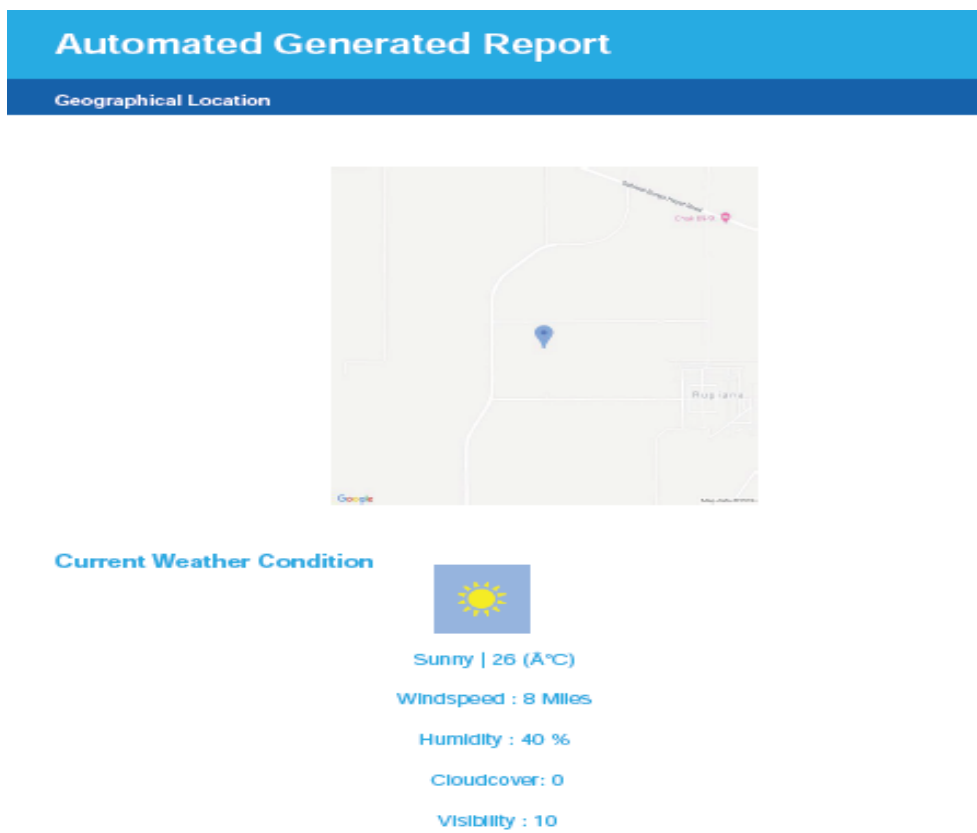


Figure 21: Exported PDF report of selected area

4.3 Mobile application and its functionalities

As mentioned earlier the “Apna Pani” app captures and transfers data to a centralized database created on an online server and the web app uses the same data to display on the Google Map. The Mobile app can easily be download from App Store (Figure 22). After “Launching Application” (Figure 23), the user needs an account to use the functionalities of the app (Figure 24). This helps the user to manage and store data efficiently.

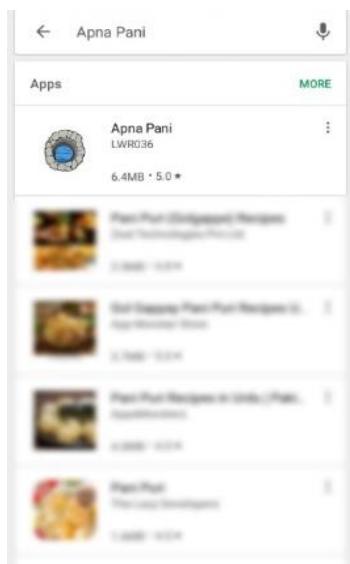


Figure 22: App installation

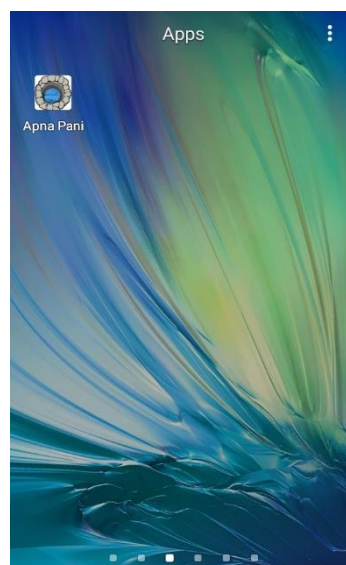


Figure 23: Launch App

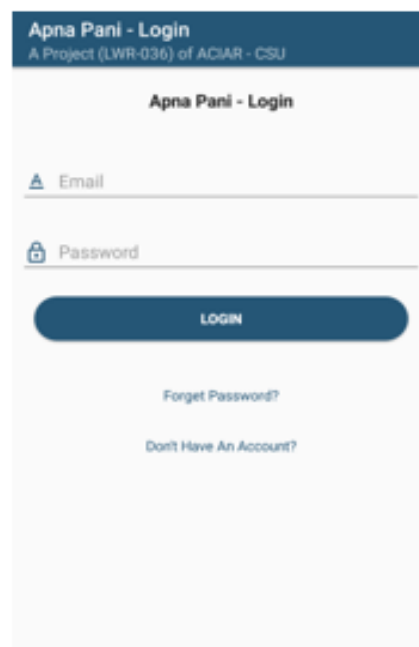
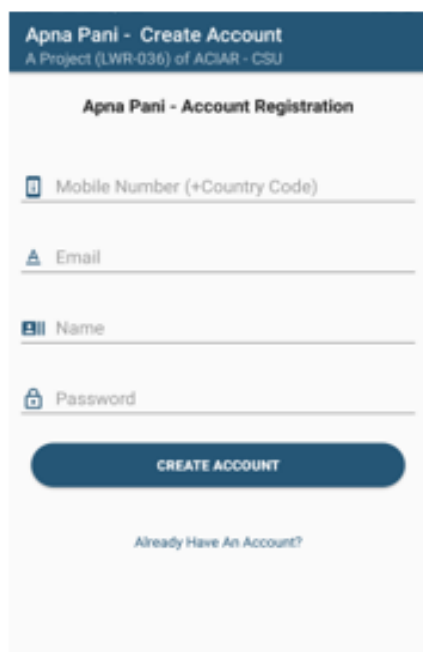


Figure 24: Account creation

Figures 25-28 show how to register a new well, report a well reading and check a well reading.

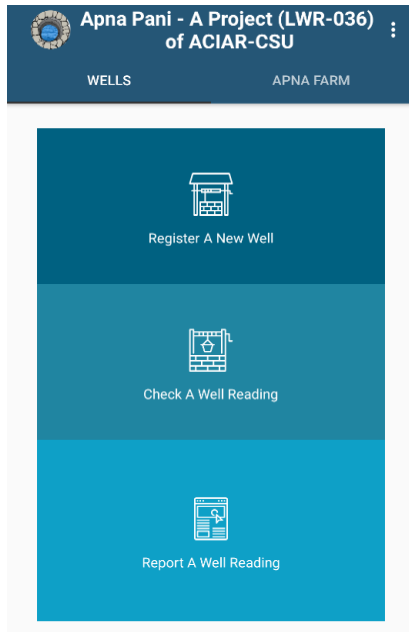


Figure 25: Dashboard

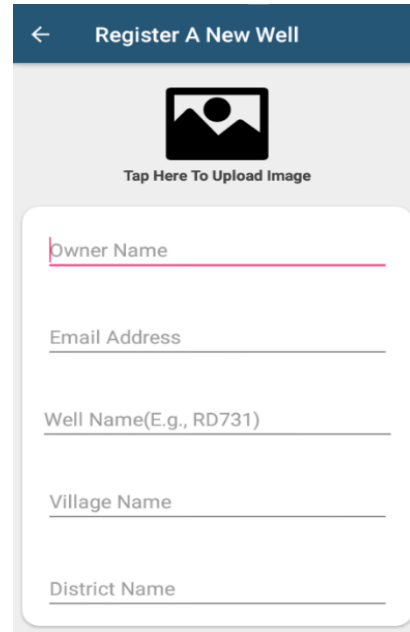
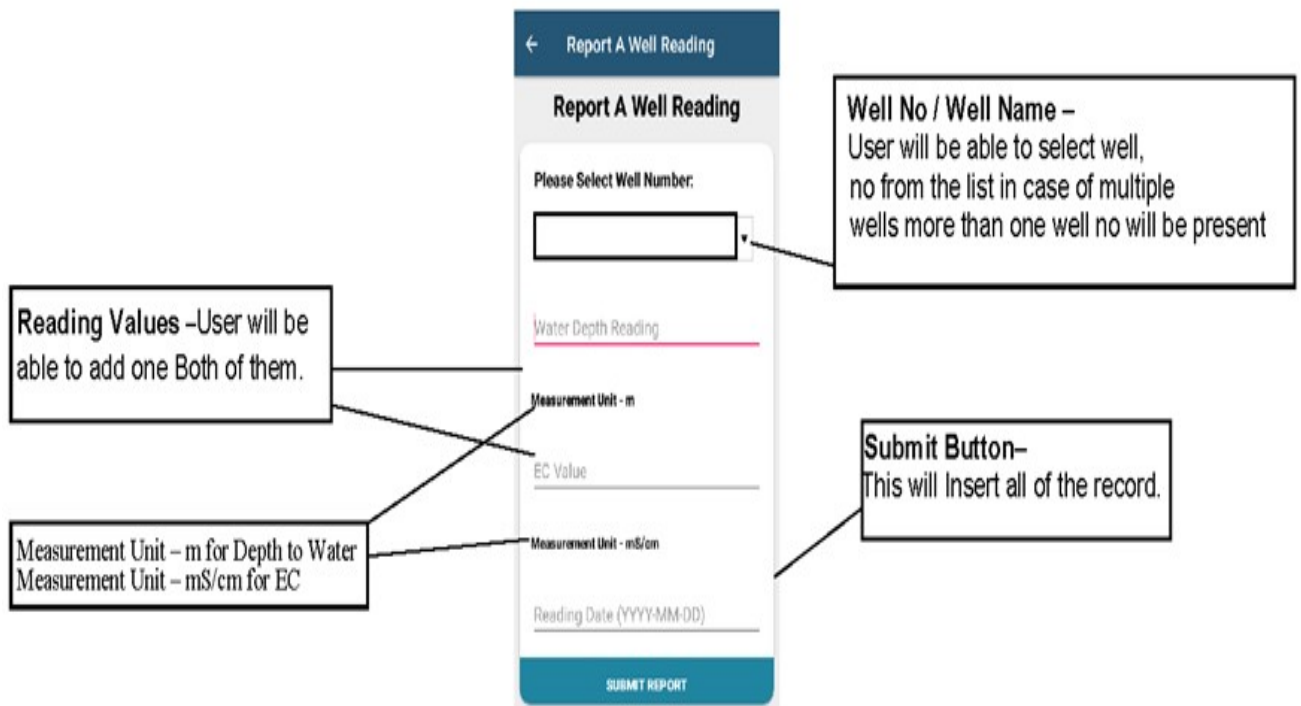


Figure 26: Register a new well



User Will be able to update record on the daily basis of the well by just selecting Well No. from the drop down and click on the Submit Report. Please Note That: Well No. will only be generated after the successful Well Insertion. User can enter date or leave it empty.

Figure 27: Report a well reading

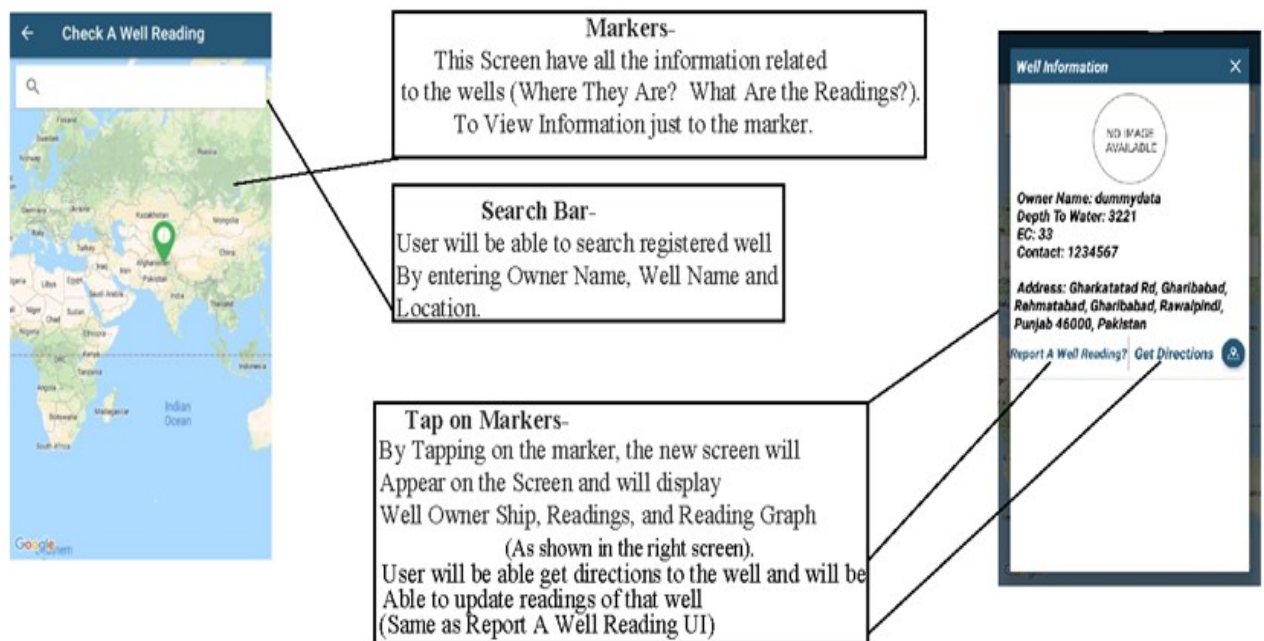


Figure 28: Check a well reading

Figure 29 illustrates the Apna Farm second module of the app. This module works same as the web app. The user will be able to geo-locate the farm and press the confirm button to see the result.

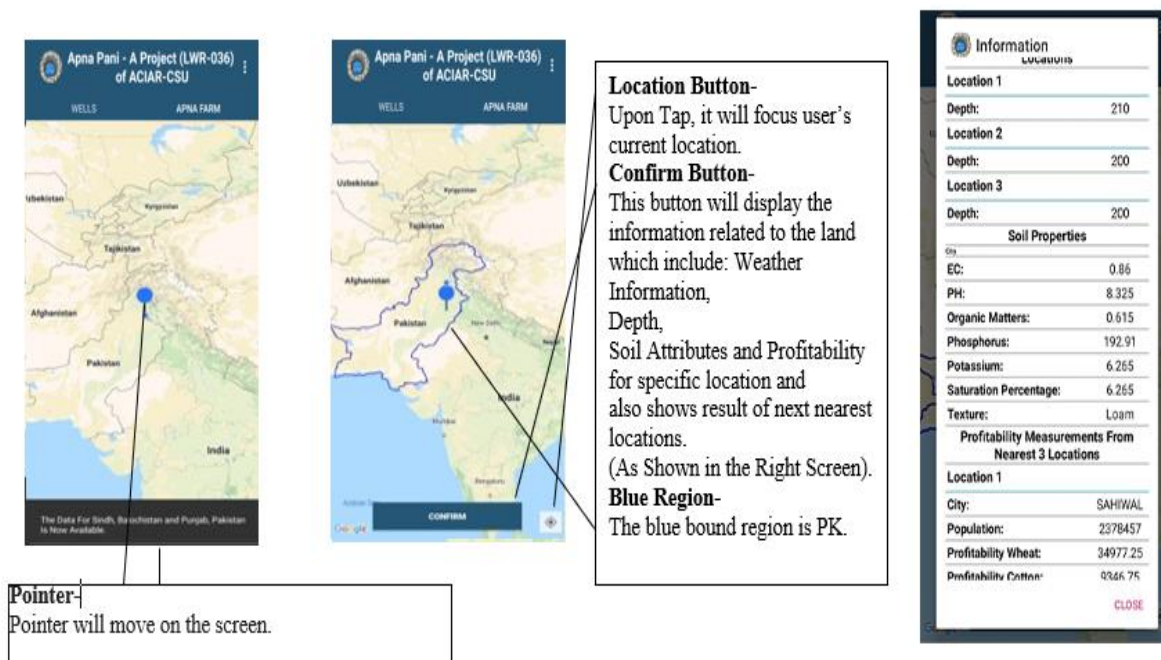


Figure 29: Apna Farm Mobile

The user will also be able to upload / download the data as a .CSV file (Figure 30).



Figure 30: Upload / download data

5 Use and trainings of the developed applications

These easy-to-use mobile and web-based spatial applications were launched by the Australian High Commissioner to Pakistan, Dr Geoffrey Shaw, and ACIAR's CEO, Prof. Andrew Campbell on Monday, July 27 2020.

Through an interactive webinar the three integrated components – Apna Pani (meaning “our water”), and its two additional modules, Wells and Apna Farms were demonstrated (Figure 31). A Pakistani farmer Sharaz Akhtar, from the village of Cheecha Watni in Punjab (a study area of the project) also shared his experiences of using the Apps (Figures 32 and 33). Following testing by the project partners, two training days were held at farmer’s fields in Chichawatni for farmers in August 2020 (Figure 34).

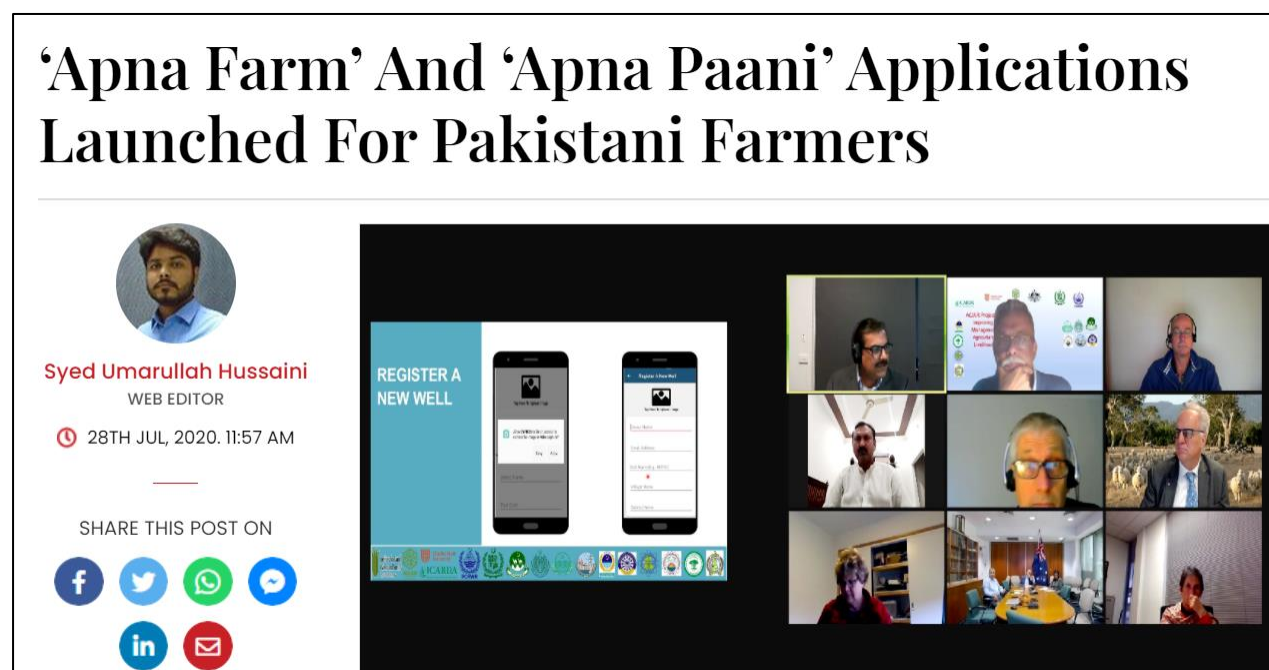


Figure 31: The launch of the developed applications

SBS Urdu

SBS URDU HOME NEWS AND FEATURES CORONAVIRUS TOPICS LISTEN WATCH CONTACT US EXPLORE SBS

UP SUN 6:00 PM AEDT Urdu radio

'Terrific tool' – the Australian app that could be a game changer for farmers in Pakistan

A Pakistani farmer works on a crop on a maize field with the help of oxen. Source: Getty Images / Tahreer Photography

'Apna paani' meaning 'our water' in Urdu is a new app launched to assist farmers challenged by declining groundwater levels in Pakistan. The app is developed by the Australian Centre for International Agricultural Research (ACIAR) to improve food security through better water management in the South Asian country.

Sheeraz Sindhu is a farmer in Chichawatni in the province of Punjab, Pakistan, and belongs to a family associated with agriculture for generations.

"This app is a terrific tool for me or any farmer," Sheeraz told SBS Urdu.

"I just have to add my location and the app tells me all the details about the water and soil immediately."

- Pakistan is one of most 'water-stressed' countries in the world
- Australia is working with Pakistan to improve food security through water management
- ACIAR CEO says Pakistan and Australian both learn from each other through the exchange of ideas and experience

The farmers in the area input the water data including water usage and consumption which is incorporated by the app that provides the overall water details to each farmer who has the app.

Similarly, the soil data is provided to the farmer to help in determining the best farming practice in relation to the soil content.

Sheeraz says for a village farmer, it is quite cumbersome to collect soil samples and take it to a faraway lab.

"I have made long journeys to check the PH level, phosphorous content, and other properties of soil in order to workout water management and produce a better crop."

According to Sheeraz, the app is now being increasingly used by farmers of other regions.

"More and more farmers from other villages are asking about this app which provides water and soil information; I am hoping it reaches other provinces soon."

Figure 32: Excerpts from the news paper



Figure 33: Young family member of a farmer is geolocating his field

6 Future

It is anticipated that the DSS App will be used and further developed beyond the time of this project. Discussion is underway to enable the transfer of the server to PCRWR. There is also the potential to provide organisation specific versions to, for example, the Pakistan Irrigation Department and other Government Departments.



Figure 34: Participants of a training on developed applications

7 References

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<https://doi.org/10.1080/00103624.2020.1854294>
- Ullah, M. K.; Habib, Z.; Muhammad, S. 2001. Spatial distribution of reference and potential evapotranspiration across the Indus Basin Irrigation Systems. Lahore, Pakistan: IWMI Pakistan. vi, 55p. [IWMI working paper 24: Pakistan country series no.8.
<https://www.iwmi.cgiar.org/publications/iwmi-working-papers/iwmi-working-paper-24/>

Annexure – User Manual (Apna Pani and Apna Farm)

(Please see the following pages)

Installation

To find the App manually, navigate to the Google Play Store and search “Apna Pani” OR https://play.google.com/store/apps/details?id=com.lwr.wells.mrkhan&hl=en_US

Select INSTALL to begin the download.

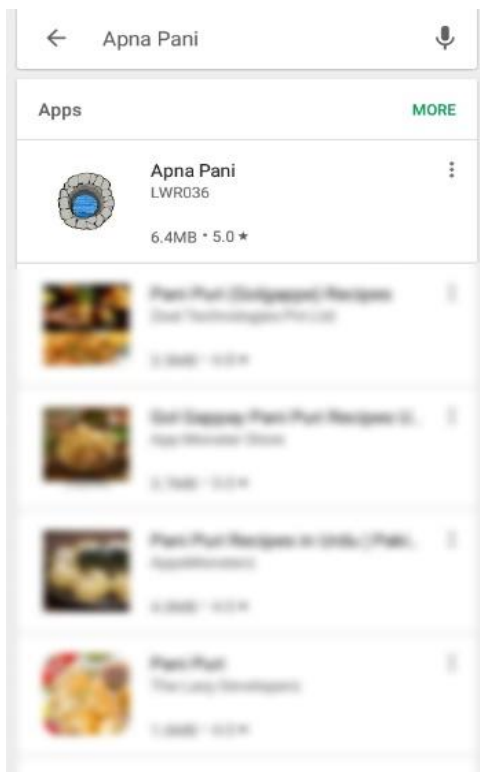
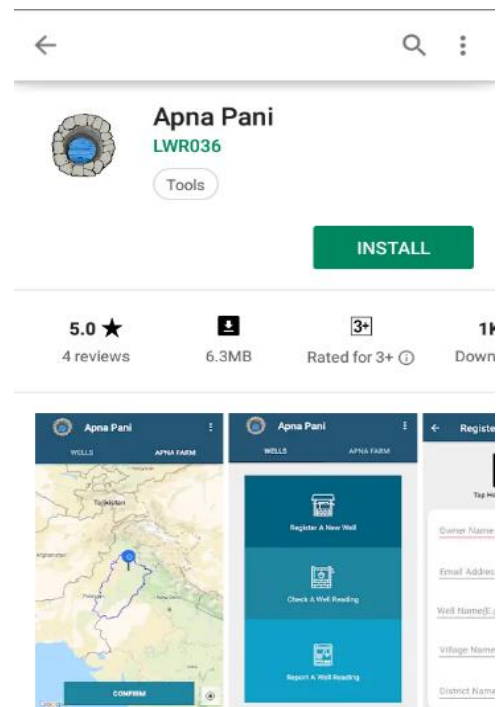


Figure 35: Search App



Apni Pani is a farm management application for smartphones.

Figure 36: Install App

Account Creation

Go to Menu Tap on  **Apna Pani Icon to open the Application.**

Apna Pani - Create Account
A Project (LWR-036) of ACIAR - CSU

Apna Pani - Account Registration

Mobile Number (+Country Code)

Email

Name

Password

CREATE ACCOUNT

[Already Have An Account?](#)

Figure 37: Account Creation 1

Apna Pani - Login
A Project (LWR-036) of ACIAR - CSU

Apna Pani - Login

Email

Password

LOGIN

[Forget Password?](#)

[Don't Have An Account?](#)

Figure 38: Account Creation 2

The user will be asked to verify their phone number and after verification the user will automatically be redirected to the Apna Pani – Create Account screen. The user must fill out the fields for account creation, or, if they already have an account, click on the button 'Already Have An Account' and login with their credentials. Please note that the user must have an active internet connection.

Launch Application & Requesting Permission

After Account Creation, the user will be asked to turn on the Location Services.

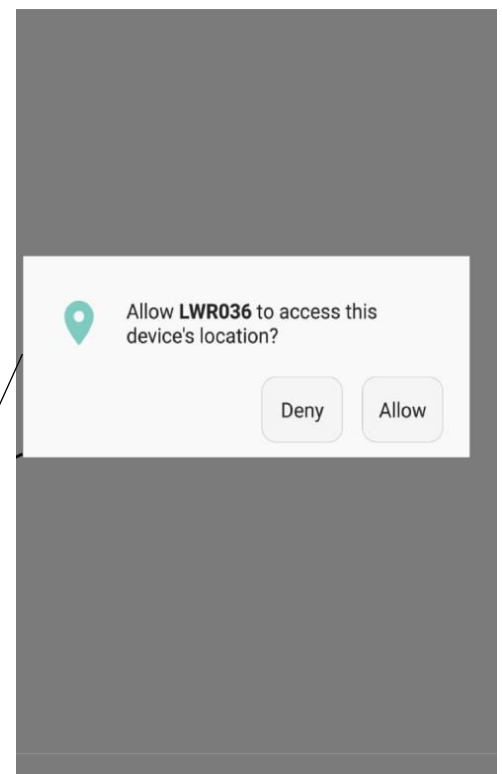


Figure 39: Request Permission

Requesting Permission- The user will be asked to allow access to location services.

Deny- Permission not granted: the user won't be able to use application properly

Allow- Permission not granted: the user will be able to use application properly.

(In order to use the application permission should be granted).

Main Screen

Apna Pani-

Main Screen of the app with two Tabs.

WELLS (Default Tab).

APNA FARM.

Menu Section – The three vertical dots are the menu and this provides downloading and sharing capabilities

Well - This Section has two windows:

Register A New Well – for registering new well.

Check A Well Reading – for checking a well's reading.

Report A Well Reading – for reporting on daily basis.



Figure 40: Main Screen

APNA FARM – The MAP Section of the Application will enable the user to navigate through the map to locate their own farm and to see different parameters of the farm.

Register A New Well UI

Requesting Permission –

The window will ask the user to give the app access to the camera.

Deny- Permission not granted: the user won't be able to upload images.

Allow- Permission granted: the user will be able to upload images

(In order to use the application permission should be granted)

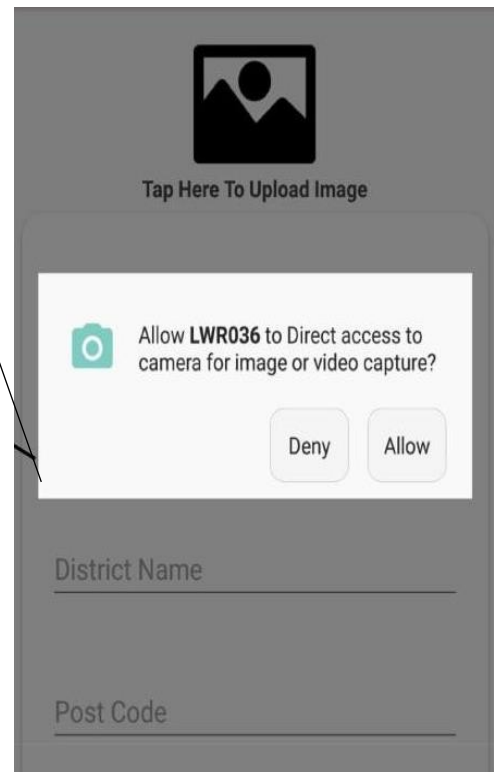


Figure 41: Request Permission

A screenshot of a mobile application form titled 'Register A New Well'. The form has a dark blue header with a back arrow and the title. Below the header is a camera icon and the text 'Tap Here To Upload Image'. The form contains several input fields: 'Owner Name', 'Email Address', 'Well Name(E.g., RD731)', 'Village Name', and 'District Name'.

Figure 42: Register a New Well

Details – It is necessary for all users to fill out the Fields.

Post code- This field is optional.

Well Name- This field is optional.

Image Uploader – The user will be able to add images of the wells.

Report A Well Reading UI

The user will be able to update and record information for the well on a daily basis by selecting "Well No." from the drop-down list and clicking on the Submit Report. **Please Note That:** Well No. will only be generated after the well has been successfully added. The user can enter a date or leave it empty.

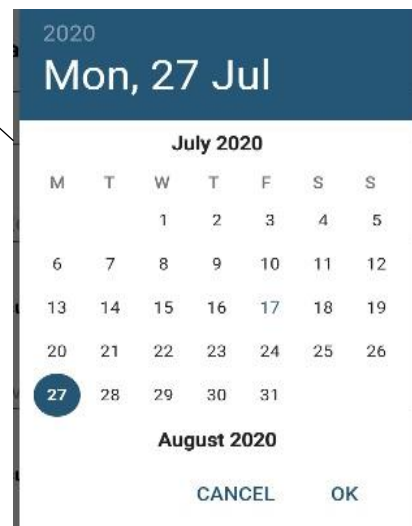
The user will be able to select well, no from the list in case of multiple wells more than one well no will be present

Reading Values –the user will be able to add one or both of them.

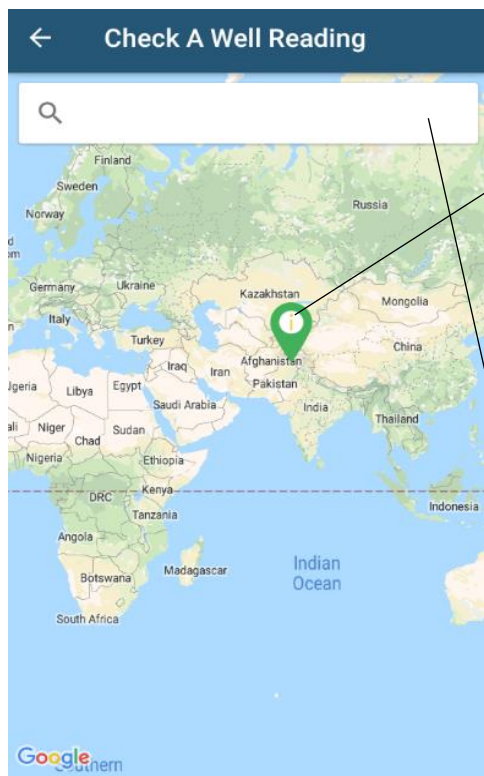
Measurement Unit: m for Depth to Water
Measurement Unit: mS/cm for EC

Submit Button – This will insert all of the record.

Figure 43: Report a Well Reading



Check A Well Reading UI



Markers - This Screen have all of the information related to the wells (i.e. Where They Are? What Are the Readings?).
To view the information, just point to the marker.

Search Bar-
The user will be able to search for a registered well by entering:
Owner Name, Well Name and Location.

Figure 45: Check a Well Reading 1

Tap on Markers-
By Tapping on the marker, a new screen will appear. This screen will display:
Well ownership, readings, and the reading graph
(As shown in the right screen).
The user will be able get directions to the well and will be able to update readings of that well
(Same as Report A Well Reading UI)

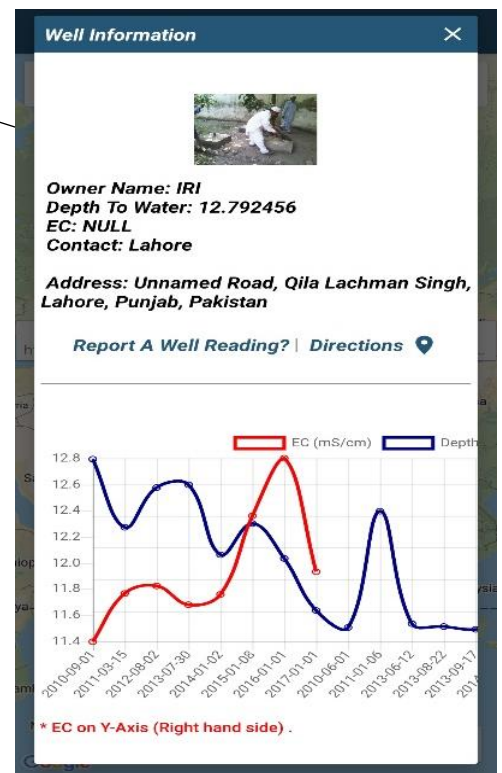


Figure 44: Check a Well Reading 2

APNA FARM UI



Figure 48: Apna Farm UI Map

Pointer – The pointer will move on the screen (now bound to move).
 In Punjab, Pakistan Only: as shown in the message. Blue Region-The blue bound region is Punjab, PK.

Location Button - Upon tap, it will focus on the user's current location.
Confirm Button - This button will display the information related to the land including: weather information, water depth, soil attributes and profitability for the specific location. Results for the nearest 3 locations are also shown.

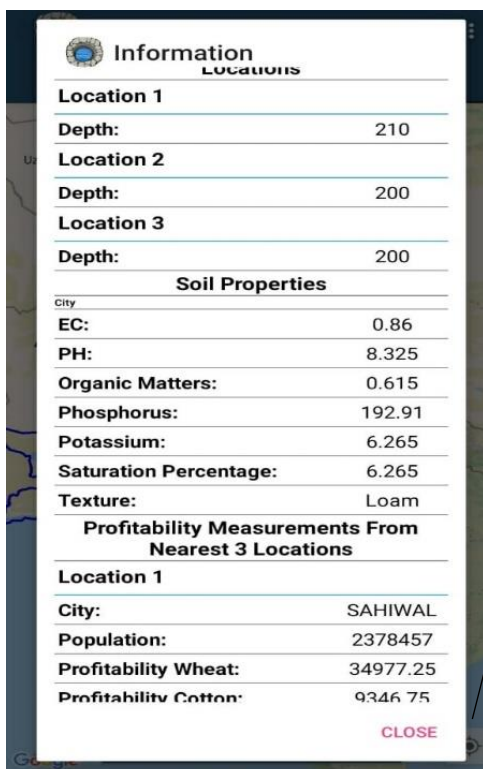


Figure 46: Apna Farm Result 1

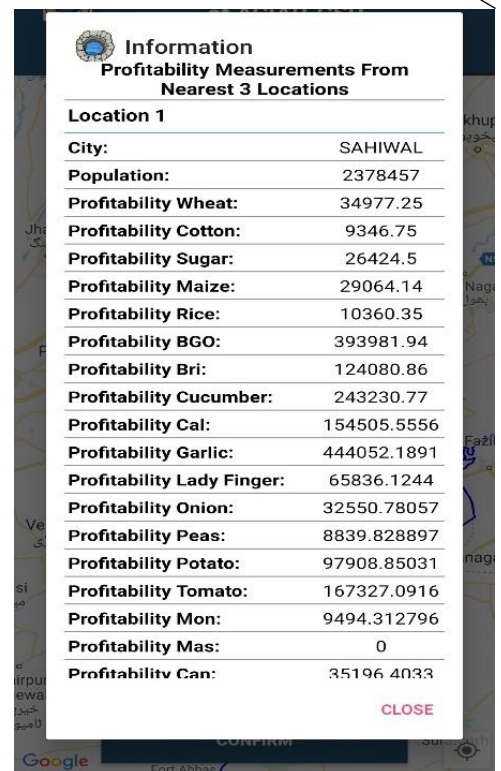


Figure 47: Apna Farm Result 2

Offline Version UI

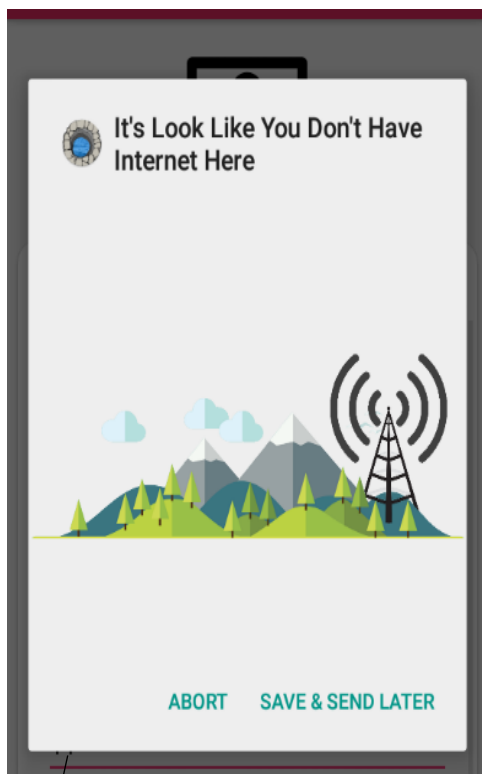


Figure 49: Offline UI

Save And Send Later-

When there is no internet connection, the following screen will appear to ask if you want to add data late when an internet connection is available or if you want to abort the operation.

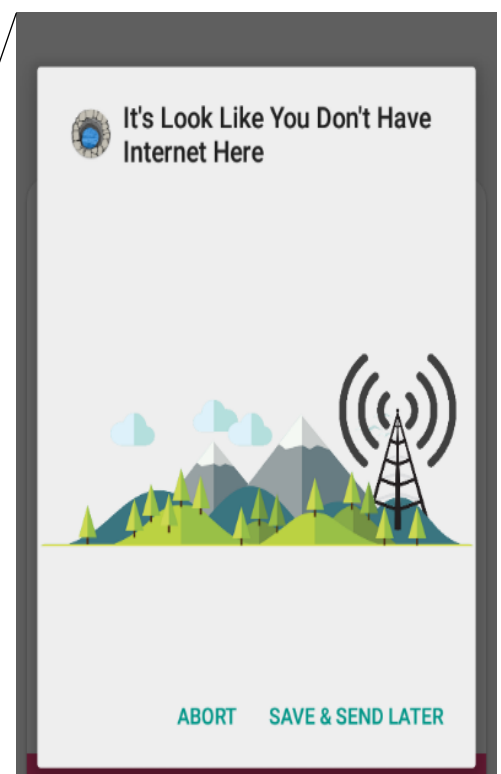
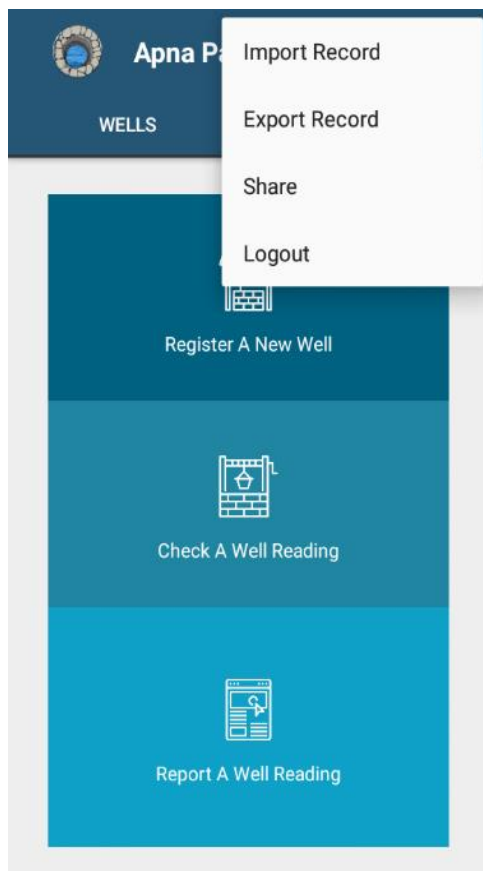


Figure 50: Offline UI

Main Menu (Downloading / Upload)



Main Menu has four options.

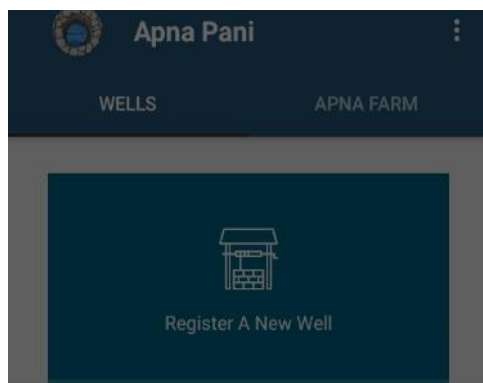
Export Data: To download CSV. file

Import Data: To upload CSV file (as shown).

Share: To Share App with others.

Logout: To Sign out from the App.

Figure 53: Main Menu



Share Via

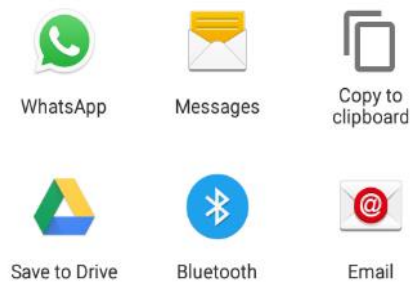


Figure 51: Main Menu Share

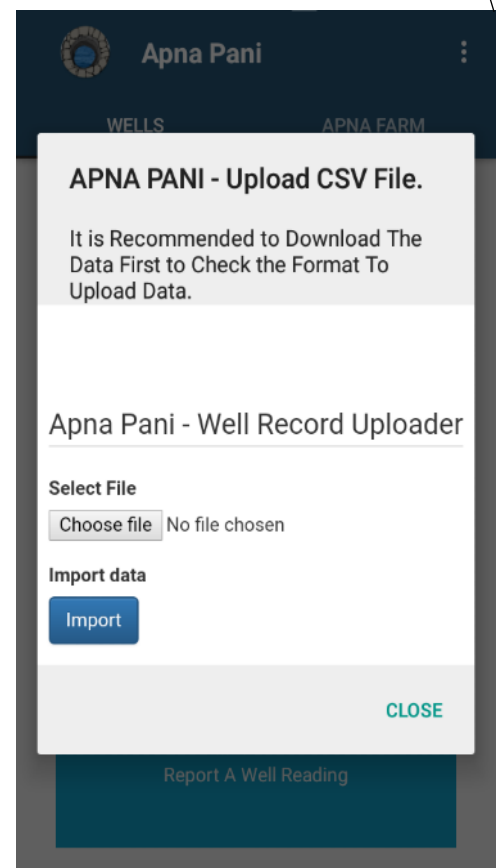


Figure 52: Main Menu Upload CSV

Check Your Well - Web Interface

To Check Please Visit: <https://www.mriaz-khan.com/aciardss>

Apna Farm - A decision Support Tool For Land And Water Resrouce Management For Crop Production

A Platform For Extension And Irrigation Staff To Guide Farmers

A Project of Australian Center for International Agricultural Research (ACIAR) - Improving groundwater management to enhance agriculture and farming livelihoods in Pakistan

COMPONENTS

Crop water requirements estimation.

■ [Intoduction Video \(English Version | Urdu Version\)](#)

Groundwater data (From mobile to Web).

Soil Properties Data ([Click here for details](#)).

Crop Profitability Data ([Click here for details](#)).

Cloud Server Synchronization To Increase Reliability And Performance.

Capable To Store Data Offline.

Map Annotations.

Export and Import Data.

→ Using above information the relevant staff members of concerned departments are enabled to guide farmers to make optimal use of land and water resources.

Figure 54: Web App Front Page

Check Your Well

Search Box to search for location / farm

Calculate Water Requirements for Crops - LWR036-CWR & APNA FARM

Search Box



Figure 55: Check Wells


Markers show registered wells.
Just take the Mouse to the marker and you will be able to see the information.

Check Your Well

Search Box



Figure 56: Check Well Data and Reading

The user will be able to check readings, readings graphs and current weather by clicking on the icon on the map 

APNA FARM

Geo locate farm by typing Lat/Long in the search bar or simply searching for the location by name. The weather information, soil attributes, crop profitability graphs and crop water requirement will be visible to the user.

30.5596603,72.7800881

Current Weather
Temperature : 25, (C)
Windspeed : 4, (Miles)
Humidity : 15
Cloudcover : 3
Visibility : 10
Weather Desc : Partly cloudy

Soil Properties
Soil OM: 0.58 %
Soil K: 244.32 ppm
Soil pH: 8.30
Soil P: 7.6 ppm

Figure 57: Geo Locate Farm to Check Data

CWR – GRAPH

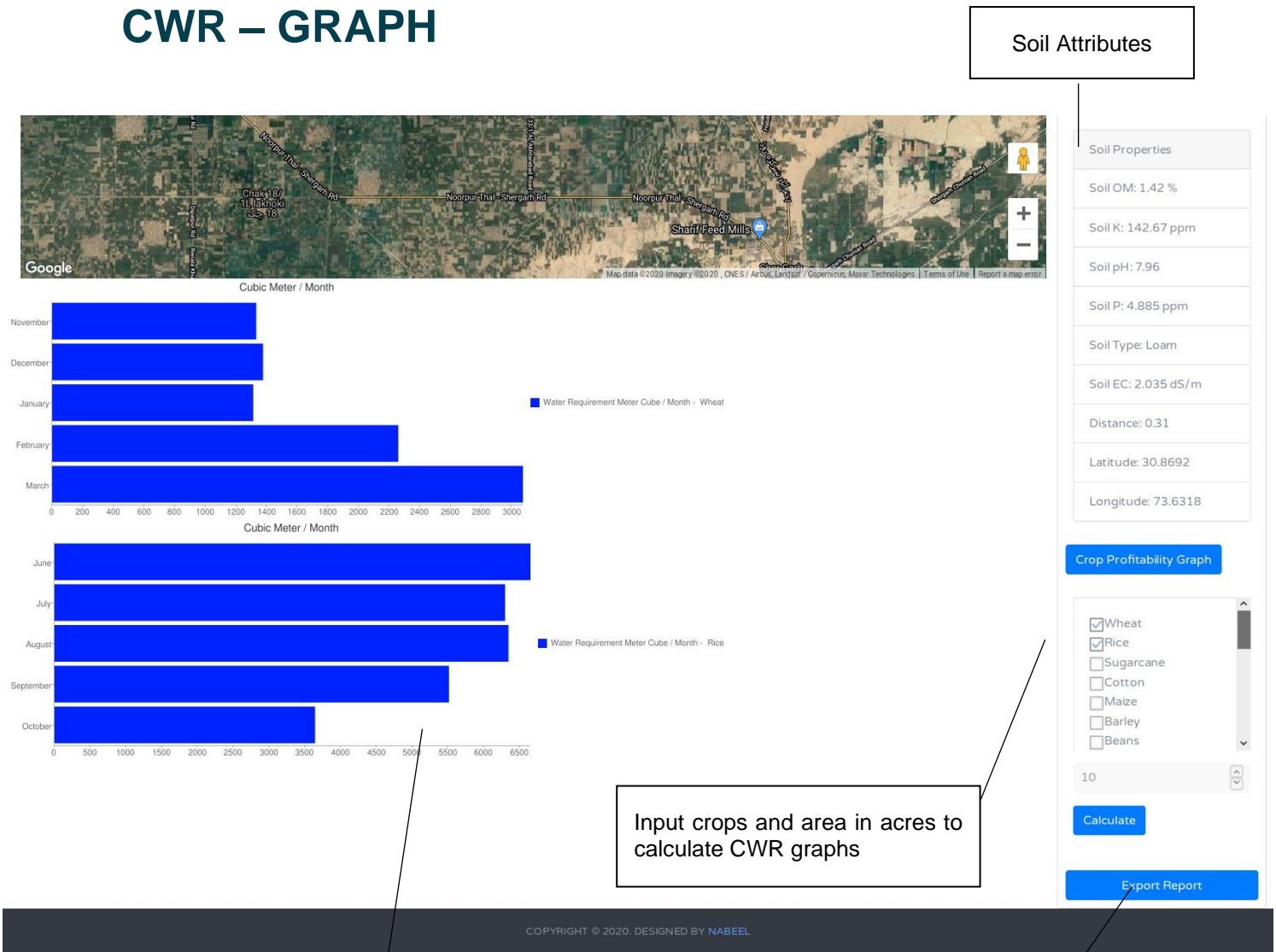


Figure 58: CWR Graphs and Export as PDF

Crop Profitability Graph

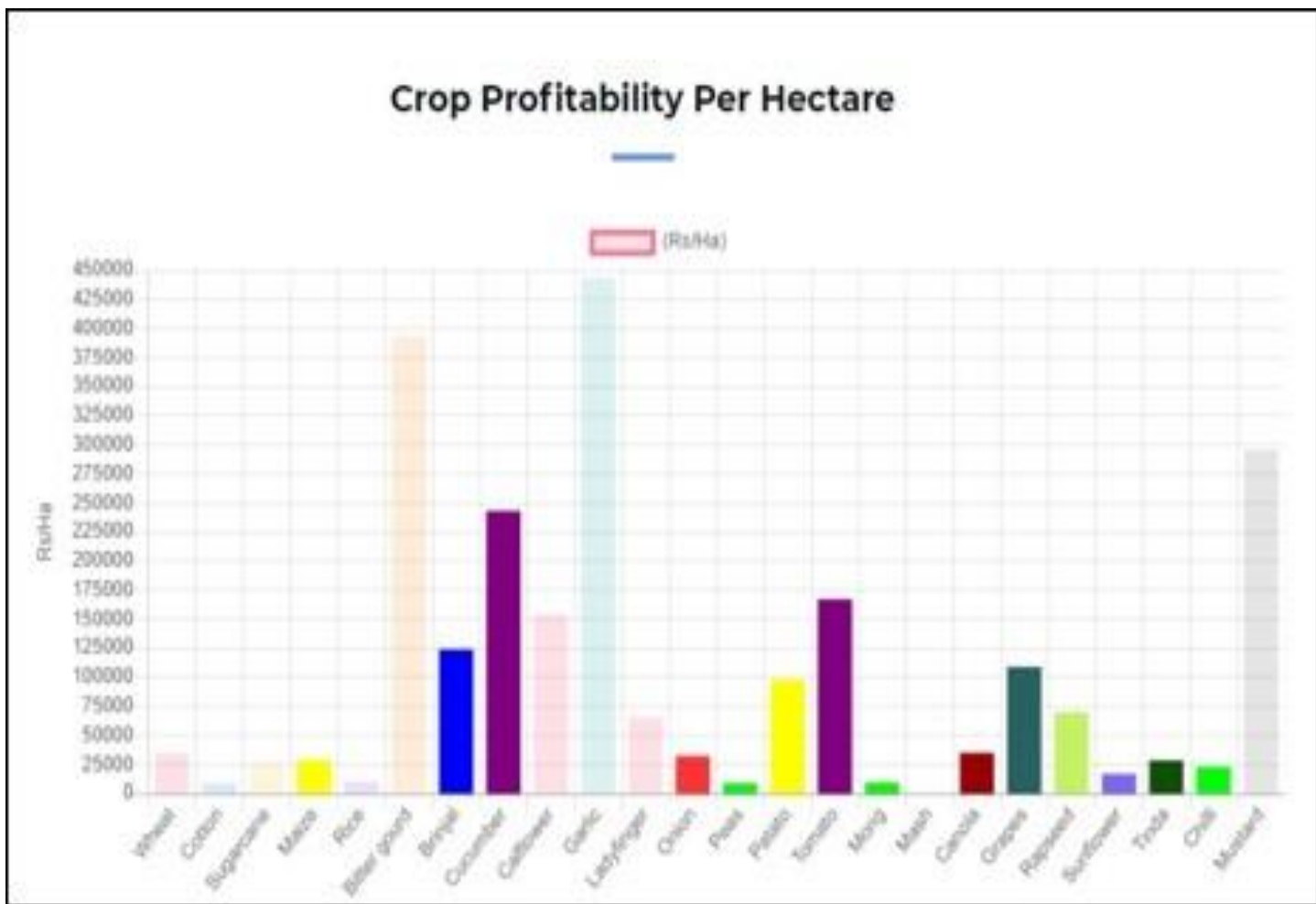


Figure 59: Crop Profitability Graphs

EXPORT RESULT AS PDF

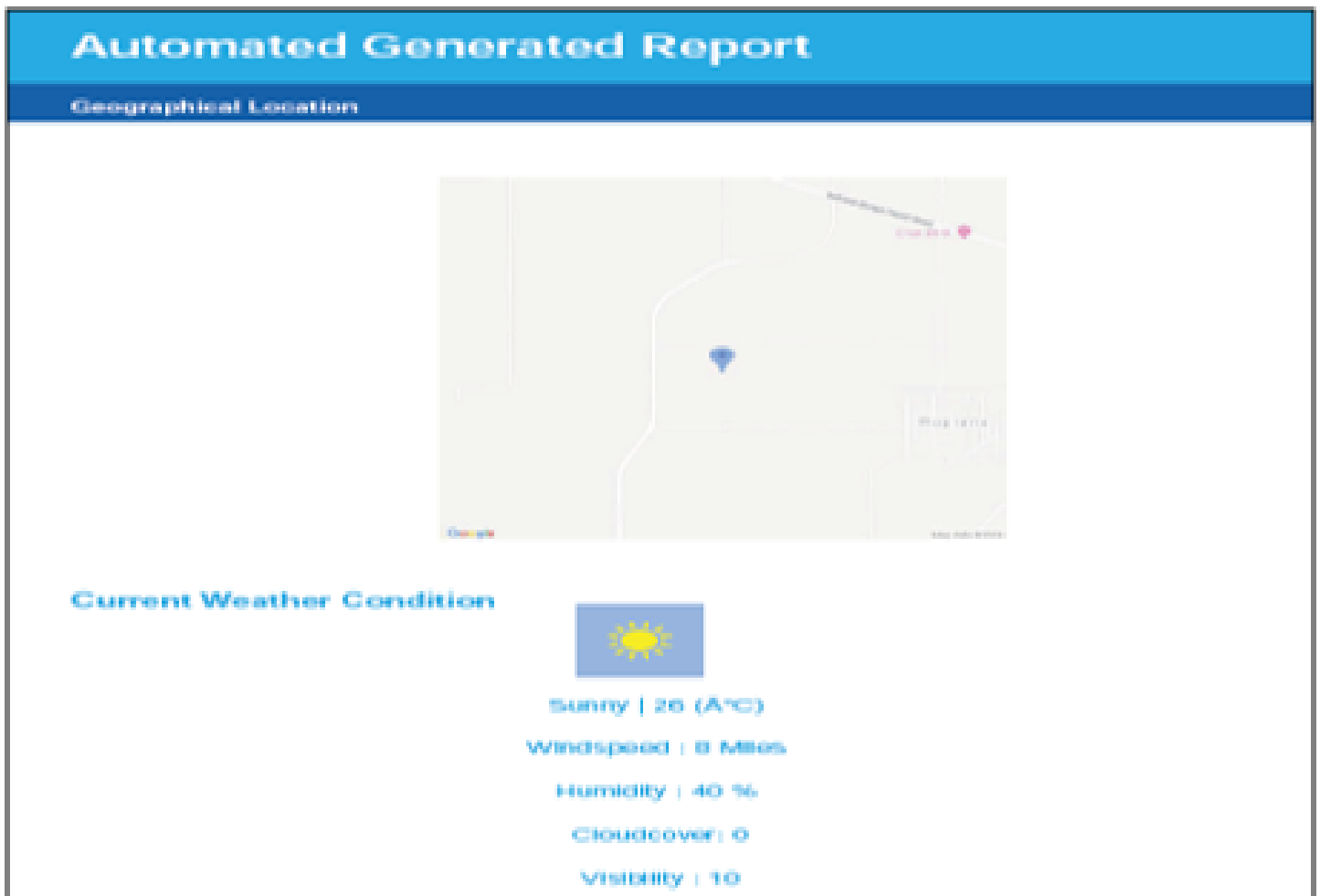


Figure 60: Exported PDF

Import Wells Record

Restricted Access: Only for the Admin - <http://mriaz-khan.com/LWR036-CWR/lwr/login.php>

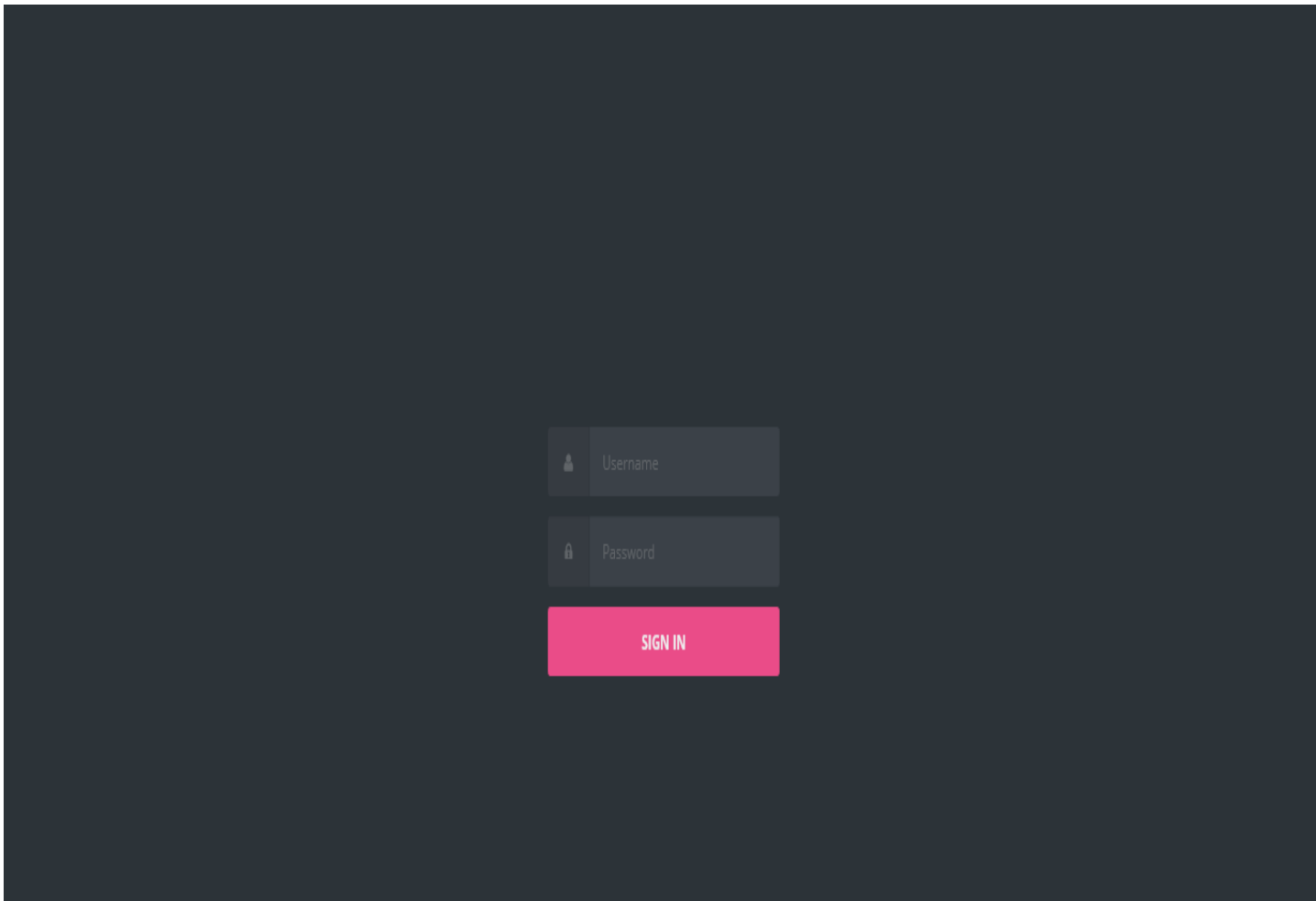


Figure 61: APNA PANI ADMIN

The Interface has three Options: Import Well's Record, Import Reading and, if you are new to the format, there is an option for you to download a demo record.

Apna Pani - CSV Uploader



If You Are New And Not Familiar With The Format Click Here To Download Data.

Figure 62: APNA PANI CSV Uploader



Research for a changing world

Institute for Land, Water and Society

PO Box 789

Elizabeth Mitchell Drive

Albury NSW 2640

Australia

Tel: +61 2 6051 9992

Fax: +61 2 6051 9992

Email: ilws@csu.edu.au

www.csu.edu.au/research/ilws