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RESEARCH ARTICLE

Web based remote agricultural control and consultancy application: An early diagnostic warning system

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Abstract: In this study, the Web-Based Remote Agricultural Struggle and Counseling Application, which was developed within the Agriculture 4.0 approach for the spread of agricultural technologies and the use of technology in agriculture, has been discussed with the technical personnel who are experts in the field, and what improvements should be made regarding the application. In the study, literature review was made, agricultural consultancy, smart agriculture and the use of digital technologies in agriculture were discussed. The Web Based Remote Agricultural Control and Consultancy Application designed in this study was developed with the Python programming language. The development and operation of the application are presented in the form of screenshots. In the research, user opinions of the application were collected through a form consisting of 4 questions to measure demographic information, a qualitative question consisting of 7 main titles, and 28 sub-titles to measure the opinions of technical personnel about the application, which was prepared by taking expert opinions. The data obtained from the research users were analyzed with the Nvivo 12 program. As a result of the analysis, it was concluded that the development of web-based agricultural control, consultancy application for technical personnel is appropriate, the interface design should be improved, and it will contribute positively to the dissemination of technology use in agriculture.

Keywords: Agriculture 4.0, smart farm, web-based consultancy, information systems

1. Introduction

In our age, it has become inevitable to show itself in the fields of agricultural education, extension and production with the rapidly developing scientific, and technological opportunities. As a result of the progress and developments in internet technologies, web-based agricultural services have gained widespread popularity through the public and private sectors. The share of the developments in the agricultural sector in the delivery of the developments in the agricultural sector to the public, and the farmers without worrying about time, space is quite high, and its importance is increasing day by day. The data formed as a result of the intensive use of information technologies in every field has been transformed into information thanks to the advancing technological opportunities, and the agricultural sector has taken its share of this information.

It is a fact that more production will be needed in the near future. In order to provide this production, it is necessary to increase the efficiency obtained from the unit area [1]. With the introduction of digital agricultural software, it is necessary to ensure the effective use of irrigation water, soil, and agricultural input components. Thanks to software that can calculate evaporation by processing instant climate, soil and product data, wireless signals sent to the manufacturer's mobile phone or automation system and appropriate sensors, it is calculated that agriculture can be done with 80% less use of water used in agriculture [2]

Digital soil maps, remote sensing, and GPS guidance are critical tools for modern farmers. Big data for precision agriculture increase yield and productivity. These high-tech tools often benefit large farms that can invest heavily in technology [3]. Especially Big Data and the Internet of Things (IoT) are the ways to minimize the dependence on climatic conditions in crop cultivation. Thus, minimizing the impact of the human factor will allow GPS tracking, digital platforms where agricultural products are marketed, and artificial intelligence to come into play [4]. Minimizing resource costs in the agricultural production process will increase the efficiency and competitiveness of agricultural production, and sustainable development [5].

Active use of digital technologies in agriculture creates a new segment of agriculture called "digital agriculture". Digital agriculture is the technological foundation of

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the agriculture of the future. Digital agriculture enables the creation of high-yield agriculture that can meet the increasing needs of the population with more economical use of limited resources. Effective control and use of the expenditure of funds allocated for the implementation of the production process, system control of the production process continues from the beginning of production to the delivery consumer.

It ensures that digitalized agricultural producers are supported in terms of production processes, that women and young people are equipped with the right information, and that agricultural inputs are made at rates that support sustainable production. In this way, maximum production and income are obtained, and as a result of the correct and effective use of resources by improving production methods in agriculture, more production is realized with less input [6,7,8]. Components of smart agriculture; includes basic systems such as global positioning systems, geographic, information systems, variable rate input application and remote sensing [9]. Information systems and portals developed for distance education have opened up new areas with the development of technology, making it necessary to design programs that will meet the different needs, and demands of people [6,10,11]. One of these needs is a web-based agricultural consultancy, and early diagnosis warning system in the field of agriculture. In this sense, there are many studies conducted in the field [12,13,14].

The aim of this research is to minimize the time, space constraints in accessing the information and consultancy services required in agricultural production with the help of the portal developed by using internet technologies, and to make this access permanent. Thanks to the developed web application, it is to add a different dimension to the technical support that all stakeholders involved in agricultural production need in the face of negative situations in production activities. With the application, it is aimed to easily monitor, control the steps that farmers, and agricultural consultants need to follow throughout the agricultural production process. It is aimed to follow the recommended irrigation, fertilization, and spraying prescriptions related to production by means of field photographs uploaded to the system at regular intervals. It is thought that following the recommended recipe throughout the production process will provide convenience for both the producer and the agricultural consultant. Thus, after a planned, programmed, well-controlled production period, a process that will be profitable for the producer, and the consumer with minimum loss, and maximum gain will be completed.

With the Internet of Things, sensors, autonomous devices, wireless communication, cloud computing, big data analytics, etc. Agricultural production values measured can provide greater productivity gains, and more information while reducing costs, thanks to the combination of various technologies such as Combined with machine learning algorithms, this information can help make better decisions and improve production-related product quality [15]. In this sense, techno-city and incubation centers of universities can transform scientific knowledge into initiatives, and create an ecosystem focused on digital agriculture [16].

The interest in smart agriculture, web-based remote support platforms is increasing day by day, and it is important for public and private sector institutions to use these platforms outside of traditional agricultural practices. It is important that such practices become widespread, especially in disadvantaged segments where access to agricultural consultancy is lacking. In the researches, the application of the opportunities created with Industry 4.0 in the agricultural field also significantly reduces the agricultural input costs, increases the profitability rate significantly, and provides significant convenience in accessing quality, clean and safe food. In this sense, the study is important.

The system used in this research was applied to 10 technical personnel working in Adana Provincial Directorate of Agriculture in Turkey. The server has been adjusted so that the system can serve 10 technical personnel. The data and evaluations obtained as a result of the survey carried out in the research are limited to the personnel who have agricultural consultancy authority.

2. Materials and Methods

An application has been developed for use in agriculture in the study. The developed application is designed to solve the early diagnosis problems of the producers in agriculture and to meet the needs of the personnel working in this field. With the designed application, interviews were held with technical personnel who are experts in their fields, about the widespread use of agricultural technologies and technology in agriculture within the Agriculture 4.0 approach. It has been revealed what improvements should be made regarding the application.

Designing the Application: The application, which consists of two different interfaces, namely Farmer and Technical Personnel, has been developed on the web platform. The reason for choosing the web platform for the development of the application is to enable users to access the application independent of time and place. In addition, during the design phase of the application, users can use phones, tablets, etc. In order to provide access from different devices, responsive design has been taken into account, which allows the web page to be shaped according to the device entered when accessed from different devices. Thus, users will be able to access the application from any device.

During the development of the application, Software Life Cycle steps were followed. In addition, a survey study was conducted for user testing in this research. The working group of the research consists of 10 technical personnel (engineers, technicians, etc.) working in Adana Provincial Directorate of Agriculture and Forestry.

The developed application is designed according to the work flow diagrams below. Screenshots of the application developed for the study are presented below.

Algorithm Code (For Manufacturers):

1- Beginning

2- Please Upload Photo with Location(message)

3- Photograph

4- Is the Photo Uploaded Correctly?

5- Step 6 if Installed Properly

If not installed, repeat step 3

6- Please Enter Note? (Message)

7- Finish

Algorithm Code (For Technical Staff):

1- Beginning

2- Photograph

3- Is the declared product and the product in the photo the same?

4- If "No", step 6,

If "Yes" continue from step 5

5- Your prescription has been created? (Message)

6- Finish

Application: Technical personnel open the photo and message from the manufacturer, check the location (parcel) of the uploaded photos, and confirm whether the declared product is the same as the disease or harmful product. If the product in the parcel and the declared product are the same, the necessary information, namely the recipe, is sent to the producer via the system via message. If the products do not match, the manufacturer is asked to either correct the statement or upload the correct photo of the product in the parcel.

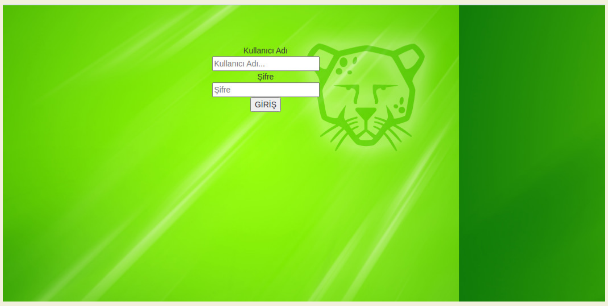
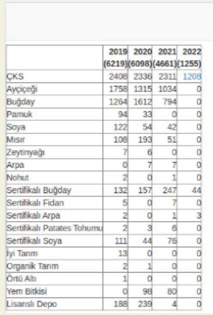


Figure 1. Login page for technical staff and manufacturers.

The login page consists of username and password fields and a login button. The login page is shown in Figure 1.



	2019 (6219)	2020 (6098)	2021 (4661)	2022 (1255)
ÇKS	2408	2336	2311	1208
Ayçiçeği	1758	1315	1034	0
Buğday	1264	1612	794	0
Pamuk	94	33	0	0
Soya	122	54	42	0
Mısır	108	193	51	0
Zeytinyağı	7	6	0	0
Arpa	0	7	7	0
Nohut	2	0	1	0
Sertifikalı Buğday	132	157	247	44
Sertifikalı Fidan	5	0	7	0
Sertifikalı Arpa	2	0	1	3
Sertifikalı Patates Tohumu	2	3	6	0
Sertifikalı Soya	111	44	76	0
İyi Tarım	13	0	0	0
Organik Tarım	2	1	0	0
Örtü Altı	1	0	0	0
Yem Bitkisi	0	98	80	0
Lisanslı Depo	188	239	4	0

Figure 2. Homepage for technical personnel.

Homepage is the page where the navigation menu is located. The home page view is given in Figure 2. The homepage consists of applications, maps and detection menus accessible to technical personnel.

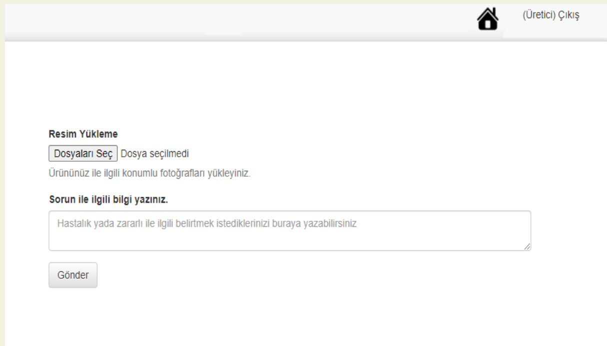


Figure 3. Homepage for manufacturers.

The "Homepage" view that manufacturers can access is given in Figure 3. Producers can upload photos related to the problematic area from the "Picture Upload" section and send their messages about the problem from the "Message" section.

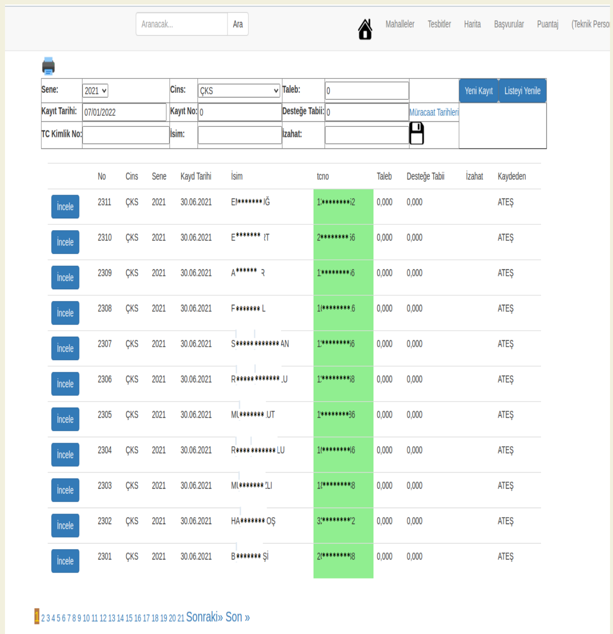


Figure 4. Reference list page.

The "Application List" page is given in Figure 4. The "Application List" page is the page where the applicant manufacturers are listed. This page contains basic information about the manufacturers such as name, identification number and year of application. When the "Review" button is pressed, detailed information about the application is accessed.

Figure 5. Detailed application list page.

The " Detailed Application List" page is given in Figure 5. The "Detailed Application List" page is the page where the applicant manufacturers are listed in detail. This page includes basic information about the manufacturers such as name, identification number and year of application, as well as product type and area information. When the product name is clicked in the "Product/Declaration/Detection" column, the photos related to the product subject to the complaint are accessed.

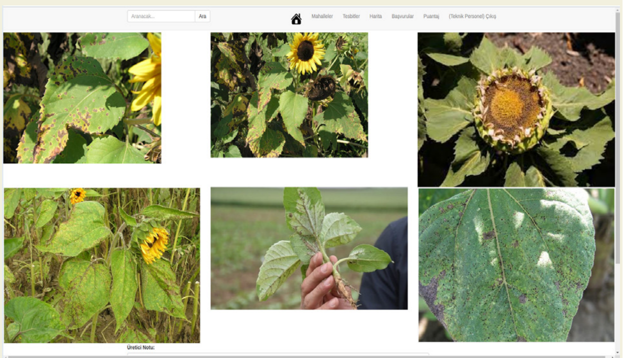


Figure 6. Product review page.

The "Product Review" page is given in Figure 6. The "Product Review" page is the page where the product photos uploaded by the manufacturers to the system are reviewed by the technical staff. By clicking on the positioned photos, necessary examinations are made, and information about the disease or pest is sent to the producers via message. In this example, the producer requests consultancy on sunflower diseases and pests.

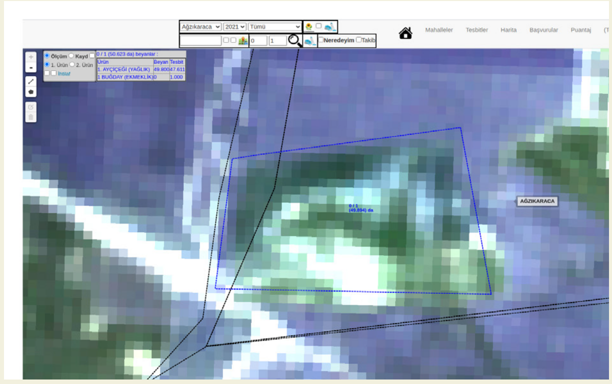


Figure 7. GIS Geographic Information System (GIS).

When you click on any photo, the parcel where the photo was taken and the declaration information about the parcel will appear on the Geographic Information System (GIS). When Figure 7 is examined, it is seen that the parcel where the photograph was taken is the immovable property with the number 0 block 1 parcel numbered in the Adana province İmamoğlu district, Ağzıkaraca Village, and the product planted and declared on the parcel from the map images is sunflower.

After the necessary examinations are made, the prescription that needs to be applied is sent as a message to the mobile phone numbers of the manufacturers registered in the system by the technical personnel.

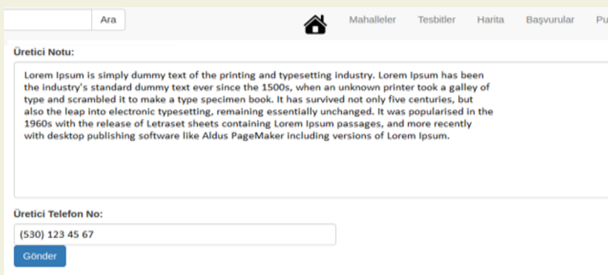


Figure 8. Message to manufacturers

Examples of maps with different dates used in the GIS module are shown in Figure 9, Figure 10, Figure 11, Figure 12, Figure 13, Figure 14, Figure 15 and Figure 16.

Examples of code used in the development of the application are shown in Figure 17, Figure 18, Figure 19, Figure 20, and Figure 21.

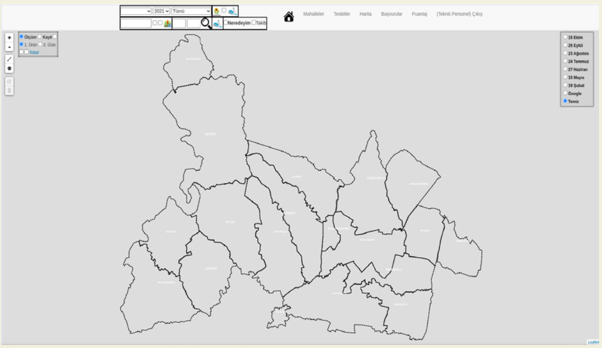


Figure 9. Map showing village boundaries

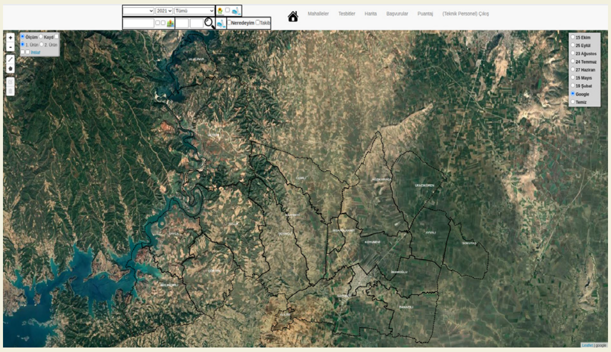


Figure 10. Google map

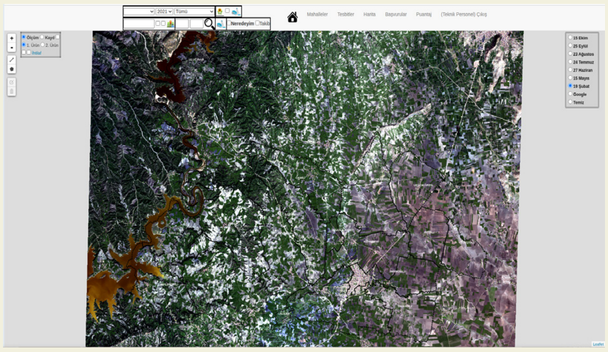


Figure 11. Infrared band image dated 19.02.2021

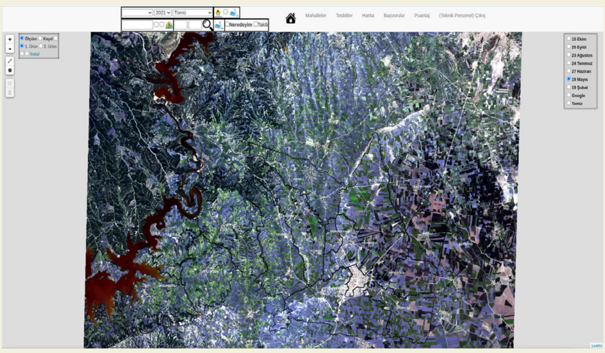


Figure 12. Infrared band image dated 15.05.2021

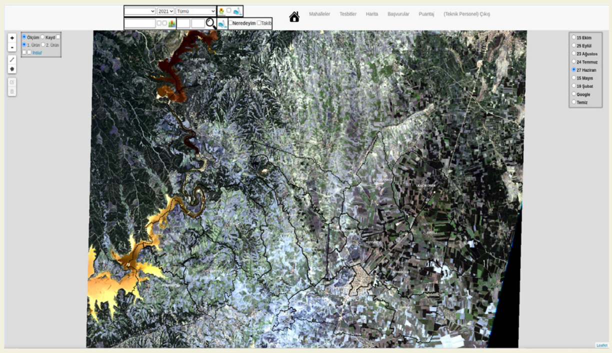


Figure 13. Infrared band image dated 27.06.2021

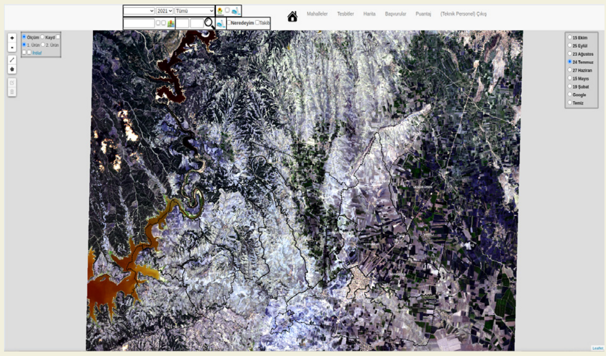


Figure 14. Infrared band image dated 27.07.2021

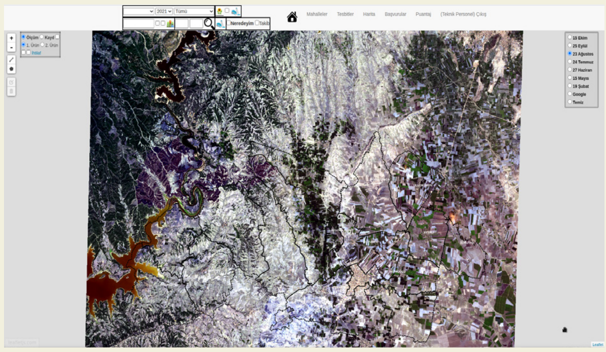


Figure 15. Infrared band image dated 25.09.2021

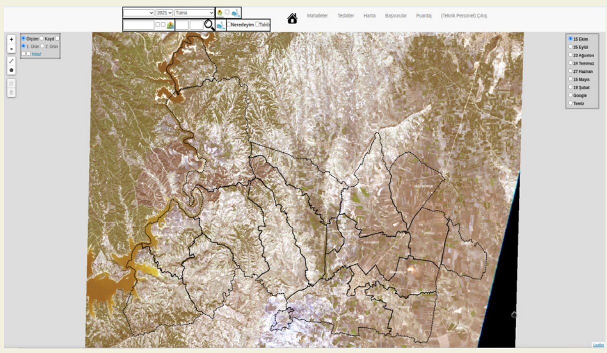


Figure 16. Infrared band image dated 15.10.2021

```html
        <img src="/static/resim/goruntuler/aycicegi1.png" width="100%"
            height="100%" class="rounded float-left" alt="Responsive image">
    </div>
    <div class="container col-md-4">
    <div class="container col-md-4">
        <img src="/static/resim/goruntuler/aycicegi3.png" width="100%"
            height="100%" class="rounded float-left" alt="Responsive image">
    </div>
    <div class="container col-md-4">
        <img src="/static/resim/goruntuler/aycicegi4.png" width="100%"
            height="100%" class="rounded float-left" alt="Responsive image">
    </div>
    <div class="container col-md-4">
        <img src="/static/resim/goruntuler/aycicegi5.png" width="100%"
            height="100%" class="rounded float-left" alt="Responsive image">
    </div>
</div>
<form>
    <div class="container">
        <div class="form-row">
            <div class="form-group col-md-10">
                <label for="textarea"> Üretici Notu:</label>
                <textarea rows="10" cols="250" class="form-control" id="textarea"></textarea>
            </div>
        </div>
        <div class="form-row">
            <div class="form-group col-md-5">
                <label for="text">Üretici Telefon No:</label> <input type="text"
                    class="form-control" id="text"></input>
```

Figure 17. HTML codes used to display images

```javascript
            {
        ip='http://78.187.108.183:81/cgi-bin/qgis_mapserv.fcgi';
        mapi="/home/burak/hifz/tesbits.qgs";
        layer=jq('input:radio[name=suret]:checked').val();
        }
    {% else %}
        ip='http://192.168.1.97:8080/geoserver/tesbits/wms';
        if (document.getElementById("id_sene").value!=6)
        {
    ip='http://192.168.1.97:81/cgi-bin/qgis_mapserv.fcgi';
    mapi="/home/burak/hifz/tesbits.qgs";
    layer=jq('input:radio[name=suret]:checked').val();
    }
    {% endif %}

    uydu  = L.tileLayer.wms(ip,{
    layers: layer,
    map: mapi,
    format: 'image/png',
    transparent : true
            },
            {
        buffer:0,
        singleTile:true,
        ratio:1,
        transitionEffect:"resize",
```

Figure 18. Codes with which maps are displayed

```python
if sualci:
    sualci=sualci.upper()
    liste=Defter.objects.filter(
        Q(isim__icontains=sualci.upper().strip())|
        Q(tcno__icontains=sualci.strip())|
        Q(kaydno__icontains=sualci.strip())
        #Q(izahat__icontains=sualci)
        ).filter(sene=cri_sene).distinct()

paginator = Paginator(liste, 11) # Show 2 contacts per page
page_liste = paginator.get_page(page)
context = {}
context["netice"]=netice
context["form"]=form
context["liste"] = page_liste
return render(request, 'defter/liste.html', context)
```

Figure 19. Codes where references are listed

Preparation of Research Questions and Collection of Data: Qualitative interview questions were developed by the researcher to measure the views of technical personnel on the practice. These questions, developed by the researcher, were arranged by experts in the field. Experts in the field consist of 6 people who work as faculty members in the field of management information systems. According to the answers from the experts, some of the questions were removed, some of them were corrected, and some of them were changed in the form. The process of collecting the data used in the research was carried out in the form of sending the interview form consisting of demographic and qualitative questions, prepared by the researcher via Google Forms, to the technical personnel and the technical personnel responding to the form. The opinions of the technical personnel regarding the application used in the study were collected. Within the scope of this study, interview forms with ten technical personnel who are experts in their fields were recorded, and the data obtained from the interviews were organized in detail.

```python
from GPSPhoto import gpsphoto
# Get the data from image file and return a dictionary
data = gpsphoto.getGPSData('/path/to/image.jpg')
rawData = gpsphoto.getRawData('/path/to/image.jpg')

# Print out just GPS Data of interest
for tag in data.keys():
    print "%s: %s" % (tag, data[tag])

# Print out raw GPS Data for debugging
for tag in rawData.keys():
    print "%s: %s" % (tag, rawData[tag])

# Create a GPSPhoto Object
photo = gpsphoto.GPSPhoto()
photo = gpsphoto.GPSPhoto("/path/to/photo.jpg")

# Create GPSInfo Data Object
info = gpsphoto.GPSInfo((35.104860, -106.628915))
info = gpsphoto.GPSInfo((35.104860, -106.628915), \
        timeStamp='1970:01:01 09:05:05')
info = gpsphoto.GPSInfo((35.104860, -106.628915), \
        alt=10, timeStamp='1970:01:01 09:05:05')

# Modify GPS Data
photo.modGPSData(info, '/path/to/newFile.jpg')

# Strip GPS Data
photo.stripData('/path/to/newFile.jpg')
```

Figure 20. Codes for obtaining location information in photos

```python
import requests

hedefNumara=uretici_telNo// SMS Göndermek istediğiniz üreticinin telefon numarası
text=mesaj_kutusu// SMS yollayacağınız mesaj
sunucu=mesaj_sunucusu// SMS yollamak için üye olunan servis

r=requests.post(mesaj_sunucusu,{'phone':hedefNumara,'message':text,'key':'sunucu'} //sunucu'a veri gönderme

if r.json()['success']==True://mesaj hedef numaraya iletildiyse'gönderildi' ekrana yazdır

print('Mesaj Gönderildi')

else:
    print('gönderilemedi') // iletilmediyse 'gönderilemedi' yazdır
```

Figure 21. Codes that send messages to manufacturers

The obtained data were arranged in sets and analyzed. The data of the participants were arranged statistically. The verbal data obtained were processed in the Nvivo 12 program as codes and categories. The coded data were categorized according to the main question titles and detailed according to the sub-questions. Findings regarding the views of the participants on the remote agricultural consultancy web application were revealed by performing the analysis of the coded data.

3. Results

In this study, the data obtained were analyzed, and the findings were analyzed in six parts. The findings are shown in tables with visual support. Within the scope of this study, interview forms with ten technical personnel who are experts in their fields were recorded, and the data obtained from the interviews were organized in detail. Obtained findings and comments are given in tables. While the answers given by the users to the questions were given directly, codes such as User 1 and User 2 were written at the beginning of the answers in order to be clear by which user the answers were given.

Demographic Findings: The findings obtained from the demographic questions of gender, age, marital status, education level, total length of service obtained as a result of the research are given below.

Gender: The distribution of the academic staff participating in the research by gender was analyzed, and the results are shown in Table 1.

Table 1. Distribution of participants by gender

User Gender	n	f
Female	3	%30
Male	7	%70
Total	**10**	**100**

As a result of the analysis, it was concluded that 3 (30%) of the participants were female and 7 (70%) were male.

Age: The age distribution of the participants participating in the study was analyzed, and the results are shown in Table 2.

Table 2. Distribution of participants by age

Age Ranges (Years)	n	f
Between 25-35	3	%30
Between 36-45	2	%20
Between 46-55	3	%30
Between 56-65	2	%20
Total	**10**	**100**

As a result of the analysis, 3 (30%) of the participants were between the ages of 25-35, 2 (20%) were between the ages of 36-45, 3 (30%) were between the ages of 46-55, and 2 of them were between the ages of 56-65.

Educational Status: The distribution of the participants participating in the study according to their educational status was analyzed, and the results are shown in Table 3.

Table 3. Distribution of participants by educational status

User Education Status	n	f
Associate degree graduate	1	%10
Bachelor' s degree	7	%70
Post Graduate	2	%20
Total	10	100

As a result of the analysis, it was concluded that 1 (10%) of the participants had an associate degree, 2 (20%) had a post degree, and 7 (70%) had a bachelor' s degree.

Professional Experience: The distribution of the participants in the study according to their total professional experience period was analyzed and the results are given in Table 4.

Table 4. Distribution of participants by length of service

Professional Experience (Years)	n	f
Between 5-15	5	%50
Between 16-25	1	%10
Between 26-35	2	%20
Between 36-45	2	%20
Total	10	100

In the distribution of the participants in the study according to their total professional working period, it was concluded that 1 of them was between 16-25 years, 2 of them were between 26-35 years, 2 of them were between 36-45 years, 5 of them were between 5-15 years.

Findings Regarding Themes, Categories and Codes of the Research: Codes were created from the data created from the answers received from the participants, and categories were created based on the codes. In the preliminary analysis of the data obtained from the interviews, seven basic categories were created in accordance with the interview questions.

When the answers given to the first category "Interface" were examined, the users stated that the interface design of the application was user-friendly, but they also stated that the color variety of the design should be increased, more agricultural themes should be included, and warning texts about page transitions should be included. They also stated that visuality would affect their working performance.

When the answers given to the second category, "Usability on Different Devices" examined, users state that the application can be used on different devices and operating systems without installation, that the platform-independent nature of the application is a great advantage. They stated that this has been exceeded.

When the answers are given to the third category, "Content Sufficiency" are examined, the users informed that the application should be enriched in terms of content, that the visual elements should be related to plant production, that the texts should be of changeable size, etc. They stated that the content should be reviewed with such criticisms.

When the answers are given to the fourth category "Technical Competence" are examined, the users say that when the application is examined from a technical point of view, the application performs its function in terms of the complete operation of the menus and buttons, the resolution time of the errors, the ease of installation, resolution, sound, and other technical features. The system team is open to feedback, it needs improvement in resolution, it is easy to enter the application because it does not require installation, audio warnings should be added to the system, etc. They stated that the system should be strengthened technically with such criticisms.

When the answers are given to the fifth category "Guidance of Users" were examined, the users stated that the application may be sufficient for the technical personnel in terms of guidance, that the farmers might have difficulties, and that the system should be promoted with preliminary information or training, especially for the farmers.

When the answers are given to the sixth category "Openness to Development" are examined, the users stated that the application is suitable for openness to development, it is suitable for software additions when necessary, it is suitable for increasing the number of users, it can adapt to current conditions, and it is appropriate to increase the system capacity with additional hardware support.

4. Discussion

Within the scope of this study, a Web-based interactive Agricultural Consulting Site was designed in the context of Remote Sensing, Geographic Information Systems (GIS), and Precision Agriculture Applications by synthesizing the traditional Agricultural Consulting and Agriculture 4.0 approaches in the literature. In addition, GIS controls included in the module providing consultancy services and audits for agricultural planting determinations will also be provided.

Agriculture 4.0 can combine various applications to meet different needs. Smart agriculture mostly uses internet technology. Various sensors placed on the equipment or in the field provide data to a platform (cloud-based) that allows the creation of an information system for users (agrisupply specialists, farmers, consultants, researchers, etc.). In this sense, sensors embedded in machines that use artificial intelligence to detect weeds to be targeted for local destruction can be given as an example.

It is aimed to evaluate the design prepared in the research by the farmers and technical personnel. For this purpose, questionnaires and qualitative interviews were conducted with the participants.

In the study, the views of 10 technical personnel working in Adana Provincial Directorate of Agriculture and Forestry in Turkey on web-based remote agricultural struggle and consultancy application design were measured by qualitative data analysis method. Demographic findings and the findings obtained from the answers to the questions directed to the technical personnel are included, and suggestions are presented for these findings.

As a result of the study, it was realized that the system that was tried to be developed was functional, but that appropriate visuals and themes should be included in the design phase. In addition, it has been concluded that the web agricultural consultancy application to be designed should have an explanatory content for users and beneficiaries, serve with a user-friendly interface, and there are deficiencies in in-app guidance and these should be eliminated. Another result that emerged from the data analysis was that the technical personnel and manufacturers, who will be included in the system for the first time, can use the application more efficiently after certain promotional activities.

In data analysis, it is stated that visual themes will affect the working efficiency, so it is necessary to use colorful and eye-catching themes that do not tire the eyes; however, it was understood in the analysis of user responses that attention should be paid to its compatibility with agricultural elements. When the answers about the use of the application on different mobile (tablet, smart phone) and fixed devices (pc, laptop) or different operating systems are analyzed, it is seen that the users do not have difficulty in accessing and using the application, the system is compatible with different devices and operating systems, and therefore the developed it has been understood that the use of the system by manufacturers, and technical personnel will easily become widespread.

In the content analysis of the user responses on the technical competence and openness to development of the system, the fact that the system does not require installation from a technical point of view is an important feature, but it has deficiencies in terms of sound, image and menu layouts; It has been concluded that there is no limitation in the number of users, that the adaptation to new technologies can be achieved easily by increasing the hardware capacity, thus making it available for use at the national and international level.

The use of information and communication technologies in digital agriculture should be expanded. Sustainable financing resources should be found in the supply and use of telephone, computer, internet, and other broadcasting tools. It should not be overlooked that the consultants who are trained and encouraged in the use of information technologies in broadcasting will contribute to the formation of an information society in rural areas.

5. Conclusion

It can be suggested that future research should be carried out in a way that covers the wider research population and sample. It may be suggested to develop systems that will enable the provision of agricultural consultancy services through artificial intelligence-supported applications, supporting the digitalization approach in smart agriculture and agriculture. In future studies, it is recommended that researchers from the field of surveying engineering work together while developing web-based remote agricultural applications.

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