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PRITHVIRAJ KADIYALA
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IMPROVING DATA MANAGEMENT FOR COW AND CALF RESEARCHERS

A THESIS APPROVED FOR THE
SCHOOL OF ELECTRICAL AND COMPUTER ENGINEERING

BY

Dr. Christan Grant, Chair

Dr. Ronald Barnes

Dr. Bin Zheng

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DEDICATION

This Thesis is dedicated to my family members Mom, Dad and Brother for believing in me throughout the Masters program. Their unwavering emotional support and encouragement has kept me going for the last two and a half years.

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Contents

1 Introduction **1**
- 1.1 Software use in Farming Industry . . . 1
- 1.2 US Department of Agriculture . . . 4
- 1.3 Motivation . . . 5
- 1.4 Problem Statement . . . 6

2 Alternate Software **7**
- 2.1 List of alternate software . . . 7
- 2.2 Pros and Cons of each software available . . . 8
  - 2.2.1 Animal Shelter Manager . . . 8
  - 2.2.2 iShelters . . . 9
  - 2.2.3 Shelter Pro . . . 10
  - 2.2.4 Cattle Max . . . 10
  - 2.2.5 CattlePro . . . 11
  - 2.2.6 CowCalf5 . . . 12
- 2.3 Table comparing all the pros and cons of alternate software . . . 13

3 Live Barn **17**
- 3.1 Technologies Used . . . 17
  - 3.1.1 Business Logic . . . 18
  - 3.1.2 Database Logic . . . 22
  - 3.1.3 Client-side . . . 25
- 3.2 How will the software be used? . . . 30
  - 3.2.1 Herdsmen . . . 30
  - 3.2.2 Scientists . . . 31
  - 3.2.3 Veterinarians . . . 31
  - 3.2.4 Inspection . . . 32
- 3.3 Different Pages . . . 32

4 Pages **34**
- 4.1 Login . . . 34
- 4.2 Home . . . 35
- 4.3 Animal . . . 36

4.3.1 Add Animal . . . 36
4.3.2 Update Animal . . . 38
4.3.3 Animal List . . . 39
4.4 Experiment . . . 40
4.4.1 Create Experiment . . . 41
4.4.2 Experiment List . . . 42
4.4.3 Edit Experiment . . . 43
4.4.4 Experiment Animal Update . . . 44
4.5 Inventory . . . 45
4.5.1 Formulary . . . 45
4.5.2 Pasture Management . . . 47
4.6 Inspection . . . 48
4.6.1 Pasture Inspection . . . 49
4.6.2 Building Inspection . . . 50
4.7 Reproduction . . . 50
4.7.1 Add New Calf . . . 51
4.7.2 Calf List . . . 53
4.7.3 Calf Update . . . 54
4.8 Health Records . . . 55
4.8.1 Health Record List . . . 56
4.8.2 New Health Record . . . 57
4.9 Report . . . 57
4.9.1 Create Report . . . 59
4.9.2 Report List . . . 60
4.9.3 Report View . . . 61
4.10 Herd . . . 62
4.10.1 Create Herd . . . 63
4.10.2 Herd List . . . 64
4.11 User Management . . . 64

5 Testimonials **67**

6 Conclusion **70**
6.1 Summary of the Thesis . . . 70
6.2 Advantages and Disadvantages . . . 72
6.3 Future Work . . . 73

A Formulae **74**
A.1 Adjusted 205 days Height and Weight . . . 74
A.2 Adjusted 365 days Height and Weight . . . 74
A.3 Frame score . . . 75
A.3.1 Cows . . . 75
A.3.2 Bulls . . . 76

A.3.3 Heifers 76

Bibliography **77**

List of Figures

3.1 This image shows the architecture of the application. 17

4.1 This image shows the log in page of the application. 34
4.2 This image shows the homepage of the application. 35
4.3 The form shows the fields to be filled when any data regarding an animal has to be changed in the system. 37
4.4 The form shows the fields to be filled when a new animal is entered into the system. 38
4.5 Figure shows the page where all the data of all the animals present in the database. 39
4.6 This form is used to create a new experiment. 41
4.7 This table shows us the animals who have been/currently in an experiment. 42
4.8 This image shows us the table of the experiments going on/already done in the facility. 43
4.9 The form shows the fields to be filled when a experiment data of an animal is entered/edited in the system. 44
4.10 This image shows us the table which keeps track of all the medications available in the facility. 45
4.11 This image shows us the pop-up where we can add more medications into the system. 46
4.12 This image shows us the table of all the pastures available in the facility. 47
4.13 This image shows us the pop-up to add new entries about what is done to a specific pasture on a specific date. 48
4.14 The image shows us a form of Pasture Inspection sheet. 49
4.15 The image shows us a form of Building Inspection sheet. 50
4.16 These images show us a form which is used to enter the data of a new born calf in the facility. 53
4.17 The image shows us a table which shows all the calves that were born in this facility previously. 53
4.18 The images show us a form to update data regarding any calf in this facility. 55

4.19 The image shows us a table of all the medical records of all the animals in the history of this facility. 56
4.20 The image shows us the form to enter medical record of an animal in the facility. 57
4.21 This image shows us the form to select a herd and the parameters required for creating a report. 59
4.22 This image shows us the table of all the reports created in the facility. 60
4.23 This image shows us the Report generated according to the data given by the user. 61
4.24 The image shows us a form where animals can be selected from a list and classified into a herd, given a herd name and also a description of the herd. 63
4.25 The image shows us the table of all the herds created in this facility. 64
4.26 The image shows us the list of all the users in the facility. 65
4.27 The image shows a pop-up that helps the superuser add a new user into the system. 65
4.28 Edit User Role. 66

List of Tables

2.1 Table comparing Alternate Software 16

Abstract

The aim of this thesis titled Improving Data Management for Cow and Calf Researchers is to develop an online database for the researchers in order to store detailed information on cattle under their supervision. Live Barn has successfully been able to maintain records for the past year, but since many of the old software available were condensely packed with all the form data, we decided to develop the application further, with the aim of simplifying the software for technology's suitability for further development. This thesis first examines the old software currently available in the market and compares the pros and cons of different software available. In the second stage, several adaptations from the previous software are undertaken. Finally the technology is applied to the development of new web-based application to maintain all the records for United States Department of Agriculture (USDA), with a year long testing phase. At the end of the testing application for each week, the researchers were asked to give some feedback according to which the application was fine-tuned. The results of the fine tuning show that Live Barn is well suited for the experiments that the researchers undertake in the facility by giving optimized data storage and faster data retrieval times. USDA expressed interest to commercialize the application. We recommend further modification to the applications for more analytical data to be displayed to the researchers to make it more visually

striking in-order to make better decisions and results clearly visible.

Chapter 1

Introduction

1.1 Software use in Farming Industry

The agriculture industry is tasked with feeding the inhabitants of planet earth, and considering that an estimated 795 million human beings go malnourished each day, the system has room for dramatic improvement[1].

From streamlining order processing to saving costs associated with labor, innovative software continues to affect various industries, including agriculture. And while modern farming remains divided between conglomerates, independent farmers, and low-paid, low-visibility workers, the industry feeding mankind is poised for rapid, data-driven change.

Below are five ways that farmers, consumers, and crops are benefiting from software-enabled technology in 2016[1].

Smart Herds

Smart herds allow farmers to connect their animals to the Internet for better tracking and monitoring. Through wearable and implants, ranchers can collect

data on the daily processes of their animals in real time.

Silent Herdsman uses wireless collars to record data on the reproductive cycle of cows within a herd, and transfer the data into immediate software. Ranchers can determine when each cow is ready to be inseminated, bolstering the rates at which each member of the herd can safely produce offspring and milk.

Vertical Farming

Vertical farming combines enterprise-level agriculture with traditional greenhouse methodology to grow crops within skyscrapers and residential urban spaces. Software automates and monitors each process within the vertical farm, and, as in the case of rural smart farms, it enables apex lighting, hydration, and space efficiency for each crop.

These urban, indoor facilities create opportunities for year-round crop production, increased seasonal yields, and reduced transport costs for bringing crops to dense market centers.

Farmbox Greens is a vertical farm inside of a two-car garage behind Dan Alberts Seattle home. It consists of 600 square feet of microgreens grown in vertically stacked trays beneath LED lights. According to a New York Times report, Farmbox Greens has revenue of under $500,000, but was profitable enough in 2014 that Mr. Albert quit his day job as a landscape architect to farm full time. He now has three employees and sells his greens to about 50 restaurants in the Seattle area, a local grocery chain and four weekly farmers markets.

Sensory-Enabled Farming

Sensory-enabled farming equipment can be used to monitor crop health, changes in soil conditions, and the presence of pests. Sensory networks like GreenSeeker, CropSpec, and Opt-Rx can prevent a variety of waste before and after each harvest, and can measure light reflectance, nitrogen levels in the soil, electrical conductivity, ground elevation, organic matter content, and pH levels. Additionally, satellite imaging of crops (known as remote sensing) uses software to photograph key agricultural regions and track productivity.

Wireless Payment Software

Wireless payment software, such as Square and PayPal, enables farmers to electronically process sales at the market, while also catering to online buyers in the restaurant or grocery sector. Urban farmers markets have surged in popularity as a means for consumers to lower their carbon footprint and buy direct; and for farmers, such payments are fluid, trackable, and paperless.

Drone Development

Drone development like that of SenseFly can assist agriculturists from the air. SenseFly drones capture high-resolution photos of fields to analyze crop health and develop accurate prescriptions for unique farming environments. Drones developed by BioCarbon have the ability to seed a billion trees each year, and help maintain plant life and crops from above.

1.2 US Department of Agriculture

The United States Department of Agriculture (USDA), also known as the Agriculture Department, is the U.S. federal executive department responsible for developing and executing federal laws related to farming, forestry, and food. It aims to meet the needs of farmers and ranchers, promote agricultural trade and production, work to assure food safety, protect natural resources, foster rural communities and end hunger in the United States and internationally.

Approximately 80% of the USDA's $141 billion budget goes to the Food and Nutrition Service (FNS) program. The largest component of the FNS budget is the Supplemental Nutrition Assistance Program (formerly known as the Food Stamp program), which is the cornerstone of USDA's nutrition assistance. The Agricultural Research Service (ARS) conducts research to develop and transfer solutions to agricultural problems of high national priority[2].

The Food Safety and Inspection Service (FSIS), an agency of the United States Department of Agriculture(USDA), is the public health regulatory agency responsible for ensuring that United States' commercial supply of meat, poultry, and egg products is safe, wholesome, and correctly labelled and packaged.

Their way of storing data in the form of books and papers is strenuous and difficult. If the data is very little then it wouldn't have been much of an issue but since they keep track of a very large amount of data. At times they have problems going back to look into specific records.

The start of web-based application started with a pointer from python-programming.net[3] and evolved into a complex system of jQuery[4], JavaScript [5], Python[6], Flask[7], mySQL[8] and REST-API[9].

1.3 Motivation

Every thing can be done remotely, then why cannot be data saved remotely was the question that plagued the scientists' mind at the US Department of Agriculture. So they contacted University of Oklahoma[10], the scientists met with Dr.Grant and some students of how to tackle the problem they had at hand and the type of solution they wanted for their current problem. When we hear about the problem there might be very different approach depending upon the each person's approach towards the problem. Being an application developer previously We were excited to pitch our idea of creating an Application that could perform all the required tasks but later were told that the researchers already use a software application. But researchers weren't exactly happy as the software only took care of some of the aspects they wanted and the for the rest of the aspects they had to maintain an Excel sheet. So resulted in the work pileup since they had two set of databases to take care of. Being an application, they had to install the software in their Workstation PC. Being in a barn the researchers did not get all the data sitting at their desks. The researchers and the caretakers had to go around the 7000 acres of land in order to test for different data and had to write down the data in a sheet and then enter the data into the application on their Workstation PC, which was then accessible to others. So, Dr.Grant came up with the idea of creating a Website that can accept the data and store in a server that can be accessed from anywhere and any type of a mobile device i.e., Personal Computer, Laptop, Tablets, Mobile Phones. Thus began the development of Live Barn.

1.4 Problem Statement

Build or develop a software that is capable of logging data of animals on a regular basis with user-based access capable of gathering data from remote locations around the barn. The software should be able to enter, edit, upload and delete data of animals individually or in a herd.

Chapter 2

Alternate Software

As we know that there are a lot of software available in the market today for any kind of commercial application. Since researchers needed a software to be built for their needs, We compared a few existing software in the market and see if they can help satisfy the needs of the researchers. We will compare the features the software provides as well as what feature each software misses out on. Comparing the software available in the market will give us a good idea about about the software are built with respect to what needs they are built. So we will briefly look into the alternate software available and then compare all of them in a tabular method to see the similarities and differences of each software.

2.1 List of alternate software

- Animal Shelter Manager
- iShelters

- Shelter Pro
- CattleMax
- CattlePro.com
- CowCalf5

2.2 Pros and Cons of each software available

2.2.1 Animal Shelter Manager

sheltermanager.com is a secure, managed, online solution for animal shelters, rescue groups and animal control facilities. It offers tools to track and report on animals passing through the care of your organization, their welfare, and medical requirements. sheltermanager.com is a Web-based application meaning all of its contents are hosted on a server and can be accessed from any device connected to the internet. This software keeps track of all the movements of the animal, in the sense when was an animal taken in and where was it moved to and also where was it sent to after the work is done with it. This software is also friendly to sites having medical records available for any animal in their system. This software also allows users to upload photos of each animal to keep track of the animal by the picture or also as a profile as in how the animal is looking right now. This software supports report generation based on all the info available about the animals in the facility along with Graphical representation for easier understanding. They also are able to handle Payments and account information. They are also able to import data from different websites which

do similar data management and also from Excel sheets. But being a shelter manager, The software is focused on IN/OUT information of the animals and keeps track of the customers who bought or adopted the animals from the shelter rather than provide analytical tools for research purposes[11].

2.2.2 iShelters

iShelters provide animal shelters and rescue with services to manage their animals for a monthly fee. No installation or maintenance (data back-ups) is required on the user part. iShelters is a Web-based application which is not required to be installed on the PC. Let's discuss the advantages of the software, and This software provides the animal profile page to keep track of an animal with the help of photos and all the required data in a single page so that whoever sees this page can get all the required data without any delay. The software also allows different employees and volunteers access the pages differently if needed. This software also helps user keep track of all the costumers to the facility or the places the facility regularly visits in order to buy something. Keeping this list will help the researchers keep track of all the stock they have and also get some new stock without any problems from the existing client. This software also helps us keep track of the medical history of the animal. This feature also allows the facilities to show the medication history of an animal regardless of whether they had the animal for whole time or got it very recently. This software having all of the above features lacks some of the features as mentioned below. The software develops reports based on the options selected by the User. Also being a software with many desired features, the pricing of the software changes according to the options checked and has no definite pricing overall[12].

2.2.3 Shelter Pro

Shelter Pro Software is an industrial strength record keeping system designed to meet the particular needs of animal services organizations. Shelter Pro Software is a Web-based application meaning all of its contents are hosted on a server and can be accessed from any device connected to the internet. This software keeps track of all the movements of the animal, in the sense when was an animal taken in and where was it moved to and also where was it sent to after the work is done. This software also helps us keep track of all the costumers to the facility or the places the facility regularly visits in order to buy something. Keeping this list will help the researchers keep track of all the stock they have and also get some new stock without any problems from the existing client. There are however a few drawbacks in the software; the software is a modular based software meaning that the software is built in bits and pieces and the user can have access to more features only if they buy the extension for the feature. This software has no customized report creation feature available as the researchers are continuously researching the animals in the facility they would like to compare the data of the animals side to side by creating a report which helps to see the outcome of an experiment much more easily. This software does have a feature of keeping track of the inventory in the facility as the software is only built to keep track of the animals and not their medical history or does not account for a veterinarian present on site[13].

2.2.4 Cattle Max

"Cut your record keeping time. Organize your records in one place. Maximize your profit potential" This is the motto for this software. Cattle Max is a

Web-based application meaning all of its contents are hosted on a server and can be accessed from any device connected to the internet. Being a website essentially can be very easy for the users to navigate throughout the software. Cattle Max, unlike the previous software, has the provision to keep track of the medications in the facility. This software also helps researchers to keep track of the breeding in the facility. So as to keep track of the off-springs born in the facility and also to keep track of the type of the offspring born in order to attain better results. There are also some features that are lacking according to the specifications the researchers wanted. The software does not have separate access for different users which necessarily might not be a required feature for some, but the scientists are looking into the software for their use needed that because there is some data that shouldn't be shared until they have carefully studied it and written about it. This software supports custom report generation based on the user needs as is desired by the scientists/researchers[14].

2.2.5 CattlePro

Each package is intended for a specific user. CattlePro^{TM} Prime and Prime Plus are designed for the registered cattle rancher. CattlePro^{TM} Choice and Choice Plus are intended for the commercial cattle producer. CattlePro^{TM} Select is intended for the smaller commercial cattle producer. Moreover, finally, CattlePro^{TM} Standard is intended for the smaller commercial cattle producer but with fewer reports. The software also allows users to keep track of the breeding records. CattleMax is an advantageous feature for the researchers since they are always trying to get new genetic modifications so that the animal has all the desired traits. This software also provides support to any number of animals

in the facility. The software does not have separate access for different users which necessarily might not be a required feature for some, but the scientists are looking into the software for their use need that because some data should not be shared until they have carefully studied it and written about it. Cattle Pro is a computer-based application which is required to be installed in the PC where it is used. So there might be some limitations to it depending on the operating system they are on. Because some software might be compatible with Windows and Mac OS, Majority of the software is not. This software is only available for Windows Operating system only. This software also doesn't provide the feature to keep track of the medical records of an animal nor does it keep track of the medications available in the facility. This software provides single herd as well as multiple herd report generation but no specific data reports which was requested by the researchers/scientists[15].

2.2.6 CowCalf5

The CowCalf5 performance programs involve adjustment factors which confirm to the most recent Beef Improvement Federation (BIF) recommendations. The BIF is a cooperative effort among more than 60 state and national beef cattle improvement programs for seed-stock and commercial producers. The BIF intends to show no preference for or discrimination against any individual breed of cattle or organization. This software support any number of animals in the facility, unlike some other software which charges differently for a different number of animals handled by the software. This software is a PC based meaning the user has to install the software on the PC that is being used for the data entry. This software is available on both Windows and MAC Operating system.

This software also has the facility to save the medical records of the animals being treated in the facility or elsewhere. This software comes as a whole package, unlike some software that has modular pricing where one has to pay for each feature or a set of features. The software does not have separate access for different users which necessarily might not be a required feature for some but the scientists are looking into the software for their use needed that because some data shouldn't be shared until they have carefully studied it and written about it. This software does not have a feature to save the medications available on-site the facility where the software is used. This software provides reports but has no customized report creation feature available as the researchers are continuously researching the animals in the facility they would like to compare some specific data of the animals side to side by creating a report which helps to see the outcome of an experiment much more easily[16].

2.3 Table comparing all the pros and cons of alternate software

In Table 2.1 we are comparing all the features in the software to see why it was essential to design a new application to solve the issues faced by the researchers. Moreover, also this provides us a look into the software solutions available in the market are just generic and cannot be modified into specific requirements. We compare the software with regards to the features available. Because in the end it is the researchers who will be using the software and it should be made sure to tailor make it for their purpose.

Firstly, we see the feature named as Unlimited Animal support. This feature

is vital for the researchers as they might bring in new animals just because they need to conduct a new experiment and if the users have to pay extra only because of that, it would be an issue because the users cannot keep on paying as they bring in new animals into the facility.

Next feature we discuss is if the application is Web-based? One request fro the researchers was that they wanted to enter the data remotely into the system what better way than to have it accessible from any device connected to the internet. The web-based application would significantly reduce the time required to enter the data and will also be very cost effective.

Health Records, Since the researchers have a veterinarian on-site, they requested to have medical records of the animals stored in the application so that anything regarding the animal can be pulled up fro the system whenever the requirement. Since they have inspections in the facility, it is much easier to pull up the records of the animal during all of its stay in the facility.

Inventory, Having a veterinarian on-site is not feasible without having some medications available on-site. While there are some medications on-site, they have to be kept track of. So Inventory in the software keeps track of the medications available on-site and dynamically update whenever some medication is given to an animal.

Report Generation, Researchers have mentioned time and again about the vitality of this feature because this feature makes their work that much easier. Having only the required data of the required animals will help notice the changes better, and when that happens usually conclusions can be drawn faster, and data can be analyzed quickly. Sharing this data is also more comfortable because the data is short and adequate to whoever will see the report.

User-Based Access, Researchers work on different levels of classification. The

herdsmen who take care of the pastures may not necessarily need access to view the data on the animals and vice-versa, Researchers might not need information about the medical history. US Department of Agriculture has various classification levels, and the users will be limited to specific pages.

Customer/People List, Researchers keep track of the recently bought medications and animals using the physical contact method or written down in a contract book physically. However, if we could directly link an animal or medication to the Customer/Client, then it would make it much easier to track the animal history before it was brought to the facility. Alternatively, the medications can be exchanged in some cases if they are about to expire.

After looking into the Pros and Cons to the softwares available in the market lets look into the software created.We will further look into the features implemented in LiveBarn in chapter 4. We will look into the overall software in chapter 3 and also individually into each of its feature in chapter 4.

Table 2.1: Table comparing Alternate Software

Features	ASM*	iShelters	Shelter Pro	CattleMax	Cattlepro	CowCalf5	LiveBarn
Unlimited Animals Support	No	Yes	Yes	Yes	Yes	Yes	Yes
Web-based Application	Yes	Yes	Yes	Yes	No	No	Yes
Health Records	Yes	Yes	Yes	Yes	No	Yes	Yes
Inventory	No	No	No	Yes	No	No	Yes
Report Generation	Yes	Yes	No	No	No	No	Yes
User Based Access	Yes	Yes	Yes	No	No	No	Yes
Customer/People List	Yes	Yes	Yes	No	No	No	No

Chapter 3

Live Barn

3.1 Technologies Used

Live Barn is an online database with a web interface created for the USDA(United States Department of Agriculture) to store detailed information on cattle under their supervision. The USDA conducts experiments on their cattle and were in need of a custom database with a web-based interface that could be interacted with from multiple devices throughout the property.

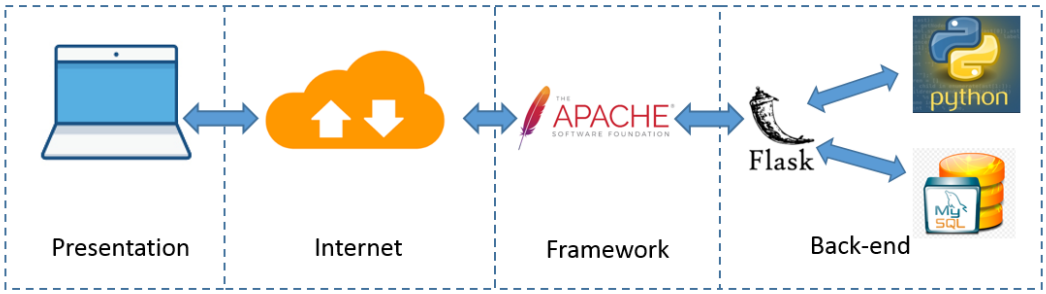


Figure 3.1: This image shows the architecture of the application.

In the Figure 3.1 we can see that the architecture is divided into 2 different

parts.

As seen in the Figure 3.1 above we can see that the Architecture is divided into 2 parts:

1. Server-side.

2. Client-side.

Server-side can be classified into two parts, them being Business Logic and Data Access Logic. Client-side can be defined as Presentation Logic.

Since there are a lot of technologies available in the market, We will be looking to choose the best technology to use in our architecture by comparing the available technology for their respective Logic.

3.1.1 Business Logic

Web Frameworks: Flask v1.0.2 vs Django v2.0

If you decide you want to build a web application, and you would like to develop it in Python, you'll probably want a so-called web framework. There are a lot of repetitive and boring parts of building back-end logic, user interface, and hooking everything up to the Internet so that users can navigate your app in their browser. A web framework aims to implement all the functionality common to most web applications, such as mapping URLs to chunks of Python code[17].

Main contrasts

- Flask provides simplicity, flexibility and fine-grained control. It is unopinionated (it lets you decide how you want to implement things).

- Django provides an all-inclusive experience: you get an admin panel, database interfaces, an ORM, and directory structure for your apps and projects out of the box.

You should probably choose

- Flask, if you're focused on the experience and learning opportunities, or if you want more control about which components to use (such as what databases you want to use and how you want to interact with them).

- Django, if you're focused on the final product. Especially if you're working on a straight-forward application such as a news site, an e-store, or blog, and you want there to always be a single, obvious way of doing things.

Django is a heavier framework than Flask if you're learning web programming, it can be harder to figure out which pieces are responsible for what functionality, and what you need to change to get the results that you want. Therefore, Using Flask can be very helpful to have a very focused approach to the goal you want to achieve at the end. Using Django will result in leaving out some of the features because you might not be able to configure some of the inbuilt features.

Which one did I choose?

I chose to go with Flask because it gives an opportunity to peek into the world of Web-development. It also has allowed me to look into a lot of libraries that give the perfect match to the desired functionality. Unlike Django which

has all the features and some of them are not configurable because they are inbuilt into the framework.

Application Server: Python v3.7.2 vs PHP v7.1.20

Python and PHP are two of the most popular high-level programming languages. PHP is traditionally used as a server-side scripting language, while Python is valued for its dynamics, availability, and simplicity[18]. Despite their almost identical popularity among developers, these two languages have many specifics and differences. The wide prevalence and use of these languages lead to the question which of them is better and more convenient?

PYTHON vs PHP: What is common between them?

At first glance, it may seem flawed to compare the two languages originally created for different purposes. However, seemingly different, PHP and Python have a number of common properties that make them popular:

- Both languages are easy to learn (compared to C++, Perl, and others)
- Both languages are accompanied by the extensive and detailed documentation
- Both languages are open source and can be updated and advanced by users with the purpose of improvement
- Wide and friendly developer communities facilitate the process of learning and working with PHP and Python
- Portability and versatility: both languages have IDEs for all the major operating systems.

Differences The PHPs syntax is almost the same as the syntax of C (due to its origins). When writing the code using this language, curly brackets, additional characters and operators, and other C elements are used. A nice moment in working with PHP is neglect of white spaces during the compilation, which brings additional usability and gives the ability to structure the code into simple logical components. An unpleasant feature of PHP is the incompatibility of the namespace conventions, which is why many developers do not perceive it as a full-fledged programming language. However, this feature is primarily due to the fact that the language initially was designed for the website management.

The syntax of Python, on the contrary, is based on the separation of the code with spaces and tabs, which significantly speeds up the process of coding, but increases the possibility of careless errors. Considering Python, its also worth noting the simplicity of commands. In fact, most of the commands in this language are similar to the corresponding words in natural English, which makes it much easier to learn.

The list of secondary PHP and Python differences is as follows:

- Python is considered a more flexible programming language, while PHP is tightly regulated.
- Python uses special packages to load additional libraries, while PHP requires loading them manually.
- Unlike PHP, where assuring the software security requires additional tools, applications written in Python are considered among the safest.
- Although Python supports a graphical user interface and can be used in web development, PHP, originally created to support web applications, is

more applicable in this area.

3.1.2 Database Logic

Database Server: PostgreSQL v11.1 vs mySQL v5.7

Here are a few examples of companies that use these databases:

- **PostgreSQL:** Apple, IMDB, Macworld, Debian, Fujitsu, Red Hat, Cisco, Skype, etc.
- **MySQL:** GitHub, US Navy, NASA, Tesla, Netflix, Facebook, Twitter, YouTube, Spotify, etc.

Is Indexing Important?

Indexes enhance database performance, as they allow the database server to find and retrieve specific rows much faster than without an index. But, indexes add a certain overhead to the database system as a whole, so they should be used sensibly.

Without an index, the database server must begin with the first row and then read through the entire table to find the relevant rows. The larger the table, the more costly the operation.

PostgreSQL: PostgreSQL includes built-in support for regular B-tree and hash indexes. Indexes in PostgreSQL also support the following features:

- **Expression indexes:** can be created with an index of the result of an expression or function, instead of simply the value of a column.
- **Partial indexes:** index only a part of a table.

MySQL: Most MySQL indexes (PRIMARY KEY, UNIQUE, INDEX, and FULLTEXT) are stored in B-trees. Exceptions include the indexes on spatial data types that use R-trees. MySQL also supports hash indexes and the InnoDB engine uses inverted lists for FULLTEXT indexes.

Clustering:

In the context of databases, refers to using shared storage and providing multiple database front-ends for clients. The front-end servers share an IP address and cluster network name that clients use to connect, and they decide among themselves who is currently in charge of serving client requests.

PostgreSQL: PostgreSQL has synchronous replication (called 2-safe replication), that utilizes two database instances running simultaneously where your master database is synchronized with a slave database. Unless both databases crash simultaneously, data won't be lost. With synchronous replication, each write waits until confirmation is received from both master and slave.

MySQL: MySQL replication is one-way asynchronous replication where one server acts as a master and others as slaves. You can replicate all databases, selected databases or even selected tables within a database. MySQL Cluster is a technology providing shared-nothing (no single point of failure) clustering and auto-sharding (partitioning) for the MySQL database management system. Internally MySQL Cluster uses synchronous replication through a two-phase commit mechanism to guarantee that data is written to multiple nodes. This contrasts with what is usually referred to as "MySQL Replication", which is asynchronous.

Since we will be using a single database for a facility saving the data into

multiple nodes in a single database is useful as we do not have a master-slave configuration present. Thus using MySQL database is more preferable.

Who's currently behind the databases?

PostgreSQL: PostgreSQL is an open-source project maintained by PostgreSQL Global Development Group and its prolific community. Here's a full list of the contributors, and the source code is on GitHub.

MySQL: MySQL's source code is available under the terms of the GNU General Public License, as well as under a variety of proprietary agreements. MySQL is now owned by Oracle Corporation. For proprietary use, several paid editions are available and offer additional functionality[19].

Which one did I choose?

In this project I have chosen to go with mySQL because of its robust functionality and its ability to query and store a lot of data together. We also see that a lot of top companies prefer mySQL over postgreSQL for the Indexing aspect and the clustering of the data. Since postgreSQL is open-source there are a lot of add-ons available which makes it more robust system but also very vast system whereas mySQL has all the features inbuilt and we shouldn't have to look into more libraries for more functionalities. Since it is the first project utilizing the database, I have chosen to go with mySQL and in the future, implementing postgreSQL is preferred because of the different libraries available which will allow users more accessibility and functionality with the data.

3.1.3 Client-side

JavaScript v1.8.5

There are lots of programming languages to choose from, but there is at least one that is used by virtually everyone. When it comes to front-end development, hardly any programmer can do without JavaScript, which is a universal solution for web interfaces creation. Moreover, it is often treated as the only solution of this kind. However, there some alternatives to JavaScript that do their job rather well. In this article, well briefly review those ones that are definitely worth a closer look.

JavaScript Overview

Before discussing alternative options, it is necessary to say a couple of words about JS and its key features that make it the most powerful tool for front-end web development. Broadly speaking, JavaScript is used for creation of all types of interactive elements of websites.

In particular, it allows executing the following tasks:

- creating all types of online interactive formsregistration forms, questionnaires and other forms that need to be filled by users.
- tracking users actions on the site, such as scrolling, zooming, clicking buttons and so on.
- accessing HTML-based component and working with them without the need of refreshing the page.
- One of the key JS advantages is its full compatibility with most existing

browsers. This language has a simple syntax and is easy to use for any purpose.

JavaScript Alternatives and Their Pros and Cons Despite all the popularity and uniqueness of JavaScript, there are some decent alternative tools that can be used for certain tasks execution. Here are some of them.

- CoffeeScript - This language is transcomplied into JS. What it does is improving readability of JavaScript and making the code simpler and shorter. CoffeeScript can also be used with Node.js. It is not a modification or a subgroup of JavaScript, though. But if you want to use it for coding, you need to know JavaScript anyway. Drawbacks of CoffeeScript include a need for compilation, a limited feature set and few specialists writing in it.

- Dart - Dart is a Googles product that offers a lot of opportunities for constructing well-structured apps. It is a new-gen high-performance language that gives pretty much flexibility to developers. Dart is regularly upgraded by Google, but if compared to JavaScript it still has fewer capabilities and a smaller community.

- TypeScript - This programming language has been developed by Microsoft. Its primary function is enhancement of JavaScript capabilities, which it is backward compatible with. When compiled to JS, any app written in TypeScript can be viewed in most browsers. It is also compatible with Node.js. TypeScript supports classes and modules connection as well as static type-checking. The community of the language is smaller

than that of JavaScript, and coding using this language it more time consuming.

Why is JavaScript Better?

As you see, today there are some real (though less popular) alternative to JavaScript. And still, youll hardly do without the latter. The reasons for it are not only above-mentioned JavaScript advantages, but also some independent facts:

- all browsers support JavaScript.
- JS scripts and plugins are used everywhere by everyone, even by regular users.
- it has the richest feature set.
- specialists who can code in JS languages are always in demand.

Finally, JavaScript is regularly upgrading, and new releases allow resolving more and more complicated tasks.

REST-API

Since JavaScript is used to decode the data received from the Web-server. There has to be a carrier for the data from the Web-server to the JavaScript. That is the *REST-API*.

What is REST-API?

REST is acronym for REpresentational State Transfer. It is architectural style for distributed hypermedia systems and was first presented by Roy Fielding in 2000 in his famous dissertation.

Guiding Principles of REST

- **Clientserver** By separating the user interface concerns from the data storage concerns, we improve the portability of the user interface across multiple platforms and improve scalability by simplifying the server components.

- **Stateless** Each request from client to server must contain all of the information necessary to understand the request, and cannot take advantage of any stored context on the server. Session state is therefore kept entirely on the client.

- **Cacheable** Cache constraints require that the data within a response to a request be implicitly or explicitly labeled as cacheable or non-cacheable. If a response is cacheable, then a client cache is given the right to reuse that response data for later, equivalent requests.

- **Uniform interface** By applying the software engineering principle of generality to the component interface, the overall system architecture is simplified and the visibility of interactions is improved. In order to obtain a uniform interface, multiple architectural constraints are needed to guide the behavior of components. REST is defined by four interface constraints: identification of resources; manipulation of resources through representations; self-descriptive messages; and, hypermedia as the engine of application state.

- **Layered system** The layered system style allows an architecture to be composed of hierarchical layers by constraining component behavior such that each component cannot see beyond the immediate layer with which they are interacting.

- **Code on demand** REST allows client functionality to be extended by downloading and executing code in the form of applets or scripts. This simplifies clients by reducing the number of features required to be pre-implemented.

Though, because REST also intend to make web (internet) more streamline and standard, he advocate to use REST principles more strictly. And thats from where people try to start comparing REST with web (HTTP). Roy fielding, in his dissertation, nowhere mentioned any implementation directive including any protocol preference and HTTP. Till the time, you are honoring the 6 guiding principles of REST, you can call your interface RESTful.

In simplest words, in the REST architectural style, data and functionality are considered resources and are accessed using Uniform Resource Identifiers (URIs). The resources are acted upon by using a set of simple, well-defined operations. The clients and servers exchange representations of resources by using a standardized interface and protocol typically HTTP[20].

How does it connect together to make the front-end display the data?

We have HTML and CSS that help us design and beautify the element on the web page. They need some data from the server-side but are not capable to decipher the data on their own. That is where JavaScript steps in. It collects data from the Server and deciphers it and sends it to the HTML + CSS to show it on the browser. All the user based functions such as clicks, zooms, scrolling

is controlled by JavaScript. But it cannot communicate with the server on its own.Data from the server is delivered to JavaScript via REST-API. So REST-api communicates with the Web-server and brings the data and delivers it to the JavaScript which deciphers it and delivers it to HTML + CSS which show the data on the screen.

3.2 How will the software be used?

The software use can be classified into four groups:

- Herdsmen.
- Scientists.
- Veterinarians.
- Inspection.

3.2.1 Herdsmen

Herdsmen are the technicians who are responsible to go around the vast lands in order to take care of the animals and report to the Scientists with the data that is requested by the scientists. Daily at 6AM herdsmen go around the 7000 acres of land to see if all the animals are well and have enough water/feed available and report to the veterinarian if there is any medical attention required to any of the animals. Herdsmen are also responsible for measuring different data off of the animal. For example, They have to measure the amount of manure produced by the animal during specific time period mentioned by the scientists. During all of this scheduled tasks they are expected to take note of the data and update

it to the system after going back to their Workstation PC and give it to the scientists in the form of an Excel sheet. So this software takes the place of the data sheets the Herdsmen will use to record the data at that point and update the information directly into the website which will reduce huge waiting time for the scientists.

3.2.2 Scientists

Scientists are mostly gonna use the software in their Workstation PC located in their Office. After Herdsmen hand them the Excel file, Scientists will try to run the different formulas for the different animals according to the different data that is being calculated. Then further analyze the data to see how well the experiment is going on. So this software will replace all of the tasks mentioned earlier and replace it with a clean interface where they can have instant access to all the data the Herdsmen are entering into the system at any given point of time.

3.2.3 Veterinarians

Veterinarians are always available on-site so as to keep the animals on-site always healthy. As the Herdsmen report that they need Veterinarians to look into some animals then Veterinarians have to look into why the animal is feeling sick and have to treat the animal and have to store the records of what medication was given to the animal (if any is given) to show to the Inspection team of how well the animals are being looked after and not treated inadequately.

3.2.4 Inspection

Inspection team might visit the facility for a surprise visit or a scheduled visit. The Facility is always responsible to keep the documentation for what is happening with the animals. If there was any issue regarding the animals or their employees how was it taken care of. If the Inspection team determines that the facility is inadequately taking care of the employees or the animals, the facility might be determined as an unhealthy work environment and wouldn't be allowed to continue their research further.

3.3 Different Pages

- Login
- Home
- Animal
- Experiment
- Inventory
- Inspection
- Reproduction
- Health Records
- Report
- Herd
- User Management

In this chapter we looked into the website as a whole explaining the main functions covered and what it can do. We looked into the architecture of the website from the server to the client side.The client side is then divided into many pages so as to not clutter the screen as was the case in their old software.

Chapter 4

Pages

4.1 Login

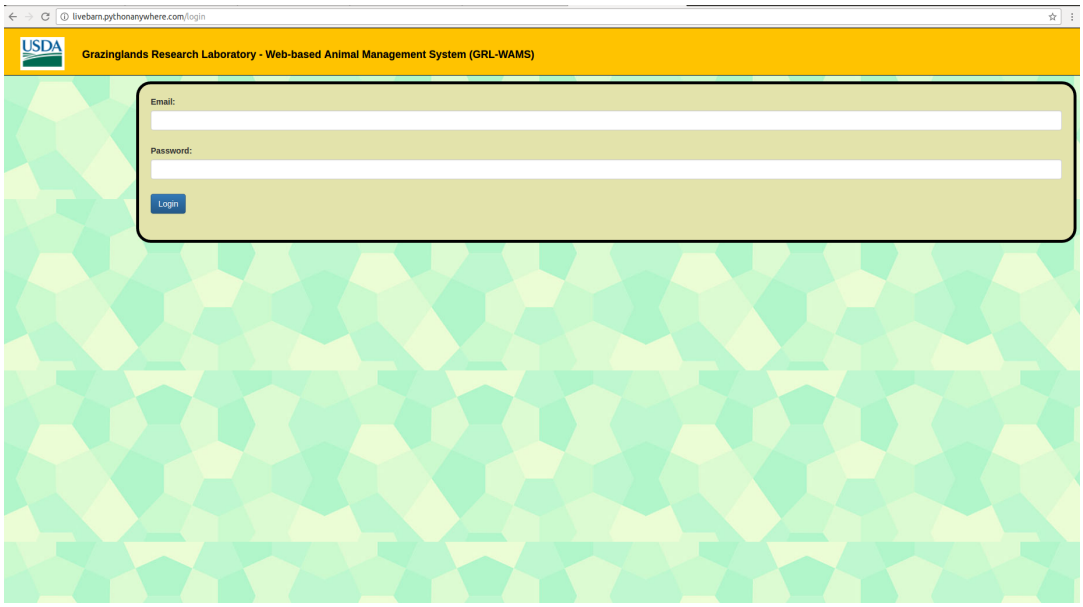


Figure 4.1: This image shows the log in page of the application.

As soon as someone enters the site address, they are redirected to the log in page. This helps them keep a layer of security for the data that they have and

the research is being conducted on. This allows to create multiple accounts for individual access to the pages. Allowing to take care control of access to specific pages to specific log ins. The passwords entered here go through complex filtering and hashing to make sure that anybody cannot access the log ins by any chance. As soon as the user has entered the password, It is converted into alphanumeric hash of length 124 characters which will be stored into the database. In case the user needs to log in then the password is taken and converted into the 124 character hash and compared to the one in the database. So nowhere in the system does the original password be revealed.

4.2 Home



Figure 4.2: This image shows the homepage of the application.

In Figure 4.2 we can see an Image Carousel and an events tab. The events tab in the bottom of the screen gives all the users a notification of the events happening in the facility. From the Home site the users will have access to

all the pages based on the the navigation pane to the left of the page. The image carousel keep scrolling around 7 images that show the images around the facility.

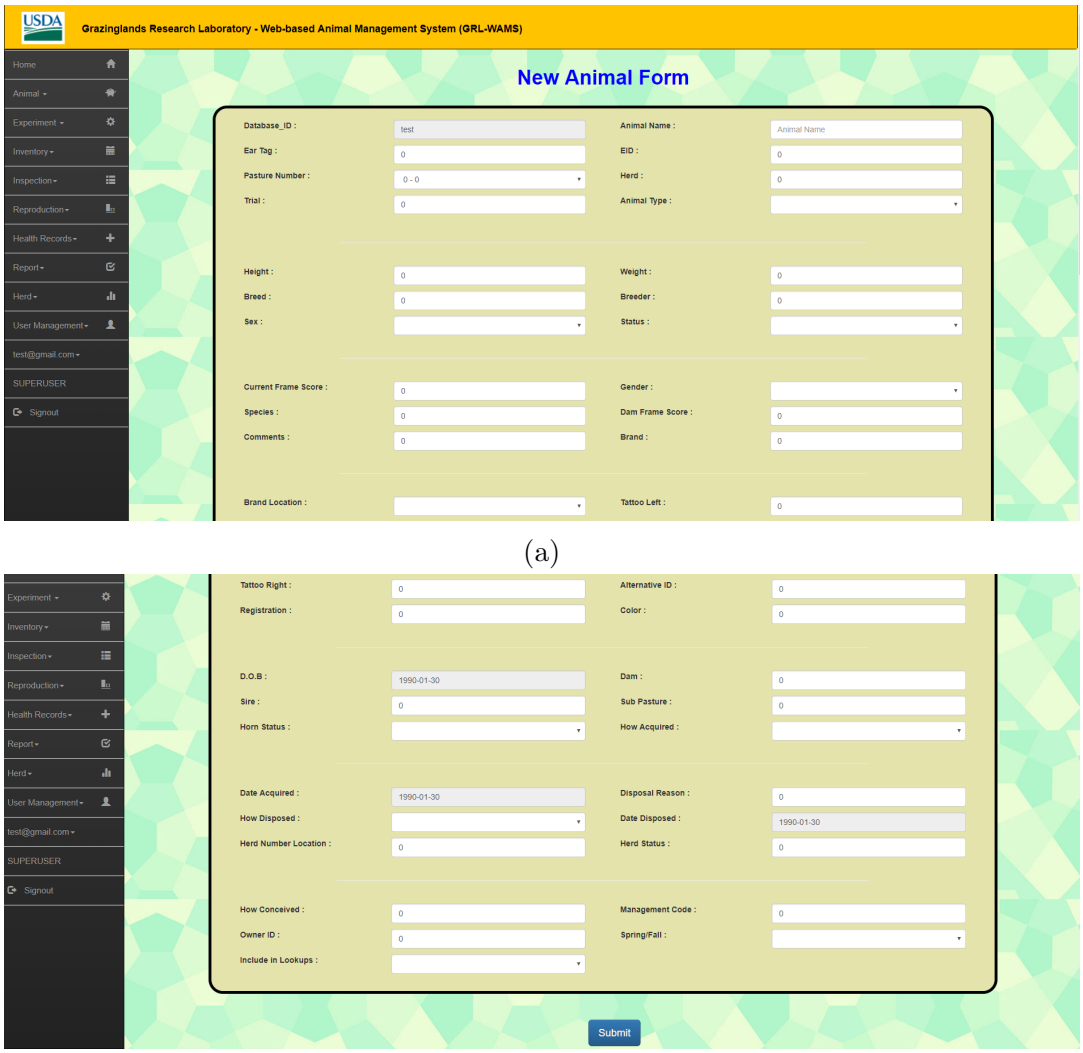
4.3 Animal

Researchers deal with animals for their different experiments and keep track of all the changes that the animal will have during its course in the Grazing Lands of US Department of Agriculture. The data viewing and saving are categorized into three pages as follows:

- Add Animal.
- Update Animal.
- Animal List.

4.3.1 Add Animal

As we can see in the form above in Figure 4.1, The form with the title Animal Add allows researchers to enter new animals into the system. Researchers keep track of many things over the time of the animal in the facility. Researchers should also be able to provide the required information out to the inspection officer whenever required. An animal bought from outside this is where the journey of the animal starts with regards to record-keeping in the facility.

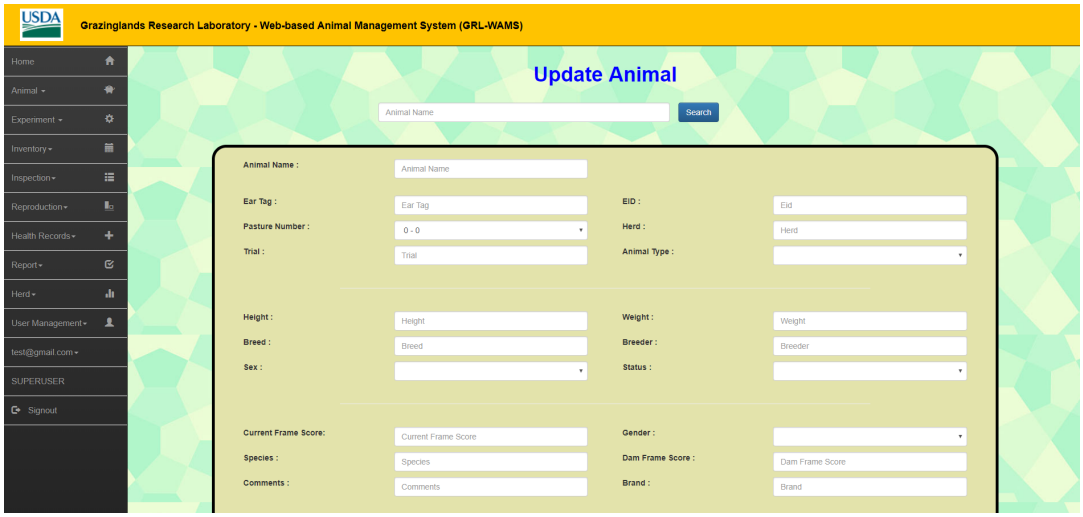


(a)

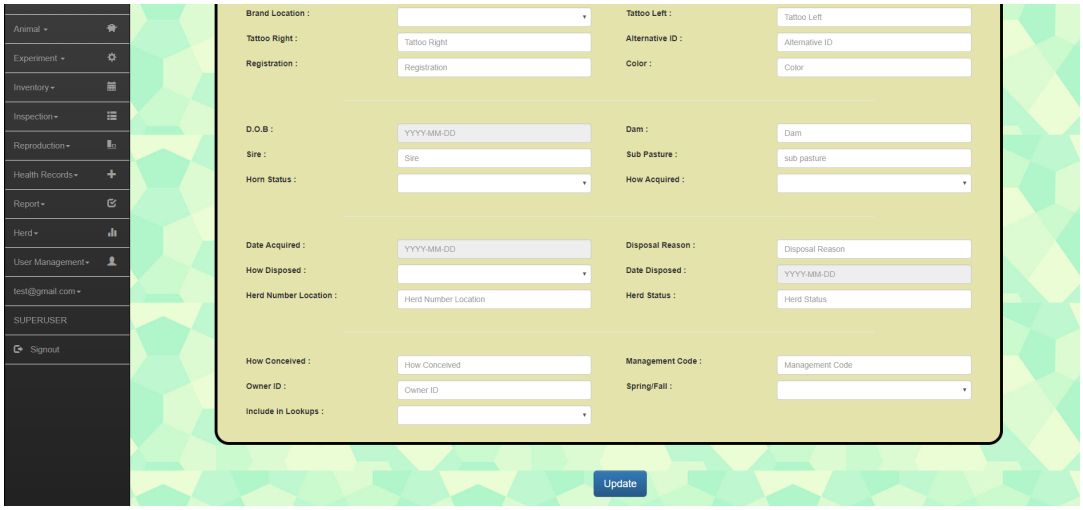
(b)

Figure 4.3: The form shows the fields to be filled when any data regarding an animal has to be changed in the system.

4.3.2 Update Animal



(a)



(b)

Figure 4.4: The form shows the fields to be filled when a new animal is entered into the system.

As we can see that this form in Figure 4.2 is similar to that of the Animal Add page in Figure 4.1, there are two purposes to this form. One is to view the information of any animal by searching in the search box given on the top of the page. Second is to edit/Update any changes that have occurred or initially

not saved. Both these functions are vital for scientists as they have to keep track of every aspect of the animals well-being.

4.3.3 Animal List

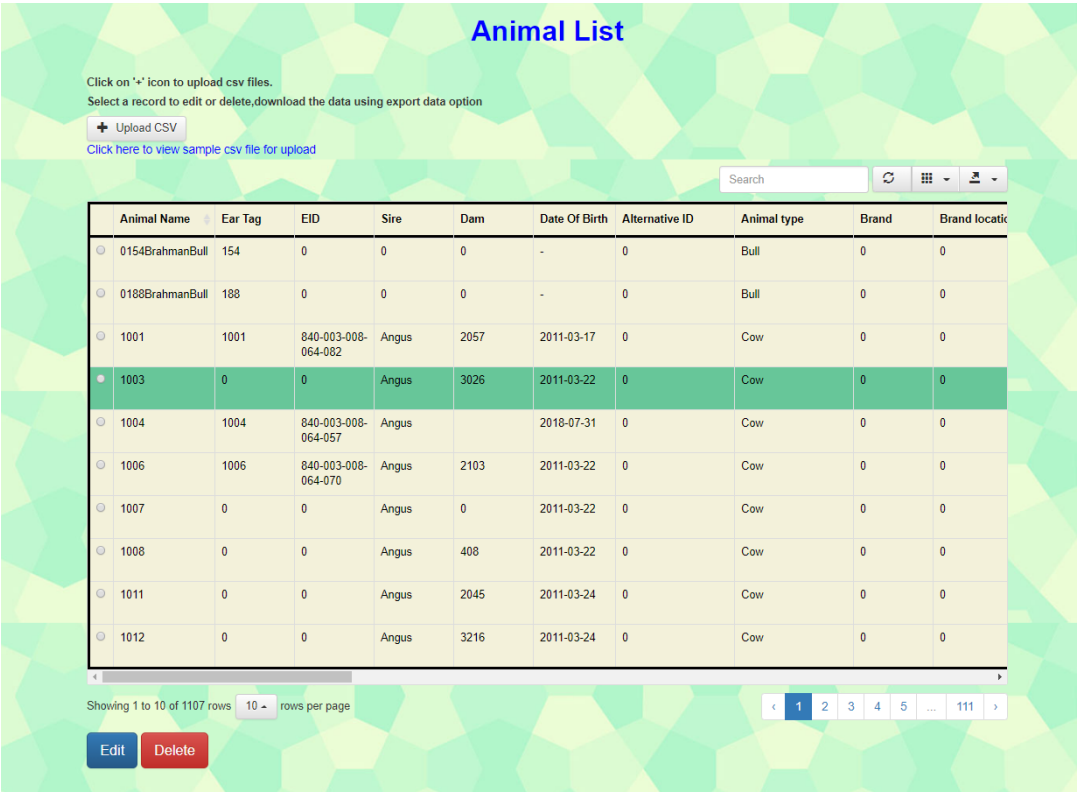


Figure 4.5: Figure shows the page where all the data of all the animals present in the database.

The table displayed in Figure 4.5 shows all of the animals that are available in the facility and also the data that is related to those animals. Animal List page is a quick way to check for an animal in the database. The page also allows researchers to select an animal and edit the parameters of the animal by selecting the radio box and clicking on the edit button; this will result in them navigating to the Animal Update Page in Figure 4.2 where they can change the different parameters of the animal as desired. There is also a delete button

which is only available to the Superuser because we would not want anyone else to tamper with the records as they have to be maintained appropriately in order to access them in case of an emergency. This page also allows researchers to upload CSV file containing all the data very quickly with the Upload CSV button on the top left of the page[21].

4.4 Experiment

The researchers create experiments groups in order to keep track of all the changes or progress they are making with the animals with specific plans. It helps them see the progress of their experiment with time. The parameters involved in the experiment are not present in the Animal page. These parameters help researchers to keep track of the essentials during the time of the experiment. We will go through how the experiment groups will be created and updated with the experiment pages as follows:

- Create Experiment.
- Experiment List.
- Edit Experiment.
- Experiment Animal Update.

4.4.1 Create Experiment

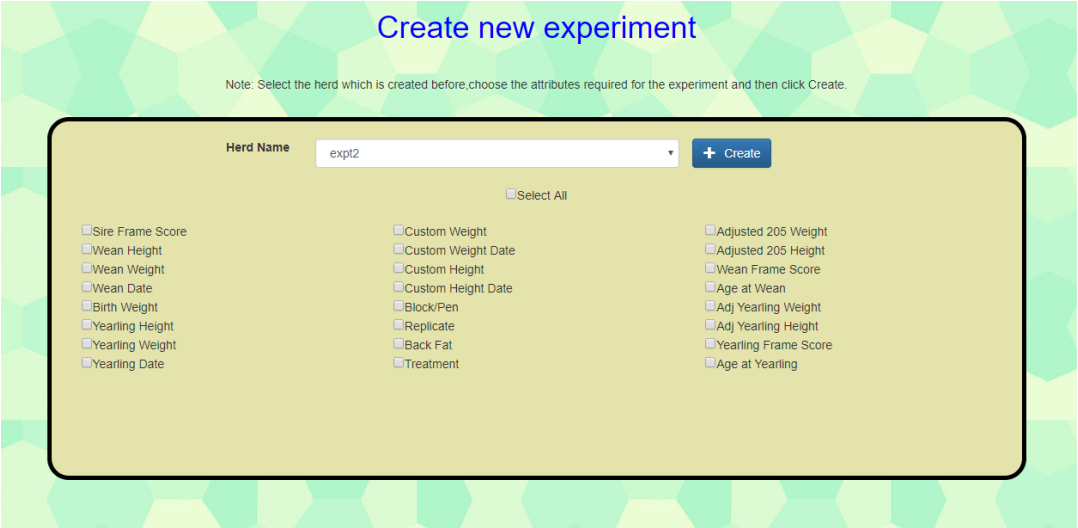


Figure 4.6: This form is used to create a new experiment.

We have created a section for the researchers to select the animals they are taking for the experiment that also allows the researchers to select a few attributes that they would like to keep track over time to observe changes frequently and change the course of their experiment accordingly. For instance, as shown in the Figure 4.6 researchers can create an experiment using the herd that is already created and selects the parameters that they would like to monitor. (Creating a herd is described Create Herd 4.10.1) [22]

4.4.2 Experiment List

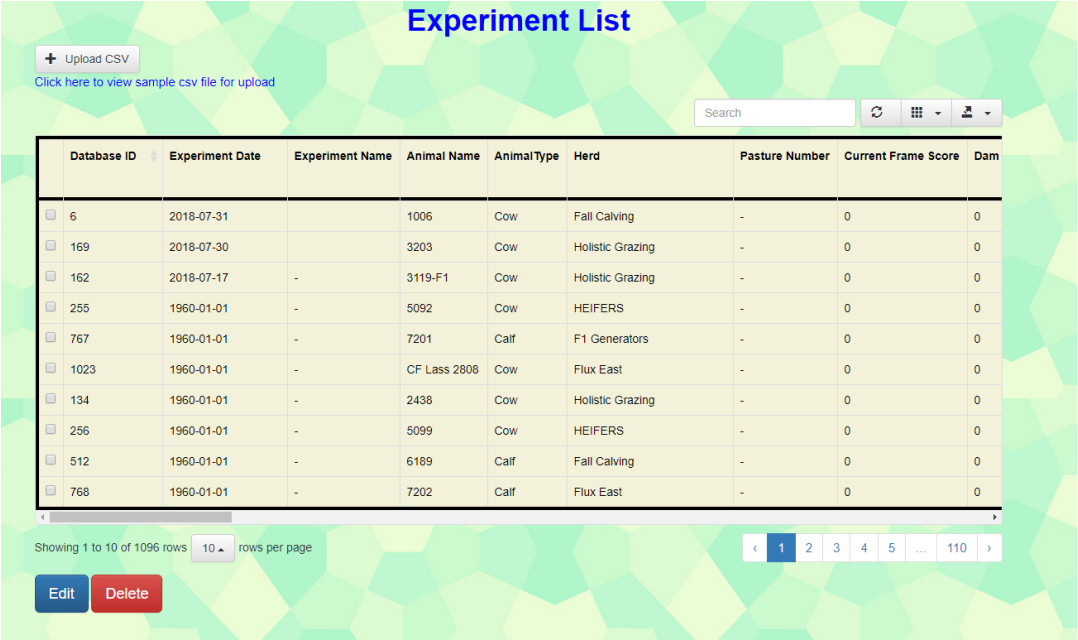


Figure 4.7: This table shows us the animals who have been/currently in an experiment.

The Figure 4.7 shows us the animals with their experiment related data. All of the animals present in the animal table should be visible here to start an experiment or to look back at what the experiment concluded. This table keeps track of all the parameters involved in the experiments and researchers can create an experiment with few parameters and keep updating those parameters related to the experiment currently going on. Here we can see Upload CSV button to the top left screen that allows researchers to upload data in CSV format or ease of transition from Excel databases to online databases[21]. Researcher can also select one of the animals to edit or delete them. Clicking on Edit would take them to the Experiment Animal Update page.

4.4.3 Edit Experiment

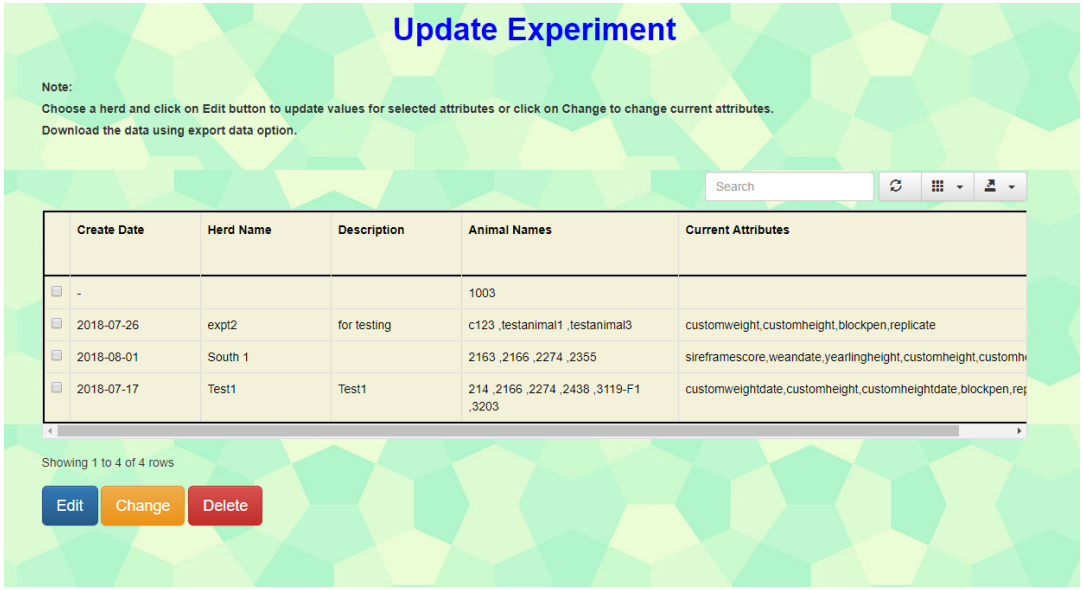
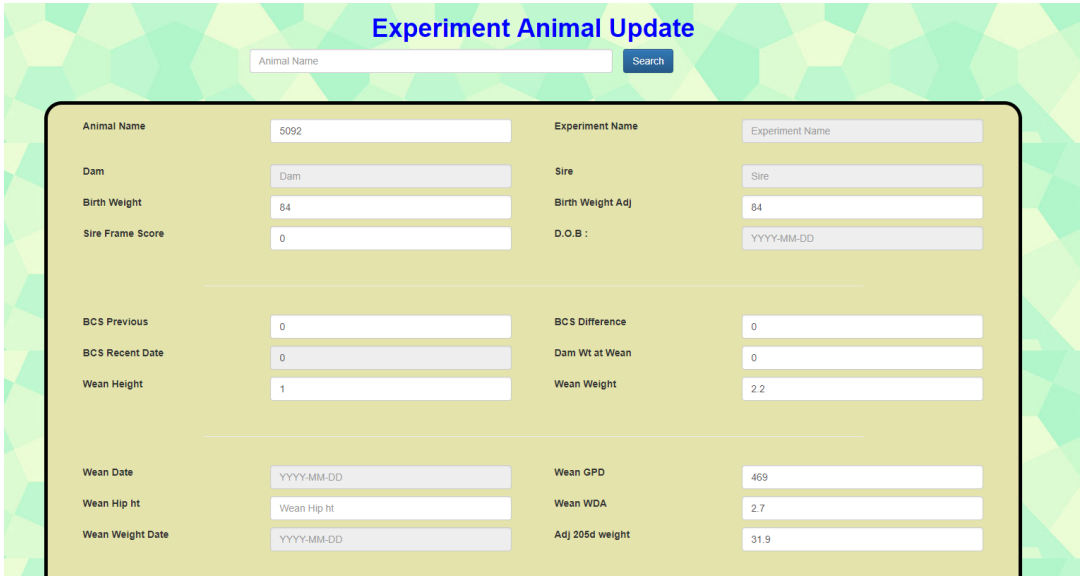


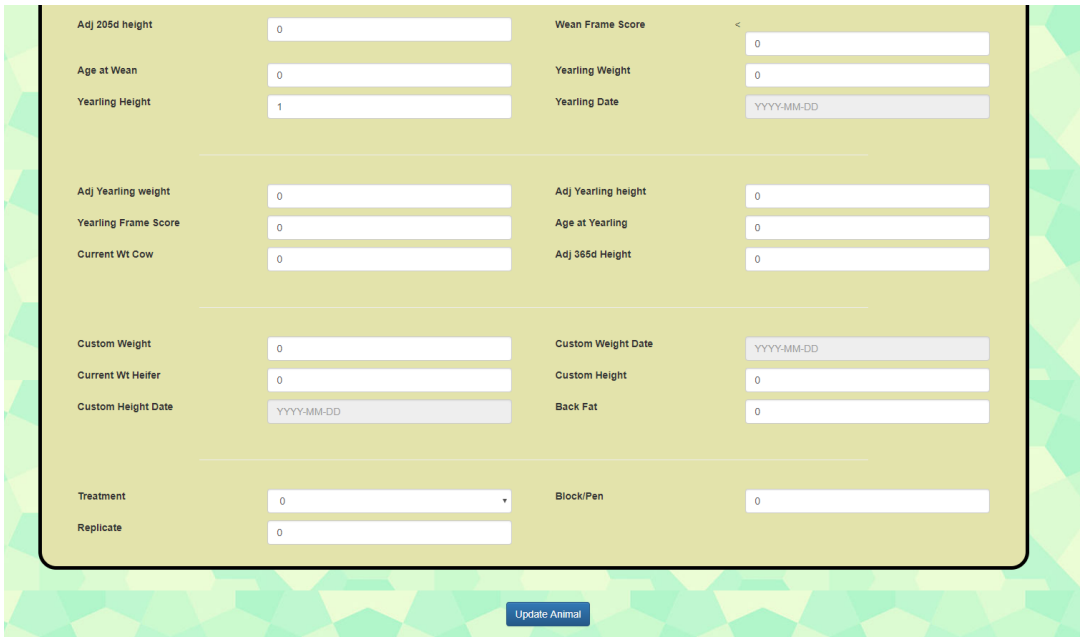
Figure 4.8: This image shows us the table of the experiments going on/already done in the facility.

Figure 4.8 above shows us all the experiments that are currently going on in the facility. The figure shows us the table with the Experiment Name, Created Date, Description, Animals in the experiment and also the selected parameters. Researchers can select an experiment and click on change to alter the parameters they are using for the experiment. Alternatively, they can click on edit to change the data for the animals for the selected parameters.

4.4.4 Experiment Animal Update



(a)



(b)

Figure 4.9: The form shows the fields to be filled when a experiment data of an animal is entered/edited in the system.

The Figure 4.5 above shows us a form consisting of all the data for an individual animal for the experimental parameters. This page allows researchers to change or add data for an animal individually.

4.5 Inventory

This section helps the researchers keep track of the assets they have such as Medicines and Pastures. So the inventory is divided into the following pages:

- Formulary.
- Pastures.

4.5.1 Formulary

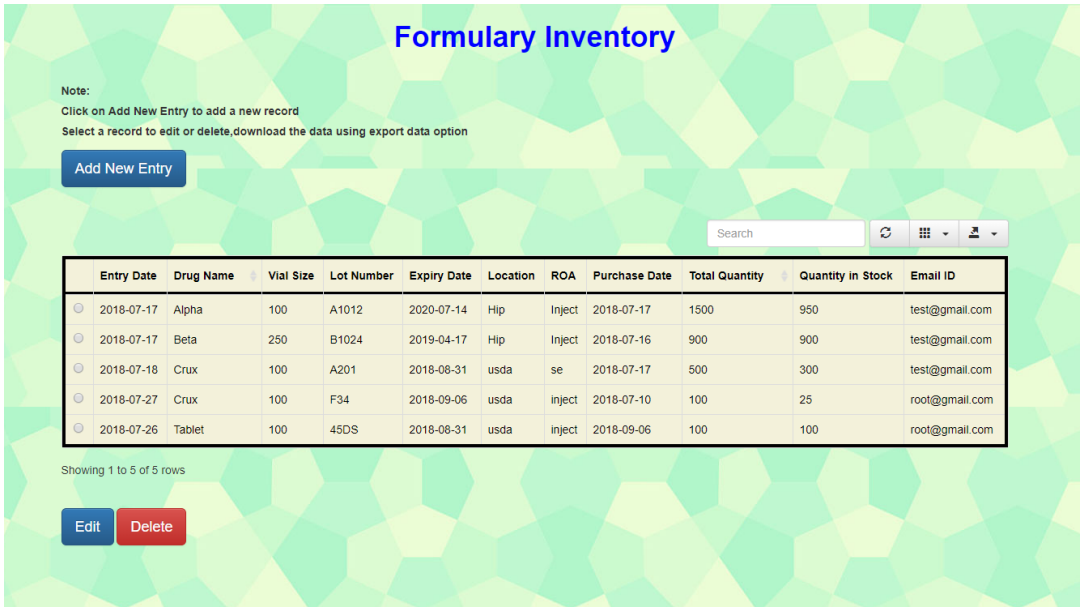


Figure 4.10: This image shows us the table which keeps track of all the medications available in the facility.

The Figure 4.10 shows us all the medicines available in the facility. This table will also keep track of all the expiry dates. However, researchers are supposed to keep track of the expiry dates since notifying the users about the expiration dates or out of stock is left out for future development. Researchers can add new medicines using the button on top saying "Add New Entry" Clicking on the Add New Entry pops up a new form as seen in the Figure 4.11 that allows researchers to enter all the details of the medication.

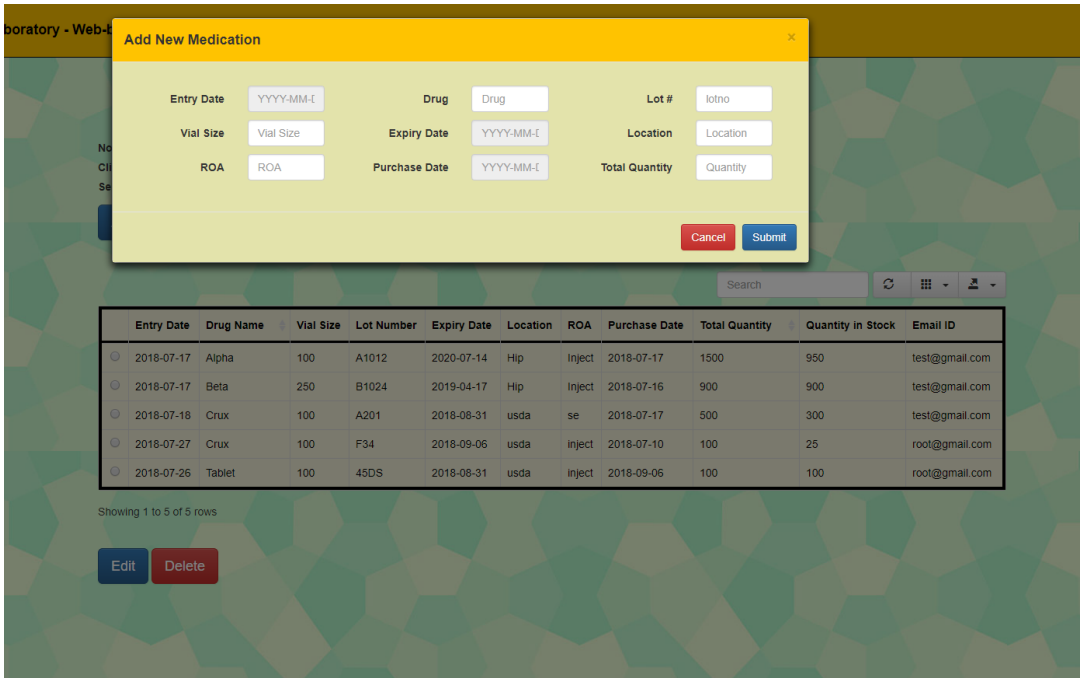


Figure 4.11: This image shows us the pop-up where we can add more medications into the system.

4.5.2 Pasture Management

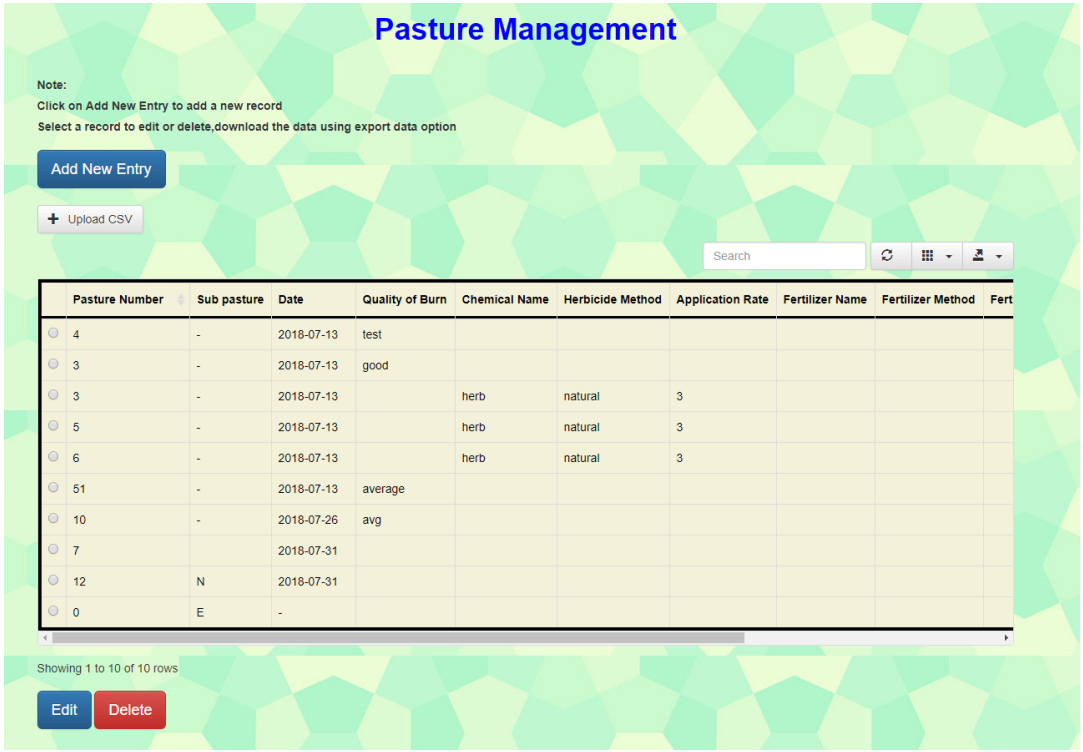


Figure 4.12: This image shows us the table of all the pastures available in the facility.

This page helps researchers keep track of the pastures and the type of grass it is growing. The date pasture was previously burned. When was the pasture treated with Fertilizers or Herbicide? What chemical was used for either? We have "Add New Entry" which pops up a small window as seen in the Figure 4.13 to enter any new data regarding the Pastures.

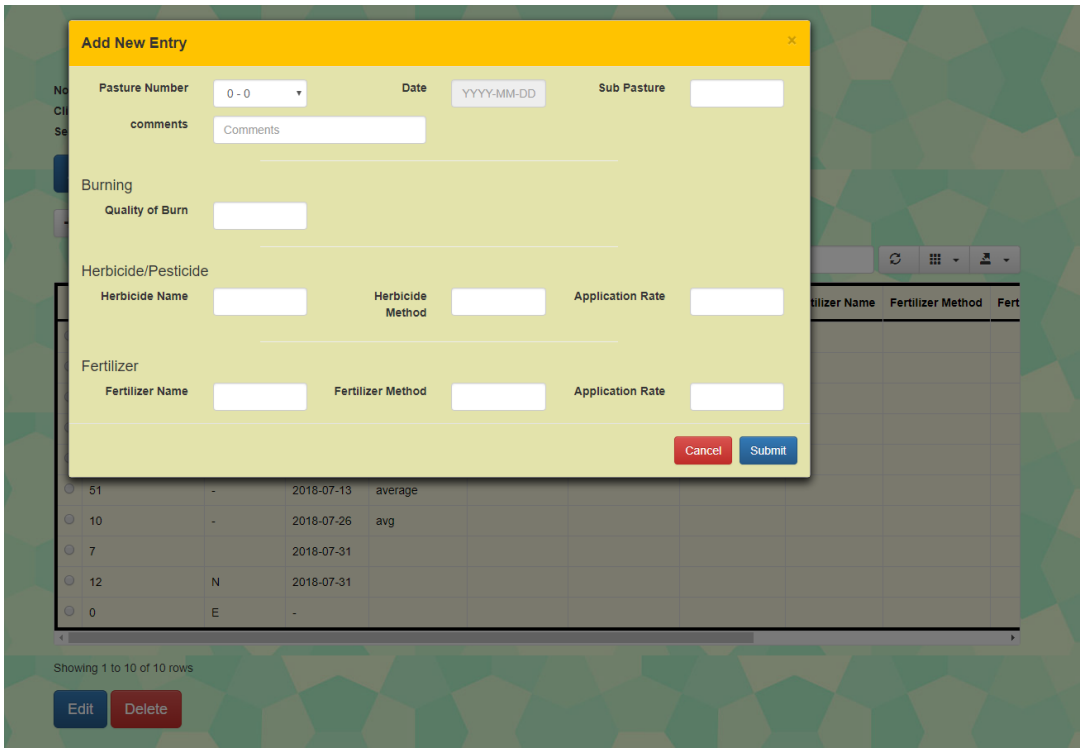


Figure 4.13: This image shows us the pop-up to add new entries about what is done to a specific pasture on a specific date.

4.6 Inspection

Experiments conducted on the animals and Researchers are gathering data on a daily basis from the animals, but the pastures they live in or the buildings they are taken to when they are not well also have to take care. So daily morning herdsmen go around the facility and check all the pastures and the buildings and submit a report with the status. Inspections have to be done daily in order to keep track that nothing has broken or if the animals are fed well Do they have access to water. So the reports are categorized into two parts:

- Pasture Inspection.
- Building Inspection.

4.6.1 Pasture Inspection



Figure 4.14: The image shows us a form of Pasture Inspection sheet.

In the Figure 4.14 we can see the various aspects of the pasture that the herdsmen have to look at and rate them in the range of Very Poor to Good condition. According to the reports given by the herdsmen, the action is taken to repair if something is not working or if something has to be repaired if it is not working correctly.

4.6.2 Building Inspection

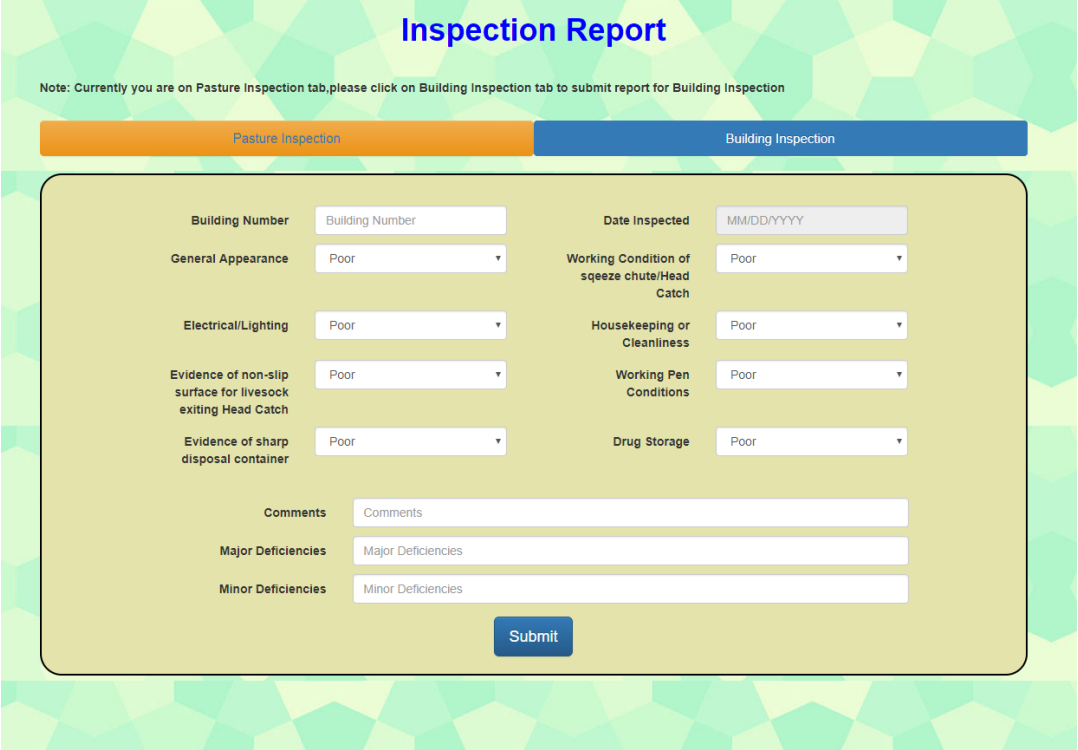


Figure 4.15: The image shows us a form of Building Inspection sheet.

In this Figure 4.15 we can see the aspects of the buildings the herdsmen are looking for any problem. It might be as simple as water access to serious issue as Electricity not available in the building. So the herdsmen have to keep track of all the buildings and schedule maintenance accordingly to take care of the animals well.

4.7 Reproduction

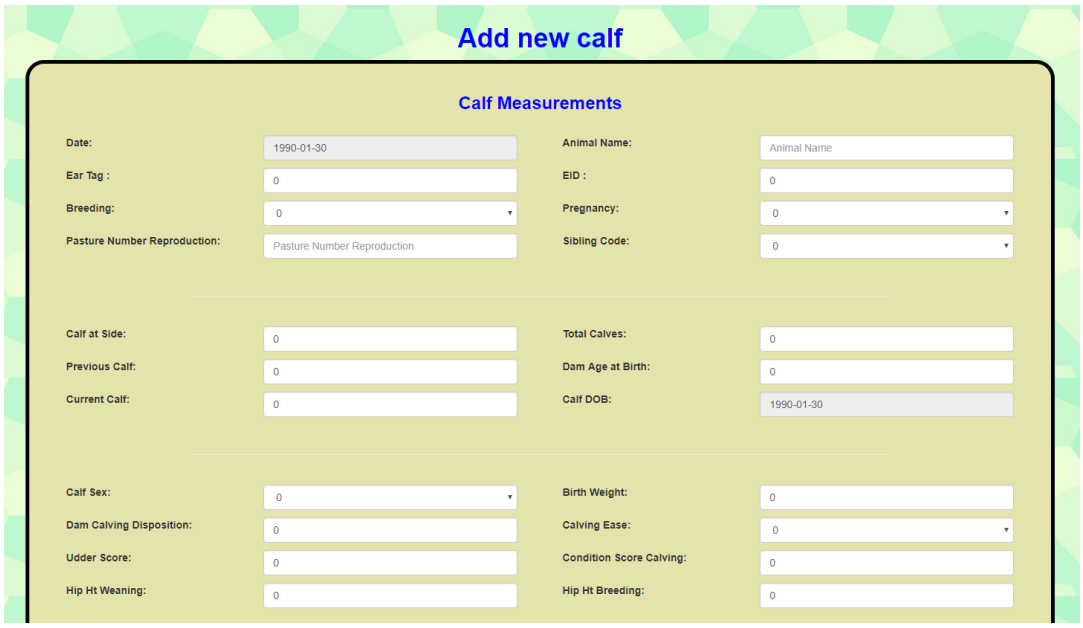
Since experiments are going on to produce an offspring with desirable features. Different breeds of the species are mated, study the offspring for the desirable features. So This page here keeps the record of all the data for that purpose.

Classify the page into three sub pages:

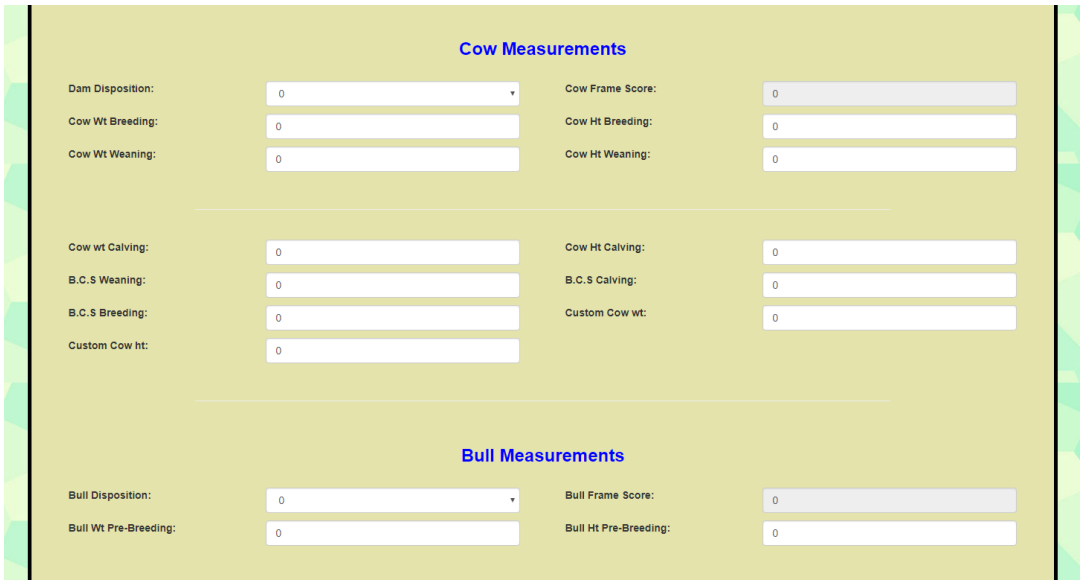
- Add New Calf.
- Calf List.
- Calf Update.

4.7.1 Add New Calf

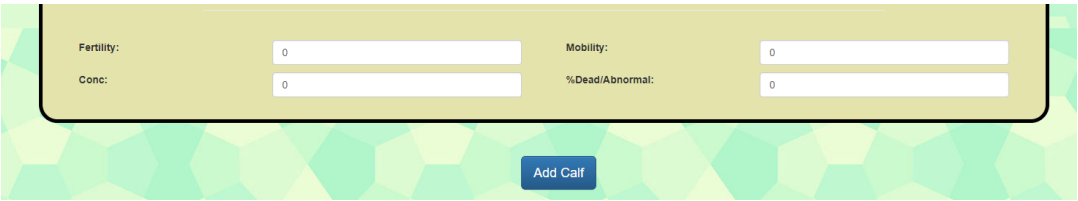
The Figure 4.16a, 4.16b and 4.16c above helps researchers keep track of the new calves born in the facility. It helps researchers keep track of all the desired features they needed and by keeping track of the cross they had to do to get that cross with desired Features in an animal. For instance, Jersey animal is capable of producing more meat and survive cold whereas Indian Cow is capable of producing more milk [23][24].


Add new calf
Calf Measurements
Date:
1990-01-30
Animal Name:
Animal Name
Ear Tag :
0
EID :
0
Breeding:
0
Pregnancy:
0
Pasture Number Reproduction:
Pasture Number Reproduction
Sibling Code:
0
Calf at Side:
0
Total Calves:
0
Previous Calf:
0
Dam Age at Birth:
0
Current Calf:
0
Calf DOB:
1990-01-30
Calf Sex:
0
Birth Weight:
0
Dam Calving Disposition:
0
Calving Ease:
0
Udder Score:
0
Condition Score Calving:
0
Hip Ht Weaning:
0
Hip Ht Breeding:
0

(a)


Cow Measurements
Dam Disposition:
0
Cow Frame Score:
0
Cow Wt Breeding:
0
Cow Ht Breeding:
0
Cow Wt Weaning:
0
Cow Ht Weaning:
0
Cow wt Calving:
0
Cow Ht Calving:
0
B.C.S Weaning:
0
B.C.S Calving:
0
B.C.S Breeding:
0
Custom Cow wt:
0
Custom Cow ht:
0
Bull Measurements
Bull Disposition:
0
Bull Frame Score:
0
Bull Wt Pre-Breeding:
0
Bull Ht Pre-Breeding:
0

(b)



(c)

Figure 4.16: These images show us a form which is used to enter the data of a new born calf in the facility.

4.7.2 Calf List

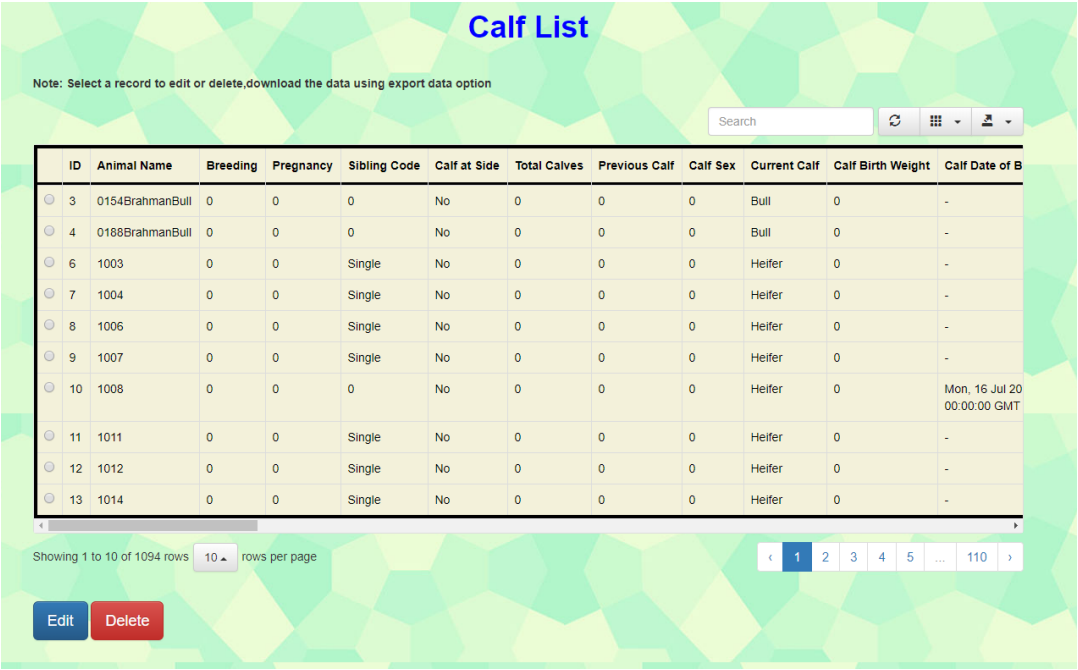
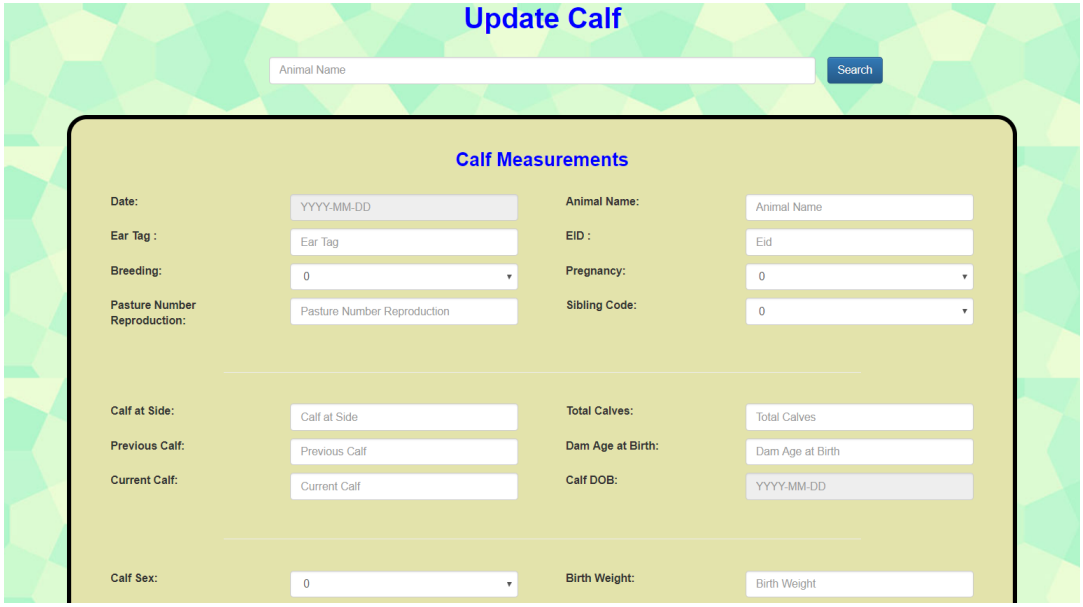


Figure 4.17: The image shows us a table which shows all the calves that were born in this facility previously.

The Figure 4.17 shows us the list of calves born in the facility. It streamlines researchers looking for specific type of breed and do more experiments to make more desirable features added to one the list compromises of all the animals born in the facility and gives researchers a place where they can find a calf easily and make changes to it if needed or look at its data.

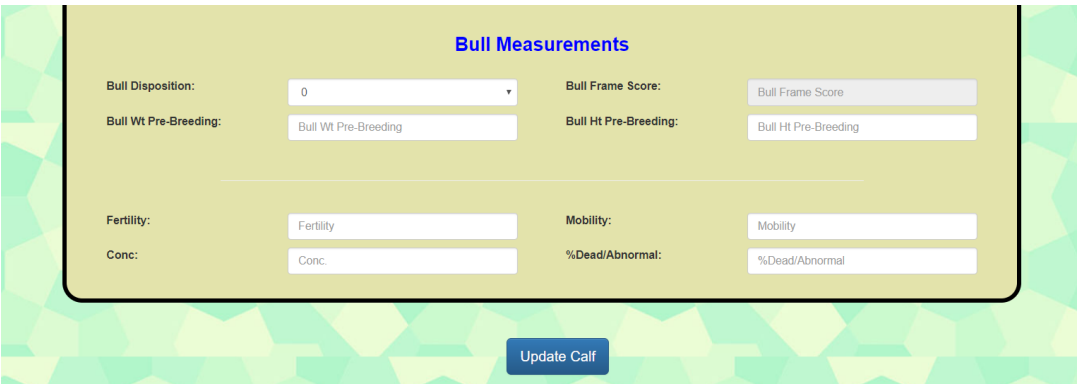
4.7.3 Calf Update



(a)



(b)



(c)

Figure 4.18: The images show us a form to update data regarding any calf in this facility.

The Figure 4.18 above shows us the form where the researchers will change some information of an animal if they had not entered it previously or had entered it wrong. For any reason, researchers can quickly change the data there so that there is correct information stored in the database.

4.8 Health Records

There are many animals in the facility, and due to some reason, the animal can fall sick. So it has to be treated before researchers can put it through another experiment or continue the current experiment. So they maintain health records of the animal with the help of a veterinarian on site. We can classify this page into two subpages:

- Health Record List.
- New Health Record.

4.8.1 Health Record List



Figure 4.19: The image shows us a table of all the medical records of all the animals in the history of this facility.

The Figure 4.19 above shows the records for the veterinarian. The veterinarian has to look after the welfare of the animals. And also keep track of all the medications given to the animals. So all the medications given to all the animals will be stored in that table and searching for an animal will return all the medications given to that animal.

4.8.2 New Health Record



Figure 4.20: The image shows us the form to enter medical record of an animal in the facility.

The Figure 4.20 above helps the veterinarian to add new health records into the system to keep track of it. Sometimes the samples of blood are sent to external labs for inspection, and outside labs return PDF reports, so we also have the feature to store the lab results as PDFs, or test is conducted in the local facility they can always type it into the system.

4.9 Report

This feature was specifically asked by the researchers because this wasn't available in any other software they were using. Researchers like to group up the animals while conducting some experiments. So instead of going through each animal in the animal update page. We have given them a facility to group the animals and form a herd and get information for the whole herd within a time

frame. That will help researchers recognize the changes over time and can be quickly analyzed to conclude quickly. Since many experiments are going on at one point in time, It is much easier to read and analyze reports which consist only the required information.

The Report page is classified into three subpages as follows:

- Create Report.
- Report List.
- Report View.

4.9.1 Create Report



Figure 4.21: This image shows us the form to select a herd and the parameters required for creating a report.

In Figure 4.21, we can see that there is a slot for Start date, End Date, Herd and a lot of parameters. This page helps the users create a report with all the required parameters they would like to keep track of. After the user selects a start date and an end date, the user has to choose the herd of which he wants the data. Then the user will press on the submit button which will process the

request to produce a report with the given details.

4.9.2 Report List



Figure 4.22: This image shows us the table of all the reports created in the facility.

In Figure 4.22 we can see a list of all the reports created in the facility. We can also select the different data about the reports namely the parameters selected, start date, end date and the herd selected for the data. The user can choose to view a report by selecting one of the reports and then clicking on the view button. Alternatively, else the user can also delete a report if it is no longer useful. The user can also get an Excel file exported from the table with the currently displayed data.

4.9.3 Report View

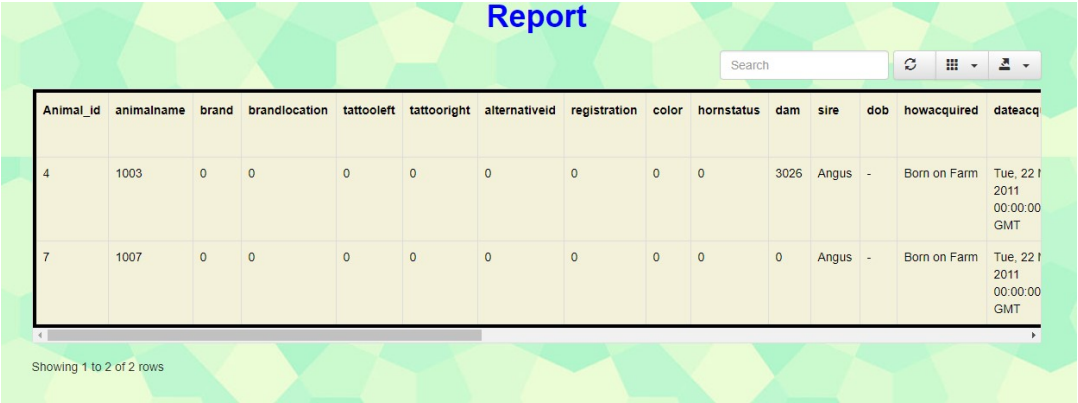


Figure 4.23: This image shows us the Report generated according to the data given by the user.

In Figure 4.23 we can see the animals to the leftmost column and then the animal name and then we have all the parameters selected by the user. The user can select any number of parameters. Depending on the start date and the end date and the number of changes the user has made to an animal between the two given dates we can see a different number of rows. This report feature was one of the high priority requirement because of the ease to read the data and compare when the data present is what the user had selected during the creation of the report. Using the reports, researchers can publish papers like the following much more easily.

- Influence of solar radiation on the productivity and nutritive value of herbage of cool-season species of an understorey sward in a mature conifer woodland[25].

- Effects of winter stocker growth rate and finishing system on: I. Animal performance and carcass characteristics[26].

4.10 Herd

Similar to the report, Herd feature was also requested by the researchers which allows the researchers to group up the animals into a herd and can enter the constant information of all the animals at once.Creating a herd allows the researchers to use the herd in multiple places such as Experiments, Medical Examinations, Reports and Animal Updates. So instead of going through each animal in the animal update page. We have given them a facility to group the animals and form a herd and change one parameter for all the animals through the herd selection.

The herd page is classified into two sub pages as follows:

- Create Herd.
- Herd List.

4.10.1 Create Herd

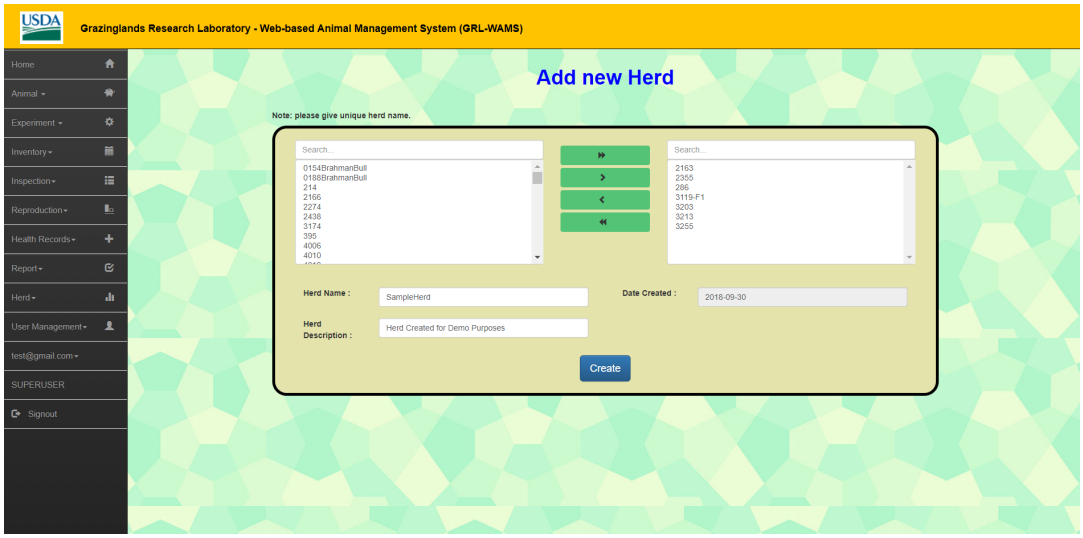


Figure 4.24: The image shows us a form where animals can be selected from a list and classified into a herd, given a herd name and also a description of the herd.

In the Figure 4.24 above we can see the creation of a sample herd to demonstrate the use of the database to create an maintain the herd. Further in many other tabs, we will go through we will call the herd name to see all the animals in the specific herd and make changes to them[27].

4.10.2 Herd List

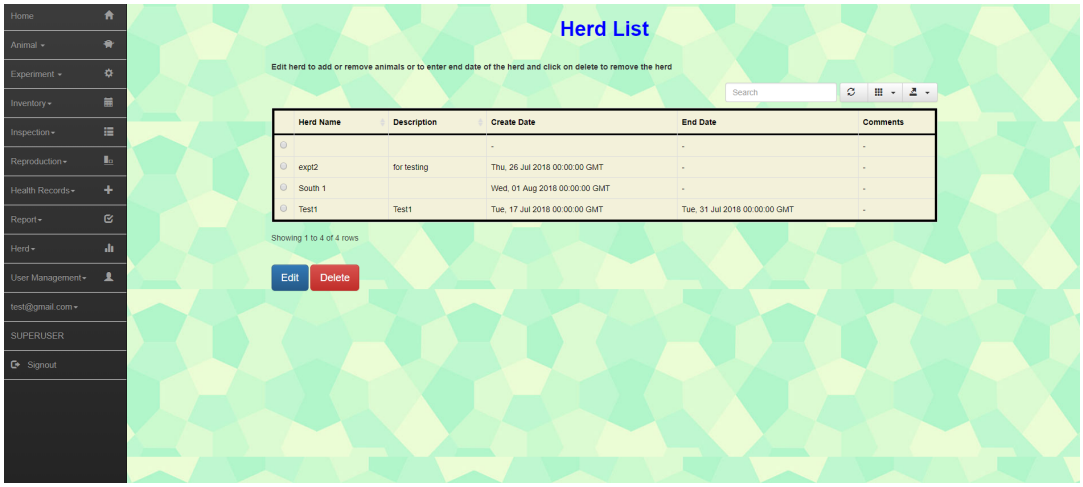


Figure 4.25: The image shows us the table of all the herds created in this facility.

In this page, we can see all the herds created in the system. We also have a column for description that provides spaces for the researchers to provide comments regarding the herd as a note to self or others. Researchers also like to see the start date and end date of a specific experiment depending upon the dates the herd was created and until when used. This page also lets researchers change the description, the animals in the specific herd for any reason[27].

4.11 User Management

This section helps the Head of the Researchers(SuperUser) to add/remove user privileges. Superuser can see the list of all the users in the system. Since nobody can use the software without logging into the system. If there is an account that can log in to the system, then the SuperUser can see them in the User List as seen in the Figure 4.26.

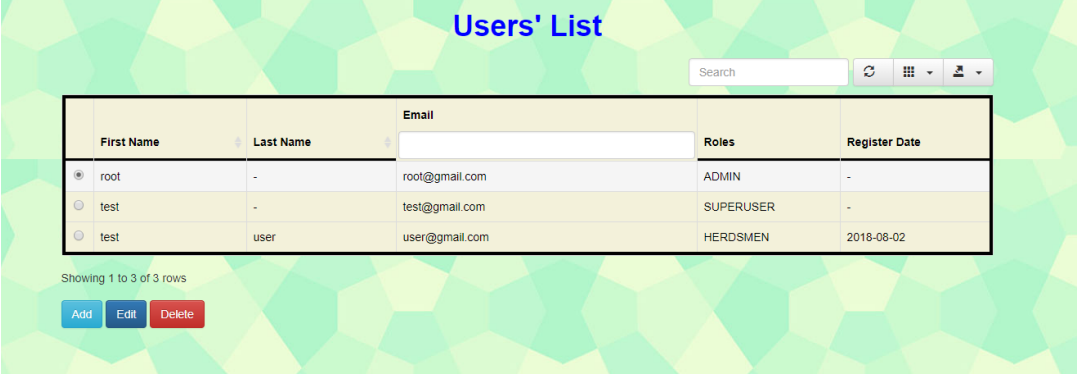


Figure 4.26: The image shows us the list of all the users in the facility.

SuperUser can add new users as shown in Figure 4.27,

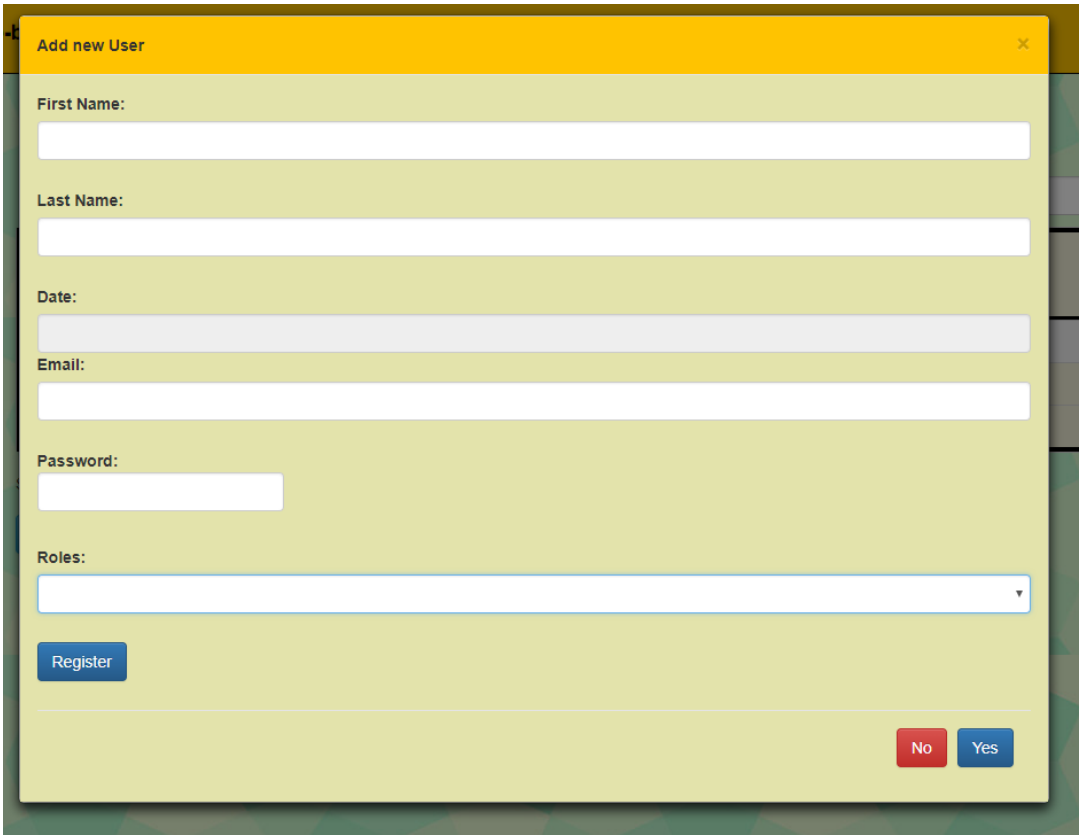


Figure 4.27: The image shows a pop-up that helps the superuser add a new user into the system.

and then give the user the details where the user can change the password

for their use. Except for the SuperUser no other user has access to this page so that one can gain access to something they usually wouldn't need. Making sure that the data is not spread around or leaked. Once SuperUser has created a profile he can change the role of the user to change what pages he can access using the Edit option after selecting the user and clicking on the Edit button that will pop up the following window in the Figure 4.28.

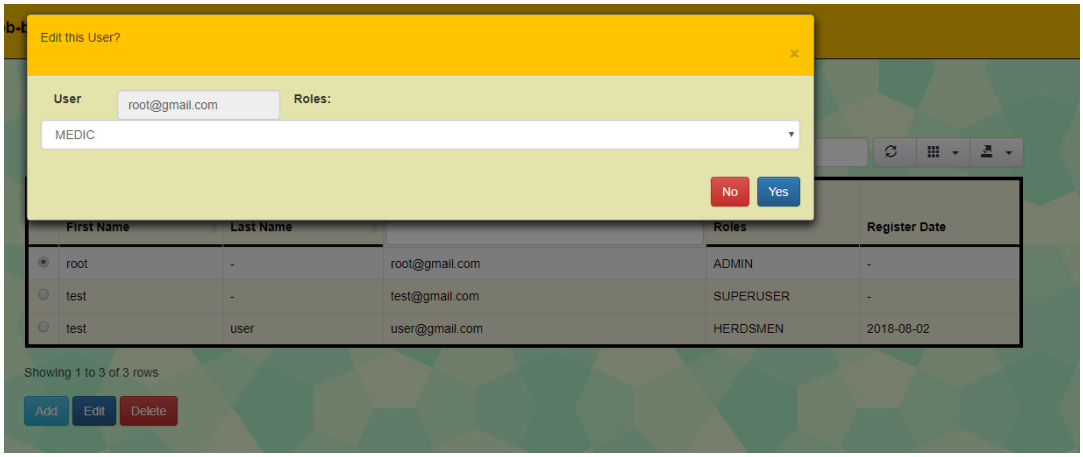


Figure 4.28: Edit User Role.

Chapter 5

Testimonials

The website was developed specifically for USDA scientists. Hence their survey was used to validate the project undertaken.

Response 1:

The primary goal of the project was to develop a web-based user-friendly animal management database to store and query data for research purposes for cattle herd managed by USDA-ARS Grazinglands Research Laboratory.

Research experiments with cattle are conducted by several scientists. In their life time, cattle may go through several experiments. This database allows us to store all the data in one database. This helps the researchers with selection of cows for their experiment. It also provide both researchers and the managers with most recent data on a real-time basis. Moreover, it provides information that we need to provide when we sell the cattle for slaughtering. This is important because, buyers want to know all the information including breed, feed, medication received, etc. It also helps us to meet the Animal Welfare Act requirements on research animals. In addition, it helps us track costs

and benefits of different animal management practices.

With respect to segregated web-pages, Each web-page is designed to input data for either individual cow/calf or group of cattle. The software can satisfactorily store and query data on all cattle that USDA-GRL manages for research purposes.

Now, we are in the phase of allowing animal management group entering the data into the database using user-friendly interfaces real-time and fix any problem that arise during the data entry processes. Also, based on the feedback from the animal management group, we will work towards improving the application.

In the near future, Consumers of the meet wants to know everything about the meat that they are buying. It may allow super markets to charge premium prices based on how these cattle were managed. For example, supermarkets can sell grass-fed beef at a premium price. There is a potential to sell this product/service to research institutions to manage their research animals.

Advantages/Positives of the website/software:

- Researchers will have instant access to research data.
- Reduce loss of data when an employee leaves the job.
- It allows us to track complete life cycle analysis of cattle.

Response 2:

The expectation from the website/software was to develop and implement a web-based record keeping system that researchers can access from the web and use in the field. The problem with the current system is that they are computer

based, are difficult to use, and must pay for individual units for each computer. Advantages:

- Web-based.
- Compatible with excel.
- Easy to use in the field while collecting data on livestock research.
- Unlimited users can access the database at one time, with real-time data entry and analysis.

Adding functions for commercial application would be the next step.

Chapter 6

Conclusion

6.1 Summary of the Thesis

Developing a new application based from the old software already present in the market to tailor-make the features for the researchers and help them maintain the detailed data regarding the cattle in their facility helps the researchers utilize time more efficiently in carrying out more of the experiments and analyzing the data than Data entry and storage. In the end the application developed is focused entirely on the ease of use for researchers so they should be comfortable with the visually-expansive design than the outgoing condensed design. This application helps researchers to keep track of all the changes and create reports and share it with fellows for better analyzing and experimenting. Having both the animal data as well as the health data in a single place researchers can keep track of the health of the animal while carrying on with the experiments. This also helps them to show all of the documentation very easily to the Health Inspector who is there for the verification of the well being of the animal.

In Chapter 1 we discuss about the impact of the software in the Farming

industry. We discuss what the motivation was for the project to start and how it is going to impact the researchers. Problem statement is defined and we later see into how we solve the issues faced by the researchers with the current software and method of maintaining the data.

In Chapter 2 we discuss about the alternate software available in the market to see if there already a software that is capable of handling all the requirements of the researchers. We have a table that helps us look and compare the features more accurately. Concluding is the features that were requested and how all the current software have some and not one software had all of them.

In Chapter 3, We have a brief description of the working of the software and explains all the components included in it. It shows us all the different technologies involved in making the software and how they are being used. Further into the software is explained along with screen-shots of each feature available in the software.

In Chapter 4 we have discussed about the features available in the software and how they will helping the researchers complete their tasks and how it will be much easier for the researchers to complete their tasks. Some of the features requested were not available in any other software on the market and had to be designed in house according to the specific requests from the researchers. In Short the researches will have individual access based on their clearance level and can add, edit or delete animal data. They can make ,edit or delete herds(groups of animals) and can edit their data together which will be useful to reduce the data entry by almost 50% since they don't have to go and do the exact same thing for all the animals.

In Chapter 5 we have the testimonials from the researchers about the software LiveBarn since they have been using it for quite a while for testing and

pointing out the mistakes or the edits they need.

6.2 Advantages and Disadvantages

Advantages

- Usable on any device connected to Internet.
- Reduces the waiting time.
- Reduces loss of data.
- Makes documentation easier.
- Instant calculations make the analyzing faster.
- Easier to generate reports.
- User-based Access control keeps the data in safe hands.
- Notice board displays the events going on in the facility.
- Keep track of animals and the Medicine Inventory in one place.
- Super-User can add, delete or modify other user roles.
- Ability to import data via csv Files allows scientists to import the old data easily.

Disadvantages

- Not available to use if there is no internet access.
- New users might need to go through a little bit of training to use the software.

6.3 Future Work

This application was designed with only one facility's point of view. So there is only one database available. For future purposes for the application to be marketable we need to develop more databases that will hold the data for other facilities in a different database which is disconnected from the current database so as to not confuse with the data interchange.

The SQL Database connection currently works on the SQL Query method, which might be open to SQL Injection causing an security issue. Using SQL-Alchemy in the future Update will resolve the issue. Doing that will change the communication method between the server and the client-side.

Server is based on the freely available domain, It should be refreshed every 3 months in order for the website to be functioning. We could port the website to a more permanent domain to avoid shutting down of the whole website.

Appendix A

Formulae

A.1 Adjusted 205 days Height and Weight

$$\begin{aligned} Adjusted\ 205\ day\ Height &= \frac{Height}{Weaning\ Date - DOB} * 205 \\ Adjusted\ 205\ day\ Weight &= \frac{Weight}{Weaning\ Date - DOB} * 205 \end{aligned} \tag{A.1}$$

After a calf is born in the facility, Height and Weight of a calf are kept track to see how healthy a calf is growing to be. Adjusted 205 days Height and weight are the automatically calculated fields for the scientists according to their initial Height and weight to compare the present Height and Weight of the animal (Calf) to assess the health condition of the animal.

A.2 Adjusted 365 days Height and Weight

$$\begin{aligned} Adjusted\ 365\ day\ Height &= \frac{Height}{Yearling\ Date - DOB} * 365 \\ Adjusted\ 365\ day\ Weight &= \frac{Weight}{Yearling\ Date - DOB} * 365 \end{aligned} \tag{A.2}$$

Similar to the Adjusted 205 days Height and Weight, Scientists also keep track of the calf until it is one year old (365 days) or in their terms yearling.

A.3 Frame score

Frame Score of an animal tells the scientists of the sizes of an animal and also regarding the health of an animal. It is calculated based on the hip height of the animal and then compared to the weight of the animal which tells the scientists if the animal is under-weight, overweight or just healthy. It is very important for the animal scientists to keep track of the health of the animal because they want animal to grow protein content and not fat content for more Beef quantity to be produced per animal.

Frame Score calculation is different for different animals depending on their sex and age.

Cows will have three formulae depending on their age. The software will automatically calculate the age of the animal and apply the appropriate formula accordingly. Whereas Sire will have just two formulae according to their age where they will be Bulls or Heifers.

A.3.1 Cows

Upto 12 months

$$FrameScore = [-11.7086 + (0.4723 * Height) - (0.0239 * 730) + [0.0000146 * (730 * 730)] + [0.0000759 * (Height * 730)]] - 0.4 \quad \text{(A.3)}$$

From 12 to 24 months

$$FrameScore = [-11.7086 + (0.4723 * Height) - (0.0239 * 730) + [0.0000146 * (730 * 730)] + [0.0000759 * (Height * 730)]] - 0.9 \quad (A.4)$$

Greater than 24 months

$$FrameScore = [-11.7086 + (0.4723 * Height) - (0.0239 * 730) + [0.0000146 * (730 * 730)] + [0.0000759 * (Height * 730)]] - 1.1 \quad (A.5)$$

A.3.2 Bulls

Ages between 5 and 21 months

$$\begin{aligned} Frame\ Score = & -11.548 + (0.4878 * Hip\ Height + 1) \\ & - (0.0289 * Days\ until\ Weaned) \\ & + [0.00001947 * (Days\ Until\ Weaned)^2] \\ & + [0.0000334 * ((Hip\ Height + 1) * Days\ Until\ Weaned)] \end{aligned} \quad (A.6)$$

A.3.3 Heifers

Ages greater than 21 months

$$\begin{aligned} Frame\ Score = & -11.548 + (0.4878 * Hip\ Height + 1) \\ & - (0.0289 * Days\ until\ Weaned) \\ & + [0.0000146 * (Days\ Until\ Weaned)^2] \\ & + [0.0000759 * ((Hip\ Height + 1) * Days\ Until\ Weaned)] \end{aligned} \quad (A.7)$$

All of the formulae above will be used in the experiment page, where the scientists will keep track of other important data as they are conducting experiments. The formulae which will automatically calculate the age of the animals and display the result will help scientists save time as they do not have to do the same calculation repeatedly for different animals.

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