A Report to Offer Engineering Solutions to Eliminate the Hunger Problem of Stray Dogs in Erdek Umut Street

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ABSTRACT

Stray dogs often suffer from starvation because they rely on humans for food. Having so little number of shelters around the world, gathering them in the shelters is not solution for their hunger. This study aims to propose three engineering solutions to establish a regular feeding system for stray dogs in pilot area, Erdek Umut Street. The root cause of the problem in pilot area is lack of coordination among residents which occurs because of lack of containers in the street, low population during winter, and isolation of residents. The offered solutions which are RFID Tag System, Bluetooth System, and Smart Feeding System are evaluated considering cost, sustainability, and practicality by using market research, survey, and expert opinion methodologies. Among the constructed optimal solutions, Smart Feeding System was selected as the most optimal since its high sustainability and practicality despite its cost. Others cannot be an optimal solution since RFID System was found to be cost-effective but lacks practicality whereas Bluetooth System was highly unsustainable. An action plan is recommended to build a fully operational Smart Feeding System, which includes ordering components, coding the circuit, collecting phone numbers of volunteers, integrating the circuit into the machines, and testing the system.

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1. INTRODUCTION

According to a study conducted in 2018, there are approximately 900 million dogs worldwide, of which 200 million (22%) are stray dogs, 520 million (58%) are free-range dogs, and 180 million (20%) are pets [1]. Free-range dogs can find their food in nature, and pets are fed by their owners. However, it is difficult for stray dogs to find food on their own due to urbanization, which is why they depend on humans for food [2]. Therefore, this study only focuses on the solutions to satisfy the nutritional needs of stray dogs.

The care of stray dogs, which outnumber pets, is undertaken by municipalities, shelters, and volunteers, which are a small part of society [3]. In America, which has the largest dog population in the world, 670 thousand dogs out of 70 million had to be euthanized in shelters in 2020 due to the lack of budget allocated for stray dogs and the lack of coordination between officials and volunteers [3]. On the other hand, the death of the dogs could have been prevented by establishing a system where they could be fed regularly on the streets without needing shelter, especially since eating a meal every 24 hours is enough for them to live a healthy life [4].

For this study, Turkey was chosen as the pilot country since the country has only 250 shelters for 10 million stray dogs that require volunteers to take responsibility for feeding dogs [5]. In Turkey, Balıkesir Erdek's Umut Street was chosen as the pilot area since the area has great fluctuations in its population due to its popularity in summer months which required the sharing of responsibility for stray dogs between municipalities, shelters, which will be referred to as officials in the remainder of the report, and volunteers.

This study aims to establish a regular feeding system for stray dogs in Erdek Umut Street to prevent stray dogs from starving to death by ensuring they are fed regularly to become an example of sharing the responsibility of feeding stray dogs between officials and volunteers to prevent the death of dogs whose basic needs cannot be met.

2. PROBLEM DEFINITION

In Erdek the population is approximately 32 thousand in the winter months, increasing approximately ten times in the summer months but number of stray dogs does not change according to the seasons [6] [7]. This situation causes stray dogs to starve, especially in winter. In Umut Street, which consists primarily of summer houses, ten dogs live in two groups every season (see Appendix A). They suffer from hunger, especially in winter, since there is no regular feeding system. The problem can be investigated considering the following parameters:

- "Who" – Volunteers and officials are involved in the problem that influences Stray Dogs.
- "What" – The stray dogs in Erdek Umut Street cannot be fed regularly.
- "When" – Especially in winter; however, the problem still exists in other seasons.
- "Where" – At Erdek Umut Street.
- "Why" – Lack of coordination among the people.
- "How" – Stray dogs starve because they are not adequately fed.

The root cause, the lack of coordination among the people, occurs for three reasons:

(1) The lack of containers of food and water for the stray dogs in the street prevents people from knowing whether the animals are hungry or not by the fullness of these containers.

(2) People are more isolated from each other than usual since Umut Street is a summerhouse street, which makes it difficult to know if the dogs were fed.

(3) Very few people remain in the street during winter.

3. PROPOSED SOLUTIONS

The proposed technical solutions to eliminate the problem are:

(1) Cloud-based RFID tag system tracks stray dogs' feeding times.

(2) Bluetooth-integrated LED system to track the feeding times of stray dogs.

(3) A smart feeding machine.

3.1. Cloud-based RFID Tag System

Radio Frequency Identification Technology (RFID) is a communication technology that uses radio waves to transmit data [8]. RFID systems consist of RFID tags and RFID readers [8]. RFID tags have an integrated chip that stores the information and an antenna for receiving and transmitting signals [8]. The solution uses a passive high-frequency RFID tag. The passive RFID tag has the disadvantage of low-range communication but the advantage of not requiring a power source [8]. It uses the energy of the radio waves that the reader device sends and transmits the data stored inside using this energy [8]. High-frequency RFID tag, i.e Near Field Communication (NFC) Tag, is chosen since most mobile phones can communicate with NFC Tags.

This solution uses an RFID tag (see Appendix B), a mobile phone with built-in RFID reader ability, a mobile app, and a cloud system. The solution prerequires the registration of the stray dogs since their ear tags (see Appendix C) are used. In this solution, the RFID tags are inserted into the dogs' ear tags and store the information of the last fed time. All dogs in the street, volunteers, and officials are registered to the mobile app. The information of the last fed

time of all dogs are stored in the cloud system, and if any dog's last feeding time is passed 24 hours, all users are notified. When a user feeds the dog, the user uses his mobile phone to change the data on the RFID tag to the current time, and the data on the cloud system are changed synchronously (See Appendices D-E for detailed flow diagram, mobile app interface, and app notifications). The officials will insert an RFID tag, and the mobile app developer will develop a mobile app. Similar products exist for storing contact information in case a pet is lost [9].

3.2. Bluetooth-integrated LED System

Bluetooth is a communication system that operates on 2.4 GHz radio frequencies [10]. While NFC tags can be read from a few centimeters, Bluetooth devices can be communicated about 30 meters with the disadvantage of requiring an energy source, unlike RFID tags [10].

This solution uses a simple circuit consisting of the NRF52832 low-energy Bluetooth module (see Appendix F) and LEDs.The solution prerequires the registration of the stray dogs since their ear tags (see Appendix C) are used. This solution inserts the circuit above the dogs' ear tags. When the feeder connects the Bluetooth module with her phone, the timer in the circuit is reset. When the timer is below 24 hours, the LED becomes green; otherwise, the LED becomes red (see Appendix G for a detailed flow diagram). This way, people can see the dogs' last fed time around them. Similar products exist in terms of when the Bluetooth connection is established, a device does some predetermined action. For example, Apple Airtag, which has the same Bluetooth module inside, plays a sound when the Bluetooth connection is established [11]. A hardware developer will construct this circuit and officials will place it into the dogs' ear tags.

3.3. The Smart Feeding Machine

Currently, some places other than the pilot area have feeding systems for stray animals that are required to manually check the stock of food and water by volunteers and officials [12]. This solution proposes the development of the current feeding systems by using Global Positioning System (GPS) technology. The GPS devices work by calculating the distance of itself from at least four different satellites [13]. Then GPS device detects its position on the Earth [13]. This solution uses a simple circuit consisting of the ultrasonic transducer, a microcontroller, a GPS module, a feeding system with food and water containers, and a notification system to see the activated machines. The ultrasonic transducers are inserted into containers and measure the time it takes to receive back the ultrasonic waves it sends. If the time is above some threshold value, the microcontroller activates the GPS module, and notification is sent to the users (See

Appendix H for a detailed flow diagram). Two of these machines will be placed on Umut Street, and the volunteers and officials will be registered to this notification system. GPS technology is used for similar purposes, such as tracking pet positions [14].

4. CRITERIA FOR ASSESSING SOLUTIONS

The solutions are assessed in terms of cost, practicality, and sustainability.

4.1. Cost

The solution cost is important since the municipalities often don't allocate much money to care for stray dogs [3]. The cost of each solution per dog is evaluated by the following steps:

4.1.1 Cloud-based RFID Tag System

- The one-time cost of developing the app, purchase and shipment of the RFID tags and their installment on the dogs.
- The yearly cost of the cloud system, and municipality employee (based on hourly work).
  are calculated.

4.1.2 Bluetooth-integrated LED System

- The one-time cost of purchase and shipment of the components, implementation and coding of the circuit, and replacement of dogs' ear tags with circuit-installed new bigger tags
- The yearly cost of the municipality employee (based on hourly work)
  are calculated.

4.1.3 The Smart Feeding Machine

- The one-time cost of purchase and shipment of the components, implementation and coding of the circuit, and purchase and shipment of the feeding machines
- The yearly cost of the municipality employee (based on hourly work)
  are calculated.

4.2. Practicality

The solutions are evaluated in terms of the practicality of their usage:

- Cloud-based RFID Tag System: The practicality of communicating with the NFC tag and mobile app usage are checked.
- Bluetooth-integrated LED System: The practicality of communicating with Bluetooth and seeing the LED are checked.
- The Smart Feeding Machine: The practicality of placing food into one place and tracking the stock through the notification system are checked.

4.3. Sustainability

The solutions are evaluated in terms of usage time. Sustainability in harsh conditions such as rain, strokes from other dogs, and extreme temperatures are checked.

5. PROPOSED RESEARCH METHODOLOGY

Proposed criteria is assessed using market research, expert opinion, and survey.

5.1. Market Research

Market research is conducted in hardware manufacturer sites for determining the costs of the circuits the solutions needs and in freelancer sites for implementing that circuits and necessary mobile app first solution needs. Also, other sites such as server and feeding machine manufacturer websites are used for determining the cost of remainings for each solution.

5.2. Expert Opinion

Hardware vendors and verified experts on the internet were consulted to construct the real optimal implementation of the solutions. Hardware vendors were also consulted to understand technical capabilities of hardware to assess the sustainability of each solution. Mobile app developers on the internet were consulted for the implementation details of the necessary app the first solution needs.

5.3. Survey

Surveys are conducted with officials and residents to compare solutions' practicality regarding easiness, automation, contact with dogs, necessary equipments and usage likeliness.

6. RESULT AND ANALYSIS

6.1 Optimal Implementations

Optimal implementation of the solutions are constructed by using research methodologies to be fair while comparing them by the proposed criteria.

6.1.1 Implementation Details of the RFID Tag System

RFGATE RFWL-D28 NFC Tag will be used for the RFID Tag as it is one of the most sustainable and cheap RFID Tag in the market [15].

Current dogs' ear tags are big enough for the system; hence, no need for replacement.

Two separate apps are needed for the mobile application of the system [16]. Android app will be written in Java using NFC Library and IOS app will be written in Swift using NFC Core Library [16] [17] [18]. Firebase Realtime Database will be used as a free cloud system [16].

6.1.2 Implementation Details of the Bluetooth System

For implementation of the circuit, NRF52832-QFAA microcontroller will be used with integrated NRF52832 Bluetooth module and timer. The circuit containing the microcontroller also will have micro-usb for programming the circuit via nRF Connect extension of VS Code IDE and 2 LED for green and red lights (See Appendix I for schematic and PCB Design of the system which are constructed by consulting expert from Nordic Semiconductor Company) [19].

The Watchdog Timer of the microcontroller will be used for controlling the LEDs of the circuit [20]. It is a down counter which uses the value of the CRV register as a starting value when START event is triggered and when the counter reaches zero, it triggers the TIMEOUT event [20]. The circuit will be programmed to trigger the START event when the bluetooth connection is made and turn on the green LED. Also, the circuit will handle the TIMEOUT event by turning off the green LED and turning on the red LED.

The size of the circuit is approximately 40 mm x 40 mm which is not small enough to fit into the current ear tags of the dogs [21]. Therefore, the tags will be replaced by the bigger tags that is used for cows [22].

6.1.3 Implementation Details of the Smart Feeding System

For implementation of the circuit, arduino with GPS and GSM modules, Solar Power Manager and its panel, and two ultrasonic sensors are needed (See Appendix J).

The circuit will use solar power to operate and use SMS technology to notify the officials and volunteers. GSM along with GPS do not require additional internet connection [23]. Therefore, the circuit do not require any outside dependency except the batteries need replacement after seven subsequent rainy day that solar energy cannot be used [24]. The system will send an SMS when the water or meal containers have low supply to the users that their numbers is hardcoded in arduino.

Lastly, feeding machines will be ordered from pugedon company [25].

6.2 Analysis

The offered solutions were evaluated based on cost, sustainability, and practicality using literature review, market research, and expert opinion as the research methodologies. Consulting to the municipality employee, cost was given the lowest weight with 15% and sustainability was assigned twice the weight of cost (30%), while practicality was considered the most important

factor, receiving the remaining percentage of the weights (55%) [26]. Each criterion were assessed using a point-based system (See Appendix K for pie chart of assigned weights).

6.2.1 Cost Analysis

Cost is the least important criteria with weight 0.15. Erdek Municipality has an 80 Million TL Budget; therefore, money is not much important but at most $3000 can be allocated for each street if maintenance cost of the system is low [26]. There is already 2 personnel for feeding stray animals in the streets that have food containers but these personnel need to check the containers in case they are empty [26]. They spend appr. 30 minutes per street; therefore variation in the workload were taken into consideration while cost analysis [27].

The cost criteria ratings for one-year expenses is constructed where 5 is the maximum rating. The system takes into account the opinions of the municipality and assigns points based on the cost of the solution. Solutions with a cost ranging from $0 to $250 receive 5 points, $250 to $500 receive 4 points, $500 to $1000 receive 3 points, $1000 to $2000 receive 2 points, $2000 to $3000 receive 1 point (See Appendix L for the cost chart). Note that otherwise stated, cost are assumed to be one-time cost. Also one-year additional costs assumes no inflation over a year.

6.2.1.1 RFID Tag System Cost Analysis

For the RFID Tag System, 10 tag cost $7.7 with no replacement over the year since the data can be overriden 10.000 times [15][28]. Firebase hosting costs $0 [29]. IOS app costs $210 and Android app costs $104 [30] [31]. Assuming 1 hour of work per day, additional cost of the municipality personnel over a year is $290 [26]. The system takes 3 points since the total cost of the system is $611.7 (See Appendix M for the table of the cost analysis of RFID Tag System).

6.2.1.2 Bluetooth System Cost Analysis

For the Bluetooth System, the production of ten circuit cost $170.74 [21]. Coding of the circuit costs $105 [32]. Assuming 1 hour of work per day, additional cost of the municipality personnel over a year is $290 [26]. For the previously mentioned replacement of the dogs' ear tags cost $8 for personnel and $2 for purchasing the new ear tags [22] [26]. The system takes 3 points since the total cost of the system is $575.74 (See Appendix N for detailed cost analysis).

6.2.1.3 Smart Feeding System Cost Analysis

For the Smart Feeding System, the production of two circuit for one machine each cost $162.80. Coding of the circuit costs $157 [33]. Assuming 15 minutes of work per day, additional cost of the municipality personnel over a year is -$145 [26]. There is 1 subsequent 7 not sunny

days in Erdek in a year; therefore, batteries need replacements for one time which cost $8 * 2 = $16 [34] [35]. 2 machine costs $1000 * 2 = $2000 and $10 for their shipment [36]. The total cost of the system is $2290.8, the system takes 1 points (See Appendix O for detailed cost analysis).

6.2.2 Sustainability Analysis

Sustainability is the second important criteria with weight 0.30. The solutions must be durable since they cannot change easily. The following each 3 points worth five questions are used for assessing the sustainability:

- Is the solution waterproof?
- Can the solution work in extreme temperatures?
- Does the solution needs replacements?
- Is the solution durable to physical contact?
- Can this solution be used for a long time?

Questions are answered using data sheets from hardware vendors and there is 4 possible answer for each question (No, Major Drawback, Minor Drawback, Yes). Following sections will answer the questions in the order of appearance above.

6.2.2.1 RFID Tag System Sustainability Analysis

- RFID Tags are waterproof, but the antenna cannot work in wet conditions (2 pts) [37].
- The system can work between -20°C to 70°C (3 pts) [15].
- The system can work without replacement for 10 years. (3 pts) [28].
- The existing RFID tags in the dogs' ears do not have problem from physical contact. The system will most likely be durable to physical contact (3 pts).
- The solution can be used for 10 years (3 pts) [28].
  Therefore, RFID Tag System gets a total of 14 points out of 15 from the sustainability.

6.2.2.2 Bluetooth System Sustainability Analysis

- The circuit of the Bluetooth System is not waterproof (0 pts) [20].
- The circuit can work between -40°C to 125°C (3 pts) [20].
- Its batteries needs replacement every year that means extra work for officials (2 pts) [38].
- The weight of the circuit is 342.51 gr, and its dimensions are 4 x 4 cm [21]. Therefore, it is highly probable that the circuit can be damaged (1 pts).
- Because of the above reasons, dogs will probably tear the circuit (1 pts) [26].
  Therefore, Bluetooth System gets a total of 7 points out of 15 from the sustainability.

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6.2.2.3 Smart Feeding System Sustainability Analysis

- The smart feeding machine protects the circuit from the water (3 pts).

- The machine protects the circuit from extreme temperatures (3 pts).

- Its batteries can only tolerate 7 subsequent rainy day in a year (2 pts) [39].

- The machine protects the circuit from physical contact (3 pts).

- The circuit can work for decades (3 pts) [40].

    Therefore, Smart Feeding System gets a total of 14 points out of 15 from the sustainability.

6.2.3 Practicality Analysis

    Practicality is the most important criteria with weight 0.55. The solutions must be practical so that feeding of the dogs should be systematic and easy. The following each 3 points worth five questions are used for assessing the practicality:

- Is the solution easy to use?

- Is the solution automated the process?

- Does the solution not need contact with the dogs?

- Does volunteers and municipality personnel have the necessary technical equipment?

- One the long run, how likely will the solution be used?

    The questions were prepared by conducting a survey with street residents (only 20% of them) and talking to municipality personnel (See Appendix P for survey questions). Questions were answered by additional short questions where needed and data sheet from the experts. For each question, there is 4 possible answer (No, Major drawback or at least 30% state it is a problem, Minor drawback or at most 30% state it is a problem, Yes). Following sections will answer the questions in the order of appearance of the questions.

6.2.3.1 RFID Tag System Practicality Analysis

- 40% do not find the solution easy to use (1 pts).

- The solution do not automate the process since there is manual reading of tags (1 pts).

- The tags can be read within 30 cm (1 pts) [15].

- Not all users satisfy the required technical equipments since 10% either have not a smartphone or use IOS < 14.0 (IOS app is only work for IOS >= 14.0) (2 pts).

- 60% most likely not use the system as it is tedious to read the tags (1 pts).

    Therefore, RFID Tag System gets a total of 6 points out of 15 from the practicality.

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6.2.3.2 Bluetooth System Practicality Analysis

- 20% do not find the solution easy to use (2 pts).
- The solution do not automate the process since there is manual process to connect Bluetooth (1 pts).
- The bluetooth can be connected within 30 m (2 pts) [10].
- Municipality personnel can't know the status of the LEDs from a distance (2 pts).
- The circuit is too heavy and 50% not capable to see Leds from a distance (1 pts).

  Therefore, Bluetooth System gets a total of 8 points out of 15 from the practicality.

6.2.3.3 Smart Feeding System Practicality Analysis

- 90% find the solution easy to use (3 pts).
- The solution automate the process by automatic detection and notification system (1 pts).
- Volunteers do not need contact with the dogs as they put supplies into the feeding machines (3 pts).
- 100% have a phone with SMS capability (3 pts).
- 100% most likely use the system (3 pts).

  Therefore, Smart Feeding System gets a total of 15 points out of 15 from the practicality.

7. CONCLUSION AND RECOMMENDATIONS

Based on the points, the most optimal solution is Smart Feeding System (See Appendix Q for the calculation). The optimal solution has the advantages of having well-tested working examples, high automation of the process and long sustainability along with the disadvantage of high cost. Although the RFID Tag System proved to be the most cost effective of the alternatives, it suffers from high impracticality, whereas Bluetooth System lacks sustainability.

The six-week action plan is recommended to ensure the system is installed and fully operational. The following course of actions will be followed in this six week (For weekly actions, see Gantt chart of the action plan in Appendix R):

1. Circuit components will be ordered.
2. Machines will be ordered from Pugedon Company.
3. Coding and testing of the circuits will be done.
4. Municipality will contact the street residents to save their phone numbers into the system.
5. Circuits will be integrated into the feeding machines.
6. 1-week test with the Street residents will be conducted.

8. APPENDICES

APPENDIX A

Figure 1: Living Positions of the Two Groups of the Stray Dogs

APPENDIX B

Figure 2: RFID Tag Small Enough to Fit in the Dog's Ear Tag [41]

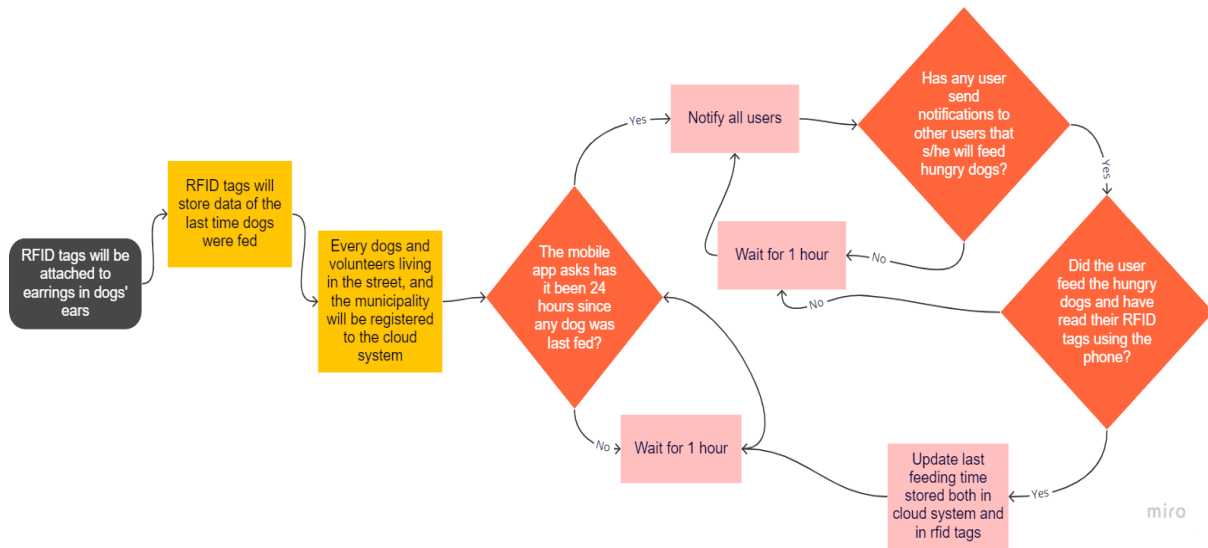### APPENDIX C

Figure 3: The Dog's Ear Tag [42]

APPENDIX D

Figure 4: The Flow Diagram of RFID Tag System

APPENDIX E
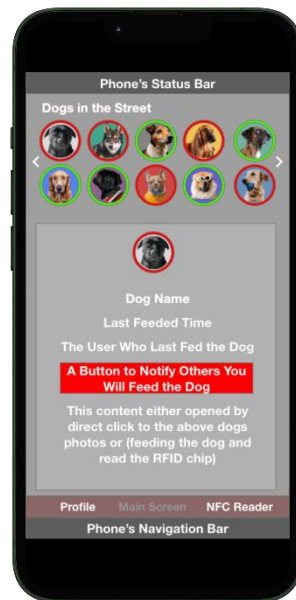
Figure 5:The Mobile App Interface of RFID Tag System [43]

Figure 6: App Notification 1

{Username} will feed {Dog name} soon.

Figure 7: App Notification 2

{Dog name} was fed by {username}.

Figure 8: App Notification 3

APPENDIX F

15.8mm

12mm
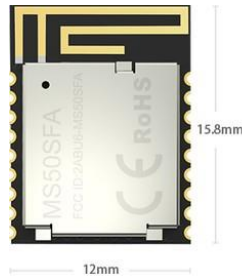
Figure 9: The NRF52832 Bluetooth Module [44]

APPENDIX G
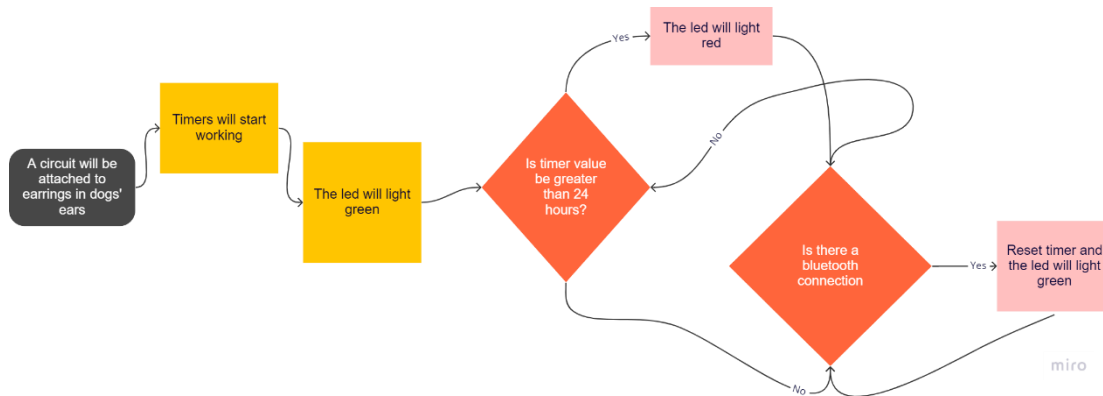
Figure 10: The Flow Diagram of Bluetooth-integrated LED System

APPENDIX H
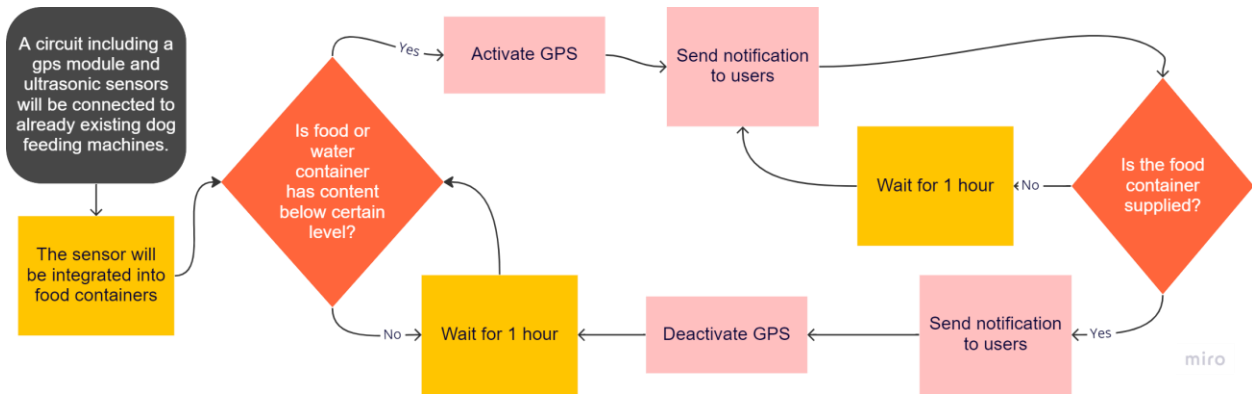
Figure 11: The Flow Diagram of the Smart Feeding System

APPENDIX I

Figure 12: Schematic of the Bluetooth System

Figure 13: PCB Design of the Bluetooth System

APPENDIX J

Figure 14: Arduino Uno [45]

Figure 15: GSM Module [46]

Figure 16: GPS Module [46]

Figure 17: Solar Power Manager [47]

Figure 18: Solar Panel [47]

Figure 19: Ultrasonic Sensor [48]

Figure 20: Assigned Weights of the Criteria

Figure 21: Cost Criteria Ratings for 1 Year Expenses

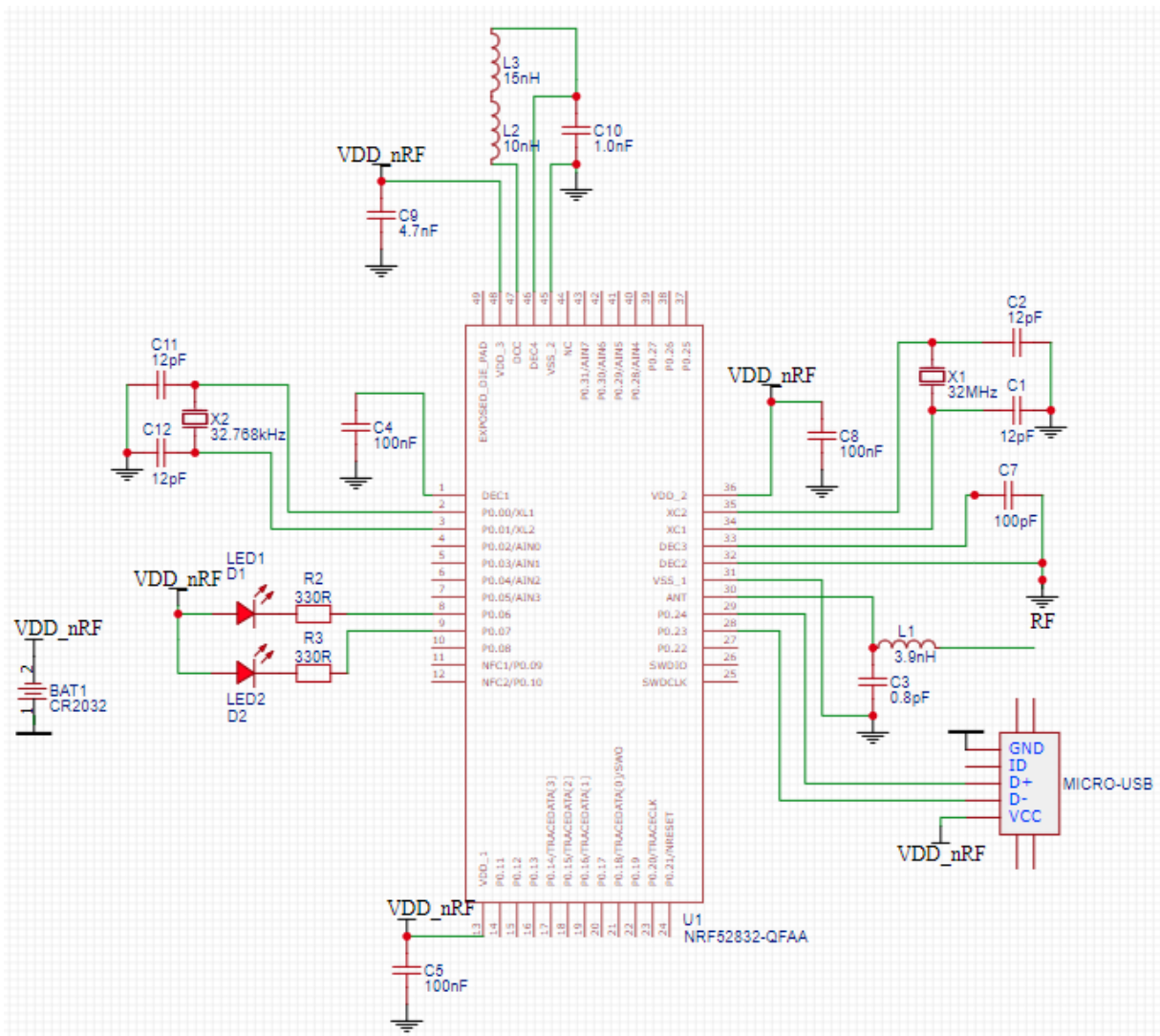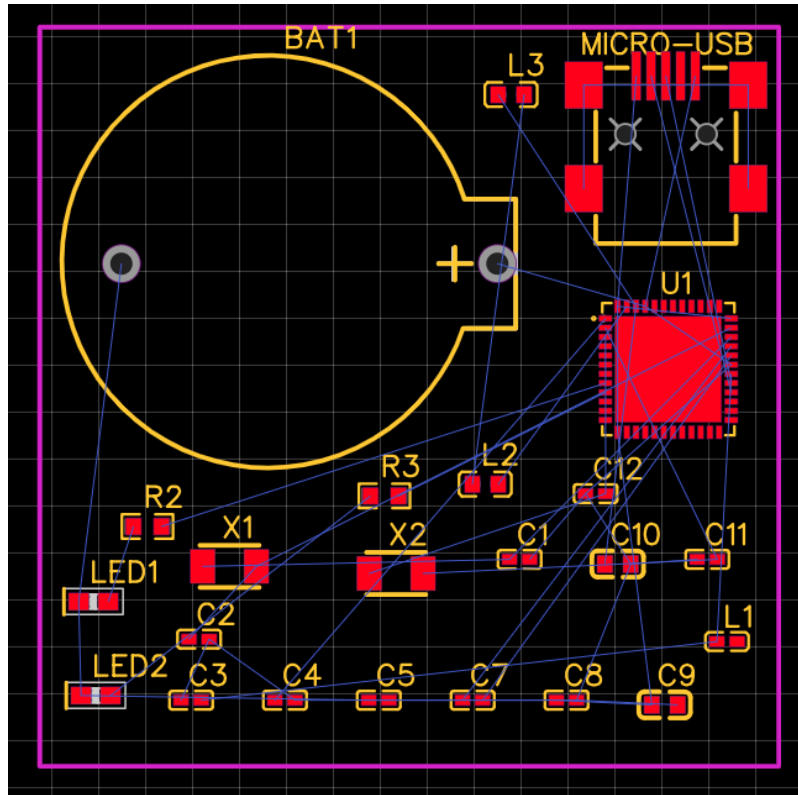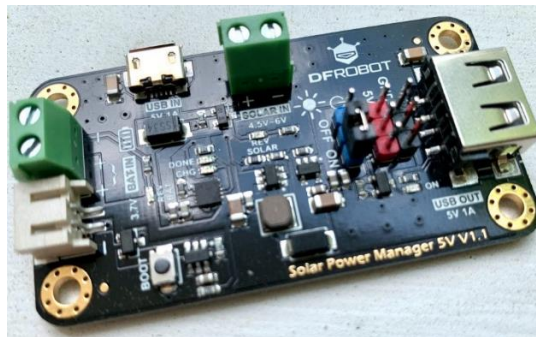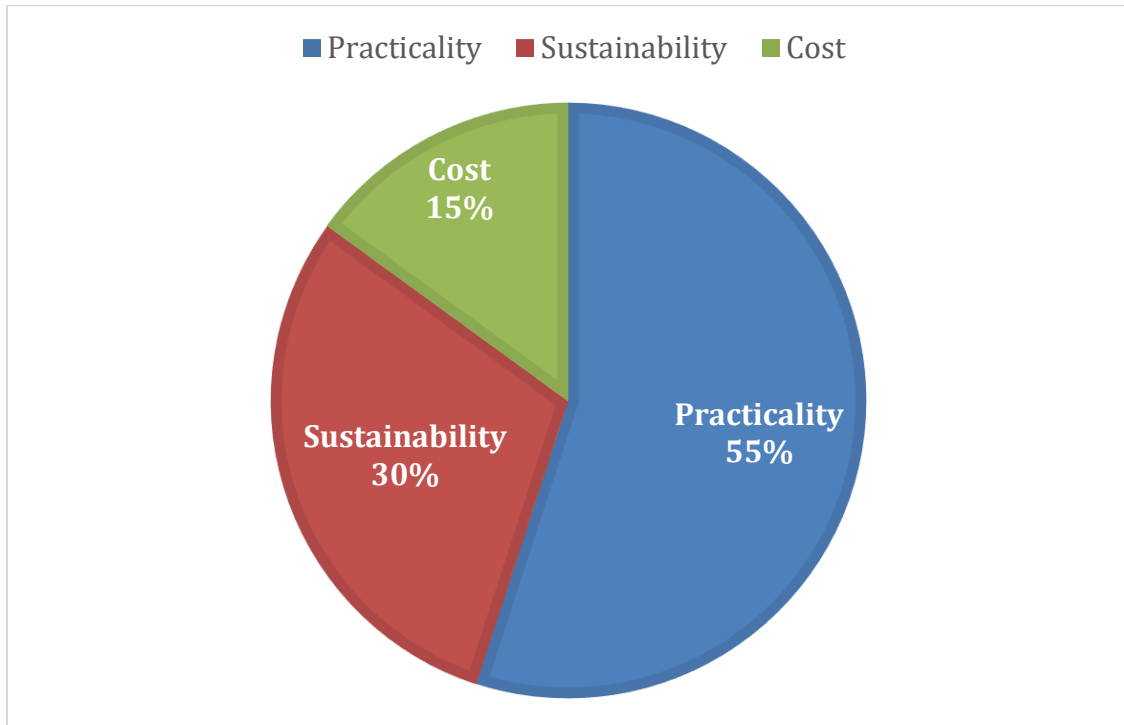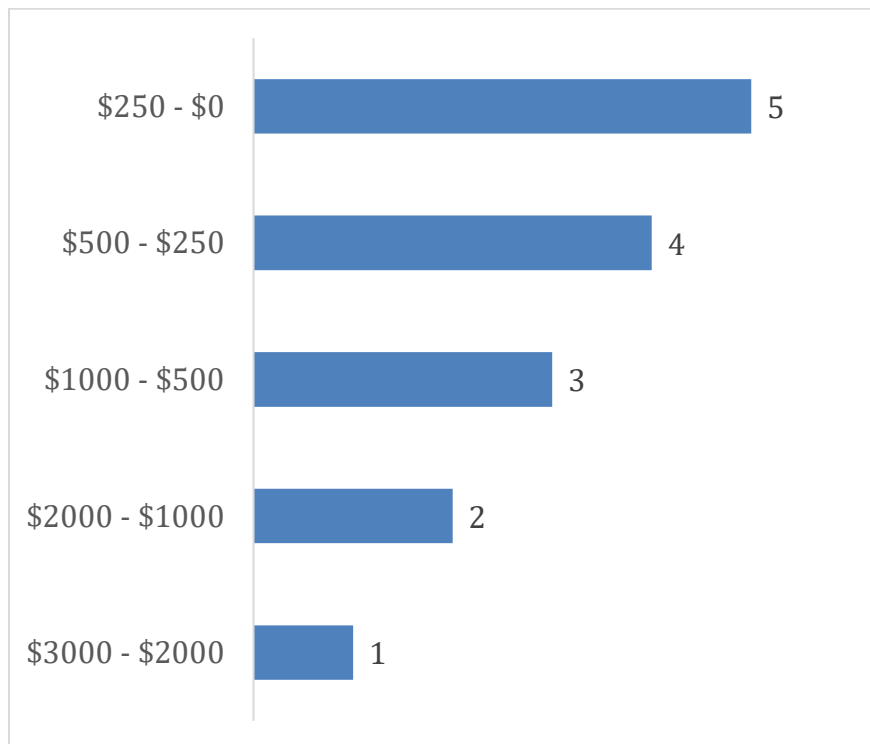| Expenses	One-Time Cost	1 Year Add. Cost (No Inflation)	Total Cost	Comments
RFGATE RFWL-D28 NFC Tag (Free Shipping)	$0.77 [15]	-	$0.77 * 10 = $7.7	Data can be overriden 10.000 times [28].
Firebase Hosting	-	-	$0	Free up to 10 GB storage [29].
IOS App Dev.	$210 [30]	-	$210	
Android App Dev.	$104 [31]	-	$104	
Expected Cost of Municipality Personnel (hourly work)	-	$290 [26]	$290	Calculated assuming 1 hour of work per day.

Table 1: Cost Analysis of RFID Tag System

ID	Name	Designator	Footprint	Quantity	Manufacturer Part	Manufacturer	Supplier	Supplier Part
1	CR2032	BAT1	BAT-TH_CR2032-2-1	1	CR2032-2-1		LCSC	C9900018737
2	12pF	C1,C2,C11,C12	C0402	4				
3	0.8pF	C3	C0402	1				
4	100nF	C4,C5,C8	C0402	3				
5	100pF	C7	C0402	1				
6	4.7nF	C9	C0603	1				
7	1.0nF	C10	C0603	1				
8	3.9nH	L1	L0402	1				
9	10nH	L2	L0603	1				
10	15nH	L3	L0603	1				
11	D1	LED1	DIOC0603_N	1	19-217/R6C-AL1M2VY/3T	EVERLIGHT(台湾亿光)	LCSC	C72044
12	D2	LED2	DIOC0603_N	1	19-217/R6C-AL1M2VY/3T	EVERLIGHT(台湾亿光)	LCSC	C72044
13	u-m-m5ss-	MICRO-USB	MICRO-USB-SMD_MICRO-USB-13	1	u-m-m5ss-w-2	HRO	LCSC	C91144
14	330R	R2,R3	R0603	2				
15	NRF52832	U1	QFN-48_L7.0-W7.0-P0.50-TL-EP5.7	1				
16	32MHz	X1	CRYSTAL-SMD_L3.2-W1.5	1	XTAL-3215		LCSC	C9900008713
17	32.768kHz	X2	CRYSTAL-SMD_L3.2-W1.5	1	XTAL-3215		LCSC	C9900008713

Table 2: BOM (Bill of Materials) File of the Bluetooth Integrated Circuit

PCB Price
- Confirm Production file $0.50
- Production $5

SMT Price
- Setup fee $25.00
- Stencil $7.86
- Components $37.69
- Feeders Loading fee $18.90
- SMT Assembly $1.83
- Confirm Parts Placement $0.43
- Hand-soldering labor fee $3.50
- Manual Assembly $0.47
- Packaging fee $0.47
- Shipping $69.09

Total $170.74

Figure 22: One Time Cost of Ten Circuit [21]

Cost of Coding NRF52:
- $105 (One Time) [32]

Expected Cost of Municipality Personnel
(hourly work):
- $8 (One Time) [26]
- $290 (1 Year) [26]

Cost of New Ear Tags:
- $2 (One Time) [22]

(Assuming the circuit will not break.)

Total $405

Figure 23: Other Costs

Ardunio Price:
- $25 * 2 = $50 (One Time) [45]

Ultrasonic Distance Sensor:
- $4.50 * 4 = $18 (One Time) [48]

Sim Module:
- $11 * 2 = $22 (One Time) [46]

Solar Power Manager with Panel:
- $25.40 * 2 = $50.80 (One Time) [47]

Gps Module:
- $6 * 2 = $12 (One Time) [46]

Additional Components (Wires Breadboard etc.)
- $10 [49]

Total $162.80

Figure 24: One Time Cost of 2 Circuit

Cost of Coding Ardunio:
- $157 (One Time) [33]

Expected Cost of Municipality Personnel (hourly work):
- -$145 (1 Year) [26]

Replaced Battery Cost:
- $8 * 1 * 2 = $16 (1 Year) [34] [35]

Machine Cost:
- $1000 * 2 = $2000 (One Time) [36]

Expected shipment cost:
- $10

Total $2038

Figure 25: Other Costs

Questions	Yes	No
Are you comfortable in close contact with the dogs while feeding?		
Do you have a smartphone or iPhone with IOS > 14.0 ?		
Do you have a phone with SMS functionality?		
Are you comfortable with allocating 5 minutes of time after every feeding?		
Can you see a led with appr. 1cm diameter from 10m distance?		
Do you prefer feeding dogs by using a central or local container?		
Is a system to see the feeding status of the dogs usable?		

Table 3: Practicality Problem Analysis Survey with Residents and Municipality Personnel

APPENDIX Q

CRITERIA				
Solution	**Cost**	**Sustainability**	**Practicality**	**Total**
RFID Tag System	3/5 * 0.15	14/15 * 0.3	6/15 * 0.55	0.59
Bluetooth System	3/5 * 0.15	7/15 * 0.3	8/15 * 0.55	0.52
Smart Feeding System	1/5 * 0.15	14/15 * 0.3	15/15 * 0.55	0.86

Table 4: Evaluation of the Results

1. Circuit components will be ordered.

2. Machines will be ordered from Pugedon Company.

3. Coding and testing of the circuits will be done.

4. Municipality will contact the street residents to save their phone numbers into the system.

5. Circuits will be integrated into the feeding machines.

6. 1-week test with the Street residents will be conducted.

Figure 26: Actions to be taken for implementing Smart Feeding Machine

	w1	w2	w3	w4	w5	w6
1	███					
2	███	███	███	███		
3		███				
4			███			
5					███	
6						███

Figure 27: Gantt Chart of the Action Plan

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