BACHELOR THESIS & COLLOQUIUM – ME234804

DESIGNING OF MULTI-COLORED LED LAMP FOR ATTRACTING AND COLLECTING FISH AT FLOATING BAGAN IN LEBAK REGENCY

RIZAL ABDURRAZAQ
NRP. 5019201113

SUPERVISORS:
Dr. Eddy Setyo Koenhardono, S.T., M.Sc.
NIP. 196807011995121001

Juniarko Prananda, S.T., M.T.
NIP. 199006052015041001

DEPARTMENT OF MARINE ENGINEERING
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DOUBLE DEGREE PROGRAM
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APPROVAL SHEET

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BACHELOR THESIS

Submitted to fulfil one of the requirements
For obtaining a bachelor's degree in engineering at
Undergraduate Study Program of Marine Engineering
Department of Marine Engineering
Faculty of Marine Technology
Institut Teknologi Sepuluh Nopember

By: **Rizal Abdurrazaq**
NRP. 5019201113

Approved by Head of Marine Engineering Department:

Signature ....

Head of Department : Beny Cahyono, S.T, M.T., Ph.D
NIP./NPP. : 197903192008011008
Date : July 2024

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NRP. 5019201113

Approved by Final Examiner Team:

1.	Dr. Eddy Setyo Koenhardono, S.T., M.Sc.	Supervisor	(1/8/24)
2.	Juniarko Prananda, S.T., M.T.	Co-Supervisor	( )
3.	Dr. Eng. Adi Kurniawan, S.T., M.T.	Examiner	(1-8-'24)
4.	Prof. Ir. Sardono Sarwito, M.Sc.	Examiner	( )
5.	Ir. Agoes Ahmad Masroeri, M. Eng, D. Eng	Examiner	( )

SURABAYA

July 2024

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STATEMENT OF ORIGINALITY

The undersign below:

Name of student/NRP	: Rizal Abdurrazaq/5019201113
Department	: Marine Engineering
Supervisor I	: Dr. Eddy Setyo Koenhardono, S.T., M.Sc.
Supervisor II	: Juniarko Prananda, S.T., M.T.

Hereby declare that the Final Project with the title of "DESIGNING OF MULTI-COLORED LED LAMP FOR ATTRACTING AND COLLECTING FISH AT FLOATING BAGAN IN LEBAK REGENCY" is the result of my own work, is original, and is written by the following the rules of scientific writing.

If in the future there is a discrepancy with this statement, then I am willing to accept sanctions in accordance with the provisions that apply at Institut Teknologi Sepuluh Nopember.

Surabaya,

Student,

Rizal Abdurrazaq
NRP. 5019201113

Acknowledge Supervisor 1	Acknowledge Supervisor 2
1/8/24	
Dr. Eddy Setyo Koenhardono, S.T., M.Sc. NIP. 196807011995121001	Juniarko Prananda, S.T., M.T. NIP. 199006052015041001

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ABSTRACT

DESIGNING OF MULTI-COLORED LED LAMP FOR ATTRACTING AND COLLECTING FISH AT FLOATING BAGAN IN LEBAK REGENCY

Student Name / NRP	**:**	**Rizal Abdurrazaq / 5019201113**
Department	**:**	**Marine Engineering FTK - ITS**
Advisor	**:**	**Dr. Eddy Setyo Koenhardono, ST, M.Sc.** **Juniarko Prananda, S.T., M.T.**

Abstract

This research is motivated by the state of fish production in Lebak Regency, which can still be increased beyond current production, considering the large water area in Lebak Regency. To maximize fish production in the Lebak Regency, this research will create multi-colored light-emitting diode (LED) lamps. The objectives of this research are to (1) obtain a design for multi-colored LED submersible lights to attract and collect fish catches in fisheries production in Lebak Regency, (2) determine the performance of multi-colored LED lamps to attract and collect fish catches in fisheries production, and (3) determine the factors that influence the success of using multi-colored submersible LED lamps for calling and collecting fish among Bagan fishermen. To guarantee success, this research will be carried out using an experimental method with stages: literature study, observation, designing multi-colored LED lamps, manufacturing, testing, and data processing, as well as conclusions and suggestions. The multi-colored LED lamp design has the following characteristics: (a) Arduino Uno is used as a microcontroller in the multi-colored LED design, (b) the target lumens for the multi-colored LED is 6000, (c) the number of LED lamps required is 499, (d) the total power required of 90 watts, (e) the battery capacity required is 120 Ah. On the other hand, the calculated cost of making multi-colored LEDs is IDR. 1,057,400, and the monthly operational costs are Rp. Rp. 46,808.28. The performance of multi-colored LED lamps shows that the fish caught using multi-colored LED lamps is better than the fish caught using white LED lamps, judging from the type of fish and the weight of the fish caught. In addition, Bagan fishermen responded positively to using multi-colored LED lamps in fishing. Thus, the results of this research are expected to be useful for increasing fish catches among Bagan fishermen in Lebak Regency by using multi-colored LED submersible lamp.

Keywords: Multi-colored LED lamp, attracting fish, collecting fish, step chart, Arduino Uno.

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ABSTRAK

PERANCANGAN LAMPU LED MULTI WARNA UNTUK MEMANGGIL DAN MENGUMPULKAN IKAN PADA BAGAN APUNG DI KABUPATEN LEBAK

Nama Mahasiswa / NRP	**:**	**Rizal Abdurrazaq / 5019201113**
Departemen	**:**	**Marine Engineering FTK - ITS**
Dosen Pembimbing	**:**	**Dr. Eddy Setyo Koenhardono, S.T., M.Sc.**
		Juniarko Prananda, S.T., M.T.

Abstrak

Penelitian ini dilatarbelakangi oleh keadaan produksi ikan di Kabupaten Lebak yang masih dapat ditingkatkan melebihi produksi saat ini, mengingat luas wilayah perairan di kabupaten Lebak yang cukup luas. Untuk memaksimalkan produksi ikan di kabupaten Lebak, penelitian ini membuat lampu *light emitting diode* (LED) multiwarna yang dapat dicelupkan ke dalam laut. Tujuan dari penelitian ini adalah untuk: (1) mendapatkan desain lampu *submersible* LED multiwarna untuk menarik dan mengumpulkan hasil tangkapan ikan, (2) mengetahui kinerja lampu LED multiwarna untuk menarik dan mengumpulkan hasil tangkapan ikan, dan (3) mengetahui respon nelayan bagan terhadap penggunaan lampu LED multiwarna. Untuk menjamin keberhasilan, penelitian ini dilakukan dengan metode eksperimen dengan tahapan: studi literatur, observasi, perancangan lampu LED multiwarna, pembuatan, pengujian, dan pengolahan data, serta penarikan kesimpulan dan saran. Disain lampu LED multiwarna memiliki karkateristik: (a) Arduino Uno digunakan sebagai mikrokontroller dalam design lampu LED multiwarna, (b) target lumens LED multiwarna adalah sebesar 6000, (c) jumlah lampu LED yang dibutuhkan adalah 499 buah, (d) total daya yang dibutuhkan sebesar 90 watt, dan (e) kapasitas baterai yang dibutuhkan sebesar 120 Ah. Di sisi lain, perhitungan biaya pembuatan LED multiwarna adalah sebesar Rp. 1,057,400 dan biaya operasional per bulan nya sebesar Rp. 46.808,28. Ditinjau dari jenis dan bobot tangkapan ikan, kinerja lampu LED multiwarna menunjukkan bahwa hasil tangkapan ikan yang lebih baik dibandingkan dengan lampu LED warna putih. Di samping itu, nelayan bagan memberikan respon positif terhadap penggunaan lampu LED multiwarna dan merekomendasikan penggunaan lampu LED multi warna kepada nelayan lainnya. Dengan demikian, hasil penelitian ini diharapkan bermanfaat untuk meningkatkan hasil tangkapan ikan di kalangan nelayan bagan di Kabupaten Lebak.

Kata kunci: Lampu LED multiwarna, memanggil ikan, mengumpulkan ikan, bagan tancap, Arduino uno.

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PREFACE

Utmost gratitude and praise to the Almighty God for His boundless blessings throughout the completion of this bachelor thesis. His guidance and grace have been instrumental in every step of this journey.

Completing this bachelor thesis would not have been possible without the invaluable contributions and support of numerous individuals, whom Author would like to acknowledge and extend heartfelt appreciation:

1. Author's beloved parents for their unwavering love, prayers, and unwavering support. Their encouragement and sacrifices have been the foundation of author's success.
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9. Author self for successfully completing this bachelor thesis, along with four years of study in the Marine Engineering Department. This journey has been both challenging and rewarding, and Author proud of the personal growth and knowledge gained throughout this process.

This bachelor thesis is a culmination of countless hours of dedication, support, and collaboration. Author humbled and honored to have had the opportunity to work on this project. May this thesis contribute positively to the field of study and serve as a testament to the power of collective effort and unwavering determination.

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LIST OF ABBREVIATIONS

AHP	:	Analytical Hierarchy Process
AIS	:	Automatic Identification System
AUV	:	Autonomous Underwater Vehicles
BPS	:	Badan Pusat Statistik
CFD	:	Computational Fluid Dynamic
FADs	:	Fish Aggregating Devices
GPIO	:	General-Purpose Input/Output
HSV	:	High Speed Vessel
IR	:	Infrared
IRR	:	Internal Rate of Return
ITS	:	Institut Teknologi Sepuluh November
LED	:	Light Emitting Diode
NPV	:	Net Present Value
RGB	:	Red-Green-Blue
TL	:	Tube Light
UPS	:	Uninterruptible Power Supplies
UV	:	Ultraviolet
VRLA	:	Valve-Regulated Lead-Acid

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LIST OF SYMBOLS

E	-	Energy
f	-	Frequency, in Hz = s^{-1}
h	-	Planck's constant, h = 6.626 x 10-34 Js
m	-	Mass
g	-	Percepatan gravitasi
λ	-	wavelength
v	-	Speed of light
ρ_{sw}	-	Berat jenis sea water
η_0	-	Effisiensi open water

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CHAPTER 1
INTRODUCTION

1.1 Research Background

Lebak Regency (Latin: Kab. Lebak) is a regency in Banten Province, Indonesia. The capital is Rangkasbitung. This regency borders Serang Regency and Tangerang Regency to the north, Bogor Regency and Sukabumi Regency to the east, the Indian Ocean to the south, and Pandeglang Regency to the west. Lebak Regency consists of 28 sub-regencys, which are further divided into 340 villages and 5 sub-regencys. The government center is in Rangkasbitung Regency, which is in the northern part of the regency. This city is crossed by the Jakarta-Merak railway line. Geographically, the Lebak Regency area is at 105 25′ – 106 30′ East Longitude and 6 18′ – 7 00′ South Latitude. The northern part of this regency is lowland, while the southern part is mountainous, with the peak of Mount Halimun at the southeastern tip, namely on the border with Bogor Regency and Sukabumi Regency. The Ciujung River flows north, and is the longest river in Banten (Kabupaten Lebak, 2024).

Figure 1.1. Location map of Lebak Regency

The coastal and marine area of Lebak Regency spans approximately 1,064 km^2, which is home to a variety of marine life and provides ample opportunities for fish production. Lebak Regency (Figure 1.1) covers a land area of around 3,426.56 km^2, contributing significantly to its diverse ecological system. In 2017, Lebak Regency achieved a fishery production of 320,000 tons, which increased to 395,000 tons in 2021. This indicates a growth of 23.44% in fishery production over four years (BPS Lebak, 2024). The substantial potential of Lebak's waters remains largely untapped, offering a significant opportunity for further development to enhance the livelihood of its fishing communities.

Indonesia is among the well-known countries that produce high-quality fish and fisheries products (Samad, et al., 2020), including fish from the Lebak regency. In general, the fishing practices employed by fishermen in Lebak Regency utilize basic fishing gear, such as fishing rods, nets, traps, boats, and traditional canoes (jukung) equipped with various fishing tools, methods, and techniques. The profile of fishermen in Lebak Regency is typically characterized by their limited use of modern equipment, relying heavily on very basic fishing facilities and capabilities, which makes it challenging to transition to more advanced methods (Noor, et al., 2022). For instance, fishermen using lift nets (bagan) rely on a static fishing pattern, where fish are attracted to the multi-coloreded LED lamps installed on the bagan. To attract fish to the location of the bagan, submersible lamps are used, although the light from traditional kerosene lamps (petromak) has a limited range due to some of the light being reflected upwards.

The success rate of fishing by Bagan fishermen is greatly influenced by the power of the light dispersion range of the lamp; therefore, to extend the range is to put the light source in the water. According to Siregar and Koenhardono (2020), with the use of LED lamps, electric energy can be reduced because it can be used for 10 fishing trips. The fish-catching lamp can also be controlled up to 120 meters away, making it easier for fishermen to catch fish with the lamp without having to lower the lamp boat to catch fish. Test results on the effect of lights on fish show that lights with red lights can catch fish within two minutes. In order to modernize the fishing equipment for Bagan fishermen in Lebak Regency, it is necessary to conduct a pilot project on the use of submersible fishing lights.

In this research, a multi-colored LED submersible lamp with blue, red and white colors will be designed. The existence of light can be utilized for organisms in the water is very dependent on the ability of light to penetrate the water layer. Blue and green light colors have the ability to penetrate deeper layers of water than red colors that are absorbed by water only a few meters and white colors that have been shown to have an influence on squid catches (Baskoro, 2007).

1.2 Problem Statement

1. What is the design of multi-colored LED submersible lamp for attracting and collecting fish catches in fisheries production?
2. How is the testing conducted for the multi-colored LED submersible lamp to attract and collect fish catches?
3. What are the impacts of using multi-colored LED submersible lamp on fish attraction and collecting in bagan fisheries?

1.3 Research Objectives

The objective of this Final Project research is to make efforts to enhance fish catch yields among bagan fishermen in Lebak Regency through multi-colored LED-based submersible lamps. The detailed objectives of this research are as follows:

1. To obtain the design of multi-colored LED submersible lamp for attracting and collecting fish catches in fisheries production.
2. To determine the performance of multi-colored LED lamp for attracting and collecting fish catches in fisheries production.
3. To measure the responses from the fisherman on how ease of using the multi-colored LED Lamp.

1.4 Scope of Research

The problem constraints of the research are as follows:

1. The design and testing of submersible multi-colored LED lamp for bagan fishermen in Lebak Regency.
2. Considerations for the design of multi-colored LED submersible lamp are based solely on operational ease and operational costs.
3. Analysis of the impacts of multi-colored LED lamp usage on fish and bagan fishermen is conducted solely based on data obtained during testing in Binuangeun Beach, Lebak Regency.

1.5 Research Benefit

The benefits of writing this Final Project are as follows: enhancing fish catch yields among bagan fishermen in Lebak Regency using multi-colored LED submersible lamps.

1. Providing new insights into the potential application of multi-colored LED lamp technology in improving fish catch yields sustainably.
2. Offering information to fisheries traditional practitioners to enhance operational efficiency and sustainability of fishing activities.
3. Assisting policymakers in designing regulations that support the sustainable use of multi-colored LED lamp technology in traditional fisheries.

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CHAPTER 2
BASIC THEORY

2.1 Bibliometric Analysis

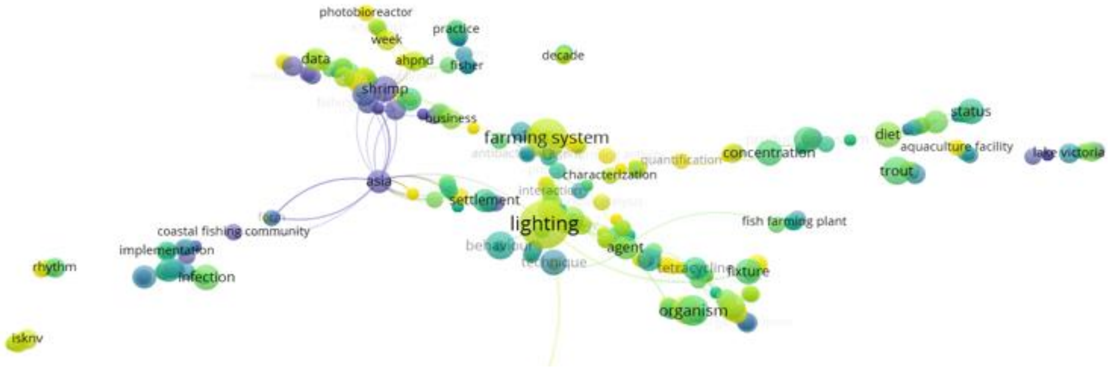

Figure 2.1 Bibliometric Analysis

The network map included in the Bliometric analysis provides an overview of the research’s position in relation to existing literature. As illustrated in Figure 2.1, a substantial corpus of research has been conducted on the subject of lighting. This lighting is employed as fish bait due to the fact that fish possess a photobioreactor, which serves to attract them to light. The present study will investigate the use of LED lamping, which is capable of changing color and is submersible, as a potential tool for attracting fish. This is still a relatively new area of research, with only a few studies conducted thus far on the use of multicolour LED lamps for attracting and gathering fish.

2.2 Literature Review

In examining the potential applications of multi-colored LED lamps in fisheries, it is evident that previous studies offer valuable insights. Research conducted by Adil et al. (2023) indicates that the composition of fish catches is influenced by a number of factors, including weather conditions. For instance, strong winds accompanied by large waves can disrupt the stability of lighting on collecting vessels, reducing catches of certain fish species. The Bagan model is based on the hypothesis that the gear is more effective in the fishing process around Fish Aggregating Devices (FADs).

In a study conducted by Siregar and Koenhardono (2020), the influence of light color on the efficiency of attracting specific fish was observed. The use of red-colored lights was found to result in the gathering of fish within a period of two minutes, whereas the use of other colored lights was unsuccessful in attracting fish at the test site. This phenomenon can be attributed to the varying sensitivity of fish eyes to different light colors. The fish species that were observed to gather in the vicinity of the red-colored light at the test site was the Nile tilapia (Oreochromis niloticus). With regard to the efficacy of light color in the context of squid fishing, it was determined that blue light is conducive to attracting squid, whereas white light is optimal for capturing them.

As reported by Jayanto et al. (2013), the data analysis of the two FADs revealed a significant effect of FADs on catch. This is because the presence of FADs creates a substantial quantity of food (phytoplankton) in the vicinity of the FADs, which can attract the attention of small fish to approach the FADs.

Research by Rudiyanto et al. (2020) indicated that catch results are influenced by several factors, including environmental parameters such as physical, chemical, and biological factors. Among these parameters, physical factors exert a significant influence on catch results, as they relate to fish behavior. The majority of fish lured and caught in fishing gear respond to light stimulation, contingent on the characteristics and behavior of the fish in response to light color stimuli. The responses of the fish to the two light colors used in the study were found to be distinct.

Waris et al. (2018) conducted research that demonstrated the efficacy of LED lamps in attracting fish to the Bagan fishing gear. Some fish species exhibit positive phototaxis properties, whereby fish respond to light by approaching and gathering around the light source at a specific distance and time interval in pelagic fish. The aggregation of fish around the light is a behavior exhibited by fish in search of food. The flashing light bait stimulates the visual sense of the target fish.

In alignment with these studies, this research aims to contribute further to the exploration of the potential and risks associated with the use of multicolour LED lamps in fisheries, with a particular focus on the specific local contexts.

2.3 Bagan

Bagan is one of the lift nets that are operated at night in coastal waters using lights to attract fish. As documented by Subani (1972), the bagan was first introduced in Indonesia in the early 1950s and has undergone numerous modifications since that time. The bagan was initially employed by fishermen in South Sulawesi, specifically those from Makassar and Bugis communities. Subsequently, the fishermen of the region disseminated the technique throughout the archipelago, and it eventually became a widely recognized practice across Indonesia.

2.3.1 Fixed Bagan

A fixed bagan is a specific type of bagan group (Sasmita, 2024). In essence, this type of fishing apparatus is a structure constructed from bamboo that is affixed in a manner that ensures its stability in the water. Consequently, this fishing apparatus is immobile. As the tool is anchored to the seabed, the depth of the sea in which it operates is constrained to shallow waters. The net, situated in the center of the rectangular bagan, is attached to a frame constructed of bamboo as it can be seen on figure 2.2. On all four sides, there are bamboo crosses and intersections, which serve to reinforce the construction of the map. The map-building process is completed by the construction of a house at the center of the map. This structure serves several purposes, including providing a place to rest, protecting the lights from the rain, and offering a vantage point from which to observe the fish. The structure is topped by a bamboo roller, which is used to pull the net.

Figure 2.2 Fixed Bagan
(Source: merdeka.com)

2.3.2 Floating Bagan

Bagan perahu is a type of fishing gear classified as a bagan type lift net, which is utilized by fishermen to catch small pelagic fish as it can be seen on figure 2.3. This fishing gear was first introduced by Bugis fishermen in Makassar in the 1950s. Bagan boats are distinguished by their lightweight and straightforward design, which allows for their use by a single or dual vessel. The construction of this floating bagan is a rectangular net, which is suspended and opened by means of two poles (Dollu, et al., 2023). The top of the net is equipped with a buoy, while the bottom is tied with ballast. In the case of manual operation, a towing rope is affixed to the net at the bottom. In the event that a winch is utilized, the vessel is also equipped with a reeling mechanism, the number of which corresponds to the number of ropes employed. This rope serves a dual function, acting as both a trawl and a lifting mechanism for the net in the water.

Figure 2.3 Floating Bagan
(Source: Teddy Oswari researchgate.net)

2.4 Fish Aggregating Devices

Fish, both adult and juvenile, have a natural tendency to aggregate around floating structures such as logs, drifting algae, or dead marine organisms. While the exact reasons for this behavior remain somewhat elusive, fishermen have capitalized on this phenomenon for centuries by using fish aggregating devices (FADs). FADs are artificial structures designed to mimic these natural structures, thereby attracting and concentrating pelagic fish in a predictable location for increased fishing efficiency. A primary type of FAD is the Moored Fish Aggregating Device (MFAD), which is securely anchored to the seafloor. This particular FAD configuration, often referred to as a rumpon in certain regions, has been widely adopted by fishermen due to its stability and predictability. While drifting FADs have gained prominence in industrial fisheries, particularly for tuna, the focus of this study is on the moored variety, commonly known as the rumpon. (Janin et al, 2024)

2.4.1 Rumpon

According to the Decree of the Minister of Maritime Affairs and Fisheries of the Republic of Indonesia No. 2, Article 19 of 2011, Fish Aggregating Devices (FADs) are described as instruments designed to gather fish, utilizing various forms and types of solid object attractors that function to draw fish together. Based on figure 2.4, FADs are constructed in a manner similar to trees and are planted at a specific depth in marine waters, serving as a refuge, foraging ground, spawning site, and aggregation point for fish. Consequently, the FADs can be regarded as a focal point for fish in the sea, facilitating the implementation of more efficient fishing operations for fishermen. FADs are fishing aids whose function is to act as a helper to attract the attention of fish to gather in one place, which is then held for capture. The components of FADs include buoys or rafts, anchors, anchor ropes, fish houses, and in some cases, buoys are utilized as an additional component (Mustono, 2018).

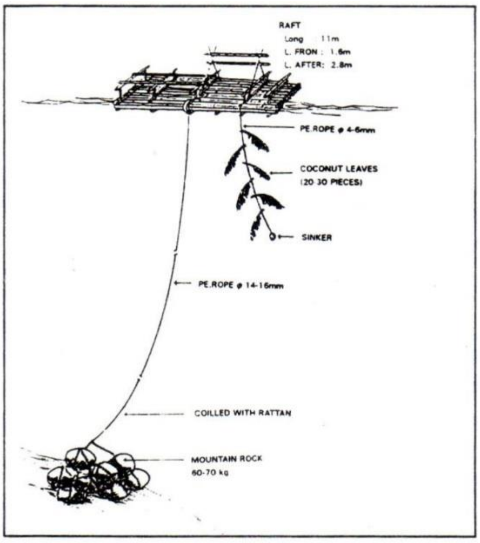

Figure 2.4 Baited FADs
(Source: knepublishing.com)

2.4.2 Lightning

Since the 17th century, two distinct theories about the nature of light have emerged. Isaac Newton suggested that light consists of a stream of particles, while Christian Huygens proposed that light propagates as a wave. The wave form would then necessitate the presence of a medium for propagation, a substance that is pervasive in our environment but not visible or discernible to the human eye. The nature of light is now understood to be a combination of particle and wave properties. Both theoretical frameworks can explain certain aspects of light. Light as a wave

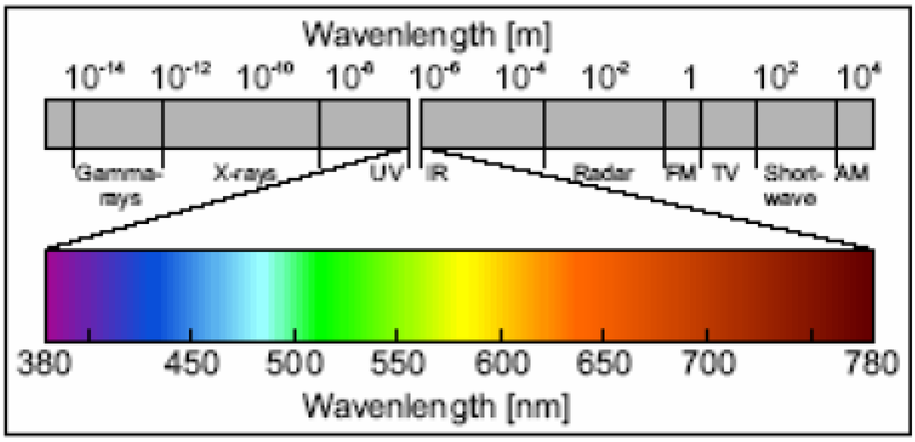

Figure 2.5 Light as a Wave

The electromagnetic spectrum encompasses a vast array of radiation, encompassing radio waves with wavelengths of several meters, magnetic rotation, and X-rays with wavelengths of less than one million per meter. Figure 2.5 illustrates the electromagnetic spectrum, spanning from 380 to 780 nanometers. This is the portion of the electromagnetic spectrum that the human eye is capable of perceiving as light. Ultraviolet (UV) and infrared (IR) radiation are sometimes included in the category of light, but this statement is not entirely accurate because they cannot be perceived by the human eye without the use of an auxiliary instrument. All waves can be described by three fundamental characteristics: frequency, wavelength, and amplitude. The relationship between frequency and wavelength can be expressed by the following formula:

$$c = \lambda . f \tag{2.1}$$

Where,

λ = wavelength

f = frequency (Hz) = s-1

c = speed of light, c = 3000000 km s-1

The speed of light can be justified in a vacuum. The speed of light will be reduced when it propagates through a medium such as water or glass that is optically dense. This will result in friction due to the indentation caused by some of the light propagating through one medium to another.

Optical phenomena can be explained by both wave theory and particle theory, which are associated with reflection and diffraction. The phenomenon of diffraction, which is the bending of light when it encounters an edge, is a form of defraction. The incision results in a portion of the umbra light being situated behind an obstruction, although this phenomenon is typically not considered. Meanwhile, reflection was elegantly described by Newton as an elastic separation of light particles, akin to the reflection of a billiard ball on a billiard table.

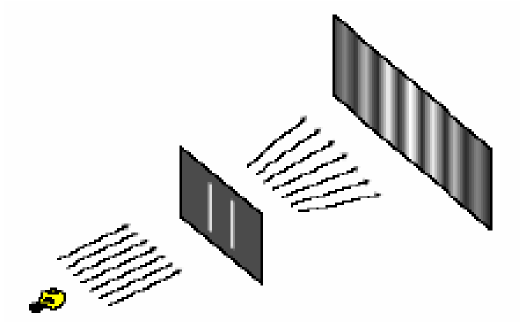

Figure 2.6 Light Spread

Although the theory of diffraction and reflection of light was initially questioned by some physicists, the subsequent mathematical structure developed by Augustine Jean Frénaud fulfilled the theory that light is a wave. Albert Einstein subsequently elucidated that although light is a wave, it does not necessitate a medium of propagation analogous to that of waves in general.

Einstein proposed that light is both a wave and a particle. In 1900, shortly before Einstein articulated his perspective, Planck mathematically posited that electromagnetic radiation is not generated by continuous heating of the body, but rather by breaking the unit. He successfully demonstrated that electromagnetic energy radiation is proportional to frequency, with a constant h, which is known as Planck's constant and is formulated as follows:

$$E = hf \tag{2.2}$$

Where,
E = Energy
f = Frequency, in Hz = s^{-1}
h = Planck's constant, h = 6.626 x 10-34 Js
While the relationship of the speed of light (v) in km/sec, with the wavelength (λ) in meters and the frequency (f) in Hertz:

$$v = \lambda x f \tag{2.3}$$

The speed of light in a vacuum is 3,105 km/second. As illustrated in Fig. 2.2, the emission of light with varying wavelengths can result in the perception of different colors by the human eye. The maximum sensitivity of the human eye is 55500 A (0.555 µm), which is perceived as a yellowish green color. The visible light spectrum is constrained by ultraviolet (UV) and infrared (IR) radiation. Ultraviolet (UV) light cannot be directly perceived by the human eye, but fluorescent substances can be employed to generate light that can be seen by the human eye. Examples of fluorescent materials utilized in fluorescent lamps or TL (tube light) include: Ultraviolet radiation can be employed for the purposes of fingerprint detection, photocopying, and metal crack detection, without undergoing a conversion to visible light. It is not employed as an illumination source because the eye is unable to detect light with wavelengths longer than 780 nm, as well as IM. Nevertheless, IM can be employed as a heat source, such as in paint dryers, space heating, cooking, and healthcare applications.

2.4.3 Petromax

Pressurized kerosene lanterns (Petromax) operate by vaporizing kerosene in a preheated fuel tube, then mixing the vapor with air and burning the mixture to achieve high flame temperatures. This high-temperature, non-luminous flame heats the mantle, generating light. When fully pressurized, a Petromax lantern emits approximately 1300 lumens of light (Mahapatra, et al., 2009).

2.4.4 Halogen

Halogen lamps, an advanced form of incandescent lighting, are widely used in optical microscopy because of their reliability and consistent light output. These lamps, which evolved from older tungsten filament lamps, produce a continuous spectrum of light, but emit a significant amount of energy as heat. Introduced in the early 1960s, tungsten-halogen lamps feature a quartz envelope filled with halogen gas, which allows the lamp to operate at higher temperatures and improve its lifetime compared to traditional incandescent lamps. These lamps are particularly popular in microscopy for brightfield, photomicrography, and polarized light applications because of their stability and ability to produce bright, consistent illumination. While less effective for UV applications, their durability and efficiency aket hem a preferred choice in many industrial and scientific environments. The halogen regenerative cycle helps reduce filament degradation, extending lamp life and ensuring minimal changes in light output over time (Hume,2012).

2.4.5 Light Emitting Diode

A light-emitting diode (LED) is a lamp that can emit light due to an electronic circuit in the form of a semiconductor diode that is given a voltage. LED can emit monochromatic light that varies in color depending on the type of material used. LED are the choice today because they are known to be energy efficient. In an experiment, it was found that the fuel consumption of LED lamps was reduced by 15–17%. A 6-watt LED bulb can produce 450 lumens, comparable to a 60-watt incandescent bulb. This is because LED maximizes the conversion of electricity into light, unlike incandescent bulbs, which convert electricity into heat and then light. In terms of capacity, LED life is about 50,000 hours (Siregar and Koenhardono, 2020).

Figure 2.7 Light Emitting Diode
(source: azooptics.com)

LEDs (Figure 2.7) are composed of various compounds such as indium gallium nitride (InGaN), aluminum gallium arsenide (GaAlAs), or aluminum gallium indium phosphide (AlGaInP). The specific type and amount of semiconductor material determine the wavelength and color of the emitted light. LEDs are available in a broad spectrum of wavelengths, including blue (450–500 nm), red (625–700 nm), and green (500–565 nm), though each type of LED covers only a narrow range of wavelengths. However, combinations of LEDs, along with additional mechanisms, can produce white light with a wavelength range similar to natural sunlight. Although LEDs are typically described by the color of light they emit as perceived by the human eye, photons and light of different wavelengths inherently lack color. Color is merely the human eye’s perception of various wavelengths. Visible light, or white light within the 400-700 nm wavelength range, accounts for 42-43% of total sunlight in energy terms and can be separated into wavelengths perceived as seven colors: violet/indigo/blue (400-500 nm), green (500-565 nm), yellow (565-590 nm), orange (590-625 nm), and red (625-700 nm). When cultivating phytoplankton at specific wavelengths, LEDs of particular colors are a more practical source of the desired wavelengths compared to splitting sunlight with a prism or other methods. Although LEDs often have higher initial installation costs for the same amount of visible light, they are more cost-effective overall due to their greater energy efficiency and longer operating life (Mahari et al., 2024).

The recent research investigates how to improve the effectiveness of night fishing, with a focus on optimising lighting for floating bagan, a gear commonly used by Gejugan fishermen. Previous studies have highlighted the importance of light in attracting fish to the gear. Traditional lighting methods, such as petromax and fluorescent lamps, are limited by the fact that they operate above the water surface, causing light reflection.

Figure 2.8 Strip-Light Emitting Diode

To address this issue, as it can be seen on figure 2.8 recent research explored the use of LED lamps, particularly submersible ones, for floating bagan. The study found that submersible LED lamps outperformed surface lights. Building on this, the current research aims to improve the design of LED lamps by increasing their dimensions and introducing a dimming system. This innovation uses 5mm super-bright blue LED lamps, which are cost-effective compared to the types used previously. The dimming system is designed to optimize light intensity for improved fishing efficiency during night operations.

2.5 Fishing Techniques

The basic principle of Light Fishing is to utilize light to help gather fish in the water so that they are easier to catch. Fish are attracted to light because of their natural characteristics such as phototaxis, the desire to feed, and the desire to aggregate to avoid predators. In practice, the lights used in light fishing should be able to collect fish from a long distance, make the fish gather around the light source, and make the fish stay there for a considerable period of time. The strength of the light, the influence of the weather, and the movement patterns of fish to the light also need to be considered in light fishing (Baskoro, 2007).

In the context of fishing techniques, the term “Bagan” is used as one of the most effective fishing gears, mainly utilized by fishermen in Indonesia. Bagan is a type of fishing gear that is designed to catch small pelagic fish. Its operation is based on the fundamental principle of attracting fish to the surface of the water using a light attractor. The fishing process begins with lowering the net and activating the lights at night, after which the net is lifted once the fish have gathered around the bagan. The type of net utilized is typically constructed from waring with a specific mesh size, calibrated to the dimensions of the bagan and the targeted fish. There are two prevalent categories of nets: fixed nets and moving nets. A fixed bagan, which encompasses a platform to house the chart and a square-shaped net, is immobile, whereas a moving chart can be relocated as needed and does not impede the shipping channel. The use of petromax lamps in the bagan as light attractors has disadvantages related to fuel consumption and the efficiency of the light produced. Therefore, the development of more efficient light technologies, such as multi-colored LED lamps that can be dipped in water, can be a better alternative to increase the effectiveness of light fishing (Susanto et al., 2018).

2.6 Fish Attraction Behavior to Light

The behavior of fish in response to light stimuli is a critical aspect to consider for optimizing fishing strategies, especially in the context of submersible multi-colored LED lamps. Based on Baskoro’s research (2007), fish tend to exhibit maximum phototactic behavior before midnight, making fishing more effective during this period. Light plays a significant role in influencing various aspects of fish behavior, including stimulating feeding, evading capture, and attracting them towards the light source. Moreover, artificial light has the ability to attract marine organisms, establishing a complete food chain within the water layer.

It's observed that hungry fish are more attracted to light for feeding compared to satiated ones. The success of using multi-colored LED lamps underwater depends on several factors, such as light intensity, duration, and the behavior of both predators and prey. Fish may exhibit either positive phototaxis (approaching light) or negative phototaxis (avoiding light) depending on the circumstances. Furthermore, various factors affect the effectiveness of artificial light, including brightness, stability, and the presence of natural moonlight.

Fish are found to be sensitive to light, demonstrating preferences for certain light types and intensities. The use of underwater multi-colored LED lamps is often more effective due to their stability and reduced light loss compared to surface lights (Susanto et al., 2018). Environmental factors like season, moon phase, and the presence of predators also influence the success of light fishing with multi-colored LED lamps. Additionally, different fish species, sizes, ages, and environmental conditions play a role in determining their preferences for light intensity, color, and duration.

Understanding fish behavior in response to light stimuli is crucial for developing effective fishing tactics using multi-colored LED lamps and designing or modifying fishing gear for improved efficiency and effectiveness underwater.

2.7 Arduino Uno

The Arduino Uno is a widely-used microcontroller board popular for electronics projects and prototyping. It's based on the Atmega328P microcontroller and comes with a set of digital and analog input/output pins (Figure 2.9) that can be easily programmed and controlled. The LED design was created using an Arduino prototyping microcontroller platform, which consists of five components: a computer with the chosen programming environment, an Arduino prototyping platform, a constant current LED driver, the LED itself, and a power supply (Teikari et al, 2012).

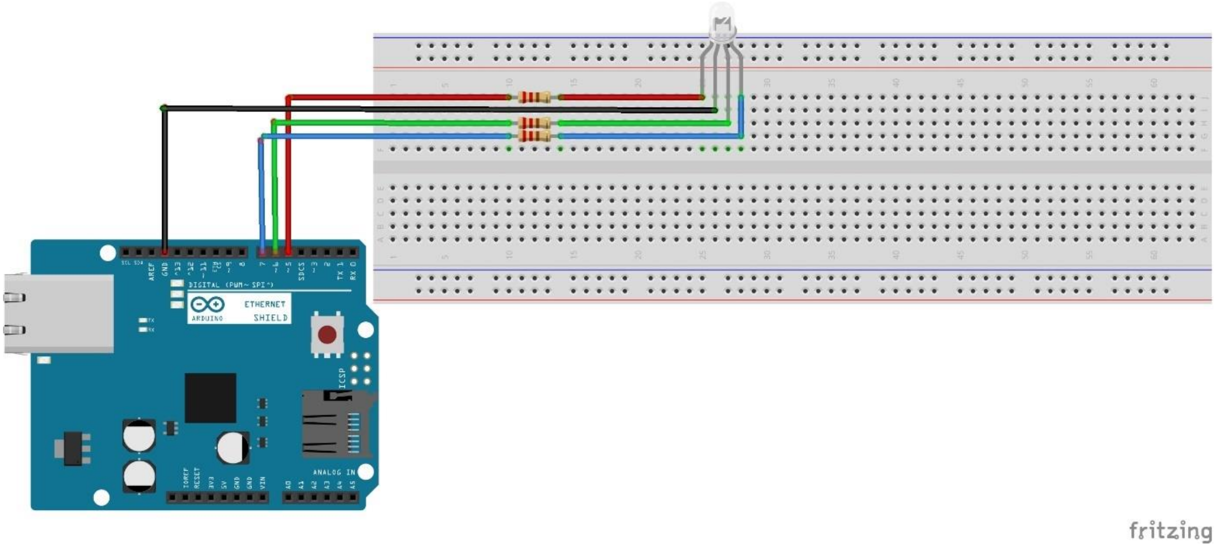

Figure 2.9 LED Schematic using Arduino Uno
(Source: projecthub.arduino.cc)

In this research, the use of Arduino Uno serves a critical purpose in enabling dynamic control of the multi-coloured submersible LED lamp. By integrating Arduino Uno, the researchers gain the ability to not only adjust the colour of the lamp, but also program it to automatically change colours based on predefined settings.

Known for its versatility and ease of use, Arduino Uno acts as the central control unit, enabling seamless communication between the user's input commands and the LED lamp. Its programmable interface allows researchers to implement algorithms to precisely regulate the LED's colour output, providing flexibility to adapt to changing fishing conditions or preferences.

The general steps involved with the components include programming the Arduino Uno using Arduino IDE program, interfacing it with the LED driver to ensure a consistent power supply, connecting the LED itself and providing a suitable power supply. This approach, as demonstrated by Teikari et al. (2012), provides a robust framework for implementing sophisticated LED control systems, paving the way for improved performance and adaptability in night fishing applications.

2.8 Rechargeable Battery

A battery is a component that can convert chemical energy into electrical energy so that it can be used as a source of electrical power for an electronic device. The battery consists of a cathode (positive terminal), an anode (negative terminal), and electrolyte as a conductor. The battery has a direct current (DC) output. Batteries can be divided into two types: primary batteries, which can only be used once, and secondary batteries, which can be recharged (Figure 2.10). Examples of disposable batteries include zinc-carbon batteries, alkaline batteries, lithium batteries, and others. While rechargeable batteries include Ni-Cd (nickel cadmium) batteries, Ni-MH (nickel metal hydride) batteries, and so on (Siregar and Koenhardono., 2020).

Figure 2.10 Rechargeable Battery
(Source: wubenlight.com)

2.9 Density of LED Lamp

The design of this multi-colored LED lamp needs to be submersible to work better in collecting fish. Immersion is necessary to reduce the effect of reflections on the water surface that can deflect light so that the dispersion of light in water can work effectively. What needs to be considered is the difference between the density of seawater and the density of the LED circuit. Based on Zhu et al, (2024) the formula for density is.

$$\rho_{lamp} = \frac{m_{lamp} + m_{cover}}{V_{total}} \tag{2.4}$$

Where:
ρ_{lamp} = density of LED lamp system in kg/m³.
m_{lamp} = mass total LED lamp in kg.
m_{cover} = mass total cover in kg.
V_{total} = volume total LED lamp system in m³.

In making multi-colored LED submersible lamps, care must be taken regarding waterproof packaging or covers so that all electronic components and connections in LED lamps can be protected from water and pressure. The deeper the lamp is submerged, the greater the pressure from the water given to the lamp. The cables and connections between the lamp and the accumulator power source must also be protected from water, using waterproof connectors or waterproof insulating materials. To increase the mass of the lamp design, weights will be used to allow the lamp to sink. These weights must be integrated into the lamp design so that it does not interfere with the function or aesthetics of the lamp. After the calculation is done, it is necessary to ensure that the density of the lamp design is greater than the density of seawater, which is usually 1025 kg/m^2.

2.10 Investment Criteria for Cost Calculation of Multi-colored LED Lamp

Various indices have been developed to obtain rational descriptions of a project to decide whether it can be financed in the program or not. These indices are called investment criteria. The types of investment criteria are:

1. Decision Process

Technical decisions are usually summarized in a set of alternatives in which several measures of merit have been included and calculated for each alternative. The economic measures of merit include capital costs, operating costs, revenues, taxes, economic life, and time value of money. When all of these inputs are known with certainty, the decision process is called deterministic. However, if some or all of the inputs are available within a certain range, the decision process is called a decision under uncertainty. One book state that there are six stages in the decision process, but this is not discussed in this paper (Tryfos, P. 2001).

2. Net Present of Value (NPV)

To determine whether an investment is feasible or not, it can be calculated by finding the net present value, which brings all values to the benchmark price at the beginning of the investment (Grubbström, 2022).

To calculate the net present value, the following formula is determined:

$$NPV_K = \sum_{j=0}^{n} A_j(\frac{P}{F}, i, j) \quad (2.5)$$

Where:
NPVK : net present value, alternative k
Aj : net cash flow year-j
J : total economic life (years)
(P/F,i,j): future payment present worth factor year j

3. Rate of Return

The classic definition of the Internal Rate of Return (IRR) is the rate at which the net present value (NPV) of a cash flow stream is zero. However, this definition does not guarantee the uniqueness or existence of an IRR. While the interpretation of a unique IRR is common for evaluating investment efficiency, it’s not immediately obvious why an investment criterion based solely on comparing IRRs would be consistent with the Net Present Value (NPV) criterion. The examples illustrate situations where different investment criteria can lead to inconsistent project selection decisions. To ensure consistency with NPV, any rate of return investment criterion should not only be uniquely determined, but also depend on a benchmark rate of return. This benchmark could be an external rate against which investment returns are compared. The goal is to construct an investment criterion that is consistently consistent with

NPV and produces decisive selections for any given return benchmark, with the unique value of the IRR being relevant whenever the criterion is definitively applied (Weber, 2014).

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CHAPTER 3
RESEARCH METHODOLOGY

3.1 Research Flow Diagram

This research uses an experiment method to produce a multi-colored LED lamp for attracting and collecting fish at floating bagan in Lebak Regency. The complete research methodology is shown in Figure 3.1 with the steps taken as follows:

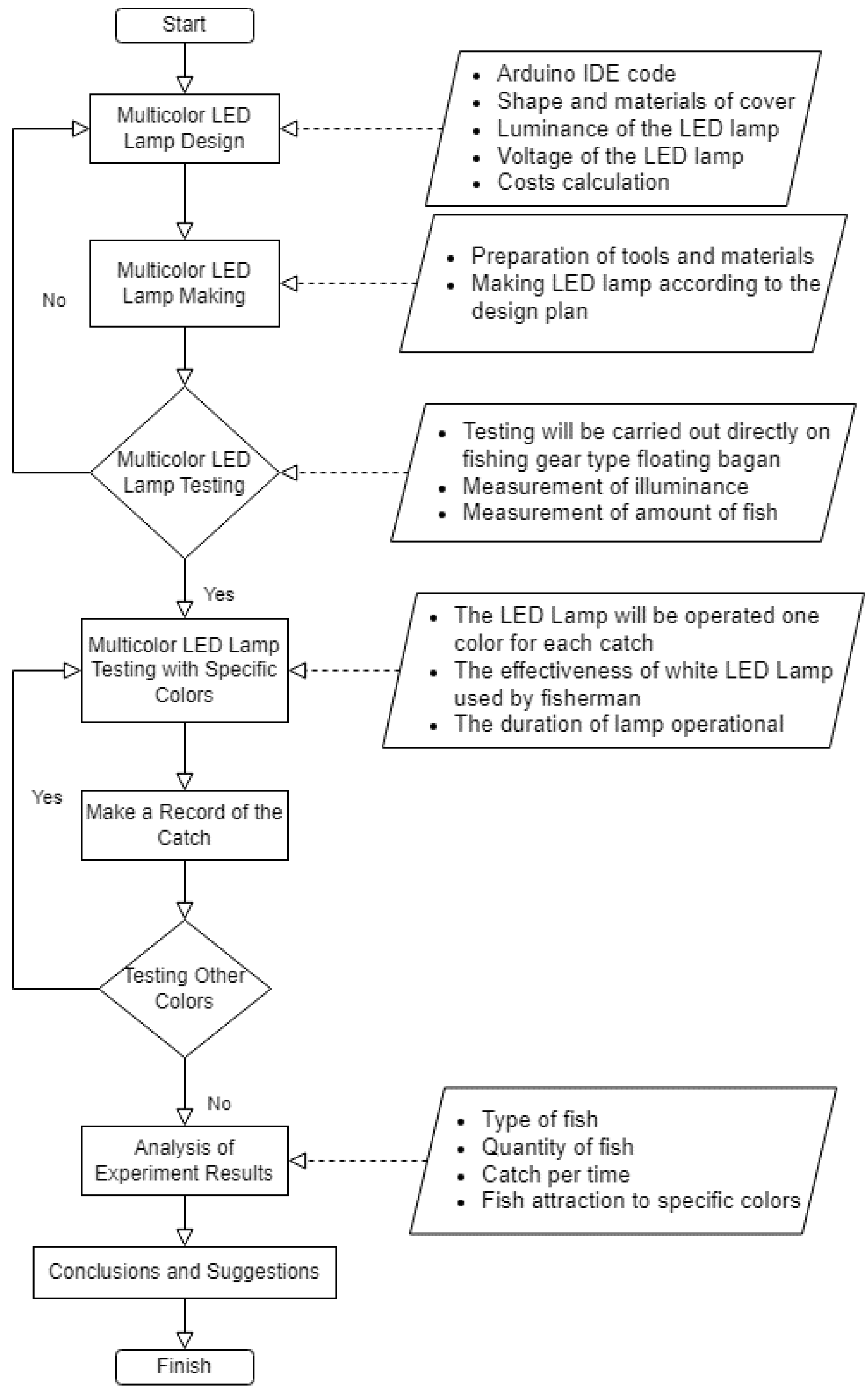

Figure 3.1 Flowchart Research Methodology

3.2 Research Stages

3.2.1 Multi-colored LED Lamp Design

Before designing the multi-colored LED lamp, we conducted interviews. These data were obtained through interviews with bagan fishermen in Lebak regency. The data on the condition and size of the Lebak fishermen's bagan included the area of the fishing gear, including the length, width, and depth of the net fishing gear installed on the bagan. Data on the condition and size of the fisherman's bagan were used to determine the amount of lamp illuminance required on the area. The amount of petromax illuminance was used as a reference in selecting the type of fishing light to be installed on the tool. Meanwhile, data on the effectiveness of petromax included the length of time required by fishermen in a fishing operation, where the data was a consideration of the time that would be used to determine the amount of electrical power required for a fishing operation on the bagan. Thus, the use of electrical energy sources from accumulators would be more applicable. Economic efficiency was the data on operating costs required in one fishing operation, including the amount of costs required due to the use of fuel oil as an energy source for Petromax and data on other cost requirements during fishing operations on fishing boats with Petromax lamps. The data was used only to compare the use of underwater light method aids with the water surface light method using petromax from an economic point of view.

The information about the condition of the fishing gear used by the fishermen bagan type was used as a consideration in the design process so that the tools to be made could be applied directly and according to the conditions of the fishermen bagan. With the data obtained from interviews in the field, the next step was to plan the design of the underwater light method fish collection tool. The amount of illuminance produced by the petromax Lamp was used to select the type of lamp to be installed on the tool. The illuminance produced by the petromax could be known from the information provided by the fishermen about their LED lamps. The fishermen were asked about the conditions and duration of LED lamp use, which were then used as a basis for selecting the appropriate electric lamp.

The taking of illuminance will also be done directly on the fishermen's bagan by measuring the illuminance of the petromax lamp and the finished fishing light to reinforce that the fishing light to be made has the same light illuminance or greater than the petromax lamp used by the bagan fishermen. The measurements are made with a lux meter tool owned by the Electrical and Ship Automation Laboratory of ITS Marine Engineering Department. Illuminance in lux is measured by lm/m^2 or lumens per square meter. The area of the fishing gear used by fishermen is used as a consideration in determining the type of lamp to be installed on the tool. Thus, the type and power of the fishing light to be installed can be known based on the illuminance produced by the lamp. Then, in the design process, the input from the fishermen of Binuangeun village in Lebak regency is also considered in order to obtain a tool design that is applicable and in accordance with the operating conditions of the light aids for Bagan type fishermen in Lebak regency.

3.2.2 Multi-colored LED Lamp Making

After carrying out the design planning process and design verification by considering the illuminance produced by the fishing light as well as the ease of operation, the next step is to make the tool in its actual form. The consideration that will be used in addition to the amount of illuminance is the impermeability of the electrical aid. This impermeability is used to create an impermeable space for the fishing light, so that during operation it does not cause leaks that could lead to a short circuit of the electric current in the tool. In addition, considerations of applicability and ease of use of the tool are adapted to the size and condition of the fishing card. Before starting the tooling process, the first step is to prepare and obtain the completeness of each component, both electrical installation components and tooling components.

The materials that must be prepared in the electrical installation are.

1. LED lamp
2. Impermeable place for the lamp in the form of acrylic tube
3. Connection cable
4. Switch

After the above materials are prepared, the next step is to make the tool according to the design plan.

3.2.3 Multi-colored LED Lamp Testing and Data Processing

At this stage, the process of testing the underwater multi-colored LED lamp method fish catching tools has been completed. Tool testing will be carried out directly on fishing gear type floating bagan owned by fishermen in the Binuangeun beach of Lebak Regency. The data that will be obtained in testing the tool in the form of data regarding the operation of the tool in the form of stages in the operation of the tool, the number of fish caught by the fishermen and the length of time required and all processes that occur during testing. The testing of the tool is carried out about 4 trips of fishing operation. In addition, as a comparison of the acquisition of catches, at the same time data will also be taken from other bagan that are closest to the test bagan. The other bagan will still use Petromax lights in fishing operations. Then, to support the completeness of the data, it will be asked for information on fish catches in the span of five operations before testing the tool. The data obtained will be analyzed technically and economically, including the ease of operation and the economic side of the amount of operating costs and catches obtained by the Bagan fishermen.

3.2.4 Conclusions and Suggestions

The conclusion contains the results of the data processing obtained during the testing of the tools, as well as the phenomena that occurred during the testing of the tools. The first conclusions will be directed to the relationship between the amount of light illuminance produced by the fish-catching tool and the catch obtained both by the card with a petromax lamp and by the card with a fishing light, the level of suitability of the electrical installation design and construction of the tool with the condition of the fisherman’s fishing gear, the choice of the lamp color in accordance with the attraction of fish to the color of light, and other conclusions related to the operational process of the underwater light method fish-catching tool. These results will be documented in the form of a research report.

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CHAPTER 4
RESULTS AND DISCUSSION

4.1 The design of multi-colored LED submersible lamps for attracting and collecting fish catches in fisheries production

4.1.1 Duration of lamp usage of bagan fishermen

The duration of lamp use among Bagan fishers is not only a focus of fishing techniques, but also reflects traditional practices in the field. In this study, data on the duration of lamp use was gathered through direct interaction with fishers operating in the research site. One of the observed practices was the use of lights from sunset to sunrise. This suggests that the lighting of the bagan is maintained throughout the night.

The most common types of lamps used in this practice are mercury lamps and tube lamps. Mercury lamps are distinguished by their brighter and more intense light, while tube lamps exhibit a more uniform lighting pattern. The selection of these two types of lights is based on considerations of effectiveness in attracting fish to the vicinity of the bagan and facilitating the fishing process.

Consequently, in view of the necessity for lighting throughout the night, the development of multi-colored LED lamp technology with specifications that can function efficiently and effectively throughout the duration of fishermen's operations will be implemented. The objective is to optimize fishing outcomes by considering the preferences and requirements of fishermen regarding the type of lamp utilized.

4.1.2 Design of underwater multi-colored LED lamp

The use of Arduino Uno as a microcontroller is crucial in the design of multi-colored LED lamps, as it enables the programming and control of such LED lamps. The first stage involves preparing the Arduino Uno microcontroller and using the Arduino IDE as a platform for compiling the desired program. The following is the code that will be implemented in this research.

Based on figure 4.1, the code presented is the implementation of a program designed to regulate the color of red-green-blue (RGB) LED lamps using the Arduino platform. At the initial stage, a variable definition is provided that defines the Arduino GPIO (general-purpose input/output) pins that will be utilized to control the LED colors. Specifically, the pins are defined as BLUE (pin 3), GREEN (pin 5), and RED (pin 6). Additionally, a BUTTON is defined on pin 2 to change the LED color mode.

Moreover, in the setup() function, the BUTTON pin is initialized as an input with an internal pull-up resistor using the INPUT_PULLUP mode. This ensures that the button pin is in a known state when not pressed. The BLUE, GREEN, and RED pins are initialized as outputs using the pinMode() function, which is crucial to guarantee that the pins can transmit the outgoing signals necessary to regulate the RGB LEDs.

4_pinled.ino

```
// Defining variables and the GPIO pins on Arduino
#define BLUE 3
#define GREEN 5
#define RED 6
#define BUTTON 2

// Defining color mode
int mode = 0;

void setup() {
  pinMode(BUTTON, INPUT_PULLUP);  // Set the button pin as input with internal pull-up resistor
  pinMode(BLUE, OUTPUT);          // Set the LED pins as output
  pinMode(GREEN, OUTPUT);
  pinMode(RED, OUTPUT);
}

void loop() {
  if (digitalRead(BUTTON) == LOW) {
    mode = mode + 1;
    delay(400);  // Debounce delay
  }

  // Set the LED color based on the mode
  switch (mode) {
    case 0:  // Off
      analogWrite(BLUE, 255);
      analogWrite(GREEN, 255);
      analogWrite(RED, 255);
      break;
    case 1:  // White (tuned)
      analogWrite(BLUE, 0);
      analogWrite(GREEN, 0);
      analogWrite(RED, 0);
      break;
    case 2:  // Red
      analogWrite(BLUE, 255);
      analogWrite(GREEN, 255);
      analogWrite(RED, 0);
      break;
    case 3:  // Green
      analogWrite(BLUE, 255);
      analogWrite(GREEN, 0);
      analogWrite(RED, 255);
      break;
    case 4:  // Blue
      analogWrite(BLUE, 0);
      analogWrite(GREEN, 255);
      analogWrite(RED, 255);
      break;
  }

  // Reset mode if it exceeds 4
  if (mode > 4) {
    mode = 0;
  }
}
```

Figure 4.1 Arduino IDE Code

In the primary operational phase of the program, represented by the loop() function, the system continually checks if the BUTTON is pressed. If the BUTTON is detected as pressed (digitalRead(BUTTON) == LOW), the mode variable is incremented, and a delay of 400 milliseconds is added to debounce the button and prevent multiple increments from a single press.

The LED color is set based on the mode variable using a switch-case structure. Each mode sets the LED colors to a specific state as it can be seen on figure 4.2: Case 0 turns off all LEDs by setting the PWM value to 255 (off state for common anode LEDs), Case 1 sets all

LEDs to white by setting the PWM value to 0 (full brightness), Case 2 turns on the red LED by setting its PWM value to 0 and the others to 255, Case 3 turns on the green LED by setting its PWM value to 0 and the others to 255, and Case 4 turns on the blue LED by setting its PWM value to 0 and the others to 255.

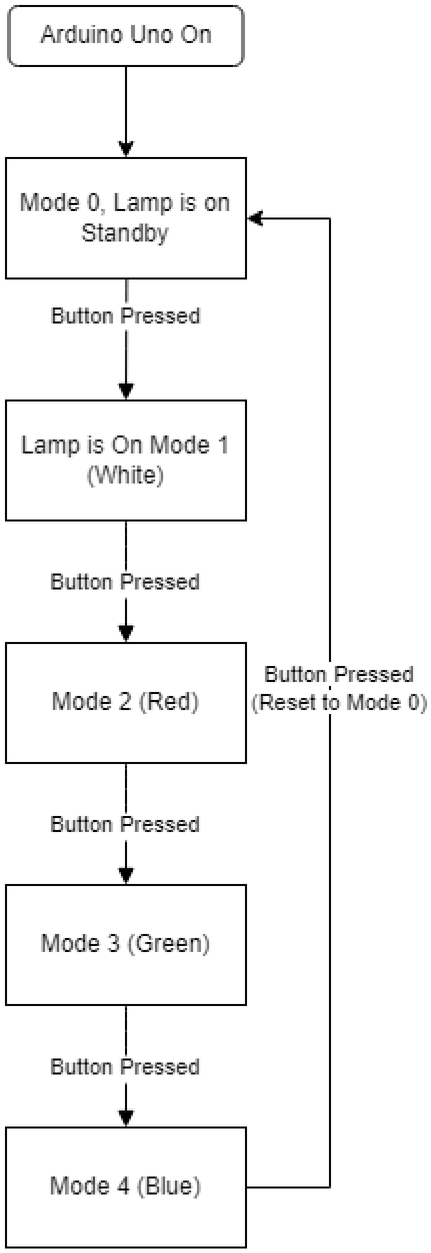


Figure 4.2 Block Diargram of Arduino Uno

The analogWrite() function is used to transmit a PWM signal to the pins connected to the LEDs, which controls the brightness and color of the LEDs based on the specified intensity. The delay() function is also incorporated to regulate the interval between LED color changes, ensuring the system operates smoothly without rapid, unintended changes. Finally, the mode is reset to 0 if it exceeds 4 (Figure 4.2), ensuring the system cycles through the predefined color modes.

In the context of this research, the program will be modified to implement a multi-colored LED lamping system that can function effectively throughout the night. It is anticipated that the LED lamping system will provide optimal illumination and can be adapted to the specific requirements of the research project. In the implementation phase, the researcher will apply the principles outlined in the code to design an LED lamp system that aligns with the research requirements.

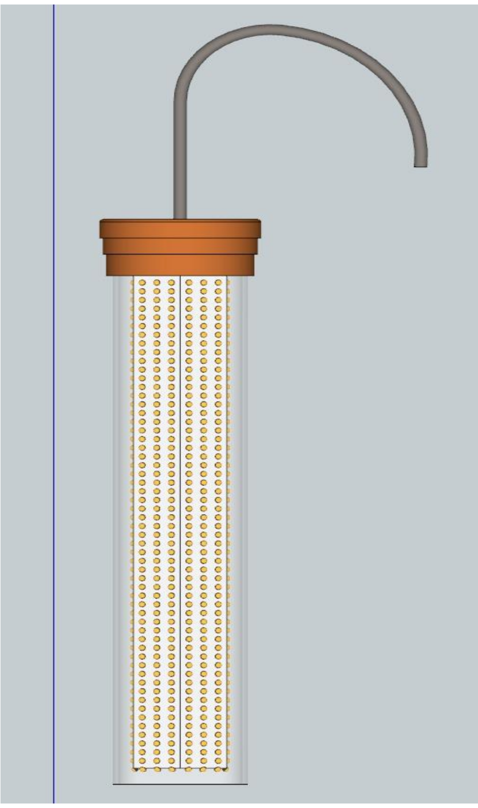


Figure 4.3 Design of Multi-colored LED Lamp Submersible

When designing and assembling a multi-colored LED submersible lamp, attention to the choice of shape and materials used is very important. The first stage in the design of this multi-color LED submersible lamp is the selection of a vertical tube or cylinder shape (Figure 4.3). The choice of this shape was based on the consideration of a smaller surface area, thus reducing the possibility of being tossed around by the waves. The tube shape also provides flexibility in manufacturing and allows a ballast to be fitted at the bottom. In addition, the tube shape helps to evenly distribute the light to the surrounding area. Clear acrylic tubes were chosen as the protective material due to their water-swell properties, strength and good light transmission compared to glass and clear PVC. The addition of ballast is designed to prevent the lamp from being carried away by the current when placed in the water and to avoid the potential frightening of fish, which may cause them to flee from the light source.

The lamp tube is fitted with a cover at the bottom using a special acrylic adhesive and a cover at the top to allow the tube to be opened and closed and the lamp to be removed and inserted. Once all the components have been made, the lamp is tested for watertightness and its success is determined by the absence of water entering the tube.

Table 4.1 Luminous Intensity of the RGB Flash LED Diode

5mm RGB Flash LED Diode Product Information					
	Forward Voltage	Wavelength	Luminous Intensity	Reverse Current (uA)	Viewing Angle (deg)
	(if=20mA)	(if=20mA)	(if=20mA)	Vr=5v	(if=20mA)
Red	2.0~2.4V	620-630nm	4000-5000 mcd	10	30°
Green	3.0~3.4V	520-525nm	12000-14000 mcd	10	30°
Blue	3.0~3.2V	460-465nm	12000-14000 mcd	10	30°

$$Lumens = mcd \times \left(\frac{Viewing\ Angle\ in\ degrees}{2}\right)^2 \times \frac{\pi}{180} \times \frac{1}{683}$$

Luminous Intensity (mcd) measures the amount of light emitted by a source in a specific direction, typically quantified in millicandelas (mcd). The Viewing Angle, measured in degrees, determines the extent from which the emitted light is observed (Table 4.1). Converting luminous intensity to lumens involves several steps: initially, the luminous intensity (mcd) is adjusted for the viewing angle by halving it and then raising the result to the power of half the viewing angle in degrees. This adjustment compensates for the decrease in light intensity with increasing viewing angles (Putra, Andre Agusta G., et al., 2020). Subsequently, the result is converted from millicandelas to candelas by multiplying it by π (3.14159) and dividing by 180, accounting for the standard measurement unit shift. Finally, the converted value is further transformed from candelas to lumens by dividing it by 683, a conversion factor reflecting the relationship where 1 candela equates to approximately 683 lumens. (Satwiko, S. 2012). Table 4.2. shows the lumens of RGB LED.

$$Lumens = mcd \times 0.00146 \times Viewing\ Angle\ in\ degrees^2$$

Table 4.2. The value of lumens of RGB LED

No.	**Color**	**Rated Luminous Intensity (mcd)**	**Viewing Angle in degrees**	**Lumens**
1	Red	4500	30	4.155
2	Green	13000	30	12.03
3	Blue	13000	30	12.03

The selection of a total target of 6000 lumens is based on observations of how fishermen currently use 8 white LED lamps of 3500 lumens each. These lamps are placed in the center of the fishing platform, divided into two points (left and right), with 4 LED lamps placed close together on each side, forming a square shape. The total lumens produced by this setup is 14000 lumens. However, observations of illuminance at certain heights using a lux meter revealed that the reflection from the water surface causes a significant difference in lux values. Since the multicolored LED lamps in this study are designed to be submerged in water, while the white LED lamps used by the fishermen are positioned above the water surface, a target of 6000 lumens was chosen. This setting takes into account the reduction in light intensity due to reflections, which can be reduced by about half depending on the turbidity of the water.

Total Target Lumens: 6000

$$Number\ of\ LEDs = \frac{Total\ Target\ Lumens}{Highest\ lumens/LED}$$

$$Number\ of\ LEDs = \frac{6000\ lumens}{12.03\ lumens}$$

So, the required number of LEDs are:

$$Number\ of\ LEDs \approx 499\ LEDs$$

The lamp circuit will be assembled in parallel. Where each LED has a forward voltage of about 2.4V-3.4V (and 3.2V for blue). By using a 3.7V supply voltage, we can connect each LED in parallel strings. From the required number of LEDs, it can be concluded that there will be 500 parallel strings. However, a direct connection to the 3.7V supply voltage would result in overvoltage for some LEDs and insufficient voltage for others, leading to potential damage and uneven brightness. To address this challenge, a DC-DC converter will be employed. This converter efficiently steps down the 3.7V supply voltage to the appropriate level required by the active LED color. When red LEDs are activated, the buck converter will regulate the voltage to approximately 2.4V. Conversely, for green LEDs, the output voltage will be adjusted to 3.4V. Similarly, for blue LEDs, the converter will dynamically adjust the voltage to approximately 3.2V. This dynamic voltage regulation ensures optimal operating conditions for each LED color, maximizing efficiency and lifespan while achieving consistent color rendering.

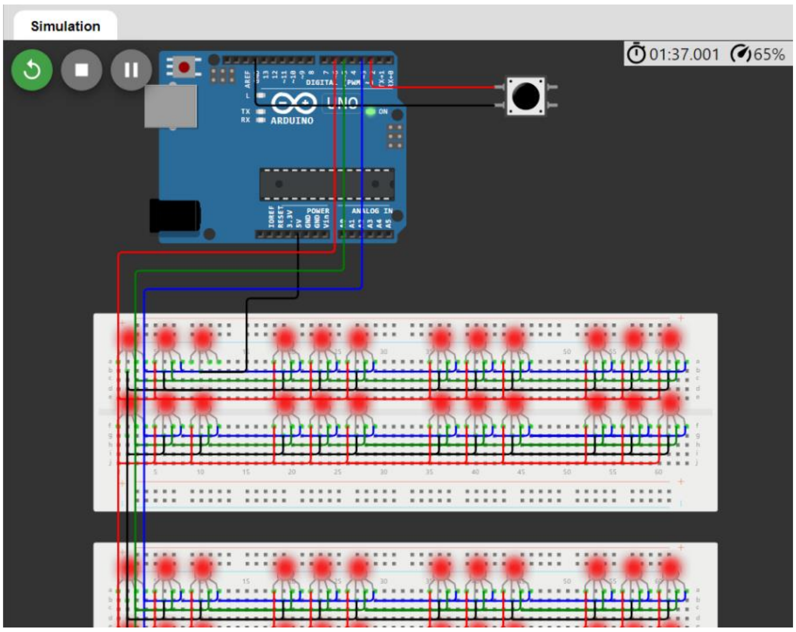


Figure 4.4 Simulation of LED Lamp Red Color

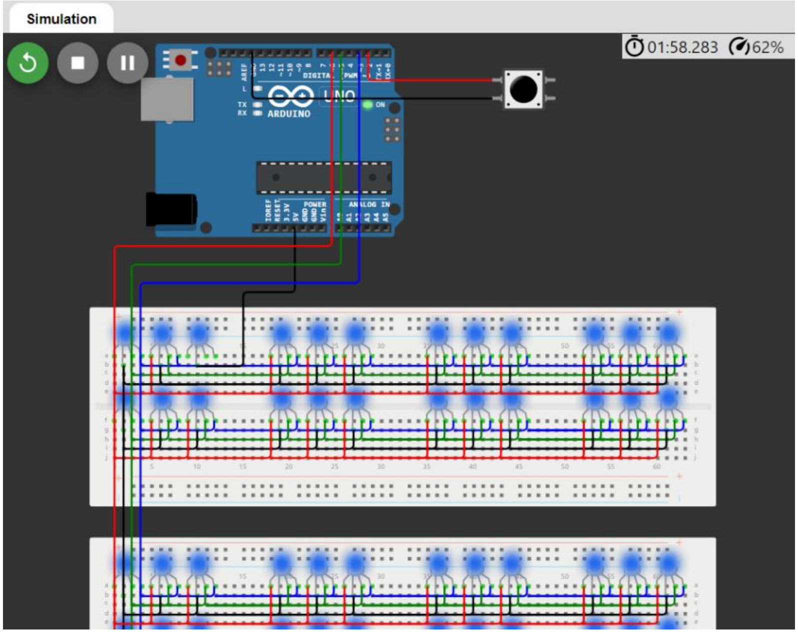


Figure 4.5 Simulation of LED Lamp Blue Color

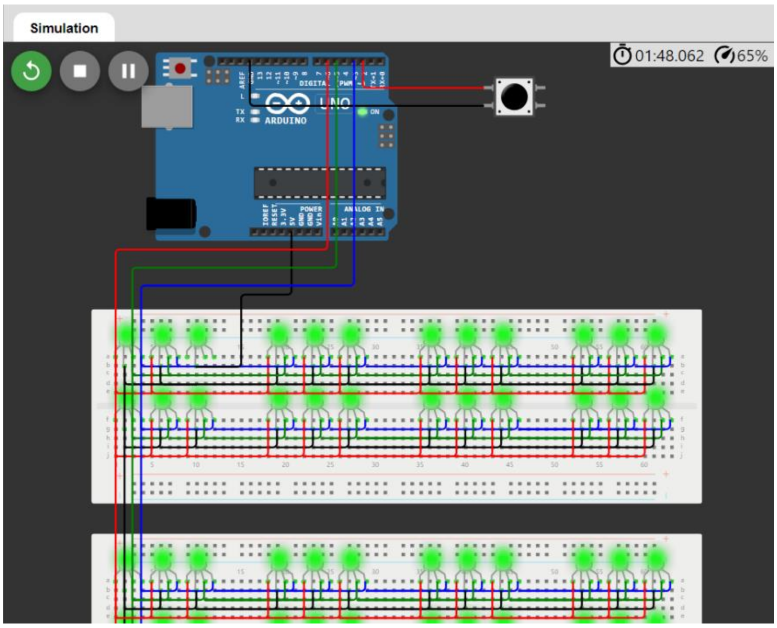


Figure 4.6 Simulation of LED Lamp Green Color

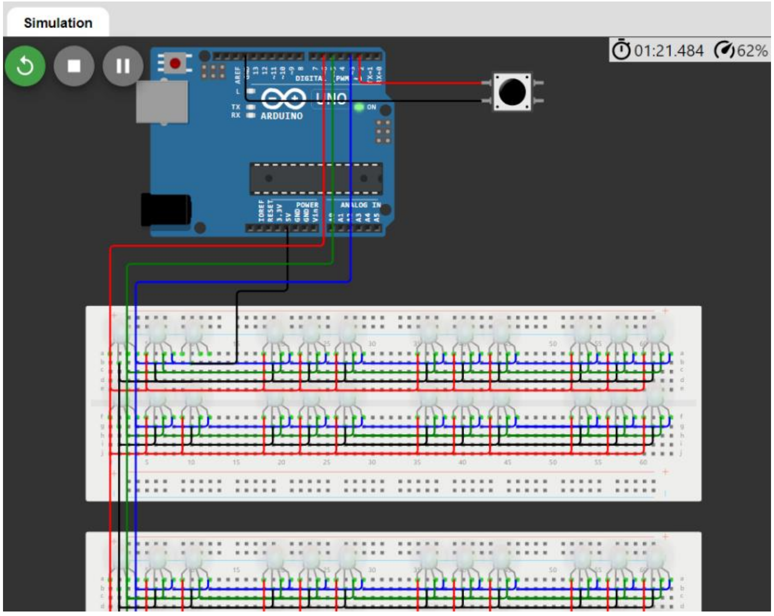


Figure 4.7 Simulation of LED Lamp White Color

Figures 4.4 to 4.7 illustrate the simulation of the multi-colored LED lamp in red, blue, green, and white colors using Wokwi.com, an online simulator for ESP32, STM32, and Arduino microcontrollers. These simulations demonstrate the functionality and behavior of the LED lamp under different color settings. Wokwi.com provides a robust platform for testing and validating the electronic components and their interactions within the system, ensuring that the design performs as expected before physical implementation. Each figure corresponds to a specific color simulation, showcasing the LED lamp's ability to switch between various colors efficiently, which is a critical aspect of the overall design. This step is essential for verifying the control logic and the stability of the LED outputs when subjected to different input commands.

Calculating power for each LED

$$P = V \times I$$

- Power per LED color

$$P_{red} = 2.4V \times 0.02A = 0.048W$$

$$P_{green} = 3.4V \times 0.02A = 0.068W$$

$$P_{blue} = 3.2V \times 0.02A = 0.064W$$

- Total Power per LEDs

$$P_{total} = P_{red} + P_{green} + P_{blue}$$

$$P_{total} = 0.048W + 0.068W + 0.064W = 0.18W$$

- Total Power for 500 LEDs

$$P_{total} = 0.18W \times 500 = 90W$$

Calculating Current

Calculation of the design LED Lamp multi-colored parameter is shown at Table 4.3, through these stages:

Total Current for 500 parallel:

$$I_{total} = 500 \times 20mA = 10000mA = 10A$$

Calculating Battery Capacity for 12 hours

$$Capacity\ (Ah) = I_{total} \times Operating\ Time\ (hours)$$
$$Capacity\ (Ah) = 10\ A \times 12\ hours = 120Ah$$

Table 4.3. Calculation of the design LED Lamp multi-colored

No	Description	Required
1	Total Lumens	6000
2	Number of LEDs Chosen	500 LEDs
3	Circuit Type	500 Parallel strings
4	Total Power	90 W
5	Total Current	10A
6	Battery Capacity (12 hours)	120 Ah, 3.7 V
7	Battery Charger	5V, 10A

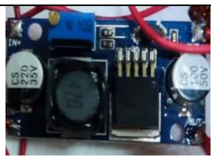
4.1.3 **Tools and materials used for multi-colored LED lamping (including costs involved)**

Tool and Materials

The description of tools and materials used in the design of LED Lamp multi-colored is shown at Table 4.4. and comparison between floating bagan, single color lamp, single color LED strip, and LED Lamp multi-colored is shown in Table 4.5.

Table 4.4. The description of tools and materials used in the design of LED Lamp multi-colored

No	Tools & Materials	Figure	Quantity	Source
1	LED RGB 4P		500	Shopee
2	PCB Board (7x18 cm)		7	Local Store

No	Tools & Materials	Figure	Quantity	Source
3	Transistor		3	Local Store
4	Battery 3.7V, 8.8Ah		16	Local Store
5	Arduino Uno		1	Shopee
6	Acrylic Tube		1	Local Making
7	Regulator DC Step-Up		1	Shopee
8	Cable		6 (meter)	Local Store

Source: Online and Local Market

Table 4.5. The Comparison between floating bagan, single color lamp, single color LED strip, and LED Lamp multi-colored

	Floating Bagan	Multi-colored LED LED (this study)
Lamp Type	LED lamp (white)	LED 4 pin
Power (Watt)	280 (35x8)	90
Operational duration (hours)	11-12	11-12
Luminance (cd/m2)	3500	6000
Power source	Genset	Battery
Total fish catch (kg)	20.1	54.7

4.1.4 Cost Calculation of Multi-colored LED Lamp

Calculation of multi-colored LED Lamp is divided into two sections: Capital cost for tools and materials and operational cost, described at Table 4.6 and Table 4.7.

Table 4.6. Capital Cost for tools and materials of LED Lamp

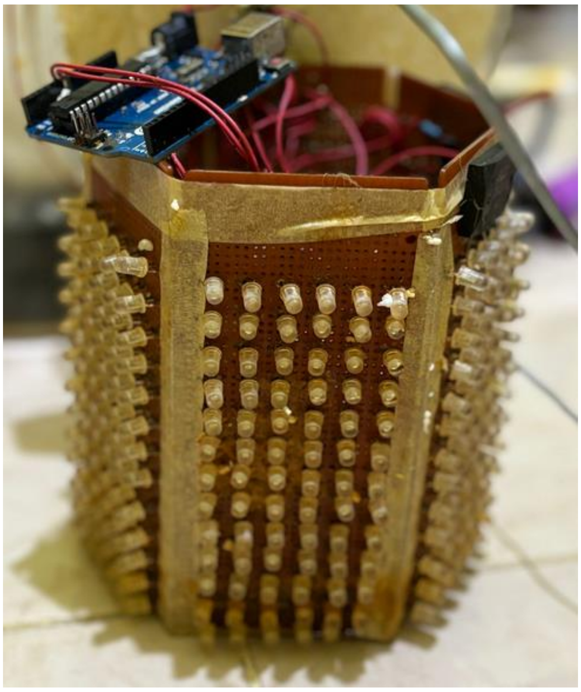
No	Tools & Materials	Quantity	Price per unit (Rp.)	Total Price (Rp.)
1	LED RGB 4P	500	400	200,000
2	PCB Board (7x18 cm)	7	6,000	42,000
3	Transistor	3	30,000	90,000
4	Arduino Uno	1	57,500	57,500
5	Battery 3.7V, 6Ah	16	13,750	220,000
6	Acrylic Tube	1	284,000	284,000
7	Regulator DC Step-Up	4	13,900	13,900
8	Cable (in meter)	6	10,000	60,000
9	Battery Charger	1	90,000	90,000
	Total			**1,057,400**

Table 4.7. Operational Costs of LED Lamp

No	Description	Unit	Quantity	Price per unit (Rp.)	Total price	Elucidation
1	Electricity cost per day	kwh	1.08 (90-watt x 12 hour)	1,445	1,560.6	PLN Price Tariff May 2024 (the assumption is that the middle price is taken)
2	Gasoline cost per day	L	8	10,000	80,000	

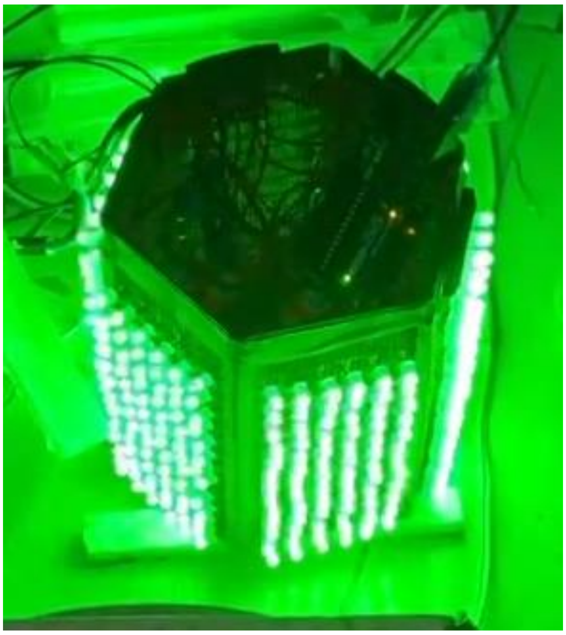
4.1.5 The multi-colored LED lamp

After passing several steps in designing, finally we can make the multi-colored LED lamp, as shown in Figure 4.8. Figure 4.8 (a) shows the multi-colored LED lamp on standby, (b) in operation with red color, (c) in operation with green color, and (d) in operation with blue color.



(a) LED multi-colored on standby

(b) red color LED in operation



(b) green color LED in operation

(d) blue color LED in operation

Figure 4.8 The multi-colored LED lamp developed in this study

4.2 The performance of multi-colored LED lamps for attracting and collecting fish catches in fisheries production

4.2.1 Illuminance of muticolor LED

One performance of multi-colored LED lamp is characterized by illuminance. For this study, measuring the multi-colored LED lamp illuminance with two conditions, as shown in Table 4.8.

Table 4.8. the illuminance of multi-colored LED Lamp

No.	COLOR	**Lamp Above Water Surface (50 cm)**		**Lamp at Water Surface (0 cm)**
		Illuminance at water surface (Lux)	Illuminance below water 50 cm (Lux)	Illuminance below water 50 cm
1	WHITE	1923	914	1828
2	RED	372	167	289
3	GREEN	1117	502	1036
4	BLUE	838	377	812

Table 4.8 illustrates that illuminance values exhibit considerable variation contingent on the lamp's position in relation to the water surface and the color of the light. When the lamp is situated at a height of 50 cm above the water surface, the illuminance at the water surface is 1923 lux for white, 372 lux for red, 1117 lux for green, and 838 lux for blue. However, due to the reflection at the water surface, which typically ranges from 50% to 90%, the illuminance values below the water surface (at 50 cm depth) decrease to between 914.78 lux and 182.90 lux for white, 167 lux for red, 502 lux for green, and 377 lux for blue. When the lamp is situated at

the water surface, the illuminance values observed at a depth of 50 cm below the surface are 1828.52 lux for white, 289 lux for red, 1036 lux for green, and 812 lux for blue. This indicates an exponential absorption effect within the water. The penetration of white, red, green, and blue light waves into water is affected by their respective wavelengths. Shorter wavelengths (blue and green) generally penetrate deeper than longer wavelengths (red), which influences the observed illuminance values at different depths.

4.2.2 Number of fish caught

Tables 4.9 to 4.12 show data on fish catches grouped by type of lamp and type of fish. On the first day of fishing, a multi-colored LED lamp leaking caused a problem, so fishing was only carried out using white LED lamp, usually used by fishermen. On the second day and thereafter, we used multi-colored LED lamp to collect and catch fishes as previously planned. We group the fish catch based on the range of time and they are name by haul I (19.00-20.30), haul II (21.00-22.30), haul III (23.00-01.00), haul IV (01.30-03.30), haul V (03.30-05.00), and haul VI (05.10-06.10). However, when the multi-colored LED lamp is operated on the floating bagan, the haul distribution slightly shifts according to the wind conditions and the fishermen's readiness.

Table 4.9. The number of fish caught on First day's catch (09/07/2024)

No.	Lamp Color	Time	Total Time (minute)	Fish Type	Quantity (kg)	Total quantity (Kg)
1	white	21.00-23.00 (haul II)	120	white anchovies (teri putih)	0.3	5.5
				gayot fish	2.1	
				Bagas fish/ Ekor Kuning (caesionidae)	0.3	
				Largehead hairtail (Ikan Layur)		
				Anchovies (ikan bilis)	1.1	
				pepetek fish	1.7	
Catch Per Time (Kg/Hour)					2.75	
2	white	01.50-03.50 (haul IV)	120	white anchovies (teri putih)	0.2	6.6
				gayot fish	0.4	
				Largehead hairtail (Ikan Layur)	1.1	
				Anchovies (ikan bilis)	3.1	
				pepetek fish	1.8	
Catch Per Time (Kg/Hour)					3.30	
3	white	04.00-05.50 (haul VI)	110	gayot fish	0.8	8
				cendro fish	0.4	
				Anchovies (ikan bilis)	3.8	
				pepetek fish	3	

Catch Per Time (Kg/Hour)	4.37
Average Catch Per Time (Kg/Hour)	3.47
Total fish on first's day (kg)	20.1

From Table 4.9, we can make a diagram which shows the type of fish and its number, as shown in Figure 4.9.

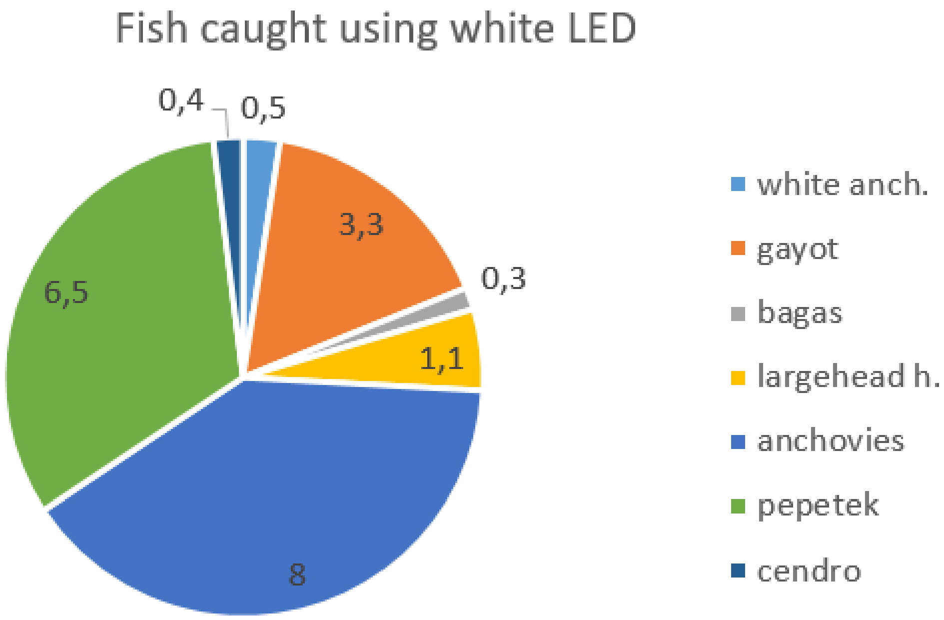


Figure 4.9 Composition of type of fish caught using white LED lamp

In Figure 4.9, we observe the composition of fish caught using a white LED lamp during a fishing expedition in Bagan Apung on the first day. The total weight of the catch is 20.1 kg. The largest proportion of the catch is Anchovies, which weigh 8 kg, making it the most abundant type of fish caught. In contrast, the least abundant is Bagas, weighing only 0.3 kg. Other types of fish caught include White Anchovy at 0.5 kg, Gayot at 3.3 kg, Largehead Hairtail at 1.1 kg, Pepetek at 6.5 kg, and Cendro at 0.4 kg. This data indicates that Anchovies are the predominant species attracted by the white LED lamp, while Bagas is the least attracted.

Table 4.10. The number of fish caught on Second day's catch (10/7/2024)

Lamp Color	**No. of haul**	**Time**	**Total Time (minute)**	**Fish Type**	**Quantity (kg)**	**Total quantity (Kg)**	**Catch per time (Kg/h)**
Red	III	23.50-01.40 Note: for this time, this fisherman usually catches fishes with the small number	110	Largehead hairtail (Ikan Layur- Trichiurus lepturus)	0.5	0.5	0.27

	V	03.30-04.50	80	Largehead hairtail (Ikan Layur)	3.4	15.3	11.50
				pepetek fish	0.3		
				Koleang awi	11.1		
				Shrimp	0.5		
Green	I	20.30-21.40	70	whitebait (teri putih)	0.3	14	11.97
				gayot fish	0.5		
				Largehead hairtail (Ikan Layur)	1		
				Anchovies (ikan bilis)	3.7		
				Koleang awi	8		
				Shrimp	0.4		
				Squid	0.1		
	IV	02.04-03.20	76	Largehead hairtail (Ikan Layur)	0.6	6.9	5.43
				Anchovies (ikan bilis)	0.8		
				Koleang awi	5.5		
Blue	II	22.20-23.30	70	white anchovies (teri nasi)	0.5	1.8	1.54
				Anchovies (ikan bilis)	0.4		
				Koleang awi	0.9		
	VI	05.00-05.55	55	white anchovies (teri nasi)	0.5	2.9	3.15
				bagas	0.4		
				Largehead hairtail (Ikan Layur)	0.2		
				Koleang awi	1.8		
	Total time			**Total fish**		**41.4**	

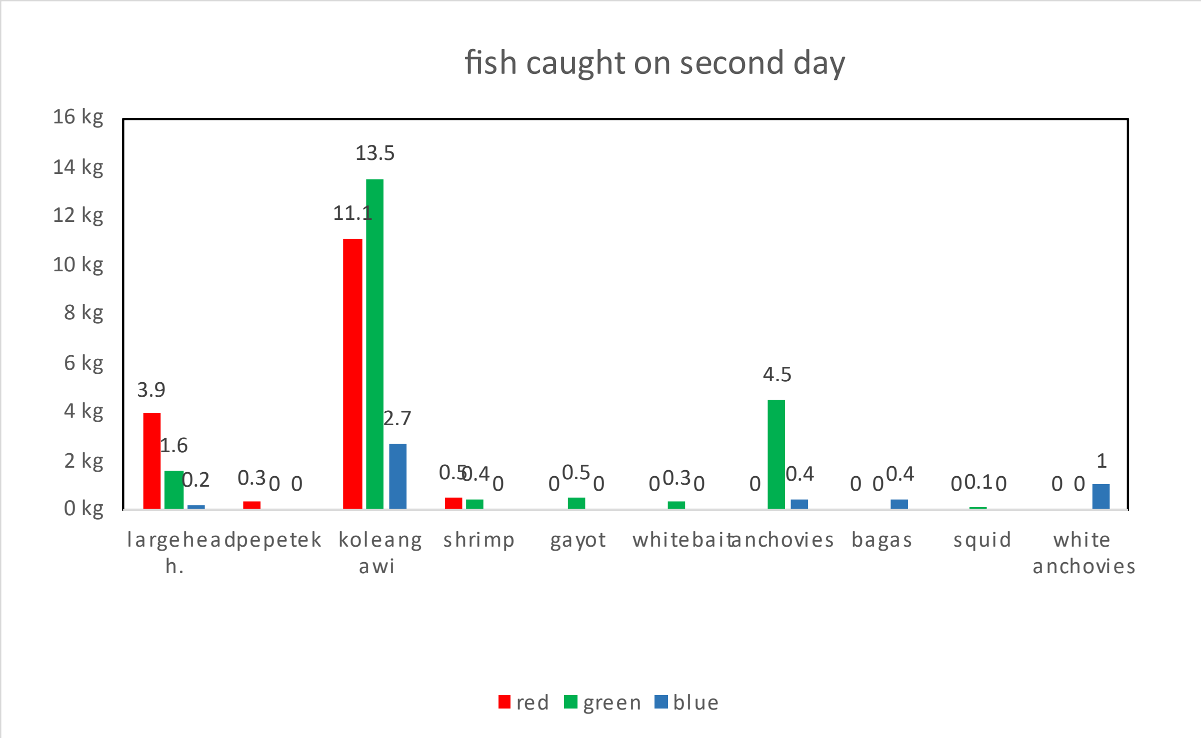


Figure 4.10 Comparison type of fish based on LED color on second day

Based on Figure 4.10, we can observe that on the second day, koleang awi were predominantly attracted to the green color LED, with a catch of 13.5 kg, followed by the red LED with 11.1 kg, and the blue LED with 2.7 kg. Largehead hairtail showed a preference for the red LED, with a catch of 3.9 kg, compared to 1.6 kg with the green LED and 0.2 kg with the blue LED. Anchovies were more attracted to the green LED, with a catch of 4.5 kg, while none were caught with the red and blue LEDs. Other species such as shrimp, gayot, and white anchovies had relatively low catches, with shrimp catches being 0.5 kg for both red and blue LEDs and 0.4 kg for the green LED.

Because of the fact that fisherman usually get fish with small number in the range of time 00.00-02.00, then we conduct the research in the time as shown in table 4.11 and 4.12.

Table 4.11. The number of fish caught on third day's catch (11/07/2024)

Lamp Color	No. of haul	Time	Total Time (minute)	Fish Type	Quantity (kg)	Total quantity (Kg)	Catch per time (Kg/h)
Red	I	19.20-20.50	90	whitebait (teri putih)	0.5	15.7	10.47
				gayot fish	0.8		
				Largehead hairtail (Ikan Layur)	1.8		
				Anchovies (ikan bilis)	3.9		
				Koleang awi	6.9		
				Shrimp	0.8		
				Squid	1.0		

	IV	01.50-03.20	90	Largehead hairtail (Ikan Layur)	0.9	8.4	5,6
				pepetek fish	1.4		
				Koleang awi	4.8		
				Anchovies (ikan bilis)	1.3		
Green	II	21.00-22.30	90	whitebait (teri putih)	0.7	16.2	10.8
				gayot fish	1.8		
				Largehead hairtail (Ikan Layur)	1.2		
				Anchovies (ikan bilis)	3.3		
				Koleang awi	7.6		
				Shrimp	0.7		
				Squid	0.9		
	V	03.40-05.00	80	Largehead hairtail (Ikan Layur)	3.1	13.9	10.45
				Anchovies (ikan bilis)	1.1		
				Koleang awi	9.7		
Blue	III	22.40-00.10	90	white anchovies (teri nasi)	1.2	6.8	4.53
				Anchovies (ikan bilis)	0.8		
				Koleang awi	1.4		
				Largehead hairtail (Ikan Layur)	3.4		
	VI	05.10-06.10	60	white anchovies (teri nasi)	0.5	4.8	4.8
				bagas	1.1		
				Largehead hairtail (Ikan Layur)	0.8		
				Koleang awi	1.7		
				Shrimp	0.7		
Total time				**Total fish**		**65.8**	

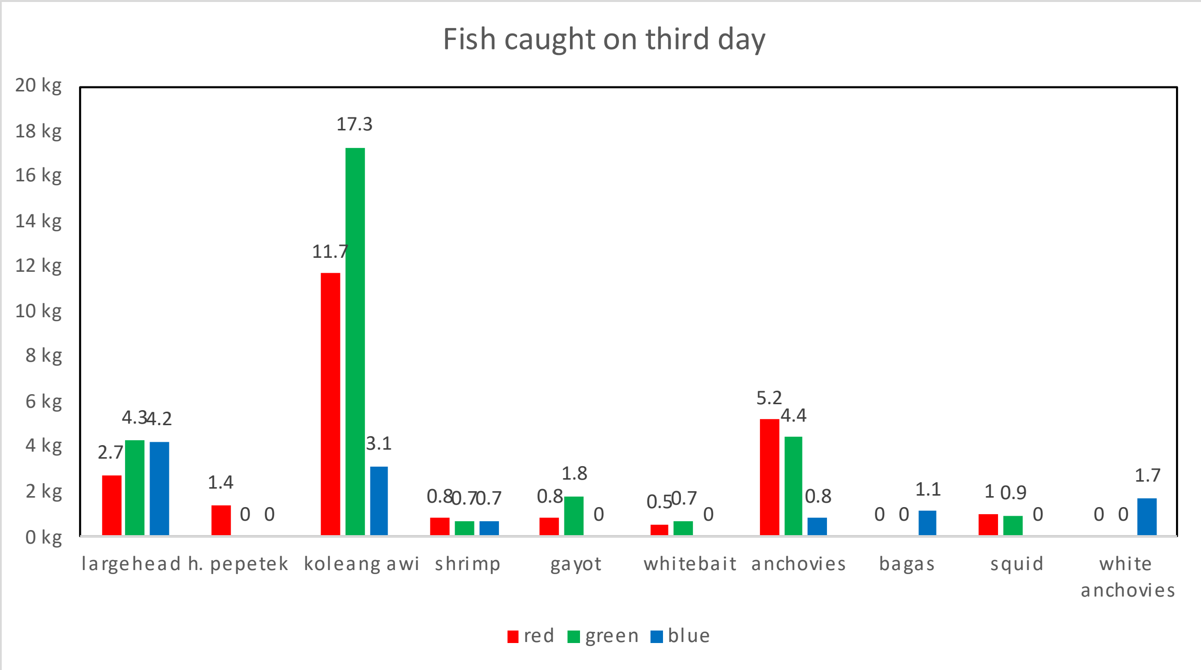


Figure 4.11 Comparison type of fish based on LED color on third day

Based on Figure 4.11, we can see that on the third day, koleang awi were more attracted to the green color LED, as well as largehead hairtail, which showed higher catches with the green LED compared to red and blue LEDs. Specifically, 17.3 kg of koleang awi and 4.3 kg of largehead hairtail were caught with the green LED, compared to 11.7 kg and 2.7 kg with the red LED, and 3.1 kg and 3.2 kg with the blue LED, respectively. Anchovies, on the other hand, were more attracted to the red color LED, with 5.2 kg caught compared to 4.4 kg with the green LED and 0.8 kg with the blue LED. Other species, such as shrimp, gayot, and white anchovies, showed relatively low catches across all LED colors, with shrimp catches being 0.8 kg with the red LED, 0.7 kg with the green LED, and 0.7 kg with the blue LED.

Table 4.12. The number of fish caught on Fourth day's catch (12/07/2024)

Lamp Color	**No. of haul**	**Time**	**Total Time (minute)**	**Fish Type**	**Quantity (kg)**	**Total quantity (Kg)**	**Catch per time (Kg/h)**
Red	II	21.00-22.30	90	whitebait (teri putih)	0.5	14.8	9.87
				gayot fish	0.7		
				Largehead hairtail (Ikan Layur)	1		
				Anchovies (ikan bilis)	3.9		
				Koleang awi	8.1		
				Shrimp	0.4		
				Squid	0.2		
	V	03.40-05.00	80	Largehead hairtail (Ikan Layur)	2.1	9.4	7.07

				pepetek fish	3.8		
				Koleang awi	1.6		
				Anchovies (ikan bilis)	1.9		
Green	III	22.40-00.10	90	Largehead hairtail (Ikan Layur)	1.8	8.9	5.93
				Anchovies (ikan bilis)	1.3		
				Koleang awi	5.8		
	VI	05.10-06.10	60	Largehead hairtail (Ikan Layur)	3.4	6.9	6.9
				Gayot fish	0.5		
				Anchovies (ikan bilis)	1.2		
				Koleang awi	1.8		
Blue	I	19.20-20.50	90	white anchovies (teri nasi)	1.3	11.4	7.6
				Anchovies (ikan bilis)	1.8		
				Koleang awi	3.5		
				Largehead hairtail (Ikan Layur)	4.9		
	IV	01.50-03.20	90	white anchovies (teri nasi)	1.0	5.7	3.8
				bagas	0.2		
				Largehead hairtail (Ikan Layur)	0.8		
				Koleang awi	2.9		
				Shrimp	0.8		
Total time				**Total fish**		**57.2**	

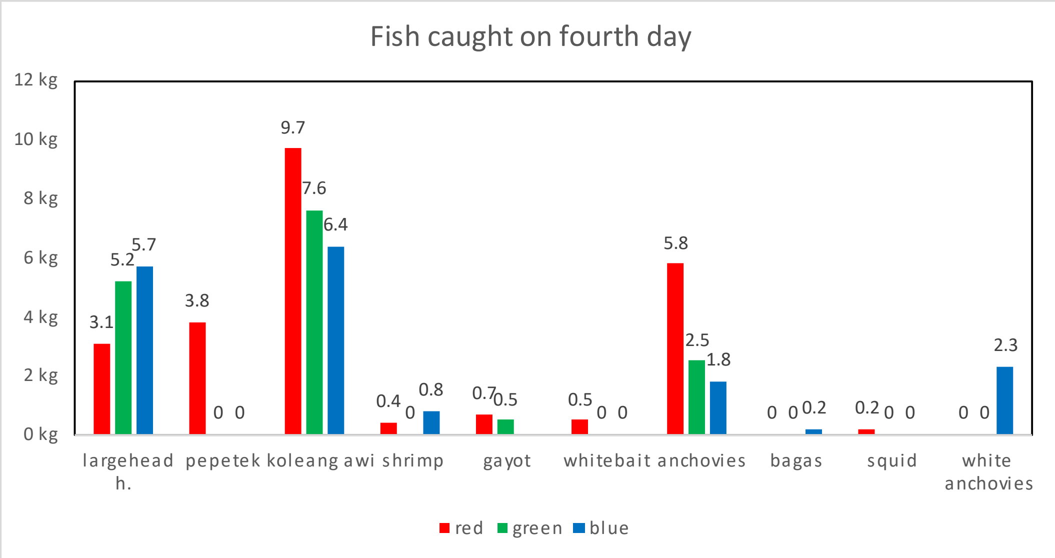


Figure 4.12 Comparison type of fish based on LED color on fourth day

Figure 4.12 shows the fish catch data for the fourth day. On this day, largehead hairtail were more attracted to the red LED, with a catch of 5.7 kg, followed by 5.2 kg with the blue LED, and 3.1 kg with the green LED. Koleang awi showed a higher preference for the red LED as well, with a catch of 9.7 kg, compared to 7.6 kg with the green LED and 6.4 kg with the blue LED. Anchovies were predominantly attracted to the red LED, with a catch of 5.8 kg, while the blue LED resulted in 2.5 kg, and the green LED caught 1.8 kg. Other species such as shrimp, gayot, and white anchovies showed lower catches, with white anchovies being more attracted to the blue LED at 2.3 kg.

Similar to Figure 4.9, we can analyze the type of fish and its weight using table 4.10-4.12, and it is described in Figure 4.13.

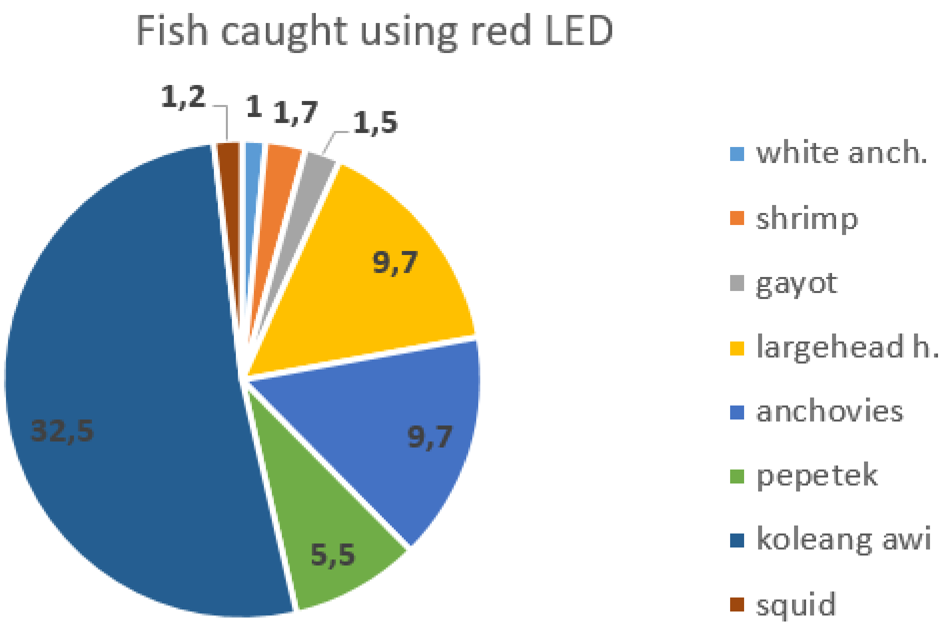


Figure 4.13 Composition of type of fish caught using red LED lamp (the number is in kg)

In Figure 4.13, we observe the composition of fish caught using a red LED lamp during a fishing expedition in Bagan Apung over three days. The total weight of the catch is 64.1 kg. The largest proportion of the catch is Koleang Awi, which weighs 32.5 kg, making it the most abundant type of fish caught. In contrast, the least abundant is White Anchovy, weighing only 1 kg. Other types of fish caught include Shrimp at 1.7 kg, Gayot at 1.5 kg, Largehead Hairtail at 9.7 kg, Anchovies at 11 kg, Pepetek at 5.5 kg, and Squid at 1.2 kg. This data indicates that Koleang Awi is the predominant species attracted by the red LED lamp, while White Anchovy is the least attracted.

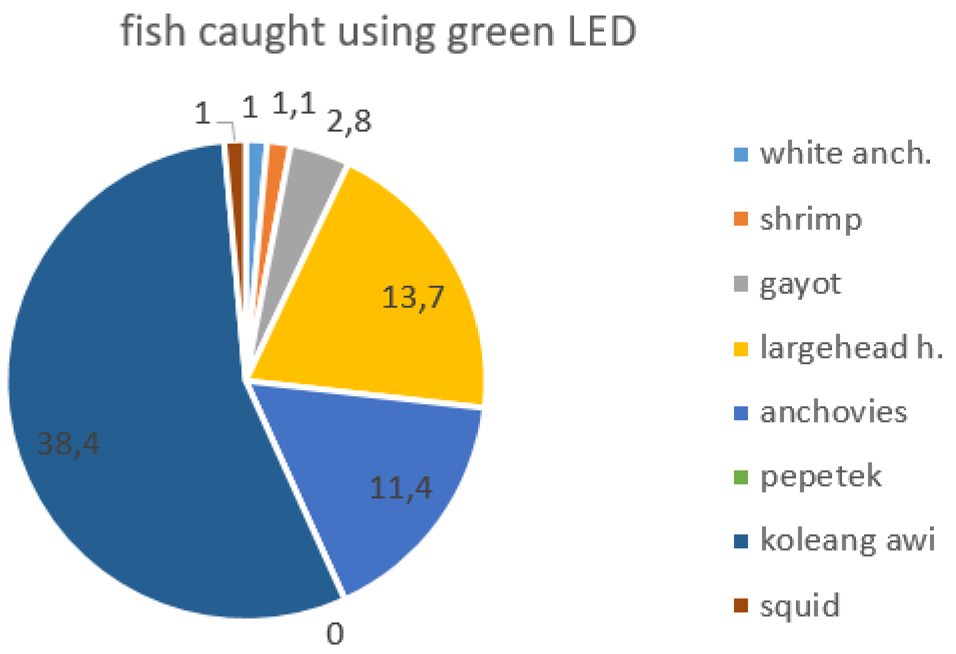


Figure 4.14 Composition of type of fish caught using green LED lamp (the number is in kg)

In Figure 4.14, we observe the composition of fish caught using a green LED lamp during a fishing expedition in Bagan Apung over three days. The total weight of the catch is 69.4 kg. The largest proportion of the catch is Koleang Awi, which weighs 38.4 kg, making it the most abundant type of fish caught. In contrast, the least abundant is White Anchovy, weighing only 1 kg. Other types of fish caught include Shrimp at 1.1 kg, Gayot at 2.8 kg, Largehead Hairtail at 13.7 kg, Anchovies at 11.4 kg, and Squid at 1 kg. This data indicates that Koleang Awi is the predominant species attracted by the green LED lamp, while White Anchovy is the least attracted.

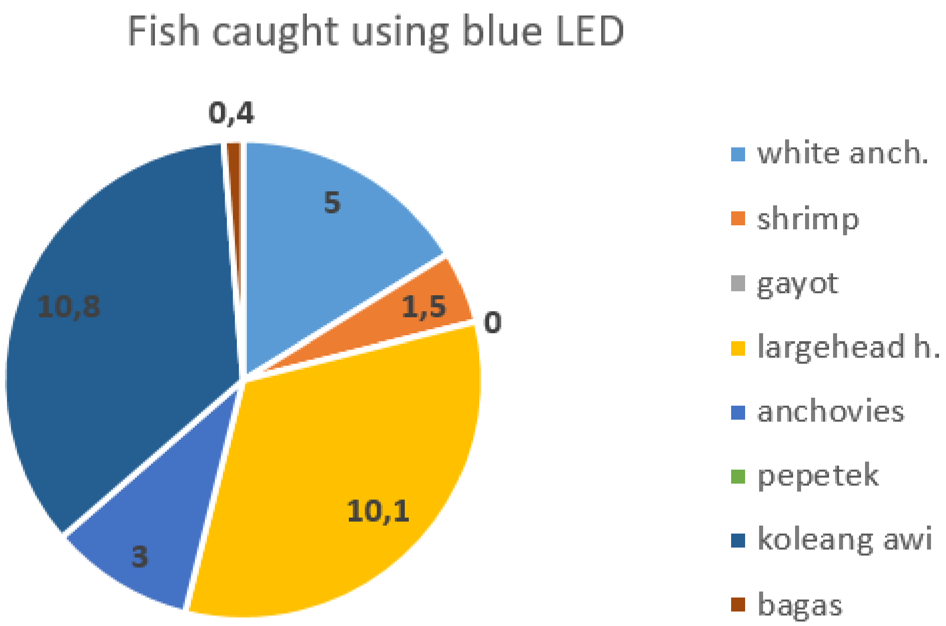


Figure 4.15 Composition of type of fish caught using blue LED lamp (the number is in kg)

In Figure 4.15, we observe the composition of fish caught using a blue LED lamp during a fishing expedition in Bagan Apung over three days. The total weight of the catch is 30.8 kg. The largest proportion of the catch is Koleang Awi, which weighs 10.8 kg, making it the most abundant type of fish caught. In contrast, the least abundant is Bagas, weighing only 0.4 kg. Other types of fish caught include White Anchovy at 5 kg, Shrimp at 1.5 kg, Largehead Hairtail at 10.1 kg, and Anchovies at 3 kg. This data indicates that Koleang Awi is the predominant species attracted by the blue LED lamp, while Bagas is the least attracted.

Based on figure 4.13-4.15, it can be seen that the most fish which can be caught by multi-colored LED lamp are: largehead hairtail, anchovies, and koleang awi. If we analyze the performance of each color in multi-colored LED lamp in catching fish per hour, it can be concluded that green LED has the best performance, as shown in Figure 4.16. The data in Figure 4.16 is summarized from Table 4.9-4.12.

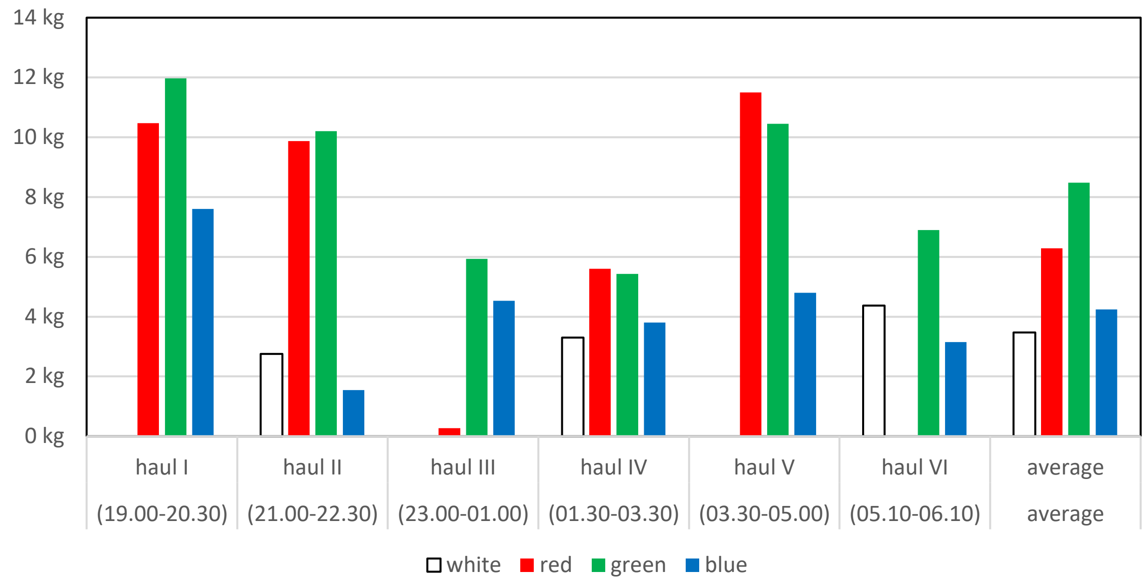


Figure 4.16 The performance of each color in multi-colored LED and white LED lamp

Figure 4.16 shows the performance of each color in multi-colored LED and white LED lamp in which is characterized by its performance in catching fish per hour. For each haul, red and green LED have a good performance compared to blue and white LED. The explanation for this can be attributed to the wavelength of light that is comfortable or attractive to the eyes of fish.

Fish have different sensitivities to various wavelengths of light, which is influenced by the structure and function of the photoreceptors in their eyes. Red (about 620-750 nm) and green (about 495-570 nm) wavelengths of light tend to be more effective in attracting fish than blue (about 450-495 nm) and white (which is a mixture of various wavelengths) wavelengths (Helfman et al, 2009).

Studies have shown that many fish species are more responsive to green light because their eyes have more photoreceptors that are sensitive to these wavelengths. This increases the visibility and attractiveness of green LED lights in certain water conditions, ultimately improving fishing efficiency. Green wavelengths of light have been demonstrated to be the most attractive to plankton. Plankton represents a primary food source for many baitfish, and when plankton congregate in the illuminated regions of the water column, baitfish are observed to migrate in order to partake of the abundant food source. These results are also in line with research conducted by Bryhn et al (2014).

4.3 The responses from the fishermen on how ease of using the multi-colored LED Lamp

Table 4.13 shows the response from the fishermen on how ease of using the multi-colored LED Lamp.

Table 4.13. The response from the fishermen on how ease of using the multi-colored LED Lamp.

No	Part 1 Respondent Information		
1	Duration of being a bagan fisherman	:	20 years
2	Gender	:	male
3	Catch Location	:	Binuangeun beach
	Section 2 Experience and Knowledge		
4	Experience and use of multi-colored LED lamps	:	0 years
	Section 3 Effectiveness		
5	Effectiveness of lamp use	:	Effective; fish caught using multi-colored LED lamp bigger compared with white LED.
6	Type of fish	:	Koleang awi, largehead hairtail, and anchovies
	Section 4 Constraints, Suggestions, and Recommendations		
7	Constraints	:	leaks when immersing the multi-colored LED lamp in seawater
8	Recommendations	:	It's very strongly recommended for fishermen to use multi-colored LED lamp.
9	Suggestions or Comments	:	The case must be more watertight; If damage occurs, it is easy to repair. The LED circuit can be waterproof

From Table 4.13 it can be concluded that the multi-colored LED lamp has shown significant advantages for use in fishing operations at Binuangeun beach. The respondent, with 20 years of experience as a bagan fisherman, indicated that the multi-colored LED lamps are highly effective, particularly noting that the fish caught using these lamps tend to be larger compared to those caught with white LED lamps. The respondent identified several types of fish that are more attracted to the multi-colored LED lamps, including Koleang awi, largehead hairtail, and anchovies.

However, there are some constraints associated with the use of these lamps, such as leakage issues when the lamp is submerged in seawater. Despite this, the respondent strongly recommends the use of multi-colored LED lamps to other fishermen due to their effectiveness. Suggestions for improvement include ensuring the lamp casing is more watertight and making the LED circuit waterproof, as well as making repairs easy if damage occurs. Overall, the multi-colored LED lamp is considered a beneficial tool for enhancing fishing efficiency and reducing operational costs.

CHAPTER 5 CONCLUSION AND SUGGESTION

5.1 Conclusion

1) The multi-colored LED lamp design has the following characteristics: (a) Arduino Uno is used as a microcontroller in the multi-colored LED design, (b) the target lumens for the multi-colored LED is 6000, (c) the number of LED lamps required is 499, (d) the total power of multi-colored LED lamp is 90 watts, (e) the battery capacity required is 120 Ah. On the other hand, the calculated cost of making multi-colored LEDs is IDR. 1,057,400,00 and the monthly operational costs are Rp. Rp. 46,808.28.
2) The performance of the multi-colored LED lamp shows that the fish caught using multi-colored LED lamps is better than the fish caught using white LED lamp, judging from the type of fish and the weight of the fish caught. Specifically, the comparison of daily catch weight shows significant improvements: the catch increased by 105.97% on the second day (41.4 kg) compared to the first day (20.1 kg), by 227.36% on the third day (65.8 kg), and by 184.08% on the fourth day (57.2 kg). Additionally, when comparing the white LED to each color of the multi-colored LEDs, the catch weight increased by 218.41% for red LEDs (64.1 kg), by 245.77% for green LEDs (69.4 kg), and by 53.23% for blue LEDs (30.8 kg). These results clearly demonstrate the enhanced performance of multi-colored LED lamps in increasing fish catches.
3) In addition, Bagan fishermen responded positively to using multi-colored LED lamps in fishing. Thus, the results of this research are expected to be useful for increasing fish catches among Bagan fishermen in Lebak Regency by using multi-colored LED dipping lights.

5.2 Suggestion

1) Further studies are needed in making multi-colored LED lamp case because during the first test, there was a leak due to seawater pressure.
2) It is recommended to make detailed calculations of the mass of the multi-colored LED lamp to ensure that it can be submerged. The buoyancy and weight distribution need to be precisely balanced in order to maintain the stability and functionality under water.
3) It is recommended that the design of the multi-colored LED lamp be explored with a particular focus on adjustable lumens, with the objective of addressing the varying lighting needs that may be required. Furthermore, it would be beneficial to consider a design that allows all colors of the lamp to be turned on simultaneously, rather than one color at a time, with the aim of providing more versatile and dynamic lighting options.

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ATTACHMENTS

Attachment 1. The instrument of responses from the fishermen on how ease of using the multi-colored LED Lamp

Petunjuk:

Mohon isi kuesioner berikut ini dengan jujur dan lengkap. Data yang Anda berikan akan sangat berguna untuk penelitian kami. Terima kasih atas partisipasinya.

Bagian 1: Informasi Responden

1. Nama:
   Suhro
2. Lama menjadi nelayan bagan:
   Kurang lebih 20 tahun
3. Jenis Kelamin:
   - Laki-laki
   - ~~Perempuan~~
4. Lokasi Penangkapan:
   Pantai Binuangeun, Malingping, Lebak, Banten

Bagian 2: Pengalaman dan Pengetahuan

5. Apakah Anda pernah mendengar tentang lampu LED multi-colored untuk penangkapan ikan?
   - ~~Ya~~
   - Tidak
6. Apakah Anda pernah menggunakan lampu LED multi-colored untuk penangkapan ikan?
   - ~~Ya~~
   - Tidak
7. ~~**Jika ya**, sudah berapa lama Anda menggunakan lampu LED multi-colored?~~
   - ~~Kurang dari 1 bulan~~
   - ~~1-3 bulan~~
   - ~~3-6 bulan~~
   - ~~Lebih dari 6 bulan~~

   Jika tidak, alat bantu apa yang biasa Anda gunakan selama ini?
   - Lampu Petromak
   - Lampu LED, warna putih 35 watt, 8 buah lampu

Bagian 3: Persepsi dan Efektivitas

8. Apakah alat bantu yang anda gunakan tersebut efektif (memberikan hasil yang baik)?
   - Ya, dalam hasil tangkapan hampir sama, pembedanya kalau lampu petromak jika ditinggal tidur lampu akan mati, sedangkan lampu LED akan terus menyala.
   - ~~Tidak~~

10. Jenis ikan apa saja yang lebih banyak tertarik dengan penggunaan lampu LED multi-colored?
    (Isikan jenis-jenis ikan): ikan koleang awi, ikan bilis, pepetek, dan ikan layur
11. Apakah penggunaan lampu LED multi-colored meningkatkan hasil tangkapan Anda?
    - Ya
    - ~~Tidak~~
12. Bagaimana pengaruh penggunaan lampu LED multi-colored terhadap biaya operasional penangkapan ikan?

- Menurun sangat jauh (250rb banding 2rb)
- ~~Tetap~~
- ~~Meningkat~~

Bagian 4: Kendala dan Rekomendasi

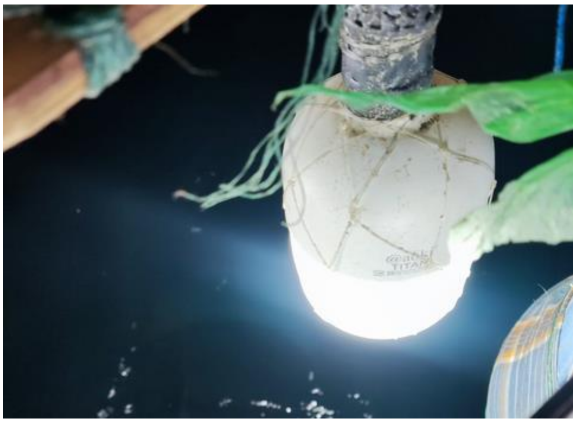
13. Apa saja kendala yang Anda hadapi dalam penggunaan lampu LED multi-colored?
    - Kendala teknis (kerusakan lampu akibat air rembes)
    - ~~Biaya (misalnya, harga lampu, biaya perawatan)~~
    - ~~Kurangnya pengetahuan/pelatihan~~
    - Lainnya: (jelaskan)
14. Apakah Anda akan merekomendasikan penggunaan lampu LED multi-colored kepada nelayan lain?
    - Ya
    - ~~Tidak~~
15. Saran atau komentar tambahan tentang penggunaan lampu LED multi-colored dalam penangkapan ikan:
    - Casing harus lebih kedap air,
    - Apabila terjadi kerusakan mudah untuk diperbaiki
    - Rangkaian LED bisa tahan air

Attachment 2. Photos of activities

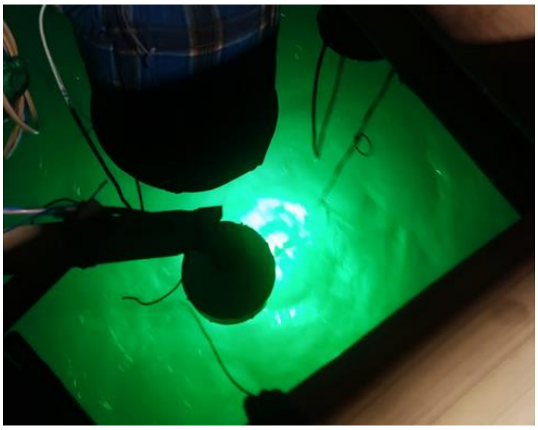
Photo A. Multi-colored LED lamp repair activities

Photo B. Departure of researchers to the Binuangeun floating bagan

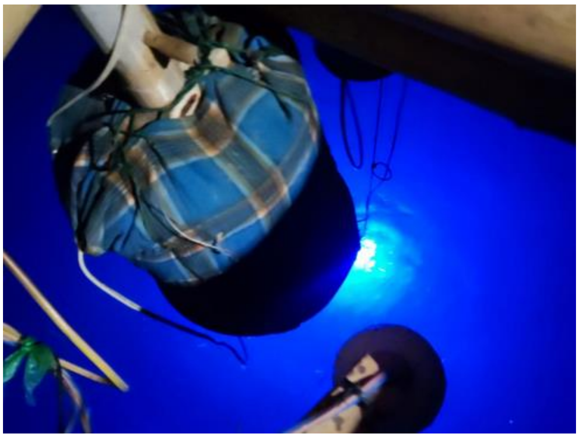
Photo C. The situation in bagan



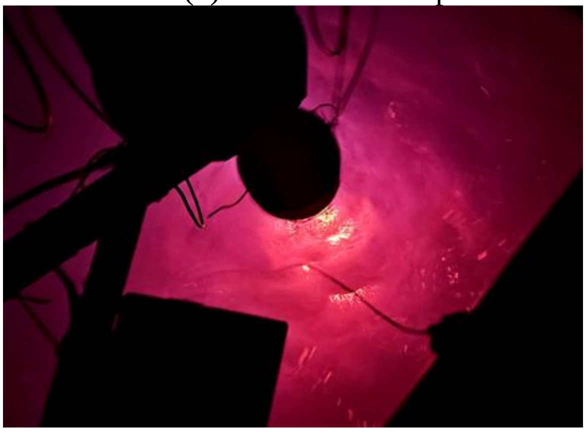
(a) White LED lamp



(b) Green LED lamp



(c) Blue LED lamp



(d) Red lLED lamp

Photo D. Immersion of multi-colored LED lamp into the sea

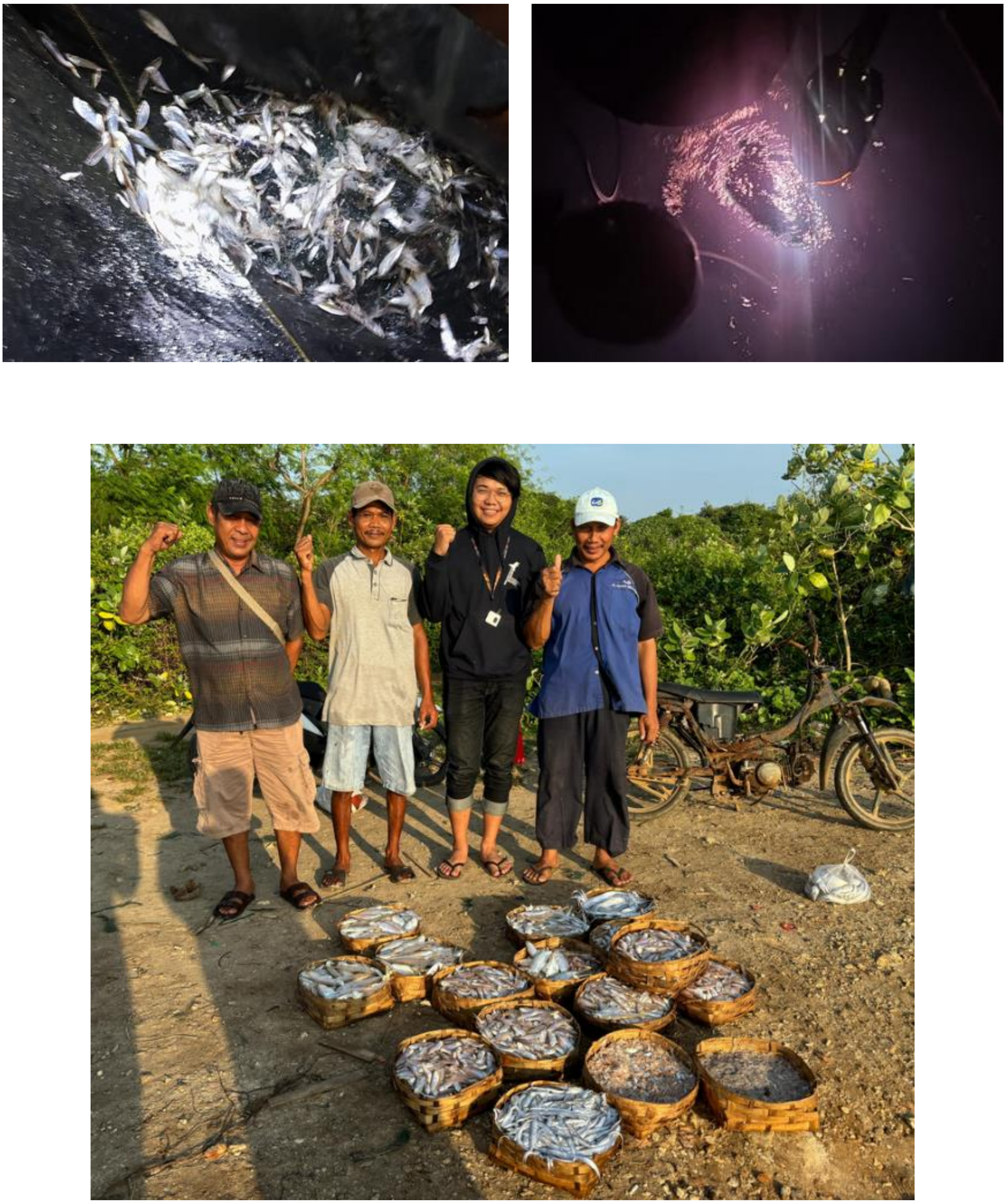


Photo D. Fish caught using multi-colored LED lamp

(a) White anchovies/teri nasi

(b) Bagas

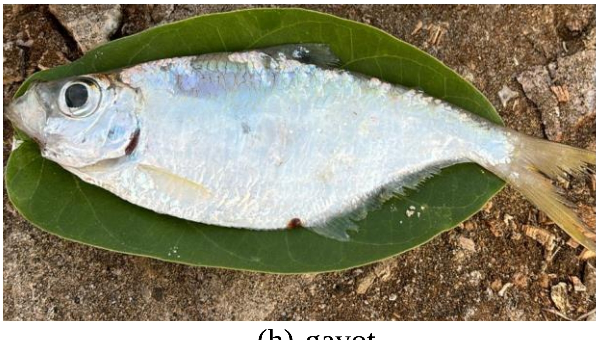
(c) Pepetek

(d) Koleang awi

(e) layur

(f) bilis/ anchovies

(g) Cendro



(h) gayot

Photo E. The types of fish

Author Biography

Rizal Abdurrazaq, born in Bandung on September 28, 2001, is the youngest son and has two older brothers. His last formal education was at SMA Taruna Bakti, Bandung from 2017 to 2020. During the writing of this bachelor thesis, he pursued an undergraduate degree in Marine Engineering at Institut Teknologi Sepuluh Nopember and Hochschule Wismar as part of a double degree program. Throughout his academic journey, he gained both academic and non-academic experiences, aligning with his field of study and beyond. Notable academic experiences include his first internship at PT. PAL Indonesia as a Machinery Outfitting Design Student Intern and his second internship at PT. Pertamina EP Cepu Field as a Reliability, Availability & Maintainability Student Intern. In addition to his academic pursuits, he actively participated in various committees and organizations such as Petrolida 2021, and Farewell Party Committee 126 2022.