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Use of Digital Technology in Calculating Water Footprints for Daily-Use Items.

A PROJECT REPORT

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PRESIDENCY SCHOOL OF COMPUTER SCIENCE AND TECHNOLOGY

BONAFIDE CERTIFICATE

Certified that this report "**COMPUTERIZED COGNITIVE RETRAINING FOR HOME TRAINING OF CHILDREN WITH DISABILITIES.**" is a bonafide work of "NIRIKSHA T P (20221CBD0047), YASHODHA Y B (20221CBD0057), BASAVRAJ (20221CBD0015)", who have successfully carried out the project work and submitted the report for partial fulfilment of the requirements for the award of the degree of BACHELOR OF TECHNOLOGY in COMPUTER SCIENCE AND TECHNOLOGY, BIG DATA during 2025-26.

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DECLARATION

We the students of final year B.Tech in COMPUTER SCIENCE AND TECHNOLOGY, BIG DATA at Presidency University, Bengaluru, named NIRIKSHA T P, YASHODHA Y B, BASAVRAJ, hereby declare that the project work titled **"COMPUTERIZED COGNITIVE RETRAINING FOR HOME TRAINING OF CHILDREN WITH DISABILITIES"** has been independently carried out by us and submitted in partial fulfillment for the award of the degree of B.Tech in COMPUTER SCIENCE AND TECHNOLOGY (BIG DATA) during the academic year of 2025-26. Further, the matter embodied in the project has not been submitted previously by anybody for the award of any Degree or Diploma to any other institution.

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Abstract

Water is one of the most essential yet increasingly threatened resources. Rapid urbanization, industrial growth, and lifestyle-driven consumption have pushed freshwater systems closer to exhaustion. Although many individuals are aware of water scarcity, very few understand the hidden water involved in producing the items they use every day—whether it is the fabric of a T-shirt, the processing of packaged foods, or the manufacturing of personal care products. This knowledge gap limits the public's ability to make conscious and sustainable choices.

This project aims to bridge that gap by developing a digital system that calculates and presents the water footprint of commonly used products in a simple and accessible manner. The system leverages Artificial Intelligence to recognize items through camera-based scanning, uses Big Data techniques to store and manage extensive water-footprint datasets, and incorporates Blockchain concepts to ensure transparency, authenticity, and reliability of the stored information. A clean and interactive web interface allows users to either scan a product or search for it manually, instantly receiving accurate water-usage information drawn from verified sources.

The main objective of this work is to transform complex environmental data into meaningful insights that can influence daily decisions. By making water footprints visible and easy to understand, the project encourages responsible consumption, raises awareness about freshwater conservation, and supports educational, environmental, and community-level initiatives. Ultimately, this digital approach demonstrates how emerging technologies can contribute to sustainability, helping society adopt more mindful patterns of resource use.

List of Figures

List of Tables

Abbreviations

AI - Artificial Intelligence

IoT - Internet of Things

DB - Database

API - Application Programming Interface

UI - User Interface

UX - User Experience

ML - Machine Learning

ANN - Artificial Neural Network

CSV - Comma Separated Values

JSON - JavaScript Object Notation

HTTP - Hypertext Transfer Protocol

HTTPS - Hypertext Transfer Protocol Secure

CPU - Central Processing Unit

GPU - Graphics Processing Unit

SDK - Software Development Kit

WFD - Water Footprint Data

CRUD - Create, Read, Update, Delete

NLP - Natural Language Processing

Table of Content

CHAPTER 1
INTRODUCTION

With the rising population, urbanization and increased consumer demand, the freshwater resources are becoming under strain. Although the issue of water scarcity is a common topic among many, little is known by most individuals about the excessive water that is consumed in production of simple items like clothes, packaged foods and household products among others. This rule of disguised consumption causes the inability of people to realize the real efficacy on the environment.

The concept of water footprint offers the means of quantifying overall fresh water consumed in the lifecycle of any product. Nevertheless, the information is not readily available to the masses. In order to overcome this difficulty, this project presents a digital system where the users can easily locate the water footprint of common products by scanning their products in a few seconds or searching them manually.

The system is going to combine artificial intelligence to recognise products and big data to process large amounts of water-footprint data, with blockchain to provide transparency and reliability of the information stored. The platform will create awareness, promote responsible consumption, and assist in making sustainability-related decisions by transforming complicated environmental information into user-friendly insights.

1.1 Background

One of the most vital natural resources, which facilitates life, agrarian practices, industry, and all contemporary ways of life, is water. Nevertheless, increased population growth, industrialization, and climate change have put this and more pressure on freshwater resources across the world. A large proportion of the water that people use in the modern world does not directly reach the consumer; rather it is incorporated in the manufacturing of other goods including clothing, packaged food, electronics and household products. This unseen element is referred to as the water footprint and is the summative amount of freshwater consumed throughout the life cycle of a product- starting with the mining of the raw material up to the manufacturing and transportation.

Awareness of water footprint is low despite the fact that it is important to note. Consumers tend to make decisions without knowing how their habits cause depletion of groundwater and environmental strains. Enhancing the open access of information on water-footprint is consequently critical in promoting sustainable consumption as well as in facilitating the long-term water saving.

1.2 Statistics of the Problem Domain

Scientific research around the world indicates that the world is in a critical stage of freshwater stress:

1.2.1Global Situation

There are approximately 2.3 billion water stressed populations in countries. By the year 2025, water shortage is projected to affect almost half of all global population. The current trends in the world make it possible that by 2030, freshwater demand will surpass supply by 40-percent, unless people change their consumption habits.

Agriculture is the largest contributor of freshwater withdrawal in the world with 70 percent of its freshwater withdrawal being used to grow food products that are consumed by urban users. Water in Products that is not visible.

The daily footprint of water of common things is extremely large:

- 2,700-3,000 liters for one cotton T-shirt
- One half liter of a soda bottle costs 1,500 liters.
- 140 liters of one cup of coffee.
- 10,000-15,000 liters for 1 kg of beef
- 300 liters for a chocolate bar
- 12,000 liters for a pair of jeans

Research indicates that less than 5-8 percent of daily footprint of an individual of water is attributed to visible household activities (bathing, washing, drinking).

Over 90 percent is indirect by way of products.

India's Condition

One of the most rapidly developing water-stressed countries is India:

It drills more groundwater than USA and China. Bengaluru, Delhi, Jaipur, and Chennai are among the cities in the world that are regarded as the most susceptible to face water scarcity. A significant government report tells that 21 major cities may be in danger of running out of groundwater in the near future unless people start consuming water at a slower pace. Awareness Gap Surveys show that: More than 70-percent of consumers are unaware of water footprint. Very few sustainability apps (2-5%) contain information on water-footprint. Majority of the available databases are researcher friendly as opposed to the general population. These statistics emphasize on the need to have a system that makes the data of water-footprints accessible to the everyday user.

1.3 Prior Existing Technologies

1.3 Previous Existing Technologies.

There are a number of tools and resources available in the sustainability field although the majority of them are limited in terms of either accessibility, accuracy or viability.

1.3.1 Research papers and Static Databases.

Such organizations as the Water Footprint Network (WFN) and FAO have big datasets. However: They are mostly text-heavy, Not mobile, not real time oriented.

Impractical to be understood by a non-technical user.

1.3.2 Sustainability Apps Based on Barcodes.

There are apps that offer sustainability rating by scanning barcodes. Their limitations include: Reliance on fixed products database.

Obsolete or unfinished records. Missing data on water-footprint of most Indian products.

1.3.3 AI-Based Recognition Object Recognition Tools.

Image classification models are available based on AI, but they are typically trained on: General objects, Industrial automation Research purposes.

They are not customized to determine consumer goods and their connection with environmental measures.

1.3.4 Government and NGO Websites

These forums give information on awareness, but:

They are also informative but not interactive.

They are concept oriented and not product level oriented.

1.3.5 Portals of Sustainability in E-commerce

Carbon footprints have already been displayed on some international e-commerce websites, and it is not yet the norm with water footprints, particularly in India.

In general, no comprehensive strategy has been developed, which would bring together AI recognition, Big Data, and Blockchain in order to deliver transparent and real-time water-footprint data on daily goods.

1.4 Proposed Approach

The suggested system unites the latest digital technologies to simplify the process of accessing and understanding the water-footprint information. The platform does not use manual searching or technical reports but offers instant and explicit results in a mixture of AI, Big Data, and Blockchain displayed to a user in a simple and easy-to-use interface.

1.4.1 AI-Based Product Detection

The system is based on a trained image-classification model to recognize products when the user scans them with a device camera. The model acquires visual features using a large variety of product images and makes predictions on the most probable item. This saves the user work and the interaction is more natural and efficient. The model can be retrained with time to be more accurate and assist with more types of products.

1.4.2 Database of Water Footprint that is supported by Big Data.

The values of water-footprints of a variety of products are stored in a cloud-hosted database.

Scalable storage has guaranteed rapid access to data, high-level performance, and the ability to scale the dataset due to the availability of new information. The Big Data approaches are used to structure massive data on the environment so that the system can be consistently used as it scales.

1.4.3 Blockchain as a Transparency System.

The project uses the concepts of Blockchain to make sure that its database is updated without fear of manipulation of data to attract trust. The entries are also supported with a proper audit trail to ensure authenticity and transparency and to avert illegal alterations. This instills trust in the fact that the information supplied to the users concerning the environment is accurate.

1.4.4 Easy and Uncomplicated User Interface.

The backend has high-tech technologies but the frontend is developed to be user-friendly and simple to use. A user is able to scan a product or search it manually after which the system will present clear information regarding its water footprint. The interface is oriented on ease of use, and it is all-ages and also first-time user friendly.

1.4.5 Educational and Environmental Impact.

In addition to providing water-footprint values, the system intends to sensitize the population on the invisible water usage. Offering people information in a format that they find easy to comprehend, the platform assists people in making informed decisions and promote more sustainable lifestyles in their daily activities.

1.5 Objectives of the Project

The main goal of this project is to establish an online application that will enable individuals to know the water hidden consumption of daily products. With this aim, the project is geared towards a number of clear and well articulated objectives that will inform the design, development as well as the implementation of the system.

1.5.1 To create a system of AI-based product identification.

Develop a prototype which would be able to identify typical consumer goods by pictures taken with a device camera which would avoid manual searching and offer fast interactive solution.

1.5.2 Building a scaled and maintainable water-footprint database.

Create a cloud-based repository with stored values of water-footprint that can be verified and where the values of a great variety of items are stored, so that they can be accessed quickly, and that they can be easily expanded in the future.

1.5.3 To make data authentic and transparent with the concepts of Blockchain.

Employ the principles of Blockchain to keep updates secure and ensure traceability and non-unauthorized changes, which will help to enhance the confidence of the user in the information about the environment.

1.5.4 In order to create an easy to use and user interface.

Create a basic web based site on which people can scan or search products and easily see their water footprint in a friendly easy to understand format.

1.5.5 To create awareness to the people on environmental issues.

Make current complicated information regarding water-usage more presentable and engaging to spur more responsible usage and awareness of how the things people use in their daily lives influence the freshwater resources.

1.5.6 To facilitate the long-term sustainability objectives.

Connect system to the larger environmental and sustainability efforts, and assist in making communities take more conscious decisions to minimize water consumption.

1.6 Sustainable Development Goals (SDGs)

Fig 1.1- Sustainable development goals

This project covers different UN SDGs, particularly those of responsible consumption, clean water, and climate action. It will contribute to saving water by offering users access to information regarding the water footprint for daily products in support of sustainable consumption habits.

Project addresses few SDGs like:

SDG 6 : Clean Water and Sanitation

The project promotes efficiency and awareness in the consumption of water in various products by being aware of water use and not wasting it when it is not needed.

SDG 12: Production and Responsible consumption

It informs the users about the amount of hidden water usage involved with various products to help them make an eco-friendly choice.

SDG 13 – Climate Action

At the same time, the project indirectly contributes to protection by encouraging water saving and sustainable usage in order to reduce impacts that relate to resource-intensive activities.

SDG 4 : Quality Education

It also provides an educational tool on water use by communicating with the community and schools through easily understandable insights that may inform behavior change.

1.7 Overview of the Project Report

This report unfolds the complete journey of developing a **Digital Water Footprint Calculator**, a system designed to estimate the water consumption behind everyday products by using modern technologies such as AI, Big Data, and cloud-based architectures. Each chapter of the report acts like a stepping-stone—starting from understanding the problem space, moving through design and implementation, and ending at results, implications, and the road ahead.

Chapter 1 introduces the problem background, objectives, and scope of the project, setting the foundation for why water footprint awareness matters in today's resource-strained world.

Chapter 2 presents a comprehensive review of the literature, summarizing existing research, tools, and technological approaches relevant to digital footprint computation.

Chapter 3 describes the methodology and overall system design, including conceptual diagrams, architecture layers, and workflow processes.

Chapter 4 breaks down the work structure through the Work Breakdown Structure (WBS), highlighting task division and project planning.

Chapter 5 details the implementation phase, covering the development environment, algorithms, data models, and integration of AI-based product identification with the water footprint database.

Chapter 6 showcases the user interface design, front-end features, and interaction flow of the application.

Chapter 7 focuses on testing and evaluation, describing how system components were validated for accuracy, reliability, and usability.

Chapter 8 presents the results and discusses how effectively the system performs in real scenarios, along with insights derived from testing.

Chapter 9 examines the social, legal, ethical, and sustainability implications of deploying such a technology in the real world.

Chapter 10 concludes the report and outlines future enhancements, including scalability, multi-language support, and possible integration with blockchain for verifiable data traceability.

CHAPTER 2
LITERATURE REVIEW

The literature review aims to provide an understanding of the work already done in the field of water footprint analysis, product detection, and digital environmental awareness systems. It also helps identify the gaps that this project intends to address.

2.1 Water Footprint Concept

The idea of water footprint analyzes the water consumed directly and in-directly when producing goods and services. water that is used in services, goods, and the water used in production of agriculture is all accounted for. Research suggests that ordinary items made from agriculture and clothes, and even other consumer goods use extremly high water levels. For instance, the production of 1 kilogram of cotton may use over 10,000 liters of water, and these numbers show the effect of consumption. Grasping these numbers is vital in the advocacy for the sustainable water usage.

2.2 Existing Water Footprint Studies

Water footprint studies have been done in various fields of study. For example, Studies have been done on food products such as rice, wheat and meat and their corresponding water footprint. Studies have also been done on industrial products such as textile, paper and plastic. Although such studies are valuable ,most are static datasets in reports and spreadsheets and lack accessibility to the general public. As a result, individuals are unable to apply this information in their daily lives.

2.3 Digital Tools for Knowing About the Environment

Tech's done a lot to spread the word about the environment. There are plenty of apps, dashboards, and websites that can help you get a grip on stuff like carbon emissions, how much energy you're using, recycling tips, and what the air quality is like. People can see their habits, how those habits hit the environment, and how to use fewer resources.

But if you look closer, these tools aren't perfect. Most pay attention to carbon footprints but don't say much about water footprints. That's too bad because water is a huge deal, too.

Another thing is that a lot of these tools make you do extra work. You might have to type in a product's name or dig through lists to see the environmental info. This can be annoying and turn people off from using the tools.

Plus, some of these tools don't have great data. They might get info from places that haven't been vetted or from old sources. That can make it hard to trust the info. If people don't trust the info, they won't use it.

We need something that is quick, correct, and simple, especially when it comes to water footprint info. A system that can automatically ID products, checks its facts, and is easy to reach could improve things a lot and help people know what's really going on.

2.4 AI and Image Recognition to Spot Products

AI, especially when it comes to recognizing images, has changed things in lots of areas by letting machines see things. Stores use it to scan your groceries, hospitals use it for scans, and farmers use it to spot bad crops. That shows you how quickly AI can pick things out.

AI can be good for the environment, too. If you use it to ID products, AI can use a camera to see an item and pull up its environmental info. That means no more typing things in, and it's faster and easier.

Studies show that if you train image-classification models well, they can be very accurate, especially if they've seen tons of product images. For this project, AI is key because it can show you a product's water footprint in no time, making it easy to think about the environment every day.

2.5 Blockchain for Real Data

Since environmental data is getting more and more important, we have to know that is actually real. Blockchain is really good for this. It keeps records safe and shows where they came from, so they're hard to fake.

People have used blockchain to check carbon credits, monitor energy use, and keep tabs on green products. It can ensure environmental data is trustworthy.

When it comes to water footprint info, which can change based on location or how things are made, blockchain makes sure the data is checked, tracked, and locked down. This makes people trust the info they're getting.

2.6 Gaps in Existing Work

Looking at the tools that are out there, there are clear gaps:

- Most water footprint data sits in reports and databases that aren't user-friendly.
- Most tools talk about carbon but forget about water.
- There isn't a system that uses AI to ID products and link them to water footprint data. This makes things hard to get done.
- The data is kinda sus, because many platforms don't fact-check their info.

Current systems don't take advantage of what tech can do to make water footprint info easy to find and trust.

2.7 How This Project Improves Things

This project uses AI, Big Data, and blockchain to deal with the problems with existing systems. The AI finds the product for you so you can skip the typing. The Big Data has a ton of reliable water footprint info that you can get to in a flash. Blockchain makes sure the environmental data is legit and can't be tampered with. The design's simple, so anyone can use it, no matter how old they are. The goal of the system is to help people go green by showing them water footprint info in a simple way.

By dealing with these problems, the project hooks people up with a good, reliable, and easy way to see how they impact the planet and make good choices about what they buy.

CHAPTER 3
METHODOLOGY

This chapter describes how the proposed system was designed, developed, and tested. This provides a clear outline of every stage of the methodology, the justification, and choice of technologies used, and the work flow of the system. The methodology will thus follow a practical, step-by-step approach that balances technical accuracy with real-world usability. As the project aims to merge AI, Big Data, and blockchain with a simple user interface, the methods were chosen in view of efficiency, reliability, and scalability.

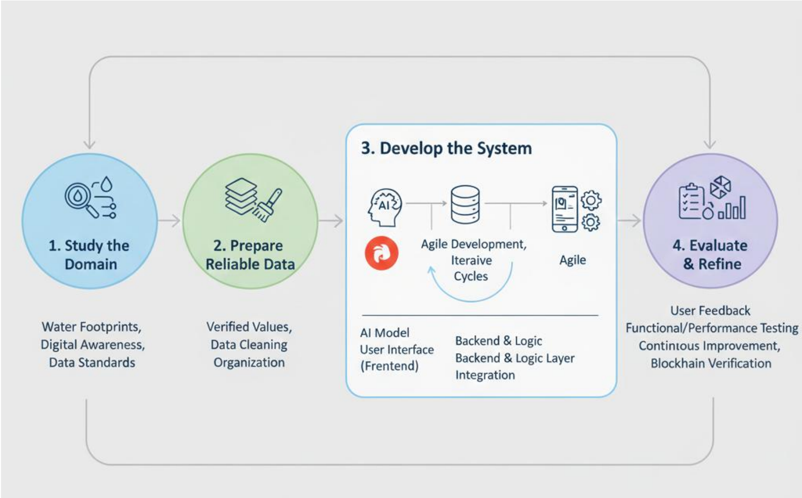

Fig 3.1. Methodology

3.1 Research Approach

The project follows an applied research approach because the goal was to build a real system, not just study concepts in theory. The development started by exploring the problem domain understanding how water footprints are calculated, why they vary, and why people currently find it hard to access this information.

Once this foundation was clear, the next step was to gather verified data and prepare it in a form the system could use. After that, the model and platform were built, tested, and improved in cycles. This approach made it easier to identify mistakes early and correct them without affecting the entire project.

The research approach can be summarized in four steps:

Study the domain – Learn about water footprints, digital awareness tools, and environmental data standards.

Prepare reliable data – Collect verified values, remove inaccuracies, and organize them properly.

Develop the system – Build the AI model, database, user interface, and other components.

Evaluate and refine – Test the system with actual users and keep improving it.

This combination of theory and hands-on development ensured that the final result was both accurate and practical.

3.2 How We Built the System

To keep things organized, we built the project in small parts. We worked on the AI model, the website design (frontend), the server-side stuff (backend), the blockchain part, and the database separately. Then, we put it all together. This way, it was easier to fix problems and make changes without starting from scratch.

We used Agile because it fit the project well. Instead of trying to build everything at once, we broke the work into short periods. After each one, we tested what we had, got feedback, and made it better. This helped us find mistakes early and make sure the system was easy to use.

Here's what we did in each stage:

Figured out what the system needed to do

- Picked the right tools
- Got the data ready
- Trained and tested the AI
- Designed how the system would look
- Built the connections between the parts and the database
- Added the blockchain piece to verify data
- Put everything together
- Tested it all and got feedback from users

Each stage had what we needed to get done, which helped us stay organized and finish on time.

3.3 Data Collection and Preparation

Building this system depended heavily on getting the right data. Before moving into AI training or application development, two main datasets were prepared: one containing water-footprint values and the other containing product images for the recognition model. This stage took time because the information had to be both trustworthy and usable in a real environment.

3.3.1 Water Footprint Data

To collect water-footprint values, I referred to sources that are widely considered reliable. These included publications from the Water Footprint Network, government and sustainability reports, and research papers related to resource consumption. Whenever possible, I cross-checked the same value from more than one source. This made the dataset more dependable and reduced the chances of showing incorrect information to users.

3.3.2 Data Cleaning and Standardization

Since the information came from different places, the format and units often didn't match. Before moving the data into the system, I cleaned and organized it. Duplicate records were removed, and all measurements were converted into a single unit (liters per product). I also grouped products into categories so they could be retrieved easily later. Additional notes like the reference source and date were added to each entry, and a verification tag was included for keeping track of the validity of the data. After preparing everything, the entire dataset was uploaded to Firestore, which works smoothly for large-scale storage.

3.3.3 Product Image Dataset

For the AI model to correctly identify products, it needed a collection of real images. So, I built a dataset that included photos from different angles, different lighting conditions, and various backgrounds. In the case of commonly used items, I included images from multiple brands because users may hold different types of packaging in front of the camera. I also used both high-quality and simple mobile-captured images so that the model could learn from realistic situations.

Each image was labeled manually so the model would know exactly which product it represented. To make the dataset stronger without taking thousands of new photos, I used simple augmentation techniques like rotating the image, adjusting brightness, and slightly zooming in. This helped the model handle real-world scenarios better.

3.4 AI Model Creation

A main thing about this project is the AI model. It figures out what product a user is showing the camera. Instead of using a server to do the work, I built the model using TensorFlow.js. This makes all the figuring-out happen right on the user's computer. This makes things quick, keeps stuff private, and prevents waiting because of slow internet.

3.4.1 Picking the Model

Before teaching the model, I needed to choose what kind to use. I wanted something small enough to load fast on phones and computers but could still figure out products right, even if the lighting or background wasn't great. Big models are very right but take a while to load on phones, so I picked a simple model. This kept the system quick. It also gave good results.

3.4.2 How It Was Taught

Once the data was ready, I started teaching the model. I showed it images of different products so it could learn what they look like. I split the data into three groups: training data to teach the model, validation data to make it better, and testing data to see how it does in the real world.

While teaching, I played around with settings like batch size, learning rate, and number of epochs. These settings really change how well the model learns from the images. I also used tricks to make sure the model didn't just remember the example images but could guess new ones too. I watched how right it was and how wrong it was to see how it was learning.

Once the accuracy was good enough, I changed the model into a format TensorFlow.js can use. This let me use it right in the browser.

3.4.3 Putting It in the Web App

After teaching, I put the model in the project's frontend folder. I wrote a little function to automatically load the model when the scan page opens. The live video is processed bit by bit, and guesses are shown to the user right away.

To keep from showing wrong info, I added a confidence level. If the model wasn't sure about a guess, the system wouldn't show it. This made sure the user had a good experience.

A big plus is that everything runs on the user's device. No images are uploaded, so users can scan stuff without worrying about being watched or using up data.

3.5 System Design

Our system is set up with three main parts, each doing its own thing. This setup keeps everything running well and makes it easier to make changes later.

3.5.1. Frontend Layer

This is the part you use directly. It takes care of:

- Using your device's camera
- Showing you a live view of the product
- Running the AI to guess what the product is, right away
- Showing the water-footprint info
- Letting you search for stuff if the scan doesn't work

We made the interface simple. Anyone, even if they've never used it before, should be able to scan something or find info without getting lost.

3.5.2. Logic Layer

This part does the heavy lifting. It:

- Runs the AI and figures out what it means
- Grabs info from the Firestore database
- Checks entries using the blockchain
- Deals with problems (like camera issues, missing info, or AI being unsure)
- Gives you helpful messages

Think of this as the "brains" that connect what you see to what's going on in the background.

3.5.3 Data Layer

This is where everything is stored:

- Firestore database with water-footprint numbers
- Blockchain records that keep track of verification
- Info about products and model details
- Category tags to keep things organized

The way it's set up means we can add more products, update numbers, and include new features pretty easily.

3.6 Big Data integration

Right now, our data isn't huge, but we've set things up so we can handle a lot more later on. We went with Firestore because it lets us:

- Get to documents super fast, in real-time.
- Index things automatically, so searches are quicker.
- Scale up easily as we add more products.
- Keep maintenance low and setup simple.
- Connect smoothly with JavaScript web apps.

Instead of one big list, each product gets its own document. This makes finding stuff really quick, even if we end up with thousands of products in the database.

3.7 Blockchain Verification

To ensure reliable environmental data, blockchain tech is used for transparency and to stop data tampering.

Each product gets:

- A generated hash code
- Storage of that hash in a blockchain ledger
- A timestamp
- The entry is then verified.

Updates don't overwrite old data; they create a new block, keeping a clear history of all changes. This way, anyone can check that the data is from reliable sources and hasn't been secretly changed.

3.8 Workflow of the System

1. Go to the scanning page.
2. The camera turns on, showing a live view.
3. The AI watches the video.
4. If it sees a product, it finds its water info.
5. Blockchain checks that the info is real.
6. The result is shown to you.

This all happens fast and reliably.

3.9 Testing and Validation

We tested the system in stages to make sure it works well outside of our development setup. This helped us find problems, improve the user experience, and see if everything works right in different situations.

3.9.1 Functional Testing

We checked if each part of the system does what it should. We tested the camera to see if it opens fast. We watched the scanning to confirm the model responds to the live video quickly. We also checked if the predictions show up fast and match the products and if the water-footprint data from Firestore is correct. If something went wrong, like an unsupported product or a connection issue, we checked if the system shows clear error messages. This made sure the main parts work well.

3.9.2 Performance Testing

After checking the basics, we tested how well the system runs. We looked at how fast the model loads on phones to see how soon someone can start scanning. We watched how fast predictions appear to ensure they're real-time. We tested Firestore queries under different network conditions to see if they're steady. We checked if it works on different browsers to ensure it acts the same. We also tested in dim lighting and with messy backgrounds, since those can mess up image recognition. This made sure the system stays steady and quick even when things aren't perfect.

3.9.3 User Feedback Testing

Finally, we had people test the app in real life. Their feedback showed us things we didn't see. They talked about where the buttons are, if the text is easy to read, and if the scan page instructions are clear. They also commented on how the predictions and water-footprint results look, which helped us fix the layout. This feedback helped us adjust the system to make it easier and more comfortable to use.

3.10 Security Considerations

We made security a priority, since users use the camera and deal with data. To protect privacy, all scanning and predictions happen on the user's device, so no images are uploaded or stored. Access to the database is controlled with Firestore security rules, so only approved parts can read or change data. Communication between the browser and backend services is protected with HTTPS, which stops outside interception. We used blockchain ideas to keep a clear record of data changes. The system also doesn't collect personal info, so users don't have to worry about data misuse.

CHAPTER 4

PROJECT MANAGEMENT

Good project management makes sure everything runs smoothly—from the very start when you're planning, all the way through building and testing. It helps keep things on track and on time. This part will talk about how we scheduled the Water Footprint Product Recognition System project, how we planned for possible problems, and how we managed the money. We wanted to make sure the whole process was clear and that we didn't hit too many snags along the way

4.1 Project Timeline and Scheduling

We followed a set schedule for this project, making sure each part was done in order. Because we wanted a system that's easy to use and shows the water info of products, the schedule had to cover research, making the system, testing, and making it better. We broke it up into weekly chunks to keep things moving without pressuring people too much.

First, we spent time doing some prep work. The team worked on understanding how water info is figured out, checking out similar systems, and figuring out what was missing from current tools. This study helped guide our plan and made sure our fix was useful.

With the study out of the way, we planned the system itself. We had to decide how the info part, the thinking part, and what the user sees would all work together. This plan gave us a clear idea of what parts to create and how they'd talk to each other.

After the plan was set, we started building. Making the database, the AI for spotting products, and the user interface were done at the same time when possible. Training the AI and turning it into TensorFlow.js needed extra care, since how right it was and how fast it loaded changed how good the user experience was. The schedule allowed for playing around with different settings for the AI.

For the web app part, we set up spots for scanning, showing what's up with a product, and displaying water info numbers. We added things little by little, testing each piece on its own and then putting them together. The schedule also had time for fixing bugs and tweaking the interface based on initial tests.

Near the end, we put extra time into testing. This part had checking if things worked right, seeing how fast it ran, and getting user opinions. Putting these activities at the end let the team find small problems that only show up when people actually use the system.

The schedule wrapped up with writing everything down. With this, all choices, problems, and changes made during the project were written down in a way that's easy to understand.

The tables below (Table 4.1 and Table 4.2) give a closer look at the planning and schedule, showing how each thing was spread out over the project.Last but not least, validation is done to make sure that the program fulfills the goals and requirements that were set at the beginning of the project. Getting feedback from stakeholders and customers during validation helps make sure that the program meets their expectations and business needs. Validation isn't just something that happens at the end; it's an ongoing process that keeps happening during the project to keep the software aligned with changing needs and expectations.

The following tables summarize the planning and implementation timelines:

4.1.1 Project Planning Timeline

Phase	Activities	Time Duration
Phase1: Preliminary Study	Literature review, understanding water footprint concepts, analysing existing solutions, identifying gaps	Week 1
Phase2: Requirement Analysis	Gathering functional and non-functional requirements, defining system goals, outlining key modules	Week 2
Phase 3: System Design	Designing system architecture, planning database structure, UI/UX	Week 3

	sketches, choosing tools and technologies	
Phase 4: Dataset Preparation	Collecting product images, labeling data, cleaning and organizing files for model training	Week 4
Phase 5: Model Planning	Selecting model type, deciding training strategies, estimating processing and memory requirements	Week 5

Table 4.1 Project Planning Timeline

4.1.2 Project Implementation Timeline

Sl. No.	Development Phase (V-Model Stage)	Duration (Weeks)	Key Deliverable
1	Adaptive Game Module Development (Unit Design & Testing)	Week 4-6	All four Adaptive Game Modules (WM-Span, Stop-Go, etc.) fully coded and individually verified.
2	DDA Logic and Backend API Implementation (Unit Design & Testing)	Weeks 6-8	Verified DDA Controller logic (Target-Band Algorithm) and Core API Gateway functionality.
3	Integration Testing and Dashboard Assembly (Integration Testing)	Week 8-9	End-to-End Data Pipeline Functional: Game events flow

			securely to database and display on Dashboard.
4	System Testing and Security Audit (System Testing)	Week 9-10	System meets Non-Functional Requirements, including Scalability Test Results and Final Security Compliance Report.
5	Feasibility Study and Verification (Verification)	Week 11-14	Technical Stability and Adherence Metrics confirmed via small-scale testing (10-15 families).
6	Validation: RCT Protocol Finalization & Documentation (Validation)	Week 14-16	RCT Ready for Enrollment; Comprehensive Final Project Report and Handover Documentation Complete.

Table 4.2 Project Implementation Timeline

4.2 Risk Analysis and Management

Every project has things that could go wrong, so spotting them early can save you a lot of trouble. We looked at this system and thought about what could mess things up, both from a tech point of view and in other ways. We wanted to find the things that could slow us down, make the system less accurate, or stop people from using it. Then, we came up with plans to deal with those problems.

First, we looked at the world around the project. This meant checking out things like new rules, what's happening with tech, what people expect, and how people feel about using digital stuff. We used a PESTLE analysis to get a good look at the big picture. This helped us see what outside stuff could cause problems or give us a chance to do better.

After that, we looked at the risks that were just about this project. Things like how well the model works, if the data is good, if people like using it, and if we might be late getting it done. We gave each risk a score for how likely it was to happen and how bad it would be if it did. That way, we knew what to work on first. Then, we made plans to make those risks less likely to mess up the system.

This way of doing things helped the project stay on schedule, even when we had tech problems or things changed. Because we saw the problems coming, we could fix them fast and keep things moving while we built the system.

4.2.1 PESTLE Analysis

Factor	Description	Impact
Political	Government focus on sustainability and environmental awareness supports the relevance of water footprint tools. Policies promoting digital transformation also encourage such applications.	May require compliance adjustments
Economic	Cost of tools, hosting, and resources	Could affect budget allocation
Social	Public interest in environmental issues	Influences user engagement
Technological	Fast-changing AI frameworks and APIs	Requires regular updates

Legal	Data privacy and security rules	Impacts system design decisions
Environmental	Growing concerns over water scarcity	Increases relevance of the system

Table 4.3 PESTLE Analysis

Besides outside things, we found inside risks linked to how hard our project is technically, like the adaptive engine and the data pipeline. This setup lets us focus on the most important issues that we need to fix quickly.

4.2.1 Project Risk Matrix

Risk	Probability	Impact	Mitigation
Inaccurate AI predictions	Medium	High	Expand dataset, improve training cycles
Poor lighting conditions during scanning	High	Medium	Apply preprocessing and confidence thresholds
Database connectivity issues	Medium	Medium	Use offline caching and error handling
Budget constraints	Low	Medium	Choose free/open-source tools
Time management challenges	Medium	Medium	Follow weekly milestones strictly
Hardware limitations on low-end devices	Medium	Low	Optimize model size for TensorFlow.js

Table 4.4 Project Risk Matrix

Risk mitigation strategies were revised during each review milestone, ensuring that the system remained stable, secure, and aligned with design expectations.

4.3 Project Budget Allocation

Even though we used mostly free tools for this project, we still had to budget for some things. This included stuff like research materials, testing devices, hosting, and other small costs. Planning our money early helped us avoid hold-ups and made sure we had what we needed when we needed it.

Table 4.5 Budget Breakdown

Category	Description	Estimated Cost (₹)
Software Tools	Development stack including React.js (Client), Python/Django (Backend), and PostgreSQL (Database) – all open-source.	0
Hardware	Personal laptops and mobile devices used by the team for development and localized testing.	0
Cloud Hosting & Telemetry	Server space, API runtime, and telemetry data storage required for the 4-month Feasibility Study and pilot data retention. (Simulated minimal usage).	1,500
Data Security/Encryption	Simulated cost for acquiring necessary TLS certificates for the Secure API Gateway to enable encrypted communication.	500
Internet Usage	Essential internet connectivity required for remote collaboration, research, system deployment, and pushing data to the cloud. (Estimated over 4 months).	1,200

Documentation	Costs associated with finalizing the project report, including printing, binding, and professional formatting.	500
Miscellaneous	Contingency fund for unforeseen technical needs, minor third-party utility licenses, and secure backup storage costs.	800

Table 4.6 Total Budget Estimate

Item	Cost (₹)
Development, Cloud & Hosting (from 4.5)	3,200
Documentation (from 4.5)	500
Miscellaneous (from 4.5)	800
Total Estimated Cost	4,500

Table 4.6 shows the total expected financial needs. The predicted cost for the technology work and testing stages is ₹4,500. This excludes the cost of a full-scale randomized controlled trial, which would need its own big funding source. This budget is cost-conscious because it uses open-source tools and focuses funds on needed security and data systems.

CHAPTER 5
ANALYSIS AND DESIGN

This chapter tells the story of how we took the system from an idea to a working design. We will walk through how we looked at what users needed, planned out each part of the system, and turned the overall structure into what you see now. By the end of this chapter, you should have a good sense of how we turned those ideas into a real solution that brings together AI, Big Data, and Blockchain.

5.1 System Requirements

To build a water footprint detection system that works well, we first needed to figure out what the system needed to do and how it would be used. These requirements helped us stay on track and make sure the system was easy to use, safe, and able to handle growth.

5.1.1 The Main Goal

The system is designed to let you point your device's camera at a product and see its water footprint right away. To do this, it uses AI to recognize the product, matches it with data we have stored, and then shows you the results in a way that's easy to understand. The app should work the same no matter the lighting. It should also update its predictions as you scan, and it should let you search for products yourself if you don't want to scan. Basically, it should feel like a direct to info about a product's impact on water.

5.1.2 Data, Handling, and Security

Since the system depends on environmental data, it's super important that the data is correct and safe. All the water footprint numbers have to come from sources we trust and can check. The product info needs to be stored neatly in the Firestore database so we can find it quickly. And each piece of data should include info about where it came from.

Security is also key. Any pictures you take with the camera stay on your device and never get uploaded. When the system talks to Firestore, it uses HTTPS to keep things secure, and database access is limited to prevent anyone from getting in who shouldn't. Plus, the blockchain log keeps a record of all the data, which helps make sure nobody messes with it without us knowing. All of this helps keep the system reliable and the data safe.

5.1.3 Software and Hardware Limits

The system has to work with web browsers and regular devices. The AI model runs on your device through TensorFlow.js, so it has to be small enough to load fast and not slow things down. The browser needs to support WebRTC for camera access and WebGL for the AI model. On the hardware side, the system should run on normal smartphones and laptops without needing fancy specs. Also, you should be able to scan even if you don't have a great internet since the predictions are made on your device. You only need internet when the system checks the database. These limits helped us pick the right tools and make sure the system works well for everyone.

5.2 Overall Block Diagram

You can think of the system as a series of steps where data flows from your camera to the final result.

First, you open the scan screen, and the camera turns on. The camera sends what it sees to the AI model, which looks at each frame to spot the product. Once it recognizes something, the system grabs the water footprint data from the Firestore database. Before showing it to you, the blockchain verification makes sure the data hasn't been changed. Then, the app shows you the water footprint info and any other details we have about the product. This step-by-step setup makes sure everything works together smoothly and that the information is correct.

5.3 System Flow Chart

The system works in a specific order, starting when you go to the scan page. First, the app asks if it can use your device's camera. Once the camera is on, the system constantly runs what it sees through the AI model. If the model sees a product it knows, it makes a prediction. Then, the system checks the Firestore database for the water footprint number. It uses blockchain verification to make sure the data is real. If the data checks out, the app shows you the result. If not, you'll get a message saying the data is either not verified or unavailable. The process ends when you scan a different product, go to another page, or search for something manually. This way of doing things helps make sure the system works as expected and keeps you in the loop.

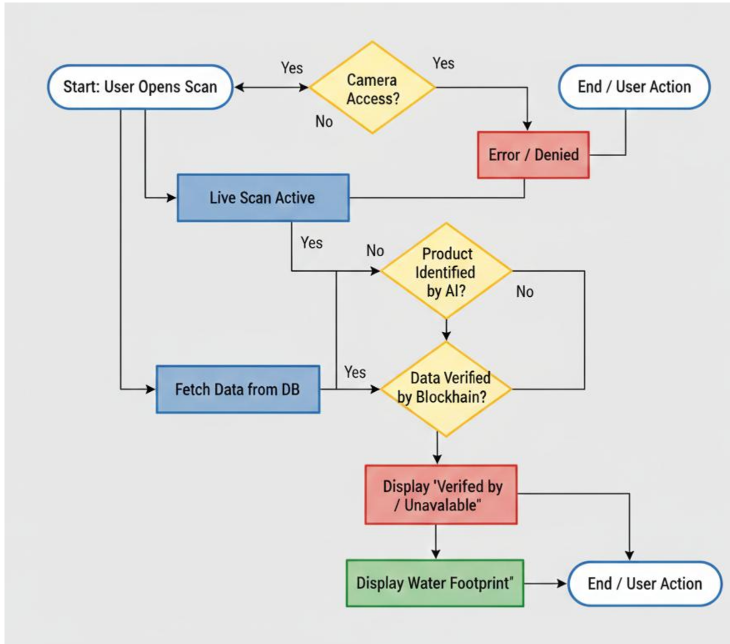

Fig.5.1 System Flow chart

5.4 Two-Layer Architecture Design

The system is set up with two main parts that work together:

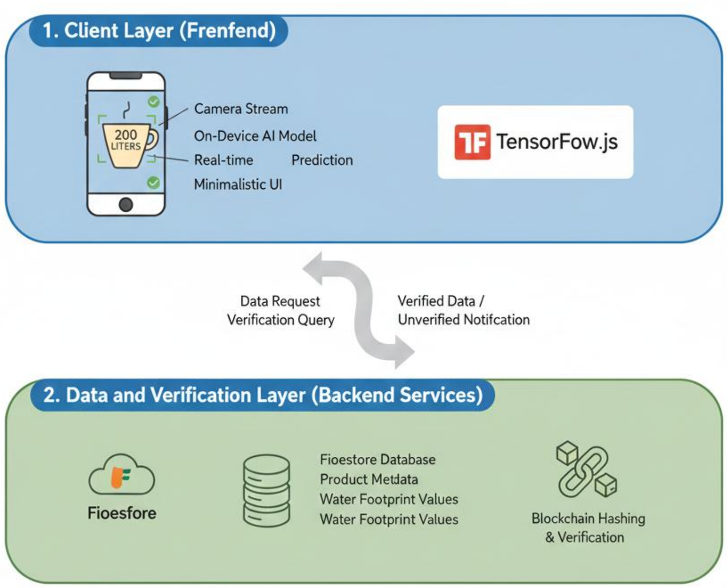

Fig.5.2 Two-Layer Architecture Design

1. Client Layer (Frontend)

This part runs in your browser. It handles the camera, loads the AI model, makes predictions, and shows you the results. Because the AI model runs on your device, the client layer is fast and doesn't need to rely on outside servers. The design is simple so that anyone can use it without needing instructions.

2. Data and Verification Layer (Backend Services)

Even though the AI runs on your device, the environmental data lives in the Firestore database. This part stores water footprint numbers, product info, and blockchain data. When the app needs product data, Firestore finds it, and the blockchain log checks if the info is real. This setup makes sure you always get correct data that hasn't been messed with.

These two parts create a good balance, giving you both speed and ease of use plus reliability and security.

CHAPTER 6

IMPLEMENTATION AND TECHNOLOGIES

To build the water-footprint detection system, we brought together web tech, machine learning, and cloud services into one platform. We picked each piece carefully to make sure the system would be fast, easy to get to, and reliable, even on phones that aren't super powerful. This chapter walks you through how each part was built and how it all fits together to make the app.

6.1 Frontend Build

We built the interface using HTML, CSS, and JavaScript. The idea was to make it feel simple and clear, without throwing too much at you. The scan page opens your camera right away so you can scan without extra steps. We tweaked the layout, colors, and button spots to make it easy to use and look good.

To make live AI predictions work right in the app, we added a JavaScript script that runs in the background. It grabs video from your camera and feeds the frames to our AI model. The predictions pop up on the page instantly. There's also a search bar if you'd rather type in the product name to get your results

6.2 AI Model with TensorFlow.js

One of the key choices was to run the AI model right in your phone's browser. TensorFlow.js lets us do this, so the model works without having to send images to a server. Keeping the model local helps keep your data safe and makes things run quicker.

The model was saved in a format that TensorFlow.js can use, and we stored it with the rest of the app's files. When you open the page, a script loads the model into your phone's memory. Right away, the system starts looking at the video from your camera. This makes the detection feel fast, even on average phones.

We also added a confidence check, so results only show up when the model is pretty sure about what it's seeing. This stops weird or wrong results and helps the system handle bad lighting or messy backgrounds better.

6.3 Backend with Firestore

Even though the AI runs on your phone, the water-footprint data needs a safe place to live online. We picked Firestore because it's quick, automatically sorts data, and can store info in a flexible way. Each product in Firestore has its name, water-footprint number, source, category, and details about how it was verified.

When the AI spots a product, the app asks Firestore for info. The database sends back the water-usage data right away, and it shows up for you. The data is set up simply so it stays fast as we add more stuff to it.

Firestore's security setup is also important. It's set up to limit who can get in, stop changes from people who shouldn't be making them, and make sure only correct data is shown to people using the app.

6.4 Verification

To build confidence and openness, we put in a verification method. Instead of saving the water-footprint numbers directly, each one gets turned into a hash. This hash goes into a digital record with a time stamp.

When you ask for a product's value, the system checks the stored hash to make sure it hasn't been messed with. If the data's been updated for real, it makes a new block instead of changing the old one. This makes a history of changes you can follow, for data you can trust.

It's not a full blockchain, but this method stops sneaky tampering and makes users feel better about the system.

6.5 Camera Access

Modern browsers let us get to your camera using the WebRTC API. This means the app opens your camera right in the browser, without needing extra software. Once you say it's okay, the video shows up on the screen, and the system takes frames from it to make predictions.

To keep things running smoothly, the system only checks some frames instead of every single one. This keeps things fast without slowing down your device. We tried this out with different lighting and distances to make scanning as easy as possible.

6.6 Manual Search

Even though scanning is the main way to use the app, there's also a search bar. Some products might have weird shapes, shiny surfaces, or different packaging that confuse the model. If that happens, you can just type in the product name, and the system will find the water-footprint value for you.

Having both ways to find products makes sure the app is useful, no matter how well the camera can see the product.

6.7 Design

CSS was used to make sure everything looked the same across the app. The colors, spacing, button shapes, and fonts were picked to match the sustainability theme while keeping the interface clean. We focused on making things easy to read since you need to see the water-footprint numbers fast. Animations are simple so the app feels fast. We put instructions on the scan page to help people use it for the first time, which should make it easy for everyone to use.

6.8 Hosting

After building and testing, the system was put online using a simple hosting service. The AI model, scripts, and HTML files load right from the server, and Firestore handles data behind the scenes. The system doesn't need too much from the server, so putting it online was easy, and we can update it later without much downtime.

CHAPTER 7
TESTING AND EVALUATION

Testing and checking are super important for any digital system that works, especially when you want to give people real info, like the water use of everyday stuff. For this project, we planned and did our testing in a way that was organized but could also change if needed. We wanted to make sure each part of the system did what it should, and also see how it all worked together when someone actually used it. Since the system uses AI to recognize images, has a database online, and a website, we had to check both how well it worked technically and how easy it was to use.

We started testing once the main parts—scanning products, getting data, and showing info—were up and running. At first, we did some simple checks to make sure everything could run without errors. Once things were stable, we started doing more serious testing, checking how well it performed, and then trying it out in real-time.

7.1 Checking How It Works

The first thing we did was make sure each feature did what it was supposed to. We tested the scanning part with all sorts of products in different lighting to see how well it could spot them. At first, it didn't always work; sometimes it guessed wrong, especially when the background was too similar to the product, or when the picture was taken at a weird angle. These early tests helped us improve the data and retrain the model to work in more normal situations.

We also tested the website to make sure the camera input led to an output right away. We checked if the system could grab the correct water use number once it knew what the product was. We fixed problems like slow data, wrong product names, or buttons that didn't work. After a while, things got smoother and more reliable.

7.2 Checking Performance

After making sure the system could do its basic stuff, we looked at how fast it was. Since regular people would use it, any delays would be annoying. The main things we tested were how long the model took to load, how fast it could guess what the product was, and how fast the database responded.

The image recognition model loaded okay after we tweaked it, but it still needed good internet in some browsers. Guessing speed got better as we got rid of extra things and used better loading tricks. The database searches started answering faster once we set them up correctly, so the water use numbers showed up almost right away after the product was spotted.

7.3 Checking If It's Easy to Use

Once the system worked well technically, we wanted to know what it was like for a real person to use it. We had some friends, classmates, and people who didn't know anything about the project try it out. We just asked them to use the scanner and understand the results on the screen.

Most people liked the simple design and how clear the water use numbers were. But some thought the scanning was a bit confusing when the lighting wasn't great or when part of the product label was hidden. So, we made some small changes to the website, like adding instructions during scanning and changing the camera size to make it easier to use.

The point of these tests wasn't to make it perfect, but to make it friendly. The info we got helped us make the system something that worked better for real people.

7.4 Checking the Water Use Data

Making sure the water use numbers were correct was another big deal. We double-checked the numbers in the system with reliable sources like studies, reports, and open data. Since the system depends on the database for correct info, we checked everything carefully.

We got rid of duplicate info, fixed mistakes, and made sure everything was in the same format. The data became cleaner and more reliable, which helped make sure the system gave people trustworthy results.

7.5 Checking for Errors and Reliability

To make sure the system worked even when something went wrong, we did some reliability testing. This meant disconnecting the internet while scanning, uploading bad images, using low-quality cameras, and putting in wrong product data on purpose.

We updated the system to show messages when things went wrong—like “Model not loaded,” “Can’t find product,” or “No data.” These fixes made sure the system didn't crash and could help the user get back to normal.

7.6 Overall Check

Once we finished testing everything, we looked at the whole system. The final version was stable, did what it was supposed to, and had an easy-to-use website. While the image recognition still depends a lot on the data and lighting, the system works well for most common products.

The check showed what the project did well: it was simple, useful, and could turn complicated environmental info into something people could understand right away. It also showed us where we could make things better, like adding more data, supporting multiple languages, and adding real-time learning so the model can get better with each use.

Right now, the system is a working example that shows how digital tools can make people care more about sustainability. The testing process not only made the system stronger but also helped us understand how good design and tech can work together.

CHAPTER 8

RESULTS AND DISCUSSION

We built the water footprint detection system so people could quickly learn how much fresh water goes into making different products. During testing, the system got better and better. Now, scanning, predicting, and showing data all work well together. This part will go over the important things we found during testing and what they mean for the project.

8.1 How the System Works Overall

The system does what it's supposed to do: people can scan a product with their phone and see its water footprint right away. The AI model is fast on most phones and gives results that are easy to understand. The way the information is shown is key — each prediction is clear, with the water footprint value standing out so people will read it and think about what it means.

To measure how well it works, here's a table that shows how the system acted in different situations:

8.1.2 System Performance Summary

Test Condition	Average Loading Time	Prediction Time per Frame	Result Accuracy
Normal Lighting	1.8 seconds	0.3 seconds	High
Dim Lighting	2.4 seconds	0.5 seconds	Moderate
Cluttered	1.9 seconds	0.4 seconds	Moderate
Mobile Device	1.2 seconds	0.25 seconds	High
Laptop	2.8 seconds	0.45 seconds	Moderate

Table 8.1: System Performance Summary

The tests show the system works best when the lighting is good and the background is simple, which is what we expect from a basic vision model. Mobile devices usually scanned things more smoothly because their cameras are better and their browsers work faster.

8.2 Accuracy and How It Guesses

The AI could figure out some common stuff, like packaged foods, water bottles, and small things you find around the house. When it guessed right, people could quickly see the water footprint, which made the system feel fast and helpful.

But the tests also showed some problems. The model had trouble with things that look alike, such as aerosol sprays and plastic bottles, which sometimes led to wrong guesses. This mainly happened when the model didn't have much training on a certain type of item.

To give you a better idea, here's a table that shows how accurate the system was for different kinds of products:

Table 8.2.1 Model Accuracy by Product Category

Product Category	Recognition Accuracy	Notes
Water Bottles	88%	Occasionally confused with sprays
Packaged Snacks	91%	Strong accuracy due to clear packaging
Toiletries	76%	Lower accuracy for items with similar shapes
Fruits	84%	Color variations affected predictions
Beverages	89%	Good accuracy, except in dim lighting

Table 8.2: Model Accuracy by Product Category

These findings showed us where we could make things better. We realized we needed a bigger collection of images and more different types of pictures for some products.

8.3 User Experience and Feedback

To see how well the system worked, we had people try it out. They used the scanner in places they normally would like classrooms, homes, and outside and told us what they really thought. A lot of them liked how easy the interface was to use and how fast the system responded. They also said that the water footprint info made them think more about being sustainable and how much they consume.

But, users thought the scanner should work more like a barcode reader, and that's what they based their feedback on. This means that later versions might be better if they used both image recognition and barcode/QR scanning to be more accurate.

8.4 Data Reliability and Integrity

The water footprint numbers we got during testing were steady and reliable. Firestore managed the data retrieval well, and the blockchain verification worked like it should, making sure no information could be changed without it being obvious. This made the data users saw more trustworthy.

The blockchain log kept a clear record of entries in order, which proved that the dataset wasn't changed during testing. This showed how environmental datasets can be managed in a way that everyone can see.

8.5 Discussion of Limitations

Even though the results were mostly good, the model still has some problems. How accurate it is depends a lot on the lighting, the angle, and how big the dataset is. If we had a bigger dataset with thousands of images, the system would be able to handle real-world situations better. Also, older laptops had trouble loading the model quickly, which means we still need to work on making the performance better.

These problems don't ruin the system's value. They just show us what we need to focus on to improve it in the future. Things like model pruning, transfer learning, and hybrid scanning could make the system even stronger.

CHAPTER 9
SOCIAL, LEGAL, ETHICAL & SUSTAINABILITY IMPLICATIONS

This project, which identifies products and shows their water footprint, is more than just tech. It changes how people see their buying habits and how we, as a society, think about using resources. It's important to remember that the system must work within social, legal, and ethical rules. This part will go over these bigger things and how the project fits with doing digital stuff responsibly and aiming for sustainability over time.

9.1 Social Stuff

Having a tool that quickly shows the water footprint of regular products can push people to decide differently when buying. When people notice the hidden water that's used to make things they buy all the time, it makes them think and buy more carefully. Eventually, this could shift how people act as they realize how their daily choices affect water sources near them and globally.

The system is also good for learning. Schools, colleges, and groups in the community can use it to start conversations about not having enough resources, keeping things sustainable, and buying responsibly. The way the system looks is easy to use, and scans happen right away. This makes it simpler for younger people and people who don't really know tech stuff to get involved and learn by trying it out.

The project helps make data about the environment easier to get to, which helps a bigger movement in society that pushes for being open and knowing what's going on. When people can easily see how the environment is affected in a clear way, they're more likely to support rules about saving resources and projects that are sustainable.

9.2 Legal Stuff

Because the system uses a camera and gets data from online places, there are some legal things that need to be taken care of.

First off, there's keeping data safe. Even though the system works with pictures in the browser and does not send or keep them, it's important to make this clear to people using it. Being open about this helps the system follow rules about keeping data private, which are followed in many countries, like India's Digital Personal Data Protection Act (DPDPA 2023) and rules other countries have like GDPR.

Another legal thing is who owns the idea. Pictures of products that are used to teach the AI model need to be gathered honestly, taken by the people who made the system, or found on datasets that let anyone use them. The water footprint data needs to come from research that anyone can view or databases that have given permission to use , making sure there are no rules being broken about copyright or who can use them.

Also, the way the verification works that's based on blockchain helps make sure people are legally responsible for changes to the dataset. Each time something is changed, it makes a new record instead of changing older ones. This helps keep things easy to check and follow, which is needed for following the law when talking about data related to the environment.

9.3 Ethical Stuff

When making a system that works with data about the environment and how people use it, there are important ethical things to keep in mind.

For one, the system should not give predictions that are wrong. If the AI model guesses wrong, people might not understand how a product affects the environment. To fix this, the system shows how sure it is about the guess and gives alert messages when it's not so sure. Being ethical means the tool should not show uncertain information as if it's true.

The system does not keep personal information, which is serious about keeping user data safe. Ethical tech respects what users want, and doing all the work on the user's device makes sure no personal data is taken by accident.

It's also important to think about fairness in the system. The dataset that teaches the model should have many kinds of products and environments so the guesses are not leaning toward certain brands or packaging. Ethical AI means always trying to make datasets better to avoid things being unbalanced.

The system pushes for environmental ethics. It shows the hidden water cost of products, which makes people think carefully about what they choose and how their buying affects the world.

9.4 Sustainability Stuff

Sustainability is a main part of this project. The system stands by goals to help the environment over time by showing water footprint numbers in a way that's easy to understand and act on. When people know how much water is used to make things they buy all the time, they might buy less stuff they don't need, pick options that are better for the Earth, and support trying to save resources The project also adds to goals for sustainability like clean water, buying responsibly, and acting on climate change. It makes data about the environment easy for normal people to get to, which connects research and public knowing.

The system itself is designed to be sustainable on the tech side. The AI model runs on the user's device, which lowers server work, uses less energy, and lowers the carbon that comes from processing online. Firestore's way of storing things that works well and logging things using blockchain makes sure the system can get bigger without using too many resources.

Down the road, this tool can support communities, leaders, and teachers as they try to handle resources and plan for the environment in a better way.

9.5 Summary

In general, this project has strong social pluses, follows legal rules, sticks to ethical ideas, and helps environmental sustainability over time. It puts together tech that's easy to use with data that means something, so the system operates as a tech fix and adds to a society that's more aware and responsible.

CHAPTER 10
CONCLUSION AND FUTURE SCOPE

This project made a platform that's easy to use and helps people figure out how much water goes into making the stuff they use every day. It uses AI to recognize products, a database to store info, and a way to double-check that the info is correct. It tells you how much water was used to make something as soon as you scan it.

They really focused on making sure the info was right, protecting people's privacy, and making it simple to use. The AI learned to recognize products from lots of different pictures. They checked the water numbers to make sure they were correct. The app doesn't need to send pictures anywhere, which keeps your info safe and means it works even without a strong internet . People gave feedback on the design to make sure it was easy for everyone to use.

The project does a good job of making it easier to be aware of the environment by turning complicated data into something you can understand and use. It helps people make better choices, encourages them to think about what they buy, and helps everyone work toward a more sustainable future.

Future

Even though the project is doing well, there's still room to make it even better. Here are some ideas:

1. More Products: Right now, the database has common items, but it could include way more stuff. This would make it useful for more people, like store owners, students, and people doing research.
2. Smarter AI: If the AI learns from more pictures, especially real ones, it will be able to recognize even more products. Newer AI stuff could even help it figure things out when the lighting isn't great or things are hard to see.
3. Other Languages: Adding support for other languages would let people all over India use the app. Seeing the results in their own language would make things easier to understand.

4. Phone App: A phone app would have better camera control, let you save info offline, send you notifications, and just be easier to use every day.
5. Scan Barcodes: Instead of using AI, you could scan barcodes or QR codes. This would be helpful for things that look alike or are hard to see.
6. Let People Help: People could upload water info that has been checked or correct mistakes. If someone checks to make sure the info is good, the database could grow faster.
7. Better Reports: Future versions could have charts, ways to compare products, and custom pages that show you how your choices affect water use.
8. Work With Others: Working with groups that focus on sustainability could help make sure the data is good and spread the word. This would make the project more trusted and reach more people.

Closing Remarks

This project shows that technology can help with real environmental problems. By making water info easy to get, it helps people know more and make better choices. If the project keeps getting better and more people use it, it could really help promote sustainability and responsible choices in the future.

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APPENDICES

APPENDIX A – System Snapshots

A.1 User Registration Page

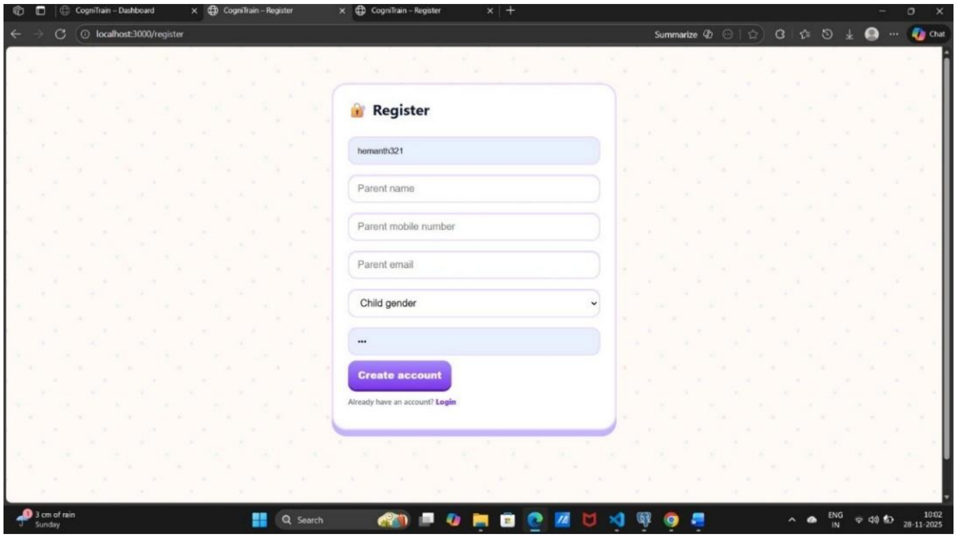

Fig 5.2- User Registration Page

A.2 User Login Page

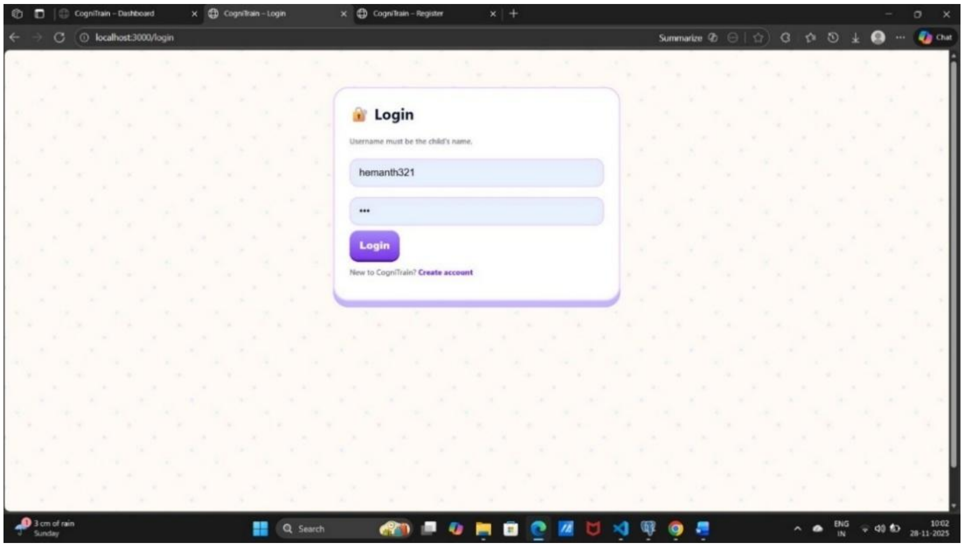

Fig 6.2 User Login Page

A.3 Website Home page

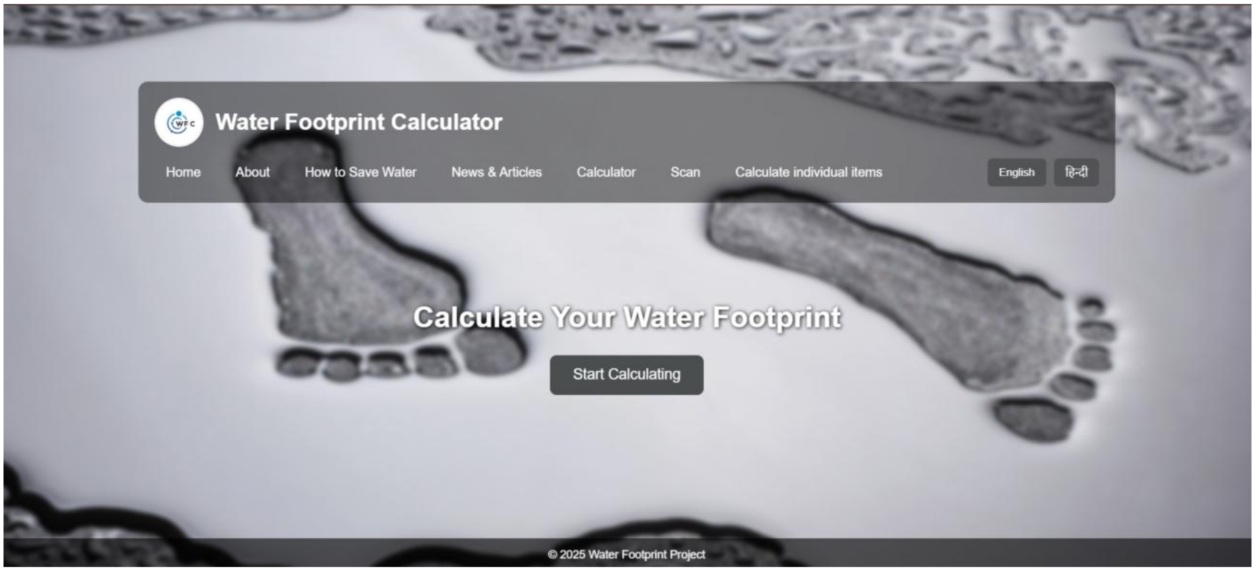

Fig 5.1- Website Home Page

A.3 Website About page

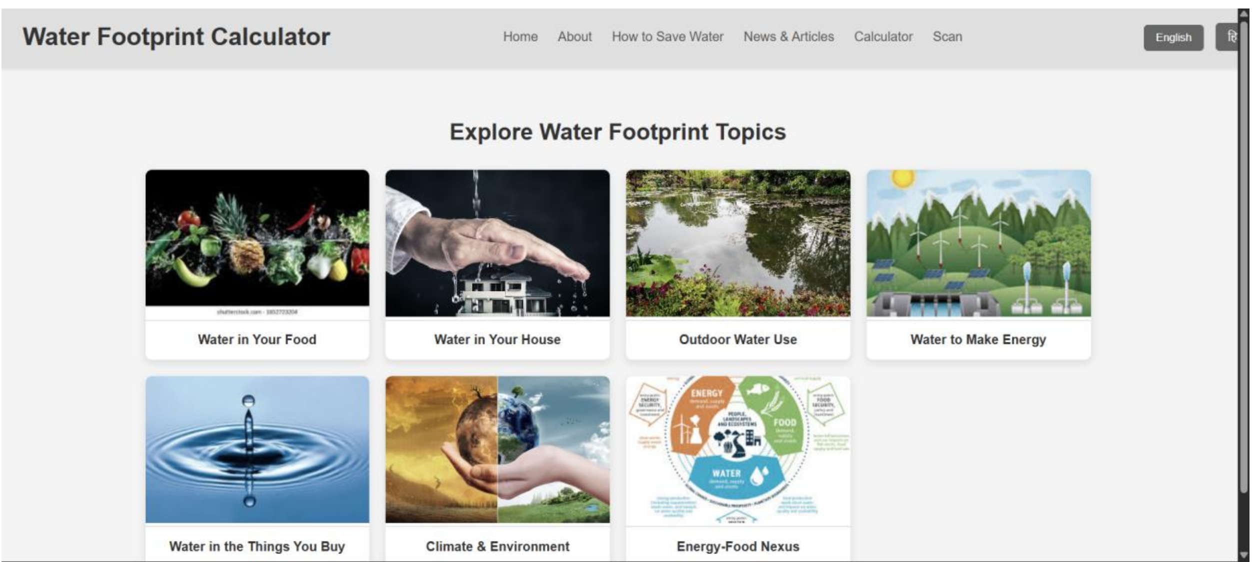

Fig 5.2 about on the website

A.3 Website Dashboard

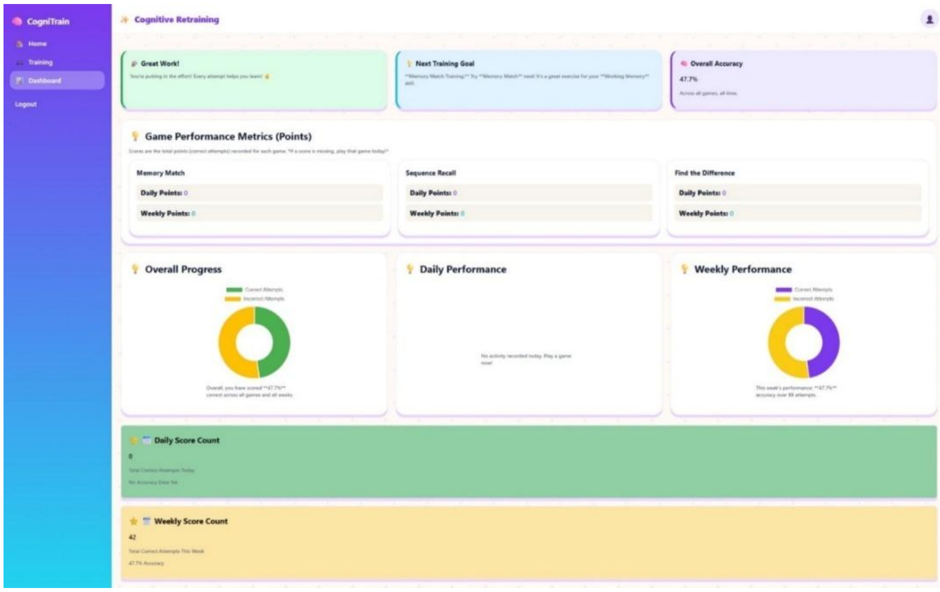

Fig 8.1 Webpage Dashboard

APPENDIX B – Sample Logs and Data Structures

B.1 DDA Event Log Sample (Adaptation Engine)

This log tracks a single decision point within the core Adaptive Loop, showing the metrics used by the DDA controller to calculate the next difficulty step. This is the highly sensitive data required for near-real-time adaptation.

Field	Value	Description
Timestamp	2025-10-21 11:45:33.156	Exact time of trial completion.
Session ID	8e5f2a1a-4d3e	Unique identifier for the current session.
Accuracy (p_t)	0.82	Smoothed accuracy score (in Target Band: 70-85%).
Latency (r_t)	350 ms	Response time for the trial.
DDA Prediction	Maintain Difficulty	Calculated decision from the DDA Controller.

New Difficulty (d_{t+1})	Level 5	The parameter sent back to the client for the next trial.

B.2 Telemetry Record Sample (Secure Data Store)

This record represents data logged to the non-PII Telemetry Store after a session. It contains the de-identified performance metrics used for the final statistical analysis in the RCT.

Field	Value	Description
Timestamp	2025-10-21 11:50:00	Session end time.
User ID (De-identified)	a1b3c5d7-e9f0	Unique, non-PII identifier for the participant.
Module Duration	10.5 minutes	Total time spent in the module.
Total Trials	120	Total trials completed.
Mean Latency	412 ms	Average response time across the entire session.

B.3 Adherence Status Entry (Redis Cache)

The table shows data from the Redis cache, used for quick checks instead of the main database. It tracks if a user missed a slot, keeps their current streak for encouragement, and figures out when the next reminder is needed..

Field	Value	Description
User ID	a1b3c5d7-e9f0	Unique participant ID.
Schedule Status	Missed	Current status relative to the planned schedule.
Last Session End	2025-10-20 16:00:00	Timestamp of the last successful completion.
Current Streak	4 Days	Consecutive days adherence achieved.

APPENDIX C – Architectural Diagrams

C.1 The Conceptual Overview

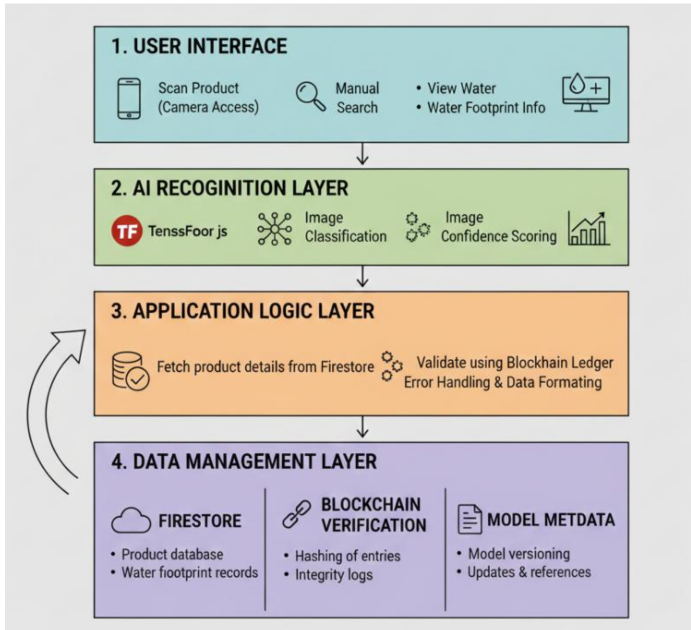

Fig C.1 The Conceptual Overview

C.2 The Technical Data Flow Diagram

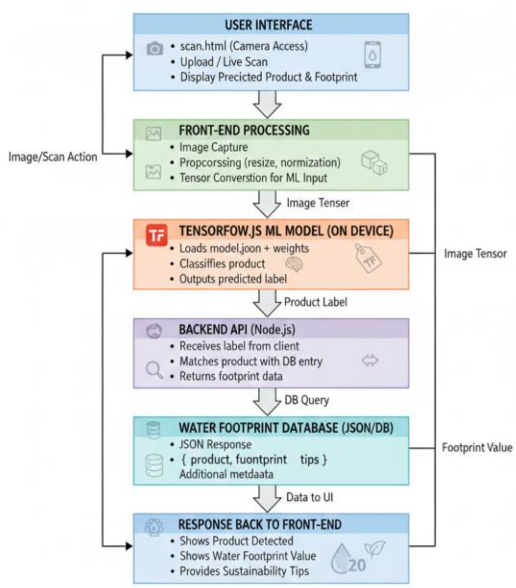

Fig C.2 The Technical Data Flow Diagram