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An App-Based Solution to Water Foot Print: Tracking and Mitigating Personal Water Usage

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Abstract: **"This research paper explores the development and implementation of an innovative app-based solution aimed at addressing personal water footprints. With water scarcity becoming an increasingly pressing global issue, individual responsibility and awareness are crucial. The app utilizes user-friendly interfaces and data visualization tools to empower individuals to monitor their daily water consumption across various activities such as household usage, diet, and transportation. Through a combination of qualitative user feedback and quantitative analysis, this paper evaluates the efficacy and user acceptance of the app-based solution. Ultimately, this research contributes to the emerging field of digital technologies for sustainable development by offering a scalable and accessible tool for addressing individual water footprints and fostering a culture of conservation. This paper discusses the design, functionality, and potential impact of the app, highlighting its significance in fostering environmental consciousness and contributing to water conservation efforts on a personal level.**

Keywords **: Water footprint, Personal water usage, mobile application, sustainability, water conservation, Digital technologies, image recognition, machine learning, user interface design, cross-platform development, firebase integration, user engagement, environmental education**

I. INTRODUCTION

Water, the source of life, is a finite resource crucial for sustaining ecosystems, agriculture, industries, and human life. However, our planet's water resources are under increasing stress due to factors such as population growth, urbanisation, climate change, and pollution.

Water conservation has emerged as a critical necessity to ensure the availability of clean and sufficient water for current and future generations. Every individual's water usage contributes to the collective impact on water resources, highlighting the importance of addressing personal water consumption habits.

In recent years, there has been a growing awareness of the environmental impact of personal water usage. From the water-intensive processes involved in producing food to daily activities like bathing and watering plants, every action contributes to an individual's water footprint.

To address this issue, we propose an innovative app-based solution designed to empower individuals to track and mitigate their personal water usage effectively. By harnessing the power of technology, our app aims to provide users with a convenient platform to monitor their water footprint and adopt sustainable water conservation practices in their daily lives.

Secondly, existing tools for tracking and mitigating water usage often lack convenience and accessibility. While there are resources available for understanding water footprints at a broader level, such as for businesses or municipalities, there is a gap when it comes to providing individuals with user-friendly solutions tailored to their daily routines.

Lastly, we believe in the potential impact of our proposed app in promoting water conservation practices. By providing users with a simple yet powerful tool to monitor their water usage, visualise their impact, and receive personalised recommendations for improvement, we aim to empower individuals to make informed decisions and take tangible steps towards reducing their water footprint. Through collective efforts driven by awareness, measurement, and improvement, we can work towards safeguarding our precious water resources for future generations.

II. MOTIVATION

In the words of the renowned British physicist and mathematician, William Thomson Kelvin, lies a profound insight: "What is not defined cannot be measured. What is not measured, cannot be improved. What is not improved, is always degraded." This quote encapsulates the essence of our motivation behind developing the proposed app-based solution for tracking and mitigating personal water usage.

Firstly, there is a growing recognition of personal environmental responsibility. Individuals are increasingly realising the impact of their actions on the environment and are eager to adopt sustainable practices. However, without the means to quantify their contributions to water conservation efforts, it becomes challenging for individuals to take meaningful action.

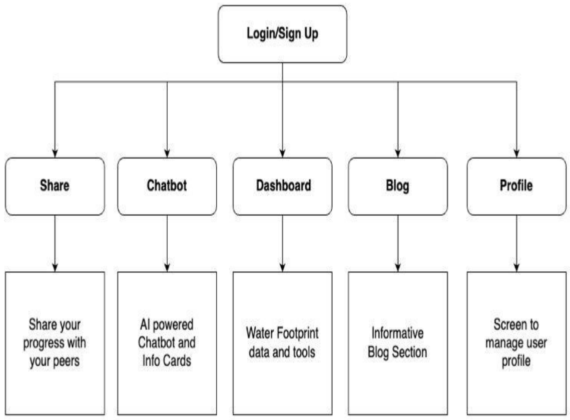

Fig 1. Aqua Trace Flowchart

III. OBJECTIVES

- Intuitive App Development:
- Design user-friendly interfaces for easy navigation and interaction.
- Implement intuitive features for seamless tracking and management of water usage.
- Image Recognition and Machine Learning Integration:
- Develop image recognition algorithms to accurately identify water footprints associated with food items and activities.
- Utilise machine learning techniques to continually improve the precision of water footprint assessment.
- Visualisation Tools:
- Create graphical representations to visualise the user's water footprint over different time frames (e.g., daily, weekly, monthly).
- User Awareness:
- Creating awareness about the topic by educating the user about Blue, Grey and Green Water Footprints for food items and better/sustainable alternatives for some daily activities.

III. PROPOSED METHODOLOGY

App Development Framework

- Flutter for Cross-Platform Development: We utilize Flutter to ensure seamless compatibility across multiple platforms, including iOS and Android. This allows us to reach a broader user base while maintaining a consistent user experience.
- Integration of Firebase: Firebase serves as the backbone of our app, providing robust backend infrastructure and efficient data management capabilities. With Firebase, we can securely store user data, including daily water footprint records, and implement features such as user authentication for a personalised experience.

Water Footprint Tracking

- Image Recognition:
- Leveraging MobileNet CNN with depthwise separable convolution for precise identification of food items in images.
- Integration of advanced image recognition techniques to accurately assess the water footprint associated with each food item captured by users.

- Tech stack Used:

1. Frontend: The frontend of the app is built using Flutter. Flutter enables rapid UI development with its hot reload feature, offering a rich set of pre-designed widgets for seamless, cross-platform frontend creation.
2. Postgres SQL: PostgreSQL is a robust open-source database system, offering ACID compliance, full-text search, and JSON support, making it ideal for scalable and complex backend architectures demands. We used

- Depthwise Separable Convolution:
- The inclusion of depthwise separable convolution within our MobileNet CNN enhances the efficiency of our image recognition process.
- This technique decomposes the standard convolution operation into two separate layers, depthwise convolution and pointwise convolution, resulting in reduced computational complexity and improved performance.

- User-Friendly Interfaces:
- Implementation of intuitive interfaces featuring capture/upload buttons for effortless submission of food item images.
- Inclusion of options for users to input accurate quantities of food items or specify timeframes for activities, ensuring tailored water footprint tracking.

Postgres SQL to store the water footprint of various activities and food items.

3. Firebase: Firebase offers a real-time database, user authentication, and hosting solutions, streamlining backend development. We chose Firebase for its real-time database, user authentication, and seamless scalability, which are crucial for the backend of a Water Footprint Tracker, ensuring efficient data management and user engagement.
4. Express JS: Express was chosen for its streamlined backend development, enabling rapid deployment and easy scalability, which are essential for the responsive data handling required by a Water Footprint Tracker application. We used Express JS to make an API get the water footprint of the food items and activities from the SQL database.

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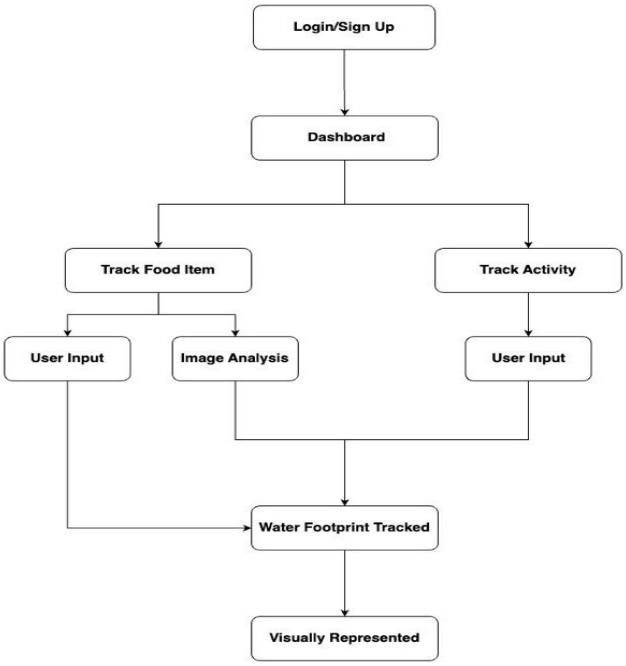

Fig 2. Architecture of Aqua Trace

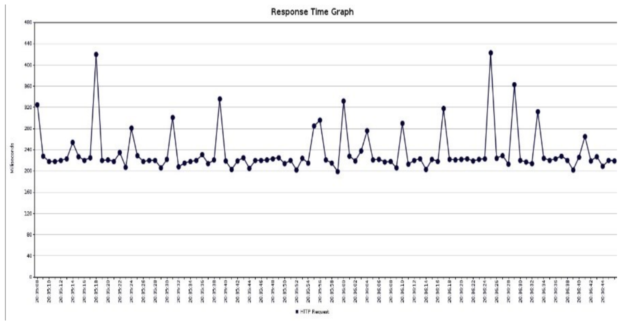

Fig 3. Response time of retrieving user data API

IV. INTERFACE DESIGN

Our app encompasses a range of features designed to facilitate effective water footprint tracking and promote user engagement:

- Login Screen: Users authenticate securely via email and password using Firebase authentication.

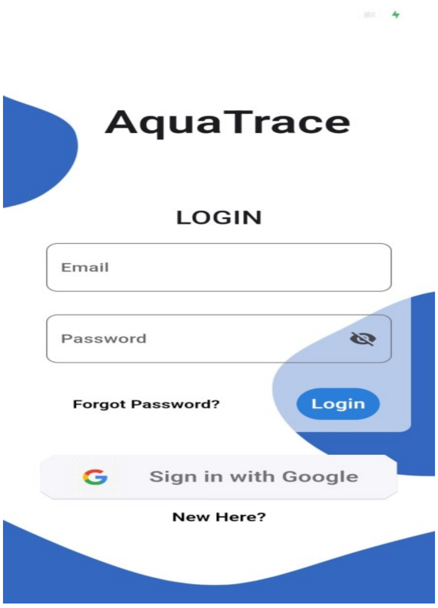

Fig 4: Login Screen of Aqua Trace

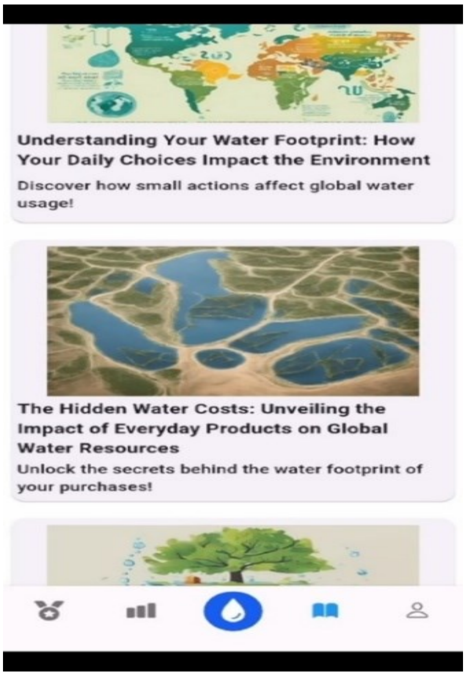

Fig 5: Blog Section

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- Blog Screen: The Blog Screen is a pivotal feature of our app, designed to provide users with a wealth of information on water footprints and related environmental topics. This section serves as an educational resource aimed at deepening users' understanding of the intricate relationships between their daily activities, consumption patterns, and water usage. By offering insightful content, the Blog Screen empowers users to make informed decisions that contribute to water conservation efforts.

Weekly Activty Chart: This feature offers users a snapshot of their water consumption trends over a weekly period, providing valuable insights and encouraging sustainable behaviour change.

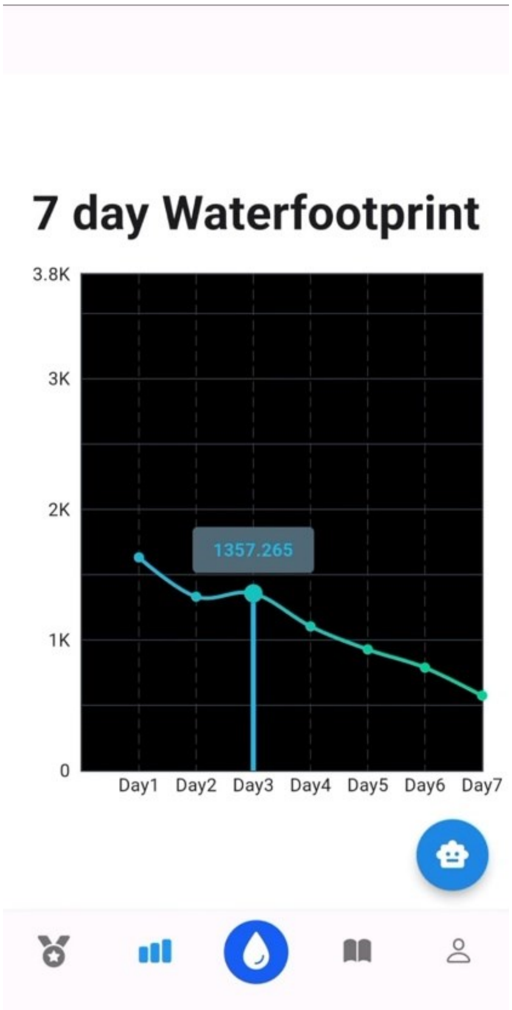

Fig 6: Weekly Activity Charts

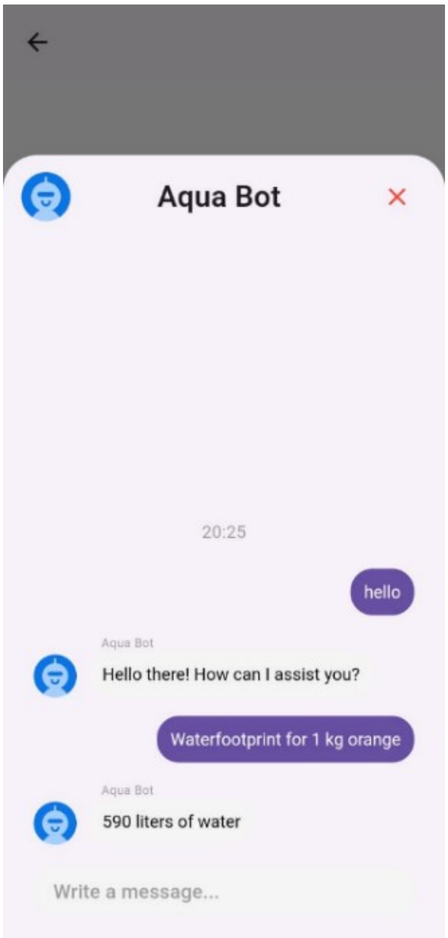

Fig 7: Aqua Bot

- Chatbot: Users can ask questions related to water footprint, and an AI-powered chatbot provides prompt and informative responses. This chatbot serves as a virtual assistant, providing users with prompt, informative, and contextually relevant responses to their questions.
- Main Screen: The central hub for water footprint tracking, featuring a circular progress chart and a comprehensive list of tracked items/activities. Users can also access historical data using the date picker.

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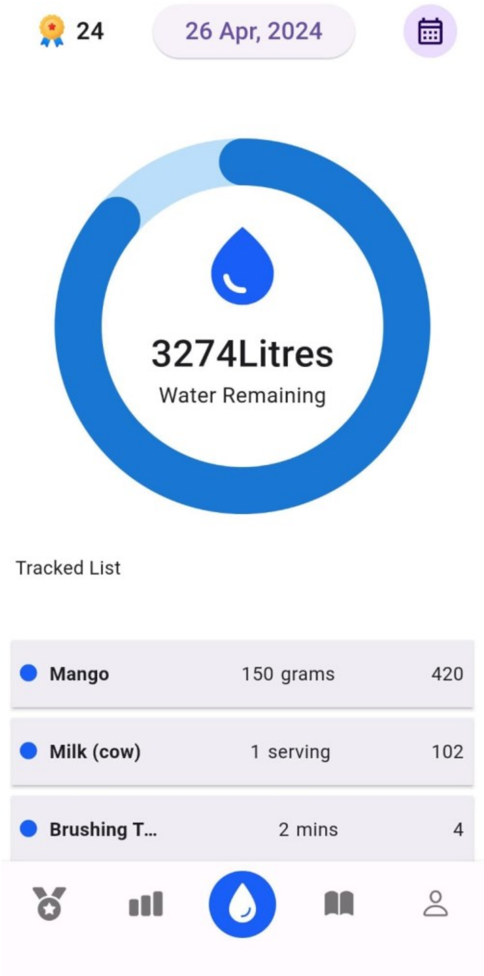

Fig 8: Home Screen

- Tracking Food Items: The Tracking Activities feature of our app is designed to empower users to comprehensively monitor their water usage across a variety of daily activities. By providing a detailed and user-friendly interface, this feature allows users to gain insights into their water consumption habits and take proactive steps towards conservation.
- Tracking Activities: Users can search for activities and track them in terms of minutes.

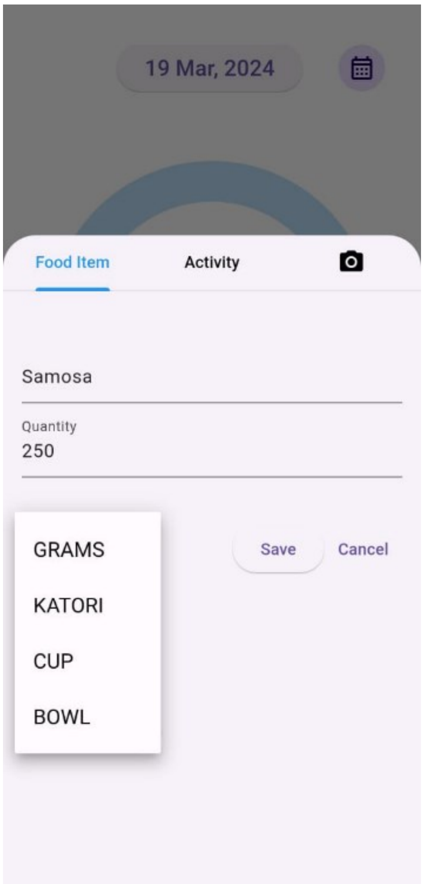

Fig 9: Food Items water footprint tracker

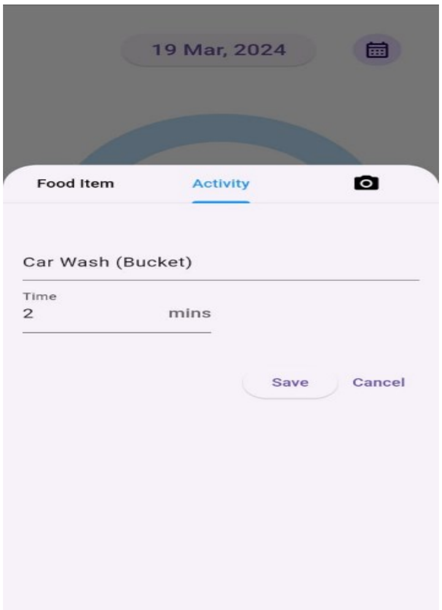

Fig 10: Activity Tracker

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Fig 11: Leaderboard

Leaderboard: One of the standout features of our app is the Leaderboard, designed to inspire and motivate users to actively participate in water conservation efforts through a touch of healthy competition. This feature serves not just as a tool for individual tracking, but as a platform for collective engagement and community-building around sustainable practices.

IV. RESULTS AND DISCUSSION

- Performance Evaluation
  In assessing the accuracy and reliability of our image recognition model for tracking water footprint associated with food items, we conducted rigorous evaluations:
- Data Collection: We meticulously compiled a dataset comprising over 3000 images of various food items to train our model effectively.
- Model Training: Initially, we trained our model on a subset of 19 food items using a convolutional neural network (CNN) architecture. We evaluated the model's performance across multiple epochs (25, 50, 75, 100, 125, 150, 175, and 200) to determine the optimal training duration.

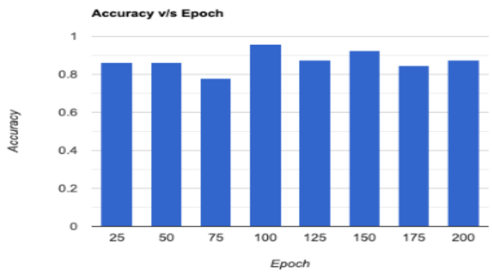

Fig 12: Accuracy v/s Epoch comparison graph

- Accuracy Comparison: The accuracy of our model was
- measured for each epoch, with notable variations observed.
- Notably, the highest accuracy of 95.8% was achieved at epoch
- 100, indicating optimal learning and model convergence.

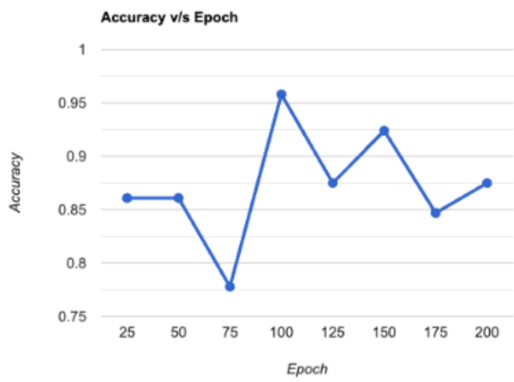

Fig 13: Graph comparing accuracy at various epoch levels

- Learning Rate: We utilised a learning rate (alpha) of 0.001
- during the training process to control the speed at which the
- model adapts to changes in the dataset. This parameter significantly
- influences model performance and convergence.

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25 Epoch				50 Epoch		
Class	Accuracy	# Samples		Class	Accuracy	# Samples
Beetroot	1	4		Beetroot	1	4
Dhokla	1	4		Dhokla	1	4
Gajar Halwa	0.75	4		Gajar Halwa	0.5	4
Cucumber	1	4		Cucumber	1	4
Grapes	1	4		Grapes	1	4
Pear	0.75	4		Pear	0.75	4
Jalebi	1	4		Jalebi	1	4
Medu Vada	0.75	4		Medu Vada	0.75	4
Orange	0.5	4		Orange	0.75	4
Pasta	1	4		Pasta	1	4
Brinjal	0.75	4		Brinjal	0.75	4
Apple	1	4		Apple	1	4
Samosa	0.75	4		Samosa	1	4
Spinach	1	4		Spinach	1	4
Strawberry	1	4		Strawberry	0.75	4
Watermelon	0.5	4		Watermelon	0.75	4
Banana	1	4		Banana	0.75	4
Mango	0.75	4		Mango	0.75	4
	0.861				**0.861**	

Fig 14: Accuracy of food items at different 25 and 50 epoch

75 Epoch				100 Epoch		
Class	Accuracy	# Samples		Class	Accuracy	# Samples
Beetroot	1	4		Beetroot	1	4
Dhokla	0.5	4		Dhokla	1	4
Gajar Halwa	1	4		Gajar Halwa	1	4
Cucumber	0.75	4		Cucumber	1	4
Grapes	0.75	4		Grapes	1	4
Pear	0.5	4		Pear	1	4
Jalebi	1	4		Jalebi	1	4
Medu Vada	0.75	4		Medu Vada	1	4
Orange	0.5	4		Orange	1	4
Pasta	1	4		Pasta	1	4
Brinjal	1	4		Brinjal	1	4
Apple	0.75	4		Apple	1	4
Samosa	0.75	4		Samosa	0.75	4
Spinach	1	4		Spinach	1	4
Strawberry	0.25	4		Strawberry	1	4
Watermelon	0.75	4		Watermelon	0.75	4
Banana	0.75	4		Banana	0.75	4
Mango	1	4		Mango	1	4
	0.778				**0.958**	

Fig 15: Accuracy of food items at different 75 and 100 epoch

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125 Epoch		
Class	Accuracy	# Samples
Beetroot	1	4
Dhokla	0.75	4
Gajar Halwa	0.5	4
Cucumber	1	4
Grapes	1	4
Pear	0.75	4
Jalebi	1	4
Medu Vada	0.75	4
Orange	0.5	4
Pasta	1	4
Brinjal	1	4
Apple	1	4
Samosa	1	4
Spinach	1	4
Strawberry	1	4
Watermelon	0.75	4
Banana	0.75	4
Mango	1	4
	0.875	

150 Epoch		
Class	Accuracy	# Samples
Beetroot	0.75	4
Dhokla	1	4
Gajar Halwa	1	4
Cucumber	1	4
Grapes	1	4
Pear	1	4
Jalebi	1	4
Medu Vada	0.75	4
Orange	1	4
Pasta	1	4
Brinjal	1	4
Apple	0.5	4
Samosa	0.5	4
Spinach	1	4
Strawberry	1	4
Watermelon	1	4
Banana	1	4
Mango	1	4
	0.917	

Fig 16: Accuracy of food items at different 125 and 150 epoch

175 Epoch		
Class	Accuracy	# Samples
Beetroot	1	4
Dhokla	0.5	4
Gajar Halwa	1	4
Cucumber	1	4
Grapes	0.75	4
Pear	0.5	4
Jalebi	1	4
Medu Vada	1	4
Orange	0.25	4
Pasta	1	4
Brinjal	0.75	4
Apple	1	4
Samosa	1	4
Spinach	1	4
Strawberry	1	4
Watermelon	0.5	4
Banana	1	4
Mango	1	4
	0.847	

200 Epoch		
Class	Accuracy	# Samples
Beetroot	1	4
Dhokla	1	4
Gajar Halwa	0.75	4
Cucumber	0.75	4
Grapes	1	4
Pear	1	4
Jalebi	1	4
Medu Vada	1	4
Orange	0.5	4
Pasta	1	4
Brinjal	1	4
Apple	1	4
Samosa	1	4
Spinach	1	4
Strawberry	0.75	4
Watermelon	0.5	4
Banana	1	4
Mango	0.5	4
	0.875	

Fig 17: Accuracy of food items at different 125 and 150 epoch

- Impact on Water Conservation

  Our app holds significant potential in promoting water conservation behaviour among users, as evidenced by:

- Behavioural Awareness: By providing users with real-time insights into their water footprint, our app enhances awareness of personal water usage habits. This heightened awareness encourages users to adopt more mindful and conservation-oriented behaviours in their daily routines.
- Educational Resources: Through features such as blog posts and Aqua Info, our app serves as an educational platform, offering users valuable information and tips on water conservation practices. Empowering users with knowledge fosters a deeper understanding of the importance of water conservation and motivates them to take proactive measures.
- Chatbot Integration: The inclusion of a chatbot feature enables users to ask questions related to water footprint, receiving prompt and informative responses. This interactive functionality engages users in meaningful conversations about water conservation, fostering a sense of community and shared responsibility.
- Machine Learning Model for Image Recognition: Our app utilises a machine learning model for accurate identification of food items and their associated water footprints. By leveraging MobileNet CNN algorithm, we ensure precise assessment of water usage, enabling users to make informed

V. CONCLUSION

Our research and development efforts have resulted in the creation of a comprehensive app aimed at promoting water conservation and empowering users to make informed decisions about their water usage. The app offers a range of features, including intuitive interfaces for tracking water usage associated with food items and activities, educational resources such as blogs and a chatbot for user inquiries. Advanced image

decisions about their dietary choices and consumption patterns.

In comparison to existing solutions and initiatives, our app stands out for its user-friendly interface, advanced image recognition capabilities, and commitment to personalized recommendations. While some existing tools may offer general information or tracking functionalities, our app goes a step further by providing actionable insights based on individual usage data, empowering users to make meaningful changes in their water consumption habits.

VI. FUTURE SCOPE

- Increase Model Accuracy: Continuously improving the accuracy of our image recognition model by training it on a more exhaustive and diverse dataset. This will ensure even greater precision in assessing water footprints associated with various food items.
- Add Personalised Recommendation System: Integrate a personalised recommendation system based on user preferences, habits, and water usage data. By providing tailored suggestions for water conservation practices, we can further empower users to make meaningful changes in their daily routines.
- Partnerships with Organizations and Government Bodies: Explore opportunities for partnerships with environmental

recognition powered by a machine learning model enables accurate assessment of water footprints for various food items, enhancing the app's effectiveness in promoting mindful consumption. The integration of Firebase ensures secure user authentication and efficient data management, while Flutter facilitates cross-platform compatibility for wider accessibility.

organisations, NGOs, and government bodies to increase awareness about water conservation and promote the use of our app. Collaborative efforts can amplify our impact and reach a broader audience, fostering a culture of sustainability within communities.

- Expansion of Educational Resources: Expand the range of educational resources within the app, including interactive tutorials, videos, and expert insights on water conservation practices. By providing users with comprehensive information and guidance, we can empower them to become advocates for sustainable water management.

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