INTL JOURNAL OF ELECTRONICS AND TELECOMMUNICATIONS, 2023, VOL. 69, NO. 1, PP. 127–132
Manuscript received December 29, 2021; revised February, 2023. DOI: 10.24425/ijet.2023.144341

Real Time Implementation of Amphibious Unmanned Aerial Vehicle System for Horticulture

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***Abstract*—Automating the tasks that require manpower has been considered as an area of active research in science and technology. Challenges in designing such systems include accuracy in the parameters of performance, minimal hardware, cost-efficiency, and security. The efficiency of drones designed for replacing humans is often evaluated using their weight, flying time, and power consumption. Herein, the prototype-based Drone model has been designed and discussed for horticulture applications. In this model, a horticulture drone has been designed for structuring and cutting of plants in street interstates. This methodology focuses on automation engineering that is utilized for cutting the plants in less time and less power, thereby diminishing the contamination that may happen by utilizing fuels. The epic part of this plan includes the less weight drone predesigned using Computer-Aided Three-Dimensional Interactive Application (CATIA) V5 Software. The throttle for the motors is adjusted at 50% to get the required thrust for the Unmanned Aerial Vehicle (UAV) to fly. Experimental results show that the horticulture drone has comparatively more flying time and less power consumption.**

***Keywords*—CATIA; UAV; automation; thrust; throttle**

I. Introduction

HORTICULTURE is the workmanship and study of developing plants. It incorporates plant protection, scene rebuilding, soil the board, scene, garden structure, development, and support. It is socially critical to improving the information about the plants and their uses for various human purposes just as fixing the earth and individual feel. It includes planting proliferation and improving plant development, quality, yields, and improve the protection from creepy crawlies, maladies, and natural burdens. Horticulture manages seriously refined and significant level harvests. It incorporates the vegetables, products of the soil tasteful uses, or visual delight. It is additionally utilized in the recreation center, professional flowerbed, and parkways. In horticulture, the field size is much of the time littler contrasted with arable generation. Horticulture can be used to target trees or zones of tree squares adaptively to its clear status that will trim them down when required. UAVs can work unnoticed, and underneath overcast spreads which anticipate bigger higher elevation flying machines and satellites from playing out a similar crucial. The primary regions where horticulture is utilized include control for ailments and bug bothers for crop generation with high yielding, great quality, better advantage, biology, and well-being. Drones can fly self-ruling with committed programming which permits to make a flight arrangement and send the framework with GPS also, feed in different parameters, for example, speed, height, POI (Point of Interest), geo-fence, and safeguard modes. Drones are favored over full-size flying machines because of main considerations like a blend of high spatial goals and quick turnaround capacities together with low activity cost and simple to trigger. These highlights are required in exactness farming where huge zones are checked, and examinations are done in the least time. Utilizing the aeronautical vehicle is conceivable due to the scaling down of minimal cameras and different sensors like infrared and sonar. The proposed utilization of this framework was to decide plant tallness and trim down adaptively. This article reports the literature survey about cost-efficient unmanned aerial vehicle characteristics and its funding from multinational companies between the years 2000 and 2015 [1]. The coverage area of UAV, the delay experienced by transmitter and receiver are briefly explained in this article [2]. UAV deployment problem is explained, identified, and solved in this article [3]. The drone is used for monitoring agriculture, spraying pesticides [4]. The military applications and identification of explosives are used in drones, the cattle farms scenario can also be monitored by drone [5]. The monitoring of land in terms of big scale which is classified into sparse filed and dense forest regions is broadly explained in this article [6]. The monitoring of crop quality, preventing the crops against pesticides is explained [7]. The drone can measure the spectral imaging of wheat, crops, and plants in agriculture fields [8]. The drone receiver has different challenges such as delay, power utilization, distance coverage, aerial time, and most importantly wireless communication. The coils used in UAV are spiral and multi-turn has 85.25% of efficiency [9]. The agriculture applications play an important role in the future generations, drone plays a crucial role with sensor nodes placed in different places, the infrared thermometers [10], helped to classify the data and monitor them and has a huge impact on the entire farm [11]. The path planning, signal processing applications, agriculture mapping problems, coverage area in the forest region, satellite imaging, aircraft with man, are broadly explained with drone capability [12]. The precision agriculture monitoring in sparse field vegetation and dense field vegetation, the drone will take images and monitor [13], [14]. The internet of things has booming

This study was supported by the TamilNadu State Council for Science and Technology (TNSCST) in the platform of the agriculture applications under “Science Stream”- Ref. No. ES-023.

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architecture and has integrated with a drone for upcoming generation applications such as sensor data capturing, module working, efficiency in design. The deep learning algorithms, Internet of things concepts are also integrated with a drone and other applications [15], [16]. The scope of the drone can also increase by using Raspberry Pi-3 integration [17]. The cruise control of the motor with different sensors is explained in [18]. The quadcopter four command models are explained, four-velocity models with step response are implemented with results simulation [19]. The augmented reality video services are explained in UAV, the navigation and control system are proposed in this article [20]. The transceiver circuits, radio network, encoding, and decoding techniques, development and implementation of the transceiver are taken as reference for UAV design. Horticultural crop evaluation has a huge impact on plant growth. The height of plants, number of flowers generate, number of fruits generate in plants are used in soil microbiota.

In the development of greenhouse and field experiments, besides strain XT1 augmented aerial biomass between 37 and 43.8 percentage, and tomato plant's heights increased by 20.1 and 22.2%, respectively. For the decade years, several experiments have been made on crops. However, the results show that limited studies have been made on horticultural crops. In the present review article, we have reviewed that Si in mitigating salinity stress playing a major role in developing horticultural crops. The present review helps to evaluate the role of Si and saline stress in horticultural crops for their further improvement in the future. Currently, the researchers give high priority to reduce the post-harvest losses and value addition for the horticultural crops. In post-harvest, grading plays a major role, and it is developed in horticulture through basic observation and regular practice. During this process, various drawbacks like subjectivity, tediousness, labor requirements, availability, inconsistency, etc. have occurred. To overcome this problem, researchers round the clock and working towards the development of technology-driven solutions to grade/ sort/ classify various agricultural and horticultural produce. In India, large numbers of horticultural crops are grown based on its extensive variety of soil and climatic conditions. However, constant horticultural crops have superiority over annuals as they generally required low inputs such as water, energy, etc., with high production values. India has large tracts of waste and marginal lands (96 million hectares of the cultivable wasteland). Horticulture rejuvenates degraded soils, improves land productivity, enriches diversity, and protects the environment. So, in many countries, to improve the horticulture and environment, they introduced developed horticulture on roadways. This gives a great change in pollution control and improves the city attraction. Fundamentally, Horticultural crops have a great scope for appropriating more carbon in the terrestrial ecosystem than agricultural or agroforestry systems.

Consequently, perennial horticulture-based systems provide economic gain through carbon credits. But in India, the roadside horticulture especially on highways, the city faced a great challenge in the protection of horticulture plants like water supplies, regular cutting of plants, etc. To maintain the horticulture in highways, regular manpower is required. During this process, a lot of accidental death happened. Horticulture on highways will protect our environment and at the same time, accidental death should be avoided. To overcome this problem, this prototype-based drone has been developed for cutting plants.

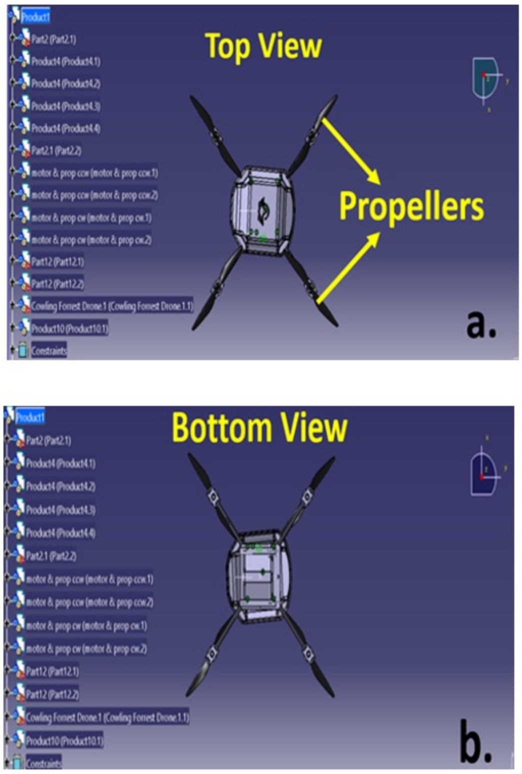

Fig. 1. Design of drone using CATIA V5 (a) Top view (b) Bottom View

Currently, Drone playing a major role in agriculture applications like seed sowing [21], spraying pesticides, crops monitoring, etc. Even though there is a research gap in the monitoring system, fails to enhance the plant growth in the highways. Especially the cutting of plants on highways makes more accidental cases. Horticulture on the highways gives more attraction for the metropolitical cities but at the same time, there is a high risk to develop horticulture on highways. To avoid these accident cases on highways and for gardening, the proposed system develops the smart prototype real-time amphibious unmanned aerial vehicle system for cutting and shaping the plants in highways as well as for gardening. Once the prototype drone works properly, then we follow up for the next level of implementation. The drones are used in many applications like spraying pesticides [4] and sowing seed balls [21] in the agriculture field, surveillance in the military [5], carrying medicines during pandemic situations, wildlife surveys for forest departments [12]. In such cases, the special drones are used for surveillance of the road damages by the Department of Highways (DOH) through vision-based technology. In vision-based technology, the roads are survived and took images by the drone which it sends to the department for survival. In our system, the drone was used to cut the plants in the highways, no need to capture any picture. The proper flying mechanism is enough to cut the plants and it can be operated manually on the highways. For the first time, we proposed the UAV system for horticulture on highways to avoid accidental death on the roadside and it can be used for gardening purposes. In the proposed system, we developed the prototype-based system, once after seeing its error rate it can be used commercially.

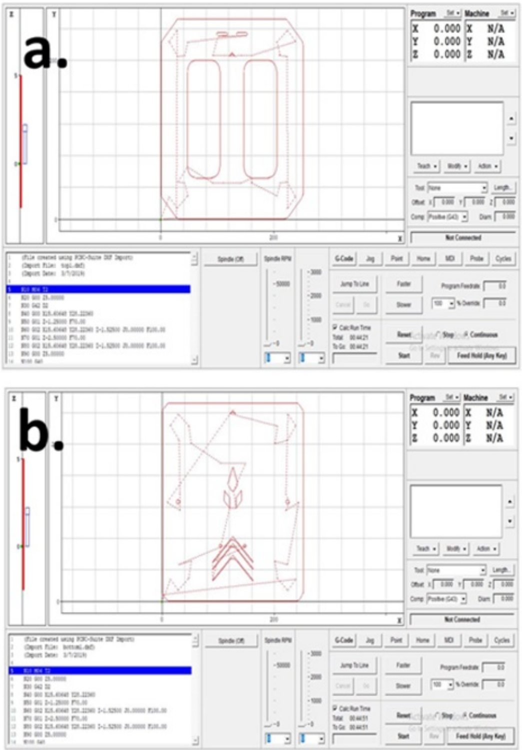

Fig. 2. CNC router Design. (a.) Top View, (b.) Bottom View

Here, the prototype was checked in both ways. In the first case, the drone was used to cut the plants with maximum height and in the second case, we tried the prototype drone to cut the grass at the minimum distance based on the proper flying mechanism. The photographic results of the drone mentioned in the following section clearly illustrate the prototype drone working successfully and it helps create an extreme platform for horticulture. This article helps the reader to understand the software design part of the prototype drone clearly and it is explained in section 2. The payload design is also clarified in section 2.2. The architecture design of the drone was enlightened in section 3. In that section, the readers can be able to study the flying mechanism of the drone, the working principle of propellers, motors, thrust, throttle, and weight calculation of the drone.

II. MATERIALS AND METHODS

A. Initial Design of the Drone

As a pre-design process, the architecture of horticulture drone is subjected to Computer-Aided Design using Catia V5, the product design software figure 1. The top view of the design is shown in figure 1a and the bottom view of the design is shown in figure 1b. Catia V5 is a widely used software in various industries, which serves as a system platform where the 3D structure of the final product could be designed, analyzed, and simulated before the actual product design. Based on the theoretical calculations and expected results, changes are made in the design and analyzed using the software tool. A novel design of a less weight drone shown is achieved by carefully placing the motors, propellers, motor mount, landing gear at the cowling using the software.

The mounting plates that are used to keep the batteries and motors fixed inside the designed structure of the drone are carefully designed using the Computer Numeric Control (CNC) router. The CNC router is a machine control software that works on 3D motion control to carefully cut the designed product parts according to the required dimensions. Figure 2a shows the bottom plate and top plate designed using a CNC router as shown in figure 2b. The two pairs of propellers rotate in opposite directions. The significant favorable position of this hardware determines its vertical departure and landing abilities. This airship is robotized using Arduino open-source improvement load up and open-source programming (Proteus) is utilized to design the flight way (waypoints, elevation, heading bearing, and speed). Once the design of plates is completed, the Arduino breakout board has been designed for automation using PROTEUS software. The PROTEUS software is used for schematic capture, simulation, and PCB layout design. Herein, it is used for designing the Arduino breakout board to control the UAV system and it is shown in figure 3.

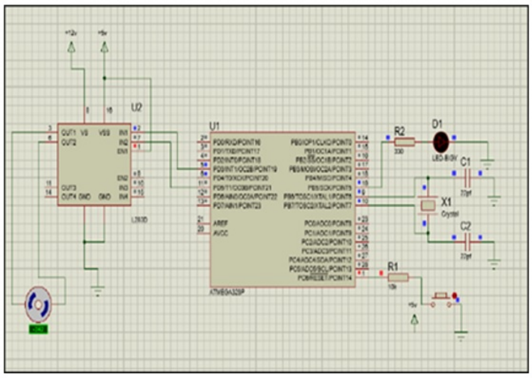

Fig. 3. Arduino breakout board design with a motor using PROTEUS sotware

B. Payload Design

The existence of drones in the present is very common. The major difference among drones appears in their area of application. Drones are designed as a support machine specially to solve the problems existing in remote sensing, agriculture, military sectors. Drones are also designed to find out disease in crop use the images taken by it while in motion from the payload sensors attached to it. Design of payload is problem-specific, where the attention is more on designing it with less weight which could even perform well. Growing and nurturing plants in the highway dividers helps in avoiding accidents on highways during night times, reduces pollution during travel, also promotes the greenery level of the area. The maintenance of these plants needs manpower on regular basis. Maintenance of crops even includes proper trimming and structuring in a timed manner. This problem is addressed here by designing a drone containing a metal blade that automatically trims the plants in scheduled time thereby reducing the need for manpower for performing this task. Figure 4a shows a circular metal blade used for pruning trees and plants and figure 4b shows the photographic image of the payload (metal blade) fixing for horticulture. Since it is a prototype-based design, the present UAV was designed and developed for cutting the small plants at the maximum height and grasses in the minimum height as an experimental.

III. RESULTS AND DISCUSSION

A. Design Architecture

The proposed architecture of the horticulture drone including all the necessary factors into consideration, designed for trimming the plants is shown in figure 5. The architecture used in this comprises of three main sub-sections namely the radio control section, the flight control section, and the payload section. The essential objective of the model is to react to the control signals and work to which it is customized and intended for. The basic components of the radio control section comprise a transmitter, receiver, and servos. The transmitter is the main box that is used to control the airplane, by transmitting the radio signals that pass through the air to the receiver. The receiver located inside the airplane receives the radio signals sent out from the transmitter and activates the flight control section. The flight controller is fundamentally the leading part of the drone, taking responsibility for every one of the directions that are given to the drone by the pilot. Brushless DC Motors (BLDC) is connected directly to the control surfaces of the airplane by linkages.

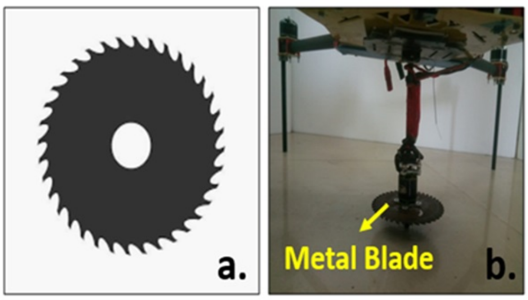

Fig. 4. Payload section (a) Metal Blade(payload) (b) Photographic view of Metal Blade connected to the drone as a payload

The Electronic Speed Control located inside the mainframe of the drone is an electric circuit that monitors, differs the speed of the motors, and controls the variations in the brakes of the drone during flight. The ESC system in the drone also plays the role of converting DC power to AC power to propel the brushless motors. A Battery Eliminating Circuit (BEC) is used to convert higher voltage from batteries to the required voltage level and provides the power supply to the controller. The four propellers are fixed, oriented vertically and each driven by a motor. Figure 6 shows the flying mechanism of the drone. Two motors in an opposite propeller pair are connected to rotate in a clockwise direction and the other two motors in the next propeller pair are connected to rotate in the anti-clockwise direction. The propeller pairs used to pull and push the drone for movement are made of plastic. The payload section in this model is designed as a metal blade that is operated using a trimming mechanism to trim the plants in the horticulture fields. In this mechanism, the Arduino board is used to control the DC motor and the motors are powered by using the battery. In figure 6, the rotating arms P1 and P2 were fixed for the anti-clockwise direction, whether P3 and P4 were fixed for clockwise rotation. For the flying mechanism, the selection of motor is important to calculate the relation between thrust and weight of the system has been calculated based on the Equation (1). The flying tool is calculated based on the vertical take-off and landing of the UAV system, when it satisfies the condition (a/g)>Patel et al.(2017) explained in Equation (1), [18].

$$Ratio = \frac{Thrust}{Weight} = \frac{ma}{mg} = \frac{a}{g} \tag{1}$$

Once the motor is ON, the metal blade rotates to trim the plants in the programmed path. Table I shows the components used in the drone design. Based on the weights of the components used in the design, the estimated weight of the drone with the payload is 4094g. The choice of the component selection relies on its compatibility, durability, and lightweight. X frames are less in weight compared to H frames.

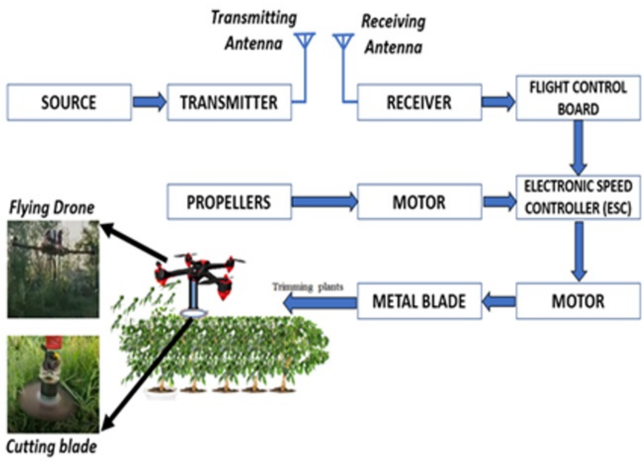

Fig. 5. Block diagram of the horticulture system

In terms of execution and activity measures, Brushless DC Motors are progressively effective variant to brushed motors in saving battery life, providing longer flight time without producing a lot of unnecessary noises and fewer maintenance costs. The flight controller signals the guideline of the motor speeds through the Electronic Speed Control (ESC) circuit and leads the drone in the right direction. The Naza V2 flight controller used in this drone adjusts the speed of the motors and in turn, maintains the body level of the drone.

Explaining research chronological, including research design, research procedure (in the form of algorithms, Pseudocode or other), how to test and data acquisition [6]–[9]. The description of the course of research should be supported by references, so the explanation can be accepted scientifically [4], [10].

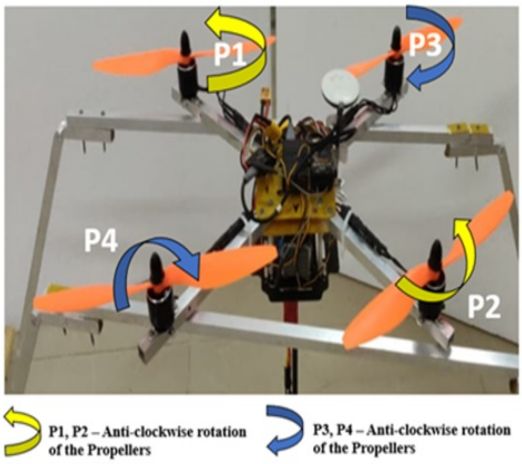

Fig. 6. Flying mechanism of the drone

B. *Estimation of Thrust*

The physics involved in achieving the stability of the flying machine lies in canceling out the net force acting on the body. Thrust can be managed by controlling the rotational speed of the rotors [21]. The thrust is determined by the size and type of propulsion system used on the flying machine and the throttle, setting selected by the design. The throttle for the motors is hence adjusted at 50%.

TABLE I
LIST OF THE COMPONENTS WITH THEIR WEIGHT ESTIMATES.

Component	Type	Est. wt. per unit	Quantity	Total Weight
Motor	Brushless DC	171g	4	684g
Esc	Brushless	46g	4	104g
Propeller	2 Blade Fixed Pitch	47g	4	108g
Battery	Re-chargeable	1386g	1	1386g
Frame	X Frame	1712g	1	1712g
Payload	Metal Blade	100g	1	100g
			Total Weight with payload	4094g
			Total Weight without payload	3994g

The rotating propellers of the drone the so-called wings of the flying machine generate the required thrust to keep the drone fly in the air. If the thrust to weight ratio is greater than one and the drag is small, the drone can accelerate straight up like a rocket. With 50% throttle adjustment, each motor in the drone is driven by a thrust of about 1049g. Table II shows the thrust, battery power consumption at 50% throttle, and the flying time of the drone.

The flying time of the UAV for the horticulture application is estimated at about 31.91 minutes based on the battery

TABLE II
THRUST AND FLYING TIME CALCULATION OF THE DRONE.

Motor thrust at 50% throttle		**Image**
For 1 motor	For 4 motors	Flying Time = (Battery capacity in amps per hour / Average amp consumption) *60 =10/18.8 * 60 = 31.91 minutes Where, Battery Capacity = 10000 math Battery Capacity in amps per hour = 10 amps per hour
1049g	4094g	
Battery power consumption at 50% Throttle		
For 1 motor	For 4 motors	
4.7	18.8 amps	

capacity in amps per hour to the average amp consumption as shown in Table II. Based on the estimated thrust, the real-time unmanned aerial system was designed for horticulture applications such as cutting the plants and grass, gardening, etc. These kinds of devices as shown in figure 7 are used for horticulture on the highways. In such a way, it avoids the accident in the highways, and it will be more useful for the green environment of society. In figure 7, the photographic image of the complete prototype UAV design is shown in figure 7a. Figure 7b shows the photographic image of the flying UAV system for horticulture. In figure 7c, the photographic image of metal blade cutting has been shown.

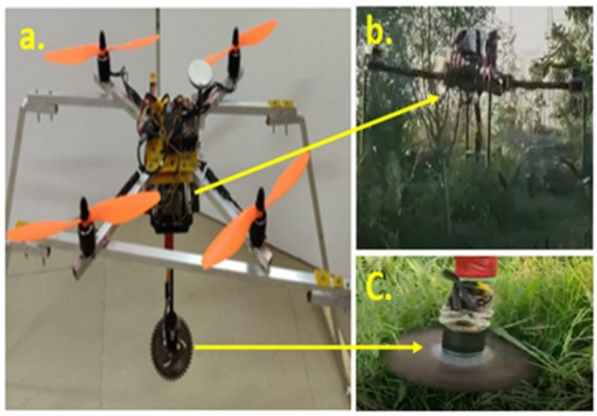

Fig. 7. Photographic Image of the Horticulture drone. (a) Complete design. (b) Flying and horticulture image (c) closer view of cutting metal blade

IV. Conclusion

In a nutshell, this wonder drone is effectively used for horticulture green environment. The drone is easy to handle. It was designed to create a good platform for green environment development. A drone works with electric power without requiring any fuels and hence behaves as a user-friendly device. The specialty of this machine is it reduces the time for trimming the plants and consumes less manpower. The design used was able to achieve a flying time of about 32 minutes. Since it is a prototype drone, it faced some problems in self-control and adaptivity while flying in the minimum distance and that will be rectified by further iterations in the future.

In the future, the drone could be programmed using GPS for navigation which further reduces the manpower. Further development of these wonder drones in the future leads to an eco-friendly pollution-free environment.

ACKNOWLEDGMENT

One of the authors (M.A) would like to thank the Garuda Aerospace Pvt. Ltd. and Agni College of Technology for supporting this work. This study was supported by the Tamil-nadu State Council for Science and Technology (TNSCST) in the platform of the agriculture applications under "Science Stream"- Ref. No. ES-023.

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