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DEVELOPMENT OF A RENEWABLE ENERGY POWERED AVIAN PEST SCARER

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Abstract: This paper developed a renewable (solar) energy powered avian pest scarer also known as scarecrow. Flocks of birds are known nuisance for grain crops farmers everywhere from time immemorial. Sometimes, these flocks of birds are often times very small, many in number, from different colonies, and easily habituate to stationary scarecrows. In some areas, human scarers are employed and stationed at ripening grains fields to scare away flocks of birds from feeding on ripe grains. This is usually time consuming and energy sapping. Scarecrows (stationary human effigies) are old ways for scaring away flock birds from grains crops farms without human intervention but the birds soon get used to them (habituate) and even use them as landing pads eventually. The effectiveness of a scarer depends on the conditions under which they are used, the technology employed and the types of flock birds involved. Scarers that are human beings like with irregular motions in the air that cannot be habituated by flocks of birds gives best results. Although, habituation by some bird species may be inevitable thereby diminishing the time of effectiveness of the scarer on the field. It is this challenge of habituation essentially that informed the development of this instant pop-up model to achieve maximum efficiency. A renewable energy powered avian pest scarer that is humane, environmentally friendly and not habituatable to avian pest is developed. It consists of pop-up scarer, an axial fan blower that is powered by batteries which is always charged back with the power from the sun through Photovoltaic (PV) modules and a motion sensor that usually senses the presence of birds before they land and activates the scarer in a panic motion. The scarer is made to pop-up and flutter in the air immediately the sensor detects flocks of birds, so as to be more effective in scaring the intruders, so that the birds do not land. It is effective in scaring stray and flocks of birds because of its sudden pop-up whenever it senses the presence of birds.

Keywords: Avian Pests Scarer, Grain Crops Farmer, Habituate, Renewable Energy, Scarecrow, Solar PV Modules

INTRODUCTION

Flocks of birds are one of the most challenging animals to keep out of agricultural grains fields and can also transmit diseases to foods. Farmers especially grain farmers can face significant financial loss due to pests' damages especially from avian pests (birds). Airports situated away from urban centers do have issues with flocks of preys which can cause problems for aeroplanes during take-off and landing as well (Wells, 2021). There are several means of dealing with or keeping away flock bird pests from desired locations especially grains farms. They can be dealt with chemically or physically. Chemicals such as Dichloro Diphenyl Trichloroethane (DDT) can be dusted on the fields by farmers to kill pest birds but it has been discovered to be harmful also to human beings as well (Haywood, 2021). Colored tapes can also be hung to reflect sunlight to the birds (Schipper, 2021) but when there is no sun or wind, it may not be as effective against the flock birds. VHS tape can be used too, it will produce a humming sound when there is breeze, it is effective when there is wind or breeze (Herlsey, 2019) but when there is no breeze or wind, it may not be effective. The best way to control major avian pests from farms and minimize damages to crops is by dispersing these pests (birds) in a safe and environmentally acceptable way is through the use of scaring technology (Agricultural Board Control, 2021). Objects can be made to resemble humans which are termed "scarecrows" to scare away flock birds. Scarecrows have been in use for a very long time to ward off flock avian pest. Rurals dwellers had invented the use of scarecrow as part of their traditional lifestyle to keep of avian pests.

Historically, in the olden days, the Egyptians, the Greeks and even the Romans all used scarecrows to protect their fields (Darrel, 2018). Immigrant German farmers in the United States made scarecrows looking like humans called "bootzamon," but later changed to "bogeyman". Many works had been carried out on scarecrows in the past. The traditional scarecrows are stationary, constructed to resemble humans in grains fields that are about to ripen, to scare away flocking birds from feeding on the field. (Lorimer, 2013) but in most situations, these traditional scarecrows and models are not alarming or threatening to birds to deter them from landing in the farm (Inglis, 1980). Howard et al. (1985) proposed models that can be active with sound and motion when flock birds are sighted but stops immediately when the birds leave which will make the birds not habituate to the model easily and fast. Sekhar (1998) showed in a study that nearly 50% of the households in the villages studied in their article had evidence of crop losses due to animal invasion. Richardson et al. (2014) assessed the effectiveness of an electronic scarecrow on 4 mammalian crop-raiders in Limpopo province of South Africa. They installed the electronic scarecrows farms and discovered that electronic scarecrows are useful weapons to mitigate human-wildlife conflict. Goboshoa et. al (2015) conducted a study to establish the types of wild animals feeding on the agricultural fields' crops and estimated the losses due to these animals. Different methods were used to analyze the data collected through semi-structured questionnaires, focus group discussion, direct observation and key informant interview. Saha et al. (2017) focused on different scientific applications which will result in better accuracy and results oriented remote agricultural fields monitoring

with less human-power. Pandapotan, and Silalahi (2019) traces various forms of local wisdom as social capital for paddy rice farmers in Deli Serdang District and related the concept of sustainable development where the emphasis is on economic growth and socio-cultural factors which can lead to the beneficial use of the environment. Inglis (1980) tested a model of scarecrow made in the likeness of human being with head and its raised hands moving at time intervals. The movements give alarming and scaring scene situations which is better than unanimated models but the birds got habituated to it. Achiron (1988) developed an inflated human effigy scarecrow placed on a 3- wheeled cart that is guided along cables in fields and orchards. However, scientific studies have not proven its efficacy on any species of birds. Beringer, et. al (2013) evaluated scarecrow that is activated by animals and a monofilament fence to reduce deer intrution into fields planted with soybean. The effectiveness of the animal-activated scarecrow (AAS) was evaluated and discovered that deer were habituating to the devices and concluded that AAS will be effective as short-term deterrence for deer in a small area. Haque and Broom (1985) carried out experiments comparing the use of kites as scarecrow and gas banger sounds to scare off woodpigeon from damaging crops and observed that damages in crop fields with a gas banger sound exceeded those in fields with a kite and concluded that kites can be more effective in reducing damage by woodpigeons if the kites can be activated mostly in mornings because habituation of the pigeons to the kite was not noticed. Cummings et. al. (1986) evaluated a combination of Purivox® Double-John carousel propane exploder and CO_2 pop-up scarecrow operated in unison in a field of ripening sunflower. It was discovered that during the first 10-day cycle trials, damages on three of the fields were reduced to a mean of 84%, while in the second cycle trials, damage was reduced further to an average of 59%. Pornpanomchai et al. (2011) developed a computer software system that can drive away birds from a farm by detecting pest birds in real time through a video frame and then generates a loud sound to drive the birds away. Brown and Brown (2021) evaluated a moving green laser beam (light) to control and scare away birds from sweet corn field and discovered that automated laser scarecrows reduced damage done by birds to sweet corn under field conditions. Mog (2017) constructed a non-harmful animal scaring system to protect a plantation farm from harmful animals with smart phone application. The system is controlled remotely by a smart phone which sets up devices such as a scarecrow balloon, an audio system and light lamps. This set up was successfully applied to a watermelon and a cabbage farm field for two years and no damage was recorded. Alneimi et. al. (2019) proposed the conversion of the traditional scarecrows to multi-function e-scarecrow (MFeSC) to perform more than one function at the same time. They suggested that MFESC should consist of sensor which will detect the sounds from intruding birds, and also an indicator to measure temperature and humidity of the farm. They suggested also that the scarecrow should contain some pieces of clothes that should be moving whenever the device senses the birds in the designated areas and should also produce noise and lightings to scare and keep birds away. Sakhare et.al. (2012) designed a cost-effective Intelligent Video Surveillance remote farm monitoring system for Indian Farms. The system will observe the intruders in the farm and force the intruder to leave the farm by initiating alarm and light to scare the intruder away. Tendolkar and Ramya (2020) proposed a solution named "CareBro" that is design to manage a farm autonomously and remotely without physical presence. The carebro is to interact with the smart farm devices in an IOT environment. The CareBro is connected to the farmer through the cloud computing, with real time monitoring and decision making thereby ensuring the perfect farm management solution in urban, rural, largescale and small-scale farmers. Roy et al (2021) proposed a pest bird-controlling protocol which is based on the use of unmanned aerial vehicle (UAV). The UAV is to reduce the request serving delay significantly due to the aerial communication mode. A detailed analysis showed the effectiveness of this solution compared to known parameters.

Often, however, the old practice of using motionless scarecrows provide only short-term protection or are ineffective in scaring flock birds. Some birds may even utilize them as perches, or associate them with favorable conditions. Flying hawk and owl scarers in some cases can be more effective than motionless scarecrows, because birds can rapidly habituate to their presence (Conover, 1982). Snake and cat scarecrow models are seldom of any value. For best results, scarecrow models should be moving irregularly, be highly visible, and be moved frequently at the site to help alleviate habituation. Dangling streamers or reflectors from scarecrows and using brightly colored loose clothing will help increase their effectiveness because they move in the wind and birds react more readily to colored and moving objects. A scarecrow that can be a good catch for farmers. Either small- or large-scale farming must be effective, affordable, environmentally friendly, autonomous, simple and scalable. The objective of this paper is to develop an inflatable renewable energy (solar) powered avian pests' scarer (scarecrow), using brightly colored loose clothing materials that will be moving which will increase its effectiveness which is effective, affordable, environmentally friendly, autonomous, simple and scalable. This will reduce financial loss due to grains crops damages caused by flock birds, and offer reliable, humane and safe agricultural bird dispersal practices. An inflatable scarecrow is an electrically operated/controlled scaring device based on the traditional scarecrow, operating electrically and recharged from a solar powered source. This scarecrow is one of the most effective ways of scaring away unwanted avian pests from the farm even before they land on the farm to feed. The inflatable

scarecrow has been a reliable device used in scaring away pest since it inflates automatically when it senses any foreign enemy (human, pest). It also creates an environment appearing hostile to birds and it is difficult for birds to habituate in such situations because the birds will not able to adapt to non-random movement of the multi-color effigy.

MATERIALS AND METHODS

— Materials

The essential materials used for this project are solar (PV) panels, Charge Controller, Batteries, Motion Sensor, scarer, axial blower fan. Each of these items are discussed below.

≡ Solar Panels

The solar photovoltaic (PV) panel, Figure 1, was used to generate the electrical energy required for the operation.

Figure 1: A Solar Photovoltaic (PV) panel

≡ Charge Controller

A 12 V/24 V 30A charge controller shown in Figure 2 was used to control the charging of the battery so that it is overcharged or over discharged. Whenever the battery is fully charged, the charge controller stops the changing process of the batteries and feeds the load unit directly. This charge controllers have one-way diodes installed in it, that prevents backflow of current from the battery back to the solar panels at night when there is no charging from the solar panels. These makes the battery retains its charge overnight.

Figure 2: A PWM Solar Charge Controller

≡ The Battery (Rechargeable, Deep Cycle)

The battery shown in Figure 3, also known as accumulator is a device for storing electrical charges for later use. The battery acts as a storage device to store over excess charges and as stabilizer to smoothen out the weather dependent electricity generation during fluctuation. The batteries used for this set-up are 12 V deep cycle rechargeable batteries because they have the capacities to charged and discharged in several thousand cycles in their life time.

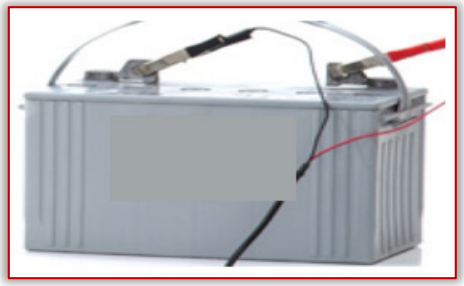

Figure 3: 12 V non-spillable Deep cycle Battery

The Motion sensor

A motion sensor shown Figure 4 senses/ detects motions/movements of flock birds from a pre-determined distance of about 30 feet from the field and activates/ triggers the fan blower in the inflatable balloon scarer which prevents the birds from landing in the protected field/farm. The birds cannot habituate to the scarer.

Figure 4: A Passive infrared (PIR) motion sensor used

The motion sensor used for this work uses passive infra-red (PID) technologies to detect movement in the covered area. It has a thin pyroelectric film material that responds to infra-red radiation by emitting electric current whenever motion is detected. It can detect objects at a distance of 30 feet in an arc of 140° whether during the day or at night depending on the settings and it has adjustable time duration of between 5 seconds and 5 minutes to work before stopping. This sensor has an operating current of 14 micro amperes (14 μA) and an operating voltage of 12V. Therefore, its power consumption is 0.000168 W (0.168 mW). The Sensor has two (2) controls which allows the sensor to be tuned to any settings for Delay Time and Lux. The "Delay Time" is the response time to trigger off the axial fan blower after detecting motion. The Time dial indicates the length of time that the sensor will stay on after it has been triggered. The Lux dial indicates the light level during which the sensor will become operational. Sensor can operate at dark or/in the day light depending on the Lux settings.

≡ The motor (inflatable scarecrow blower)

The inflatable scarer is composed of a thick, strong vinyl and nylon; therefore, it is being inflated using an electric powered fan blower. An external rotor fan unlike conventional motors whose rotors are on the inside of a wound stator is employed. An external rotor principle leads to small efficient motors, ideal for saving space. This presents

unique advantages to the fan and user in that it is extremely compact, therefore saving space, the hub and impeller becomes one integrated unit of short axial length which assure precision balancing, heat generated by the fan motor is effectively removed by the airstream, since the fan impeller acts as a rotating heat sink, speed control is possible but the fan is set to the highest speed for maximum effectiveness. The fan blower used in this work is a 12 V dc blower shown in Figure 5. The scarer will keep flying as long as the blower is working. A centrifugal fan was used because of its ability to develop pressure in a ducted air system. The blower has a housing that collects or gathers the air as it is expelled from the rotor and directs it out in a single stream into the inflatable scarer thus keeping it inflated. The blower used for the construction of this project is rated at 12 V, 4.5 A and a power consumption of 54 W.

Figure 5a: Image of a blower

Figure 5b: A Centrifugal ducted fan

≡ Inflatable scarecrow

The inflatable scarecrow is composed of thick, strong vinyl and nylon; therefore, it is inflated using an electric powered fan blower. When inflated, it stands in the air waving and mimicking a panicking human being. This situation creates fear in the flock birds and they cannot habituate this kind of random motions. Principle of constant leakage is employed with small punctures made at the edges of the inflatable scarer to allow air being blown by the fan blower to escape.

— Methods

≡ Design considerations

This section discusses the sizing of various components used for the set-up of the renewable energy powered avian pests' scarer.

✓ Solar power requirements.

There are some basic things to consider when creating a solar system set up. These include radiation insolation in the area of deployment, how much energy load would the appliance use over a period of time? How much energy can the solar panel generate over a period of time? Is the energy going to be stored and storage capacity of the battery?

✓ The appliance (Load)

The intended purpose of the scarer is to scare away birds, pest and other unwanted animals. Using the birds as the key subject. According to the research conducted on birds by a volunteer's research community (RSPB community), it was discovered that birds mostly come out to raid farms twice a day. They come out in the morning around 9 am to 12 pm, to roost and look for natural food which is a period of about 3 hours and also in the evening around 3 pm to 6 pm which is another 3 hours for feeding. So, if intended hours of use is assumed to be 6 hours, therefore, the 54 W blower which is the only electrical load since the load of the sensor is negligible compared to the overall ratings. The 54 W rotor working for a total of a period of 6 hours, will consume 54 W x 6 hours = 324 Wh of energy per day. If factor of safety of 20 % is allowed for the system, the total energy requirement will be 324/0.8 = 405 Wh.

Therefore, the energy requirement is = < 405 Wh.

✓ Battery storage Design

The battery capacity is measured in Amp hour (Ah) and Energy requirement is given in watt-hour, therefore, to convert Wh to Ah, we divide energy (Wh) by the voltage of the battery (24 V) to get Ah. The energy required = 405 Wh

Storage required i.e., battery capacity required = 405 Wh/12 V = 33.75 Ah.

If 80 % discharge is assumed, the battery capacity required will be = 42.1875 Ah.

A battery of minimum capacity of 40 Ah will be required. Four numbers of 12 Ah, 12 V batteries were connected in parallel to form a total 48 Ah at 12 V = 576 Wh.

✓ Solar panel Sizing

The sizing of the solar panels' capacity will depend on the insolation (average daily sun hours) in the area. The power generation rating of a solar panel is also given in watts. In theory, to calculate the energy it can supply to the battery, multiply watts (of the solar panel) by the hours exposed to sunshine.

The deployment is at Agbowa, Lagos, the average daily solar radiation is 5. 22 kWh/m^2/day (PV Watts) (National Renewable Energy Lab. (2021)).

The load required is = 576 WH = 0.576 kWh/day.

The solar power requirement is 0.576 kWh ÷ 5.22 kWh/m^2/day = 0.1103 m^2 at standard condition of 1000W/m^2 and T_c of 25°C.

The wattage of the solar panel = 0.1103 m^2 x 1000 W/m^2 = 110.3 W.

Two 55 W solar panels were selected and connected in parallel giving 12 V output with the following specification: Rated power of 55 W, rated voltage of 18.0 V and rated current of 3.06 A.

Open circuit voltage is 22.0 and short circuit current is 3.42 A. Photovoltaic rated at 1000 W/m^2, solar irradiation AM = 1.5 at 25^{0}C cell temperature.

≡ Experimental Set up

After obtaining all the required sizes of the various components needed for the scarer, the whole components were set up as indicated Figures 6 & 7. The motion sensor senses the presence of a bird or flock of birds and sends signal to the rotor of the fan blower which blows air at a very high speed and high pressure to jack up the inflatable scarecrow suddenly. The inflatable scarer jumps up waving in the air in a panicking mode with irregular motions that cannot be predicted.

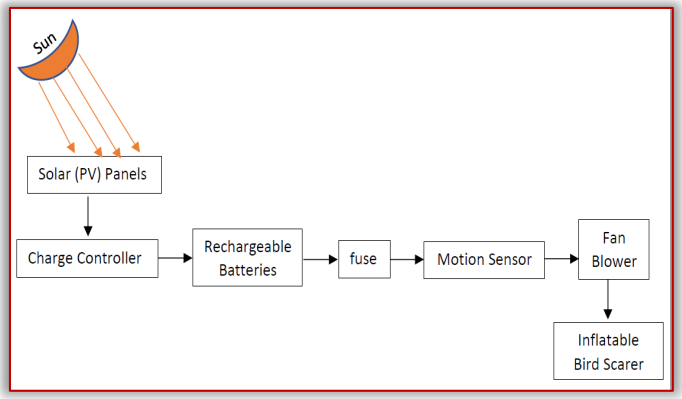

Figure 6: The block diagram set-up of the renewable energy avian pests' scarer

Figure 7: The set-up of the renewable energy avian pests' scarer

DISCUSSION

The components were set up as indicated in Figure 6. The sensor is positioned to capture objects of approach. Immediately, the object of approach is within 30 feet of the sensor, the inflatable scarer jumps up and started panicking motions in the air (Figure 7). The motions stopped after 120 seconds of inactivity. This invention is able to scare away flock birds and any avian pest.

CONCLUSIONS

Renewable energy powered avian pests' scarer was developed. A passive infra-red motion sensor was used to detect the approach of pest flock birds which normally triggers the inflatable scarer to jump up into panicking motion in the air to scare away the birds. The birds were not be able to habituate to it because of the unpredictable motions of the scarer and life like reactions to the bird approaches.

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