IoT based smart greenhouse

Conference Paper · December 2016

DOI: 10.1109/R10-HTC.2016.7906846

3 authors:

Ravi Kishore Kodali
National Institute of Technology, Warangal
109 PUBLICATIONS **1,822** CITATIONS
SEE PROFILE

Vishal Jain
National Institute of Technology, Warangal
4 PUBLICATIONS **417** CITATIONS
SEE PROFILE

Sumit Karagwal
National Institute of Technology, Warangal
1 PUBLICATION **112** CITATIONS
SEE PROFILE

IoT based Smart Greenhouse

Ravi Kishore Kodali, Vishal Jain and Sumit Karagwal
Department of Electronics and Communication Engineering
National Institute of Technology, Warangal
WARANGAL 506004 INDIA
Email: ravikkodali@gmail.com

***Abstract*—This work is primarily about the improvement of current agricultural practices by using modern technologies for better yield. This work provides a model of a smart greenhouse, which helps the farmers to carry out the work in a farm automatically without the use of much manual inspection. Greenhouse, [1], [2] being a closed structure protects the plants from extreme weather conditions namely: wind, hailstorm, ultraviolet radiations, and insect and pest attacks. The irrigation of agriculture field is carried out using automatic drip irrigation, which operates according to the soil moisture threshold set accordingly so as optimal amount of water is applied to the plants. Based on data from soil health card, proper amount of nitrogen, phosphorus, potassium and other minerals can be applied by using drip fertigation techniques. Proper water management tanks are constructed and they are filled with water after measuring the current water level using an ultrasonic sensor. Plants are also provided the requisite wavelength light during the night using growing lights. Temperature and air humidity are controlled by humidity and temperature sensors and a fogger is used to control the same. A tube well is controlled using GSM [3] module (missed call or sms). Bee-hive boxes are deployed for pollination and boxes are monitored using ultrasonic sensors to measure honey and send mails to the buyers when they are filled. Further, the readings collected from storage containers are uploaded to cloud service (Google drive) and can be forwarded to an e-commerce company.**

Keywords- Green-house, GSM, Agriculture

I. Introduction

Agriculture in India is still carried out in conventional way and lags behind in integrating modern technologies. Around 55 percentage of Indian population has been engaged in agriculture and allied activities which constitute only 15 percent of GDP so it becomes much important for the stakeholders involved to come out of the conventional agricultural practices and modernize the agriculture using technology. The economic contribution of agriculture to India's GDP is steadily declining with the country's broad-based economic growth while large number of people continues to work in agricultural sector. Hence, there is an immediate need to improve the system, which can increase the yield and produce healthy organic food.

A. Problems faced in agricultural sector

- Places like Punjab, which receive ample amount of water through river and canal irrigation system, faces problem of soil salinity due to excess irrigation. Places with limited water supply like Rajasthan, faces problem of acute water shortage for agriculture.
- Excessive use of fertilizers, insecticides and pesticides makes the soil dependent on them, erodes fertility, increases resistance in insects and pests, pollutes ground water and nearby water bodies whenever it rains.
- Different plants require different amount of moisture, humidity, temperature and light wavelength, and lack of awareness of this information or negligence of a person cultivating land can cause plants to die before maturing.
- Once the harvest is produced, farmers are further exploited by middlemen in Agricultural produce marketing committee (APMC) markets (mandis) due to which truckloads of money is earned by those middlemen and farmers are forced to sell their products at throwaway price specially during Zaid season when they grow perishable vegetable and fruits.

B. Introduction to smart agricultural model

- All the above mentioned aspects of present agricultural practices should be improved to get higher yield. Hence, we move towards a smart greenhouse model where the plant is provided with an environment for its optimum growth.
- Water received from the combination of various sources like canal, rain water harvesting and from purchase from tube well owners is stored in an underground tank. This underground tank is equipped with an ultrasonic sensor which sends an sms whenever tank is empty. Tube well pump can be switched on by sending a message to the GSM module by the farmer. This water is pumped into an overhead tank which gets filled using a pump according to the set threshold value. Overhead tank is connected to drip irrigation network via a valve, which opens when moisture level falls below threshold value.
- Due to the closed structure of greenhouse, insects and pests cannot enter inside, thereby eliminating the requirement of insecticides and pesticides. Growing LED lights are switched on whenever light intensity is low for photosynthesis, this ensures faster rate of growth.
- The humidity and temperature of air in a greenhouse are measured by sensor and whenever temperature is high or air moisture becomes too low, fogger is turned on to provide the required moisture and cool down the temperature.
- Pressure/Ultrasonic sensors are embedded inside the bee hive boxes to send a mail whenever the boxes

are full. Storage containers (vegetables and fruits) are provided with ultrasonic sensors to estimate the volume and send a mail to an e commerce company about the volume, whenever the RFID tag is swiped. This eliminates the requirement of middleman. The various problems of the agricultural system and the solution adopted by us are explained in detail in the following sections.

II. Literature Survey

Although India receives ample amount of precipitation and have many large river systems but still only one third of the total agricultural land is connected via canal irrigation system. Remaining majority of the portion is dependent on monsoon or tube wells. Places with excess water faces problem of land sanity due to over irrigation and water logging. Water collected on the surface also blocks pores in the soil and kills beneficial microorganisms. Alternatively, places with limited supply of water cannot do irrigation throughout the growing season because the requirement of water often exceeds the supply due to conventional type of irrigation like sprinkler or in case allowing the water to just irrigate the field directly from water drainage channels. Effects of excessive and irregular irrigation

- Increase salinity
- Water logging
- Hindrance in air communication to plant roots
- Reduction in temperature to soil
- Land becomes marshy
- More nitrate formation in soil
- Acidity of soil

Hence, problem lies in the mismanaged use of water. For optimum use of water, we use drip irrigation. It is an irrigation method to save water by allowing water to target the roots of plant. Water obtained from all the sources like canal, rainwater harvesting, tube well etc. are not allowed to irrigate the fields directly, instead it is first stored into an underground tank. Tank is equipped with an ultrasonic sensor which measures the level of water continuously and alerts the user with a sms whenever water level falls below the threshold mark.

Relative Humidity (RH) affects leaf growth, photosynthesis, pollination rate and finally crop yield. Prolonged dry environment or high temperature can make the delicate sepals dry quickly and result in the death of flower before maturity. Hence it is very crucial to control air humidity and temperature. We place temperature and humidity sensor inside the smart greenhouse to measure humidity and temperature. When temperature rises above a certain level, microcontroller will trigger relay attached to the fogger, which will sprinkle tiny water droplets of size of micron which will remain suspended in the air and bring the temperature down. In case the air moisture falls below the set value, similar mechanism will be triggered and the small water droplets will maintain the relative humidity (RH).

Various wavelengths of light plays specific roles for plant growth since different photosynthetic pigments within plants utilize different wavelengths. During morning, leaves receive it directly from sun but in order to boost up the rate of growth, we have provided the greenhouse with plant growing lights which will turn on whenever the reading from LDR sensor falls below cut-off value.[4] Advancement in LED technology have made it possible to build LEDs that emit the light in a very specific spectra to achieve very specific outcomes in plant growth. We can effect plants primary and secondary metabolism, which are directly associated with the output quality.

Fig. 1: Drip irrigation using soil moisture sensor

To avoid involvement of middleman and their adverse effects on farmers we proppsed an IoT based solution, to inform the buyers (agencies) about the goods produced by a farmer. The farmer just have to swipe his [5] authorized RFID card and then automatically it will send an e-mail to the buyer sharing the information of quantity of goods produced at that instant of time.

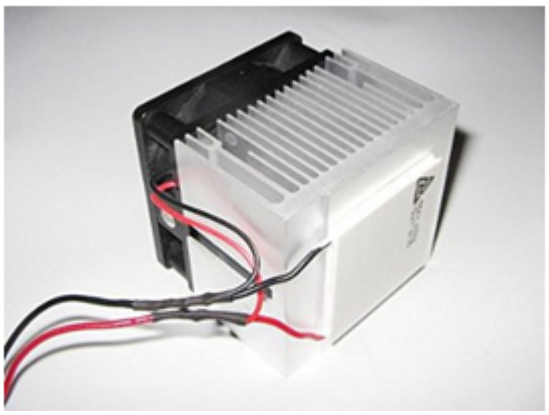
III. Methodology

A. Irrigation System

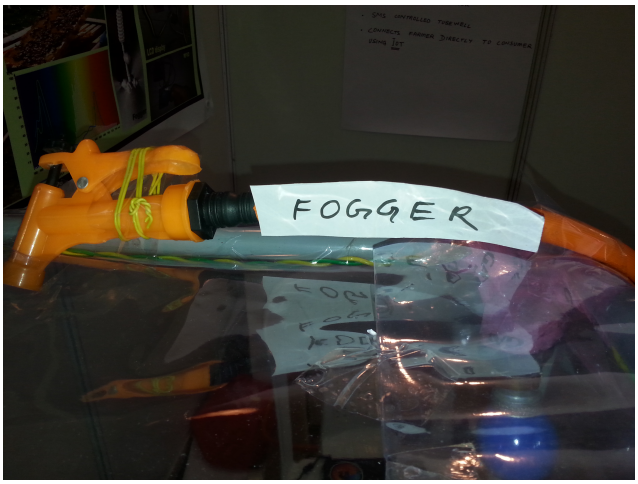
For optimum use of water, we use drip irrigation. It is an irrigation method to save water by allowing water to target the roots of plant. Water obtained from all the sources like canal, rainwater harvesting, tube well etc. are not allowed to irrigate the fields directly, instead it is first stored into an underground tank. Tank is equipped with an ultrasonic sensor which measures the level of water continuously and alerts the user with a sms whenever water level falls below the threshold mark. The user then sends an sms to the gsm module, which retrieves the sms and triggers the relay to switch on the tube well. Microprocessor switches off the pump once the underground tank is filled. The water in overhead tank is measured through an ultrasonic sensor and the microprocessor switches on or off the pump according to the threshold set. This overhead tank is connected to a network of drip irrigation pipes and can be operated through a solenoid valve. The moisture sensors are deployed in the field which measures the soil moisture and opens the valve whenever moisture is below threshold and closes it when moisture has reached optimum value[6].

B. Air Temperature and Humidity Control

We place temperature and humidity sensor inside the smart greenhouse to measure humidity and temperature. When temperature rises above a certain level, micro-controller will trigger relay attached to the fogger, which will sprinkle tiny water droplets of size of micron which will remain suspended in the air and bring the temperature down. In case the air moisture falls below the set value, similar mechanism will be triggered and the small water droplets will maintain the relative humidity (RH). In case the relative humidity is at threshold and further cooling is required, Peltier module is used which can be powered by solar panels and can regulate the temperature by cooling or heating as per the requirements. Glass greenhouse structure can hold the heat during night time, that prevents the leaves from frost bite in cold winter night in some cold and dry areas.



(a) Peltier fan



(b) Water sprinkler:fogger

Fig. 2: Controlling Temperature and Humidity

C. Growing Led Light

Various wavelengths of light plays specific roles for plant growth since different photosynthetic pigments within plants utilize different wavelengths. During morning, leaves receive it directly from sun but in order to boost up the rate of growth, we have provided the greenhouse with plant regrowing lights which will turn on whenever the reading from LDR sensor falls below cut-off value. Advancement in LED technology have made it possible to build LEDs that emit the light in a very specific spectra to achieve very specific outcomes in plant growth. We can effect plants primary and secondary metabolism, which are directly associated with the output quality.

(a) Regrowing lights

(b) Smart apiculture

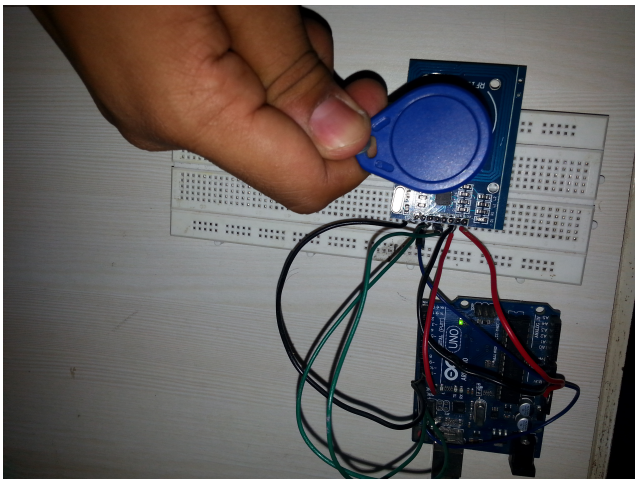
D. Smart apiculture

Similarly, apiculture is also integrated inside the setup because it does not receive any breeze or insects from outside which can aid the pollination. Bee hive boxes are fitted with ultrasonic sensor to estimate the current level of honey, and an e-mail will be sent to a procurement unit whenever the level reaches a threshold set value. Thus honey produced can directly be sold to end customers.

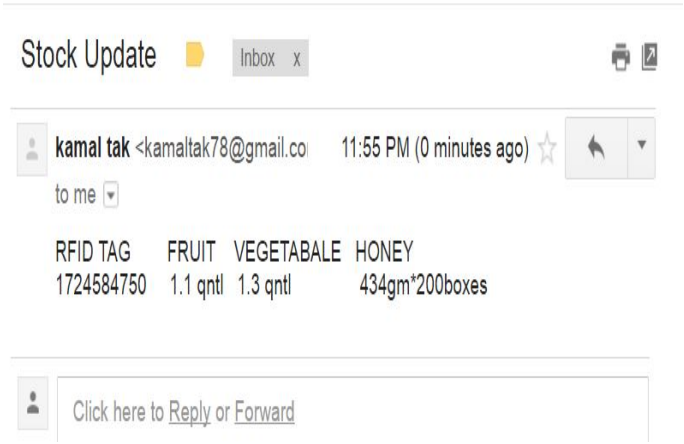
E. End Market Connection

To save the farmer from the clutches of APMC and middlemen, we have designed a marketing system which connects farmer to customer directly, bypassing the middlemen. The storage house will have containers equipped with ultrasonic sensor that are used to estimate the volume of the products inside. Whenever fruits and vegetables are plucked, they are

stored in these containers and farmer will swipe a RFID tag, and the data from all the containers will be updated on google spreadsheet and a mail will be send to an e-commerce website. Hence the buyer has the knowledge of the quantity stored by farmer.[7]



(a) Authenticating rfid tag



(b) Update data

Fig. 4: Market connection

IV. Implementation

A. Hardware-Software Resources

1) Intel Galileo Gen 2 and Arduino[8]
2) Accessible Wifi
3) Ultrasonic Sensor[9]
4) Regrowing LED lights
5) Peliter fan
6) GSM sim900a
7) RFID tag and sensor
8) LCD for display
9) Relays for connecting pumps, peltier, lights, fogger
10) Arduino IDE (Software)

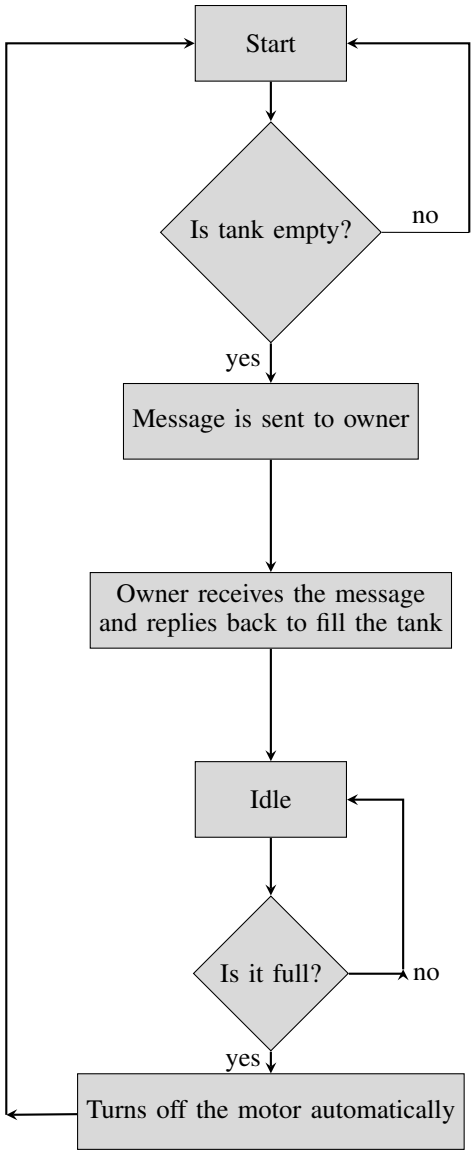


Fig. 5: Use of GSM to control motor

B. Setup

V. Results

VI. Further Scope

The Smart Greenhouse can be further upgraded in many ways and can be used in wide agricultural applications. It can be placed and operated in any of the environmental conditions to grow any kind of vegetation. Non-conventional energy sources such as solar panels[10], wind mills are used to supply power to the automatic greenhouse equipments and Peltier effect for cooling purpose. [11]Soil-less farming can be performed to further improve the nutritional value. Integration of farming with IoT can make it much more efficient and profitable activity. Smart Greenhouse has a bright scope of future in agriculture field and it will create a revolution in the way the agriculture is carried out in India.

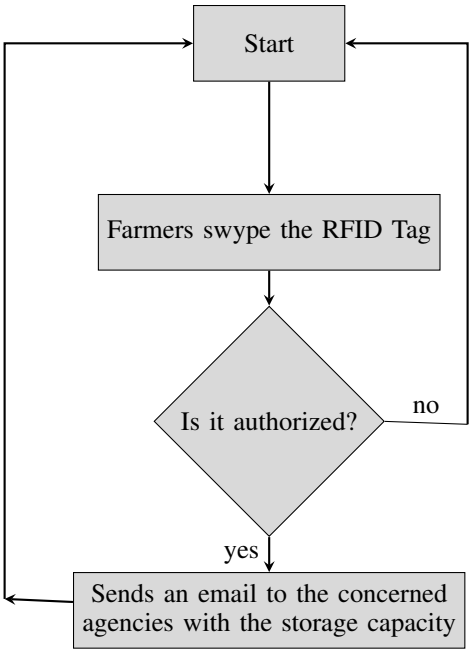


Fig. 6: Use of RFID in selling the products

Fig. 7: Implementation setup

VII. CONCLUSION

The advantage of Smart Greenhouse over conventional farming is that we were able to produce insecticide and pesticide free crops and create a climate for the proper growth of plants and even provides alternative source of income through apiculture, selling tube well water etc. Moreover, this system can be installed by any individual in his house (Roof-top greenhouse), who doesn't have knowledge about farming. Since one can maintain any climatic condition in this type of Greenhouse, it is possible to cultivate any type of crop. Hence, we grow plants like Hibiscus which are imported to India. We can reduce 70%-80% water requirement. It also increases yield and rate of growth and produces organic agricultural products. Most importantly, we are able to connect farmer directly to consumer using IoT, which can save him from the clutches of middlemen. It reduces effort and time of farmer and makes farming efficient and profitable activity.

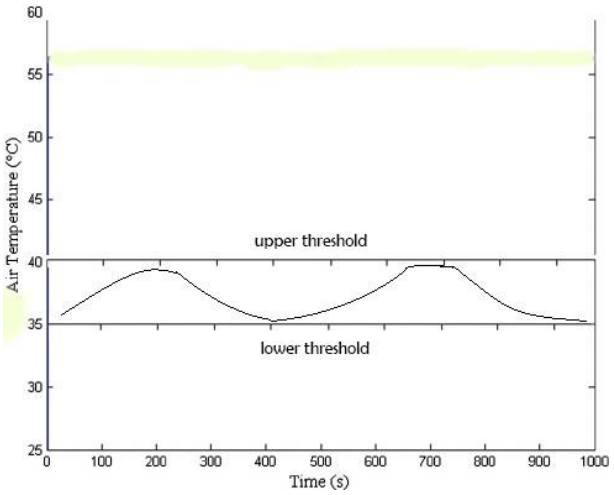


Fig. 8: Temperature variation

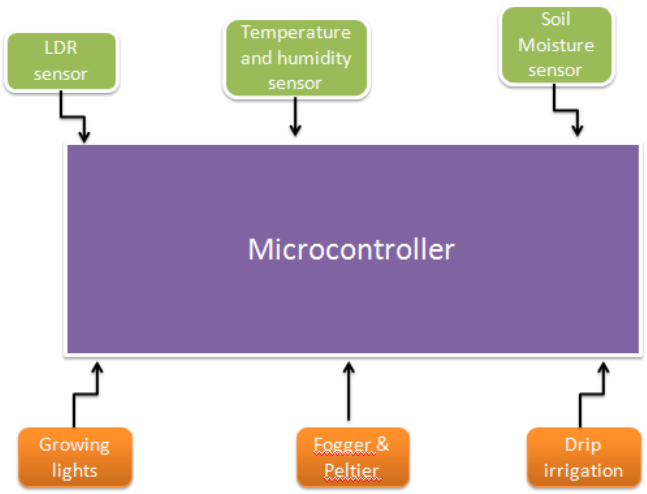


Fig. 9: Sensors controlling devices

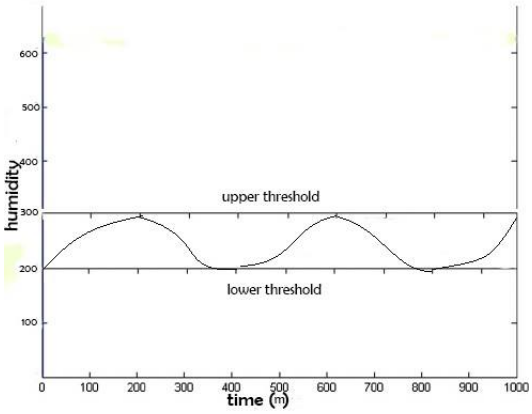


Fig. 10: Variation of soil humidity

REFERENCES

[1] A. Bseiso, B. Abele, S. Ferguson, P. Lusch, and K. Mehta, "A decision support tool for greenhouse farmers in low-resource settings," in *Global Humanitarian Technology Conference (GHTC), 2015 IEEE*, Oct 2015, pp. 292–297.

[2] K. A. Czyzyk, S. T. Bement, W. F. Dawson, and K. Mehta, "Quantifying water savings with greenhouse farming," in *Global Humanitarian Technology Conference (GHTC), 2014 IEEE*, Oct 2014, pp. 325–332.

[3] Z. Xiaoyan, Z. Xiangyang, D. Chen, C. Zhaohui, S. Shangming, and Z. Zhaohui, "The design and implementation of the greenhouse monitoring system based on gsm and rf technologies," in *Computational Problem-solving (ICCP), 2013 International Conference on*, Oct 2013, pp. 32–35.

[4] M. Mahdavian, M. B. Poudeh, and N. Wattanapongsakorn, "Greenhouse lighting optimization for tomato cultivation considering real-time pricing (rtp) of electricity in the smart grid," in *Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (ECTI-CON), 2013 10th International Conference on*, May 2013, pp. 1–6.

[5] D. S. Kim, T. H. Shin, and J. S. Park, "A security framework in rfid multi-domain system," in *Availability, Reliability and Security, 2007. ARES 2007. The Second International Conference on*, April 2007, pp. 1227–1234.

[6] P. Laiolo, S. Gabellani, L. Pulvirenti, G. Boni, R. Rudari, F. Delogu, F. Silvestro, L. Campo, F. Fascetti, N. Pierdicca, R. Crapolicchio, S. Hasenauer, and S. Puca, "Validation of remote sensing soil moisture products with a distributed continuous hydrological model," in *2014 IEEE Geoscience and Remote Sensing Symposium*, July 2014, pp. 3319–3322.

[7] V. Sorathia, Z. Laliwala, and S. Chaudhary, "Towards agricultural marketing reforms: Web services orchestration approach," in *2005 IEEE International Conference on Services Computing (SCC'05) Vol-1*, vol. 1, July 2005, pp. 260–267 vol.1.

[8] Y. A. Badamasi, "The working principle of an arduino," in *Electronics, Computer and Computation (ICECCO), 2014 11th International Conference on*, Sept 2014, pp. 1–4.

[9] A. Carullo, F. Ferraris, and M. Parvis, "A low-cost contactless distance meter for automotive applications," in *Instrumentation and Measurement Technology Conference, 1996. IMTC-96. Conference Proceedings. Quality Measurements: The Indispensable Bridge between Theory and Reality., IEEE*, vol. 1, 1996, pp. 84–89 vol.1.

[10] N. Datta, M. N. Ahmed, R. Liya, N. Zaman, and B. B. Pathik, "Efficiency improvement of a solar power plant using combine cycle: An experimental study on a miniaturized solar power station," in *Information Technology and Electrical Engineering (ICITEE), 2014 6th International Conference on*, Oct 2014, pp. 1–5.

[11] YangYang, Z. Chang, and S. Yin, "Influence of fly ash and soilless substrates on chemical properties of their compound medium and tall fescue growth," in *Electric Technology and Civil Engineering (ICETCE), 2011 International Conference on*, April 2011, pp. 5118–5122.