ISSN (e): **2250 – 3005** || *Volume, 07 || Issue, 08|| August – 2017 ||*
International Journal of Computational Engineering Research (IJCER)

Asurvey on contribution of the Internet of Things and smart systems to agricultural practices

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ABSTRACT:
The growing demand for agriculture products contradicts the challenges associatedwith the decline in farming land size and labour workforce. Recent literature acknowledges thattheInternetofThings(IoT)playsacrucialroleinenhancingthesmartaspectsalreadydeployed in agriculture. Smart farming is an emerging concept because of IoT sensors capableof aggregating information about their agriculture fields under real-life circumstances. Thepaper aims to survey the recent implementation of IoT based monitoring systems applied inagricultureworldwide.A systematic literature review carriedout to investigate the extent ofIoT adoption in agriculture industries. The understanding of Reason to adopt IoT, the Scale ofadoption andthe cost andbenefit of IoT adoptionweredrawn from papers publishedinSCOPUS, Web of Science, and DOAJ between 2010 up to early 2020. Twenty-eight mostrelevant articles extracted from the search. This paper recommends strategies to adopt an IoT-based monitoringtoolpertinentto irrigationsystemsimplementationinIndonesia.

I. INTRODUCTION

Withtheexplosivegrowthofthehumanrace,whichmeanspopulationgrowth,conventionalorancient farming methods have become unable to compensate for growth with satisfaction. Therefore,advanced farming methods are needed to approach the food needs of an increasing human population.In recent years, intelligent farming systems based on embedded systems and the Internet of Things(IoT)havegainedtractionandpopularityamongpeopletoincrease foodproductionforhumans[1].

The Internet of Things (IoT) plays an essential role in smart agriculture. Smart agriculture is anemerging concept because IoT sensors can provide information about crop condition [2]. IoT connectsagricultural devices and collects data information. It applies in a variety of applications such as farmsconnectivity, smart environment, water management, measurement tools, crop monitoring, and otheragricultureautomationsystems.Theconnecteddevicesarecapableofanalyzingaggregatedinformationandthensending ittothe monitoringcentre[2].

The functional aspect of IoT is to connect every object in the world for the human to control themthroughtheinternet.TheconceptofIoTproposedafewyearsago;perhapsitisnotwrongtoquotethat this term has become a benchmark for establishing communication between objects. In the contextof the current IoT position, identification of the most prominent applications in the IoT field has beenhighlighted, and comprehensivereviewshavebeen carried outaccurately in thearea ofAgriculture[3].

From the emergence of IoT, there are different approaches to interacting objects with each other,also between objects and humans. Based on the context presented, this article surveys the use of IoT invariousagriculturalsettingsthatdonotlimittomobilerobots,drones,imageextractionandprocessing. Specific to the proposed works are those related to centralized processing, cost reduction,andmaximizingcomputerpower[4].Theworksuggestedtargetsthedevelopmentoflow-costintelligent systems for smart irrigation [5]. The cost of IoT adoption devoted attention [6], as thepassage should give farmers an alternative to increase production and limit crop damage. Intelligent orprecise farming systems are expected to play an essential role in growing agricultural activities [7].Several researchers are relevant to the topic of the Internet of Things in Smart Agriculture. By theadvent of the IoT [8], it set the new direction for innovative research in agriculture. Therefore, thispaper proposes for the strategies to adopt an IoT-based monitoring tool pertinent to irrigation systemsimplementationin Indonesia.

II. METHODS

This paper adopted a systematic literature review [9] to sort, identify and draw knowledge fromgathered

reference. This method is employed to delve deeper into a specific topic of interest.Recentfinding underlined that it is the most effective method in exploring preexisting research topics. Thisresearch explored hundreds of articles indexed in SCOPUS, Science Direct, and DOAJ. Publishedbetween2010and2020.Toscopeddowntheappropriateknowledge,theresearch'agriculturemonitoring systems', 'drip irrigation systems', and 'internet of things' as the keywords. Twenty-eightmost relevant articles extracted from the search. The articles, then, classified into three categories asdepictedinFigure1.

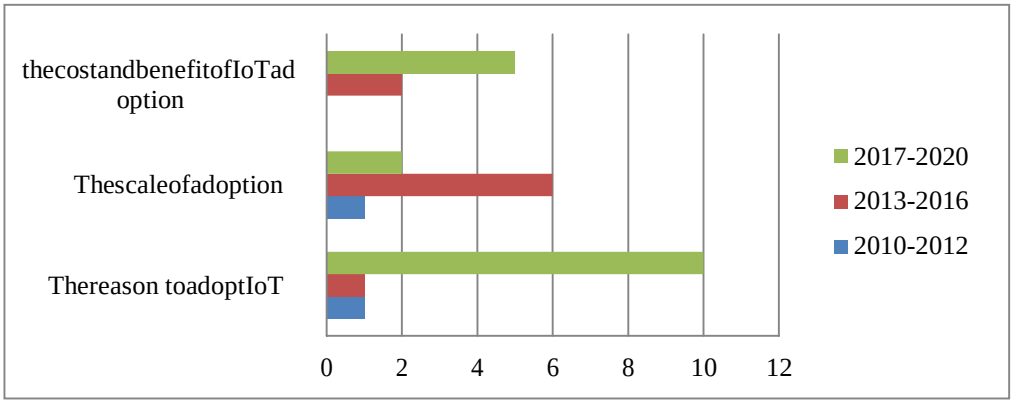

Figure1. Thenumberofpapers bycategories.

According to Figure 1, most of the papers argued for the reasons for adopting the Internet of Thingswere published in 2017 - 2020. Alike, those discussed on the cost and benefits of adopting IoT. It isslightly different from the topic of IoT scale of adoption that mostly published between 2013 - 2016. Amatric of concept was applied to draw a conceptual framework from the overarching literature [10].The matrics were reorganized according to papers' publication date, show the longitudinal aspects ofthe topic, the insight suggested by each article related with research questions, and the description oftheeach papers'causalrelationship[11].

III. RESULTS AND DISCUSSION

Figure 1 summarizes the articles investigated in this study by their categories. Twenty-one articlesdiscussed the application of IoT in agriculture, while twelveof the selectedpapers addressed the useof IoT-based devices in agricultural activities [12]. The gist of each category is elaborated in thefollowingsections.

ThecostsandpotentialbenefitsofadoptionofInternetofThings

The work proposed here focuses on the adoption of a low-cost system in smart irrigation. Wherein, thesystem utilizes IoT to create appliance employed in the network communicate with themselves, withcapabilities such as user interaction, setting the estimated drip irrigation schedule, controller andremote data monitoring. The proposed system has proven to be adequately intelligent, low cost andportable,makingitsuitablefor greenhouses,agriculture,andso forth [5].

The advantage of an IoT device is that it is cheaper and consumes less power. Intelligent farmingsystems have been designed and synthesized. This system can be used in greenhouses and plantsdepending on temperature. It is predicted that future capabilities will be more potent by the addition ofmoderntechniques suchasirrigationmethods,theuseof solarpower sources[2].

ThefollowingarethemainbenefitofIoTin agriculture:

- Real-timedatabenefitscostreductionofdecisionmakinginlogisticandqualitativetraceabilityof foodproduction.
- Cropmonitoringallowsthereductionofcostsaswellaspreventingthetheftinthefarmland.
- Theautomaticirrigationsystem[13]worksinresponsetothevaluesoftemperature,humidityand soilmoistureobtainedthrough sensors.
- Operationalefficiencyandproductivityimprovementsupportedbyalargeamountofdataanalysisofthedecision supportsystems[14,15].
- Theprocessforcommunicatingwithotherdevicesandservicesontheinternettocarryoutthetasks requestedbyusers[16].

Adequate water use and remote monitoring provide smart solutions in areas that lack water andpeople who are far from their agriculture. The need to conserve natural resources is justified by the useof such automation. Its easy access, cost-effectiveness, and usability make it versatile and thus suitablefor a variety of potentials such as adaptability and portability enable it for the deployment in thefarmland[5].

TheReasontoadopt Internetof Thingsinagriculture

Agriculture is the backbone of the country's economy [17]. Most of the work of the population in ourcountry is agriculture. As we mentioned before, farmers still use the manual method for monitoringplants,andotheractivities,therearesomedisadvantageswhenweapplythemanualmode,itconsumes much time, we need to be present to monitor the plants, they fail to detect the right situation.Water is the primary agricultural resource, so the government must provide irrigation and propermanagement of water. Land issues are also one of the reasons for low profits; some farmers do nothave land to harvest. Land leasing techniques are adaptable to solve this problem [18]. Alike, a cloud-capable CLAY-MIST (C.M.M.) measurement index based on temperature and relative humidity toassess plantcomfortlevels[19].

Intelligentorprecisefarmingsystemsareexpectedtoplayanessentialroleinincreasingagricultural activities [7]. Therefore we can use technology in an efficient way to get accurate resultsand save time. Now we will look at technology in agriculture, there are many technologies, but now allprefer to use IoT for agriculture-related work. With the help of technology, we can monitor the harvestfrom anywhere, and we can provide water to the fields from a distance from the location, plantdetection can also be done without being in the field[19]. Overall the area of the country if weconsidertheagriculturalsectordoesnotreceiveadequateattention.Nowadays,technologyiseverywhere,butit is stillatan earlystagein adoptingtechnologyto thefarmingindustry[19].

IoT is potentially applied through an agricultural drone [6] which is a relatively inexpensive dronewith a mechanism that provides farmers with an alternative to increase yields and reduce crop damage.IoT also applied as intelligent greenhouses [20] which include aquaponics and small-scale systems[21]. The application of IoT in vertical farming [22] allows the control of moisture and groundwaterusing computers or cellular devices such as tablets and smartphones. In particular, advances with theInternetofThings,artificialintelligence,androboticshave,amongotherthings,enabledautomated and data-based agriculture [23]. The increasing demand for food, both in quantity and crop quality, hasincreased the need for intensification and industrialization in the agricultural sector. IoT is an up-and-comingtechnologyfamilythatcan offermanysolutionsto agricultural modernization [24].

Thescaleoftherelevant researchadoption

Research related to the topic of the Internet of Things in Smart Gardening. Analysis by Ray [8], forexample, explains the advent of the Internet of Things (IoT) as a new direction for innovative researchin agriculture. Low cost, autonomous, energy-efficient and robust solutions with features like artificialintelligence and much-needed maintenance. Overall, various aspects of IoT must be met in such a waythat agriculture becomes intelligentandthriving.

Prathibha, Hongal [2] report in IoT-based Monitoring Systems in Smart Gardening underscore thevitalrole of IoTin smart agriculture.The concept of smart farming arisessince IoTsensors arecapable of providing information about the farm's real-time condition. The research aims to takeadvantageof developing technologies, namely IoT andIntelligentAgriculture,using automation.Automationmonitoringcanreduce human strengthandbemore natural.

Gondchawar and Kawitkar [25] propose to enrich agricultural activities by utilizing automation andIoT technology. The system comprises an intelligent application-based remote controller that monitorssoil moisture and executes watering automation based on accurate real-time field data. Included in thesystemsisanirrigationmechanismequippedwithsmartcontrolanddecisionmakingbasedonreal-lifeagriculturaldata.

Rajalakshmi and Mahalakshmi [26] argue for crop-fields monitoring systems using soil moisture,temperature,humidity,andlightsensors.Datafromsensorswillbeconveyedwirelesslytothewebserver under encrypted JSON format. Notifications will be sent to mobile farmers regularly, andfarmerscanmonitortheconditionofthefieldfromvirtuallyanywhere.Thesystemwillbebeneficialinwater-scarce areas and92% more efficientthanconventionalapproaches.

Baranwal and Pateriya [27] 's project focused on the safety and protection of agricultural productsfrom insect attacks in the fields. The security provides real-time notificationsonce it detectsanintrusion.Pythonscriptsintegratesensorsandelectronic devicesadoptedinthesystems.

Sales, Remédios [28] explain that wireless sensor networks performance in a three-node network,including the acquisition, collection, and analysis of data such as temperature and soil moisture. Whilethe benefits of irrigation in agriculture are reducing waterconsumption and the environment, theCloud Computing capabilities offer a large amount of data for high watering supported by wirelesssensorsandnetworkactuators.Thisworkisaimedatagriculture,greenhouses,andlandscapes.Monitoringsoil moisturetoassesstheplant's needsforwater andconservationconsideration.

Kassim and Mat [29] describe a wireless sensor network as the best way to solve agriculturalproblemssuch asoptimizing agriculturalresources, decision-making support, andlandmonitoring.The approach provides real-

time information about land and plants that help farmers to make the rightdecision. IoT based precision farming systems comprise hardware and network architecture, and theprocess control software for precision irrigation systems. The software collects data from currentsensors that optimize the use of water fertilizers through irrigation and also maximizes the yield ofcrops.

Modernagriculturerequiresabetterirrigationmanagementsystemtoconservewateruseinagriculture and related activities [30]. Four prevalent factors adopted in smart irrigation systems arereal-timeintegrationofweatherforecastdata,farmers' controlsystemsfrom anywhere,activatingWiFi and Ethernet connections, increasing synchronization with humidity sensors installed on thefarmer's yard, and reducing monthly farmer bills that help conserve resources limited water power. IoTcontinuestogainpopularityinsystems relatedtoirrigationmanagementaroundthe world.

Controlleduseofpesticidesandfertilizershelpsimprovecropqualitywhileminimizingagriculturalcosts.Thepredictoro fpesticideusesinthefarmlandrequiresthemonitoringofprobabilityandoccurrenceofpestsinplants.Theneedtocollectdi seaseandinsectpestinformation

using sensor nodes, data processing, and mining, are enabled with the help of the IoT infrastructure[31].

IV. CONCLUSION

Various studies have been carried out in adopting IoT technology. There are several aspects examined,namely the Reason for taking IoT, the Scale of adoption, and the costs and benefits of IoT adoption.Intelligentfarmingsystemshavebeendesignedandintegrated.Thesystemisdevelopedmoreefficiently and is beneficial for farmers. It provides information on temperature, humidity and soilmoisture. Researchers propose and need to build an intelligent agriculture system based on IoT. Theapplication of such a system in the field will be able to help advance crop harvests and globalproduction. In the future, this system can be improved by adding some modern techniques such as theuseof solarpowersources

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