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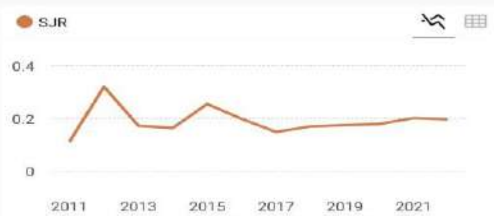

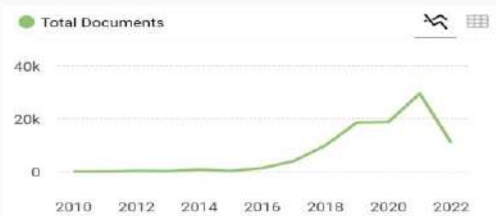

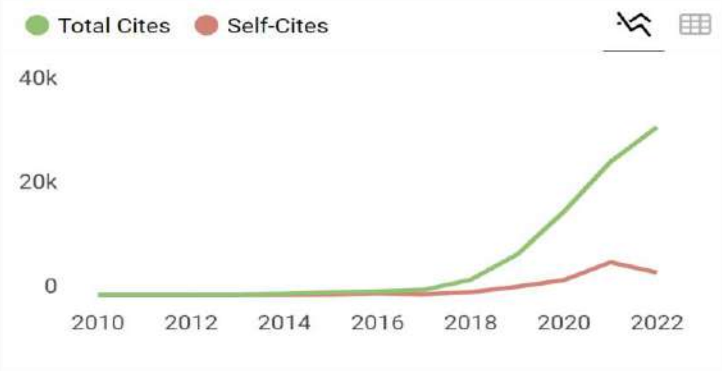
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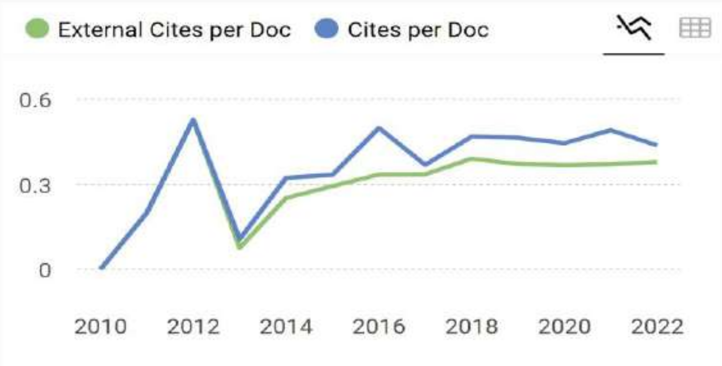
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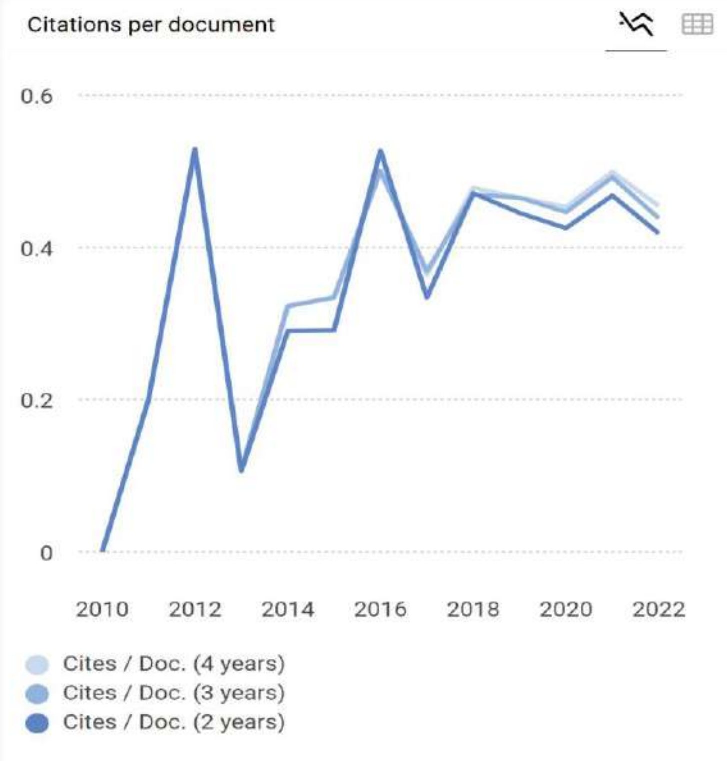
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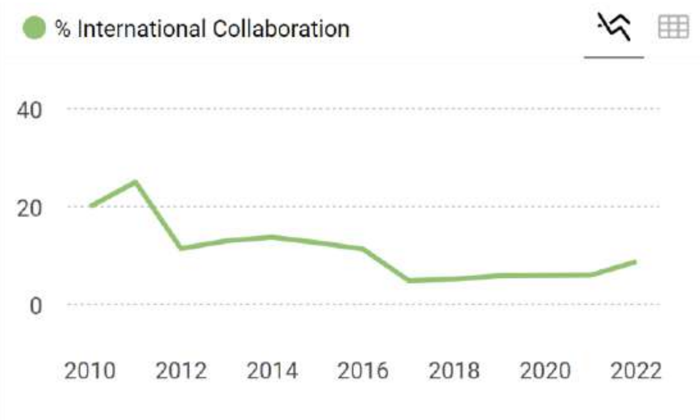
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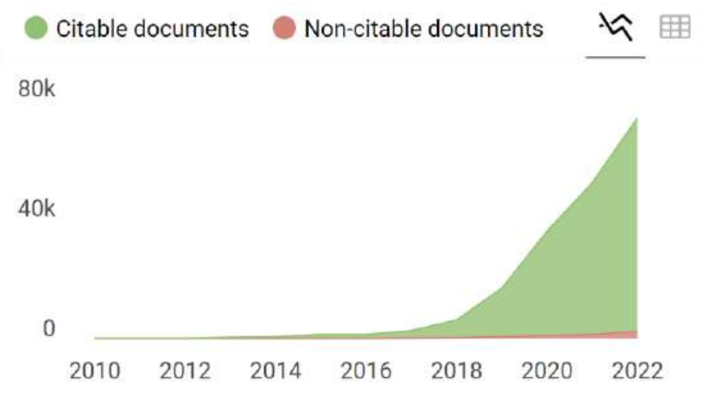
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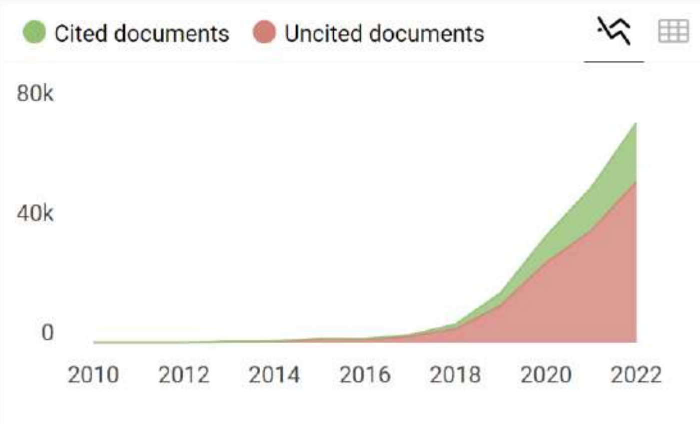
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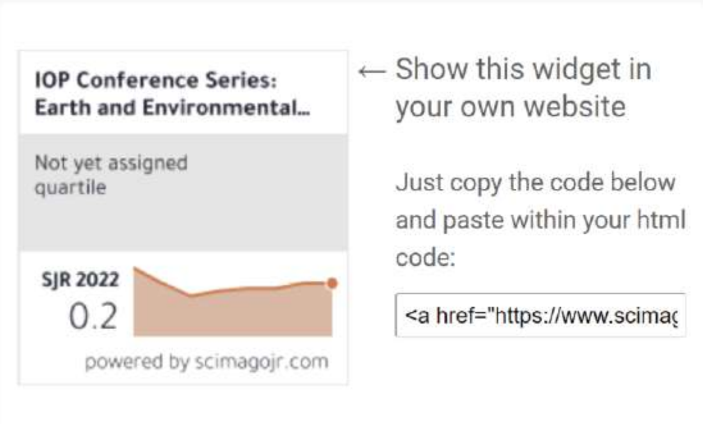
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Preface

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THE 5th INTERNATIONAL CONFERENCE ON AGRICULTURAL TECHNOLOGY AND ENGINEERING, AND ENVIRONMENTAL SCIENCES

(ICATES 2023)

"Building Agricultural Innovation in a Changing Environment"

September 20, 2023

Organized by:

Department of Agricultural Engineering

Agricultural Mechanization and Workshop Research Center

Supported by:

Faculty of Civil Engineering and Earth Resources

LPPM Universitas Syiah Kuala

PERTETA ACEH

Preface

It gives us great pleasure to introduce to you this companion report for the 5th International Conference on Agricultural Technology and Engineering, and Environmental Science (The 5th ICATES) 2023, an event that continues to serve as a prestigious platform for global researchers and experts. Built around our conference theme, "Building Agricultural Innovation in a Changing Environment", a drive to be champions of innovation and resilience in the face of environmental shifts has underpinned our discussions. We believe that the intricate interplay of agricultural technology, engineering, and environmental science is crucial in addressing pervasive issues, such as climate change, that threaten the sustainability of agricultural practices. This conference is an arena for pioneering thinkers from field scientists to tech developers to discuss, debate and exchange ideas about meeting these challenges head-on.

This 5th iteration of the conference witnessed enormous participation, illustrating the immense importance the global scientific community places on our collective mission. Out of the numerous accomplished works we received, we were pleased to accept 72 papers for publication from the total 112 submissions. These papers were rigorously reviewed by our esteemed panel and were selected for the richness of their insights, their strong empirical underpinning and their commitment to advancing our understanding of agriculture and environment in the context of a changing world. This report presents analytical summaries of these well-researched papers, detailing their methodologies, findings, and implications. It serves as a testament to the ongoing commitment of our participants to further new and emerging research within this sector.

The pioneering research showcased in this report, we hope, will foster an evolving dialogue around sustainable agriculture and technological development. More importantly, it paves the way for transformative innovations that can face the challenging needs of our changing environment head-on. We extend our heartfelt appreciation to all the researchers and participants who have contributed to the conference and this report. Your work pushes the frontier of our understanding and catalyzes the global drive for innovation in agricultural technology, engineering, and environmental science. In essence, this report, and by extension the conference, illustrates our mandate to bring forth inventive thoughts, practical realities, scientific developments, and prospective models to navigate the complexities of modern agriculture in a changing environment. We hope that our readers engage with these materials with an open mind, and we look forward to collaborative learning, policy discourse, and the practical adoption of these innovative ideas to catalyze change in our world.

Cordially yours,

Dr. Muhammad Dhafir
Chairperson ICATES 2023

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KEYNOTE SPEAKER ABSTRACT

NIRS FOR SUSTAINABLE AGRICULTURE AND FOOD PRODUCTION: PAST, PRESENT, AND FUTURE

Prof. Dr. Daniel Mörlein

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Abstract

Since its first applications mid past century, near infrared spectroscopy (NIRS) has become a widespread technique for quality assessment, fraud detection, and process control all of which are relevant to agriculture and food production. NIRS is based on molecular vibrations, i.e. interactions of a sample's molecules with incident light. It is non-destructive, fast and typically no or little sample preparation is involved which is why it can be called a green technology. Its application helps also reducing costs and resources thus contributing directly to achieving the UN sustainable development goals (SDGs). This talk will cover some basic concepts behind NIRS, current research into its application in the agri-food sector, and an outlook on ongoing developments and future applications. It is anticipated that advances in miniaturization, cloud-computing and further cost-reduction will likely contribute to even more widespread applications in the future.

ERGONOMIC RESEARCHES FOR SAFETY, PRODUCTIVITY AND SUSTAINABILITY IN AGRICULTURAL WORK SYSTEMS IN INDONESIA: A BRIEF OVERVIEW

Prof. Dr. Ir. M. Faiz Syuaib, M.Agr.

Director of Research, Technology and
Community Service Ministry of Education and Culture, Indonesia
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Abstract

Modernization and industrialization move faster and imply for changing the needs and challenges in all lines of human life. On the other hand, these developments also challenge or even 'force' us to change the work systems, tools and methodologies that eventually need for interventions to produce a match and suitability between the work and worker characteristics. The agricultural sector is no exception, which is still the largest provider of employment in many developing countries in the world, including Indonesia. Work in the agricultural sector is one of the most risky and dangerous jobs, however, manual work that relies on human power is still very dominant in most cases. Therefore, problems of productivity, work safety and welfare are important issues in which requires ergonomic intervention in order to produce the best formulation in the design of sustainable work systems. Anthropometric data are a prerequisite for designing tools and equipment that enable workers to achieve better performance and productivity while providing better safety and comfort. Ergonomics studies and approaches are increasingly needed to overcome various potential risks and at the same time to be able to increase work productivity and safety in agricultural work systems in Indonesia. Compared with groups of people from other countries, the Anthropometry of Indonesians have very similar dimensions and characteristics to Indians, but tend to be smaller than other Eastern nations and definitely smaller than most Western nations. The muscle load distribution during oil-palm harvesting is higher in the upper limb, such as shoulder and back, upper arms, and neck.

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DOUBLE-POROSITY IN THE SUBSURFACE

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Abstract

The subsurface of the ground is a complex environment where various phases of solids, liquids and gases are involved. This is especially true for the unsaturated zone in the ground which acts as the first line of defence against contaminants for groundwater sources. In the case of multiphase immiscible flow in the unsaturated zone, the transport of the fluids found within the pores of the unsaturated zone is very complex. This is compounded by the structure of the soil matrix itself, which may exist in different forms. One of these forms is known as double-porosity, which occurs naturally in various subsurface media such as agricultural top-soils, rock aquifers and compacted soils. The double-porosity phenomenon occurs when two discrete continuums with vastly different characteristic pore size overlaps each other. Here, the inception of double-porosity and its development over the years will be expounded, with emphasis on multiphase fluid flows. Special attention is given to studies involving migration of non-aqueous phase liquids in double-porosity media. Research related to double-porosity is mainly divided into two categories, physical laboratory-based experiments and numerical modelling. For physical laboratory-based experiments, they can be further grouped into studies on the fluid flow process in double-porosity subsurface media, mechanistic studies on the double-porosity structure itself, and studies done on double-porosity samples from actual sites. In here, experiments on organic fluid movement in double-porosity soil based on image analysis is highlighted. Using a unique photographic method that can capture non-aqueous phase liquid migration in double-porosity samples, the migration pattern results are presented and a saturation calibration curve relating the image hue values to the actual non-aqueous phase liquid saturation was obtained. As for the numerical modelling part, the multiphase immiscible flow was modelled by way of Galerkin's weighted-residual method with an implicit scheme for the temporal discretization. The physical relationships between the solid matrix and the fluid phases were expressed as functions of capillary pressures. The validated model was run on different scenarios of multiphase flow and non-aqueous phase liquids pollution. From both physical experiments and numerical modelling, organic liquid pollutants are found to travel further within a shorter amount of time in double-porosity soil compared to soil with single-porosity. This finding brings about immense implication to the effort to protect and preserve groundwater sources.

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EVALUATION OF WATER QUALITY USED IMAGE-BASED FOR LAND AND WATER MANAGEMENT

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Abstract

Sustainable development requires a balance between environmental protection, social, and economic development, and prosperity. Land and water resources are crucial for ensuring sustainable development. Water supplies are hampered by inappropriate biophysical characteristics of the land and human activity. The quantity and quality of water are impacted both directly and indirectly, independent of climate change causes. One of the categories in the land use for discharge and sedimentation simulations is vegetation conditions. The methodological framework of preliminary catchment studies on the ecological environment (climate, soil, vegetation, and the involvement of humans) must be met for water and land resources to be used sustainably. One of them is the difficulty in making quick predictions while monitoring water quality on a broad scale. It is impossible to detect spatial-temporal fluctuations in water quality in a location using data gathered from field samples. Current technological developments mean that water quality evaluation can be carried out in an integrated manner for long-term information using remote sensing techniques. This paper will discuss data acquisition using remote sensing and geographic information systems (empirical algorithms) to quickly detect changes and trends in water quality. The use of Satellite Imagery to observe water quality will be very practical and efficient in terms of time and cost and can provide information over a very wide area. The use of this technology and geographic information systems can quickly detect changes and provide water quality information. Remote sensing technology can identify and analyze the results of recording the spectral characteristics of water with parameters that determine water quality. Collecting data in the field often cannot represent large areas to identify variations in water quality so that technology can provide information to formulate policies to maintain water quality. One of the parameters to determine water quality is the concentration of Total Suspended Solid (TSS). To assess the performance of the algorithm obtained, the TSS content of image processing has been validated with field data taken at several points in the area. The contribution of this information is very important for creating land and water management planning scenarios to formulate planning and management policies and to better explore the potential impact of decisions on the environment.

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Mapping the Distribution of Coffee Agroforestry in the Upper Ciliwung Watershed, West Java, Indonesia

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Mapping the Distribution of Coffee Agroforestry in the Upper Ciliwung Watershed, West Java, Indonesia

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Abstract. Land management by combining annual crops with seasonal crops is known as agroforestry. Agroforestry has a positive impact on watershed sustainability as it improves the watershed ecologically, economically, and socially. Coffee agroforestry is an agroforestry that incorporates coffee plants in their system. Coffee agroforestry in the Upper Ciliwung Watershed is spread across several sub-watersheds, but there is conflicting information related to the distribution and extent of agroforestry which results in no precise information on the coffee plants distribution. Therefore, this study aims to map the distribution and extent of coffee agroforestry in the Upper Ciliwung Watershed and identify the composition of the agroforestry system in the Upper Ciliwung Watershed. This study is done through satellite imagery interpretation and ground truth check of coffee agroforestry in the study area. The data are analyzed using descriptive qualitative method to describe obtained information on the coffee agroforestry from field observation. The results show that there are four sub-watersheds that have coffee agroforestry in the Upper Ciliwung Watershed, which are Cibulao, Cisuren, Cikoneng, and Rawa Gede sub-watersheds. Cibulao sub-watershed has a coffee agroforestry area of about 20 hectares, Cisuren has an area of about 32 hectares, Cikoneng has an area of about 5 hectares, and Rawa Gede has an area of about 5 hectares. In total, the coffee agroforestry areas in the Upper Ciliwung Watershed are approximately 62 hectares.

1. Introduction

Perennial or forestry crops combined with intensively managed agricultural crops are known as agroforestry. The application of traditional agroforestry patterns as watershed conservation in land management in Indonesia is common in the community. The advantages of agroforestry system are that it can preserve the environment, increase land productivity by producing various crops which lead to increasing farmers' income, and support sustainable ecological balance [1–4].

Coffee is quite widely cultivated by people in Indonesia as an alternative to agroforestry-based forest management. Coffee-based land management is known as coffee agroforestry. Coffee is a type of perennial plant that has a low erosion value and coffee has botanical properties that play a role in soil and water conservation [5]. Coffee is a plant that belongs to the Rubiaceae family with the genus *Coffea*. The part of the coffee plant that is utilized is the seeds, generally the use of coffee plants is the fruit seeds which can be used as a drink.

The Upper Ciliwung Watershed is one of the coffee producing areas. In 2009-2013, the Cibulao Green Forest Farmers Group planted coffee independently, then in 2014 the IPB Regional Development Planning Center (P4W) provided guidance to provide knowledge to members on how to plant coffee and harvest coffee properly. [6]. Other than Cibulao, there is no certain information about the existence of coffee agroforestry practice in Upper Ciliwung Watershed. Currently, there is a lack of information related to the extent and distribution of coffee agroforestry in the Upper Ciliwung Watershed. Accurate information on the coffee distribution is needed so that this information can be used as a basis for further coffee agroforestry development. Considering the importance of spatial information about the coffee agroforestry pattern in the Upper Ciliwung Watershed, this study aims to map the distribution of the coffee agroforestry and identify the composition of the agroforestry system in the Upper Ciliwung Watershed. The results of this study hopefully can serve as an initial study for future coffee agroforestry management and development.

2. Materials and methods

This research was conducted in the Upper Ciliwung Watershed areas that practice coffee agroforestry. There are a total of four areas that practice coffee agroforestry in Upper Ciliwung Watershed, which are Cibulao, Rawa Gede, Cikoneng, and Cisuren. The map of the distribution of research sampling locations and ground truth checks in the field presented in Figure 1. The coordinates of the study area are presented in Table 1. The tools used in this research are GPS (global positioning system) to mark the sampling locations' coordinates, stationery, computers, and data processing software, such as ArcGIS 10.5. The materials used in this research are 4.7-meter resolution Planetary Imagery obtained in 2023, slope map, land use map of Upper Ciliwung Watershed in 2018, and administrative boundary maps. The land use change in the study area is rather slow, therefore, the time difference between land use map and field ground truth check is considered appropriate.

This research begins with image interpretation which aims to describe information about coffee agroforestry and its land area in the Cibulao, Rawagede, Cikoneng, and Cisuren areas. Image interpretation using manual visual delineation method, on screen digitization on 4.7-meter resolution planetary image in 2023, by observing similar agroforestry-based coffee plants on resolution planetary image. After the interpretation process is complete, a ground check point is carried out at the research location to obtain the accuracy of information and land area in image interpretation of coffee agroforestry. We also carried out interviews with the coffee farmers. The analysis method in this research is a qualitative descriptive method to describe information on coffee agroforestry components by direct observation of coffee plant in the Upper Ciliwung Watershed.

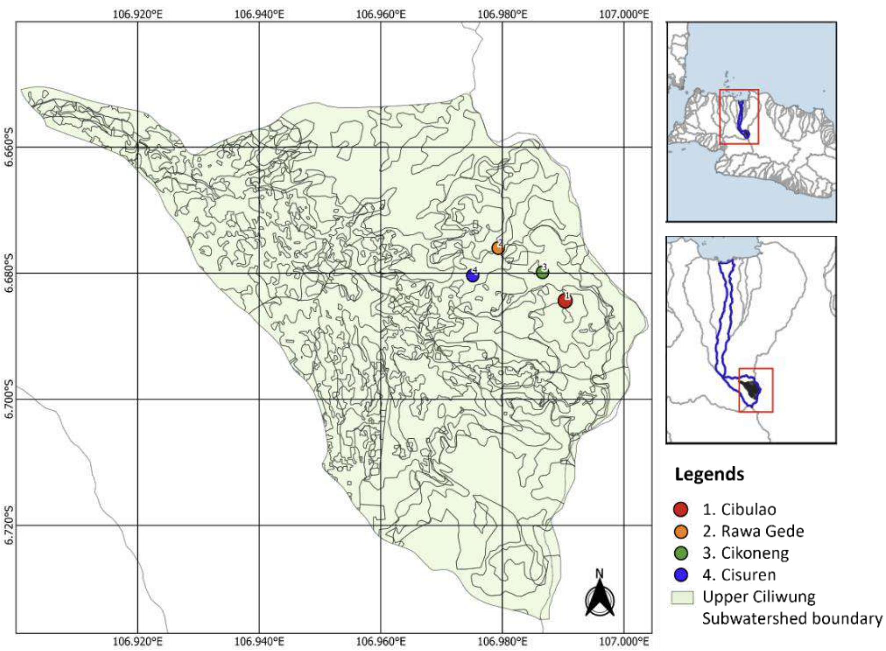

Figure 1. Map of research sampling locations
(Source: BPDASHL, 2023, with modification)

Table 1. Coordinates of the sampling locations

Sample	Location	Coordinate		Altitude (meters above sea level)
		X	Y	
1	Cibulao	106.990	-6.684	1391
2	Rawa Gede	106.979	-6.676	1407
3	Cikoneng	106.986	-6.679	1396
4	Cisuren	106.975	-6.680	1245

3. Results and discussion

Land use map of Upper Ciliwung Watershed is presented in Figure 2. Land use in the Upper Ciliwung Watershed is dominated by built-up area for 21.11% coverage and followed by secondary dryland forest (19.83%), mixed plantation (18.87%), farmland (15.68%), primary dryland forest (13.65%), paddy field (7.28%), scrub/shrub (3.09%), water body (0.33%), and bare land (0.16%). The distribution of coffee agroforestry according to field observation is shown in Figure 2, marked with black triangles symbol. Coffee agroforestry is found in four areas, Cibulao, Rawa Gede, Cikoneng, and Cisuren. These four areas have hilly and undulating topography. According to the interviews with the farmers, the largest coffee agroforestry is found in Cisuren with an area of about 32 hectares, followed by Cibulao with an area of about 20 hectares, Cikoneng with an area of about 5 hectares, and Rawa Gede with an area of about 5 hectares. In total, the coffee agroforestry areas in the Upper Ciliwung Watershed are approximately 62 hectares.

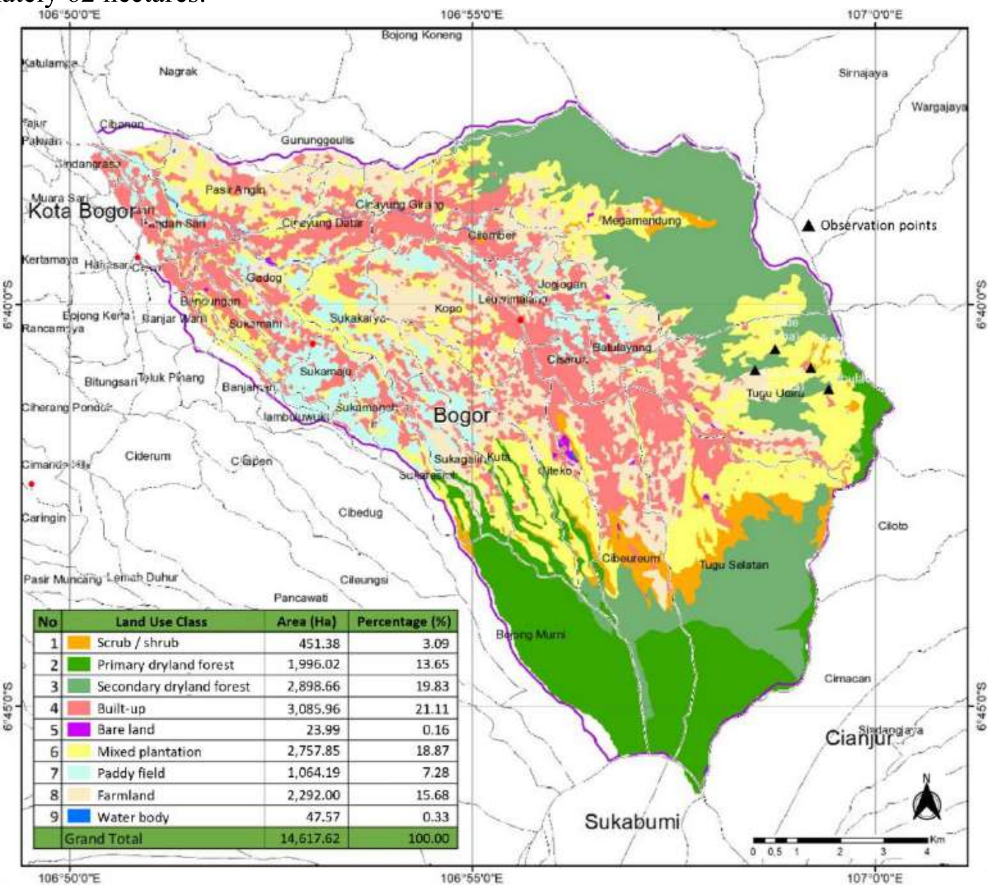

Figure 2. Land use map of Upper Ciliwung Watershed in 2018
Source: Land use map of Upper Ciliwung Watershed 2018

Coffee can grow on various land use patterns. The results of image interpretation and field observations show that in the Upper Ciliwung Watershed, coffee is mostly distributed in secondary dryland forest land use, namely Cibulao, Rawa Gede and Cisuren. Meanwhile, coffee agroforestry in Cikoneng is found in scrub / shrub land use (Figure 2**Error! Reference source not found.**). Practicing coffee agroforestry on scrub/shrub land is very good for land rehabilitation, this is in line with existing studies that stated the use of shrubs in the application of agroforestry patterns indicates that there is an effort to improve the land by rehabilitation [8,3].

Four areas that have coffee agroforestry in the Upper Ciliwung Watersheds have different plant compositions. According to the field observations, the agroforestry type and composition of each location is summarized in Table 2.

Table 2. Coffee agroforestry composition in the study area

No	Location	Agroforestry type	Composition
1	Cibulao	Agrosilviculture	*Coffea canephora* (robusta coffee) *Musa* sp. (banana) *Persea americana* (avocado) *Antidesma bunius* (bignay) *Neolamarckia cadamba* (burflower-tree) *Syzygium polyanthum* (salam) *Artocarpus heterophyllus* (jackfruit) *Schima wallichii* (needlewood tree) *Paraserianthes falcataria* (Peacocksplume)
2	Cisuren	Apiculture	*Coffea arabica* (arabica coffee) *Pinus merkusii* (pine) *Cinchona* sp. (*sulibra*) *Apis* sp. (honeybee)
3	Cikoneng	Agrosilviculture	*Coffea arabica* (arabica coffee) *Musa* sp. (banana) *Agathis dammara* (dammar) *Pinus merkusii* (pine) *Cinnamomum* sp. (cinnamon) *Maesopsis eminii* (umbrella tree) *Toona sureni* (suren toon) *Persea americana* (avocado)
4	Rawa Gede	Agrosilviculture	*Coffea arabica* (arabica coffee) *Agathis dammara* (dammar) *Persea americana* (avocado) *Cinchona* sp. (*sulibra*) *Artocarpus heterophyllus* (jackfruit)

Source: Field observation, 2023.

Differences in the coffee agroforestry model in the four regions of the Upper Ciliwung Watershed are influenced by the topographic conditions that exist in each region. A rather complex composition is found on coffee agroforestry in Cibulao, shown by more plant combinations. Land use patterns are very influential in optimizing productivity on land [7]. The coffee agroforestry in Cisuren is found in secondary dryland forest areas and they practice an apiculture system, a system that maintains honeybees in a forest (Figure 3). Utilization of agroforestry patterns in secondary dryland forest areas is a good land optimization method, especially in upland areas, as found in Cibulao (Figure 4), Cikoneng (Figure 5), and Rawa Gede (Figure 6).

Figure 3. Coffee agroforestry in Cisuren with apiculture system
(Source: photos by authors, Citra Planet with resolution of 4.7 meter, 2023)

Figure 4. Coffee agroforestry in Cibulao with agrisilviculture system
(Source: photos by authors, Citra Planet with resolution of 4.7 meter, 2023)

Figure 5. Coffee agroforestry in Cikoneng with agrisilviculture system
(Source: photos by authors, Citra Planet with resolution of 4.7 meter, 2023)

Figure 6. Coffee agroforestry in Rawa Gede with agrisilviculture system
(Source: photos by the authors, 2023)

4. Conclusions

Based on the results of image interpretation of Planet Resolution Imagery and direct observation at the research site, Cisuren has a larger coffee agroforestry land area of 32 ha, Cibulao of about 20 hectares, Cikoneng of about 5 hectares, and Rawa Gede of about 5 hectares. Research data information related to the distribution of coffee agroforestry in the Upper Ciliwung Watershed is expected to be a basic reference in conducting coffee agroforestry development and research related to coffee plants in the future.

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Mapping the Distribution of Coffee Agroforestry in the Upper Ciliwung Watershed, West Java, Indonesia

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Abstract. Land management by combining annual crops with seasonal crops is known as agroforestry. Agroforestry has a positive impact on watershed sustainability as it improves the watershed ecologically, economically, and socially. Coffee agroforestry is an agroforestry that incorporates coffee plants in their system. Coffee agroforestry in the Upper Ciliwung Watershed is spread across several sub-watersheds, but there is conflicting information related to the distribution and extent of agroforestry which results in no precise information on the coffee plants distribution. Therefore, this study aims to map the distribution and extent of coffee agroforestry in the Upper Ciliwung Watershed and identify the composition of the agroforestry system in the Upper Ciliwung Watershed. This study is done through satellite imagery interpretation and ground truth check of coffee agroforestry in the study area. The data are analyzed using descriptive qualitative method to describe obtained information on the coffee agroforestry from field observation. The results show that there are four sub-watersheds that have coffee agroforestry in the Upper Ciliwung Watershed, which are Cibulao, Cisuren, Cikoneng, and Rawa Gede sub-watersheds. Cibulao sub-watershed has a coffee agroforestry area of about 20 hectares, Cisuren has an area of about 32 hectares, Cikoneng has an area of about 5 hectares, and Rawa Gede has an area of about 5 hectares. In total, the coffee agroforestry areas in the Upper Ciliwung Watershed are approximately 62 hectares.

1. Introduction

Perennial or forestry crops combined with intensively managed agricultural crops are known as agroforestry. The application of traditional agroforestry patterns as watershed conservation in land management in Indonesia is common in the community. The advantages of agroforestry system are that it can preserve the environment, increase land productivity by producing various crops which lead to increasing farmers' income, and support sustainable ecological balance [1–4].

Coffee is quite widely cultivated by people in Indonesia as an alternative to agroforestry-based forest management. Coffee-based land management is known as coffee agroforestry. Coffee is a type of perennial plant that has a low erosion value and coffee has botanical properties that play a role in soil and water conservation [5]. Coffee is a plant that belongs to the Rubiaceae family with the genus *Coffea*. The part of the coffee plant that is utilized is the seeds, generally the use of coffee plants is the fruit seeds which can be used as a drink.

The Upper Ciliwung Watershed is one of the coffee producing areas. In 2009-2013, the Cibulao Green Forest Farmers Group planted coffee independently, then in 2014 the IPB Regional Development Planning Center (P4W) provided guidance to provide knowledge to members on how to plant coffee and harvest coffee properly. [6]. Other than Cibulao, there is no certain information about the existence of coffee agroforestry practice in Upper Ciliwung Watershed. Currently, there is a lack of information related to the extent and distribution of coffee agroforestry in the Upper Ciliwung Watershed. Accurate information on the coffee distribution is needed so that this information can be used as a basis for further coffee agroforestry development. Considering the importance of spatial information about the coffee agroforestry pattern in the Upper Ciliwung Watershed, this study aims to map the distribution of the coffee agroforestry and identify the composition of the agroforestry system in the Upper Ciliwung Watershed. The results of this study hopefully can serve as an initial study for future coffee agroforestry management and development.

2. Materials and methods

This research was conducted in the Upper Ciliwung Watershed areas that practice coffee agroforestry. There are a total of four areas that practice coffee agroforestry in Upper Ciliwung Watershed, which are Cibulao, Rawa Gede, Cikoneng, and Cisuren. The map of the distribution of research sampling locations and ground truth checks in the field presented in Figure 1. The coordinates of the study area are presented in Table 1. The tools used in this research are GPS (global positioning system) to mark the sampling locations' coordinates, stationery, computers, and data processing software, such as ArcGIS 10.5. The materials used in this research are 4.7-meter resolution Planetary Imagery obtained in 2023, slope map, land use map of Upper Ciliwung Watershed in 2018, and administrative boundary maps. The land use change in the study area is rather slow, therefore, the time difference between land use map and field ground truth check is considered appropriate.

This research begins with image interpretation which aims to describe information about coffee agroforestry and its land area in the Cibulao, Rawagede, Cikoneng, and Cisuren areas. Image interpretation using manual visual delineation method, on screen digitization on 4.7-meter resolution planetary image in 2023, by observing similar agroforestry-based coffee plants on resolution planetary image. After the interpretation process is complete, a ground check point is carried out at the research location to obtain the accuracy of information and land area in image interpretation of coffee agroforestry. We also carried out interviews with the coffee farmers. The analysis method in this research is a qualitative descriptive method to describe information on coffee agroforestry components by direct observation of coffee plant in the Upper Ciliwung Watershed.

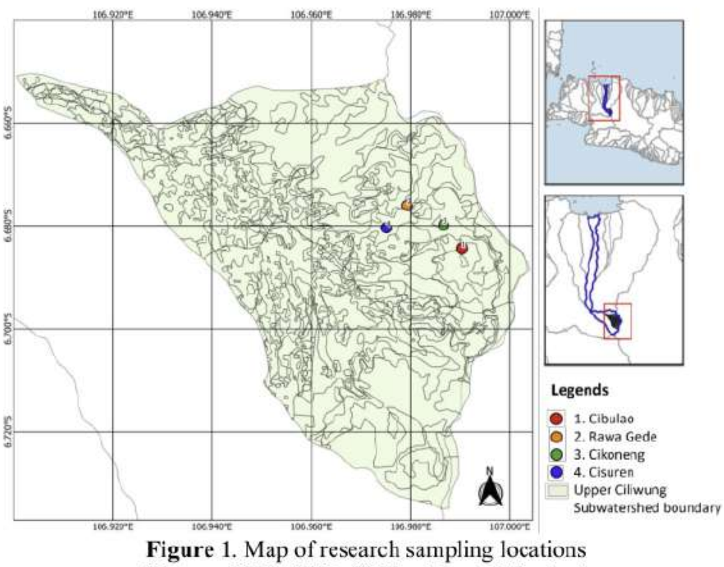

Figure 1. Map of research sampling locations
(Source: BPDASHL, 2023, with modification)

Table 1. Coordinates of the sampling locations

Sample	Location	Coordinate		Altitude (meters above sea level)
		X	Y	
1	Cibulao	106.990	-6.684	1391
2	Rawa Gede	106.979	-6.676	1407
3	Cikoneng	106.986	-6.679	1396
4	Cisuren	106.975	-6.680	1245

3. Results and discussion

Land use map of Upper Ciliwung Watershed is presented in Figure 2. Land use in the Upper Ciliwung Watershed is dominated by built-up area for 21.11% coverage and followed by secondary dryland forest (19.83%), mixed plantation (18.87%), farmland (15.68%), primary dryland forest (13.65%), paddy field (7.28%), scrub/shrub (3.09%), water body (0.33%), and bare land (0.16%). The distribution of coffee agroforestry according to field observation is shown in Figure 2, marked with black triangles symbol. Coffee agroforestry is found in four areas, Cibulao, Rawa Gede, Cikoneng, and Cisuren. These four areas have hilly and undulating topography. According to the interviews with the farmers, the largest coffee agroforestry is found in Cisuren with an area of about 32 hectares, followed by Cibulao with an area of about 20 hectares, Cikoneng with an area of about 5 hectares, and Rawa Gede with an area of about 5 hectares. In total, the coffee agroforestry areas in the Upper Ciliwung Watershed are approximately 62 hectares.

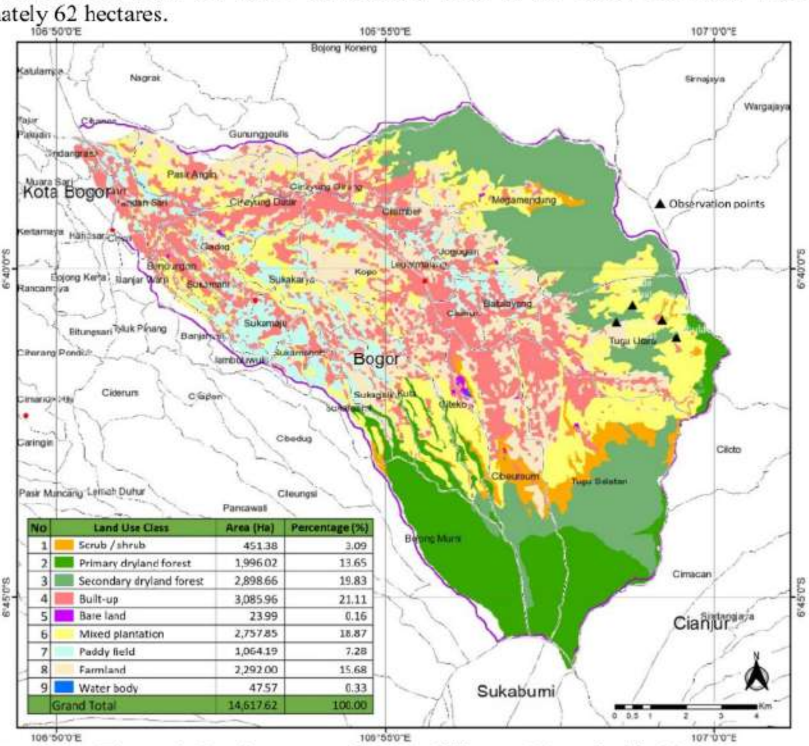

Figure 2. Land use map of Upper Ciliwung Watershed in 2018
Source: Land use map of Upper Ciliwung Watershed 2018

Coffee can grow on various land use patterns. The results of image interpretation and field observations show that in the Upper Ciliwung Watershed, coffee is mostly distributed in secondary dryland forest land use, namely Cibulao, Rawa Gede and Cisuren. Meanwhile, coffee agroforestry in Cikoneng is found in scrub / shrub land use (Figure 2**Error! Reference source not found.**). Practicing coffee agroforestry on scrub/shrub land is very good for land rehabilitation, this is in line with existing studies that stated the use of shrubs in the application of agroforestry patterns indicates that there is an effort to improve the land by rehabilitation [8,3].

Four areas that have coffee agroforestry in the Upper Ciliwung Watersheds have different plant compositions. According to the field observations, the agroforestry type and composition of each location is summarized in Table 2.

Table 2. Coffee agroforestry composition in the study area

No	Location	Agroforestry type	Composition
1	Cibulao	Agrosilviculture	*Coffea canephora* (robusta coffee) *Musa* sp. (banana) *Persea americana* (avocado) *Antidesma bunius* (bignay) *Neolamarckia cadamba* (burflower-tree) *Syzygium polyanthum* (salam) *Artocarpus heterophyllus* (jackfruit) *Schima wallichii* (needlewood tree) *Paraserianthes falcataria* (Peacocksplume)
2	Cisuren	Apiculture	*Coffea arabica* (arabica coffee) *Pinus merkusii* (pine) *Cinchona* sp. (*sulibra*) *Apis* sp. (honeybee)
3	Cikoneng	Agrosilviculture	*Coffea arabica* (arabica coffee) *Musa* sp. (banana) *Agathis dammara* (dammar) *Pinus merkusii* (pine) *Cinnamomum* sp. (cinnamon) *Maesopsis eminii* (umbrella tree) *Toona sureni* (suren toon) *Persea americana* (avocado)
4	Rawa Gede	Agrosilviculture	*Coffea arabica* (arabica coffee) *Agathis dammara* (dammar) *Persea americana* (avocado) *Cinchona* sp. (*sulibra*) *Artocarpus heterophyllus* (jackfruit)

Source: Field observation, 2023.

Differences in the coffee agroforestry model in the four regions of the Upper Ciliwung Watershed are influenced by the topographic conditions that exist in each region. A rather complex composition is found on coffee agroforestry in Cibulao, shown by more plant combinations. Land use patterns are very influential in optimizing productivity on land [7]. The coffee agroforestry in Cisuren is found in secondary dryland forest areas and they practice an apiculture system, a system that maintains honeybees in a forest (Figure 3). Utilization of agroforestry patterns in secondary dryland forest areas is a good land optimization method, especially in upland areas, as found in Cibulao (Figure 4), Cikoneng (Figure 5), and Rawa Gede (Figure 6).

Figure 3. Coffee agroforestry in Cisuren with apiculture system
(Source: photos by authors, Citra Planet with resolution of 4.7 meter, 2023)

Figure 4. Coffee agroforestry in Cibulao with agrisilviculture system
(Source: photos by authors, Citra Planet with resolution of 4.7 meter, 2023)

Figure 5. Coffee agroforestry in Cikoneng with agrisilviculture system
(Source: photos by authors, Citra Planet with resolution of 4.7 meter, 2023)

Figure 6. Coffee agroforestry in Rawa Gede with agrisilviculture system
(Source: photos by the authors, 2023)

4. Conclusions

Based on the results of image interpretation of Planet Resolution Imagery and direct observation at the research site, Cisuren has a larger coffee agroforestry land area of 32 ha, Cibulao of about 20 hectares, Cikoneng of about 5 hectares, and Rawa Gede of about 5 hectares. Research data information related to the distribution of coffee agroforestry in the Upper Ciliwung Watershed is expected to be a basic reference in conducting coffee agroforestry development and research related to coffee plants in the future.

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