**UNIVERSITAS TRISAKTI**
**LEMBAGA PENELITIAN DAN PENGABDIAN KEPADA MASYARAKAT**
Jl. Kyai Tapa No. 1 Grogol, Jakarta Barat 11440, Indonesia
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http://lppm.trisakti.ac.id/
lppm@trisakti.ac.id

# KONTRAK PENELITIAN TAHUN ANGGARAN 2023

**ANTARA**
**LEMBAGA PENELITIAN DAN PENGABDIAN KEPADA MASYARAKAT**
**UNIVERSITAS TRISAKTI**

**DENGAN**
**PENELITI UNIVERSITAS TRISAKTI**

**Nomor: 706/A/LPPM/USAKTI/VII/2023**

Pada hari ini **kamis** tanggal **enam** bulan **juli** tahun **dua ribu dua puluh tiga** kami yang bertandatangan dibawah ini:

1. **Prof. Dr. Ir. Astri Rinanti, M.T., IPM**
   **2234/USAKTI**
   : Direktur Lembaga Penelitian dan Pengabdian kepada Masyarakat Universitas Trisakti, berdasarkan Surat Keputusan Rektor Universitas Trisakti No. 265/USAKTI/SKR/IV/2022 dalam hal ini bertindak untuk dan atas nama Universitas Trisakti, yang berkedudukan di Lembaga Penelitian dan Pengabdian Kepada Masyarakat Gedung M Lt. 11 Jl. Kyai Tapa No. 1 Grogol Jakarta-11440, untuk selanjutnya disebut **PIHAK PERTAMA**;

2. **Rini Fitri**
   **0110087903**
   : Dosen Biasa Program Studi Arsitektur Lanskap Fakultas Arsitektur Lanskap dan Teknologi Lingkungan, Universitas Trisakti, dalam hal ini bertindak sebagai Pengusul dan Ketua Pelaksana Penelitian Tahun Anggaran 2023 untuk selanjutnya disebut **PIHAK KEDUA**.

**PIHAK PERTAMA** dan **PIHAK KEDUA** secara bersama-sama bersepakat mengikatkan diri dalam suatu kontrak, dengan ketentuan dan syarat sebagai berikut:

## Pasal 1
## Dasar Hukum

**Kontrak Penelitian** ini berdasarkan kepada:

1. Undang-Undang Republik Indonesia Nomor 17 Tahun 2003 tentang Keuangan Negara;
2. Undang-Undang Republik Indonesia Nomor 20 Tahun 2003 tentang Sistem Pendidikan Nasional;
3. Undang-Undang Republik Indonesia Nomor 01 Tahun 2004 tentang Perbendaharaan Negara;
4. Undang-Undang Republik Indonesia Nomor 15 Tahun 2004 tentang Pemeriksaan Pengelolaan dan Tanggung Jawab Keuangan Negara;
5. Undang-Undang Republik Indonesia Nomor 12 Tahun 2012 tentang Pendidikan Tinggi;
6. Peraturan Pemerintah Nomor 26 Tahun 2015 tentang bentuk dan Mekanisme Perguruan Tinggi Negeri Badan Hukum:
7. Peraturan Presiden Nomor 13 Tahun 2015 tentang Kementerian Riset, Teknologi, dan Pendidikan Tinggi;
8. Peraturan Presiden Nomor 16 tahun 2018 tentang Pengadaan Barang dan Jasa Pemerintah;
9. Peraturan Menteri Keuangan Nomor 139/PMK.02/2015 tentang Tata Cara Penyediaan, Pencairan, dan Pertanggungjawaban Pemberian Bantuan Pendanaan Perguruan Tinggi Negeri Badan Hukum;
10. Peraturan Menteri Keuangan Nomor 32/PMK.02/2018 tentang Standar Biaya Masukan Tahun 2019;
11. Peraturan Menteri Keuangan Nomor 60/PMK.02/2018 tentang Persetujuan Kontrak Tahun Jamak oleh Menteri Keuangan;
12. Peraturan Menteri Keuangan Nomor 69/PMK.02/2018 tentang Standar Biaya Keluaran Tahun 2019;
13. Peraturan Menteri Riset, Tekologi dan Pendidikan tinggi Republik Indonesia Nomor 15 Tahun 2015, tentang Organisasi dan Tata Kerja Kementerian Riset, Tekologi dan Pendidikan tinggi;
14. Peraturan Menteri Riset, Teknologi dan Pendidikan Tinggi Republik Indonesia Nomor 69 tahun 2016 tentang Tata Cara Pembentukan Komite Penilaian dan/atau Reviewer Penelitian;
15. Peraturan Menteri Riset, Teknologi dan Pendidikan Tinggi Republik Indonesia Nomor 6 tahun 2018 tentang Bantuan Operasional Perguruan Tinggi Negeri;
16. Peraturan Menteri Riset, Teknologi dan Pendidikan Tinggi Republik Indonesia Nomor 20 tahun 2018 tentang Penelitian;
17. Peraturan Direktur Jenderal Perbendaharaan Kementerian Keungan Republik Indonesia Nomor 15/PB/2017 tentang Petunjuk Pelaksaaan Pembayaran Anggaraan Penelitian Berbasis Standar Biaya Keluaran Sub Keluaran Penelitian;

| PIHAK PERTAMA | PIHAK KEDUA | Hal 2 dari 10 |
|---|---|---|
| ............ | ............ | |

## Pasal 2
## Ruang Lingkup

(1) Ruang lingkup **Kontrak Penelitian** yang pendanaannya bersumber dari Daftar Isian Pelaksanaan Anggaran (DIPA) Direktorat Riset, Teknologi dan Pengabdian Kepada Masyarakat, Direktorat Jenderal Pendidikan Tinggi, Riset, dan Teknologi Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi Tahun Anggaran 2023, Nomor SP DIPA-Nomor SP DIPA-023.17.1.690523/2023 revisi ke-4 Tanggal 31 Maret 2023 dan berdasarkan Kontrak antara Lembaga Layanan Pendidikan Tinggi Wilayah III (LLDIKTI WILAYAH III) dengan Universitas Trisakti Nomor 1440/LL3/AL.04/2023 Tanggal 26 Juni 2023.

(2) Identitas penelitian ini adalah sebagai berikut:

| | | |
|---|---|---|
| a) Ketua Pelaksana | : | **Rini Fitri** |
| b) Judul penelitian | : | Perencanaan Lanskap Agroforestri Berbasis Kopi untuk Pengelolaan DAS Ciliwung Hulu berkelanjutan |

## Pasal 3
## Jangka Waktu

Jangka waktu pelaksanaan penelitian sebagaimana dimaksud dalam Pasal 1 sampai selesai 100%, adalah terhitung sejak **26 Juni 2023** dan berakhir pada **1 Desember 2023.**

## Pasal 4
## Target Luaran

(1) **PIHAK KEDUA** berkewajiban untuk mencapai target luaran wajib penelitian berupa:
   a) Laporan Kemajuan
   b) Laporan Final

(2) **PIHAK KEDUA** diharapkan dapat mencapai target luaran tambahan penelitian berupa*):
   a) Artikel ilmiah yang dipublikasikan pada jurnal internasional.
   b) Artikel ilmiah yang dipublikasikan pada prosiding internasional.

(3) **PIHAK KEDUA** berkewajiban untuk melaporkan perkembangan pencapaian target luaran sebagaimana dimaksud pada ayat (1) kepada **PIHAK PERTAMA.**

## Pasal 5
## Jangka Waktu

(1) **Kontrak Penelitian** ini dilaksanakan dalam jangka waktu 1 (satu) tahun sebagaimana tersebut pada Pasal 3

(2) **Kontrak Penelitian** sebagaimana dimaksud pada ayat (1) dilaksanakan untuk penelitian sebagaimana tercantum dalam Lampiran yang merupakan bagian yang tidak terpisahkan dari **Kontrak Penelitian** ini.

## Pasal 6
## Hak dan Kewajiban

(1) **PIHAK PERTAMA** mempunyai kewajiban:
   a. Menyalurkan pendanaan penelitian kepada PIHAK KEDUA;
   b. Melakukan pemantauan dan evaluasi;
   c. Melakukan penilaian luaran penelitian; dan
   d. Melakukan validasi luaran tambahan.

(2) **PIHAK KEDUA** mempunyai kewajiban:
   a. **Menandatangani Kontrak Penelitian** yang mengatur hak dan kewajiban yang memuat antara lain:
      1. Nama pelaksana;
      2. Judul penelitian;
      3. Jumlah dana penelitian;
      4. Tata cara dan termin pembayaran;
      5. Jangka waktu pelaksanaan;
      6. Batas akhir pelaporan;
      7. Mencantumkan pemberi dana penelitian dalam publikasi ilmiah;
      8. Luaran penelitian; dan
      9. Sanksi.

   b. Mengkoordinir tim peneliti dan bertanggung jawab atas terlaksananya **Kontrak Penelitian** yang dilakukan.

   c. Memantau pengunggahan ke laman **BIMA** dokumen sebagai berikut:
      1. Revisi proposal penelitian;
      2. Catatan harian pelaksanaan penelitian;
      3. Laporan kemajuan pelaksanaan penelitian;
      4. Surat Pernyataan Tanggungjawab Belanja (SPTB) atas dana penelitian yang telah ditetapkan;

5. Laporan akhir penelitian;
6. Luaran penelitian.

(3) **PIHAK PERTAMA** mempunyai hak menerima dokumen hasil unggahan di laman BIMA sebagai berikut:
1. Revisi proposal penelitian
2. Catatan harian pelaksanaan penelitian
3. Laporan kemajuan pelaksanaan penelitian
4. Surat Pernyataan Tanggungjawab Belanja (SPTB) atas dana penelitian yang telah ditetapkan
5. Laporan akhir penelitian
6. Luaran penelitian

(4) **PIHAK KEDUA** mempunyai hak mendapatkan dana penelitian dari **PIHAK PERTAMA.**

**Pasal 7**
**Laporan Pelaksanaan Penelitian**

(1) **PIHAK KEDUA** berkewajiban untuk menyampaikan kepada **PIHAK PERTAMA** berupa laporan kemajuan dan laporan akhir mengenai luaran penelitian dan rekapitulasi penggunaan anggaran sesuai dengan jumlah dana yang diberikan oleh **PIHAK PERTAMA** yang tersusun secara sistematis sesuai pedoman yang ditentukan oleh **PIHAK PERTAMA**.

(2) **PIHAK KEDUA** berkewajiban mengunggah Laporan Kemajuan dan Catatan harian penelitian yang telah dilaksanakan ke BIMA sesuai jadwal yang ditetapkan Direktorat Riset dan Pengabdian Masyarakat, Deputi Bidang Penguatan Riset dan Pengembangan, Kementerian Riset dan Teknologi/Badan Riset dan Inovasi Nasional.

(3) **PIHAK KEDUA** berkewajiban menyerahkan *Softcopy* Laporan Kemajuan dan Rekapitulasi Penggunaan Anggaran 70% kepada **PIHAK PERTAMA,** sesuai jadwal yang ditetapkan Direktorat Riset dan Pengabdian Masyarakat, Deputi Bidang Penguatan Riset dan Pengembangan, Kementerian Riset dan Teknologi/Badan Riset dan Inovasi Nasional.

(4) **PIHAK KEDUA** berkewajiban mengunggah Laporan Akhir, capaian hasil, Poster, artikel ilmiah dan profil pada BIMA paling lambat sesuai jadwal yang ditetapkan Direktorat Riset dan Pengabdian Masyarakat, Deputi Bidang Penguatan Riset dan Pengembangan, Kementerian Riset dan Teknologi/Badan Riset dan Inovasi Nasional.

(5) Laporan hasil Penelitian sebagaimana tersebut pada ayat (4) harus memenuhi ketentuan sebagai berikut:
  a. Bentuk/ukuran kertas A4;
  b. Warna cover putih
  c. Di bawah bagian cover ditulis:

Dibiayai oleh:

**Direktorat Riset, Teknologi dan Pengabdian Kepada Masyarakat, Direktorat Jenderal Pendidikan Tinggi, Riset, dan Teknologi Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi Tahun Anggaran 2023, Nomor SP DIPA- Nomor SP DIPA-023.17.1.690523/2023 revisi ke-4 Tanggal 31 Maret 2023**

**dan**

**Berdasarkan Kontrak antara Lembaga Layanan Pendidikan Tinggi Wilayah III (LLDIKTI WILAYAH III) dengan Universitas Trisakti Nomor 1440/LL3/AL.04/2023 Tanggal 26 Juni 2023**

## Pasal 8
## Monitoring dan Evaluasi

**PIHAK PERTAMA** dalam rangka pengawasan akan melakukan Monitoring dan Evaluasi internal terhadap kemajuan pelaksanaan Penelitian Tahun Anggaran 2023 ini sebelum pelaksanaan Monitoring dan Evaluasi eksternal oleh Direktorat Riset dan Pengabdian Masyarakat, Deputi Bidang Penguatan Riset dan Pengembangan, Kementerian Riset dan Teknologi/Badan Riset dan Inovasi Nasional

## Pasal 9
## Penilaian Luaran

Penilaian luaran penelitian dilakukan oleh Komite Penilai/*Reviewer* Luaran sesuai dengan ketentuan yang berlaku. Apabila dalam penilaian luaran terdapat luaran tambahan yang tidak tercapai maka dana tambahan yang sudah diterima oleh peneliti harus disetorkan kembali ke kas negara.

## Pasal 10
## Cara Pembayaran

**PIHAK PERTAMA** menyalurkan pendanaan penelitian sebesar: **Rp.85.100.000,- (Delapan puluh lima juta seratus ribu rupiah)** yang dibebankan kepada Daftar Isian Pelaksanaan Anggaran (DIPA) Direktorat Riset, Teknologi dan Pengabdian Kepada Masyarakat, Direktorat Jenderal Pendidikan Tinggi, Riset, dan Teknologi Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi Tahun Anggaran 2023, Nomor SP DIPA- Nomor SP

DIPA-023.17.1.690523/2023 revisi ke-4 Tanggal 31 Maret 2023 dan berdasarkan Kontrak antara Lembaga Layanan Pendidikan Tinggi Wilayah III (LLDIKTI WILAYAH III) dengan Universitas Trisakti Nomor 1440/LL3/AL.04/2023 Tanggal 26 Juni 2023.

(1) Pendanaan penelitian sebagaimana dimaksud pada ayat (1) dibayarkan oleh **PIHAK PERTAMA** kepada **PIHAK KEDUA** secara bertahap:
   a) Pembayaran Tahap Pertama sebesar 70% yaitu **Rp.59.570.000,- (Lima puluh sembilan juta lima ratus tujuh puluh ribu rupiah)**
   b) Pembayaran Tahap Kedua sebesar 30% yaitu **Rp.25.530.000,- (Dua puluh lima juta lima ratus tiga puluh ribu rupiah)**
   c) Dari Bank BNI kepada rekening Peneliti melalui mekanisme kliring dan pemindah bukuan.

(2) Pendanaan penelitian sebagaimana dimaksud pada ayat (1) huruf a, diberikan dengan ketentuan apabila revisi proposal penelitian telah diunggah ke laman BIMA.

(3) Pendanaan penelitian sebagaimana dimaksud pada ayat (1) huruf b, dengan ketentuan apabila **PIHAK PERTAMA** telah menerima dokumen sebagai berikut:
   a) Laporan akhir pelaksanaan penelitian
   b) Surat Pernyataan Tanggungjawab Belanja (SPTB) atas dana penelitian yang telah ditetapkan

(4) Dana luaran tambahan sebagaimana dimaksud pada ayat (1) huruf c dibayarkan kepada **PIHAK KEDUA** bersamaan dengan pembayaran Tahap Kedua.

(5) Apabila luaran tambahan dinyatakan tidak valid oleh **PIHAK PERTAMA** sebagaimana dimaksud Pasal 4 ayat (1), maka dana luaran tambahan yang sudah diterima harus disetorkan kembali ke kas negara.

(6) Pendanaan **Kontrak Penelitian** sebagaimana dimaksud pada ayat (1) dibayarkan kepada peneliti sebagai berikut.

| | | |
|---|---|---|
| Nama Ketua Peneliti/pemilik rekening | : | **Rini Fitri** |
| Nomor Rekening | : | **0968170427** |
| Nama Bank | : | **BNI** |
| Alamat Bank | : | |
| NPWP Ketua Peneliti | : | **156937609104000** |

(7) **PIHAK PERTAMA** tidak bertanggungjawab atas keterlambatan dan/atau tidak terbayarnya sejumlah dana, yang disebabkan oleh kesalahan **PIHAK KEDUA** dalam menyampaikan informasi sebagaimana dimaksud pada ayat (9).

## Pasal 11
## Penggantian Keanggotaan

(1) Perubahan terhadap susunan tim pelaksana dan substansi penelitian dapat dibenarkan apabila telah mendapat persetujuan dari Direktur Riset dan Pengabdian Masyarakat Direktorat Jenderal Penguatan Riset dan Pengembangan.

(2) Apabila Ketua tim pelaksana penelitian tidak dapat menyelesaikan penelitian atau mengundurkan diri, maka **PIHAK KEDUA** wajib menunjuk pengganti Ketua Tim Pelaksana penelitian yang merupakan salah satu anggota tim setelah mendapat persetujuan tertulis dari Direktur Riset dan Pengabdian Masyarakat Direktorat Jenderal Penguatan Riset dan Pengembangan.

(3) Dalam hal tidak adanya pengganti ketua tim pelaksana penelitian sesuai dengan syarat ketentuan yang ada, maka penelitian dibatalkan dan dana dikembalikan ke Kas Negara.

## Pasal 12
## Pajak

**PIHAK KEDUA** berkewajiban memungut dan menyetor pajak ke Bank setempat yang berkenaan dengan kewajiban pajak berupa:
1. Pembelian barang dan jasa dikenai PPN sebesar 10% dan PPh 22 sebesar 1,5%;
2. Pajak-pajak lain sesuai ketentuan.

## Pasal 13
## Kekayaan Intelektual

(1) Hak Kekayaan Intelektual yang dihasilkan dari pelaksanaan penelitian diatur dan dikelola sesuai dengan peraturan dan perundang-undangan.

(2) Setiap publikasi, makalah, dan/atau ekspos dalam bentuk apapun yang berkaitan dengan hasil penelitian ini wajib mencantumkan **PIHAK PERTAMA** sebagai pemberi dana.

(3) Hasil penelitian berupa peralatan adalah milik negara dan dapat dihibahkan kepada institusi/lembaga melalui Berita Acara Serah Terima (BAST)

## Pasal 14
## Keadaan Kahar

(1) **PARA PIHAK** dibebaskan dari tanggung jawab atas keterlambatan atau kegagalan dalam memenuhi kewajiban yang dimaksud dalam **Kontrak Penelitian** disebabkan atau

diakibatkan oleh peristiwa atau kejadian diluar kekuasaan **PARA PIHAK** yang dapat digolongkan sebagai keadaan memaksa (*force majeure*).

(2) Peristiwa atau kejadian yang dapat digolongkan keadaan memaksa (*force majeure*) dalam **Kontrak Penelitian** ini adalah bencana alam, wabah penyakit, kebakaran, perang, blokade, peledakan, sabotase, revolusi, pemberontakan, huru-hara, serta adanya tindakan pemerintah dalam bidang ekonomi dan moneter yang secara nyata berpengaruh terhadap pelaksanaan **Kontrak Penelitian** ini.

(3) Apabila terjadi keadaan memaksa (*force majeure*) maka pihak yang mengalami wajib memberitahukan kepada pihak lainnya secara tertulis, selambat-lambatnya dalam waktu 7 (tujuh) hari kerja sejak terjadinya keadaan memaksa (*force majeure*), disertai dengan bukti-bukti yang sah dari pihak yang berwajib, dan **PARA PIHAK** dengan itikad baik akan segera membicarakan penyelesaiannya.

## PASAL 15
## PENYELESAIAN PERSELISIHAN

(1) Apabila terjadi perselisihan antara **PIHAK PERTAMA** dan **PIHAK KEDUA** dalam pelaksanaan **Kontrak Penelitian** ini akan dilakukan penyelesaian secara musyawarah dan mufakat

(2) Dalam hal tidak tercapai penyelesaian secara musyawarah dan mufakat sebagaimana dimaksud pada ayat (1) maka penyelesaian dilakukan melalui proses hukum yang berlaku dengan memilih domisili hukum di Pengadilan Negeri Jakarta Barat.

## Pasal 16
## AMANDEMEN KONTRAK

Apabila terdapat hal lain yang belum diatur atau terjadi perubahan dalam **Kontrak Penelitian** ini, maka akan dilakukan amandemen **Kontrak Penelitian**.

## PASAL 17
## SANKSI

(1) Apabila sampai dengan batas waktu yang telah ditetapkan untuk melaksanakan Penelitian Terapan Unggulan Perguruan Tinggi telah berakhir, **PIHAK KEDUA** tidak melaksanakan kewajiban sebagaimana dimaksud dalam Pasal 4 ayat (2), maka **PIHAK KEDUA** dikenai sanksi administratif.

(2) Sanksi administratif sebagaimana dimaksud pada ayat (1) dapat berupa penghentian pembayaran dan tidak dapat mengajukan proposal penelitian dalam kurun waktu dua tahun berturut-turut.

**PASAL 18**
**LAIN-LAIN**

Dalam hal **PIHAK KEDUA** berhenti dari jabatannya sebelum **Kontrak Penelitian** ini selesai, maka **PIHAK KEDUA** wajib melakukan serah terima tanggung jawabnya kepada pejabat baru yang menggantikannya.

**PASAL 19**
**PENUTUP**

Surat Perjanjian kontrak ini dibuat rangkap 2 (dua) bermaterai cukup sesuai dengan ketentuan yang berlaku, dan biaya materai dibebankan kepada **PIHAK KEDUA**.

| PIHAK PERTAMA | PIHAK KEDUA |
|---|---|
| **Prof. Dr. Ir. Astri Rinanti, M.T., IPM** | **Rini Fitri** |
| **NIK: 2234/USAKTI** | **NIDN: 0110087903** |

**Mengetahui**
Dekan

**Dr. Melati Ferianita Fachrul, M.S**
**NIK: 1922/USAKTI**

| PIHAK PERTAMA | PIHAK KEDUA | Hal 10 dari 10 |
|---|---|---|
| .............. | .............. | |

Direktorat Riset dan Pengabdian Masyarakat Direktorat Jenderal Riset dan Pengembangan
Kementerian Riset, Teknologi, dan Pendidikan Tinggi
Gedung BPPT II Lantai 19, Jl. MH. Thamrin No. 8 Jakarta Pusat
https://simlitabmas.ristekdikti.go.id/

**PROTEKSI ISI LAPORAN AKHIR PENELITIAN**



# LAPORAN AKHIR PENELITIAN MULTI TAHUN

ID Proposal: 680b5281-ced5-454e-9137-4e9fe32cea3e
laporan akhir Penelitian: tahun ke-1 dari 3 tahun

## 1. IDENTITAS PENELITIAN

### A. JUDUL PENELITIAN

| |
|---|
| Perencanaan lanskap agroforestri berbasis kopi untuk pengelolaan DAS Ciliwung Hulu berkelanjutan |

### B. BIDANG, TEMA, TOPIK, DAN RUMPUN BIDANG ILMU

| Bidang Fokus RIRN / Bidang Unggulan Perguruan Tinggi | Tema | Topik (jika ada) | Rumpun Bidang Ilmu |
|---|---|---|---|
| Kebencanaan | - | | Ilmu Tanah |

### C. KATEGORI, SKEMA, SBK, TARGET TKT DAN LAMA PENELITIAN

| Kategori (Kompetitif Nasional/ Desentralisasi/ Penugasan) | Skema Penelitian | Strata (Dasar/ Terapan/ Pengembangan) | SBK (Dasar, Terapan, Pengembangan) | Target Akhir TKT | Lama Penelitian (Tahun) |
|---|---|---|---|---|---|
| Penelitian Kompetitif Nasional | | | SBK Riset Dasar | 2 | 3 |

## 2. IDENTITAS PENGUSUL

| Nama (Peran) | Perguruan Tinggi/ Institusi | Program Studi/ Bagian | Bidang Tugas | ID Sinta | H-Index |
|---|---|---|---|---|---|
| RINI FITRI - Ketua Pengusul | Universitas Trisakti | Arsitektur Lansekap | Koordinasi tim, koordinasi dengan BPDASHL Ciliwung Citarum, melakukan analisis data, menetapkan dan menghasilkan luaran Pelitian | 6035689 | 2 |
| NUR INTAN | Universitas | Arsitektur | Membantu Ketua | 5989396 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| SIMANGUNSONG - Anggota Pengusul | Trisakti | Lansekap | Melaksanakan penelitian, analisis data, membuat site plan agroforestri dan menyiapkan luaran penelitian | | |
| HERIKA - Anggota Pengusul | Universitas Trisakti | Perencanaan Wilayah Dan Kota | Membantu ketua analisis data, mendesain model agroforestri dan membantu pelaksanaan penelitian dan persiapan luaran | 6769835 | 6 |

**3. MITRA KERJASAMA PENELITIAN (JIKA ADA)**

Pelaksanaan penelitian dapat melibatkan mitra kerjasama, yaitu mitra kerjasama dalam melaksanakan penelitian, mitra sebagai calon pengguna hasil penelitian, atau mitra investor

| Mitra | Nama Mitra |
|---|---|

**4. LUARAN DAN TARGET CAPAIAN**

**Luaran Wajib**

| Tahun Luaran | Jenis Luaran | *Status target capaian (accepted, published, terdaftar atau granted, atau status lainnya)* | *Keterangan (url dan nama jurnal, penerbit, url paten, keterangan sejenis lainnya)* |
|---|---|---|---|
| 1 | Artikel di Jurnal Internasional Terindeks di Pengindeks Bereputasi | Submited | Jurnal Rural Landscape |
| 2 | Artikel di Jurnal Internasional Terindeks di Pengindeks Bereputasi | | New Zealand Journal of Forestry Science |
| 3 | Artikel di Jurnal Internasional Terindeks di Pengindeks Bereputasi | | Jurnal Forestry Chronicle (Scopus |

**Luaran Tambahan**

| Tahun Luaran | Jenis Luaran | *Status target capaian (accepted, published, terdaftar atau granted, atau status lainnya)* | *Keterangan (url dan nama jurnal, penerbit, url paten, keterangan sejenis lainnya)* |
|---|---|---|---|

**5. ANGGARAN**

Rencana anggaran biaya penelitian mengacu pada PMK yang berlaku dengan besaran minimum dan maksimum sebagaimana diatur pada buku Panduan Penelitian dan Pengabdian kepada Masyarakat

**Total RAB 3 Tahun Rp. 0**

**Tahun 1 Total Rp. 0**

| Jenis Pembelanjaan | Komponen | Item | Satuan | Vol. | Biaya Satuan | Total |
|---|---|---|---|---|---|---|

**Tahun 2 Total Rp. 0**

| Jenis Pembelanjaan | Komponen | Item | Satuan | Vol. | Biaya Satuan | Total |
|---|---|---|---|---|---|---|

**Tahun 3 Total Rp. 0**

| Jenis Pembelanjaan | Komponen | Item | Satuan | Vol. | Biaya Satuan | Total |
|---|---|---|---|---|---|---|

## 6. KEMAJUAN PENELITIAN

### A. RINGKASAN

Pengembangan teori perencanaan lanskap agroforestri kopi sebagai alternatif mengatasi permasalahan di DAS Ciliwung Hulu, terkait metode skala regional untuk pertimbangan penerapan lanskap agroforestri sebagai salah satu penggunaan lahan hulu dan hilir DAS berkelanjutan merupakan urgensi dari penelitian ini. Salah satu upaya pengelolaan yang dapat dilakukan di DAS Ciliwung Hulu adalah dengan perencanaan lanskap agroforestri berbasis kopi agar dapat menjadi alternatif dalam mengatasi permasalahan di kawasan DAS Ciliwung Hulu. Tujuan penelitian untuk: 1). Menyusun struktur spasial dan tipe lanskap agroforestri DAS Ciliwung Hulu 2). Merencanakan lanskap agroforestri kopi berkelanjutan.

Tahapan penelitian tahun pertama berupa pengumpulan data biofisik, ekonomi dan sosial budaya yang digunakan sebagai bahan analisis dalam perencanaan lanskap agroforestri berbasis kopi di DAS Ciliwung Hulu. Tahapan penelitian tahun kedua berupa analisis kriteria kesesuaian lahan untuk evaluasi kesesuaian lahan agroforestri berbasis kopi. Tahapan penelitian tahun ketiga terdiri dari 4 (empat) yaitu (1) sintesis : untuk menghasilkan usulan konsep pemecahan masalah yang dituangkan ke dalam perencanaan lanskap agroforestri kopi melalui pendekatan Multi Dimensi Scaling (MDS). (2) konsep perencanaan lanskap agroforestri kopi dengan cara meningkatkan kombinasi tanaman semusim dan kopi dalam unit lahan. (3) pengembangan konsep rencana lanskap agroforestri kopi untuk menentukan pengembangan konsep perencanaan, model penggunaan lahan sesuai dengan standar perencanaan, (4) perencanaan lanskap agroforestri kopi terdiri atas rencana ruang, sirkulasi, vegetasi lanskap agroforestri kopi dan menampilkan hasil akhir berupa, gambar rencana lanskap serta site plan. Luaran yang ditargetkan pada tahun pertama berupa artikel pada Jurnal Rural Landscape (Scopus Q3) yang saat ini statusnya sudah di submit. Luaran tambahan pada tahun pertama ini yaitu telah mengikuti seminar internasional di Banda Aceh "5th International Conference on Agricultural Technology, Engineering, and Environmental Sciences" yang dilaksanakan oleh Department of Agricultural Technology Universitas Syiah Kuala pada tanggal 20 September 2023 dengan judul artikel "Mapping the Distribution of Coffee Agroforestry in the Upper

Ciliwung Watershed, West Java, Indonesia”. Kertercapaian luaran tambahan ini berupa paper dengan status saat ini (Accepted) Under consideration for publication pada IOP Publising, rencana akan terbit pada bulan Desember 2023. Pada Tahun pertama tingkat kesiapan teknologi (TKT) berupa data ilmiah yang diperoleh, secara kuat menunjukkan bahwa agroforestri berbasis kopi dapat menjadi model konservasi dalam pengelolaan DAS Ciliwung Hulu berkelanjutan yang artinya masih pada TKT 1. Hasil penelitian yang diperoleh pada tahap satu ini diperlukan kajian lebih lanjut untuk analisis kriteria kesesuaian lahan untuk agroforestri berbasis kopi.

## B. KATA KUNCI

Berkelanjutan; DAS; Lanskap Agroforestri; Kopi

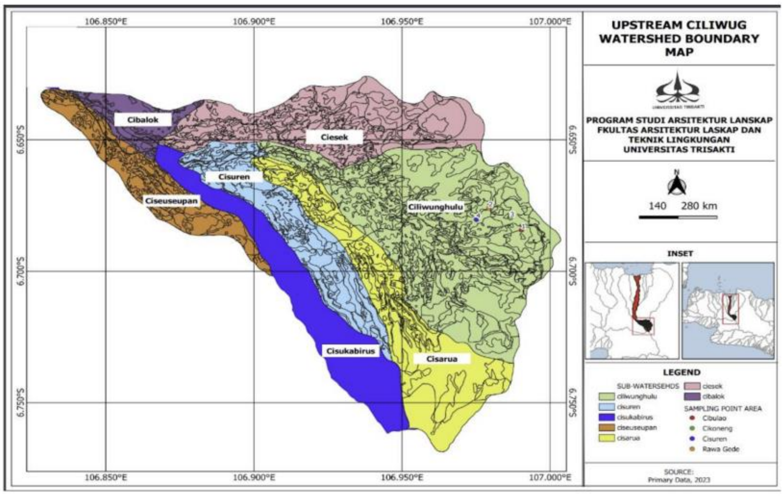
Pengisian poin C sampai dengan poin H mengikuti template berikut dan tidak dibatasi jumlah kata atau halaman namun disarankan seringkas mungkin. Dilarang menghapus/memodifikasi template ataupun menghapus penjelasan di setiap poin.

C. **HASIL PELAKSANAAN PENELITIAN:** Tuliskan secara ringkas hasil pelaksanaan penelitian yang telah dicapai sesuai tahun pelaksanaan penelitian. Penyajian meliputi data, hasil analisis, dan capaian luaran (wajib dan atau tambahan). Seluruh hasil atau capaian yang dilaporkan harus berkaitan dengan tahapan pelaksanaan penelitian sebagaimana direncanakan pada proposal. Penyajian data dapat berupa gambar, tabel, grafik, dan sejenisnya, serta analisis didukung dengan sumber pustaka primer yang relevan dan terkini.

**1. Hasil Pelaksanaan Penelitian**

**Keadaan Umum dan Batas DAS Ciliwung Hulu**

Pada tahap penelitian ini telah berhasil melakukan pengumpulan berupa data biofisik yang digunakan sebagai bahan analisis dalam perencanaan lanskap agroforestri berbasis kopi di DAS Ciliwung Hulu. DAS ini berada pada titik koordinat secara geografis daerah penelitian terletak antara 6°37' - 6°46' LS dan 106°50' – 107°0' BT dan secara adminstrasi berada di wilayah Kabupaten Bogor, Provinsi Jawa Barat, meliputi Kecamatan Cisarua, Kecamatan Megamendung, Kecamatan Ciawi, Kecamatan Sukaraja, dan Kecamatan Bogor Timur. Secara topografi, DAS Ciliwung Hulu terdiri dari 7 (tujuh) Sub DAS yaitu Sub DAS Cibalok, Sub DAS Cisukabirus, Sub DAS Ciseusepan, Sub DAS Cisuren, Sub DAS Ciesek, Ciliwung Hulu, dan Sub DAS Cisarua (Gambar 1) dan foto kombinasi agroforestri kopi di DAS Ciliwung Hulu disajikan pada (Gambar 2).




Gambar 1 Peta Lokasi Penelitian
(Sumber: Modifikasi dari BPDASHL, 2023)

**A** **B**

Gambar 2 A) Kombinsi (Kopi) dan Pinus sebagai spesies tahunan; B) Kombinasi dari tanaman semusim (Pisang), tanaman Kehutanan (Kopi – Puspa dan Rasa)
(Sumber: Foto oleh peneliti, 2023)

Data biofisik fisik yang telah diperoleh merupakan hasil dari deliniasi peta dasar dan *ground chek* lapang sehingga menghasilkan peta batas DAS, peta *land use* dan peta sebaran agroforestri berbasis kopi dan jenis tanah DAS Ciliwung Hulu. Kawasan hulu DAS Ciliwung berfungsi sebagai daerah pelindung dan penyangga wilayah DAS Ciliwung, jika terjadi perubahan pada komponennya maka akan mempengaruhi seluruh bagian DAS. DAS itu menjadi penting dan saling terkait antara bagian hulu, bagian tengah dan hilir, DAS Ciliwung Hulu merupakan bagian penting dari DAS Ciliwung yang memiliki bentuk mendaun/*dendritic*, mempunyai pola seperti ranting daun, anak sungai bergabung pada sungai utama dengan sudut yang tajam menyebabkan sangat berpotensi terjadinya banjir bandang (Anggraheni et al., 2018; Ali et al., 2016). DAS Ciliwung Hulu memiliki peran penting dan mempunyai arti strategis sebagai pengatur hidro-orologi lingkungan bagi wilayah hulu-hilir termasuk wilayah DKI Jakarta. DAS Ciliwung Hulu merupakan salah satu DAS yang kondisinya kritis, kondisi ini menyebabkan terjadinya perluasan dan perubahan penggunaan lahan menjadi penggunaan lain terutama kawasan pemukiman di hulu Ciliwung (Hasibuan et al., 2022; Robo et al., 2019; Wang et al., 2012).

## Kondisi Biofisik DAS Ciliwung Hulu

### Kondisi Topografi dan Jenis Tanah di DAS Ciliwung Hulu

DAS Ciliwung merupakan wilayah pegunungan dengan ketinggian 300 m hingga 3.000 m dan tergolong dataran tinggi. Kemiringan lereng di lokasi penelitian yaitu DAS Ciliwung Hulu disajikan pada Tabel 1, kemiringan lereng di Rawa Gede dan Cisuren lebih curam dibandingkan di Cibulao dan Cikoneng. Jenis tanah di DAS Ciliwung Hulu adalah inceptisol, ultisol, dan entisol, dengan jenis tanah yang paling dominan di wilayah tersebut adalah inceptisol (BPDASHL, 2007).

Table 1. Jenis tanah, kemiringan lereng dan ketinggian tempat

| Nama Daerah | Jenis Tanah | Kemiringan | Ketinggian Tempat |
|---|---|---|---|
| Cibulao | Inceptisol | 8 % - 15 % | 1391 |
| Cikoneng | Inceptisol | 8 % - 15 % | 1396 |
| Rawa Gede | Inceptisol | 16 % - 25 % | 1407 |
| Cisuren | Inceptisol | 16 % - 25 % | 1245 |

Sifat fisik dan kimia sampel tanah menurut hasil analisis laboratorium di lokasi penelitian disajikan pada Tabel 2. Nilai nitrogen (N) terendah terdapat di Cibulao sebesar 0,51% sedangkan nilai N tertinggi terdapat di Cisuren sebesar 0,98%. Kadar fosfor (P) tertinggi terdapat pada Cibulao (187,8 ppm), sedangkan nilai P terendah terdapat pada Cisuren (22,5 ppm). Kalium (K) terendah terdapat pada Cisuren (0,14 me%) sedangkan tertinggi terdapat pada Cibulao (2,29 me%). Nilai C-organik tertinggi terdapat di Cisuren sebesar 17,33% dan terendah terdapat di Cibulao sebesar 6,00%. Seluruh nilai pH sampel tanah di daerah penelitian bersifat asam, dengan nilai pH di Cibulao 4,53, Cikoneng 5,00, Rawa Gede 4,98, dan Cisuren 4,12. Nilai N, P, dan K tidak sepenuhnya organik, karena petani kopi di Cibulao diketahui memupuk tanaman dengan pupuk P untuk meningkatkan produktivitas kopi.

Table 2. Hasil analisis tanah di Cibulao, Cikoneng, Rawa Gede dan Cisuren

| Hamlet Name | Soil Analisis | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | N (%) | P (ppm) | K (me%) | Org-C % | pH | Texture | | |
| | | | | | | % Silt | % Clay | % Sand |
| Cibulao | 0.51 | 187.8 | 2.29 | 6.00 | 4.53 | 42.27 | 28.76 | 24.33 |
| Cikoneng | 0.67 | 39.2 | 0.30 | 7.59 | 5.00 | 45.86 | 12.75 | 35.85 |
| Rawa Gede | 0.56 | 38.6 | 1.06 | 6.39 | 4.98 | 29.33 | 21.16 | 43.35 |
| Cisuren | 0.98 | 22.5 | 0.14 | 17.33 | 4.12 | 49.42 | 14.18 | 29.63 |

Note : N = Nitrogen, P = Phosphorus, K = Potassium, Org-C = Organic carbon

### Iklim & Hidrologi

Iklim di DAS Ciliwung Hulu berdasarkan data iklim selama 10 tahun dari Stasiun Badan Meterologi Klimatologi dan Geofisika dan data curah hujan bulanan (mm) DAS Ciliwung Hulu tahun 2010 - 2019 dari stasiun tersebut terdiri dari (Citeko, Gunung Mas, Gadog, dan Katulampa) disajikan pada Tabel 3.

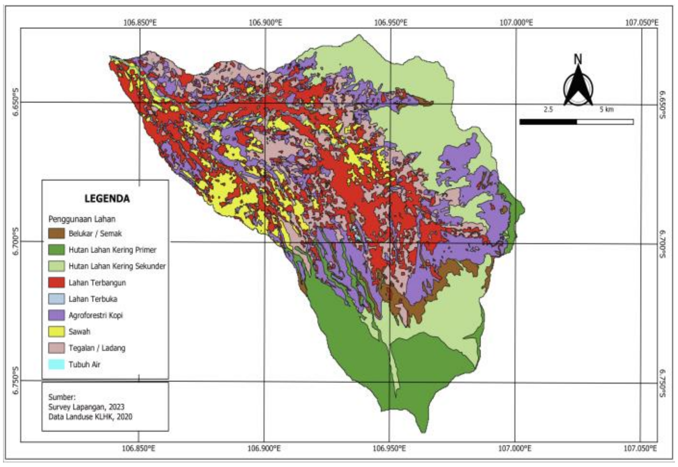
Tabel 3 Data curah hujan bulanan (mm) DAS Ciliwung Hulu tahun 2010 - 2019

| Thn | Bulan | | | | | | | | | | | | CH Wilayah (mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | Mei | Jun | Jul | Ags | Sep | Okt | Nov | Des | |
| 2010 | 490.7 | 530.4 | 510.3 | 115.8 | 259.8 | 276.7 | 174.4 | 323.5 | 436.1 | 397.4 | 327.6 | 333.2 | 3977.46 |
| 2011 | 363.0 | 220.5 | 246.1 | 270.1 | 242.8 | 150.7 | 59.4 | 13.4 | 59.5 | 255.8 | 366.7 | 323.6 | 2505.28 |
| 2012 | 376.0 | 403.7 | 226.9 | 321.4 | 206.3 | 97.4 | 42.2 | 26.3 | 157.7 | 288.8 | 419.4 | 461.4 | 2972.67 |
| 2013 | 813.5 | 356.0 | 380.2 | 308.0 | 531.7 | 144.6 | 329.8 | 169.0 | 144.1 | 282.5 | 308.5 | 516.7 | 4206.14 |
| 2014 | 1079.6 | 551.5 | 360.0 | 331.5 | 291.8 | 194.9 | 219.2 | 282.3 | 42.8 | 130.6 | 552.8 | 373.2 | 4600.88 |
| 2015 | 369.5 | 368.0 | 443.2 | 294.1 | 196.4 | 21.9 | 7.4 | 59.5 | 20.7 | 50.8 | 549.5 | 492.4 | 2315.62 |
| 2016 | 371.1 | 590.4 | 601.7 | 509.5 | 239.0 | 193.6 | 321.5 | 135.6 | 348.1 | 408.2 | 373.3 | 177.7 | 3508.07 |
| 2017 | 294.3 | 652.2 | 323.3 | 405.6 | 247.7 | 151.9 | 102.8 | 89.2 | 75.0 | 418.0 | 434.1 | 305.7 | 3682.47 |
| 2018 | 335.5 | 707.3 | 418.1 | 348.5 | 177.2 | 171.2 | 24.7 | 32.0 | 152.7 | 195.7 | 460.8 | 250.6 | 3407.89 |
| 2019 | 436.0 | 424.1 | 226.1 | 517.9 | 156.2 | 77.2 | 28.6 | 31.3 | 74.6 | 140.3 | 119.3 | 382.5 | 2847.54 |

Bentuk DAS Ciliwung Hulu secara keseluruhan menyerupai kipas dengan anak-anak sungai mengalir ke sungai utama dari bagian kiri dan kanan. Anak-anak sungai tersebut mengalir terkonsentrasi ke satu titik di sekitar Katulampa dengan bentuk *outlet* yang menyerupai leher botol. Sungai utama mengalir dari arah selatan ke utara (Fitri, 2020). Intensitas curah hujan berkorelasi positif dengan peningkatan dan limpasan permukaan (limpasan), yang dapat meningkatkan limpasan sungai dan variabilitasnya.

## Penggunaan Lahan

Penggunaan lahan di DAS Ciliwung Hulu sebagian wilayah lebih didominasi oleh wilayah hutan tanaman sebesar 25,64%. Penggunaan lahan di wilayah DAS Ciliwung Hulu terdiri atas hutan lahan kering primer, hutan lahan kering sekunder, hutan tanaman, kebun campuran, kebun teh, lahan terbangun, lahan terbuka, pertanian lahan kering, sawah, semak belukar dan air. Kawasan DAS Ciliwung Hulu sebagian besar sudah dimanfaatkan untuk budidaya, baik untuk keperluan pertanian maupun non-pertanian. Hutan terdapat dibagian hulu yaitu sekitar Gunung Gede dan Gunung Pangrango (Hutapea, 2005; Fitri, 2020). Penggunaan lahan di DAS Ciliwung Hulu Provinsi Jawa Barat disajikan pada Gambar 3 dan Tabel 4.




Gambar 3 Peta penggunaan lahan DAS Ciliwung Hulu

**Tabel 4. Penggunaan Lahan DAS Ciliwung Hulu**

| No | Penggunaan Lahan | Luas (ha) | Persentase (%) |
|---|---|---|---|
| 1 | Hutan lahan kering primer | 553,8 | 3,66 |
| 2 | Hutan lahan kering sekunder | 1557,1 | 10,31 |
| 3 | Hutan tanaman | 3872,8 | 25,64 |
| 4 | Kebun campuran | 573,2 | 3,79 |
| 5 | Kebun the | 1189,6 | 7,87 |
| 6 | Lahan terbangun | 2711,8 | 17,98 |
| 7 | Lahan terbuka | 277,8 | 1,83 |
| 8 | Pertanian lahan kering | 2544,6 | 16,85 |
| 9 | Sawah | 1153,3 | 7,63 |
| 10 | Semak belukar | 664,2 | 4,39 |
| 11 | air | 1,8 | 1,19 |
| | Total | 15.101 | 100 |

Sumber : Hasil penelitian Fitri, 2020.

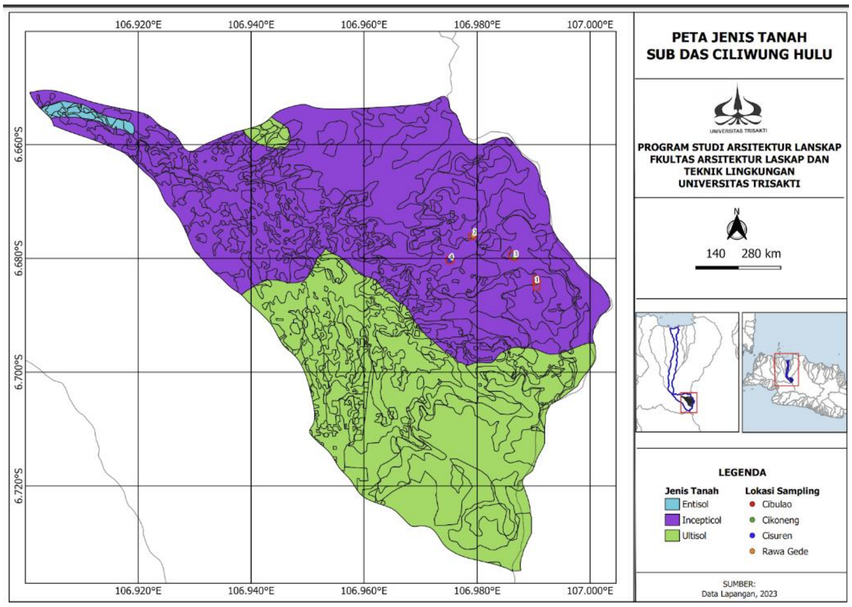
## 2. Hasil Analisis

Data ilmiah yang diperoleh digunakan untuk menyusun secara spasial sebaran lanskap agroforestri berbasis kopi dapat menjadi model konservasi dalam pengelolaan DAS Ciliwung Hulu berkelanjutan. Agroforestri berbasis kopi tersebut dengan kombinasi yaitu (kopi - *Coffea arabica)*, tanaman kehutanan (puspa - *Schima wallichii)*, (rasamala - *Altingia excelsa)*, (kayu afrika - *Maesopsis eminii)*, (damar - *Agathis dammara)*, dan tanaman pertanian (pisang - *Musa paradisiaca*). Keempat lokasi agroforestri kopi mempunyai jenis tanah inceptisol, lokasi pengambilan sampel tanah ditandai dengan titik-titik berwarna, sebaran agroforestri berbasis kopi dan jenis tanah pada Gambar 4. Deskripsi lanskap agroforestri berbasis kopi dan jenis tanahnya di DAS Ciliwung Hulu disajikan pada Tabel 5.

Tabel 5 Deskripsi lanskap agroforestri, jenis tanah, tanaman kehutanan dan kemiringan lereng

| Nama lokasi | Jenis Tanah | Tanaman Kehutanan | Kemiringan Slope |
|---|---|---|---|
| Cibulao (Sub DAS Ciliwung Hulu) | Incepticol | Kopi (*Coffea arabica)*, Tanaman Kehutanan Puspa (*Schima wallichii)*, Rasamala (*Altingia excelsa)* dan tanaman pertanian pisang (*Musa paradisiaca*) | 8 % - 15 % |
| Cikoneng (Sub DAS Ciliwung Hulu) | Incepticol | Kopi (*Coffea arabica)*, Kayu Afrika (*Maesopsis eminii)*, Damar (*Agathis dammara)*, dan Tanaman Pertanian Pisang (*Musa paradisiaca*) | 8 % - 15 % |
| Rawa Gede (Sub DAS Ciliwung Hulu) | Incepticol | Kopi (*Coffea arabica)*, Tanaman Kehutanan Puspa (*Schima wallichii)* dan Damar (*Agathis dammara)* | 16 % - 25 % |
| Cisuren (Sub DAS Ciliwung Hulu) | Incepticol | Kopi (*Coffea arabica)*, tanaman kehutanan Pinus (*Pinus merkusii*) | 16 % - 25 % |

Source: Primary Data, (2023)




Gambar 4 Sebaran Agroforestri Berbasis Kopi dan Jenis Tanah DAS Ciliwung Hulu
(Sumber: Modifikasi dari BPDASHL Citarum Ciliwung, 2023)

**Sebaran Lanskap Agroforestri**

Kondisi DAS Ciliwung Hulu sangat menunjang untuk pertumbuhan tanaman kopi dimana ke empat daerah tersebut Cibulao, Rawagede, Cikoneng, dan Cisuren terletak di daerah dengan topografi berbukit dan bergelombang. Sebaran tanaman kopi hasil interpretasi pada citra satelit dan ground chek dilapang yang disajikan pada gambar 5 menunjukkan bahwa sebaran tanaman kopi lebih banyak dijumpai di Cisuren has an area of about 32 hectares, Cibulao sub-watershed has a coffee agroforestry area of about 20 hectares, Cikoneng has an area of about 5 hectares, and Rawa Gede has an area of about 5 hectares. In total, there are coffee agroforestry areas of approximately 62 hectares in the Upper Ciliwung Watershed.


**Gambar 5.** Sebaran lokasi dan hasil ground check lapang
(Source: Citra Planet Resolusi 4.7 meter, 2023)

Tanaman kopi merupakan tanaman yang dapat tumbuh pada berbagai pola penggunaan lahan, hasil interpretasi dan berdasarkan pengamatan pada penggunaan lahan terlihat bahwa untuk tanaman kopi pada DAS Ciliwung Hulu menunjukkan distribusi tanaman kopi sebagian besar tumbuh pada penggunaan lahan hutan lahan kering sekunder yaitu Cibulao, Rawa Gede dan Cisuren sedangkan tanaman kopi di Cikoneng terdapat pada penggunaan lahan semak belukar. Penerapan agroforestry kopi pada lahan Semak belukar sangat baik untuk rehabilitasi lahan, hal ini sejalan dengan penelitian (Andriansyah, 2021; Purba, 2020) mengemukakan bahwa besaran nilai pada penggunaan lahan semak belukar dalam penerapan pola agroforestri mengindikasikan bahwa adanya upaya untuk memperbaiki lahan dengan jalan rehabilitasi.

**Klasifikasi Lanskap Agroforestri Kopi**

Hasil pengamatan pada lahan agroforestry kopi pada empat wilayah di DAS Ciliwung Hulu menunjukkan beberapa model pengelolaan lahan dengan berbagai komposisi penyusunnya seperti disajikan pada tabel 6.

**Table 6**. Penggunaan Lahan DAS Ciliwung Hulu

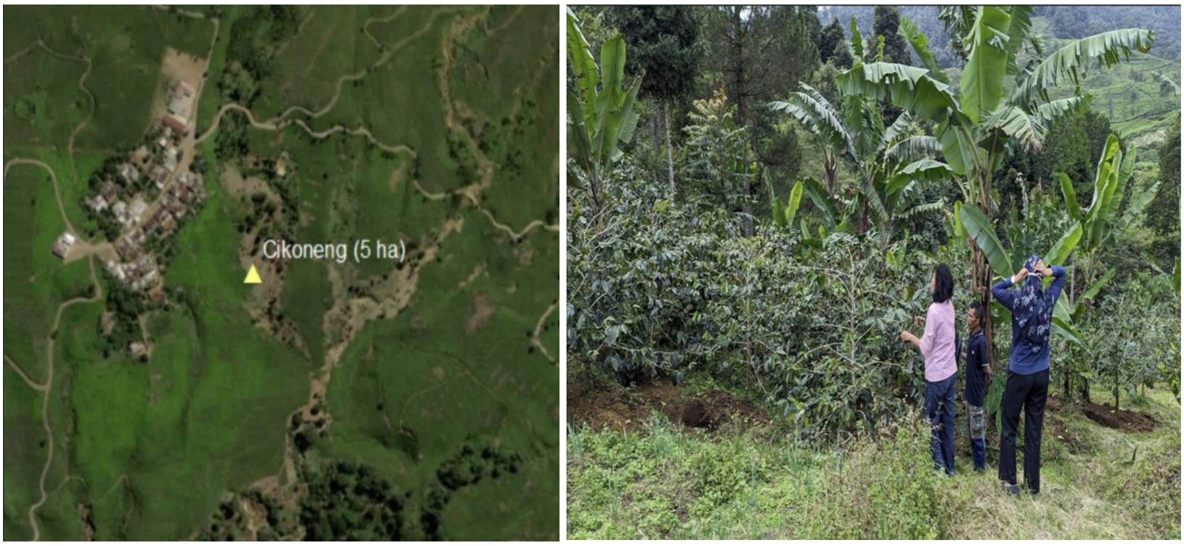
| No | Lokasi | Model Pengelolaan Lahan | Pola komposisi jenis |
|---|---|---|---|
| 1 | Cibulao | Agrosilvikultur | Kopi, Rasamala, Pisang |
| 2 | Cisuren | Apikultur | Kopi, Madu, pinus |
| 3 | Cikoneng | Agrosilvikultur | Pisang, damar |
| 4 | Rawa Gede | Agrosilvikultur | Kopi, cabai, damar |

Sumber : Hasil observasi lapangan, 2023.

Perbedaan dalam penerapan model pengelolaan lahan agroforestry kopi pada empat wilayah DAS Ciliwung Hulu ini dipengaruhi oleh kondisi topografi yang ada di tiap-tiap daerah, komposisi model pengelolaan lahan yang lebih kompleks dijumpai pada lahan kopi di Cibulao dengan kombinasi tanaman lebih banyak. Pola pemanfaatan lahan sangat berpengaruh dalam mengoptimalkan produktivitas pada lahan (Fitri et al, 2018; Hairiah et al., 2013). Pola agroforestri kopi di Cisuren dijumpai pada wilayah hutan lahan kering sekunder dengan menerapkan model apikultur dengan mengembangkan madu hutan (Gambar 6). Pemanfaatan pola agroforestri pada wilayah hutan lahan kering sekunder merupakan sebuah metode optimalisasi lahan yang baik utamanya pada daerah dataran tinggi.


**Gambar 6.** agroforestri kopi di Cisuren model apikultur
(Source: photos by the authors, 2023)


**Gambar 7.** agroforestri kopi di Agrosilvikultur Cibulao
(Source: photos by the authors, 2023)

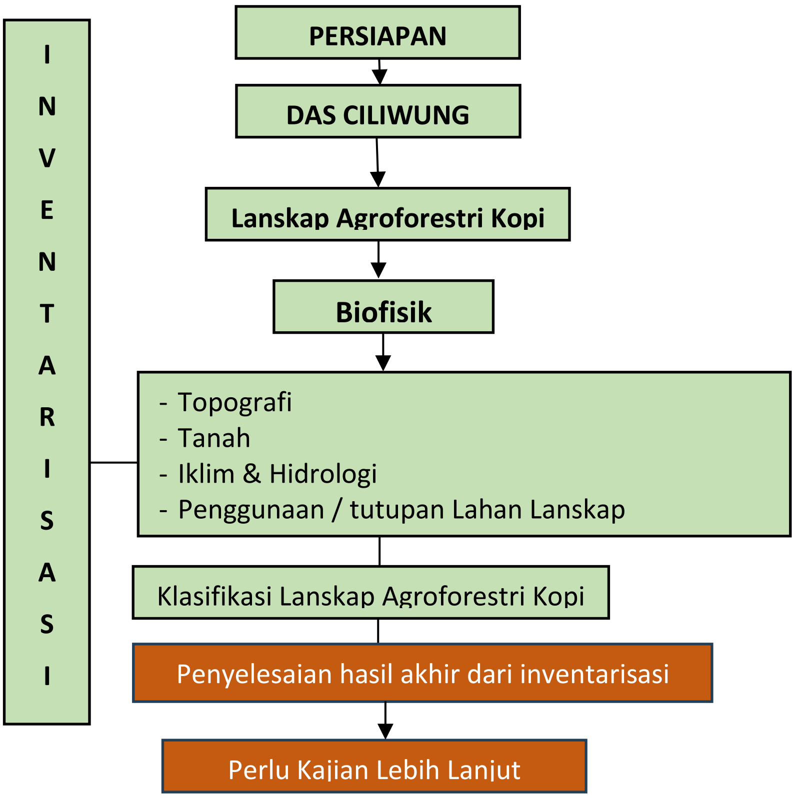



**Gambar 8.** agroforestri kopi di Agrosilvikultur Cikoneng
(Source: photos by the authors, 2023)


**Gambar 9.** agroforestri kopi di Agrosilvikultur Rawa Gede
(Source: photos by the authors, 2023)

**3. Capaian Luaran wajib dan Luaran Tambahan**

Tahapan penelitian untuk tahap perencanaan lanskap agroforestri kopi terdiri atas tahun pertama inventarisasi, tahun kedua sintesis dan tahun ke tiga perencanaan (rencana ruang, rencana sirkulasi dan rencana vegetasi lanskap agroforestri kopi di kawasan Ciliwung Hulu). Hasil perencanaan lanskap agroforestri DAS Ciliwung Hulu akan menampilkan hasil akhir berupa peta. Capaian luaran berdasarkan parameter dari kegiatan penelitian yang telah dilaksanakan pada tahap pertama ini ditunjukkan pada Gambar 10 ini:




Gambar 10. Tahapan Penelitian 2023-2025

D. **STATUS LUARAN**: Tuliskan jenis, identitas dan status ketercapaian setiap luaran wajib dan luaran tambahan (jika ada) yang dijanjikan. Jenis luaran dapat berupa publikasi, perolehan kekayaan intelektual, hasil pengujian atau luaran lainnya yang telah dijanjikan pada proposal. Uraian status luaran harus didukung dengan bukti kemajuan ketercapaian luaran sesuai dengan luaran yang dijanjikan. Lengkapi isian jenis luaran yang dijanjikan serta mengunggah bukti dokumen ketercapaian luaran wajib dan luaran tambahan melalui BIMA.

Penelitian ini telah menghasilkan 1 (satu) luaran wajib yaitu publikasi pada *Jurnal Rural Landscape*, merupakan jurnal internasional terindeks scopus dengan judul artikel **"*Coffee Agroforestry for Degraded Land Rehabilitation in Upper Ciliwung Watershed, West Java, Indonesia*"**. Artikel telah tersubmit dan sedang menunggu balasan dari penerbit. Penelitian ini juga menghasilkan luaran tambahan pada tahun pertama ini yaitu telah mengikuti seminar *Internasional di Banda Aceh "5th International Conference on Agricultural Technology, Engineering, and Environmental Sciences" yang dilaksanakan oleh Department of Agricultural Technology* Universitas Syiah Kuala pada tanggal 20 September 2023 dengan judul artikel "***Mapping the Distribution of Coffee Agroforestry in the Upper Ciliwung Watershed, West Java, Indonesia***". Kertercapaian luaran tambahan ini berupa paper dengan status saat ini (*Accepted*) **Under consideration for publication pada IOP Publising, rencana akan terbit pada bula Desember 2023.**





E**. PERAN MITRA:** Tuliskan realisasi kerjasama dan kontribusi Mitra baik *in-kind* maupun *in-cash* (untuk Penelitian Terapan, Penelitian Pengembangan, PTUPT, PPUPT serta KRUPT). Bukti pendukung realisasi kerjasama dan realisasi kontribusi mitra dilaporkan sesuai dengan kondisi yang sebenarnya. Bukti dokumen realisasi kerjasama dengan Mitra diunggah melalui BIMA.

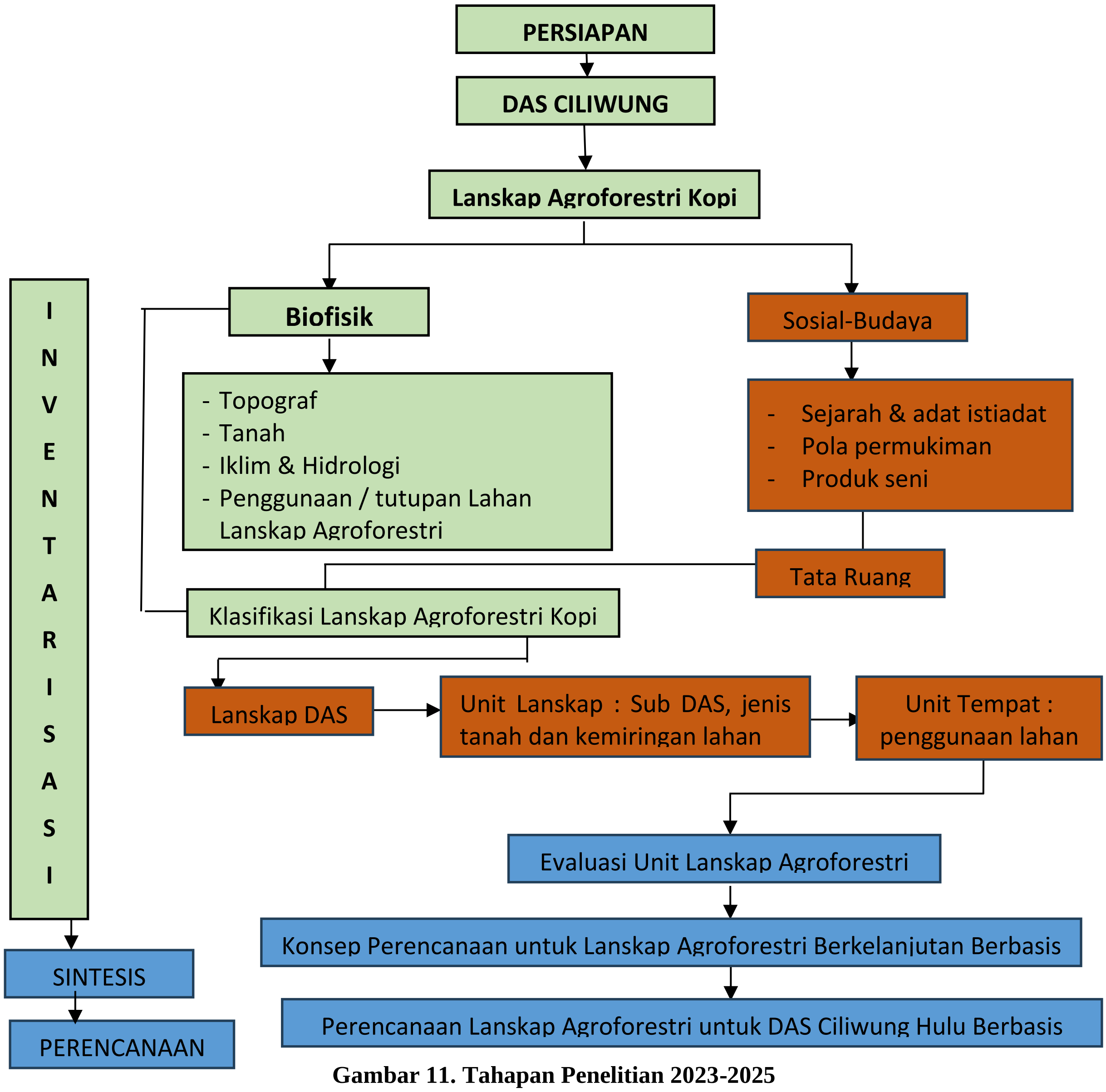
Dalam penelitian ini tidak melibatkan mitra. Semua kegiatan dilakukan di DAS Ciliwung Hulu Provinsi Jawa Barat, dan analisis di Laboratorium Teknoklogi Lanskap, Jurusan Arsitektur Lanskap, Fakultas Arsitektur Lanskap dan Teknologi Lingkungan Universitas Trisakti.

F. **KENDALA PELAKSANAAN PENELITIAN**: Tuliskan kesulitan atau hambatan yang dihadapi selama melakukan penelitian dan mencapai luaran yang dijanjikan, termasuk penjelasan jika pelaksanaan penelitian dan luaran penelitian tidak sesuai dengan yang direncanakan atau dijanjikan.

Penelitian ini dapat dilakukan dengan lancar dan tidak terdapat kendala dalam proses pelakasanaan baik di lapangan maupun di Laboratorium Teknologi Lanskap. Jurusan Arsitektur Lanskap, Fakultas Arsitektur Lanskap dan Tekologi Lingkungan Universitas Trisakti sangat mendukung pada pelaksanaan kegiatan dengan memberikan arahan yang sistematis dalam proses penyusunan laporan kemajuan dan persiapan monitoring evaluasi.

G. **RENCANA TAHAPAN SELANJUTNYA:** Tuliskan dan uraikan rencana penelitian di tahun berikutnya berdasarkan indikator luaran yang telah dicapai, rencana realisasi luaran wajib yang dijanjikan dan tambahan (jika ada) di tahun berikutnya serta *roadmap* penelitian keseluruhan. Pada bagian ini diperbolehkan untuk melengkapi penjelasan dari setiap tahapan dalam metoda yang akan direncanakan termasuk jadwal berkaitan dengan strategi untuk mencapai luaran seperti yang telah dijanjikan dalam proposal. Jika diperlukan, penjelasan dapat juga dilengkapi dengan gambar, tabel, diagram, serta pustaka yang relevan. Pada bagian ini dapat dituliskan rencana penyelesaian target yang belum tercapai.

Penyelesaian tahapan dari kegiatan penelitian untuk tahun pertama ini ditunjukkan pada gambar11. Capaian luaran berdasarkan parameter dari kegiatan penelitian yang telah dilaksanakan pada tahap pertama ini ditunjukkan pada Gambar 11. Penelitian Fundamental ini diharapkan dapat menjadi landasan bagi TIM peneliti pengusul untuk mengembangkan penelitian yang berkaitan dimasa akan datang. Jenis penelitian baik penelitian dosen maupun kolaborasi dengan mahasiswa dapat dikembangkan di universitas tim peneliti pengusul menjadi lebih mendalam dan bervariasi. Hasil penelitian yang diperoleh pada tahap satu ini diperlukan kajian lebih lanjut untuk analisis kriteria kesesuaian lahan untuk agroforestri berbasis kopi.




**Gambar 11. Tahapan Penelitian 2023-2025**

| | |
|---|---|
| (hijau) | Telah dilakukan pada Tahun 2023 Ke I yaitu telah menghasilkan artikel telah disubmit pada Jurnal bereputasi dan artikel dipresentasi pada konferensi internasional dan status *accepted* |
| (oranye) | Perlu Kajian Lebih Lanjut Tahun 2024 Ke II |
| (biru) | Perlu Kajian lebih Lanjut Tahun 2025 Ke III |

**H. DAFTAR PUSTAKA:** Penyusunan Daftar Pustaka berdasarkan sistem nomor sesuai dengan urutan pengutipan. Hanya pustaka yang disitasi pada laporan akhir yang dicantumkan dalam Daftar Pustaka.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# Coffee Agroforestry for Degraded Land Rehabilitation in Upper Ciliwung Watershed, West Java, Indonesia

## ABSTRACT

The Upper Ciliwung Watershed, West Java, plays a crucial role as a hydrological regulator for downstream areas, including the capital city of Indonesia, Jakarta. The condition of Upper Ciliwung Watershed is critical due to the conversion of land use to other uses. Coffee agroforestry is known for its potential for preventing land degradation and reducing erosion. The objective of this study is to identify the coffee agroforestry practices in Upper Ciliwung Watershed and to examine their vegetation compositions and soil conditions in relation to coffee agroforestry's potential for degraded land rehabilitation. The data are collected through field survey. Soil samples are collected from coffee agroforestry locations to analyze the soil's physical and chemical properties. We sampled the vegetation stand structure in the study area and calculated the Shannon diversity index and Importance Value of each species. The results show that there are four hamlets in one village found in Upper Ciliwung Watershed that practice coffee agroforestry system, which are Cibulao, Cikoneng, Rawa Gede, and Cisuren. The common coffee's shade trees in the study areas are *Musa paradisiaca*, *Pinus merkusii*, and *Agathis dammara*. Our findings show that the location with higher diversity index and lower disturbance have better soil physical and chemical properties that can contribute to better degraded land rehabilitation.

**Keywords**: Agroforestry, Upper Ciliwung Watershed, Coffee, Land Degradation

## 1. Introduction

The upstream area of the Ciliwung Watershed functions as a protective and buffer area for the Ciliwung watershed area. If there is a change in its components it will affect all parts of the watershed. The watershed is important and interrelated between the upstream, middle, and downstream parts. The Upper Ciliwung Watershed is an important part of the Ciliwung watershed which has a leafy or dendritic shape. It has a pattern like twigs of leaves, tributaries joining the main river at sharp angles causing a high potential for flash floods in the downstream area (Anggraheni et al., 2018; Ali et al., 2016). The Upper Ciliwung Watershed has an important role and has strategic significance as a hydrological environmental regulator for the upstream-downstream areas, including DKI Jakarta located in the downstream area. The condition of Upper Ciliwung Watershed is critical due to the conversion of land use to other uses, especially residential areas in the upper stream of Ciliwung (Hasibuan et al., 2022; Robo et al., 2019; Wang et al., 2012).

Critical watersheds that exceed their carrying capacity occur in various regions of the world due to changes in land cover or use, critical land that is damaged so that land function is reduced, due to land use that does not pay attention to the principles of conservation techniques so that it is prone to erosion, landslides, and is prone to disasters (Ambarwulan et al., 2023; Budiastuti et al., 2020; Chen et al., 2019). The Upper Ciliwung watershed is categorized as a watershed where land is degraded and changes in forest cover, the triggering factors are human activity, soil, and climate (Fitri et al., 2020; Fitri et al., 2018; Wijitkosum, 2021). Degradation of soil physical properties due to forest conversion to other use areas, more watershed areas are built up, causing an increase in surface runoff (Sulaeman 2014; Salim et al 2019). The rapid development in the administrative area of the Ciliwung watershed, especially Jabodetabek, has a negative impact, causing the conversion of agricultural land into built-up land. The impact of land conversion and land damage in the upstream Ciliwung watershed has reduced water catchment areas resulting in flooding in the downstream area (Jakarta, Tangerang, and Bekasi) (Arifien et al., 2020).

According to Forest Watch Indonesia in 2018, the Upper Ciliwung watershed, especially the Puncak area, underwent massive forest and land degradation for decades. During 2000-2016, the area of forest land that was damaged was 5.7 thousand ha and left 21% of the natural forest of the total area of the Upper Ciliwung watershed. In the Tugu Utara area of the Ciliwung Hulu watershed, there are residents' settlements located in the plantation area, namely Kampung Rawa Gede, Kampung Cibulao, and Kampung Cikoneng which were also formerly owned by PT. Sumber Sari Bumi Pakuan (SSBP) Ciliwung, where many settlements have now been built, land use has resulted in an imbalance in the use of sustainable resources, due to changes in orientation to the local community's economic, social, cultural and political issues resulting in land damage (Chan, 2018). Soil carrying capacity can be increased through the application of technology in the form of soil and water conservation, vegetation-based conservation by implementing a combination of trees and agricultural crops commonly called agroforestry (Arham, & Darusman, 2019; Fitri et al., 2022; Hani & Geraldine, 2018).

Agroforestry is a dynamic ecological system of natural resource management and land use in which trees are planted in agricultural areas, grasslands, and the application of technologies that reduce erosion, degradation, and marginal land use (Getnet et al., 2023). Traditional agroforestry practices have economic, social, and environmental benefits to sustain human and ecological systems (Huxley., 1999). Agroforestry management in watershed areas with high canopy density produces a dense layer of litter, which is very useful in increasing the infiltration rate, and has a positive impact on the hydrological function of the watershed (Hairiah et al., 2004; Suprayogo et al., 2017). The development of agroforestry in the Upstream Ciliwung Watershed is an option that has great potential to improve environmental sustainability and watershed quality (Fitri., 2018; Fitri et al., 2018). Coffee-based agroforestry with a shading system or agroforestry model aims to develop community awareness in maintaining and enhancing protected functions as well as improving community welfare and agroforestry systems through the development of coffee cultivation ensuring the continuity of ecological structures and processes within it (Suprapto., 2014; Hayyun et al., 2018 ) Development of agroforestry systems contributes to enriching biodiversity, providing timber and non-timber sources, maintaining ecosystem integrity, improving soil and water quality (Ruark et al. 2003). The role of coffee-based agroforestry development in the upstream can be beneficial for providing habitat for birds, fauna, and biodiversity conservation by building landscape corridors (Moguel & Toledo 1999; Perfecto et al. 2005; O'Connoret al., 2005; Hadiyanti., 2014). The choice of coffee-based agroforestry for watershed conservation is because it is very beneficial in regulating water management by inhibiting runoff by tree crowns and litter and reducing erosion rates (Budidarsono & Wijaya 2003; Hadiyanti 2014). Research on coffee-based agroforestry is important because so far it has never been done in the Upper Ciliwung watershed. Based on the results of agroforestry research with a combination of cropping systems with trees and agricultural crops is an effort to conserve soil and water in the sub-watershed with vegetation-based techniques (Budiastuti et al., 2020; Gao et al., 2013; Hani & Geraldine, 2018).

Agroforestry research from existing literatures discuss a lot about critical land, such as in research conducted by Adi & Pramono (2018) about rehabilitation of critical land with agroforestry using sengon, teak, banana, papaya and petai plants that have a density of less than 25%. Some agroforestry research emphasizes the impact that can prevent critical land such as shrubs or erosion prevention plants. According to research by Bujang Rusman (2017) shows that agroforestry is one way to rehabilitate critical land, with a slope of >30% and erosion-sensitive soil, from these studies few discuss more specifically about coffee trees where there are many advantages of coffee plants including production crops, preventing land from erosion, capturing water when it rains and others, for that this research will examine the coffee plant.

The objective of this study is to identify the coffee agroforestry practices in Upper Ciliwung Watershed and to examine their vegetation compositions and soil conditions in relation to coffee agroforestry's potential for degraded land rehabilitation. The results of this study are expected to provide findings on coffee agroforestry composition that can contribute to degraded land rehabilitation. Hopefully, this study can be of help for the government in managing forestry land in order to be sustainable and for the community to provide awareness of the economic value of coffee plants as alternative agroforestry plants.

## 2. Materials and Methods

### 2.1. Study area

This study covers coffee agroforestry area in the Upper Ciliwung Watershed located in Bogor Regency, West Java Province, with an area of about 15,000 hectares. Not all areas have coffee agroforestry, this study focuses only on areas that practice coffee agroforestry system. The upstream is at the peak of Mount Gede Pangrango and its downstream is at Muara Angke, Jakarta. The Upper Ciliwung Watershed is located about 600-1500 meters above sea level. Administratively, the Upper Ciliwung Watershed consists of five subdistricts, which are Cisarua, Megamendung, Ciawi, Sukaraja, and Bogor Timur Subdistricts. Topographically, the Upper Ciliwung Watershed consists of seven subwatersheds, which are Cibalok, Cisukabirus, Ciseusepan, Cisuren, Ciesek, Cisarua, and Ciliwunghulu Subwatersheds (Figure 1).

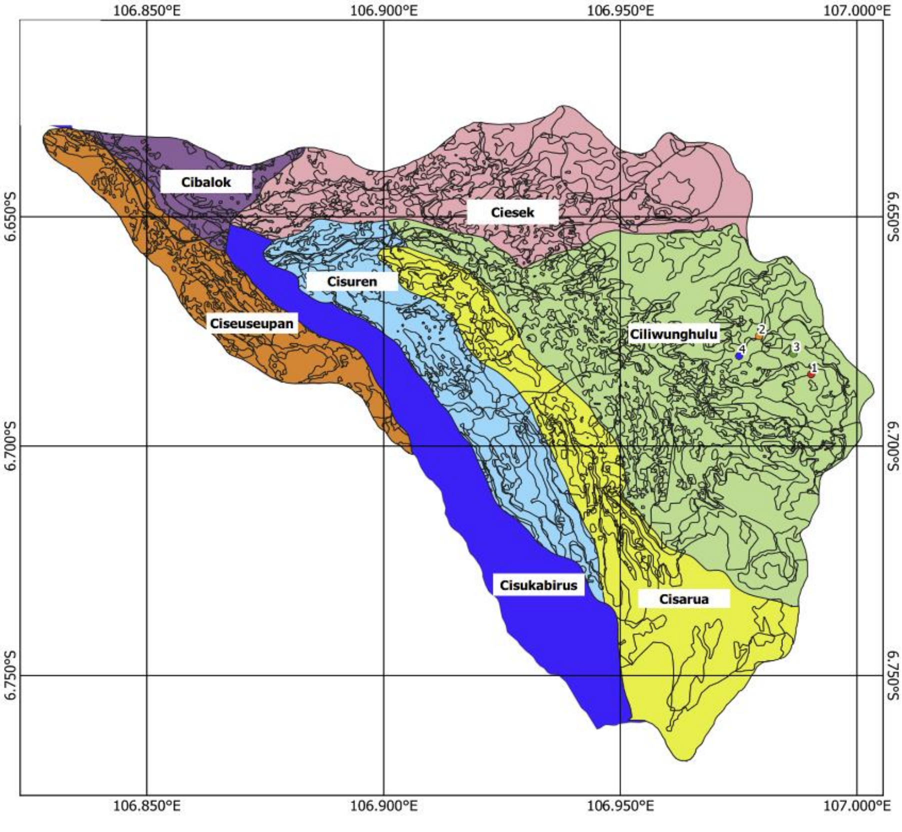


Figure 1. Study area
Source: BPDASHL (2023) with modification

### 2.2. Data Collection and Analysis

Information on the location of the coffee agroforestry practices in the study area is gathered through field survey. The research started from a location that is known to practice coffee agroforestry from an existing study (Fitri, 2018), Ciliwunghulu Subwatershed. Specifically, we started in a hamlet, a settlement area smaller than a village, named Cibulao. First, we collected information by asking a local figure from a Forest Farmer Group (Kelompok Tani Hutan) of Cibulao who practices coffee agroforestry. Forest Farmer Group is a group of farmers or individual Indonesian citizens and their families who manage forestry businesses inside and outside the forest area which includes timber forest products, non-timber forest products and environmental services, both upstream and downstream. The local figure then introduces us to other local figures who practice coffee agroforestry. Through this survey, we collected information about four coffee agroforestry locations in Ciliwunghulu Subwatershed.

Soil samples are collected from those four locations that are distributed in four hamlets to analyze the soil's physical and chemical properties. Physical and chemical properties of soil that are analyzed are soil texture, organic matter content, soil pH, and available nutrients, specifically nitrogen (N), phosphorus (P), and potassium (K). The soil sampling location is selected by purposive sampling where the soil does not look too dry or too wet and it is located in the middle of the field to avoid the edge effect. These soil samples are then brought to the laboratory for analysis.

For vegetation sampling, we record the vegetation stand structure in 20-meter-wide belt-transect of 50-meter length in each sampling location. During vegetation survey, the width of the belt-transect must allow a convenient trees counting (Mueller-Dombois & H, 1975). Researchers are allowed to decide the plot dimension based on the convenience of measuring, as long as the plot size are the same for comparison (Baxter, 2014). The study areas are hilly, which makes the field survey quite challenging to complete. We divide the area into 10 subplots of 10×10 meters. In total, we surveyed 1000 square meters for each sampling location. The subplot size is decided after considering the range of the tree sizes is very large. Furthermore, a plot of 10×10 meters is considered appropriate for forest/tree survey (Baxter, 2014).

The vegetation survey results are used to analyze the Shannon diversity index and Importance Value. Shannon Index is probably the most commonly used index to measure species diversity (Spellerberg et al., 2003). The Shannon diversity index is calculated as Equation 1.

$$H' = -\sum pi \times \ln(pi) \; ; \; pi = \frac{n_i}{N} \tag{1}$$

Where:

H' = Shannon diversity index

$n_i$ = number of individuals of a species and

N = total number of individuals

pi = the proportion of individuals in species i.

Measurements that are used to assess the Importance Value (IV) of each species are counts, cover, density, and frequency. IV is calculated as IV = RA + RD + RF, where RA is relative abundance (the percentage of the number of individuals of species *i*), RD is relative dominance (the percentage of basal area of the plot occupied by species *i*), and RF is relative frequency (the proportion of plots where species *i* occurred). The IV calculation method by (Curtis & McIntosh, 1951) serves as an estimation to measure the ecological importance of shade species in the coffee agroforestry.

## 3. Results and Discussions

### 3.1. Overview

According to field surveys and interviews with local figures, there are four locations in four different hamlets that practice coffee agroforestry, which are Cibulao, Cikoneng, Rawa Gede, and Cisuren Hamlets. All of these hamlets are located in Tugu Utara Village, Ciliwunghulu Subwatershed. The annual rainfall in the Upper Ciliwung Watershed ranges from 2,862 - 4,458 mm/year and the annual average rainfall is 3,567 mm/year. The coffee agroforestry practices in the study area are composed of several combinations of coffee with perennial plants (Figure 2a), such as banana, and coffee with annual plants (Figure 2b), such as dammar and pine trees.

Figure 2. Coffee agroforestry with (a) perennial plants, banana, in Cibulao, and (b) annual plants, pine trees, in Cisuren

### 3.2. Soil and Topographic Condition

The soil types in Upper Ciliwung Watershed are inceptisol, ultisol, and entisol, with inceptisol being the most dominant soil type in the area (BPDASHL, 2018). The distribution of soil type in the study area is shown in Figure 3. All four locations with coffee agroforestry have inceptisol soil type. Soil sampling locations are marked with colored dots in Figure 3. Slopes in Rawa Gede and Cisuren are steeper than in Cibulao and Cikoneng (Table 1).

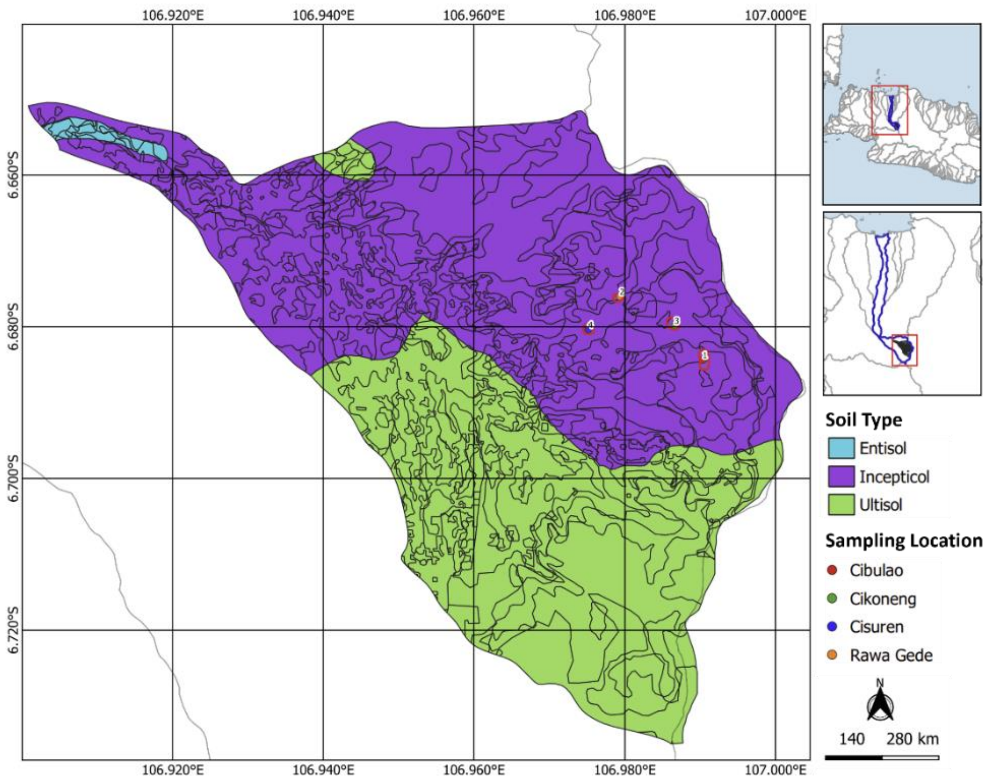


Figure 3. Soil type in the study area

Source: BPDASHL Citarum Ciliwung (2023) with modification

Table 1. Soil type, slope, and elevation of the study areas

| **Hamlet Name** | **Soil Type** | **Slope** | **Elevation (meter above sea level)** |
|---|---|---|---|
| Cibulao | Inceptisol | 8 % - 15 % | 1391 |
| Cikoneng | Inceptisol | 8 % - 15 % | 1396 |
| Rawa Gede | Inceptisol | 16 % - 25 % | 1407 |
| Cisuren | Inceptisol | 16 % - 25 % | 1245 |

The physical and chemical properties of soil samples according to the laboratory analysis results in study locations are as presented in Table 2. The lowest nitrogen (N) value is found in Cibulao at 0.51% while the highest N value was in Cisuren at 0.98%. The highest phosphorus (P) level is found in Cibulao (187.8 ppm), while the lowest P value is in Cisuren (22.5 ppm). The lowest potassium (K) is found in Cisuren (0.14 me%) while the highest is found in Cibulao (2.29 me%). The highest C-organic value is found in Cisuren at 17.33% and the lowest is found in Cibulao at 6.00%. All the pH values of the soil samples in the study area are acidic, with the pH value in Cibulao is 4.53, Cikoneng is 5.00, Rawa Gede is 4.98 and Cisuren is 4.12. The N, P, and K values are not entirely organic as coffee farmers in Cibulao is known to fertilize the plantation with P fertilizer to increase coffee productivity.

Table 2. Hasil analisis tanah di Cibulao, Cikoneng, Rawa Gede dan Cisuren

| Hamlet Name | Soil Analisis | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | N (%) | P (ppm) | K (me%) | Org-C % | pH | Texture | | |
| | | | | | | % Silt | % Clay | % Sand |
| Cibulao | 0.51 | 187.8 | 2.29 | 6.00 | 4.53 | 42.27 | 28.76 | 24.33 |
| Cikoneng | 0.67 | 39.2 | 0.30 | 7.59 | 5.00 | 45.86 | 12.75 | 35.85 |
| Rawa Gede | 0.56 | 38.6 | 1.06 | 6.39 | 4.98 | 29.33 | 21.16 | 43.35 |
| Cisuren | 0.98 | 22.5 | 0.14 | 17.33 | 4.12 | 49.42 | 14.18 | 29.63 |

Note : N = Nitrogen, P = Phosphorus, K = Potassium, Org-C = Organic carbon

### 3.3. Vegetation Composition

The vegetation composition of the four coffee agroforestry areas is recorded during field survey. Based on the survey, only coffee agroforestry in Cibulao is composed of Robusta coffee (*Coffea canephora*), Cikoneng, Rawa Gede, and Cisuren, are composed of Arabica coffee (*Coffea arabica*). According to an interview with a local figure in Cisuren, Arabica coffee is preferred due to its popularity and higher market price.

The Shannon diversity index values in all four areas are less than one (Figure 4). Usually, a diversity index value ranges from 1.5 to 3.5 (Ortiz-Burgos, 2016) in a normal forest condition. Considering the study areas are coffee agroforestry areas, the low values are due to low species evenness as all sampling locations are dominated by coffee. The vegetation compositions in Cibulao, Cikoneng, Rawa Gede, and Cisuren are presented in Table 3, Table 4, Table 5, and Table 6, respectively. Compared to other sampling locations, agroforestry in Cibulao has the highest species diversity despite having the lowest abundance. The Shannon diversity index from highest to lowest is Cibulao, Cikoneng, Rawa Gede, and Cisuren.

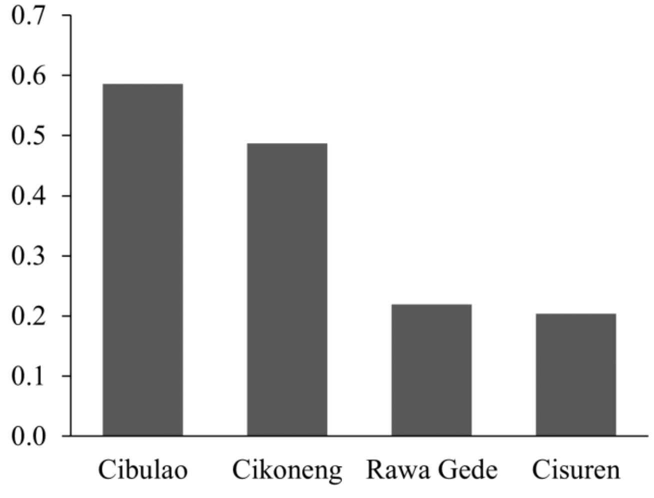


Figure 4. Shannon diversity indices in study area

Four coffee agroforestry locations are composed of different shade trees. In Cibulao, there are a total of ten species included in the vegetation structure (Table 3). The Shannon Index in Cibulao is 0.586, which is the highest value among the observed locations, and it indicates Cibulao has the highest species diversity. *Coffea canephora* has the highest importance value and then followed by *Musa paradisiaca* (banana), which is also the second most abundant species in the study plots. The planting distance between coffee plants in Cibulao is approximately 3×2.5 m, which is the largest distance compared to coffee planting distance in other studied locations. This consideration is based on the canopy diameter of mature Robusta coffee plants that is generally larger than Arabica coffee. The large planting distance caused the total number of coffee individuals in Cibulao to become the smallest compared to the other three locations. Other than *Coffea canephora* and *Musa paradisiaca*, all species have relatively low abundance and importance value.

Table 3. Vegetation composition in coffee agroforestry Cibulao (H' = 0.586)

| No | Species | Total Individuals | Relative Abundance (%) | Relative Dominance (%) | Relative Frequency (%) | Importance Value |
|---|---|---|---|---|---|---|
| 1 | *Coffea canephora* | 196 | 87.89 | 49.89 | 31.25 | 169.03 |
| 2 | *Antidesma bunius* | 1 | 0.45 | 0.24 | 6.25 | 6.94 |
| 3 | *Artocarpus heterophyllus* | 1 | 0.45 | 1.38 | 3.13 | 4.95 |
| 4 | *Musa paradisiaca* | 12 | 5.38 | 21.53 | 18.75 | 45.66 |
| 5 | *Neolamarckia cadamba* | 2 | 0.90 | 16.53 | 6.25 | 23.67 |
| 6 | *Paraserianthes falcataria* | 3 | 1.35 | 0.03 | 9.38 | 10.75 |
| 7 | *Persea americana* | 3 | 1.35 | 3.25 | 9.38 | 13.97 |
| 8 | *Schima wallichii* | 2 | 0.90 | 2.42 | 6.25 | 9.57 |
| 9 | *Syzygium polyanthum* | 1 | 0.45 | 1.98 | 3.13 | 5.56 |
| 10 | *Toona sureni* | 2 | 0.90 | 2.75 | 6.25 | 9.90 |
| | **Total** | **223** | | | | |

Cikoneng has the second highest Shannon diversity index (0.487) with nine species found in the study plots. The vegetation composition of coffee agroforestry in Cikoneng is presented at Table 4. Expectedly, *Coffea arabica* has the highest importance value. The planting distance between coffee plants in Cikoneng is approximately 2×2 m. After *Coffea arabica*, *Pinus merkusii* (pine) has the second largest importance value, despite having low abundance and low frequency. *Pinus merkusii* has the highest dominance, even surpassing *Coffea arabica* that has the highest abundance and frequency, due to the large size of the *Pinus merkusii* trees. The second largest abundance and frequency in the study plots belongs to *Musa paradisiaca*, which seemingly a common coffee shade tree in Cibulao and Cikoneng.

Table 4. Vegetation composition in coffee agroforestry Cikoneng (H’ = 0.487)

| No | Species | Total Individuals | Relative Abundance (%) | Relative Dominance (%) | Relative Frequency (%) | Importance Value |
|---|---|---|---|---|---|---|
| 1 | *Coffea arabica* | 236 | 90.08 | 34.60 | 32.26 | 156.93 |
| 2 | *Agathis dammara* | 4 | 1.53 | 2.04 | 12.90 | 16.47 |
| 3 | *Cinnamomum* sp. | 1 | 0.38 | 0.11 | 3.23 | 3.72 |
| 4 | *Citrus sinensis* | 1 | 0.38 | 0.04 | 3.23 | 3.64 |
| 5 | *Maesopsis eminii* | 3 | 1.15 | 3.48 | 9.68 | 14.30 |
| 6 | *Musa paradisiaca* | 12 | 4.58 | 18.34 | 22.58 | 45.50 |
| 7 | *Persea americana* | 1 | 0.38 | 0.06 | 3.23 | 3.66 |
| 8 | *Pinus merkusii* | 3 | 1.15 | 41.10 | 9.68 | 51.92 |
| 9 | *Toona sureni* | 1 | 0.38 | 0.24 | 3.23 | 3.85 |
| | **Total** | **262** | | | | |

The highest species abundance is found in Rawa Gede, but its Shannon index is the second lowest (0.220). In total, there are five species recorded in Rawa Gede. The coffee plants species in Rawa Gede is *Coffea arabica* var. *Gayo*, different than the other study locations. The mature size of this variety is smaller than regular Arabica coffee, which allows a smaller planting distance of around 1 to 1.5 m between each plant thus resulting in higher coffee abundance. In Rawa Gede, the second highest importance value belongs to the species *Agathis dammara* (dammar pine), which seemingly a native plant that has been around for years.

Table 5. Vegetation composition in coffee agroforestry Rawa Gede (H’ = 0.220)

| No | Species | Total Individuals | Relative Abundance (%) | Relative Dominance (%) | Relative Frequency (%) | Importance Value |
|---|---|---|---|---|---|---|
| 1 | *Coffea arabica* var. *Gayo* | 389 | 95.81 | 72.06 | 45.45 | 213.33 |
| 2 | *Agathis dammara* | 10 | 2.46 | 13.37 | 27.27 | 43.10 |
| 3 | *Persea americana* | 3 | 0.74 | 9.67 | 9.09 | 19.50 |
| 4 | *Artocarpus heterophyllus* | 1 | 0.25 | 0.36 | 4.55 | 5.15 |
| 5 | *Cinchona* sp. | 3 | 0.74 | 4.54 | 13.64 | 18.92 |
| | **Total** | **406** | | | | |

Cisuren has the lowest Shannon index value of 0.203. Other than *Coffea arabica*, there are two species in coffee agroforestry Cisuren, which are *Pinus merkusii* and *Cinchona* sp. (Table 6). The importance values of *Coffea arabica* and *Pinus merkusii* are not much different despite having a significant difference in the species abundance. The size of *Pinus merkusii* trees in the study area are very large and the dominance takes 92.64% of the study plots. The planting distance between coffee plants in Cisuren is approximately 1.5×1.5 m. The local figure in Cisuren acknowledges that this planting distance is too close, which results in crowded coffee plants and makes field maintenance hard because unwanted weeds grow quickly. Moreover, the plantation is on a hilly slope, so the environment is rather dark and damp due to the shades from *Pinus merkusii*. *Pinus merkusii* is an endemic species the study plots.

Table 6. Vegetation composition in coffee agroforestry Cisuren (H' = 0.203)

| No | Species | Total Individuals | Relative Abundance (%) | Relative Dominance (%) | Relative Frequency (%) | Importance Value |
|---|---|---|---|---|---|---|
| 1 | *Coffea arabica* | 337 | 95.20 | 7.05 | 47.62 | 149.87 |
| 2 | *Pinus merkusii* | 16 | 4.52 | 92.64 | 47.62 | 144.78 |
| 3 | *Cinchona* sp. | 1 | 0.28 | 0.31 | 4.76 | 5.35 |
| | **Total** | **354** | | | | |

### 3.4. Soil Properties and Vegetation Composition

The soils texture in Cibulao falls into the category "silty clay loam" according to soil textural triangle (USDA, 2018). Meanwhile, soils in Cikoneng, Rawa Gede, and Cisuren fall into the category "silt loam". Among the observed locations, Cibulao is the only coffee agroforestry system that incorporates Robusta coffee while the others incorporate Arabica coffee. Based on the soil chemical properties, Cibulao has the lowest N, highest P, highest K, and lowest C-organic. Soil chemical properties in Cibulao consistently have the most extreme values compared to other locations. This is possibly due to the high vegetation diversity in Cibulao and its different species of coffee.

The diversity of vegetation plays a significant role in maintaining soil quality and health (Shen et al., 2022). A mix of species creates a diverse root structure, improving soil structure and water retention, reducing erosion, and increasing nutrient cycling (Liu et al., 2015). Different plant species also deposit varying amounts of organic matter, increasing soil fertility and microbial diversity (Furey & Tilman, 2021). Monocultures, on the other hand, can deplete the soil of specific nutrients, leading to soil degradation and decreased productivity (Putra et al., 2020). Therefore, promoting a diverse range of vegetation, like practiced in Cibulao, can enhance soil condition and sustainability.

The ideal soil physical properties to decrease erosion include a dense layer of vegetation cover, a consistent soil structure with stable aggregates, a high level of soil organic matter, and a well-drained soil with good permeability (Zhu et al., 2022). These features help to improve water infiltration and retention in the soil, reduce surface runoff and soil compaction, and enhance soil stability. Proper land management practices such as reduced tillage, crop rotation, and cover cropping also contribute to maintaining and enhancing these soil physical properties, thereby reducing erosion, and preserving soil health.

The ideal soil chemical properties for degraded land rehabilitation include adequate nutrient levels, balanced soil pH, and high organic matter content. Nutrient levels should include adequate levels of nitrogen, phosphorus, and potassium. Soil pH should be in the range of 6.0 to 7.5 to support plant growth and nutrient availability (Neina, 2019). The organic matter content should be sufficient to sustain soil biological activity and improve soil structure, water holding capacity, and nutrient retention. Additionally, the soil should be free from contaminants and toxins that can harm plant growth and pose risks to human health (Nyiramigisha et al., 2021).

Cisuren has the highest organic carbon level despite having lower N, P, K values. Organic matter in soil, often referred to as soil organic carbon (SOC), is a crucial component of soil health and plays a significant role in degraded land rehabilitation. Organic matter acts as a binding agent in soil, helping to create stable soil aggregates. These aggregates enhance soil structure, reducing soil erosion and improving water infiltration and retention (Bronick & Lal, 2005). In degraded lands where soil structure may have deteriorated due to erosion or compaction, increasing SOC can help rebuild soil structure. It is worth to note that Cisuren has the lowest vegetation diversity. However, Cisuren seems to be the most undisturbed coffee agroforestry land compared to other locations. We suggest that land with low disturbance has higher SOC and can provide greater benefits in degraded land rehabilitation.

### 3.5. Research Limitations

One of the primary limitations of this research is the potential for sampling bias. The study relied on a specific sample of coffee agroforestry systems in the Upper Ciliwung Watershed. It is important to acknowledge that the sample may not fully represent the entire range of agroforestry practices in the region. Variability in practices and conditions could exist beyond the scope of this study.

This study represents a snapshot in time. Long-term trends and the sustainability of coffee agroforestry practices may not be fully addressed. Future research with extended monitoring periods could provide more insights into the system's long-term viability. Despite rigorous data collection procedures, there may be limitations regarding data quality, especially in challenging field conditions. These limitations could influence the accuracy and reliability of our results.

## 4. Conclusion

In conclusion, there are four hamlets in one village found in Upper Ciliwung Watershed that practice coffee agroforestry system, which are Cibulao, Cikoneng, Rawa Gede, and

Cisuren. Cibulao has Robusta coffee in their agroforestry system while other hamlets have Arabica coffee in their system. Cibulao has the highest diversity index, despite having the lowest vegetation abundance. Vegetation diversity plays a significant and multifaceted role in degraded land rehabilitation, and this aspect is often a key component of successful agroforestry practices, as seen in Cibulao. However, although the vegetation diversity is low, if the land disturbance is low, as seen in Cisuren, the coffee agroforestry also significantly helpful in degraded land rehabilitation.

Our findings reveal that coffee agroforestry systems in Upper Ciliwung Watershed offer promising prospects for addressing land degradation challenges. The diverse array of plant species cultivated alongside coffee not only enhances biodiversity but also contributes to soil improvement and ecosystem resilience. These practices showcase the potential of sustainable land management, aligning with the principles of agroecology and environmental conservation.

**Competing Interest**

The authors declare that they have no competing interests.

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# [RL] Submission Acknowledgement - "Coffee Agroforestry for Degraded Land Rehabilitation in Upper Ciliwung Watershed, West Java, Indonesia"

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# Coffee Agroforestry for Soil Erosion Control in the Upstream of Ciliwung Watershed, West Java, Indonesia

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## Abstract

The deteriorating condition of the upstream of Ciliwung Watershed exacerbated soil erosion and increasing flood risk in the downstream area, including DKI Jakarta, the capital city of Indonesia. Coffee holds a significant economic role in Indonesia and coffee agroforestry demonstrated effectiveness in erosion reduction. This study aims to examine the benefit of coffee agroforestry to control soil erosion through analyzing the influence of soil properties and vegetation composition. The study was conducted in four hamlets, namely Cibulao, Cikoneng, Rawa Gede, and Cisuren. Soil erosion was measured from Universal Soil Loss Equation calculation, while vegetation was measured from Shannon diversity index and importance value. The results showed that the erosion rates in all four study areas are below tolerated erosion rates. The highest erosion rate was found in Cikoneng (14.76 ton/ha/year) and the lowest is found in Cisuren (9.29 ton/ha/year). Cisuren has high slope steepness, highest organic matter content, and lowest Shannon diversity index. Cikoneng shows neither distinctive soil properties nor vegetation composition. Coffee agroforestry seems to keep the soil erosion rate under control. However, soil erosion rate is not solely dependent on individual factors, such as soil properties or vegetation cover, but rather on the combination of these elements.

***Keywords:*** Agroforestry; Coffee plantation; Soil erosion; Upstream watershed

## 1. Introduction

The Ciliwung watershed covers a large area, including the upstream and midstream areas in West Java and the downstream area in DKI Jakarta. The natural pattern and topography of the Ciliwung watershed shape the stream's characteristics, promoting the rapid flow of water downhill. The watershed exhibits a pattern reminiscent of leaf twigs, with tributaries converging at sharp angles into the main river (Ali *et al.,* 2016; Anggraheni *et al.,* 2018). West Java has high-intensity rainfall of about 3500 mm per year (BPS, 2022). The down ward incline, combined with the region's intense rainfall, exacerbated soil erosion upstream and increased the flood risks downstream. In addition, rapid urbanization, and land conversion of natural areas into urban landscapes have altered the hydrological characteristics of the Ciliwung watershed, increasing the risk of soil erosion and flooding even further. The flood volume and flood area in Ciliwung Watershed are predicted to increase 101.7% and 91%, respectively, in 2030 (Farid *et al.,* 2022).

The upstream area of the Ciliwung Watershed plays a vital role as a hydrological environmental regulator for upstream, midstream, and downstream areas.

Any alterations to the upstream components would have widespread implications for the entire watershed, particularly for the downstream area (Ahmed *et al.,* 2019). Unfortunately, the condition of the upstream Ciliwung Watershed is deteriorating, and it falls into the category of degraded land with evident changes in forest cover, attributed to human activity, alterations in soil composition, and climatic factors (Fitri *et al.,* 2020; Wijitkosum, 2021). The main reason is due to land use conversion, specifically the transition from vegetated areas to built-up areas (Hasibuan *et al.,* 2022; Robo *et al.,* 2019; D. Wang *et al.,* 2012), causing an increase in surface runoff (Salim *et al.,* 2019; Sulaeman *et al.,* 2014), that leads to flood hazard in the downstream area. DKI Jakarta, located downstream, faces a major threat due to the degradation of the upstream Ciliwung Watershed. As the capital city and the business center in Indonesia, the potential impacts are massive as it will significantly disadvantage a large population. Therefore, conserving the upstream area becomes even more crucial.

Agroforestry can be perceived as a form of agricultural landscape that integrates trees within croplands and pasturelands, providing benefits in climate change mitigation programs while simultaneously yielding crop products (Getnet *et al.,* 2023). Coffee holds a significant economic role in Indonesia, contributing substantially to the country's agricultural sector and providing livelihoods for numerous farmers. Monoculture coffee production is known to be vulnerable to soil erosion (Cerretelli *et al.,* 2023), but agroforestry systems of coffee and mixed shade trees have demonstrated effectiveness in erosion reduction through the canopy cover they provide and their role in contributing to the litter layer (Blanco Sepúlveda & Aguilar Carrillo, 2015).

Research about ecosystem services of coffee agroforestry keep increasing over the years (De Leijster *et al.,* 2021; Mokondoko *et al.,* 2022; Notaro *et al.,* 2022), and some of them focuses on their benefit in relation to soil erosion control (Blanco Sepúlveda & Aguilar Carrillo, 2015; Meylan *et al.,* 2013; Ramos Scharrón, 2023). Most of coffee agroforestry system related studies are conducted in Central and South America, and very little is known about the coffee agroforestry in Indonesia, specifically in the Upstream of Ciliwung Watershed, despite its big potential to mitigate the worsening flood hazard in DKI Jakarta. To optimize the effectiveness of coffee agroforestry in soil erosion control, it is crucial to understand the primary factors influencing soil erodibility. A study in Northern Nicaragua found that soil erosion is mainly determined by the litter layer and slope gradient (Blanco Sepúlveda & Aguilar Carrillo, 2015). Meanwhile, a different study in Anxi County, China, found that soil texture and organic matter content are the main factors (Deng *et al.,* 2016). The determinants could be different according to the locations. To the best of authors' knowledge, no such research has been conducted in the Upstream of Ciliwung Watershed.

Soil erosion rate can be determined by rainfall, runoff (Yustika *et al.,* 2019), topography (Tuo *et al.,* 2023), soil texture (Stanchi *et al.,* 2015), soil organic matter content (Obalum *et al.,* 2017), vegetation cover, land use (Lech-hab *et al.,* 2015), and human activities (Kemp *et al.,* 2020). Factors such as texture, structure, and organic content are parts of soil properties that influence the size and stability of soil aggregates, regulating the amount of soil lost to wind or water erosion (Tanner *et al.,* 2023). Other than soil properties, soil erosion is also significantly influenced by present vegetation coverage (Haigh, 2009; Wang *et al.,* 2022). Vegetation communities play important roles in an ecosystem, including increasing soil fertility, reducing erosion, and preserving biodiversity (Bishaw *et al.,* 2013), which can be evaluated through the diversity index and importance value (Budiastuti *et al.,* 2020). Therefore, soil properties and vegetation composition are significant factors that need to be considered in soil erosion studies.

The objective of this study is to examine the benefit of coffee agroforestry systems to control soil erosion by analyzing the influence of soil properties and vegetation composition on soil erosion rate in the system in the Upstream of Ciliwung Watershed.

## 2. Methodology

### *2.1 Study area*

This study covers coffee agroforestry area in the upstream of Ciliwung Watershed located in Bogor Regency, West Java Province, Indonesia, with an area of about 15,000 hectares. This study focuses only on areas that practice coffee agroforestry system. The upstream is at the peak of Mount Gede Pangrango, Bogor, and its downstream is at Muara Angke, Jakarta. The upstream of Ciliwung Watershed is located approximately 600 – 1,500 meters above sea level. The annual rainfall in the Upper Ciliwung Watershed ranges from 2,862 – 4,458 mm/year and the annual average rainfall is 3,567 mm/year. The upstream of Ciliwung Watershed consists of seven subwatersheds, which are Cibalok, Cisukabirus, Ciseusepan, Cisuren, Ciesek, Cisarua, and Ciliwunghulu Subwatersheds (Figure 1). The research is conducted from July to September 2023.

### *2.2 Data collection and analysis*

#### *2.2.1 Coffee agroforestry locations*

Information on the location of the coffee agroforestry practices in the study area is gathered through field survey. The research started from a location that is known to practice coffee agroforestry from an existing study (Fitri *et al.,* 2018), Ciliwunghulu Subwatershed. The research began in a hamlet, a residential area smaller than a village, called Cibulao. First, information was collected through interviews with a local expert from a Forest Farmer Group in Cibulao that practices coffee agroforestry. Forest Farmer Group is a group of farmers or individual Indonesian citizens and their families who manage forestry businesses inside and outside the forest area which includes timber forest products, non-timber forest products and environmental services, both upstream and downstream. The local expert then introduced other local experts who practiced coffee

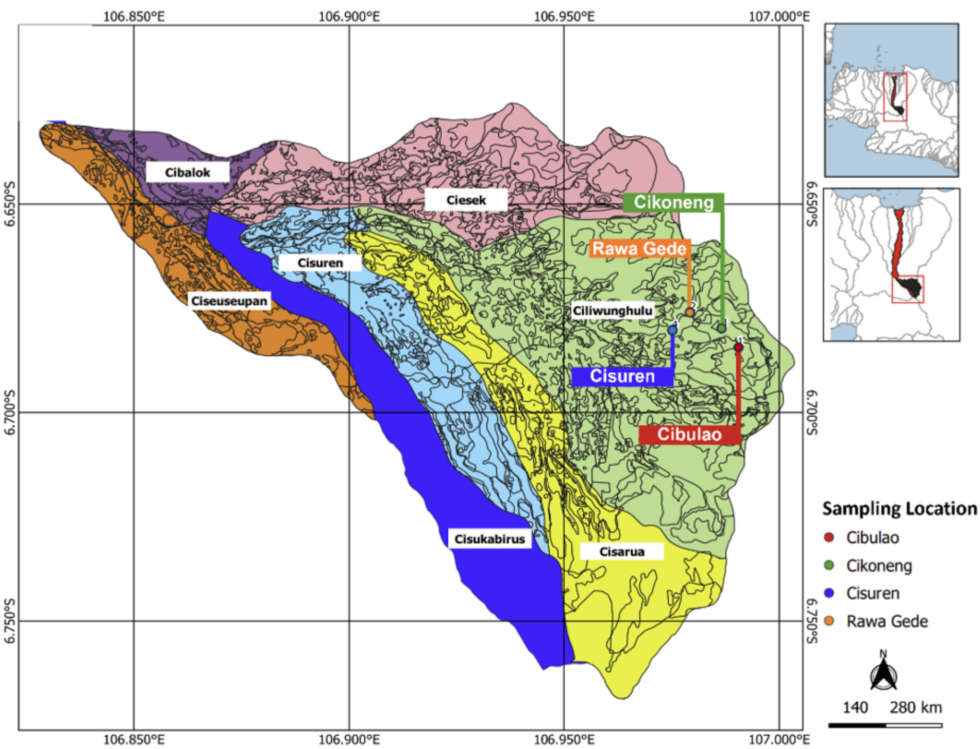


**Figure 1.** Study area (different colors showing different subwatersheds)
Source: BPDASHL (2023) with modification

agroforestry. Through this survey, information on four coffee agroforestry locations in the Ciliwunghulu Subwatershed were collected, namely Cibulao, Cikoneng, Rawa Gede, and Cisuren, was collected (Figure 1).

*2.2.2 Soil properties*

Soil samples from four research sites spread across four hamlets were taken to analyze their physical and chemical properties. These are analyzed because they influence the amount of soil lost to wind or water erosion (Tanner *et al.,* 2023). The soil sampling location is selected through purposive sampling where the soil does not look too dry or too wet and it is located in the middle of the field to avoid the edge effect. Soil sampling includes two types of samples, which are undisturbed soil samples, taken using ring samples, and disturbed soil sample, taken using a field hoe or soil drill. Each land unit soil samples were taken at a depth of 0 - 20 cm consisting of 3 ring samples of undisturbed soil, and 1 plastic sample of disturbed soil (composite soil sample) ( > 500 grams). These soil samples are then brought to the Soil Laboratory of Department of Soil Science and Land Resources IPB University for analysis.

The undisturbed soil samples were used for physical properties analysis, including bulk density, analyzed using the Black and Hartge method; soil permeability; and soil structure obtained from field observations. Meanwhile, disturbed soil samples were used for chemical properties analysis, including nitrogen (N), phosphorus (P), potassium (K), soil texture analyzed by pipette method, and soil organic matter content by Walkley and Black methods. The soil chemical properties may be related to the vegetation composition, and the vegetation may have influences on the soil erosion.

*2.2.3 Vegetation*

Soil erosion is significantly influenced by present vegetation coverage (Wang *et al.,* 2022). Vegetation communities play important roles in an ecosystem, including increasing soil fertility, reducing erosion, and preserving biodiversity (Bishaw *et al.,* 2013), which can be evaluated through the Shannon diversity index and importance value (Budiastuti et al., 2020). Therefore, we considered vegetation coverage as a factor that determines soil erosion.

To analyze the vegetation coverage, we sampled the vegetation stand structure in 20-meter-wide belt-transect of 50-meter length in each sampling location. During vegetation survey, the width of the belt-transect must allow a convenient tree counting (Mueller-Dombois & H, 1975). Researchers are allowed to decide the plot dimension based on the convenience of measuring, as long as the plot size are the same for comparison (Baxter, 2014). The study areas are hilly, which makes the field survey quite challenging to complete. We divide the area into 10 subplots of 10 × 10 meters. In total, we surveyed 1000 square meters for each sampling location. The subplot size is decided after considering the range of the tree sizes is very large. Furthermore, a plot of 10 × 10 meters is considered appropriate for forest/tree survey (Baxter, 2014).

The vegetation survey results are used to analyze the Shannon diversity index and the Importance Value. Shannon Index is probably the most commonly used index to measure species diversity (Spellerberg & Fedor, 2003). The Shannon diversity index is calculated as Equation (1).

$$H' = -\sum pi \times \ln(pi) \; ; \; pi = \frac{n_i}{N} \quad (1)$$

Where:
H' = Shannon diversity index
ni = number of individuals of a species and
N = total number of individuals
p$i$ = the proportion of individuals in species $i$.

Measurements that are used to assess the Importance Value (IV) of each species are counts, cover, density, and frequency. IV is calculated as IV = RA + RD + RF, where RA is relative abundance (the percentage of the number of individuals of species $i$), RD is relative dominance (the percentage of basal area of the plot occupied by species *i*), and RF is relative frequency (the proportion of plots where species *i* occurred). The IV calculation method by Curtis & McIntosh (1951) serves as an estimation to measure the ecological importance of shade species in the coffee agroforestry.

*2.2.4 Soil erosion*

Soil loss measurement is crucial to assess the extent of soil erosion in study areas. Measuring soil loss provides valuable data to estimate the effectiveness of coffee agroforestry practices for land rehabilitation, specifically in relation to erosion control. This study uses the Universal Soil Loss Equation (USLE) method to predict soil loss per year following Equation (1) by Wischmeier & Smith (1978). The USLE method is also used to predict tolerated erosion (Etol).

$$A = RKLSCP \qquad (2)$$

Where:
A = computed soil loss (tons/acre/year)
R = rainfall-runoff erosivity factor
K = soil erodibility factor
LS = slope length and steepness factor
C = cover management factor
P = supporting practices factor

Each component in the USLE method is described as follows.

1. R (Rainfall-runoff erosivity factor)

To determine the rainfall-runoff erosivity value (R), monthly rainfall data is acquired from the local meteorological station. The rainfall erosivity value is calculated using the Lenvain formula as follows.

$$R_{30} = 2.34\ (R_m)^{1.98} \qquad (3)$$

where $R_{30}$ = monthly rainfall-runoff erosivity; $R_m$ = monthly rainfall (cm).

The value of R for a year is obtained by summing $R_m$ for a year.

2. K (Soil erodibility factor)

Data for calculating the soil erodibility factor (K) was obtained from (1) the percentage of fine sand, dust, clay, and organic matter from the analysis of soil samples in the laboratory; (2) soil structure and soil permeability, where both data are obtained through field observations and then the results are matched with a list of soil structure and soil permeability code values, (3) soil texture class (M), where the value is obtained using the formula: M = (s + d) (100 - c), where s is the percentage of fine sand; d is the percentage of dust, and c is the percentage of clay. The soil erodibility parameter was calculated based on the adjusted K value (Hammer 1981).

$$K = \frac{1.292[2.1\,M^{1.14}(10^{-4})(12-a) + 3.25(b-2) + 2.5(c-3)]}{100} \qquad (4)$$

where:
K = soil erodibility
M = soil texture class (% fine sand + dust) (100 - % clay)
a = % organic matter
b = soil structure code
c = soil profile permeability code

3. LS (Slope length and steepness factor)

The slope length and steepness factor are determined based on data obtained from field measurements, using the equation in Arsyad (2006).

$$LS = \sqrt{X(0.0138 + 0.00965\,S + 0.00138\,S^2} \qquad (5)$$

where:
X = slope length (m)
S = slope steepness (%)

4. C (Cover management factor)

C values were determined based on interviews and field observations covering planting systems, fertilization, utilization of crop residues, soil treatment techniques, use of mulch, compost with reference to the C values of previous research results summarized in Hardjowigeno (2003).

5. P (Supporting practices factor)

The value of the P factor is determined based on soil conservation measures aimed at reducing soil erosion found in the field.

## 3. Results and Discussion

### 3.1 Soil condition

All four locations with coffee agroforestry in the study areas have inceptisol soil type. Slopes in Cibulao and Cikoneng range from 8% to 15%, meanwhile, slopes Rawa Gede and Cisuren are steeper, ranging from 16% to 25%. The analyzed properties of soil samples in study locations are presented in Table 1. The lowest nitrogen (N) value is found in Cibulao while the highest N value was in Cisuren. The highest phosphorus (P) level is found in Cibulao, while the lowest P value is in Cisuren. The lowest potassium (K) is found in Cisuren while the highest is found in Cibulao. The N, P, and K values are not entirely organic as coffee farmers in Cibulao are known to fertilize the plantation with P fertilizer to increase coffee productivity. The highest C-organic value is found in Cisuren at 17.33% and the lowest is found in Cibulao at 6.00%. All the pH values of the soil samples in the study area are acidic, with the most acidic pH is in Cisuren and the least acidic is in Cikoneng. According to soil textural triangle (USDA, 2018), the soils texture in Cibulao falls into the category "silty clay loam". Meanwhile, soils in Cikoneng, Rawa Gede, and Cisuren fall into the category "silt loam".

### 3.2 Vegetation composition

Based on the field survey, three of four observed coffee agroforestry areas Cikoneng, Rawa Gede, and Cisuren are composed of Arabica coffee (Coffea arabica). Only coffee agroforestry in Cibulao is composed of Robusta coffee (Coffea canephora). The ages of the coffee plantations vary in the study area. The age of the coffee in Cibulao and Cikoneng is more than 5 years, while in Cisuren is about 2 years. The youngest age of coffee is in Rawa Gede that is less than 1 year. Figure 2 illustrates the vegetation composition in the study area. According to a local expert, Arabica coffee is preferred due to its popularity and higher market price.

The vegetation composition and Shannon diversity index values in all four areas are presented in Table 2. The areas that have the highest to the lowest diversity index are Cibulao, Cikoneng, Rawa Gede, and Cisuren, respectively. Compared to other study areas, agroforestry in Cibulao has the highest species diversity despite having the lowest number of individuals.

Table 3 presents the importance values of vegetation in the study areas. In all four observed coffee agroforestry areas, coffee has the highest importance value compared to other species. This shows that coffee is the most dominant species in all observed areas. In Cibulao, *Coffea canephora* has the highest importance value and then followed by *Musa paradisiaca* (banana), which is also the second most abundant species in the study plots. The planting distance between coffee plants in Cibulao is approximately 3 × 2.5 m, which is the largest distance compared to coffee planting distance in other studied locations. This is due to the canopy diameter of mature Robusta coffee plants is generally larger than Arabica coffee. The large planting distance caused the total number of coffee individuals in Cibulao to become the smallest compared to the other three locations. Other than *Coffea canephora* and *Musa paradisiaca*, all species have relatively low importance value in Cibulao.

**Table 1.** Analyzed soil properties in the study areas

| Hamlet Name | N (%) | P (ppm) | K (meq%) | Org-C (%) | pH | Texture | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | % Silt | % Clay | % Sand |
| Cibulao | 0.51 | 187.8 | 2.29 | 6.00 | 4.53 | 42.27 | 28.76 | 24.33 |
| Cikoneng | 0.67 | 39.2 | 0.30 | 7.59 | 5.00 | 45.86 | 12.75 | 35.85 |
| Rawa Gede | 0.56 | 38.6 | 1.06 | 6.39 | 4.98 | 29.33 | 21.16 | 43.35 |
| Cisuren | 0.98 | 22.5 | 0.14 | 17.33 | 4.12 | 49.42 | 14.18 | 29.63 |

Note: N = Nitrogen, P = Phosphorus, K = Potassium, Org-C = Organic carbon
meq = milli equivalent

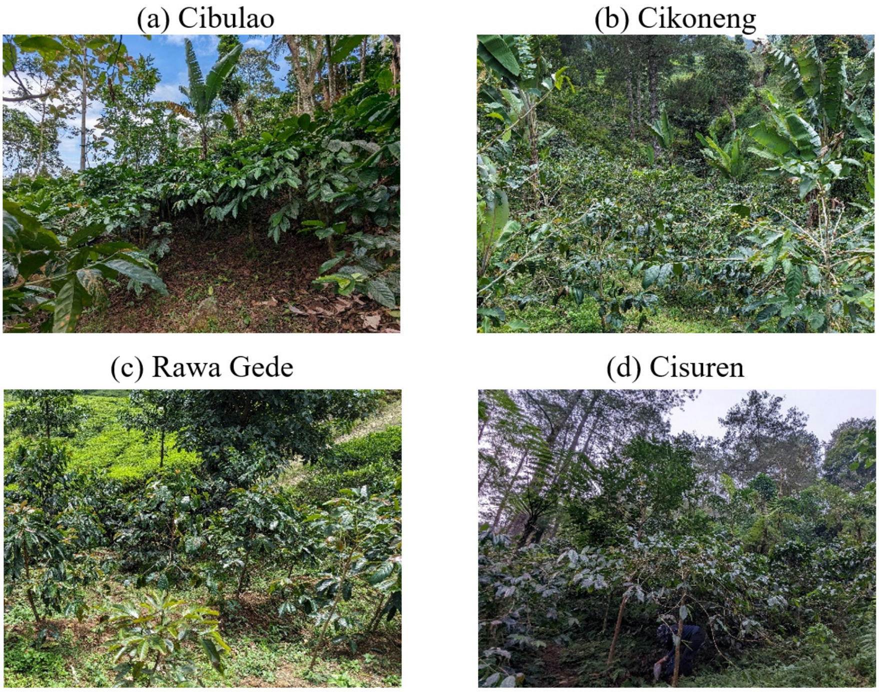


**Figure 2.** Vegetation composition in the study area

**Table 2.** Vegetation composition in the study areas

| Hamlet Name | No of Species | Species | No of Individuals | H’ |
|---|---|---|---|---|
| Cibulao | 10 | *Coffea canephora, Antidesma bunius, Artocarpus heterophyllus, Musa paradisiaca, Neolamarckia cadamba, Persea americana, Schima wallichii, Syzygium polyanthum, Toona sureni* | 223 (Coffee: 196) | 0.586 |
| Cikoneng | 9 | *Coffea arabica, Agathis dammara, Cinnamomum* sp., *Citrus sinensis, Maesopsis eminii, Musa paradisiaca, Persea americana, Pinus merkusii, Toona sureni* | 262 (Coffee: 236) | 0.487 |
| Rawa Gede | 5 | *Coffea arabica* var. *Gayo, Agathis dammara, Persea americana, Artocarpus heterophyllus, Cinchona* sp. | 406 (Coffee: 389) | 0.220 |
| Cisuren | 3 | *Coffea arabica, Pinus merkusii, Cinchona* sp. | 354 (Coffee: 337) | 0.203 |

H’ = Shannon diversity index

**Table 3.** Importance values of vegetation species in the study areas ("-" means the species is not found in the sampling location)

| Species | Importance Value / Sampling location | | | |
|---|---|---|---|---|
| | Cibulao | Cikoneng | Rawa Gede | Cisuren |
| *Coffea canephora* | 169.030 | - | - | - |
| *Coffea arabica* | - | 156.932 | 213.329 | 149.866 |
| *Agathis dammara* | - | 16.466 | 43.103 | - |
| *Antidesma bunius* | 6.940 | - | - | - |
| *Artocarpus heterophyllus* | 4.950 | - | 5.155 | - |
| *Cinchona* sp. | - | - | 18.916 | 5.351 |
| *Cinnamomum* sp. | - | 3.720 | - | - |
| *Citrus sinensis* | - | 3.644 | - | - |
| *Maesopsis eminii* | - | 14.301 | - | - |
| *Musa paradisiaca* | 45.663 | 45.505 | - | - |
| *Neolamarckia cadamba* | 23.673 | - | - | - |
| *Paraserianthes falcataria* | 10.749 | - | - | - |
| *Persea americana* | 13.973 | 3.665 | 19.497 | - |
| *Pinus merkusii* | - | 51.919 | - | 144.782 |
| *Schima wallichii* | 9.567 | - | - | - |
| *Syzygium polyanthum* | 5.556 | - | - | - |
| *Toona sureni* | 9.900 | 3.848 | - | - |

Cikoneng has the second highest Shannon diversity index (0.487) with nine species found in the study plots (Table 2). The planting distance between coffee plants in Cikoneng is approximately 2×2 m. After *Coffea arabica*, *Pinus merkusii* (pine) has the second largest importance value (Table 3). *Pinus merkusii* has the highest dominance, even surpassing *Coffea arabica* that has the highest abundance and frequency, due to the large size of the *Pinus merkusii* trees. The second largest abundance and frequency in the study plots belongs to *Musa paradisiaca*, which seemingly is a common coffee shade tree in Cibulao and Cikoneng.

Rawa Gede has the highest number of individuals including five different species (Table 2). The coffee plants species in Rawa Gede is *Coffea arabica* var. *Gayo*, different than the other study locations. The mature size of this variety is smaller than regular Arabica coffee, which allows a smaller planting distance of around 1 to 1.5 m between each plant thus resulting in higher coffee abundance. In Rawa Gede, the second highest importance value belongs to the species *Agathis dammara* (dammar pine), which seemingly a native plant that has been around for years.

Cisuren has the lowest Shannon diversity index among the study areas (Table 2). Other than *Coffea arabica*, there are two species in coffee agroforestry Cisuren, which are Pinus merkusii and *Cinchona* sp. (Table 3). The importance values of *Coffea arabica* and *Pinus merkusii* are not much different despite having a significant difference in the species abundance. The size of *Pinus merkusii* trees in the study area are very large and the dominance takes 92.64% of the study plots. The planting distance between coffee plants in Cisuren is approximately 1.5×1.5 m. The local figure in Cisuren acknowledges that this planting distance is too close, which results in crowded coffee plants and makes field maintenance hard because unwanted weeds grow quickly. Moreover, the plantation is on a hilly slope, so the environment is rather dark and damp due to the shades from *Pinus merkusii*, an endemic species the study plots.

### *3.3 Soil erosion*

Based on the analysis, the erosion rates in the study areas are below tolerated erosion rates (Table 4). The highest erosion rate is found in Cikoneng (14.76 tons/ha/year with an erosion tolerance of 16.38 tons/ha/year) and

**Table 4.** Soil erosion in the study areas

| Hamlet Name | R | K | LS | C | P | Erosion (A) (ton/ha/year) | Tolerated Erosion (Etol) (ton/ha/year) | Difference (Etol−A) |
|---|---|---|---|---|---|---|---|---|
| Cibulao | 2733,10 | 0,06 | 1,20 | 0,10 | 0,50 | 9,84 | 18,33 | 8.49 |
| Cikoneng | 2733,10 | 0,09 | 1,20 | 0,10 | 0,50 | 14,76 | 16,38 | 1.62 |
| Rawa Gede | 2733,10 | 0,05 | 4,25 | 0,20 | 0,10 | 11,62 | 15,76 | 4.14 |
| Cisuren | 2733,10 | 0,04 | 4,25 | 0,20 | 0,10 | 9,29 | 16,77 | 7.48 |

the lowest is found in Cisuren (9.29 tons/ha/year with an erosion tolerance of 16.77 tons/ha/year). The difference between predicted erosion (A) and tolerated erosion (Etol) rates from the highest to the lowest is in Cibulao, Cisuren, Rawa Gede, and Cikoneng.

### *3.4 Influence of soil condition and vegetation composition on soil erosion*

Land slope is a significant factor in soil erosion. Existing research show that steeper slopes generally experience higher erosion rates because water (rainfall or runoff) can move faster and with greater force, carrying away soil particles (Sarminah *et al.,* 2022; Siswanto & Sule, 2019; Taye *et al.,* 2013). A study conducted in the mountainous region of Central Java, Indonesia, observed a positive correlation between slope steepness and erosion rate. That study revealed a 7 – 15% increase in erosion rate for every 1% rise in slope steepness (Rahardjo *et al.,* 2021). Rawa Gede and Cisuren have steeper slopes than Cibulao and Cikoneng. However, the erosion rates in Rawa Gede and Cisuren are not necessarily higher than Cibulao and Cikoneng. The highest erosion rate is found in Cikoneng (erosion rate of 14.76 ton/ha/year; slope steepness of 8 – 15%) and the lowest is found in Cisuren (erosion rate of 9.29 ton/ha/year; slope steepness of 16 – 25%). Unlike generally predicted cases where steeper slopes should increase the soil loss, a study argues that steeper slopes can have equal or less common landslides due to differences in soil thickness (Prancevic *et al.,* 2020). According to the said study, the stability of soils is maintained through cohesive forces from plant roots and mineral cohesion, and steeper slopes are associated with thinner soil, hence thinner soils are more securely anchored. After reaching their peak erosion at approximately 30$^{o}$ hillslopes, the erosion rapidly decreases for steeper slopes. This may explain a similar phenomenon found in the study areas considering the soil sampling spot in Cisuren is indeed on a steeper hill compared to the spots in the other three locations.

It is also noteworthy that Cisuren has the highest organic matter content and the lowest Shannon diversity index. This finding contradicts an existing study that found that soil organic matter content is positively correlated with vegetation diversity (Yan *et al.,* 2023). However, another study argues that the vegetation diversity is not determined by the quantity of organic matter, but rather by the quality of organic matter (Spohn *et al.,* 2023). The assessment of organic matter quality in the study area remains uncertain as it has not undergone analysis, though this remains a potential consideration for future studies. A multi-temporal study in Hainan Island, China, states that after 7 years difference, the soil organic matter increases while the plant species diversity decreases (Yaseen *et al.,* 2022). In the present study, coffee plant (*Coffea* sp.) has the highest importance value in all study areas, and the differences between them and the species with the second highest importance value are significant. An exception is found in Cisuren where the importance value of pine trees (*Pinus merkusii*) is almost as high as the value of coffee plants with 149.866 for pine trees and 144.782 for coffee plants. Pine trees are recognized for their efficacy in erosion control because of their high interception and thick litter (Rosmaeni *et al.,* 2022). The mentioned study found that an increase in pine trees canopy coverage would decrease the soil erosion rate, even on slope with more than 40% steepness. However, pine litter is known to have allelopathy that inhibit the understory growth of the forest (Retnoningrum & Setiawan, 2021), which may explain the low Shannon diversity index in Cisuren. Furthermore, Cisuren seems to be the most undisturbed coffee agroforestry land compared to other locations. We suggest that land with low disturbance has higher organic matter and can provide greater benefits in soil erosion control.

Soil organic matter content may have a more significant impact on soil erosion compared to vegetation diversity considering organic matter acts as a binding agent in soil, helping to create stable soil aggregates. These aggregates enhance soil structure, reducing soil erosion and improving water infiltration and retention (Bronick & Lal, 2005). The ideal soil physical properties to decrease erosion include a dense layer of vegetation cover, a consistent soil structure with stable aggregates, a high level of soil organic matter, and a well-drained soil with good permeability (Zhu *et al.,* 2022). In degraded lands where soil structure may have deteriorated due to erosion or compaction, increasing organic matter content can help rebuild soil structure.

The Shannon diversity index values in all study areas are less than one (Table 2). Usually, a diversity index value ranges from 1.5 to 3.5 (Ortiz-Burgos, 2016) in a regular forest condition. Considering the study areas are coffee agroforestry areas, the low values are likely due to low species evenness as all sampling locations are dominated by coffee. The diversity of vegetation plays a significant role in maintaining soil quality and health (Shen *et al.,* 2022). A mix of species creates a diverse root structure, improving soil structure and water retention, reducing erosion, and increasing nutrient cycling (Liu *et al.,* 2015). Different plant species also deposit varying amounts of organic matter, increasing soil fertility and microbial diversity (Furey & Tilman, 2021). The lowest organic matter content is found in Cibulao, which is also the only coffee agroforestry that incorporates *Coffea robusta*, while the others incorporate *Coffea arabica*. Cibulao also has the highest Shannon diversity index of 0.586, with the second most important species is *Musa paradisiaca* or banana tree. Banana trees have less litter compared to pine trees, which may explain the reason behind the low organic matter content despite having the highest Shannon diversity index.

## 4. Conclusion

This study examined four hamlets that practice coffee agroforestry in the upstream of Ciliwung Watershed to analyze the effectiveness of coffee agroforestry for soil erosion control. The findings of this study suggest that the implemented coffee agroforestry systems in the study areas manage to keep the soil erosion rates below the tolerated thresholds, indicating a positive impact on soil conservation in the study areas.

The study emphasizes that there are complicated dynamics of soil erosion within the coffee agroforestry system. It is evident that the soil erosion rate is not solely dependent on individual factors, such as soil properties or vegetation cover, but rather on the combination of these elements. The area that has the lowest soil erosion rate is Cisuren, a sample with high slope steepness, highest organic matter content, and lowest Shannon diversity index. Suggestion was that the primary determinant of soil erosion rate is not vegetation diversity; rather, it could be the specific species of vegetation and their characteristics that may significantly influence soil organic matter content, playing a more substantial role in the erosion process.

Overall, these findings contribute valuable insights to the sustainable land management practices in the studied watershed, offering a foundation for further research and the development of targeted strategies aimed at enhancing the resilience of agricultural landscapes against soil erosion in similar geographical contexts.

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Penelitian Fundamental - Reguler

# PERENCANAAN LANSKAP AGROFORESTRI BERBASIS KOPI UNTUK PENGELOLAAN DAS CILIWUNG HULU BERKELANJUTAN

Lokasi Kegiatan: Kabupaten Bogor, Jawa Barat


Rini Fitri / 0110087903

Nur Intan  Simangunsong / 0310026805

Herika / 0306058203

Dibyanti Danniswari / 3902



**UNIVERSITAS TRISAKTI**

**2023**

## ❖Latar Belakang

- Degradasi lahan di DAS Ciliwung Hulu yang terjadi akibat perubahan penggunaan lahan, mengakibatkan menurunnya kualitas kesuburan tanah dan tanah akan mudah tererosi dan siklus nutrisi yang berjalan cepat pada ekosistem hutan.

## ❖Tujuan

1) Menyusun struktur spasial dan tipe lanskap agroforestri DAS Ciliwung Hulu.
2) Merencanakan lanskap agroforestri kopi berkelanjutan.

## ❖Kebaruan penelitian

- Sebaran lanskap agroforestri berbasis kopi dapat menjadi model konservasi dalam pengelolaan DAS Ciliwung Hulu berkelanjutan

# LUARAN DALAM BENTUK PUBLIKASI
# (ARTIKEL)

- **Luaran wajib** publikasi artikel pada *Jurnal Rural Landscape* (terindeks scopus) **"Coffee Agroforestry for Degraded Land Rehabilitation in Upper Ciliwung Watershed, West Java, Indonesia"**. Artikel telah tersubmit dan sedang menunggu balasan dari penerbit.
- **Luaran tambahan** telah mengikuti seminar internasional di Banda Aceh "5th International Conference on Agricultural Technology, Engineering, and Environmental Sciences" yang dilaksanakan oleh Department of Agricultural Technology Universitas Syiah Kuala pada tanggal 20 September 2023. "Mapping the Distribution of Coffee Agroforestry in the Upper Ciliwung Watershed, West Java, Indonesia". Kertercapaian luaran tambahan status artikel saat ini (Accepted) Under consideration for publication pada IOP Publising, rencana akan terbit pada bulan Desember 2023
- **Kesimpulan** : Data ilmiah yang diperoleh digunakan untuk menyusun secara spasial sebaran lanskap agroforestri berbasis kopi dapat menjadi model konservasi dalam pengelolaan  DAS Ciliwung Hulu berkelanjutan.
- **Saran** : Penelitian Fundamental diharapkan dapat menjadi landasan pengembangan Ilmu bagi TIM peneliti pengusul dalam mengembangkan penelitian menjadi lebih mendalam dan bervariasi.
- **Rekomendasi** : Sebagai informasi bagi masyarakat, swasta dan pemerintah dalam pengelolaan di DAS Ciliwung Hulu sehingga perencanaan lanskap agroforestri berbasis kopi dapat menjadi alternatif dalam mengatasi permasalahan di kawasan DAS Ciliwung Hulu.

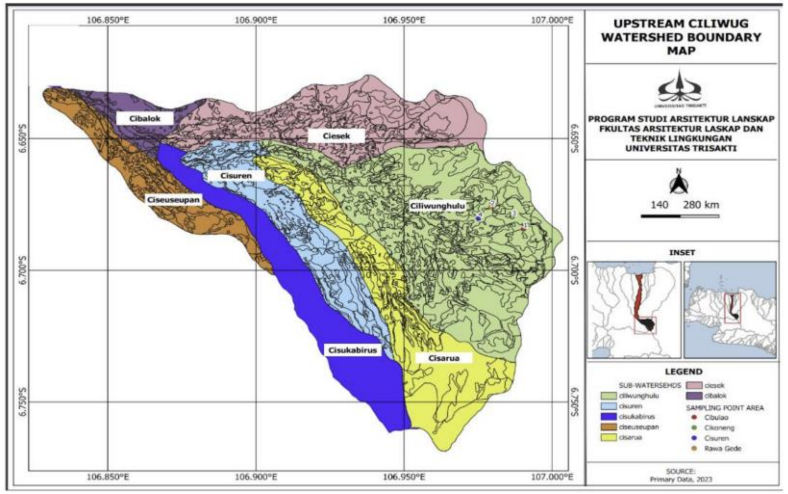
# METODE DAN HASIL UTAMA PENELITIAN

- ❖Penelitian ini menggunakan pendekatan kualitatif dengan metode deskriptif.
- ❖Tahapan penelitian tahun pertama berupa pengumpulan data biofisik, ekonomi dan sosial budaya. Interpretasi citra satelit dan *ground chek* lapang terhadap agroforestri kopi di wilayah studi.
- ❖Analisis data menggunakan metode deskriptif kualitatif.
- ❖Hasil Utama penelitian digunakan :

1. Untuk mendeskripsikan informasi yang diperoleh mengenai agroforestri kopi dari observasi lapangan.
2. Sebagai bahan analisis dalam perencanaan lanskap agroforestri berbasis kopi di DAS Ciliwung Hulu.

- Foto-foto aktivitas penelitian.

- Foto hasil-hasil penelitian.



**SURAT PERNYATAAN TANGGUNG JAWAB BELANJA**

Yang bertanda tangan di bawah ini :

Nama : Dr. RINI FITRI S.P, M.Si
Alamat : Jln.Langgar Gg H.Ami No 129

berdasarkan Surat Keputusan Nomor 265/USAKTI/SKR/IV/2022 dan Perjanjian / Kontrak Nomor 706/A/LPPM/USAKTI/VII/2023 mendapatkan Anggaran Penelitian Perencanaan lanskap agroforestri berbasis kopi untuk pengelolaan DAS Ciliwung Hulu berkelanjutan Sebesar 85,100,000

Dengan ini menyatakan bahwa :

1. Biaya kegiatan Penelitian di bawah ini meliputi :

| No | Uraian | Jumlah |
|---|---|---|
| 01 | **Bahan**<br>ATK | 812,540 |
| 02 | **Pengumpulan Data**<br>Narasumber 1 FGD persiapan penelitian (OJ) Narasumber 2 FGD persiapan penelitian (OJ) Honor Petugas Lapangan 1 (OH) 15 hari Honor Petugas Lapangan 2 (OH) 15 hari Honor Petugas Lapangan 3 (OH) 15 hari Honor Petugas Lapangan 4 (OH) 15 hari Honor Petugas Lapangan 5 (OH) 15 hari Honor Pembantu Peneliti 1 (OJ) 3 jam x 20 hari Honor Pembantu Peneliti 2(OJ)3 jam x 20 hari Honor sekretariat/Administrasi Peneliti 2 bulan Survey awal Rini Fitri 5 lokasi Survey awal Nur Intan 5 lokasi Survey awal Herika 5 lokasi Survey awal Dibyanti 5 lokasi Ground truth check Rini Fitri 5 lokasi Ground truth check Nur Intan 5 lokasi Ground truth check Herika 5 lokasi Ground truth check Dibyanti 5 lokasi Pengamatan, pengukuran jenis agroforestri Rini Pengamatan, pengukuran jenis agroforestri Nur Intan Pengamatan, pengukuran jenis agroforestri Herika Pengamatan, pengukuran jenis agroforestri Dibyanti | 29,400,000 |
| 03 | **Analisis Data(Termasuk Sewa Peralatan**<br>Analisis Data (Termasuk Sewa Peralatan) ANALISIS SAMPEL Peta Batas Sub DAS Peta Batas DAS Peta Topografi Peta Kemiringan Lereng Peta iklim Peta curah hujan Peta geologi Peta geomorfologi Peta jenis tanah Peta klasifikasi tanah Analisis Sifat Kimia Tanah (Lengkap) Analisis Sifat Fisika Tanah (Lengkap) Honor pengolah data Rini Honor pengolah data Nur Intan Honor pengolah data Herika Honor pengolah data Dibyanti Sewa laboratorium GIS dan perencanaan 10 hari Sewa peralatan survei 10 hari Sewa mobil Survey awal di Cikoneng Sewa mobil Survey awal Rawa Gede Sewa mobil Survey awal Cibulao Sewa mobil Survey awal Cisuren Sewa mobil Survey awal Ciliwung Hulu Sewa mobil Ground truth check di Cikoneng Sewa mobil Ground truth check di Rawa Gede Sewa mobil | 29,357,460 |

| | | |
|---|---|---|
| | Ground truth check di Cibulao Sewa mobil Ground truth check di Cisuren Sewa mobil Ground truth check di Ciliwung Hulu Sewa mobil pengukuran jenis agroforestri Cikoneng Sewa mobil pengukuran jenis agroforestri Rw Gede Sewa mobil pengukuran jenis agroforestri Cibulao Sewa mobil pengukuran jenis agroforestri Cisuren Sewa mobil pengukuran jenis agroforestri Ciliwung Hulu | |
| 04 | **Pelaporan, Luaran Wajib dan Luaran Tambahan** Pelaporan, Luaran Wajib dan Luaran Tambahan Luaran Wajib Jurnal Internasional bereputasi Luaran Tambahan Internasional seminar di Universitas Syiah Kuala | 25,530,000 |
| 05 | **Lain-lain** | 0 |
| | Jumlah | 85,100,000 |

2. Jumlah uang tersebut pada angka 1, benar-benar dikeluarkan untuk pelaksanaan kegiatan Penelitian dimaksud.

Demikian surat pernyataan ini dibuat dengan sebenarnya.

, 04-12-2023

Ketua,

(Dr. RINI FITRI S.P, M.Si)

NIP/NIK KTP 1111024706790002