THESIS

DEVELOPMENT OF A FUZZY-BASED DECISION SUPPORT SYSTEM FOR ENERGY CONTROL IN SOLAR-POWERED DRIP IRRIGATION

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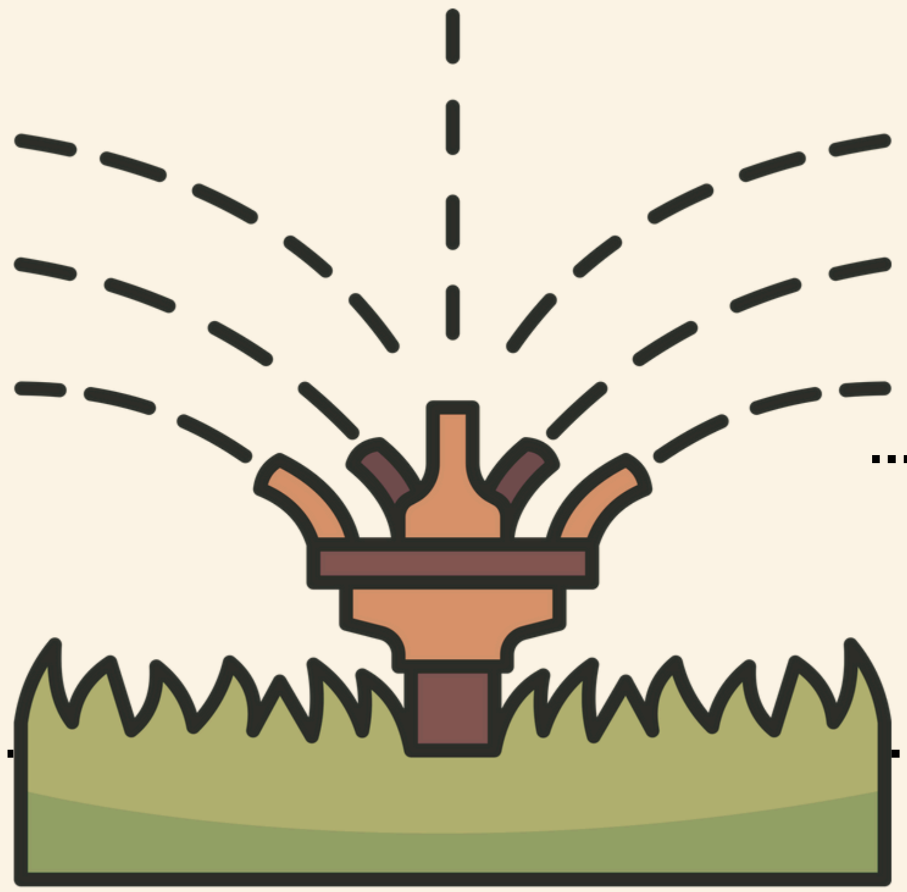


Introduction

BACKGROUND

Dryland agriculture in Indonesia has great potential with 76 million hectares of land, but it faces challenges such as low rainfall and land degradation, making proper water management essential.

West Nusa Tenggara (NTB), with an area of 1,953,275 hectares, has 1,716,944 hectares of dryland, while Lombok has 110,780 hectares of rocky dryland. The main challenges are limited water availability and uneven rainfall.

Data Collection Location: Amor-Amor Hamlet, Gumantar Village, North Lombok.

- Dryland Area: 328 hectares.
- Average Air Temperature: 29°C (hot).
- Average Rainfall: 11.02 mm (low).
- Average Air Humidity: 80% (moderate).

Proper irrigation management is needed to ensure agricultural productivity is maintained."

BACKGROUND

A solar-powered sensor-based automatic irrigation system efficiently regulates water supply for crops in dry areas, reducing waste and supporting agricultural sustainability

A fuzzy logic-based DSS manages environmental data uncertainties and provides flexible irrigation recommendations

A fuzzy logic web application optimizes drip irrigation for sustainable agriculture

Improving water and energy management efficiency.

Enabling adaptive management to weather and environmental changes

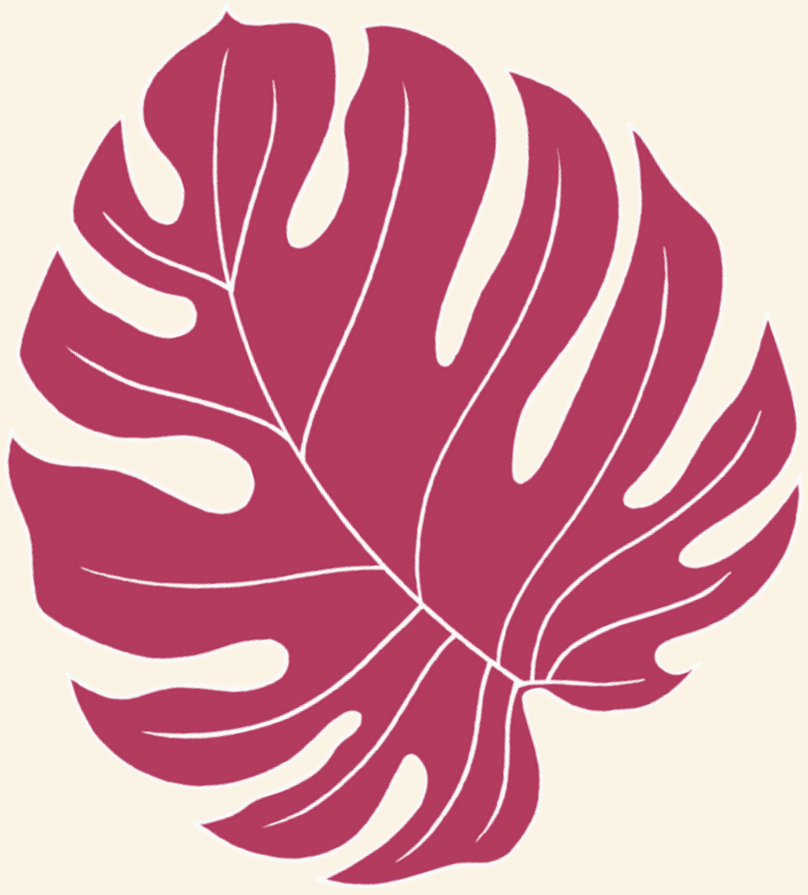
Supporting sustainable agriculture through a solar-powered smart irrigation system

PROBLEMS IDENTIFICATION

How to develop an effective Fuzzy Logic-based Decision Support System (DSS) to manage solar-powered drip irrigation in Amor-Amor Hamlet, West Nusa Tenggara to address dryland issues, control energy usage, and assist farmers in determining the optimal watering time while considering environmental factors?

PURPOSE

The purpose of this research is to develop a fuzzy logic-based Decision Support System (DSS) that can analyze watering patterns based on soil conditions (dry or wet) and environmental data. This DSS is designed to provide optimal recommendations regarding watering schedules and energy usage control in a solar-powered drip irrigation system, thereby improving the system's efficiency and effectiveness



Literature Review

RESEARCH URGENCY

The fuzzy-based Decision Support System (DSS) provides detailed, rule-based data essential for agricultural researchers

It allows for in-depth analysis of the relationship between plant conditions and soil characteristics

Unlike automated irrigation systems, DSS adapts more precisely to environmental factors

RESEARCH GAP

Previous research has focused more on optimizing water usage and irrigation system efficiency, but few have specifically integrated energy control in solar-powered drip irrigation systems

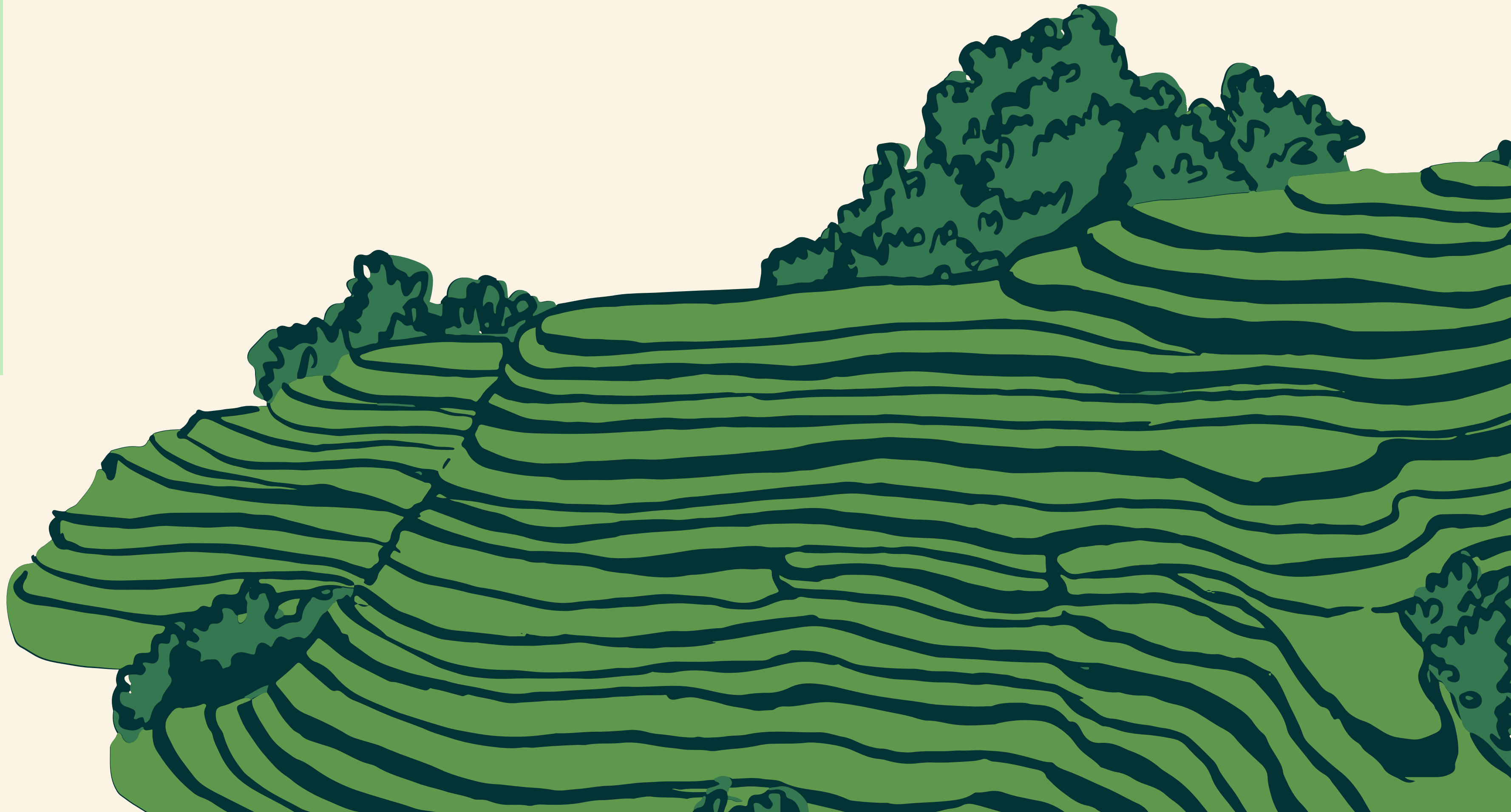
Additionally, many studies have not fully accounted for dynamic environmental variations affecting the irrigation system, such as sunlight intensity and battery conditions

RESEARCH NOVELTY

Integration of complex environmental variables like air temperature, soil humidity, sunlight intensity, and battery condition.

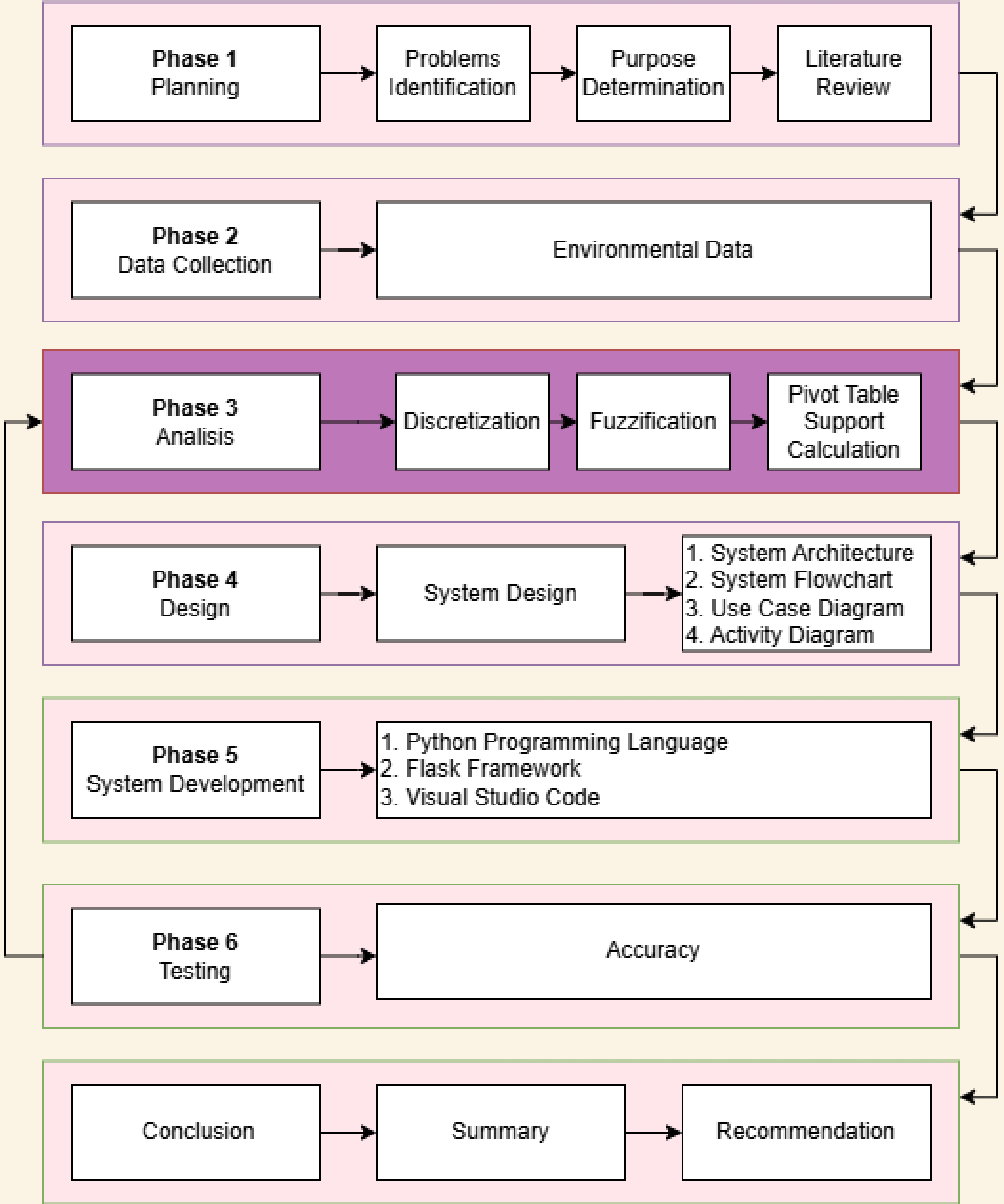
Data collected directly from Dusun Amor-Amor, a unique and previously unstudied location.

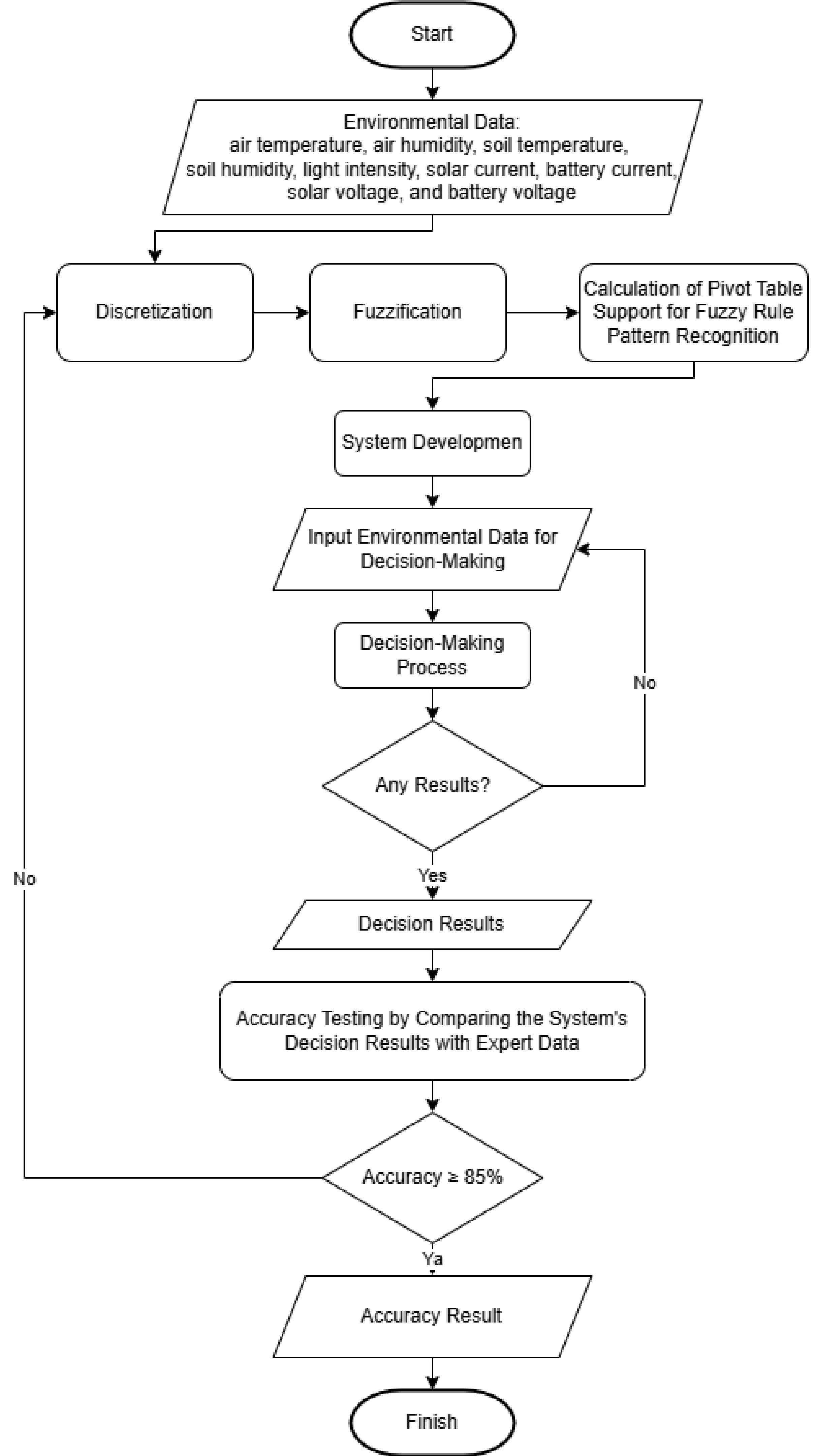
This study focuses on rule-based data analysis to assist agricultural researchers in making accurate irrigation decisions based on environmental conditions, such as the four conditions: cloudy dry, cloudy watering, sunny dry, and sunny watering.



Methodology

RESEARCH FLOW





RESEARCH PROCESS

Results and Discussion

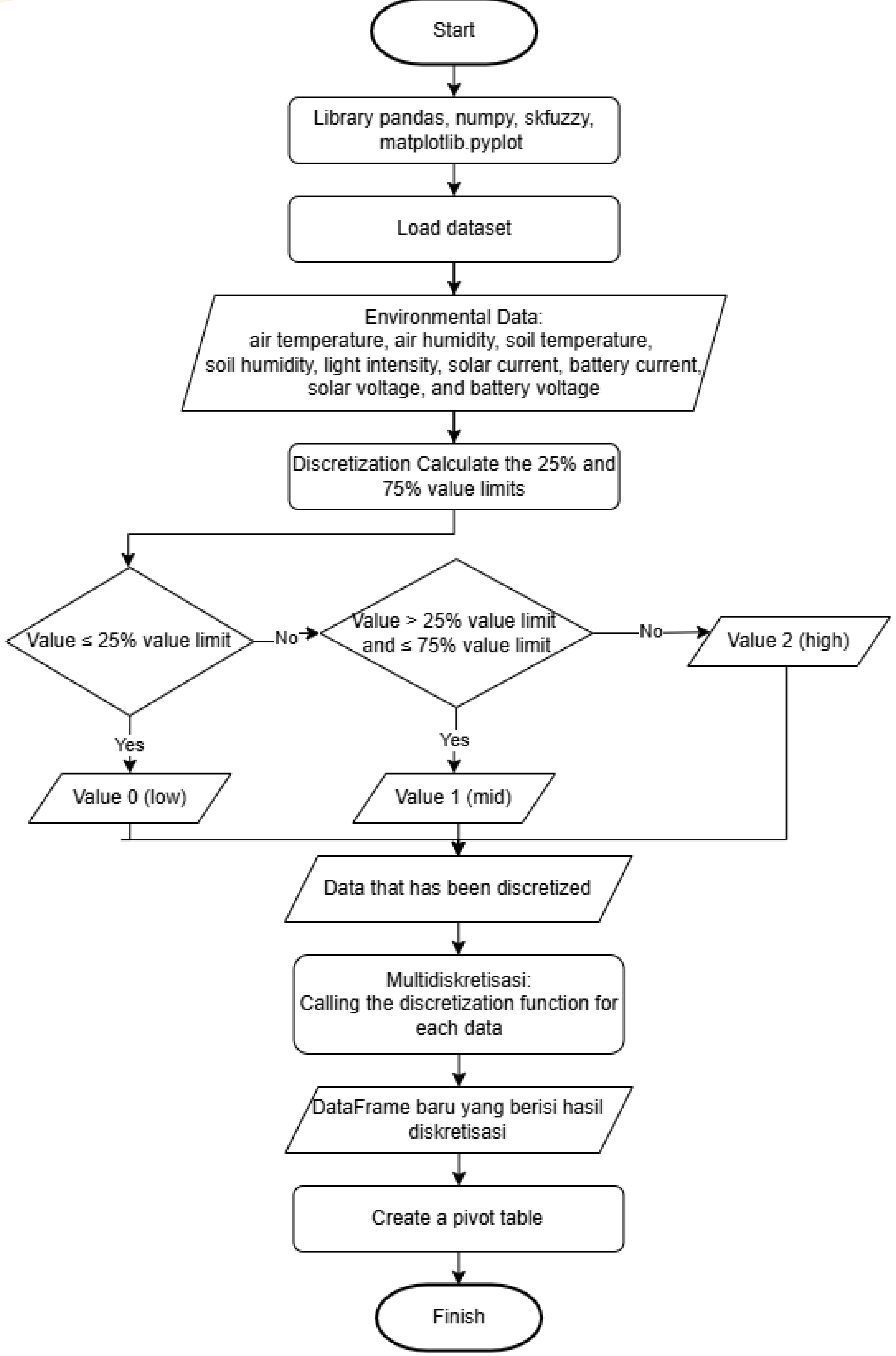
DATA

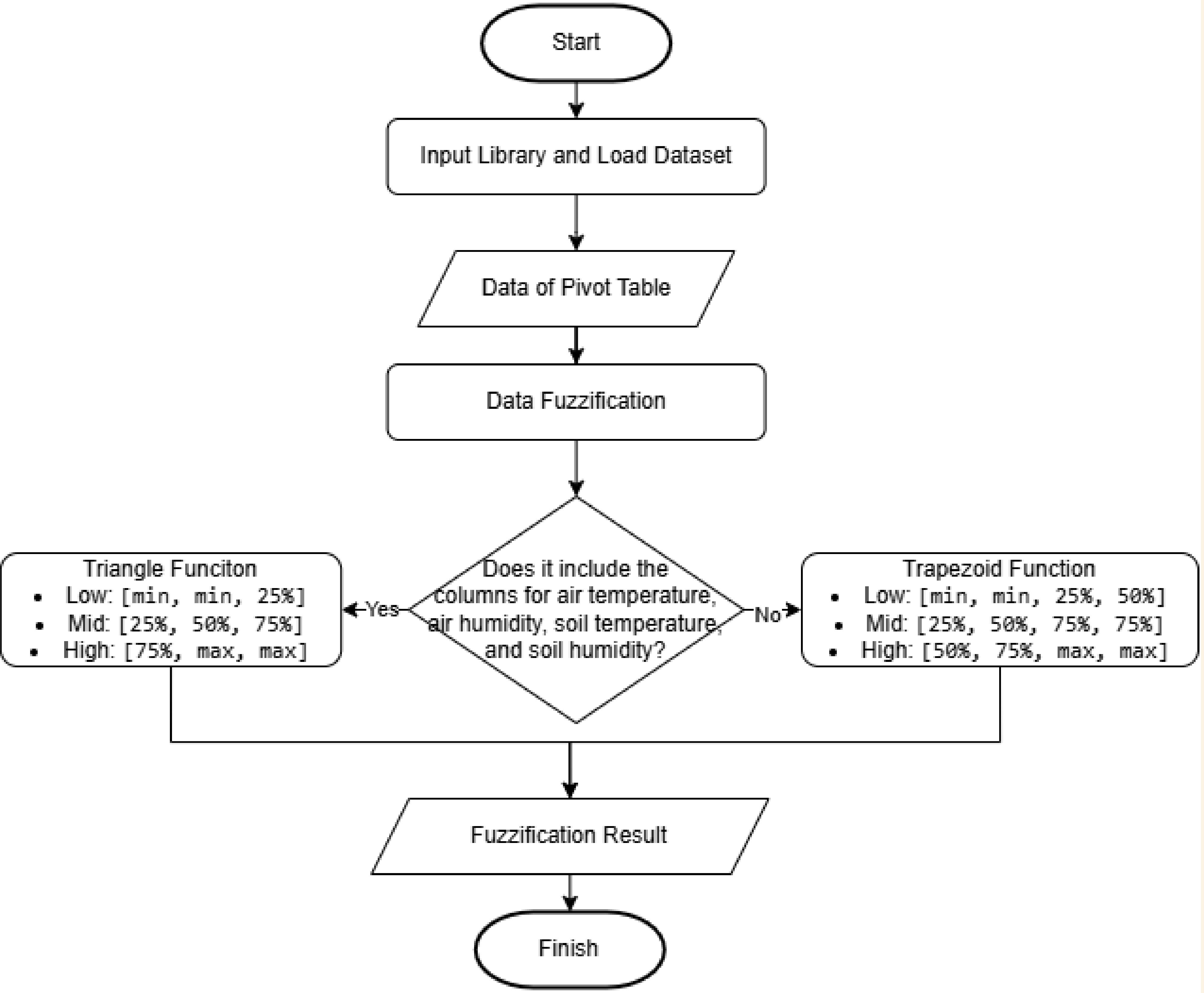
The data was collected using a drip irrigation sensor in the farmers' garden in Dusun Amor-Amor, North Lombok, over 8 months (May–December 2022). A total of 59,870 data points were collected, covering 9 variables: air temperature (SU), air humidity (KU), soil temperature (ST), soil humidity (KT), light intensity (C), solar current (AS), battery current (AA), solar voltage (TS), and battery voltage (TA).

No	SU	KU	ST	KT	C	AS	AA	TS	TA	Status
1	28.38	60	39.42	189	15204	0.233	0.167	104.61	100.22	mendung siram
2	28.79	63	33.11	190	15575	0.237	0.134	107.57	103.02	mendung siram
3	27.04	56	31.02	143	14053	0.228	0.001	10.167	9.22	mendung kering
4	27.75	64	34.53	139	14486	0.24	0.001	10.249	9.374	mendung kering
5	32.14	60	34.14	203	48762	0.399	0.171	12.39	11.023	cerah siram
6	31.75	55	33.32	199	62241	0.457	0.176	11.797	10.315	cerah siram
...	...	...	...	...	...	...	...	...	...	...
59869	32.16	52	33.14	178	49432	0.394	0.006	11.575	11.238	cerah kering
59870	32.23	52	34.23	190	52777	0.451	0.01	11.361	10.577	cerah kering

DISCRETIZATION

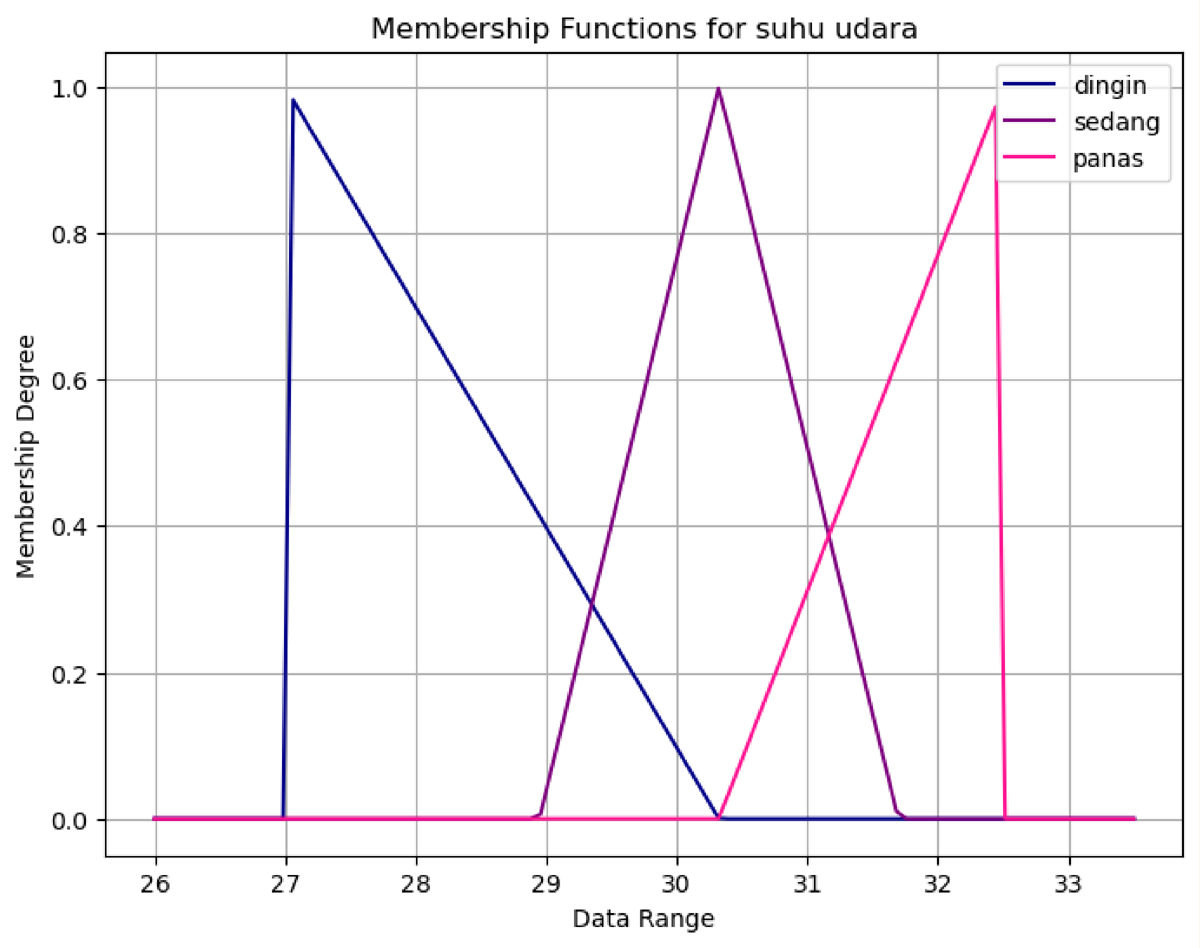
No	SU	KU	ST	KT	C	AS	AA	TS	TA	Status
0	0	1	2	1	0	0	2	2	2	cloudy watering
1	1	2	1	1	0	0	1	2	2	cloudy watering
2	0	2	1	1	1	1	2	2	2	cloudy watering
3	0	2	0	1	0	0	2	2	2	cloudy watering
4	0	2	1	1	0	0	1	2	2	cloudy watering
...	...	...	...	...	...	...	...	...	...	...
59865	1	0	1	1	1	1	1	1	1	sunny dry
59866	1	0	1	0	1	1	0	1	1	sunny dry
59867	2	0	1	1	2	1	1	1	1	sunny dry

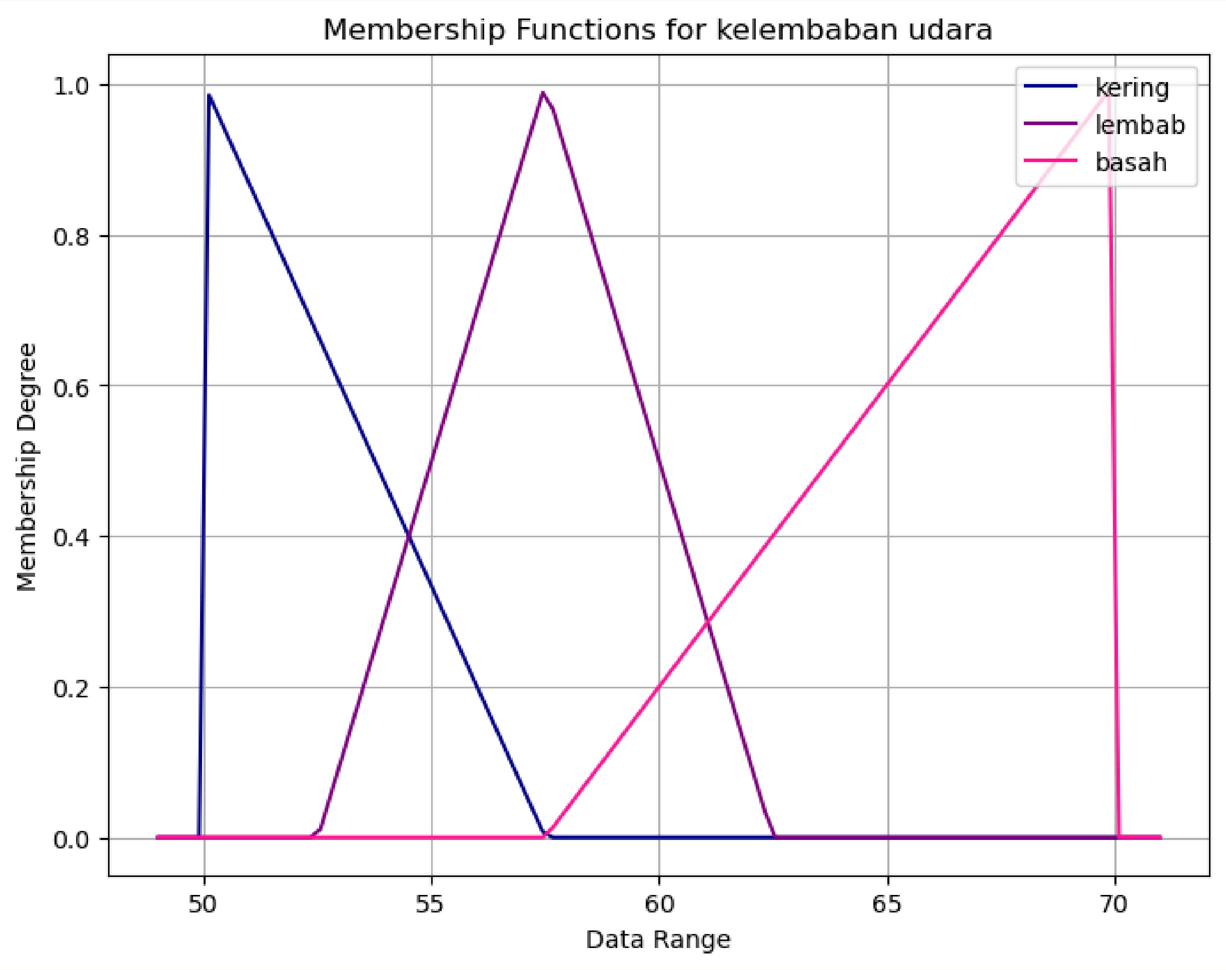


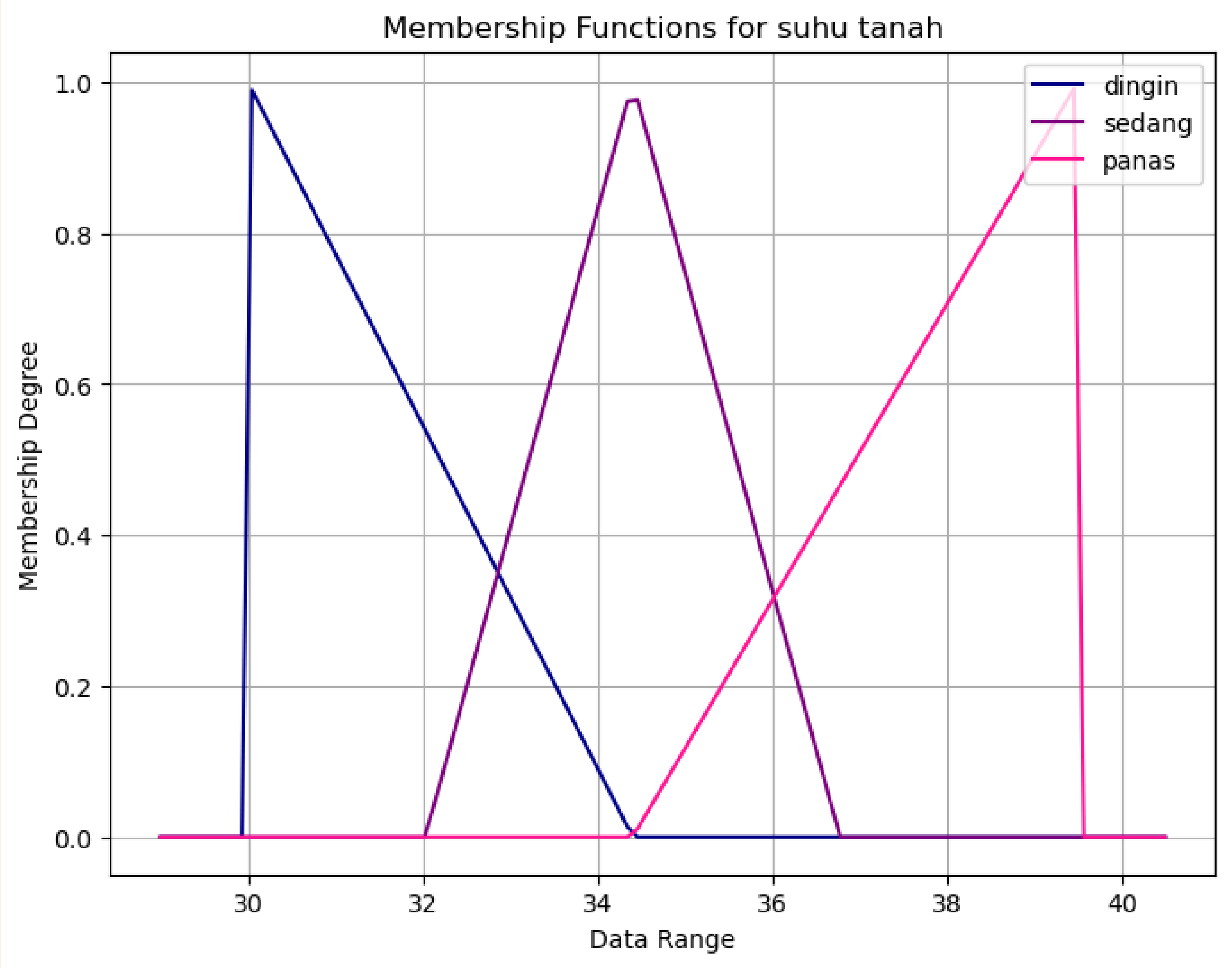


FUZZIFICATION

FUZZY MEMBERSHIP





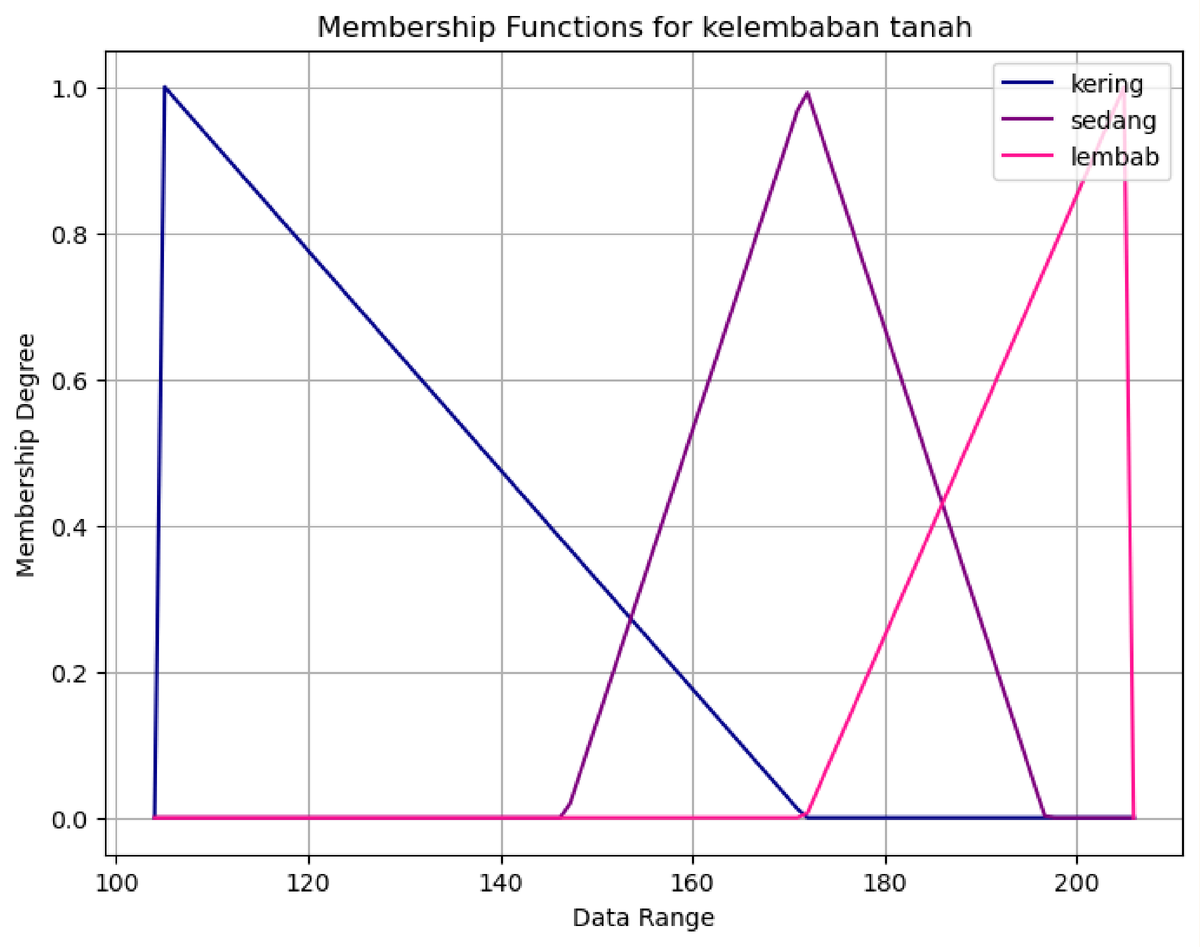


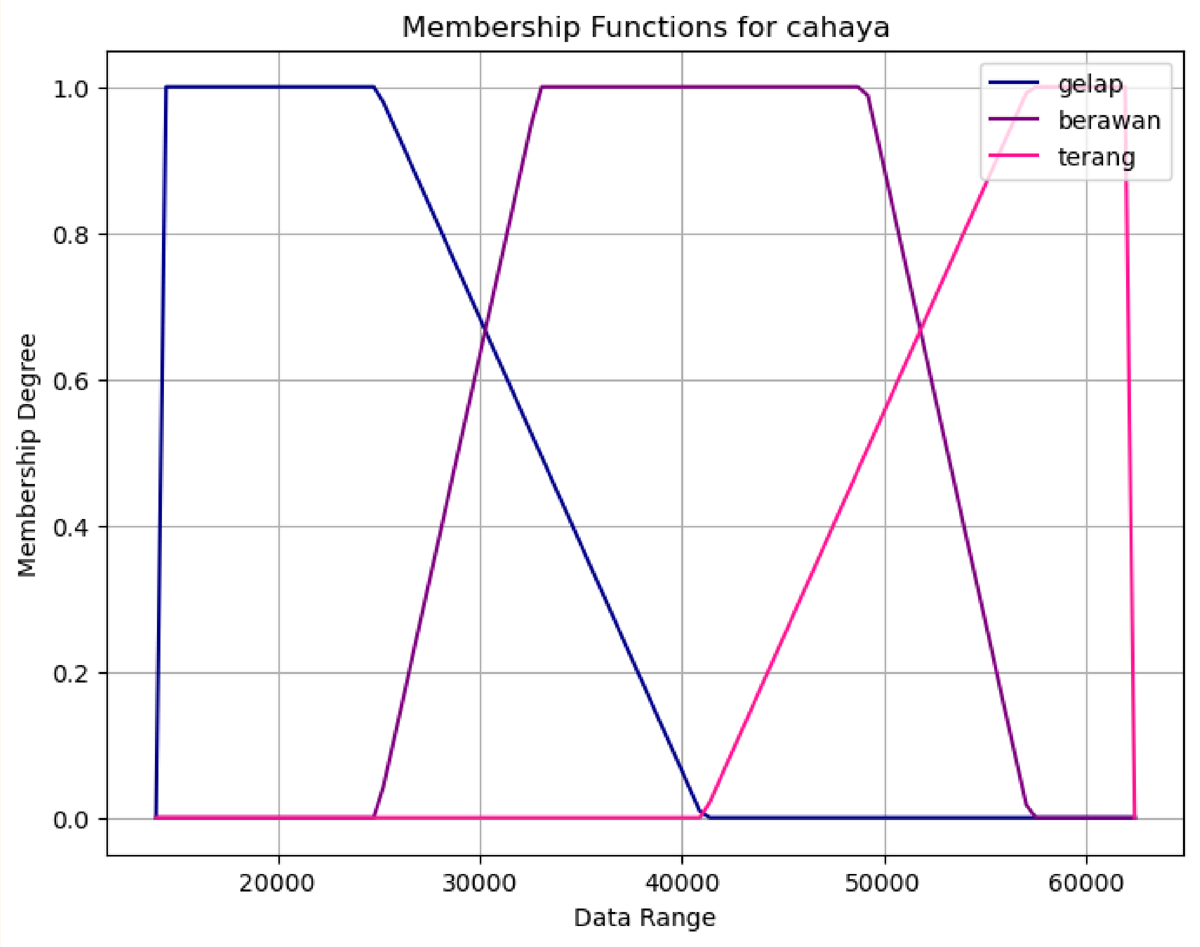
Air temperature is divided into Cold (27.0 °C - 30.3 °C), Moderate (28.7 °C - 31.4 °C), and Hot (30.3 °C - 32.5 °C)

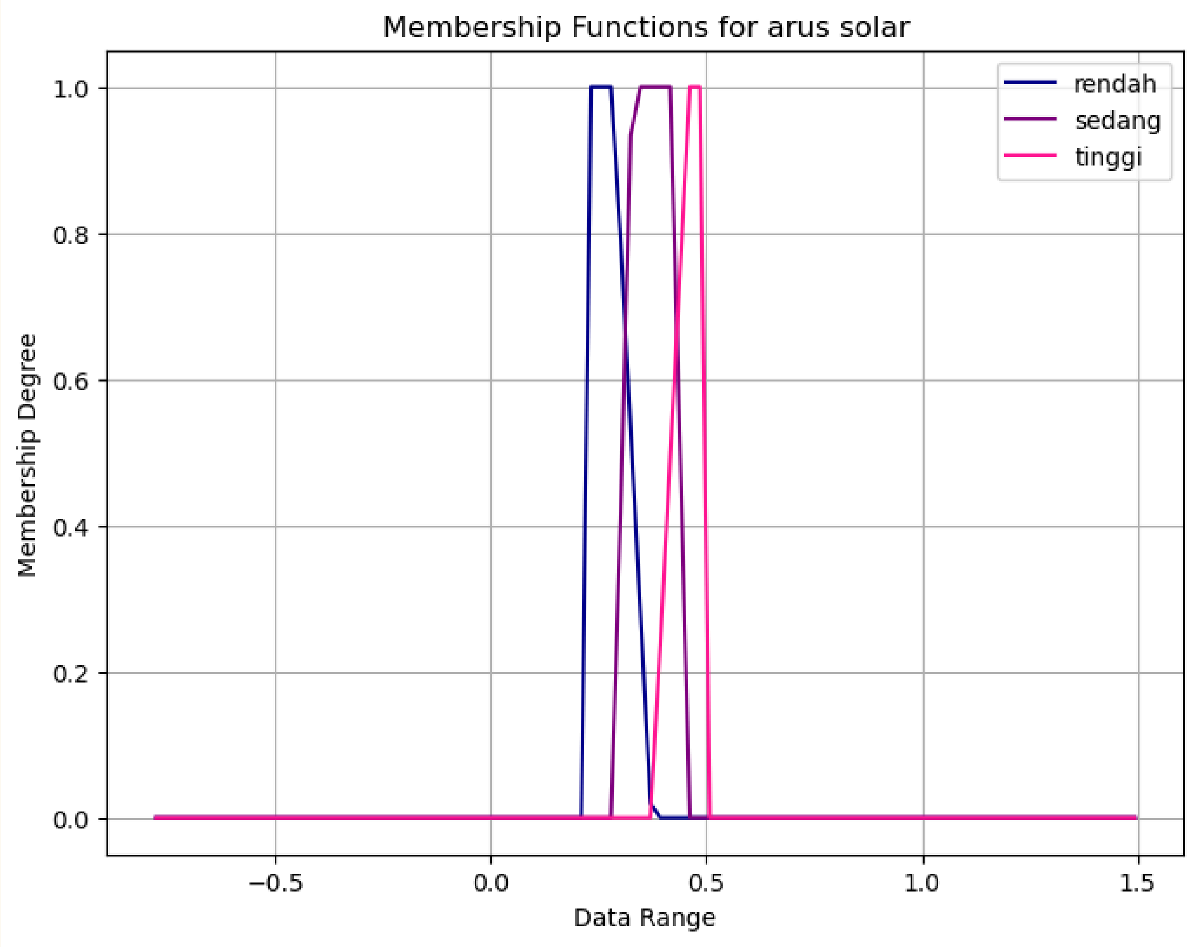
Air humidity consists of Dry (50.0% - 57.5%), Humid (53.8% - 63.8%), and Wet (57.5% - 70.0%)

Soil temperature is divided into Cold (30.0 °C - 34.4 °C), Moderate (32.2 °C - 37.0 °C), and Hot (34.4 °C - 39.5 °C)

FUZZY MEMBERSHIP





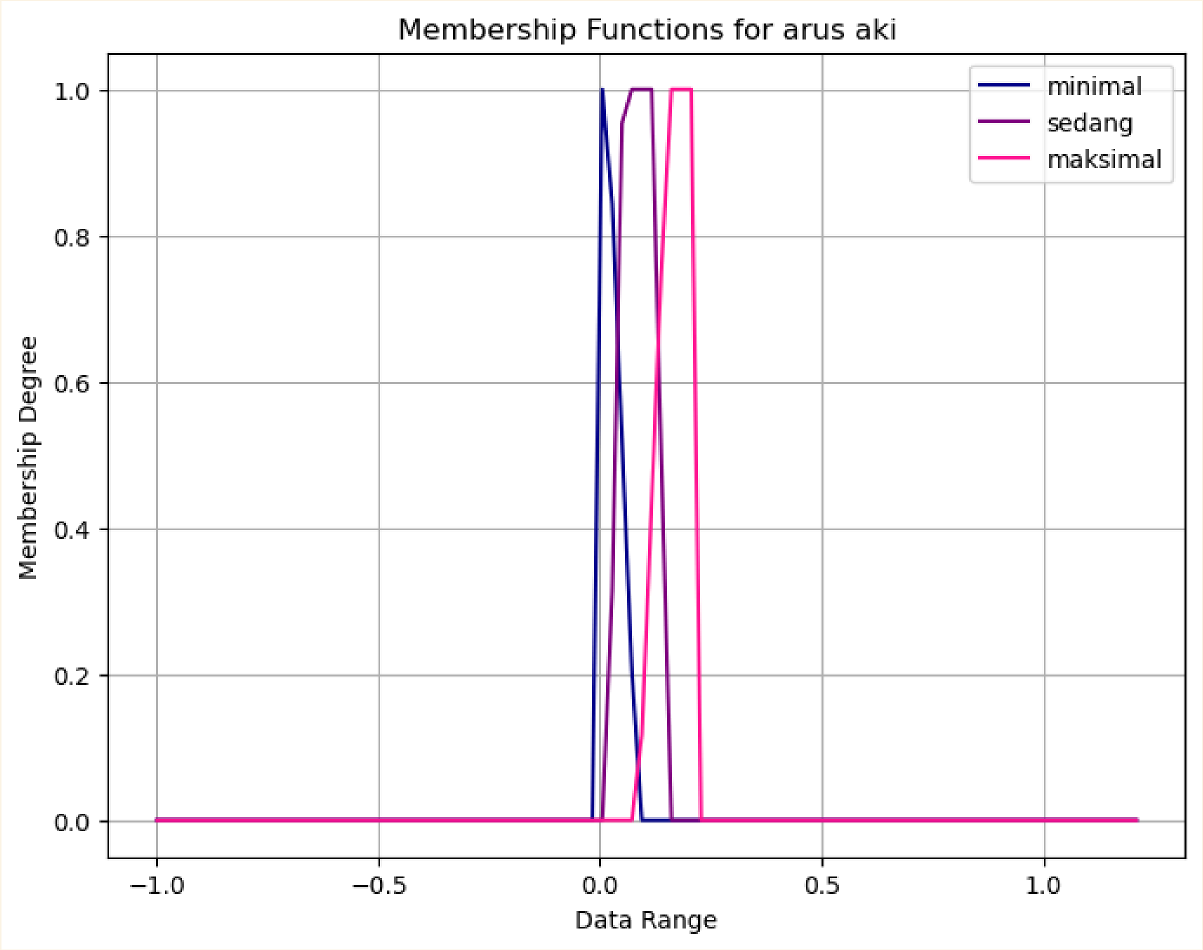


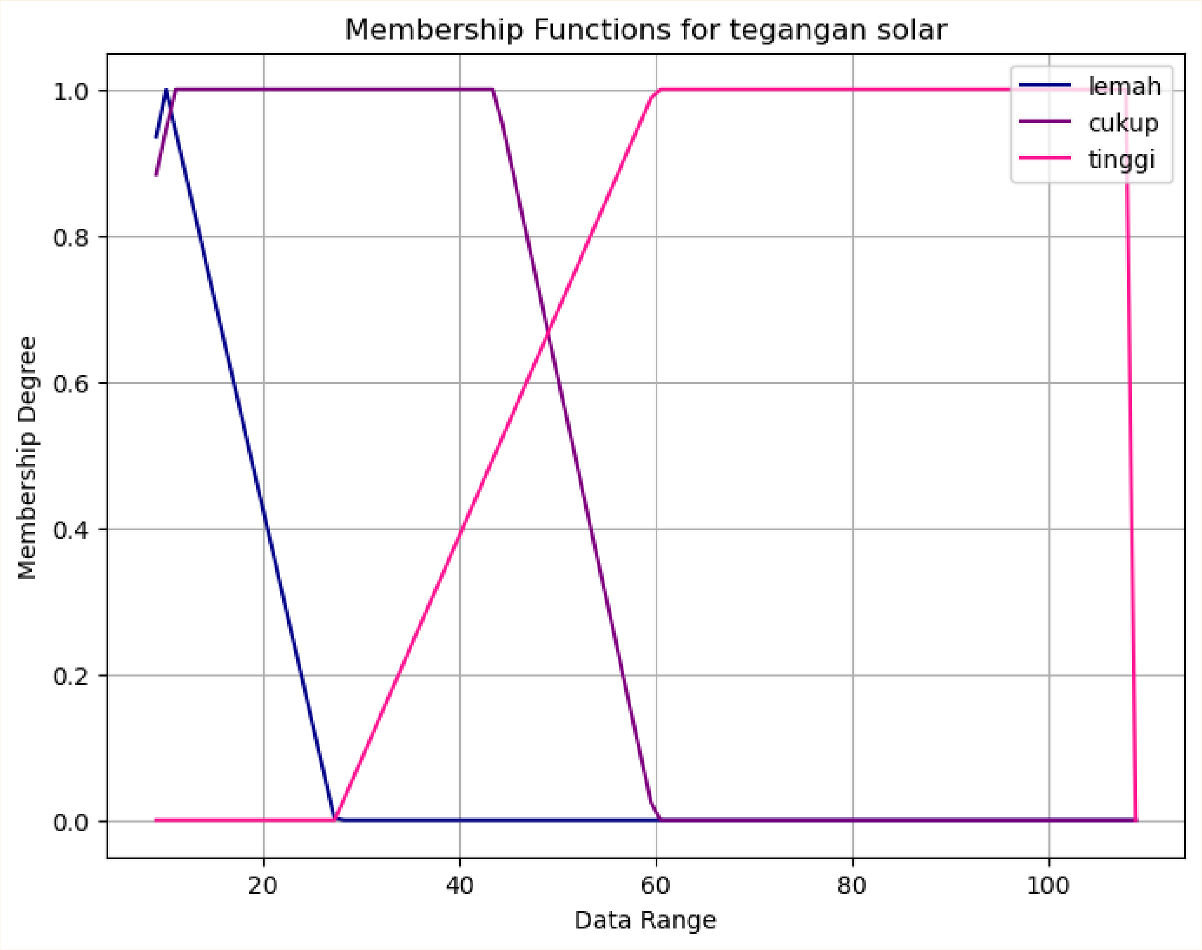
Soil humidity includes Dry (105.0% - 171.8%), Moderate (138.4% - 188.4%), and Wet (171.8% - 205.0%)

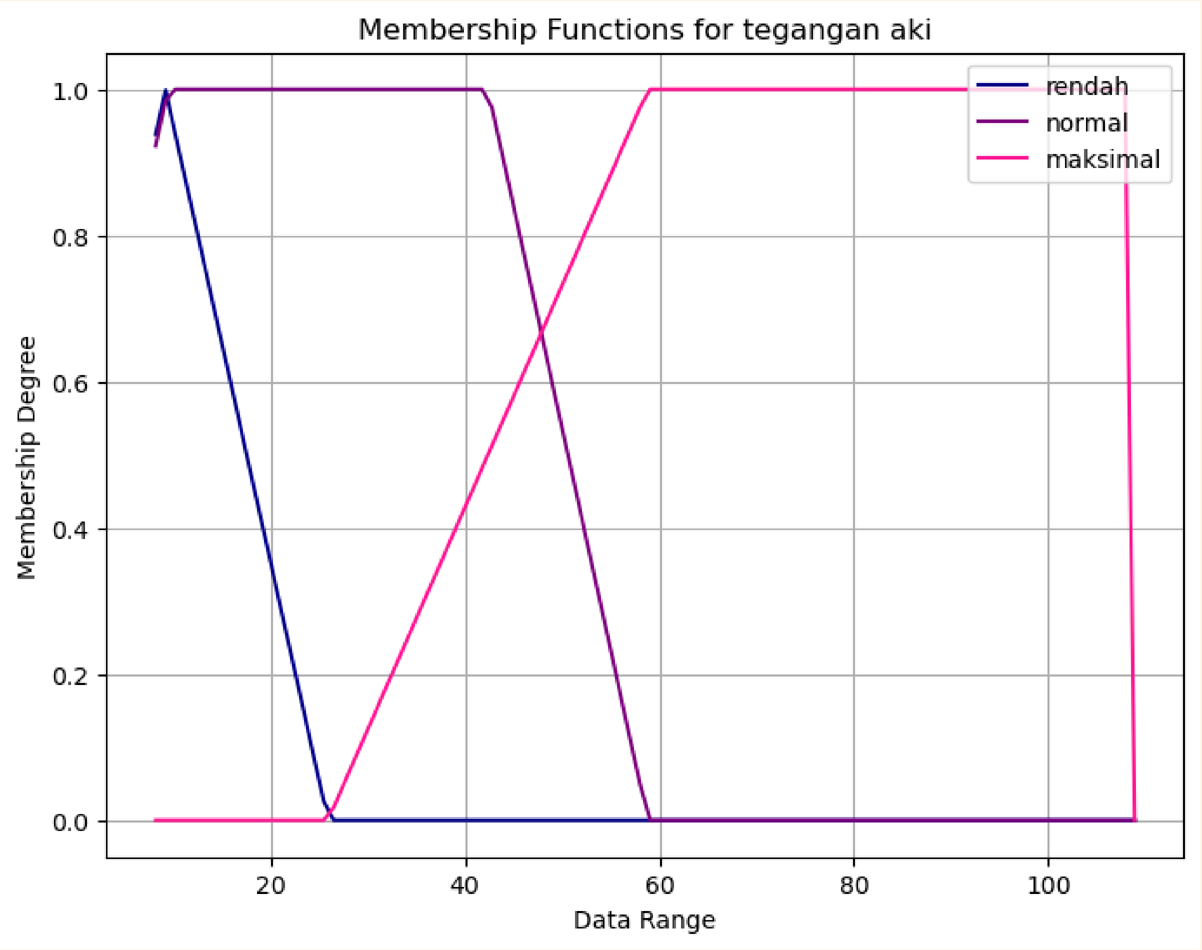
Light intensity consists of Dark (13987.0 Lux - 41046.8 Lux), Cloudy (27516.9 Lux - 57380.9 Lux), and Bright (41046.8 Lux - 62431.0 Lux)

Solar current is divided into Low (0.2 A - 0.4 A), Moderate (0.3 A - 0.48 A), and High (0.4 A - 0.5 A)

FUZZY MEMBERSHIP







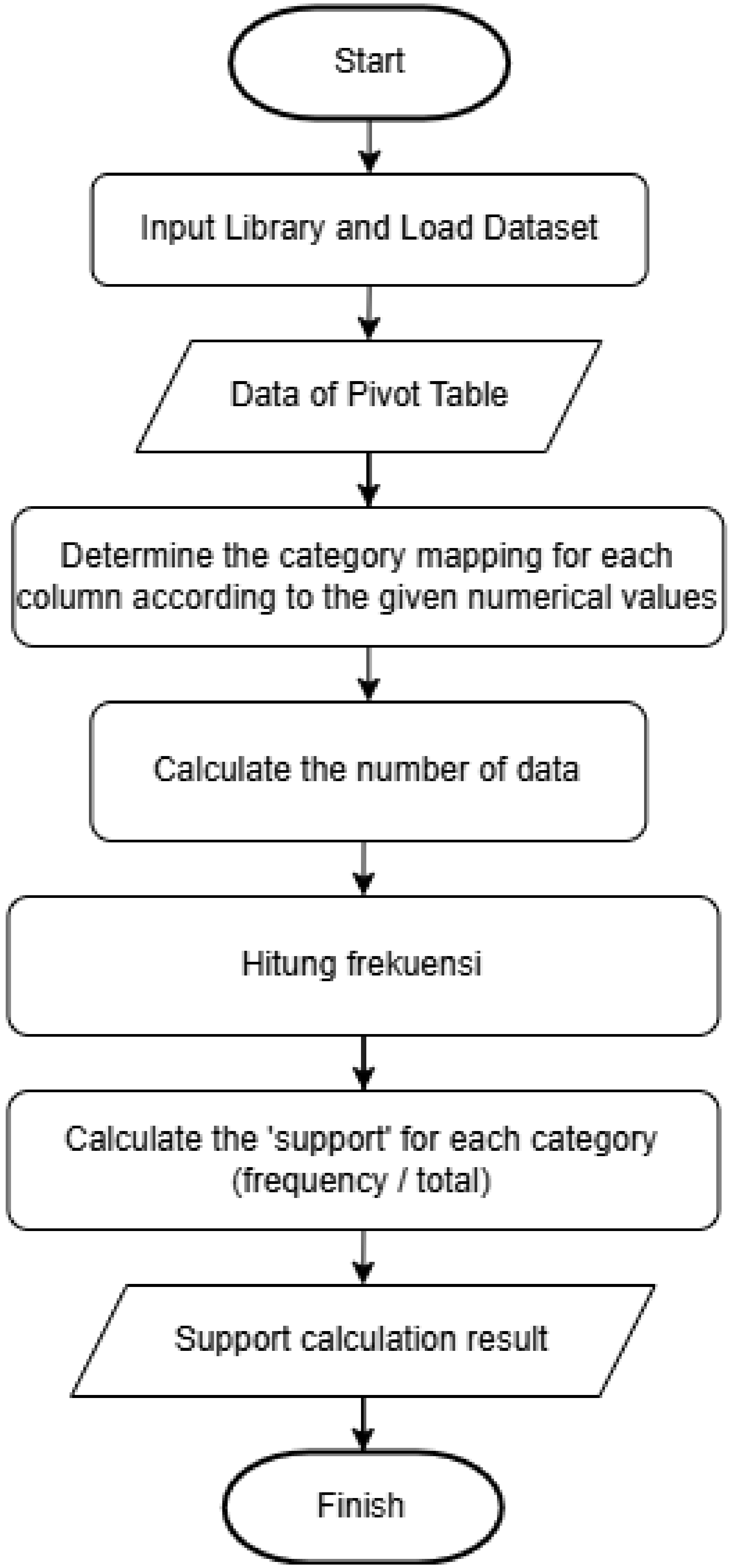
Battery current is divided into Minimal (0.0 A - 0.1 A), Moderate (0.0 A - 0.1 A), and Maximum (0.1 A - 0.2 A)

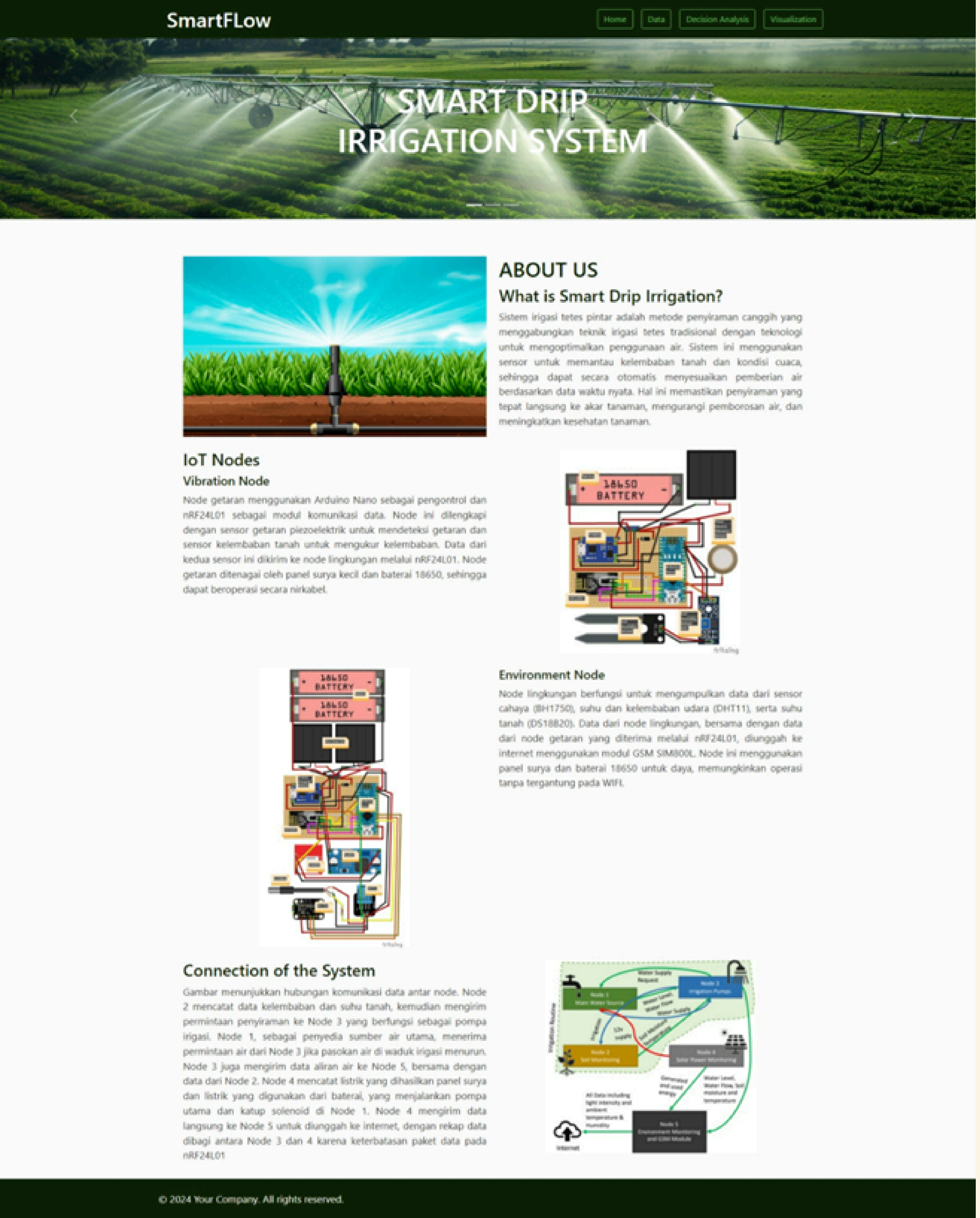
Solar voltage is divided into Weak (10.1 V - 27.3 V), Sufficient (18.7 V - 67.6 V), and High (27.3 V - 107.9 V)

Battery voltage consists of Low (9.2 V - 25.9 V), Normal (17.5 V - 60.0 V), and Maximum (25.9 V - 107.9 V)

SUPPORT CALCULATION

No	SU	KU	ST	KT	C	AS	AA	TS	TA	Status	Frequency	Support
1	dingin	lembab	panas	kering	gelap	rendah	minimal	lemah	rendah	cloudy dry	887	0.015
2	dingin	lembab	sedang	kering	gelap	rendah	minimal	lemah	rendah	cloudy dry	881	0.015
3	dingin	basah	panas	kering	gelap	rendah	minimal	lemah	rendah	cloudy dry	823	0.014
4	dingin	basah	sedang	kering	gelap	rendah	minimal	lemah	rendah	cloudy dry	672	0.011
5	dingin	basah	panas	sedang	gelap	rendah	maksimal	tinggi	maksimal	cloudy watering	607	0.010





SYSTEM DEVELOPMENT

SYSTEM DEVELOPMENT

SmartFLow

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DATA OF SMART DRIP IRRIGATION SYSTEM

Unnamed: 0	suhu udara	kelembaban udara	suhu tanah	kelembaban tanah	cahaya	arus solar	arus aki	tegangan solar	tegangan aki	status
0	28.38	60	39.42	189	15204	0.233	0.167	104.610	100.220	mendung siram
1	28.79	63	33.11	190	15575	0.237	0.134	107.570	103.020	mendung siram
2	28.18	68	33.79	192	16759	0.243	0.168	104.160	97.050	mendung siram
3	28.22	62	31.01	189	15465	0.227	0.207	107.590	107.630	mendung siram
4	28.69	66	33.03	195	15353	0.226	0.127	103.070	94.290	mendung siram
5	28.98	63	38.28	192	15469	0.231	0.185	103.040	95.080	mendung siram
6	28.01	63	38.09	193	15312	0.235	0.207	105.110	107.740	mendung siram
7	29.06	69	36.17	185	16540	0.242	0.163	107.650	95.300	mendung siram
8	28.07	64	31.42	185	15242	0.242	0.201	103.030	107.220	mendung siram
9	28.50	63	38.58	191	15737	0.238	0.209	105.040	107.050	mendung siram
10	28.11	66	38.79	195	14657	0.241	0.153	103.750	100.140	mendung siram
11	29.34	60	32.97	190	14467	0.239	0.146	105.030	98.780	mendung siram
12	28.26	65	36.14	195	16170	0.241	0.151	105.420	104.690	mendung siram
13	29.19	62	32.68	190	15639	0.240	0.149	107.690	95.930	mendung siram
14	28.96	62	36.90	189	16349	0.234	0.186	104.940	98.430	mendung siram
15	28.80	69	38.50	186	15292	0.242	0.207	105.200	107.110	mendung siram
16	29.23	67	35.08	195	15506	0.230	0.148	107.350	99.400	mendung siram
17	28.10	66	32.35	193	15348	0.235	0.161	105.240	105.360	mendung siram

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DECISION MAKING SMART DRIP IRRIGATION

Input Data to Analyze

Suhu Udara:

Sedang (28.7°C - 31.4 °C)

Kelembaban Udara:

Lembab (53.8% - 63.8%)

Suhu Tanah:

Sedang (32.2°C - 37.0°C)

Kelembaban Tanah:

Sedang (138.4% - 188.4%)

Cahaya:

Berawan (27516.9 Lux - 57380.9 Lux)

Arus Solar:

Sedang (0.3 A - 0.48 A)

Arus Aki:

Sedang (0.1 A - 0.1 A)

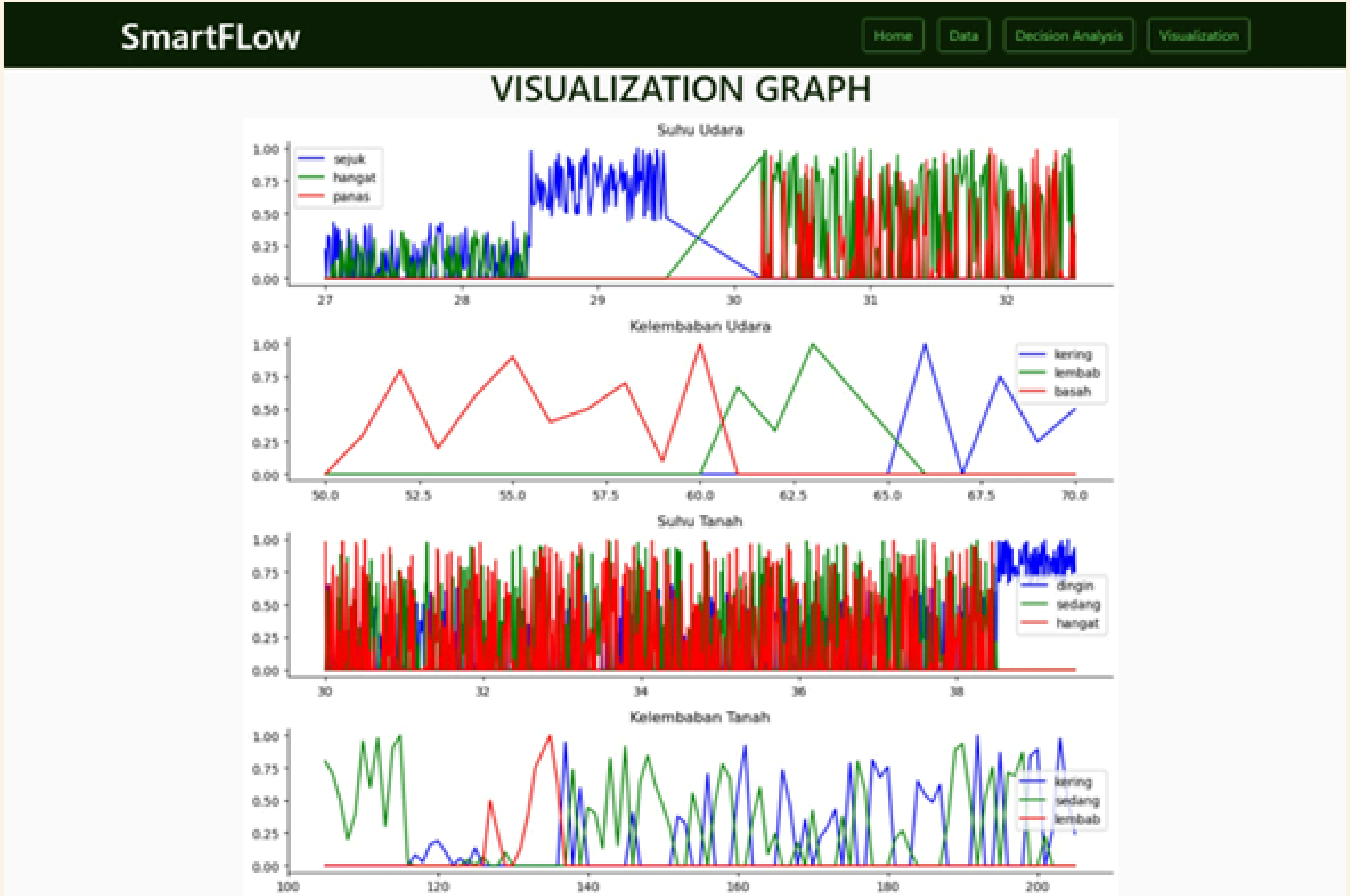
Tegangan Solar:

Cukup (18.7 V - 67.6 V)

Tegangan Aki:

Normal (17.5 V - 66.9 V)

Submit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VISUALIZATION GRAPH
Suhu Udara
sejuk
hangat
panas
Kelembaban Udara
kering
lembab
basah
Suhu Tanah
dingin
sedang
hangat
Kelembaban Tanah
kering
sedang
lembab

EVALUATION

Comparison Table of Expert and Fuzzy Results

Watering	**Environmental Data**	**Expert**	**Fuzzy Results**
1	• Air Temperature: Cold (27.0°C - 30.3°C) • Air Humidity: Wet (63.8% - 70.0%) • Soil Temperature: Cold (30.0°C - 34.4°C) • Soil Humidity: Medium (171.8% - 188.4%) • Light: Cloudy (41046.8 Lux - 51738.9 Lux) • Solar Current: Low (0.2 A - 0.4 A) • Battery Current: Maximum (0.1 A - 0.2 A) • Solar Voltage: High (67.6 V - 107.9 V) • Battery Voltage: Maximum (66.9 V - 107.9 V)	Cloudy Watering	Cloudy Watering
...	...	...	...
30	• Air Temperature: Cold (27.0°C - 30.3°C) • Air Humidity: Wet (63.8% - 70.0%) • Soil Temperature: Cold (30.0°C - 34.4°C) • Soil Humidity: Moderate (171.8% - 188.4%) • Light: Dark (13987.0 Lux - 41046.8 Lux) • Solar Current: Medium (0.4 A - 0.4 A) • Battery Current: Minimal (0.0 A - 0.1 A) • Solar Voltage: Weak (10.1 V - 27.3 V) • Battery Voltage: Low (9.2 V - 25.9 V)	Cloudy Dry	Cloudy Dry

Out of the 30 sample data, the system only made 3 incorrect decisions, resulting in a system accuracy of 90%

CONCLUSION

The fuzzy logic-based DSS is effective in addressing irrigation and energy control issues with 90% accuracy.

The system adapts to environmental conditions to optimize irrigation and energy efficiency.

It has great potential for smart and sustainable irrigation management, especially in areas with limited resources.

Thank You