Village Information Systems and AWS Integration: Enhancing Rural Climate Resilience and Sustainable Development in Andhra Pradesh

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DOI: https://doi.org/10.51584/IJRIAS.2025.10060063

Received: 11 June 2025; Revised: 19 June 2025; Accepted: 23 June 2025; Published: 09 July 2025

ABSTRACT

This research introduces the Village Information System (VIS), a pilot initiative launched in 2006 in Andhra Pradesh, India, to bridge the rural-urban digital divide and foster sustainable development. Implemented across 19 kiosks in the climatically diverse districts of Nellore (wet, tropical) and Kadapa (dry, semi-arid), the VIS project aimed to provide digital access to critical information for rural communities. A core innovation involved integrating calibrated Automatic Weather Stations (AWS) at these sites, which continuously collect high-resolution meteorological data.

The study details the design and deployment of the VIS infrastructure, including the technical specifications and rigorous calibration of the portable AWS units. It presents validation results comparing AWS data with reference instruments, demonstrating their reliability. Beyond technical aspects, the paper thoroughly explores the operational challenges encountered during VIS implementation, such as limited infrastructure and connectivity, low digital literacy, data quality issues, system design complexities, sustainability concerns, and the need for robust stakeholder engagement. Crucially, it provides a comprehensive set of practical solutions to these challenges, including hybrid connectivity models, targeted digital literacy training, standardized data management protocols, user-centric design principles, sustainable funding strategies, and decentralized technical support.

The findings confirm the efficacy of the portable AWS units in providing reliable weather data and underscore the VIS's significant role in enhancing rural communities' access to vital information. This improved access facilitates climate resilience and supports informed decision-making for agricultural productivity and overall sustainable development in varying agro-climatic zones. The detailed exploration of challenges and solutions offers invaluable insights for future initiatives aiming to deploy similar information systems in rural, resource-constrained environments.

Keywords: Rural Development, Village Information System (VIS), Automatic Weather Station (AWS), Climate Resilience, and weather parameters

INTRODUCTION

Rural areas in India differ significantly from their urban counterparts in terms of infrastructure, service availability, and overall development needs (Planning Commission, 2014[1]). Delivering essential services to approximately 640,000 villages across diverse agro-climatic zones remains a formidable challenge. To address this, a pilot Village Information System (VIS) initiative was launched in Andhra Pradesh. For this project, two districts, Nellore (characterized by a wet, tropical climate) and Kadapa (characterized by a dry, semi-arid

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VI June 2025

climate), were strategically chosen due to their distinct climatic characteristics, including variations in temperature, humidity, pressure, and rainfall.

Kadapa district, located in a semi-arid zone, frequently experiences recurrent droughts and receives annual rainfall significantly below the national average (IMD, 2021[2]). It is considered socio-economically backward, grappling with issues such as low literacy rates, significant out-migration, and widespread poverty (Government of Andhra Pradesh, 2020[3]). Groundwater levels in Kadapa, as well as in neighboring districts like Chittoor and Anantapur, are alarmingly deep, ranging from 600 to 900 feet. This is primarily due to poor groundwater recharge and limited infiltration. Even during monsoon seasons, water levels remain critically low, severely impacting agriculture and natural vegetation. The average summer temperature often reaches approximately 46°C, accelerating desertification processes in the region (Rao et al., 2015[4]).

Conversely, Nellore district falls within the tropical wet and dry (savanna) climatic zone, marked by consistently high year-round temperatures and prolonged dry spells during winter and early summer (IMD, 2021[2]). Mean monthly temperatures exceed 18°C even in winter, while summer temperatures can soar up to 48°C, particularly in interior lowland areas. Due to its coastal location, Nellore is frequently affected by cyclonic disturbances originating from the Bay of Bengal (NDMA, 2022[5]).

The VIS initiative was designed to improve the lives of rural communities in these contrasting climatic zones by providing digital access to crucial information. Development is fundamentally a process of achieving equitable and sustainable improvements in the quality of life, supported by efficient planning, diligent monitoring, and data-driven decision-making (UNDP, 2020[6]). Systematic data collection is essential for evaluating socio-economic conditions and their dynamics, thereby aiding in accurate situational assessment and future planning.

Information is central to sustainable development. The utility of data is significantly enhanced when it can be interpreted, especially in spatial and visual formats such as maps and graphs (Longley et al., 2015[7]). Combining spatial data with attribute information facilitates a quick and intuitive understanding of geographic patterns and socio-environmental differences, which is vital for effective regional planning and resource management.

Motivation and Objective of the Village Information Systems

Developing a comprehensive Village Information System requires considering multiple parameters, including political, financial, and demographic factors. However, due to time and resource constraints, only a few could be fully integrated during the pilot phase. The primary objectives of the VIS were:

i. To provide citizens with accessible data on natural resources, socio-economic conditions, infrastructure (education, health), crop suitability, and market facilities.

ii. To disseminate daily meteorological forecasts via email to each VIS kiosk.

iii. To support the formulation of long-term strategies for natural resource management and disaster preparedness through participatory community efforts.

These objectives were specifically designed to bridge the rural-urban digital divide and promote informed decision-making within rural communities (Kumar & Sinha, 2016[8]).

Topography, Climatology, and Location of Village Information Systems

The Village Information Systems (VIS) project commenced in 2006, sponsored by the Natural Resources Data Management System (NRDMS) Division, Department of Science & Technology (DST), Government of India. It was implemented by the Andhra Pradesh State Council of Science and Technology (APCOST) in collaboration with the Andhra Pradesh State Remote Sensing Applications Centre (APSRAC), Hyderabad. A total of 19 VIS units were established: 10 in Kadapa and 9 in Nellore, as illustrated in Figure 1 and detailed in Table 1.

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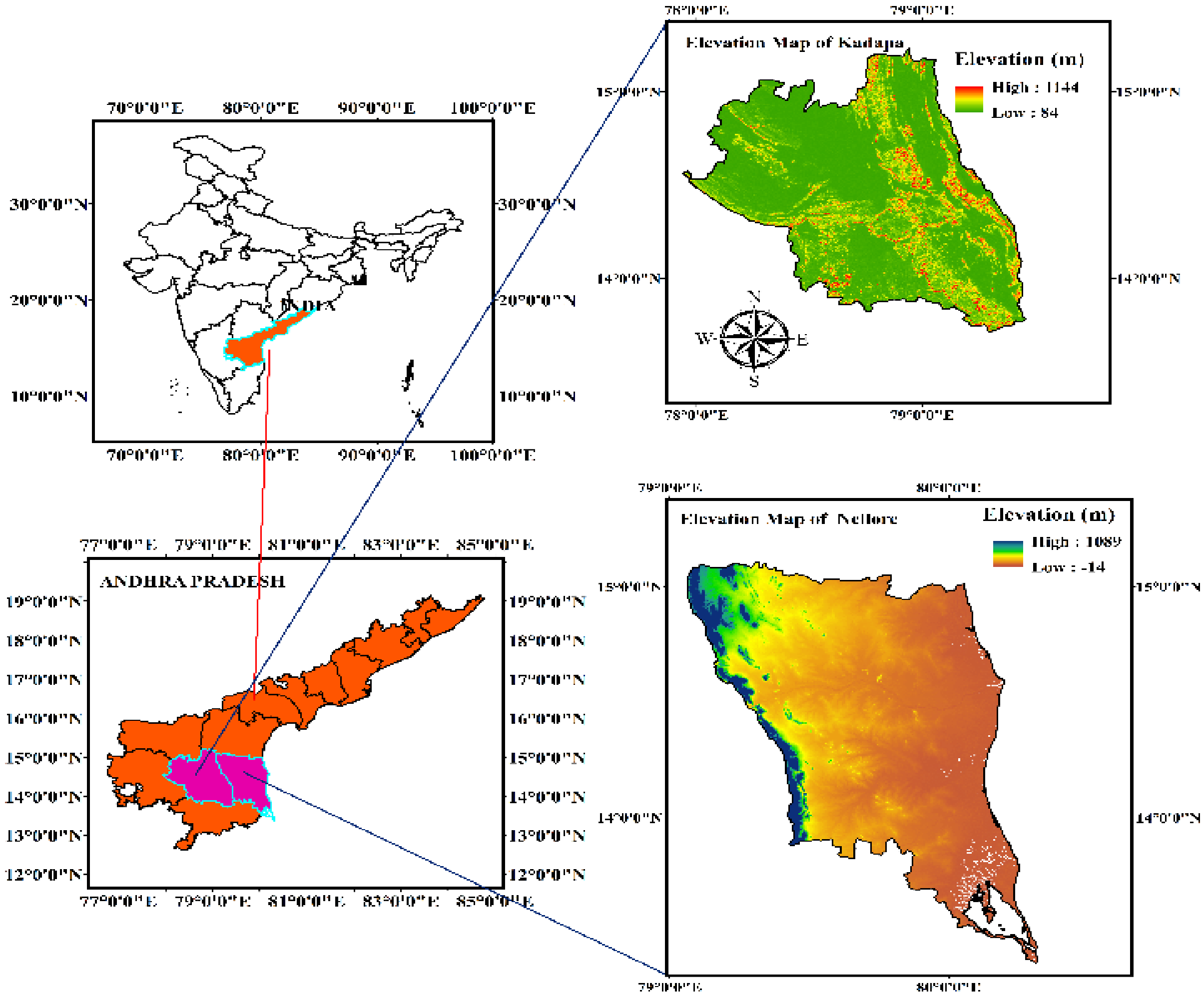

Fig 1: Location of 19-VIS located in the study area

Table 1: Location of 19- VIS spread over Nellore and Kadapa Districts

Sl. No	VIS KIOSK ESTABLISHED @ A VILLAGE	LOCATION (lat, long)	MANDAL
Nellore District			
1.	Venkanapalem	14°29.92N, 80°9.42E	Indukurupeta
2.	Mypadu	14°30.36N, 80°10.36E	
3.	Gangapatnam	14°31.55N, 80°10.40E	
4.	Kudithipalem	14°34.14N, 80°11.21E	
5.	Utukuru	14°34.63N, 80°8.78E	Vidavaluru
6.	East Gogulapalli	14°42.14N, 80°6.35E	Allur
7.	Iskapalle	14°44.28N, 80°7.13E	
8.	Juvvaladinne	14°45.02N, 80°4.95E	Bogole
9.	Dandigunta	14°38.12N, 80°8.63E	Vidavaluru

Sl. No	VIS KIOSK ESTABLISHED @ A VILLAGE	LOCATION (lat, long)	MANDAL
Kadapa District			
1.	Kamasamudram	14°35.3N, 78°6.3E	Lingala
2.	Ankalammaguduru	14°34.54N, 78°11.05E	Simhadripuram
3.	Lomada	14°33.8N, 78°15.5E	
4.	Balpanuru	14°32.22N, 78°12.00E	
5.	Saidapuram	14°31.1N, 78°15.6E	Tonduru
6.	Tonduru	14°34.7N, 78°17.5E	
7.	Inagaluru	14°33.17N, 78°16.15E	
8.	Telluru	14°31.47N, 78°15.58E	
9.	Maduru	14°31.15N, 78°13.73E	
10	Bhadrampalle	14°36.05N, 78°15.13E	

Nellore and Kadapa, despite being only approximately 150 km apart, represent two distinctly different climatic regimes. This contrast allows for a valuable comparative analysis of VIS utility across savanna and semi-arid zones. Nellore District spans 13,076 km² and lies between 13°30′ and 15°06′ N latitude and 70°05′ to 80°15′ E longitude. It is bordered by the Bay of Bengal to the east, Tamil Nadu to the south, and Kadapa and Prakasam districts to the west and north, respectively. Its terrain varies significantly, from fertile coastal belts to rocky, shrubby interiors near the Veligonda hills. The Pennar River bisects the district, profoundly influencing regional land-use patterns (CWC, 2021). Kadapa (YSR) District, with a total area of 15,379 km², is located between 13°43′–15°14′ N and 77°55′–79°29′ E. It is bounded by Kurnool to the north, Chittoor to the south, Nellore and Prakasam to the east, and Anantapur to the west. The district lies at the foot of the Eastern Ghats, exhibiting a rugged topography with sparse vegetative cover due to recurrent droughts and high evapotranspiration rates (APSDMA, 2020[9]).

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Table 2: Classification of Seasons

Climate	Month
Summer transition	May
South-West monsoon	June – September
Winter transition	October
North-East monsoon	Late Oct. to Early Dec.
Summer	Late December - April

Both districts experience seasonal climatic variations—pre-monsoon (March–May), monsoon (June–September), post-monsoon (October–November), and winter (December–February). Rainfall originates from both southwest and northeast monsoons, with the latter often bringing cyclonic storms that disrupt agriculture and housing infrastructure (Raju et al., 2018 [10]). Detailed seasonal climate data is summarized in Table 2.

Deployment of Automatic Weather Station for Vis

An Automatic Weather Station (AWS) is an automated facility designed to collect weather data, often in remote locations or to supplement traditional weather data collection methods (Ioannou et al., 2021[11]; Weerasinghe et al., 2011a[12], 2011b[13]). These stations are equipped with a variety of sensors to measure meteorological parameters and typically include capabilities for data storage and remote data transmission.

The Automatic Weather Stations (AWS) are very important in rural areas to improve the agricultural productivity. The instruments and the relevant equipment used in villages in general and for weather data creation in particular are discussed in this chapter. The AWS records 1-min air temperature (AT), relative humidity (RH), atmospheric pressure (P), rainfall (RF), wind direction (WD) and wind speed (WS). The data logger is used for storing and programming. In the present study also data logger was programmed similarly in a way to collect each sample as an average taken at regular intervals and to store simultaneously into a Village Information System (VIS) kiosk also. This work describes various meteorological sensors and communication equipment. Weather information related to temperature, light, sunshine, moisture and rainfall etc influences various activities including agriculture around the world.

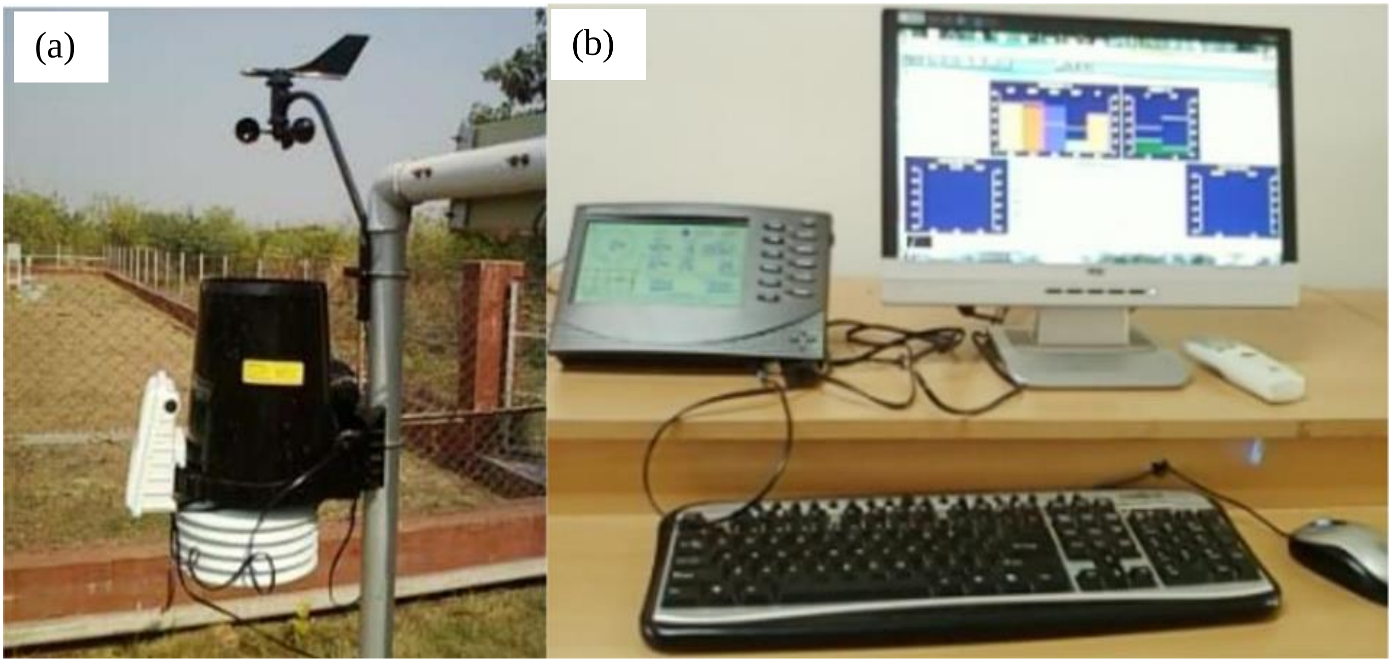

Fig.2: (a) Automatic Weather Station with meteorological sensors and (b) Data acquisition system

Davis Vantage Pro 2 model Automatic Weather Station (AWS) provides an integrated system that measures wind speed and direction, air temperature, pressure, humidity, and rainfall parameters simultaneously which is given in Table 3. Temperature and humidity sensors are protected from solar radiation and other radiated and reflected heat by a radiation shield.

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Table 3: Automatic Weather Station monitors the following parameters:

<table>
<tr><th>Sl. No.</th><th>Sensor and its Product</th><th>Other calculated Parameters</th></tr>
<tr><td>1</td><td>Barometer: Atmospheric Pressure</td><td rowspan="6">• Dew Point
• Heat – DD
• Cool – DD
• Heat Index
• THW Index
• Rain Rate
• Wind Run
• WindChill
• Evapo-transportation</td></tr>
<tr><td>2</td><td>Humidity Sensor: Inside and Outside Humidity</td></tr>
<tr><td>3</td><td>Temperature: Inside and Outside Temperature</td></tr>
<tr><td>4</td><td>Anemometer: Wind Speed/Wind Direction</td></tr>
<tr><td>5</td><td>Solar Radiation: Solar Radiation (Heat Index)</td></tr>
<tr><td>6</td><td>UV sensor: Ultraviolet Radiation Rain collector: Rainfall</td></tr>
</table>

Technical Description of Automatic Weather Station

Communication Options

If the station is installed at a remote location, data can be retrieved using various communication options, such as PSTN (Telephone line) or a GSM Modem (Mobile Service). This requires the availability of mobile service or a telephone line at the remote site. Data communication can be established through a modem via telephone lines. A V.90 Modem and a Telephone adapter are necessary for transferring data from the remote station to the central station/receive station.

The central station/receive station (VIS kiosks/computer) can be configured with the telephone numbers of a standalone weather station or a network of weather stations (e.g., STATION #1, STATION #2, STATION #3, and so on). The computer, equipped with WeatherLink software, will automatically dial the remote station at user-selectable intervals to collect data. Data can be collected from remote stations hourly, every six hours, every 12 hours, or at any other user-selectable option. The modem can be powered at remote sites by AC power (if available) or a 12V battery. The battery can be recharged by a solar panel. In such cases, the modem, battery, and electronics are housed in a weatherproof enclosure to protect them from harsh weather conditions and vandalism.

Data Logging to a Personal Computer

Obtaining information from a weather station digitally offers significant advantages over manual data collection. Utilizing the VIS-KISOK via the Davis WeatherLink data logging system for linking to the weather station represents a new dimension, enabling the retrieval of a maximum number of weather observations. The data logger stores data even when a VIS-KISOK is not connected.

Weather Link Software and Data-Logger

The Davis Vantage Pro 2 (model Automatic Weather Station - AWS) represents an integrated system designed for comprehensive meteorological data acquisition. This advanced AWS is capable of measuring key atmospheric parameters including wind speed and direction, air temperature, atmospheric pressure, relative humidity, and rainfall. A core component of this system's utility and data management is its connectivity to a personal computer or laptop via the WeatherLink software and an integrated data-logger. This report outlines the functionality of the WeatherLink system in facilitating the collection, analysis, and display of meteorological data generated by the Davis Vantage Pro 2 AWS.

The Davis Vantage Pro 2 AWS is equipped with an internal data-logger that serves as the primary storage unit for the meteorological observations. This data-logger continuously records data from the various sensors at predefined intervals, ensuring that a robust dataset is maintained even when not actively connected to a computer.

The WeatherLink software acts as the crucial interface between the AWS data-logger and a personal computer.

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Its primary functions include:

The software enables seamless download of historical meteorological data stored in the AWS data-logger to the connected computer. This allows for long-term archiving of observations, which is essential for climatological studies, trend analysis, and research. When connected, WeatherLink provides a real-time graphical and numerical display of current weather conditions. This immediate visualization of parameters such as live wind readings, temperature, and humidity offers instantaneous insights into prevailing weather. Beyond mere data collection, WeatherLink offers a suite of tools for in-depth data analysis. Users can generate customized reports, create charts and graphs (as exemplified by Fig 3, showing outputs like temperature trends, wind roses, or barometric pressure changes), and perform statistical analysis on the collected parameters. This facilitates a deeper understanding of weather patterns and events.

The software allows users to configure various aspects of the AWS and data logging, including recording intervals, alarm thresholds for specific weather conditions, and unit preferences.

WeatherLink supports the export of meteorological data into various formats (e.g., CSV, text files), making it compatible with other third-party analytical software, spreadsheet applications, and scientific modeling tools. This interoperability enhances the usability of the AWS data for a wider range of applications.

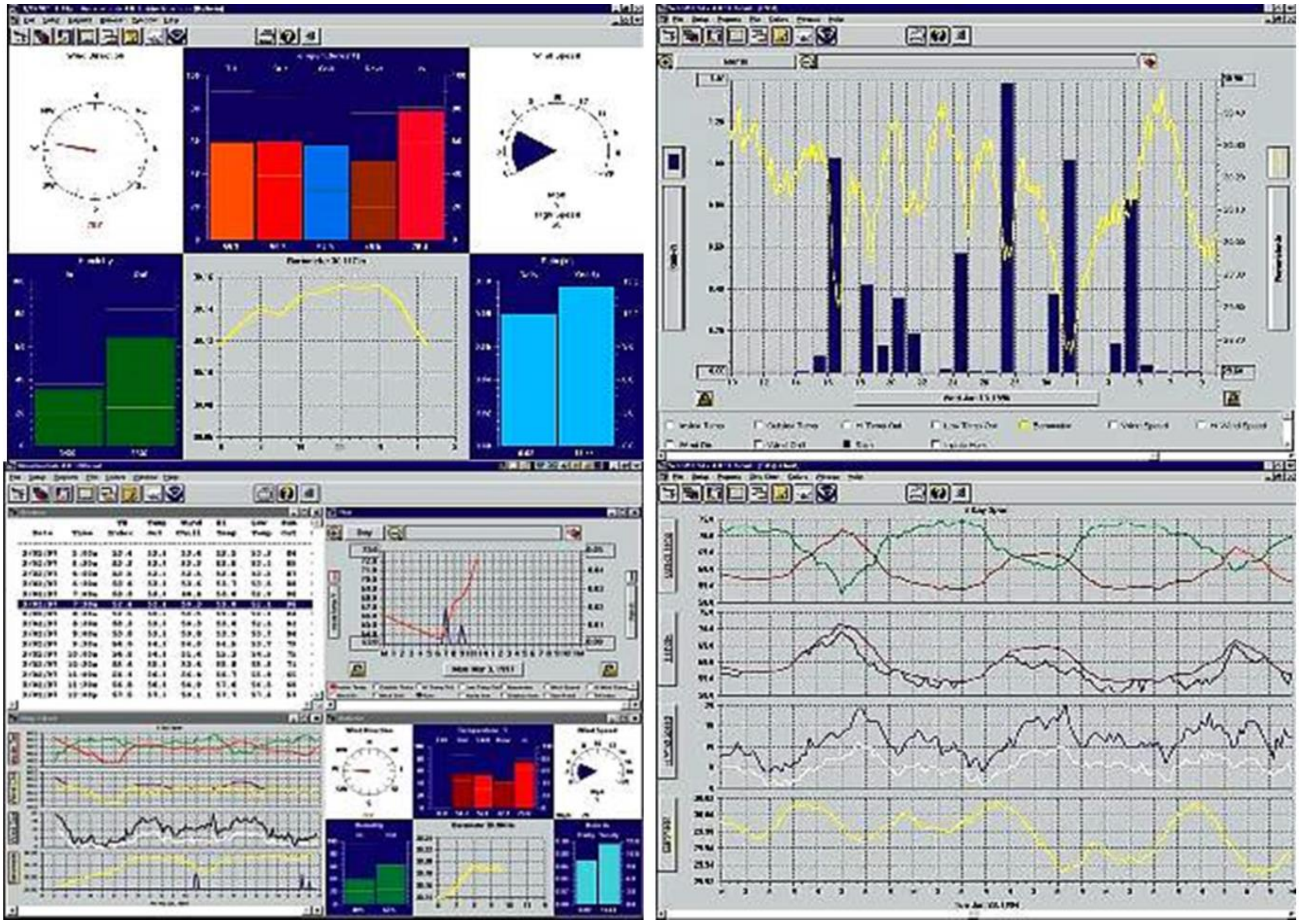

Fig. 3. Weather Link Software generated meteorological (Temperature, Pressure, Relative humidity (%), Wind speed, wind direction, Rainfall) parameters.

Data Collection at Yogi Vemana University, Kadapa

The Automatic Weather Station (AWS) temporaily installed at SARC, Department of Physics, Yogi Vemana University, Kadapa for calibration and validation of all sensors which measure the weather data. The specifications of this particular AWS are shown in Table 4.

Table 4: Specifications of the Automatic Weather Station.

Required sensors	Variable	Resolution	Range	Accuracy (+/-)
Console	Date	1 day	Month/day	8 sec./month
	Time	1 min	24 hours	8 sec./day
	Barometric pressure	0.1 mb	540-1100 mb	1 mb
	Inside humidity	1%	1-100%	3% RH
	Inside Temperature	0.1 ºC	0 to +60 ºC	0.5 ºC
ISS or Temp/Hum station	Outside Humidity	1%	1-100%	3% RH
Rain Gauge/ collector	Daily rainfall	0.2 mm	0.2-999.8 mm	1 tip/> 4%
ISS or Temp/Hum station	Outside Temperature	0.1 ºC	-40 to +65 ºC	0.5 ºC
Anemometer	Wind Speed	0.4 m/s	1-80 m/s	1 m/s
	Wind Direction	1^0	0 - 360^0	3^0

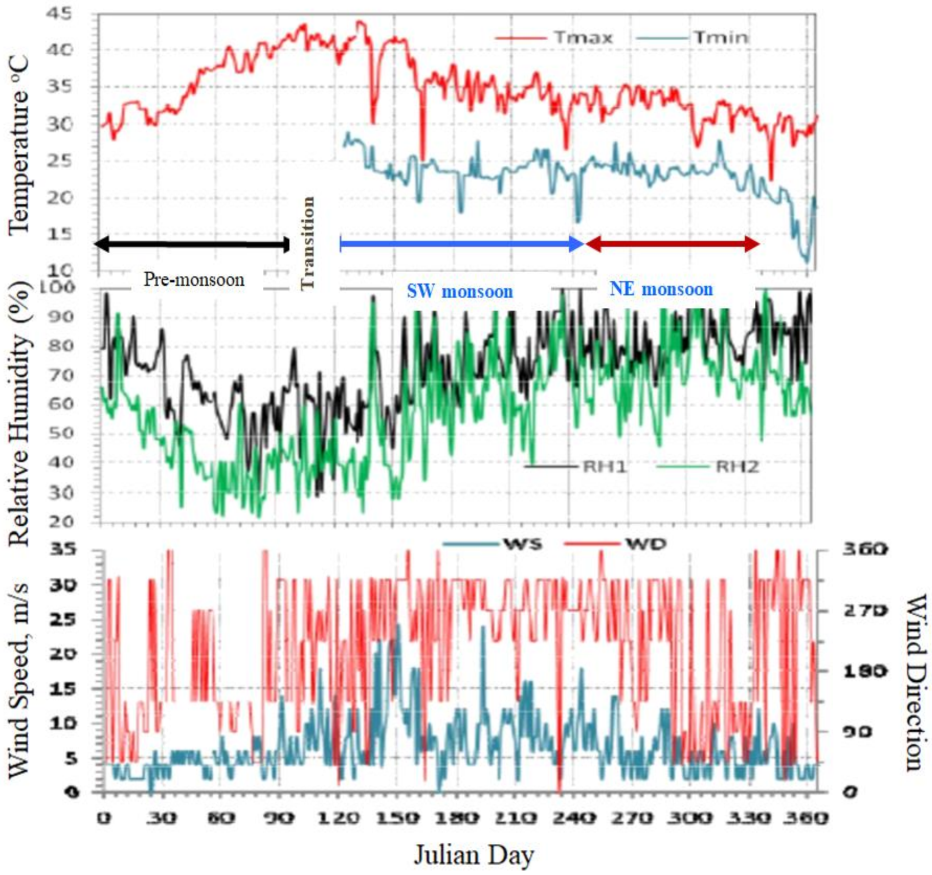

Fig. 4 Surface meteorological data collected from climatic Stations over Kadapa from 01 January to 31 December 2010. Daily variation of maximum and minimum temperature. Middle panels show relative humidity in the morning transition [08:30 hrs (Rh1)] and evening transition [17:30 hrs](Rh2). Lower panels represents average wind speed and wind direction.

Fig.4 shows the surface meteorological parameters (maximum/minimum temperature, relative humidity at 08:30 and 05:30 hrs Local Time, Wind speed and wind direction) observed from January 2010 – December 2010. From the Climatic station observations over Nellore, it is noticed that daily maximum temperatures 40°C and above during April and May, the hottest months in the year 2010 and in January and February the coolest months temperature is around 20 °C (degree Celsius). These variations are due to South-West monsoon (June to September), North-East monsoon (October to December) and JAL Cyclone (4th to 8th November). The Maximum temperature varies 26 to 45°C and minimum temperature varies 15 to 24°C in the year of 2010.

From Fig.4 most important feature of seasonal alternation of atmospheric flow patterns associated with the summer/southwest monsoon and winter/northeast monsoon can be clearly noticeable. During the NE monsoon, the general flow of surface air over the region is from northeasterly, mainly of continental origin with low humidity and also substantial precipitation falls over this region. In the SW monsoon the surface winds take the opposite direction from sea to land, bringing with them vast amounts of moisture, cloudiness and precipitation. Between these two principal seasons are the transitional seasons of the hot weather or pre-monsoon months from March to May, and retreating monsoon or post-monsoon month, October.

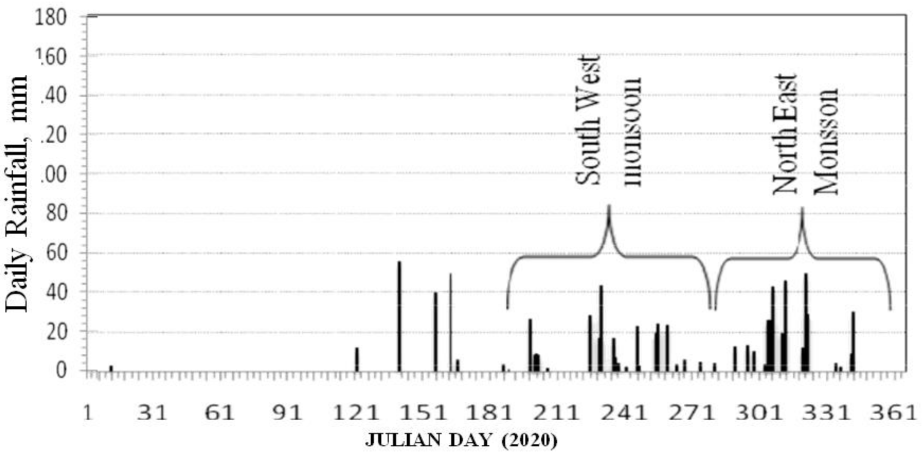

Fig.5. Daily Rainfall, mm observed over Kadapa between 01 Jan. 2010 to 31 Dec. 2010

Figure 5 provides a comparative analysis of daily rainfall accumulation in Kadapa for the entirety of 2010. A clear pattern emerges, indicating that Kadapa experienced a higher frequency of rainy days due to Andhra Pradesh's rainfall was significantly influenced by a strong La Niña event. Beyond just the number of rain days, the total rainfall accumulation was also notably greater in Kadapa. Due to La Niña, it suggests that Kadapa experience more prolonged or heavier precipitation events over the course of the year. The Fig.5 highlights the significant influence of the North-East (NE) monsoon on rainfall patterns particularly in comparison to the South-West (SW) monsoon. The higher rainfall accumulation observed during the NE monsoon is directly attributed to the formation and potential landfall of cyclones over the Bay of Bengal along the east coast region. These cyclonic systems are a characteristic feature of the NE monsoon season and are responsible for delivering substantial amounts of precipitation. to coastal and near-coastal areas like Nellore, and to a lesser extent, inland regions like Kadapa. This seasonal dominance of the NE monsoon in contributing to overall rainfall accumulation is a key climatological characteristic differentiating the rainfall regimes over Kadapa region.

Calibration of AWS and Validation of Meteorological Parameters

The shift from manual observations to automated weather stations (AWS) has revolutionized data acquisition, offering continuous measurements and enabling the deployment of observational networks in remote or hazardous environments. AWS typically measure parameters such as air temperature, relative humidity, atmospheric pressure, wind speed and direction, and precipitation, providing a rich dataset for a variety of applications (Shafer & Zickefoose, 2011[14]).

Despite their advantages, AWS are susceptible to various sources of error, including sensor drift, calibration inaccuracies, environmental interference (e.g., icing, dust accumulation), power fluctuations, and data transmission errors (Nakamura & Maekawa, 2015[15]). Consequently, raw AWS data often contain biases, random errors, and outliers that can severely compromise the utility of the information. This necessitates rigorous data validation procedures to ensure the quality, reliability, and fitness-for-purpose of the data.

While conventional data validation techniques such as plausibility checks, time-consistency checks, and internal-consistency checks are widely employed, they primarily focus on identifying gross errors and logical inconsistencies. A more advanced and metrologically sound approach involves the systematic intercomparison of AWS measurements against highly accurate and traceable reference instruments. This paper posits that "facilitated intercomparison with reference instruments" is not merely a validation technique but a cornerstone for establishing the metrological quality of AWS data. It offers a direct means to quantify measurement biases, assess instrument performance, and ultimately enhance the confidence in AWS observations.

This AWS unit underwent rigorous calibration against reference sensors at the Yogi Vemana University weather observatory (see Figure 3). This site hosts a comprehensive meteorological array, including an ISRO AWS, an IMD Climatic Station, a 15-meter Mini-Boundary-Layer Mast (MBLM), GPS radiosondes, a disdrometer, micro-rain radar, and a lightning sensor. The calibration facility at at the Semi-arid-zonal Atmospheric Research Centre (SARC), Yogi Vemana Univrersity, Kadapa provides a suitable instrument for accurate in situ calibration of the automatic weather stations (AWSs), and in general of meteorological sensors, located in remote regions thereby allowing the metrological traceability to key observables for climate change evaluation.

Fig. 6 Ground-based Instrumentation Calibration facility at the Semi-arid-zonal Atmospheric Research Centre (SARC), Yogi Vemana Univrersity, Kadapa

The calibration and validation of automatic weather stations (AWS) are crucial for ensuring the reliability and accuracy of meteorological data (Lopardo et al., 2015) [16]. This process involves comparing AWS measurements with reference instruments and establishing traceability to national or international standards (Lopardo et al., 2012) [17]. Specifically, the calibration and validation include process validation, validation parameters, equipment qualification, manufacturing processes, analytical method validation, acceptance criteria, and statistical methods.

Calibration of AWS typically involves in-situ or laboratory methods (Vuillermoz et al., 2014) [18] (Merlone et al., 2015) [19]. In-situ calibration is performed by positioning standard instruments close to the station under calibration and comparing the results [18]. Dedicated facilities for in-situ calibration enable the determination of calibration curves, allowing for corrections to acquired parameters [18]. For example, a transportable calibration facility was manufactured at the Italian Institute of Metrology (INRiM) to ensure data traceability [16]. This facility is equipped with temperature and pressure reference sensors directly traceable to metrological standards.

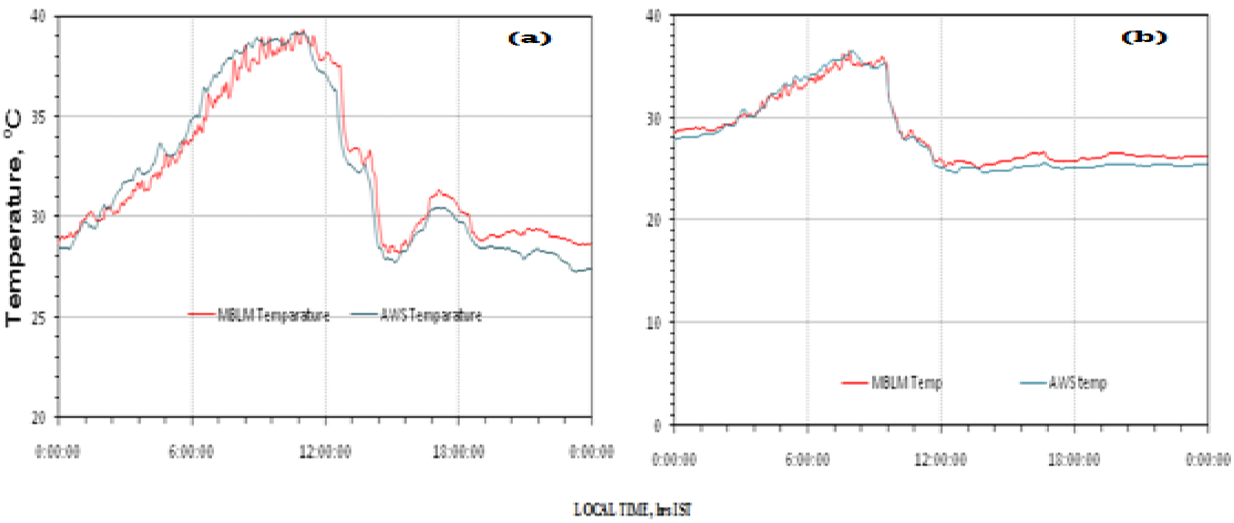

Fig. 7: Evaluation of performance of the Portable–Automatic Weather Station (AWS) using Mini-Boundary Layer Mast (MBLM) observations. (a) Diurnal variation of temperature observed on clear sunny day (20 April 2016) and (b)during passage of a thunderstorm precipitating clouds on 22 April 2016.

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VI June 2025

Temperature, Humidity, and Pressure Sensors: These sensors are critical components of AWS and require regular calibration (Wellyantama & Soekirno, 2021) [20] (Lopardo et al., 2012) [2]. An attempt is made an experiment on Portable–Automatic Weather Station (AWS) using Mini-Boundary Layer Mast (MBLM) observations. The main aim of the experiment is to evaluate the performance of the Portable–Automatic Weather Station (AWS) and data quality/reliability.

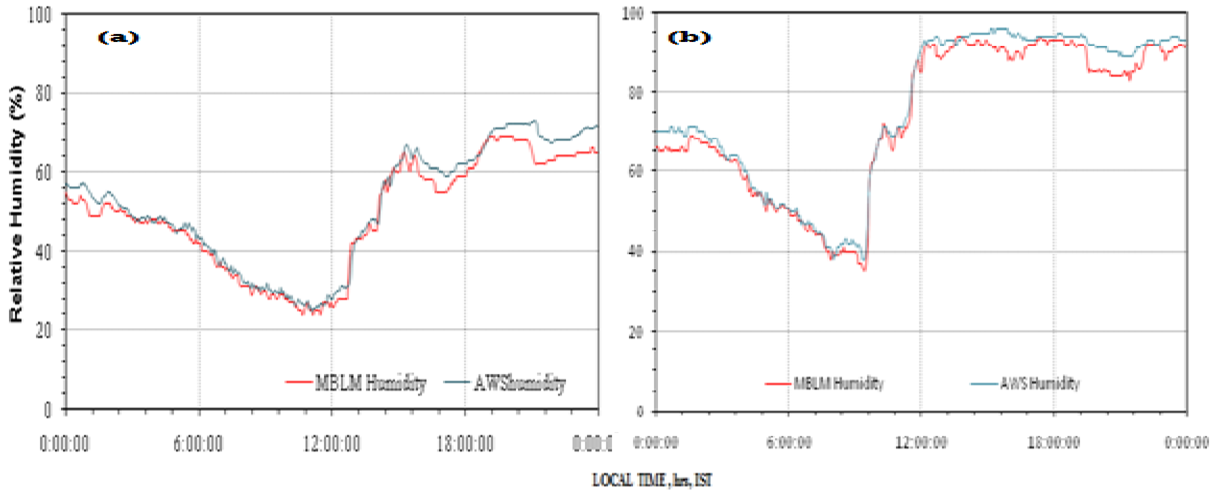

Fig. 8: Evaluation of performance of the Portable–Automatic Weather Station (AWS) using Mini-Boundary Layer Mast (MBLM) observations. (a) Diurnal variation of Relative Humidity (%) observed on clear sunny day (20 April 2016), and (b)during passage of a thunderstorm precipitating clouds on 22 April 2016.

From **Figs. 7 and 8**, a reasonable good time series correlation is noticed from the diurnal variation of temperature and relative humidity observations on clear sunny day and passage of thunderstorm clouds. From the time series data, it is found that the both instruments data evolution is more or less the same. It indicates to use Portable–Automatic Weather Station (AWS) for Village information to obtain key meteorological parameters during natural disasters such as cyclones and drought.

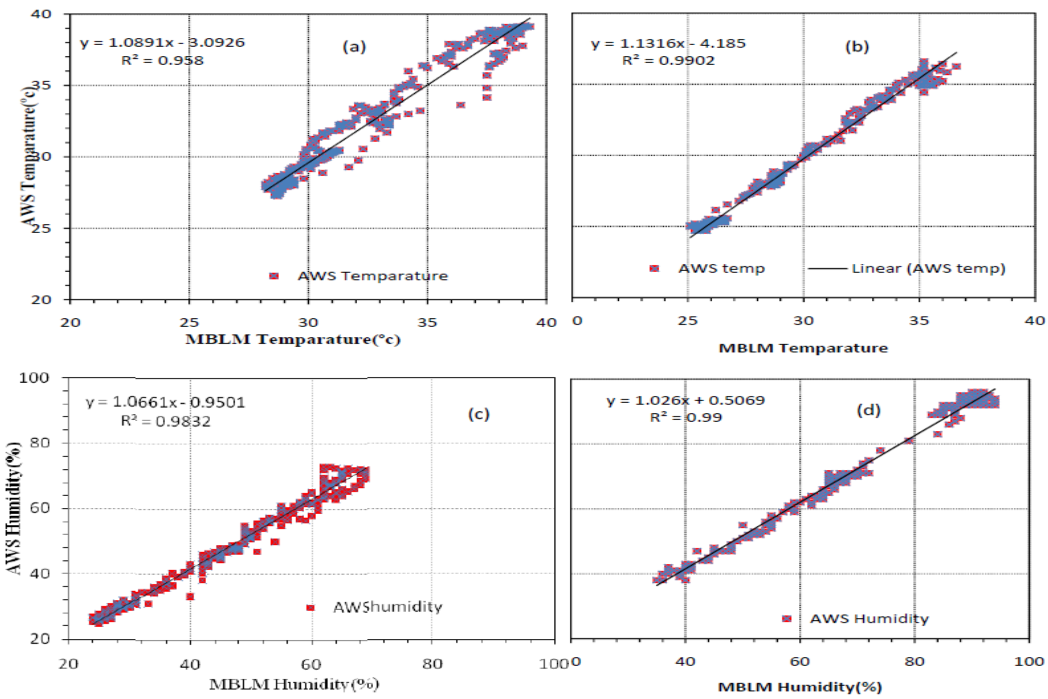

Fig. 9: Comparison of meteorological parameters (a) Scatter plot for temperature observed. (b) Scatter plot of temperature obtained from Portable –AWS and MBLM (c) Scatter plot of relative humidity observed from Portable – AWS and MBLM -sunny day, (d) Scatter plot of relative humidity obtained from portable –AWS and MBLM on passage of thunder precipitating clouds.

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VI June 2025

The Fig.9 details a comparative analysis of key meteorological parameters, specifically temperature and relative humidity, using scatter plots generated from two different measurement sources: a Portable Automatic Weather Station (AWS) and a Mobile Boundary Layer Mast (MBLM). Figures 9 (a) and (b) present scatter plots related to temperature observations. Figure (a) likely shows a general scatter plot of observed temperatures, possibly from one of the instruments or a combined dataset, providing an overall view of the temperature range and distribution. Figure (b) then provides a direct intercomparison by plotting temperature data from the Portable-AWS against those from the MBLM, allowing for a visual assessment of their agreement, highlighting any biases or discrepancies between the two measurement systems.

Figures 9 (c) and (d) extend this comparative analysis to relative humidity, but under distinct atmospheric conditions, offering insights into instrument performance during varying weather phenomena. Figure 9 (c) specifically illustrates the scatter plot of relative humidity observed from the Portable-AWS and MBLM during a "sunny day." This comparison helps evaluate the consistency of measurements when conditions are relatively stable and free from significant atmospheric disturbances. In contrast, Figure (d) presents the relative humidity scatter plot from the same two instruments during the "passage of thunder precipitating clouds." This scenario represents dynamic and high-humidity conditions, providing critical information on how well both the Portable-AWS and MBLM track rapid changes in humidity, and if their agreement differs significantly under such challenging meteorological events.

The intercomparison of temperature and relative humidity measurements between an Automatic Weather Station (AWS) and a nearby Mini-boundary layer mast (MBLM) provides crucial insights into the consistency of data obtained from both instruments. This consistency is quantitatively assessed using the coefficient of determination (R^2), a statistical measure that indicates the proportion of the variance in one variable that is predictable from the other. A high R^2 value signifies a strong linear relationship between the two sets of observations, suggesting that the measurements from the AWS closely track those from the MBLM, and vice versa. This analysis is fundamental for validating the reliability of AWS data against a reference or co-located instrument.

Rainfall Measurements

Many rainfall data acquiring instruments have been used in the past for the measurements of the rain integral parameters. Based on physical principle they are again classified: impact disdrometers, PARSIVEL disdrometers/optical disdrometers, and Doppler radar. All these instruments are able to operate continuously and unattended.

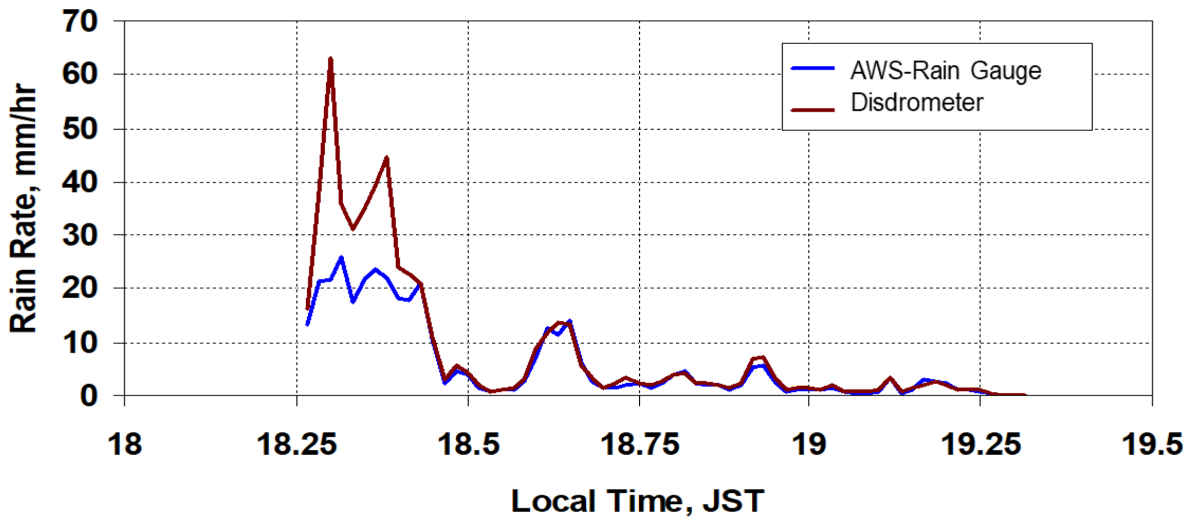

Fig. 10 Time series Comparison of rain rate obtained from AWS-Rain Gauge and disdrometer on 25 July 2016

The rainrates calculated from disdrometer were compared with the values measured at the same site tipping bucket rain guage. The disdrometer and AWS are spatially separated about 6 metres in the Meteorological Observatory located at Yogi Vemana University. For the present study, three months (September to November

2018) precipitation data was collected from disdrometer and AWS have been utilized to understand the accuracy of the PARSIVEL disdrometer in measuring the observed rain rates). The 5-minutes averaged rainrates calculated from the RSD measured by the disdrometer were compared to the values measured by a rain gauge at the same site.

The reliability of the AWS-Rain Gauge data has been assessed by comparing the data obtained from the Disdrometer. Monsoon precipitation (3369 minutes) data from 01 to 31 July 2004 were used to evaluate the precision of the AWS-Raing Gauge. ***Fig.10*** shows comparison of Rain integral parameters obtained from AWS-Rain Gauge and Disdrometer during the passage of Precipitating clouds. From the observational results it is found that rain rates are fairly in agreement with the rain gauge, but the disdrometer measured higher accumulation during lower rain rates - due to lower JWD sensitivity - and heavy rain, partly caused by splashing losses. *Fig 11* demonstrates the regression relation *[*between the two sources of measurement. The least square fitting of the two measurements is close to 0.95. The observational results are in fairly good agreement and acceptable.

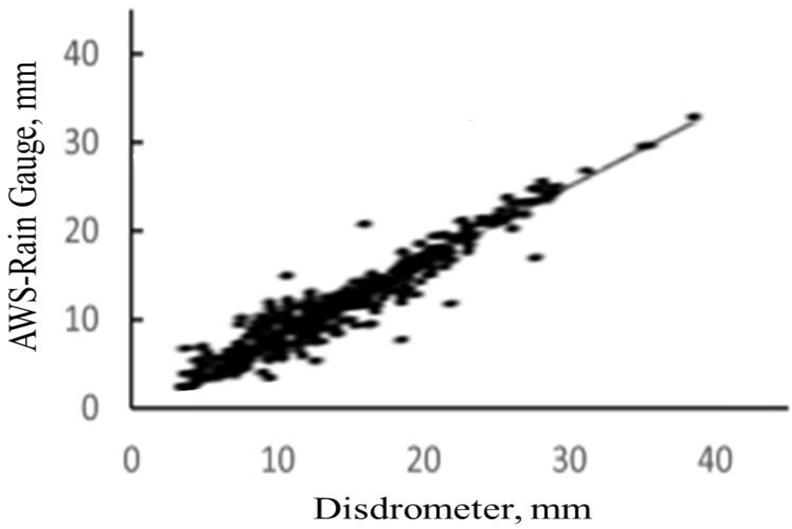

Fig 11: Comparison of Tipping Bucket Rain Gauge and rain rate (RR, mm/hr.) measured with PARSIVEL disdrometer.

Specifically, the research findings show that for key meteorological parameters including temperature, relative humidity, and rainfall, the calculated regression coefficients (R^2) were consistently greater than 0.9. Such high R^2 values are indicative of exceptionally strong linear relationships between the AWS and MBLM measurements for these variables. This robust correlation confirms a high degree of data consistency between the two observing platforms, suggesting that the AWS is providing reliable and comparable measurements to the more specialized Mini-boundary layer mast, thus affirming the quality of the AWS data for various meteorological applications.

Operational Challenges and Solutions for Village Information Systems (VIS) in Rural India

Implementing Village Information Systems (VIS) in rural areas like Kadapa, India, faces significant challenges across infrastructure, human capacity, data management, and sustainability. The core issues include limited internet and power access, a prevalent lack of digital literacy among villagers and operators, and difficulties in ensuring accurate, consistent, and secure data collection. Furthermore, many VIS initiatives struggle with non-intuitive system designs, reliance on time-bound external funding, and insufficient local community ownership and technical support, often compounded by a lack of supportive government policies.

To overcome these hurdles, the document proposes several practical solutions. These include deploying hybrid connectivity (satellite, wireless, offline sync) and solar power to address infrastructure gaps, alongside using low-cost, rugged hardware. To tackle digital literacy, it emphasizes targeted, localized training programs following a "train-the-trainer" model, complemented by simplified, visually-driven user interfaces. For data, solutions involve standardized collection protocols, leveraging crowdsourcing and geospatial integration, and utilizing secure cloud storage with validation mechanisms. Ensuring long-term sustainability requires exploring public-private partnerships, integrating with government schemes, and developing modest local revenue streams. Crucially, fostering strong local stakeholder engagement, establishing decentralized technical support hubs, and advocating for enabling government policies that promote inter-departmental collaboration are key to successful and enduring VIS implementation.

Summary of Research Work

This research introduces the Village Information System (VIS), a pioneering initiative in Andhra Pradesh, India, launched in 2006 to bridge the rural-urban digital divide and promote sustainable development. The project established 19 kiosks across the climatically diverse districts of Nellore (wet, tropical) and Kadapa (dry, semi-arid), providing digital access to crucial information for rural communities. A key innovation was the integration of calibrated Automatic Weather Stations (AWS) at these sites, continuously collecting high-resolution meteorological data.

The study meticulously details the VIS infrastructure's design and deployment, emphasizing the technical specifications and rigorous calibration of the portable AWS units. Validation results, which compared AWS data with reference instruments like the Mini-Boundary Layer Mast (MBLM) and disdrometers, consistently showed high data reliability, with coefficient of determination (R^2) values exceeding 0.9 for temperature, relative humidity, and rainfall. This robust agreement, observed across varied conditions including clear sunny days and thunderstorm passages, affirms the AWS's capability to provide accurate meteorological parameters. Beyond technical successes, the paper comprehensively addresses the operational challenges encountered during VIS implementation—such as limited infrastructure, low digital literacy, and data quality issues—and proposes a suite of practical solutions, including hybrid connectivity, targeted training, and sustainable funding models. The findings underscore the VIS's effectiveness in enhancing rural communities' access to vital information, thereby fostering climate resilience and supporting informed decision-making for agricultural productivity and overall sustainable development in diverse agro-climatic zones.

CONCLUSIONS

The integration of Automatic Weather Stations (AWS) within the Village Information System (VIS) in Andhra Pradesh demonstrates a highly effective approach to empowering rural communities with critical climate and socio-economic information. The rigorous calibration and validation process confirmed the exceptional reliability and consistency of the portable AWS units, as evidenced by high (R^2) values (>0.9) across multiple meteorological parameters like temperature, humidity, and rainfall when compared to reference instruments. This ensures that the data disseminated through the VIS kiosks is trustworthy and fit for purpose, directly addressing the foundational need for accurate information in rural development.

Furthermore, this research provides invaluable insights into the multifaceted challenges of deploying digital information systems in resource-constrained rural environments and offers actionable solutions. From overcoming connectivity limitations and improving digital literacy to ensuring data quality and promoting long-term sustainability, the proposed framework serves as a robust blueprint for future initiatives. Ultimately, the successful implementation and validation of the VIS-AWS integration highlight its significant potential to enhance climate resilience, optimize agricultural productivity, and accelerate sustainable development by enabling data-driven decision-making at the grassroots level. This work lays a strong foundation for scaling similar impactful information systems in other remote and vulnerable regions globally.

ACKNOWLEDGEMENT

We are very much thankful to Andhra Pradesh Council of Science and Technology (APCOST) for providing financial support for operation and maintaining of 19-Village Information systems (VIS). We are indebted to Prof. K. Krishna Reddy, Coordinator, Semi-arid-zonal Atmospheric Research Centre (SARC), and his research group, Department of Physics, Yogi Vemana University, Kadapa for providing VIS data and High Performance computational facility to carry out this research work. We are very much thankful to the District administration of Kadapa and Nellore district for their support for monitoring of VIS kiosk.

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VI June 2025

REFERENCES

1. Planning Commission. (2014). *Eleventh Five Year Plan 2007-2012 (Vol. 1: Inclusive Growth)*. Government of India.
2. IMD. (2021). *India Meteorological Department Climate Data for Andhra Pradesh*.
3. Government of Andhra Pradesh. (2020). *Socio-Economic Survey of Andhra Pradesh*.
4. Rao, K. S., Sarma, V. N., & Kumar, R. (2015). Groundwater Depletion and Desertification in Anantapur District, Andhra Pradesh. *Indian Journal of Environmental Protection*, *35*(6), 506-512.
5. National Disaster Management Authority (NDMA). (2022). *Cyclones in Coastal Andhra Pradesh*.
6. UNDP. (2020). *Human Development Report*. United Nations Development Programme.
7. Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. (2015). *Geographic Information Science and Systems* (4th ed.). John Wiley & Sons.
8. Kumar, M., & Sinha, P. (2016). *ICT for Rural Development: A Case Study of Village Information Systems*. Journal of Rural Development, 35(4), 453-468.
9. APSDMA. (2020). *Andhra Pradesh State Disaster Management Authority Annual Report*.
10. Raju, K. K., Subrahmanyam, K. V., & Krishnaiah, B. (2018). Rainfall variability and trends in Andhra Pradesh. *Journal of Earth System Science*, *127*(7), 1-13.
11. Ioannou, K., Bellas, A., & Vamvakaris, N. (2021). *Review of Automatic Weather Stations and Data Quality Control*. Proceedings of the European Meteorological Society Annual Meeting.
12. Weerasinghe, K. M., Alahakoon, D., & Dissanayake, S. (2011a). Design and development of a low cost automatic weather station for agricultural applications. *Tropical Agricultural Research*, *22*(3), 297-307.
13. Weerasinghe, K. M., Alahakoon, D., & Dissanayake, S. (2011b). Wireless sensor network for automated weather monitoring in agriculture. *Journal of Agricultural Sciences*, *6*(1), 17-26.
14. Shafer, M., & Zickefoose, J. (2011). *Automated Quality Control of Mesoscale Weather Data*. Proceedings of the 27th Conference on Interactive Environmental Technologies.
15. Nakamura, T., & Maekawa, K. (2015). Quality control of automatic weather station data using fuzzy logic. *Journal of Hydrometeorology*, *16*(2), 793-808.
16. Lopardo, G., Ruffino, F. G., Merlone, A., & Vuillermoz, M. (2015). A portable calibration facility for automatic weather stations. *Measurement*, *65*, 223-228.
17. Lopardo, G., Galliano, S., Giachino, G., Negro, S., & Ruffino, F. G. (2012). Calibration and validation of automatic weather stations. *Measurement*, *45*(10), 2419-2425.
18. Vuillermoz, M., Lopardo, G., & Merlone, A. (2014). In-situ calibration of temperature sensors for automatic weather stations. *International Journal of Metrology and Quality Engineering*, *5*(2), 1-8.
19. Merlone, A., Lopardo, G., & Ruffino, F. G. (2015). On-site calibration of temperature sensors for automatic weather stations. *Metrologia*, *52*(1), 1-10.
20. Wellyantama, D. A., & Soekirno, N. D. (2021). Temperature and humidity sensor calibration for automatic weather station. *IOP Conference Series: Earth and Environmental Science*, *737*(1), 012028.