H41S - 2027
Forest Friendly Flow Gauge: DIY Tipping Bucket for Precise Interception Loss Estimation!

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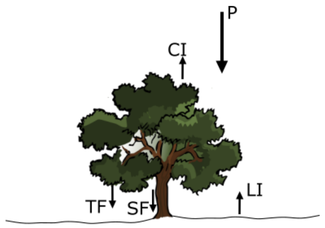
Background and Field Difficulty

Estimating Interception loss is crucial for accurate Hydrological Budgeting in forested watersheds



$$I = P - TF - SF$$

$$Q = P - I - ET + \Delta S$$

A. Existing Solution: Water from throughfall and stemflow is collected using a pipe and gutter system, and then measured in holding drums. However, this method is insufficient for gathering time-resolved data for rainfall event analysis and hydrological process modelling.

Existing Setup at Hydrological Study Field at Almora, Uttarakhand, India

B. Challenges to sampling Throughfall & Stemflow:

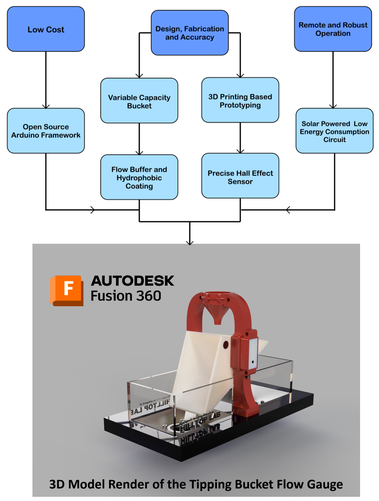
I. Manual sampling in collection drums is limited ⟶ Overflow of drums results in loss of data

II. Standard TB rain gauge ⟶ Small collection area requiring many rain gauges to be used

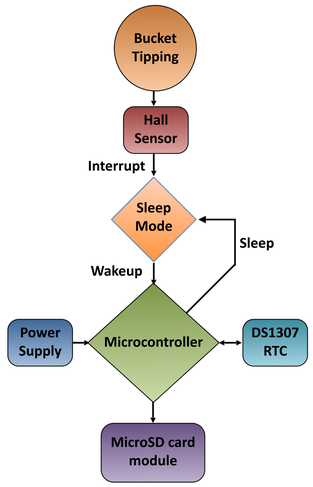
III. Standard TB flow gauges can be installed ⟶ Very Expensive (Small Market/Demand)

Hence, an open-source low-cost tipping bucket flow meter is required that can measure and record time-stamped flow rates in remote locations.

Ideation and Design of Solution

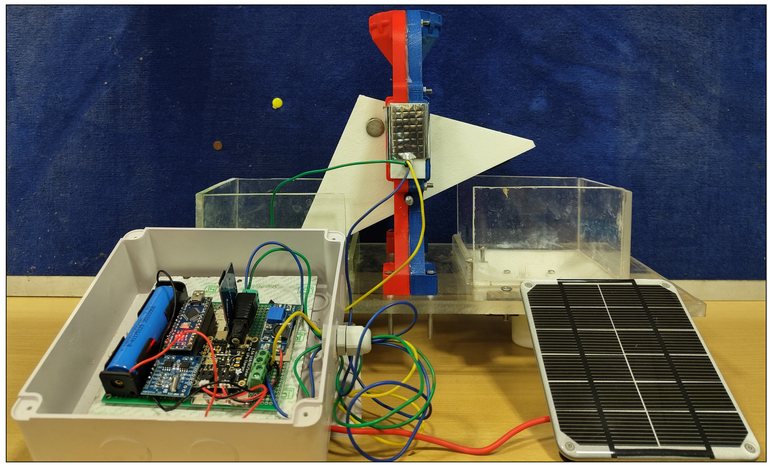


3D Model Render of the Tipping Bucket Flow Gauge



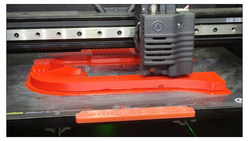
Data Logger firmware Logic Diagram

Development of Instrument



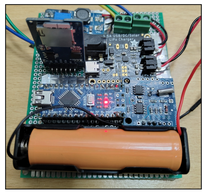
A. DIY Fabrication

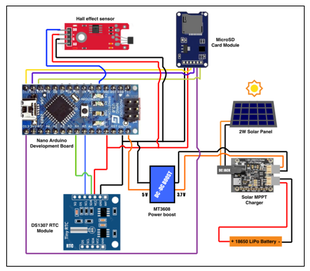
We used Fused Deposition Modelling (FDM) 3D printing technology with PLA+ material. Around 75% of the instrument can be 3D printed using any standard desktop FDM 3D printer and assembled by hand, requiring no advanced technical skills.



FDM 3D Printing on Raise3D

B. DataLogger - Modular Electronics & Open Source





Electronics – Modular approach

The Data logger was built using the following low-cost and easily available modules :

(1) Microcontroller – Nano R3 Arduino Development Board

(2) Sensor – Magnetic Hall effect sensor

(3) 18650 Li-Po 3.7V battery; 2W solar panel

(4) DS1307 RTC (real-time clock)

(5) MicroSD card for data storage and reader

(6) MPPT Solar Charger

(7) MT3608 Power booster

GitHub

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Why use a Hall Sensor?

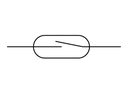
Drawbacks of Reed Sensor

I. Debouncing Error

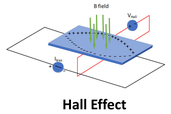
II. EM Interference

III. Limited Life

IV. Issues from Mechanical Shocks and Vibrations



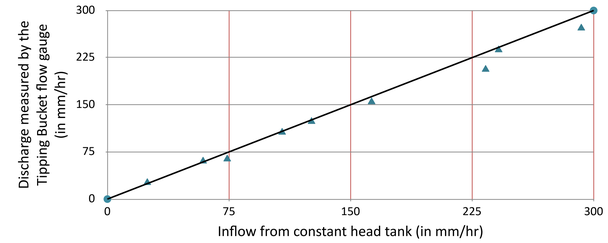
VS



When the Magnet on the Tipping Bucket moves in front of the Hall Sensor, it sends a signal (Interrupt) to the Microcontroller (Nano), which wakes it from sleep mode to record the event. By multiplying the number of tips per second with the calibrated tipping capacity, we can calculate the flow rate.

Results and Applications

A. Performance and Specifications



I. The Instrument demonstrated ⟶ **94.29% accuracy** during preliminary Lab testing.

II. Variable Tipping Resolution ⟶ **10ml - 160ml** (set by adjusting calibration screws)

III. Its wide range of tipping resolutions makes it versatile for many use cases.

IV. It can function as a tipping bucket rain gauge in the 10ml tipping resolution configuration.

B. Low Cost

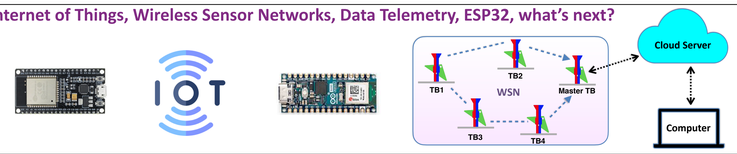
Sl. No.	Description	Unit	Qty.	Unit Cost	Cost in INR	Cost in USD
1.	Rapid prototyping	Hours	100	40/-	4000/-	50/-
2.	Electronic components	Bulk	1	2000/-	2000/-	25/-
3.	Cost of Prototype Field Testing & Miscellaneous	Bulk	1	6000/-	6000/-	75/-
Estimated per unit cost of manufacturing					₹ 12,000/-	**$ 150/-**
Market cost of nearest available solution					₹ 1,39,000/-	**$ 1600/-**

C. Application

New Setup at Hydrological Study Field at Almora, Uttarakhand, India

Way Forward

Internet of Things, Wireless Sensor Networks, Data Telemetry, ESP32, what's next?



Acknowledgements

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