NMHS-Quarterly Progress Report (QPR) – **Pro forma**

Kindly update the NMHS-Quarterly Progress Report (QPR) segregated into following Part-A. Technical Progress and Part-B. Financial Progress, in respect of the Objectives & Quantifiable Deliverables as per the NMHS-Sanction Letter.

NMHS Grant ID:	IITM/NMHS-MoEF/VD/499					Year:	2025
Project Title:	Integrated Machine Learning and Remote Sensing for Real-Time Predictive Modelling of Rainfall-Induced Landslides in Kamand Valley						
PI & Lead Implementing Organization:	Prof. Varun Dutt (PI) and Prof. K V Uday (co-PI), Indian Knowledge System and Mental Health Applications Centre (IKSMHA), Indian Institute of Technology Mandi (IIT Mandi), VPO Kamand, District Mandi, Himachal Pradesh 175005.						
Quarter (please put √):	Qtr. 1	√	Qtr. 2		Qtr. 3		Qtr. 4	
Progress Reporting Period:	from 14.10.2024 to 21.02.2025						
Project Site(s) covered:	Kamand Valley (76.974, 31.759 - 76.994, 31.784)						

Part-A. Technical Progress

(i) Progress against each of the Sanctioned **Objective***

Sanctioned Objectives	Quantifiable Progress against each Objective	*attach* Annexure
Identifying rainfall-induced Landslide-prone Areas through Advanced Geospatial Analysis.	The Interferometric Synthetic Aperture Radar (InSAR) analysis of the Kamand Valley region is in progress using Sentinel-1 satellite data. The appropriate timeline has been established for processing the relevant InSAR data to obtain velocity profiles of the Kamand Valley and identify landslide-prone areas.	Annexure- 1
Development and Deployment of Affordable Landslide Monitoring and Early Warning Systems.	The development of the landslide monitoring systems (LMS) is currently in progress. Once the high-risk areas are approved by the District Disaster Management Authority (DDMA), Mandi, the deployment process will commence.	Annexure- 2
Construction of Comprehensive ML models	Standard machine learning (ML) models have been studied. A reinforcement learning (RL) framework has been developed for landslide prediction. The feasibility of state-of-the-art RL models in landslide prediction has been analyzed, revealing their capability to handle real-time variations in data more effectively than traditional ML models. Initial results show improved accuracy in identifying high-risk areas. Initial pilot studies indicate that RL models are capable of handling the landslide prediction system efficiently and perform better than standard ML models. Further enhancements, optimizations, and testing will be undertaken to improve the model.	Annexure- 3
Real-Time deployment of Refined ML Models	Once the RL models are optimized and finalized, the trained models will be deployed for real-time monitoring and prediction.	-
Execution of Awareness and Educational Workshops	After the deployment of systems, planning for workshops will commence.	-

*As issued in the NMHS-Sanction Letter; also specify the compliance with the General Conditions.

(ii) Progress against each of the Sanctioned **Deliverable** in view of **Monitoring Indicators***

Sanctioned Deliverables	Quantifiable Progress against each Deliverable	*attach* Annexure
(Quarterly Deliverables)		
Task 1: Initiate comprehensive satellite-based analyses to identify landslide-prone areas. **Target:** Complete initial identification of high-risk areas.	The initial InSAR analysis for Kamand Valley has been completed. High-risk areas have been identified, and a request letter was sent to the District Disaster Management Authority, Mandi district, for approval. We are awaiting a response from DDMA, Mandi, to finalize the areas.	Annexure- 1,4
Task 2: Assemble the project team and outline a detailed project plan. **Target:** Complete team assembly and finalize project plan.	The project team has been recruited, consisting of three members: ● Research Associate (1) ● Senior Research Fellow (2) The Research Associate is developing the ML model and managing the project. One Senior Research Fellow is developing the LMS equipment, while the other is working on satellite data and InSAR analysis to obtain velocity profiles and identify high-risk locations.	Annexure- 5
(Overall Project deliverables)		
Deployment of LMS Systems	The landslide monitoring systems are currently in development and will be installed in high-risk areas of Kamand Valley as approved by the DDMA, Mandi.	Annexure- 2
Data Collection and Analysis	Real-time analysis of satellite-based subsidence velocity profiles has been obtained from Sentinel-1 satellite data. Since the initial study is still ongoing, a sample dataset from Jan to Feb 2024 has been collected and analysed, from which the velocity profiles have been obtained.	Annexure- 1
Predictive Model Development	Reinforcement Learning framework for landslide prediction has been developed, utilizing ground-based sensors to predict movements. Four standard state-of-the-art RL models—Deep Q-Network (DQN), Actor-Critic Method, Advantage Actor-Critic Method (A2C), and Proximal Policy Optimization (PPO)—have been developed for landslide prediction. Experimental results demonstrate that DQN significantly outperforms other RL models, achieving superior accuracy, precision, recall, F1-score, and PR-AUC metrics.	Annexure -3
Community Engagement	Educational seminars and workshops for local communities will be conducted after the deployment of the landslide monitoring systems in the identified areas.	-

Reporting and Documentation	A research paper titled *"An Empirical Investigation of Reinforcement Learning Models for Landslide Prediction: A Case Study in the Himalayan Region*" has been submitted to ACM PETRA 2025 (The 18th Conference on Pervasive Technologies Related to Assistive Environments). Feedback from the review committee is anticipated within the next quarter, and based on the outcomes, necessary revisions and enhancements will be incorporated before final publication.	Annexure -6

*As issued in the NMHS-Sanction Letter; also specify the compliance with the General Conditions.

(iii) Progress against **Data**, **Demonstration**, & **Publication**

Particulars	Description with Quantification	*attach* Annexure
• Baseline and Database *collected*:	A sample dataset of 10GB has been collected from Sentinel-1 satellite data spanning Jan to feb 2024. Velocity profiles have been obtained.	Annexure -1
• Models *demonstrated*:	Four RL models (DQN, Actor-Critic, A2C, PPO) have been developed and tested for landslide prediction. The DQN model demonstrated superior accuracy.	Annexure-3
• Trainings/ Workshops *conducted*:	Seminars and workshops for local communities will be planned after the deployment of the landslide monitoring systems in the approved areas.	-
• Knowledge Products *prepared*:	A research paper has been submitted to ACM PETRA 2025 detailing the application of RL models for landslide prediction in the Himalayan region.	Annexure-6

(iv) **Beneficiaries** & **Stakeholders**

Beneficiaries/ Stakeholders:	Total	Women	Youths	SC	ST	Farmers/HHs	Collaborations
	11	01	08	02	00	00	01

Part-B. Financial Progress

(i) **Expenditure** under each Budget Head

S#	Standard Budget Heads	Fund Sanctioned	Quarterly Expenditure	% Fund Utilization*	*Remarks, if any*
1.	Professional Services[1]	6425240	4,30,245	6.69	
2.	Training Expenses[2]	576000	0.00	0.00	
3.	Domestic Travel Expenses[3]	300000	0.00	0.00	
4.	Office Expenses[4]	200000	31,248	15.62	
5.	Printing and Publication[5]	400000	50,000	12.50	
6.	Digital Equipment[6]	898760	0.00	0.00	The equipment is in the procurement stage
7.	Materials and Supplies[7]	1200000	0.00	0.00	
	Total	10000000	5,11,493	5.11	

*Percent (%) fund utilization of the total grant sanctioned under each prescribed budget head by NMHS-PMU.

(ii) **Project Staff** Information:

S#.	Project Staff *deployed*	Designation	Fellowship/ Emoluments (paid @/ mo)	*Remarks, if any*
1.	Dr. Mirothali Chand C	Research Associate - 3	₹67,000+ 9% HRA	
2.	Mr.Sahil Sankhyan	Senior Research Fellow	₹42,000+ 9% HRA	
3.	Ms.Sangeeta	Senior Research Fellow	₹42,000+ 9% HRA	

Note: Kindly take note of the following budget components into consideration to fill the details adequately:

[1] ***Professional Services:*** Hiring charges to various services/ expertise of Govt. and Non-Govt. Institutions, Organizations for conducting Mission activities, and salary of consultants and others NMHS professional staff and payment to other departments for service rendered, Overheads. Number of manpower along with the designation and per month salary should be enlisted and submitted separately.

[2] ***Training Expenses:*** Capacity Building and Training Programs, workshops, extension programs through State Govt. agencies.

[3] ***Domestic Travel Expenses:*** Traveling expenses during the professional services, field visit for various projects sites, and meetings.

[4] ***Office Expenses:*** Recurring and non-recurring contingent expenses, Stationary charges, other Office expenses and Contingency expenses during implementation of various activities, Minor office equipment, Office assistant and Data Entry Operators.

[5] ***Printing and Publication:*** Printing and publication of the books, manuals, papers, etc.

[6] ***Digital Equipment:*** Hardware & software, Minor equipment, etc.

[7] ***Materials and Supplies:*** Lab supplies and materials store, such a light and sound systems, demonstrations models, pilot plant, educations supplies, agricultural supplies, chemical and glassware, spare parts and supplies and goods. A separate list along with per item cost with justification should be mentioned separately.

Annexure - 1

Interferometric Synthetic Aperture Radar (InSAR) analysis of Kamand Valley

Single look complex (SLC) data of January to February 2024 was collected for processing of SAR images and their respected Digital elevation model was also downloaded according to the area of interest provided. Small Baseline Subset (SBAS) technique used to measure surface deformation over time and Persistent Scatterer (PS) is used to analyze stable, highly reflective ground points (e.g., buildings, rocks, infrastructure) across multiple SAR images to measure long-term surface deformation with millimeter-level precision. Line-of-Sight (LOS) velocity refers to the rate of displacement along the radar's viewing direction measured in mm/year and indicates whether a point on the ground is moving toward or away from the satellite.

Define Sentinel-1 SLC Scenes and Processing Parameters

Descending Orbit Configuration

https://search.asf.alaska.edu/#/?polygon=POINT(72.66%2038.25)&start=2017-05-11T00:00:01Z&end=2017-12-25T23:59:59Z&productTypes=SLC&resultsLoaded=true&zoom=7.131&center=74.457,35.638&path=5-5&frame=466-466

```
[ ]  # The subswath is required for partial scene downloads and is not used for burst downloads.
     # The orbit is used to define directory names.
     ORBIT    = 'D'
     SUBSWATH = 2
     REFERENCE = '2024-01-08'
```

```
[ ]  # SCENES = """
     # S1A_IW_SLC__1SDV_20240225T005141_20240225T005209_052708_06609F_CDEB
     # S1A_IW_SLC__1SDV_20240120T005142_20240120T005210_052183_064ED6_5822
     # S1A_IW_SLC__1SDV_20240108T005142_20240108T005210_052008_0648EF_351A
     # """
     # SCENES = list(filter(None, SCENES.split('\n')))
     # print (f'Scenes defined: {len(SCENES)}')
```

Figure 1: SLC samples of Jan to Feb 2024

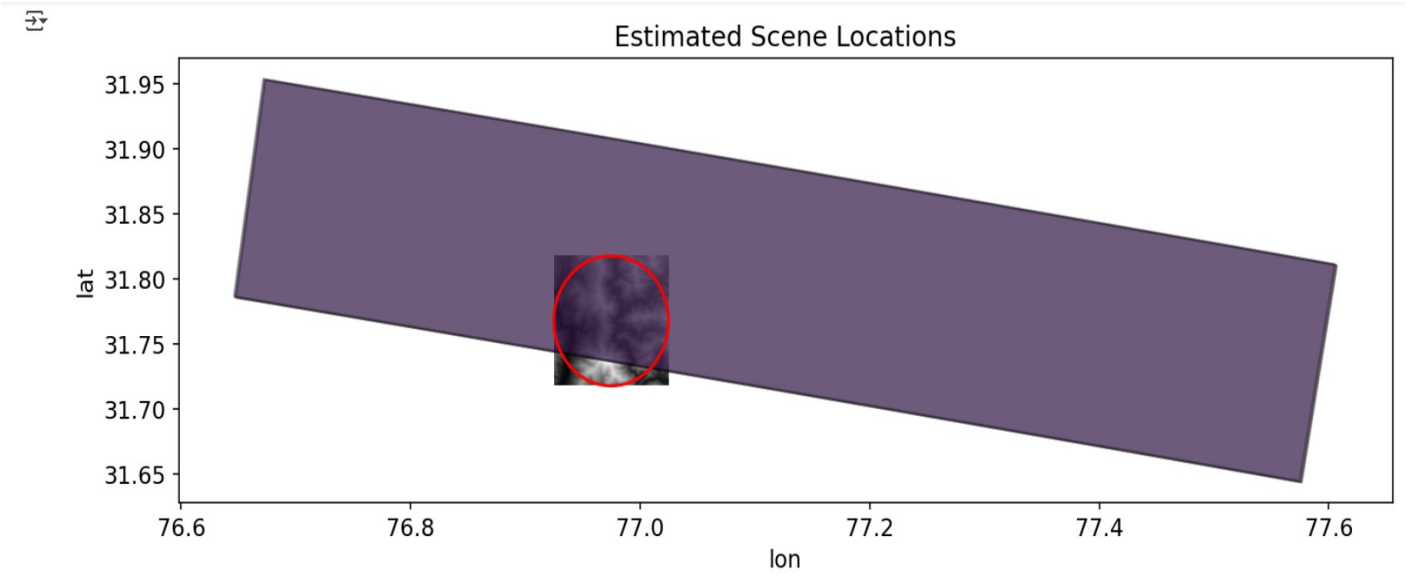


Figure 2: Digital elevation model of Jan to Feb 2024

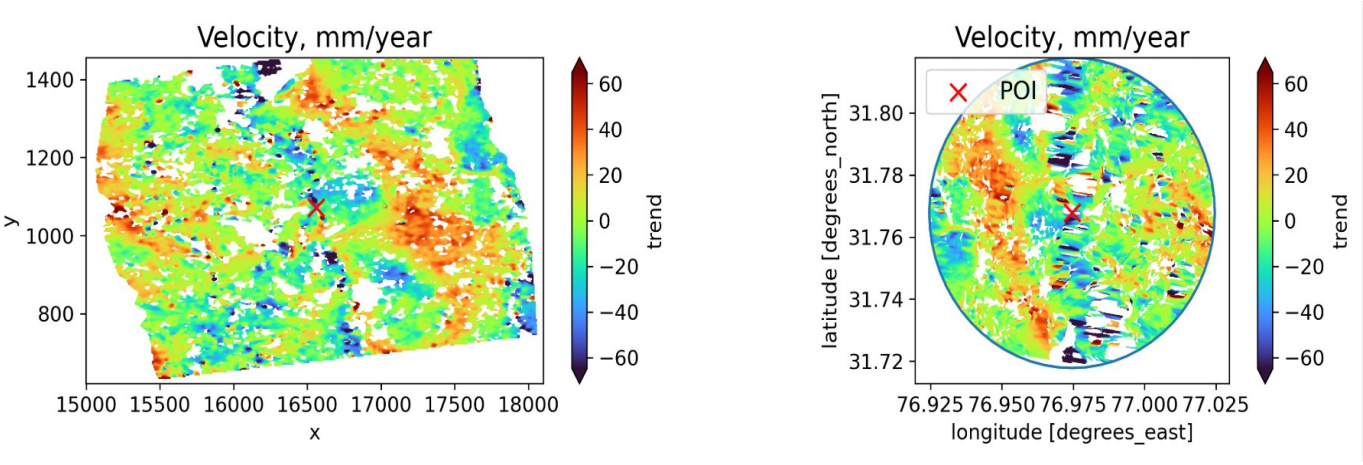


Figure 3: SBAS LOS velocity 2024

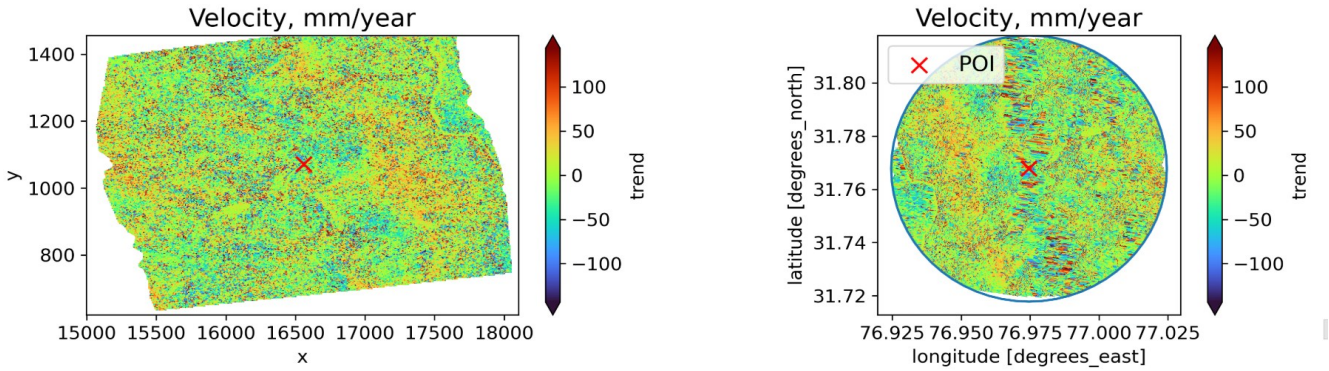


Figure 4: PS LOS velocity 2024

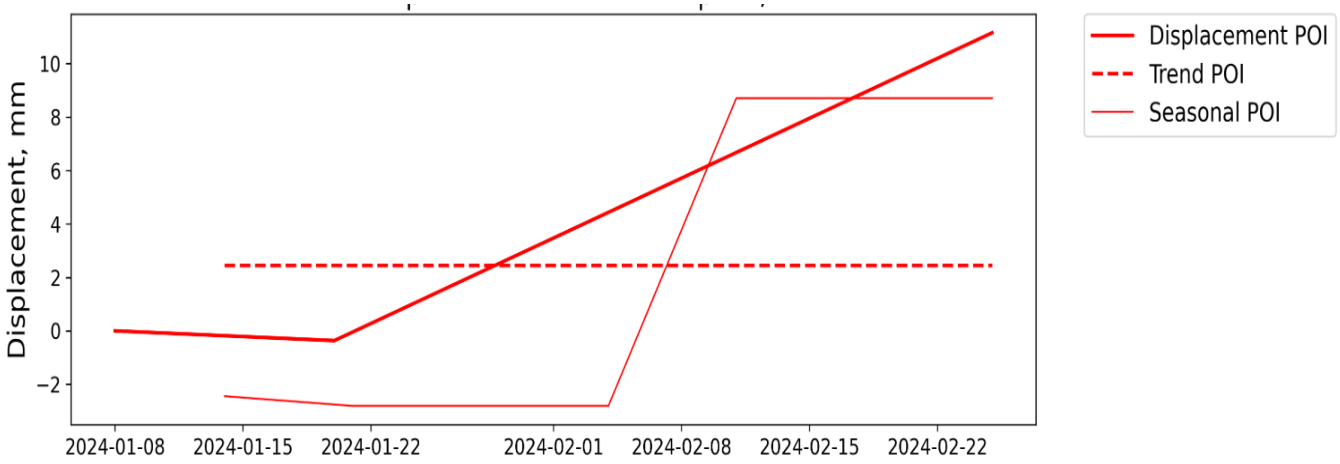


Figure 5: PS LOS displacement STL decompose 2024

```python
from scipy.spatial import cKDTree

# Define the target date and coordinates
target_date = "2024-01-08"  # Example date
target_lat, target_lon = 31.7678, 76.9746  # Example latitude & longitude

# Convert date column to datetime format
df_timeseries["date"] = pd.to_datetime(df_timeseries["date"])

# Filter data for the specific date
df_filtered = df_timeseries[df_timeseries["date"] == target_date]

# If no data is found for the exact date, find the closest date
if df_filtered.empty:
    closest_date = df_timeseries["date"].iloc[(df_timeseries["date"] - pd.to_datetime(target_date)).abs().argmin()]
    df_filtered = df_timeseries[df_timeseries["date"] == closest_date]
    print(f"⚠️ Exact date not found. Using closest date: {closest_date}")

# Convert lat/lon to numpy array for fast searching
coords = df_filtered[["lon", "lat"]].to_numpy()
displacements = df_filtered["displacement"].to_numpy()

# Build KDTree for nearest-neighbor search
tree = cKDTree(coords)

# Find nearest displacement value to the target lat/lon
_, idx = tree.query([target_lon, target_lat])
disp_value = displacements[idx]

print(f"📍 Displacement on {target_date} at ({target_lat}, {target_lon}): {disp_value:.3f} mm")
```

```
📍 Displacement on 2024-01-08 at (31.7678, 76.9746): 0.000 mm
```

Figure 6: Displacement code and output on lat long (76.97 31.76)

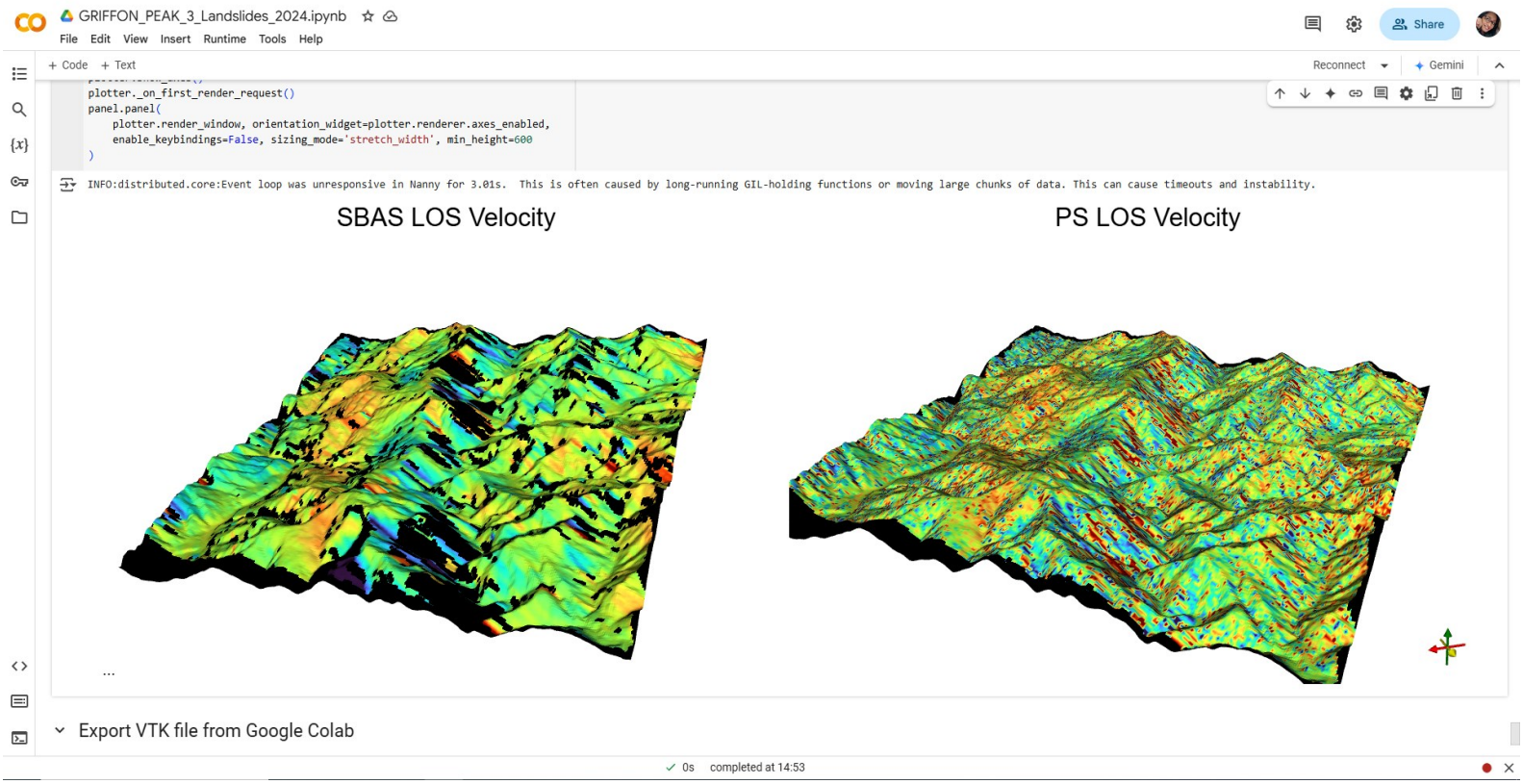


Figure 7: 3D map of SBAS and PS LOS velocities

Annexure - 2

Figure 1: Landslide Monitoring & Early Warning System - Front view

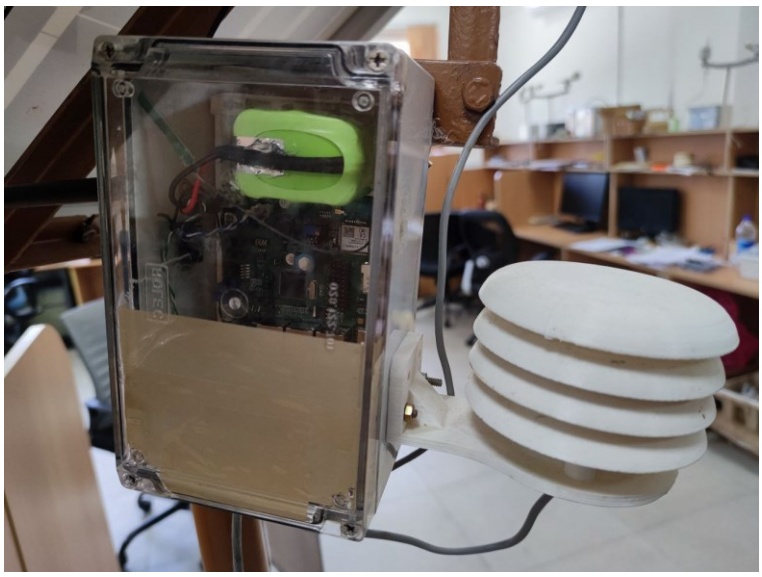


Figure 2: Sensor of LMS - Front view

Annexure – 3

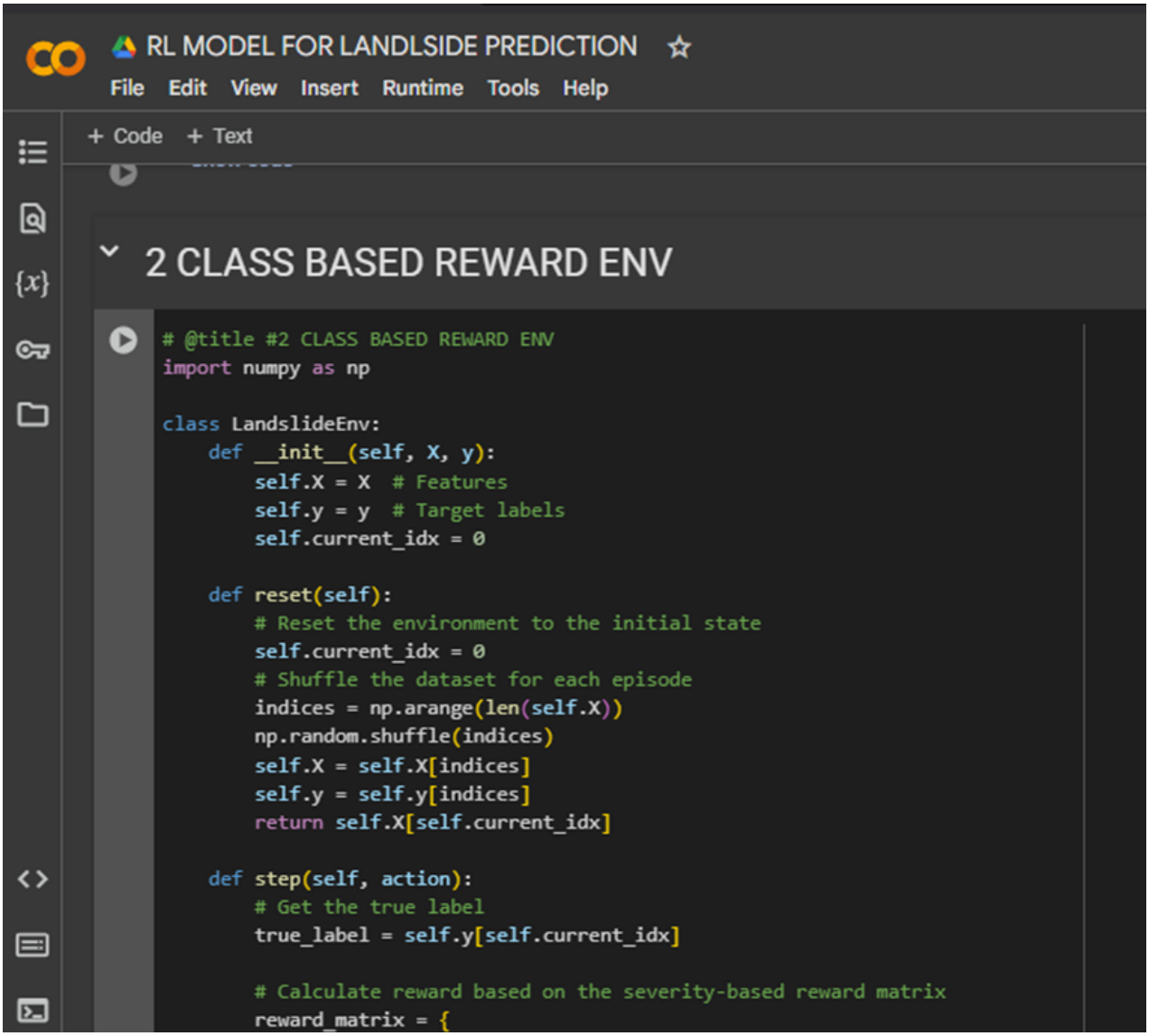


Figure 1: Sample of Reinforcement Learning framework Implementation

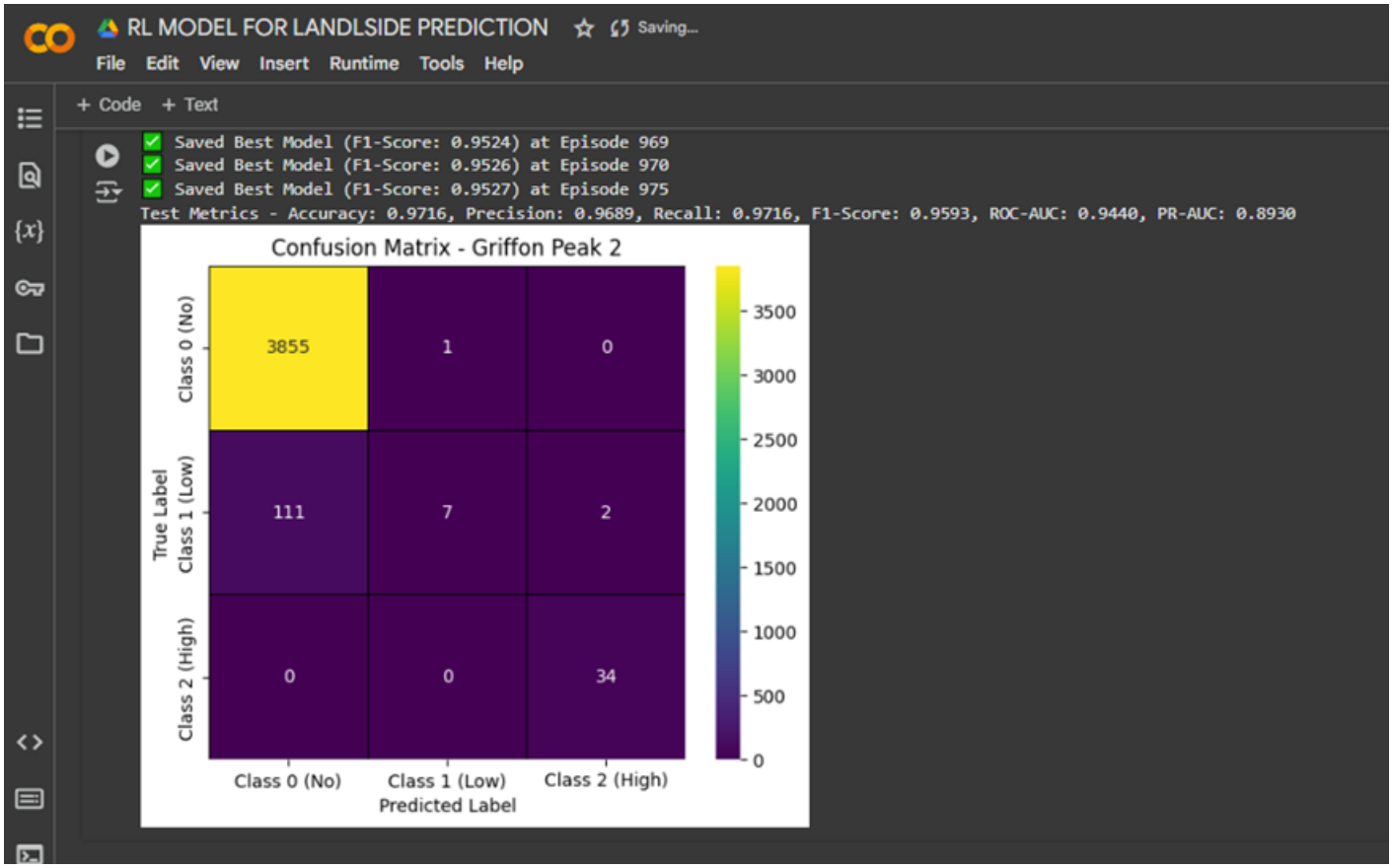


Figure 2: Sample results of the Deep-Q-Network model

Annexure - 4

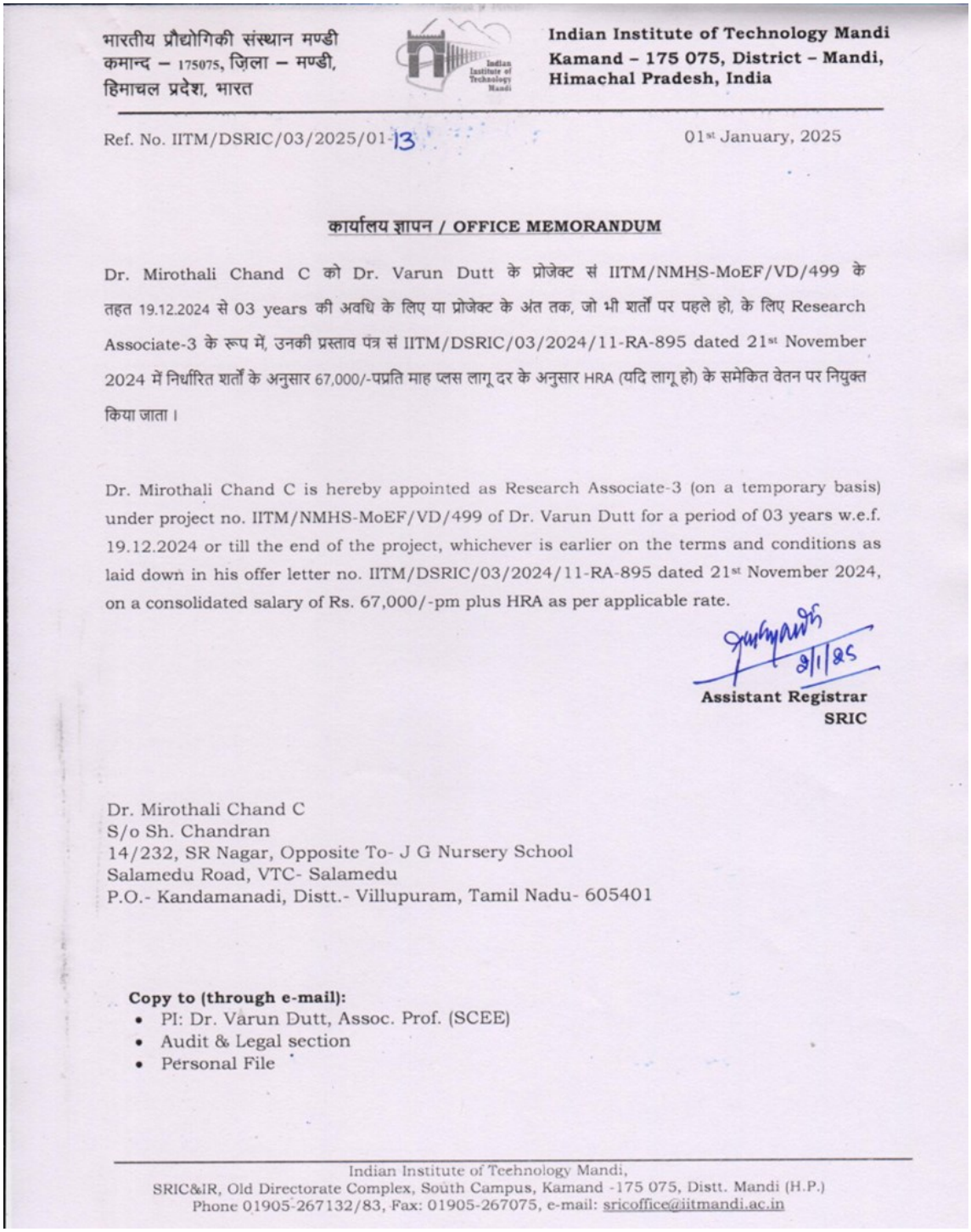
Mail to District Disaster Management Authority (DDMA), Mandi

Letter to DDMA, Mandi - Landslide NMHS Project

Annexure - 5

Appointment Letters of the Project Staff members

1. **Dr. Mirothali Chand C:** *Research Associate -3*



भारतीय प्रौद्योगिकी संस्थान मण्डी
कमान्द – 175075, ज़िला – मण्डी,
हिमाचल प्रदेश, भारत

Indian Institute of Technology Mandi
Kamand – 175 075, District – Mandi,
Himachal Pradesh, India

Ref. No. IITM/DSRIC/03/2025/01-13

01st January, 2025

कार्यालय ज्ञापन / OFFICE MEMORANDUM

Dr. Mirothali Chand C को Dr. Varun Dutt के प्रोजेक्ट सं IITM/NMHS-MoEF/VD/499 के तहत 19.12.2024 से 03 years की अवधि के लिए या प्रोजेक्ट के अंत तक, जो भी शर्तों पर पहले हो, के लिए Research Associate-3 के रूप में, उनकी प्रस्ताव पत्र सं IITM/DSRIC/03/2024/11-RA-895 dated 21st November 2024 में निर्धारित शर्तों के अनुसार 67,000/-पप्रति माह प्लस लागू दर के अनुसार HRA (यदि लागू हो) के समेकित वेतन पर नियुक्त किया जाता।

Dr. Mirothali Chand C is hereby appointed as Research Associate-3 (on a temporary basis) under project no. IITM/NMHS-MoEF/VD/499 of Dr. Varun Dutt for a period of 03 years w.e.f. 19.12.2024 or till the end of the project, whichever is earlier on the terms and conditions as laid down in his offer letter no. IITM/DSRIC/03/2024/11-RA-895 dated 21st November 2024, on a consolidated salary of Rs. 67,000/-pm plus HRA as per applicable rate.

3/1/25

Assistant Registrar
SRIC

Dr. Mirothali Chand C
S/o Sh. Chandran
14/232, SR Nagar, Opposite To- J G Nursery School
Salamedu Road, VTC- Salamedu
P.O.- Kandamanadi, Distt.- Villupuram, Tamil Nadu- 605401

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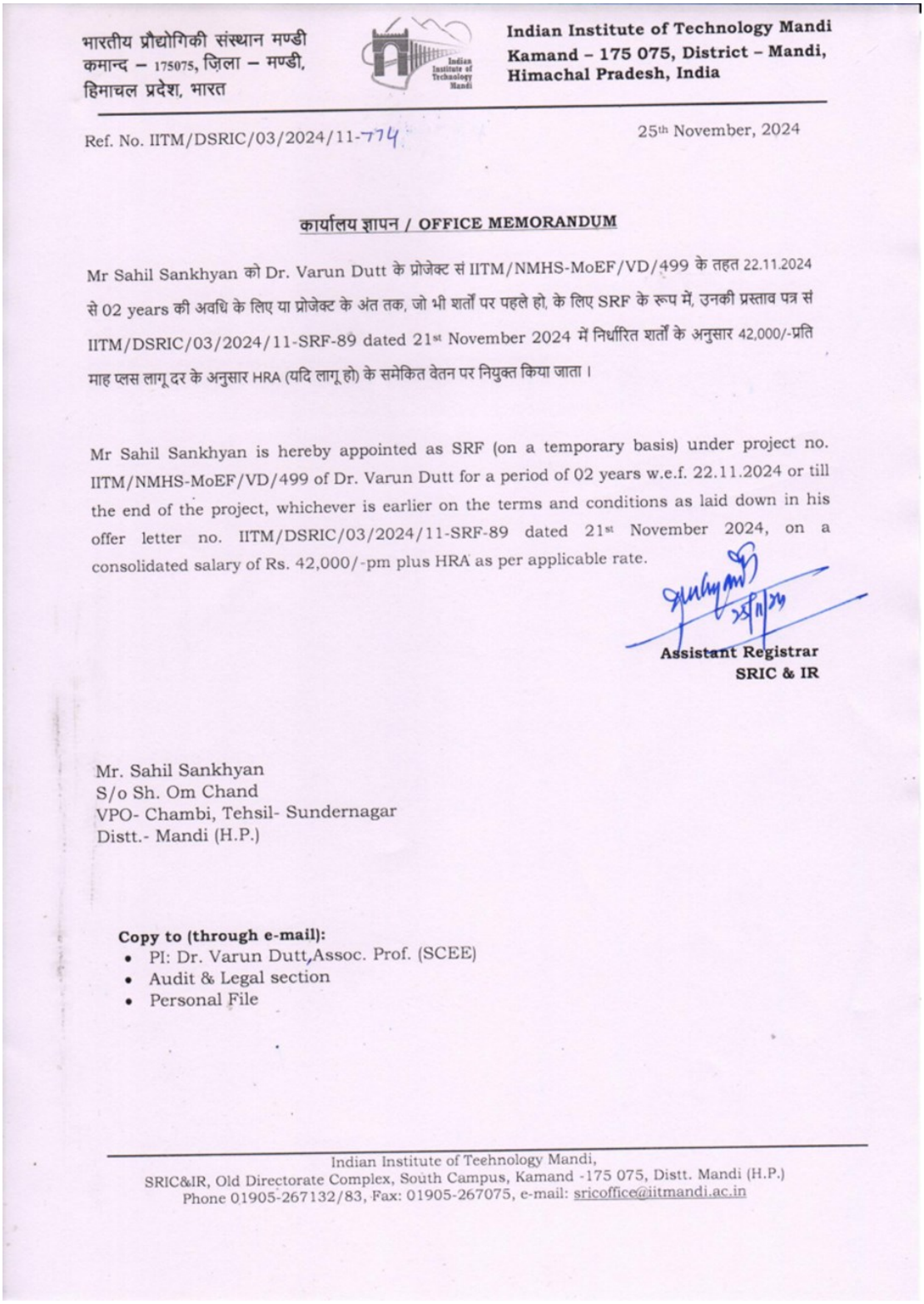
SRIC&IR, Old Directorate Complex, South Campus, Kamand -175 075, Distt. Mandi (H.P.)
Phone 01905-267132/83, Fax: 01905-267075, e-mail: sricoffice@iitmandi.ac.in

2. Mr. Sahil Sankhyan: *Senior Research Fellow*



भारतीय प्रौद्योगिकी संस्थान मण्डी
कमान्द – 175075, ज़िला – मण्डी,
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Indian Institute of Technology Mandi
Kamand – 175 075, District – Mandi,
Himachal Pradesh, India

Ref. No. IITM/DSRIC/03/2024/11-774

25th November, 2024

कार्यालय ज्ञापन / OFFICE MEMORANDUM

Mr Sahil Sankhyan को Dr. Varun Dutt के प्रोजेक्ट सं IITM/NMHS-MoEF/VD/499 के तहत 22.11.2024 से 02 years की अवधि के लिए या प्रोजेक्ट के अंत तक, जो भी शर्तों पर पहले हो, के लिए SRF के रूप में, उनकी प्रस्ताव पत्र सं IITM/DSRIC/03/2024/11-SRF-89 dated 21st November 2024 में निर्धारित शर्तों के अनुसार 42,000/-प्रति माह प्लस लागू दर के अनुसार HRA (यदि लागू हो) के समेकित वेतन पर नियुक्त किया जाता।

Mr Sahil Sankhyan is hereby appointed as SRF (on a temporary basis) under project no. IITM/NMHS-MoEF/VD/499 of Dr. Varun Dutt for a period of 02 years w.e.f. 22.11.2024 or till the end of the project, whichever is earlier on the terms and conditions as laid down in his offer letter no. IITM/DSRIC/03/2024/11-SRF-89 dated 21st November 2024, on a consolidated salary of Rs. 42,000/-pm plus HRA as per applicable rate.

25/11/24

Assistant Registrar
SRIC & IR

Mr. Sahil Sankhyan
S/o Sh. Om Chand
VPO- Chambi, Tehsil- Sundernagar
Distt.- Mandi (H.P.)

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Phone 01905-267132/83, Fax: 01905-267075, e-mail: sricoffice@iitmandi.ac.in

3. Ms. Sangeeta: *Senior Research Fellow*

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Ref. No. IITM/DSRIC/03/2025/01-97

27th January, 2025

कार्यालय ज्ञापन / OFFICE MEMORANDUM

Ms. Sangeeta को Dr. Varun Dutt के प्रोजेक्ट सं IITM/NMHS-MoEF/VD/499 के तहत 22.01.2025 से 03 years की अवधि के लिए या प्रोजेक्ट के अंत तक, जो भी शर्तों पर पहले हो, के लिए Senior Research Fellow (SRF) के रूप में, उनकी प्रस्ताव पत्र IITM/DSRIC/03/2025/01-SRF-913 dated 10th January 2025 में निर्धारित शर्तों के अनुसार 42,000/-प्रति माह प्लस लागू दर के अनुसार HRA (यदि लागू हो) के समेकित वेतन पर नियुक्त किया जाता

Ms. Sangeeta is hereby appointed as Senior Research Fellow (SRF) (on a temporary basis) under project no. IITM/NMHS-MoEF/VD/499 of Dr. Varun Dutt for a period of 03 years w.e.f. 22.01.2025 or till the end of the project, whichever is earlier on the terms and conditions as laid down in her offer letter no. IITM/DSRIC/03/2025/01-SRF-913 dated 10th January 2025, on a consolidated salary of Rs. 42,000/-pm plus HRA as per applicable rate.

Assistant Registrar
SRIC

Ms. Sangeeta
D/o Sh. Ramesh Chander
VPO & Tehsil- Narnaund
Ward no.09, Distt.- Hisar
Haryana- 125039

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- Audit & Legal section
- Personal File

Indian Institute of Technology Mandi,
SRIC&IR, Old Directorate Complex, South Campus, Kamand -175 075, Distt. Mandi (H.P.)
Phone 01905-267132/83, Fax: 01905-267075, e-mail: sricoffice@iitmandi.ac.in

Annexure - 6

Research article submitted to the Pervasive Technologies Related to Assistive Environments (PETRA) 2025 conference

PETRA_2025_paper_87.pdf