

Empowering Disaster Resilience: Community-Centered and Social Applications of Autonomous Aerial Rescue Vehicles in Disasters

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Abstract:

The integration of autonomous aerial rescue vehicles (AARVs) in India's border regions represents a transformative leap forward in disaster response and humanitarian assistance. This research highlights the immense potential of AARVs to significantly enhance community well-being, social governance and disaster management system by addressing critical needs in disaster preparedness, response, and recovery, particularly in remote and vulnerable areas. These regions often face logistical challenges that hinder timely assistance during emergencies, making the deployment of AARVs a crucial innovation. By integrating AARVs into local emergency management systems, communities can improve their resilience, self-reliance, and safety during natural disasters and crises. Beyond their role in disaster response, AARVs offer diverse applications that can positively impact underserved regions. This study explores how these advanced systems can also be utilized in sustainable agricultural practices, such as crop monitoring and pest control, as well as in public health initiatives, including medical supply delivery and disease surveillance. Furthermore, the research examines the potential of AARVs to address daily challenges, providing scalable and sustainable solutions to improve the quality of life in these areas. Ultimately, this study aims to develop a comprehensive framework for the adoption of AARVs, fostering community development and empowering marginalized regions through technological innovation.

Keywords: Autonomous aerial rescue vehicle, social governance, disaster management system, crucial innovation, sustainable practices, urban centres, logistical challenges, environmental monitoring and conservation.

1. Introduction:

India's border regions face heightened vulnerability to a variety of natural disasters, including avalanches, floods, landslides, and earthquakes. The challenging topography of these areas, coupled with insufficient infrastructure, exacerbates the impact of such disasters, often leaving communities isolated and delaying critical relief efforts. Traditional disaster response mechanisms, reliant on ground transportation and limited aerial resources, frequently prove inadequate to address the urgent needs of affected populations in these remote and inaccessible regions [1].

Autonomous Aerial Rescue Vehicles (AARVs) emerge as a transformative solution in this context [2]. With their ability to navigate difficult terrains, AARVs can deliver vital aid, conduct search and rescue operations, and assess damage in real-time, even in the most inhospitable environments [3]. Their agility and adaptability make them uniquely suited for disaster management in India's border regions. Beyond immediate disaster response, AARVs offer broader community applications, such as routine transportation of medical supplies, communication equipment, and essential goods to remote areas, thereby strengthening local infrastructure and resilience. However, ensuring these innovations align with grassroots needs requires a community-centered approach, integrating traditional knowledge systems and local capacity-building.

This paper explores the integration of AARVs not only as tools for disaster response but also as catalysts for community-led initiatives. By involving local communities in the deployment and maintenance of these vehicles, a participatory approach to disaster resilience is promoted. Such engagement empowers communities, fostering a sense of ownership and enhancing their capacity to manage crises effectively [4]. The study underscores the dual role of AARVs in bridging gaps in disaster management and contributing to sustainable local development in India's vulnerable border regions.

2. Community-Centered and Social Applications of AARVs:

2.1 Disaster Preparedness and Response:

Autonomous Aerial Rescue Vehicles (AARVs) have the potential to revolutionize disaster management and community resilience, significantly improving preparedness, response, and well-being across various sectors[5]. These innovative systems empower communities to tackle emergencies more effectively by enhancing their operational capabilities. In the realm of disaster preparedness, AARVs can serve as critical tools for training and equipping local populations. Communities can be educated on operating and maintaining these vehicles, fostering self-reliance and readiness. This knowledge allows for rapid reconnaissance, timely evacuations, and efficient delivery of supplies during emergencies, ultimately reducing response times and enhancing outcomes [6]. For example, in regions prone to flooding, AARVs equipped with advanced sensors and real-time monitoring technologies can provide invaluable assistance. These vehicles can survey vast areas quickly, helping volunteers identify high-risk zones and implement preventive measures to mitigate damage as shown in **Figure 1**. This proactive approach not only minimizes the impact on property and infrastructure but also plays a crucial role in saving lives [7].

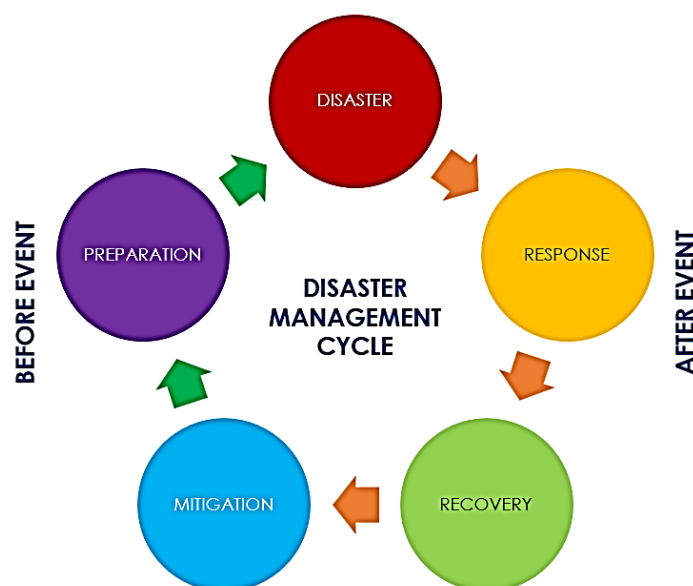


Figure 1. Disaster Management Cycle (Source: Created by Author¹).

Additionally, AARVs can streamline emergency logistics, particularly in resource-constrained or inaccessible areas. Local organizations can deploy these vehicles to establish and manage emergency supply chains, ensuring essential goods such as food, water, and medical supplies reach affected populations promptly and equitably [8]. The ability of AARVs to bypass traffic and navigate challenging terrains makes them especially effective in densely populated urban centres and remote rural areas.

By integrating AARVs into disaster response frameworks, communities can build a more resilient future[9]. These vehicles empower individuals and organizations to respond swiftly and effectively to crises, fostering a sense of preparedness and solidarity. Beyond disaster management, the applications

of AARVs in improving resource distribution and infrastructure monitoring underscore their transformative potential in enhancing community well-being and resilience [10].

2.2 Agricultural and Livelihood Support:

Autonomous Aerial Rescue Vehicles (AARVs) hold immense potential to revolutionize agriculture and livelihood support by addressing critical challenges in these sectors with precision and efficiency. In precision farming, AARVs enable farmers to monitor their crops in real-time, identifying threats like pests, diseases, or insufficient irrigation [11]. Equipped with advanced imaging technologies such as multispectral or thermal cameras, they can detect early signs of crop stress, ensuring timely interventions that prevent significant losses and enhance productivity. This capability is particularly transformative in rural or remote areas, such as border villages, where traditional methods of field inspection are labour-intensive and often insufficient for large tracts of farmland[12]. By providing detailed and accurate data, AARVs empower farmers to make informed decisions that optimize yields while minimizing resource wastage as shown in **Figure 2**.

Beyond crop management, AARVs can also play a vital role in livestock management. They can monitor the movement and health of animals, offering a reliable solution in regions where manual tracking is logistically difficult or labour-intensive [13]. By using AARVs to observe grazing patterns, detect injuries or illnesses, and even prevent theft, livestock owners can enhance their operational efficiency and animal welfare.



Figure 2. AARVs playing vital role in Agricultural sector (Source: Created by Author¹).

In the aftermath of natural disasters, the capabilities of AARVs extend to damage assessment in agricultural landscapes. By rapidly surveying affected areas, AARVs can identify the extent of crop and infrastructure damage, providing critical data that helps governments and aid organizations deliver targeted recovery assistance [14]. This timely intervention can significantly alleviate the financial and emotional burdens faced by farmers, enabling them to rebuild their livelihoods more effectively. Overall, the integration of AARVs in agriculture and livelihood support not only enhances operational precision but also strengthens resilience against adversities, making them an invaluable tool for sustainable development in rural and disaster-prone regions [15].

2.3 Public Health Initiatives:

Public health initiatives stand to gain significantly from the integration of Autonomous Aerial Rescue Vehicles (AARVs), which offer innovative solutions to some of the most pressing healthcare challenges. AARVs can play a transformative role by delivering medical supplies to regions that are otherwise difficult to access due to geographical or infrastructural barriers. This capability becomes especially vital during natural disasters, conflicts, or in remote rural areas where traditional supply

chains are disrupted or non-existent [16]. Furthermore, AARVs can bolster vaccination campaigns by ensuring the timely distribution of vaccines, especially in underserved areas, thus enhancing the reach and efficiency of immunization programs.

During health crises, AARVs have demonstrated their potential by transporting critical medicines, diagnostic kits, and protective equipment to isolated communities. For instance, pilot projects conducted across various countries have successfully showcased the use of AARVs to overcome logistical hurdles, ensuring that essential medical resources reach those in urgent need [5], [17]. This technology not only saves time but also reduces the dependency on ground-based transportation systems, which can be hindered by factors such as traffic congestion, poor road conditions, or natural obstacles.

Moreover, in emergencies, AARVs can facilitate the rapid evacuation of critically ill or injured patients from remote locations to advanced medical facilities. By bridging the gap in healthcare accessibility, AARVs can address long-standing inequities in emergency medical response, thereby improving survival rates and health outcomes [12]. These advantages underscore the potential of AARVs to revolutionize public health delivery and emergency care, particularly in areas with limited infrastructure as shown in **Figure 4**.



Figure 4. AARVs delivering medical supplies to a particular area.

2.4 Education and Skill Development:

Autonomous Aerial Rescue Vehicles (AARVs) not only revolutionize disaster response but also hold immense potential for transforming education and skill development. Integrating AARV technology into school curriculums can ignite interest in cutting-edge fields such as robotics, artificial intelligence (AI), and aeronautics among students [18]. By introducing hands-on learning experiences and workshops, schools can inspire the next generation of innovators, fostering a culture of curiosity and problem-solving [19]. This exposure could lead to the development of a skilled workforce adept in emerging technologies, critical for shaping the future of industries.

Community-based AARV initiatives also provide significant opportunities for local employment and economic growth. Establishing programs for the manufacturing, maintenance, and operation of AARVs creates a variety of job roles, ranging from skilled technicians to operational managers. Such initiatives can empower communities by equipping individuals with specialized skills, leading to sustainable livelihoods [20]. For instance, in disaster-prone regions, a cooperative might manage a fleet of AARVs, offering their services to nearby areas. This model not only enhances disaster resilience but also transforms communities into hubs of technological advancement and self-reliance.

Moreover, the establishment of AARV-based ecosystems could stimulate local economies by attracting investments and fostering small-scale industries. By enabling regions to develop expertise in a high-tech domain, AARVs have the potential to bridge technological gaps and promote inclusivity.

Thus, AARVs go beyond their immediate utility in rescue operations, emerging as a tool for community empowerment, education, and economic development.

2.5 Environmental Monitoring and Conservation:

Environmental conservation and monitoring have emerged as crucial applications for Autonomous Aerial Rescue Vehicles (AARVs). These advanced technologies play an integral role in safeguarding ecosystems, promoting biodiversity, and addressing ecological challenges [21]. AARVs are well-equipped to track wildlife movements, offering valuable insights into animal behaviours, migration patterns, and habitat utilization. This capability is particularly significant for protecting endangered species, enabling researchers and conservationists to intervene promptly in cases of threats such as poaching, habitat encroachment, or environmental changes. By providing real-time data, AARVs empower wildlife conservation efforts with increased precision and efficiency.

Beyond wildlife monitoring, AARVs are instrumental in observing landscapes for early signs of erosion, deforestation, or other environmental changes [22]. Their ability to survey vast and remote terrains ensures timely identification of ecological risks, allowing for swift mitigation strategies. Communities residing in ecologically sensitive areas, such as rainforests, wetlands, or mountainous regions, can leverage AARV technology to proactively address environmental challenges. By integrating these systems into local conservation initiatives, they can enhance resilience against natural and human-induced disruptions [23].

For instance, a Himalayan village might deploy AARVs to monitor glacial dynamics and track melting patterns. This data is critical for understanding the long-term impacts of climate change and preparing for associated risks, such as glacial lake outburst floods. By providing an aerial perspective, AARVs can significantly enhance disaster risk reduction efforts, ensuring timely alerts and facilitating informed decision-making. Furthermore, their ability to operate sustainably and with minimal environmental impact aligns with the principles of sustainable development[24]. Thus, AARVs represent a transformative tool in bridging technological innovation with ecological stewardship, offering scalable and effective solutions for environmental conservation and monitoring across diverse landscapes as shown in **Figure 5**.

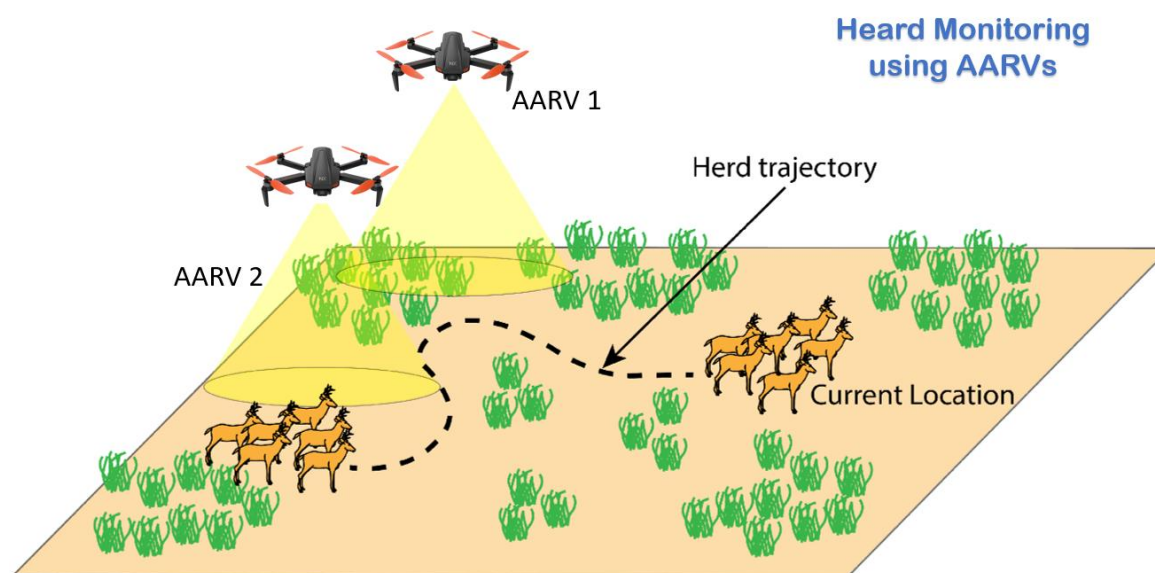


Figure 5. Heard Monitoring using AARVs (Source: Created by Author¹).

Thus, by integrating AARVs into these various aspects of daily life, communities not only enhance their disaster resilience but also unlock new opportunities for growth and self-reliance, transforming their socio-economic landscape.

3. Challenges and Solutions for Community Use:

3.1 Affordability and Accessibility:

The integration of Autonomous Aerial Rescue Vehicles (AARVs) into community systems presents several challenges that must be addressed for their effective deployment. One significant obstacle is affordability and accessibility. The substantial initial costs of acquiring and maintaining AARVs can be prohibitive for numerous rural or underserved communities [25]. To overcome this, governments and private stakeholders can implement subsidies, public-private partnerships, or microfinancing schemes that mitigate financial barriers and enhance the accessibility of this technology to grassroots users.

3.2 Skill Development:

Skill development constitutes another major challenge. Operating and maintaining AARVs requires technical expertise that is often lacking in rural areas. Communities must invest in building local capacity through training programs and workshops that focus on AARV operations, troubleshooting, and basic repairs. Establishing regional training centres and collaborating with educational institutions can ensure that community members acquire the necessary skills to utilize AARVs effectively [26].

3.3 Infrastructure Constraints:

Infrastructure constraints also pose significant difficulties, particularly in remote areas where charging stations and maintenance facilities are sparse or non-existent. Mobile charging units and regional maintenance hubs can be established to support AARV operations in such locations. Additionally, integrating renewable energy solutions, such as solar-powered charging stations, could address the lack of reliable electricity in remote regions.

3.4 Regulatory and Security Concerns:

Regulatory and security concerns further complicate the deployment of AARVs. The legal framework governing the use of autonomous vehicles is still evolving, and communities may face challenges navigating complex regulations. Moreover, ensuring the safety and security of AARVs, particularly in sensitive border areas, is critical to prevent misuse or interception. Simplified regulatory processes and clear guidelines, coupled with robust security measures, can mitigate these issues and facilitate smooth deployment [27].

By addressing these challenges through targeted solutions, communities can fully leverage the potential of AARVs to improve their disaster resilience and overall quality of life. Collaborative efforts among governments, private sectors, and local organizations will be essential to overcoming these barriers and enabling widespread adoption of AARV technology.

4. Future Prospects:

The future of Autonomous Aerial Rescue Vehicles (AARVs) in community applications presents transformative possibilities. A significant area for innovation is the enhancement of artificial intelligence and autonomous systems. Future AARVs could incorporate machine learning algorithms capable of analysing historical disaster data to predict optimal response strategies. Swarm intelligence, enabling multiple AARVs to operate in coordination, could revolutionize disaster management by covering large affected areas simultaneously and efficiently [28]. The development of hybrid power systems represents another significant advancement. Combining battery power with renewable energy sources such as solar panels or hydrogen fuel cells can substantially extend the operational range and endurance of AARVs. This would be particularly advantageous in remote regions where recharging infrastructure is limited. Establishing mobile charging stations or deploying AARVs equipped with self-sustaining energy systems could ensure continuous operations during critical periods.

Customization and modular design will play a crucial role in expanding AARV applications. Future models could feature interchangeable payload systems tailored for specific tasks, such as delivering medical supplies, food, or heavy equipment [29]. High-capacity AARVs could be developed to transport larger volumes of goods or even carry passengers during evacuations, significantly broadening their utility. Integration with smart networks and disaster management frameworks is another promising prospect. AARVs could be linked with IoT (Internet of Things) devices, ground sensors, and satellite

systems to create a comprehensive disaster response network. This would enable real-time data sharing between emergency response teams, ensuring coordinated and informed decision-making.

In addition to disaster response, AARVs could be employed in diverse contexts such as urban planning, environmental conservation, and public safety. For instance, urban AARVs equipped with advanced sensors could assist in monitoring air quality, inspecting infrastructure, or managing traffic in congested cities. In environmentally sensitive areas, AARVs could be utilized to track deforestation, monitor wildlife habitats, and survey ecosystems for climate change impacts [9]. Community engagement will remain essential in realizing the full potential of AARVs. Local populations could participate in pilot projects to refine these technologies and adapt them to specific regional needs. Educational initiatives, awareness campaigns, and hands-on training programs can empower communities to become active stakeholders in AARV deployment. This participatory approach will not only enhance the effectiveness of AARVs but also foster a sense of ownership and collaboration.

5. Conclusion:

India possesses the potential to revolutionize disaster management and promote sustainable development in its border regions through the implementation of Autonomous Aerial Rescue Vehicles (AARVs). These advanced technological solutions can address the critical gap in emergency response, particularly in remote and geographically challenging areas. By enabling communities to utilize AARVs, India can adopt a participatory approach that positions local populations at the forefront of their own safety and development initiatives. This approach not only democratizes access to technology but also fosters equity and resilience by ensuring that innovation serves as a tool for progress accessible to all [30]. The integration of AARVs into disaster management frameworks can mitigate the limitations of traditional systems, such as delayed response times and limited accessibility during emergencies. These vehicles can expeditiously deliver medical supplies, locate stranded individuals, and provide real-time information to aid decision-making processes. Beyond disaster response, AARVs can also play a significant role in development projects, such as monitoring environmental conditions, supporting infrastructure maintenance, and facilitating the transportation of essential goods to underserved areas. In conclusion, AARVs represent a transformative approach in addressing the existing challenges of disaster management and sustainable development. By embracing this emerging technology and addressing associated challenges such as regulatory frameworks, cost barriers, and technical constraints India can establish a robust model for integrating innovation into grassroots initiatives. Such an approach can serve as a global benchmark, demonstrating how cutting-edge technologies can be harnessed to enhance community resilience and sustainability [31]. This dual focus on technological advancement and community empowerment ensures that progress is both inclusive and impactful, positioning India as a leader in sustainable and resilient development practices worldwide.

References:

- [1] R. J. Garnica-Peña and I. Alcántara-Ayala, "The use of UAVs for landslide disaster risk research and disaster risk management: a literature review," Feb. 01, 2021, *Science Press*. doi: 10.1007/s11629-020-6467-7.
- [2] A. M. Bangre, K. Khas, R. Surwade, and M. Arif Kamal, "Empathy-Driven Ergonomic Design in Autonomous Aerial Rescue Systems for Smart Health Applications," *American Journal of Civil Engineering and Architecture*, vol. 13, no. 4, pp. 103–108, Sep. 2025, doi: 10.12691/ajcea-13-4-3.
- [3] L. K. Lin Tan, B. C. Lim, G. Park, K. H. Low, and V. C. Seng Yeo, "Public acceptance of drone applications in a highly urbanized environment," *Technol. Soc.*, vol. 64, Feb. 2021, doi: 10.1016/j.techsoc.2020.101462.
- [4] D. G. Costa *et al.*, "A Survey of Emergencies Management Systems in Smart Cities," *IEEE Access*, vol. 10, pp. 61843–61872, 2022, doi: 10.1109/ACCESS.2022.3180033.

- [5] S. Krishnan and I. Patnaik, "Health and Disaster Risk Management in India," 2020, pp. 155–184. doi: 10.1007/978-981-15-0924-7_11.
- [6] S. Sahu and B. L. Sahu, "Landslides disaster in India, mitigation and their impacts." [Online]. Available: <https://www.researchgate.net/publication/371077627>
- [7] A. Perwaiz *et al.*, "Disaster Risk Reduction in India-Status Report 2020."
- [8] S. H. Alsamhi *et al.*, "UAV Computing-Assisted Search and Rescue Mission Framework for Disaster and Harsh Environment Mitigation," *Drones*, vol. 6, no. 7, Jul. 2022, doi: 10.3390/drones6070154.
- [9] M. Sharma and E. S. Brandler, "Emergency medical services in India: The present and future," *Prehosp. Disaster Med.*, vol. 29, no. 3, pp. 307–310, 2014, doi: 10.1017/S1049023X14000296.
- [10] "Fire Hazard and Risk Analysis in the Country for Revamping the Fire Services in the Country Final Report-State Wise Risk Assessment, Infrastructure and Institutional Assessment of Pilot States," 2011. [Online]. Available: www.rmsi.com
- [11] Z. A. Jibon, M. A. Adnan, N. T. Nora, M. M. H. Akash, and F. Ahammed, "Development of an Autonomous UAV for Seed and Fertilizer Distribution in Precision Agriculture," in *2023 14th International Conference on Computing Communication and Networking Technologies, ICCCNT 2023*, Institute of Electrical and Electronics Engineers Inc., 2023. doi: 10.1109/ICCCNT56998.2023.10308182.
- [12] P. K. Jadhao, M. Chetna Kamath, M. Adep, M. Sawant, M. Manisha Andade, and A. Professor, "DEVELOPMENT IN EMERGENCY HEALTH SERVICES FOR RURAL AREAS IN INDIA," 2018. [Online]. Available: www.ijcrt.org
- [13] W. Ji *et al.*, "UAV Assisted Livestock Distribution Monitoring and Quantification: A Low-Cost and High-Precision Solution," *Animals*, vol. 13, no. 19, Oct. 2023, doi: 10.3390/ani13193069.
- [14] J. Su, X. Zhu, S. Li, and W. H. Chen, "AI meets UAVs: A survey on AI empowered UAV perception systems for precision agriculture," Jan. 21, 2023, *Elsevier B.V.* doi: 10.1016/j.neucom.2022.11.020.
- [15] J. M. Reynolds, "Natural Disaster Preparedness for Hydropower Projects in High Mountain Environments." [Online]. Available: <https://www.researchgate.net/publication/353260871>
- [16] Dr. P. A. Tijare, S. Salwe, P. Shinde, P. Sharma, and A. Raut, "Medical Drone in Emergency Healthcare," *Int. J. Res. Appl. Sci. Eng. Technol.*, vol. 12, no. 4, pp. 2790–2796, Apr. 2024, doi: 10.22214/ijraset.2024.60523.
- [17] N. Aamarewaran, "Problems of North-East People in Metro Cities of India: Need of Human Values for Happy and Healthy Life," *IRA International Journal of Education and Multidisciplinary Studies (ISSN 2455-2526)*, vol. 7, no. 2, p. 103, May 2017, doi: 10.21013/jems.v7.n2.p7.
- [18] G. Urs *et al.*, "Emergency Care in India: A Retrospective Cross-sectional Analysis of Health Management and Information System and Global Burden of Disease," Aug. 20, 2024. doi: 10.1101/2024.08.16.24312130.

- [19] R. Surwade, K. S. Khas, and A. Bangre, "Environmentally Responsible Product Design and Model Making," in *Sustainable Manufacturing: An Emergence in Industry 4.0*, CRC Press, 2024, pp. 87–97. doi: 10.1201/9781003309123-7.
- [20] Z. Eskandari, Z. Ghomian, S. Sohrabizadeh, A. Alibabaei, and H. Ahmadinejad, "Factors affecting development of air ambulance base: A systematic review and thematic analysis," Aug. 01, 2021, *Wolters Kluwer Medknow Publications*. doi: 10.4103/jehp.jehp_36_21.
- [21] R. S. M. A. K. Abhishek Bangre, "Prospects of double glazed windows in buildings: energy conservation and environmental sustainability," *American Journal of Civil Engineering and Architecture*, vol. 11, no. 3, pp. 64–69, May 2023.
- [22] I. V. Kovalev, D. I. Kovalev, K. D. Astanakulov, Z. E. Shaporova, V. A. Podoplelova, and D. V. Borovinsky, "Performance analysis of UAV sprayer application in precision agriculture," in *IOP Conference Series: Earth and Environmental Science*, Institute of Physics, 2023. doi: 10.1088/1755-1315/1231/1/012057.
- [23] A. M. Bangre, K. Singh Khas, and R. Surwade, "Design Innovations of Autonomous Aerial Rescue Vehicles for Urban Areas A Performance Optimization approach using Fundamentals of Computational Fluid Dynamic."
- [24] W. Ji *et al.*, "UAV Assisted Livestock Distribution Monitoring and Quantification: A Low-Cost and High-Precision Solution," *Animals*, vol. 13, no. 19, Oct. 2023, doi: 10.3390/ani13193069.
- [25] O. Ugwueze, T. Statheros, M. A. Bromfield, and N. Horri, "Trends in eVTOL Aircraft Development: The Concepts, Enablers and Challenges," in *AIAA SciTech Forum and Exposition, 2023*, American Institute of Aeronautics and Astronautics Inc, AIAA, 2023. doi: 10.2514/6.2023-2096.
- [26] M. B. Prajapati, "Urbanization, Challenges And Planning With Special Reference To India Implications And GOI Initiatives", doi: 10.53555/kuey.v30i5.3564.
- [27] M. Matracia, N. Saeed, M. A. Kishk, and M. S. Alouini, "Post-Disaster Communications: Enabling Technologies, Architectures, and Open Challenges," *IEEE Open Journal of the Communications Society*, vol. 3, pp. 1177–1205, 2022, doi: 10.1109/OJCOMS.2022.3192040.
- [28] E. Taylor and J. Rivera, "Hydrogen fuel cell-powered drone ambulance for the emergency medical services," *Future Energy*, vol. 1, no. 1, May 2022, doi: 10.55670/fpll.fuen.1.1.9.
- [29] K. Veisten, P. B. Wangsness, E. Farstad, and I. M. Ydersbond, "Will people prefer future travel with battery-powered airplanes?," *Transp. Res. D Transp. Environ.*, vol. 126, Jan. 2024, doi: 10.1016/j.trd.2023.104013.
- [30] R. Surwade, K. S. Khas, S. Raghani, and M. A. Kamal, "Model Making as a Creative Skill and Tool for Teaching-Learning Process in Architecture and Product Design," *Civil Engineering and Architecture*, vol. 11, no. 6, pp. 3278–3284, Nov. 2023, doi: 10.13189/cea.2023.110603.
- [31] R. Surwade, K. S. Khas, S. Raghani, and M. A. Kamal, "Exploring the Potential of Model Making as a Tool for Designing Sustainable Buildings," *Civil Engineering and Architecture*, vol. 11, no. 4, pp. 2231–2239, Jul. 2023, doi: 10.13189/cea.2023.110440.