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Possibility of the Applications of Drone in Library Functions and Services in India

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Abstract

Purpose: The study is emphasized on prospects of the applications of drones also known as Unmanned Aerial Vehicle (UAV) technology in library services and related functions of different sections of the library. One of the major purposes of this study is to provide doorstep services to users without physical access to the library.

Design/methodology/approach: This study designed the whole drone library system through a block diagram (Figure-1), which properly explained the works related to different sections of a library as well as the factions related to the users' perspective. It also stated different technical requirements for applying drones in library services.

Findings: Instead of many disadvantages, it has some advantages; libraries may implement drones in a collaborative way to other organizations near a library, it may reduce the high purchase cost and use open-source drone projects rather than proprietary software.

Originality: This paper mainly focused on the implications of UVA technology in library services and their all functions in the Indian context in terms of regulations of the use of drones in India, the Ministry of Civil Aviation.

Research limitations/implications: It is quite difficult to implement drone technology in Indian libraries because of the negotiable library budget with due respect to the high cost of VUA technologies and their related instruments. One of the major limitations of this study is the rules and regulations of the civil drone.

Keywords: Unmanned Aerial Vehicle (UAV), Global Positioning System (GPS), Remote Control System, Unique Identification Number (UNI), Library drone, Ground Control Station (GCS), India

1. Introduction

From a few years before, the drone has been used only in the military section for tracking terrorist activities and delivery of food, medicine, and blood to an injured soldier in a remote place. Now it's also developing for a civil and commercial purpose in the USA (Culver, 2014). Not only for military purposes but also increasing its use in many civil applications such as security purposes, aerial photography, news collection, firefighting, policing, etc. (Joiner, 2018). UAV, human-pilot-less technology, it's operated from a remote ground station using Global Positioning System (GPS) and remote-control technology. Now we live in the network era, so we are also known as Netizen (Nath, 2018). The term Netizen is a

combination of words, the Internet, and a citizen. In this network era, people are habituated with a smartphone, using this technology day by day increasing different types of online doorstep delivery services, like online shopping, buying a gift, ordering food, medicine, and many dairy products at home. Recently, UAV technology has been a major part of this doorstep delivery service. People are busy in their daily life and time is also very short of buying daily-use products from a near-distance market or shopping complex, and traffics are also a major problem in our society. From March 2019 to date, we all are suffering due to covid-19, every school, college, university, Research Organization has been shut down, every mind threatened, researchers abandoned their research, students discarded their lessons, school children left their daily activity, reading habits. In this situation, it is extremely important to re-connect with their due works and make the busy, and that will be possible when libraries will be connected to their users. Though it is tough to visit the library physically, the library can visit you on your doorstep. The drone service can remove them from the above pandemic situation (Brar et al., 2015). The only drone can help to avoid such problems and get your needed product anywhere and anytime with a short time at your door with one click. There are many business organizations that provide this doorstep delivery service like Amazon, Pizza Hut, Google, Walmart, and others. The library is such an organization that also provides remote document delivery services to users. The use of drones in the library also fulfills the fourth law of library science, "Save the time of the reader" in this technology era. With technology, users can borrow a book or any other library document from home using a mobile application, and the document will be delivered as fast as possible to the user's door. Before going to the application of drone in library, we should know the evolution of drone and drone-based services. The evolution is shown in figure-1.

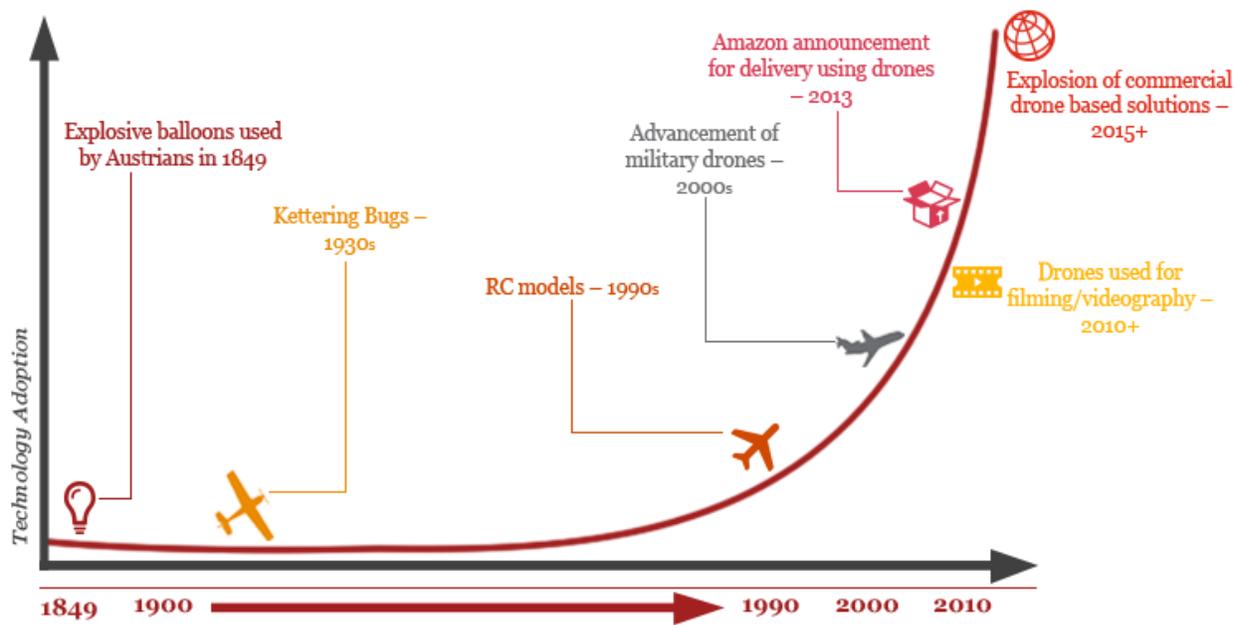


Figure-1: Evolution of drone and drone-based service

(Source: Faraz, Aiman. Data on wings – A close look at drones in India, Available at: <https://www.pwc.in/consulting/financial-services/fintech/fintech-insights/data-on-wings-a-close-look-at-drones-in-india.html>, Accessed on 19-05-2021)

2. Literature Review

The literature review is a comparative study of any topic or domain, which includes the whole published knowledge of that domain from starting to the present time. So, before starting this paper on the topic of the application of drones in the library, a comparative study is required to get an idea of the application done in the library functions and remote service.

Because of drones are mainly controlled by remote distance without a human pilot using remote controllers, mobile applications, joysticks, and embedded computers (Natarajan et al., 2018). But the main issue is that drone control is limited by the range of electromagnetic radiation. According to (Joiner, 2018), a few years ago drones were only used in military operations, and day by day we are using these in our society to serve common people in many areas like news collections, aerial photography, traffic control, security purpose, and delivery service. She also told that this technology would provide various opportunities for different types of libraries to collaborate. As Nath (2018) stated in his article titled "library drone delivery programme: a study", the application of drones in civil purposes is a significant paradigm shift. The use of drones in the library will give a new way to increase demand for the physical book in the electronic era. From Sutardja center for entrepreneurship and technology technical report (Brar et al., 2015) now present a few retailers using drone technology for doorstep delivery service, namely Amazon, Google, Walmart, Pizza Hut, etc. (Shakhatreh et al., 2019) told in his article "Unnamed aerial vehicles: a survey on civil applications and key research challenges", use of UVA technology in many civil applications, provide easy, secure, real-time monitoring using remote sensing, delivery of goods with reduced cost and low risk also a short time. UAV is treated as one of the most significant remote sensing technologies for gathering data of large areas (Salhaoui et al., 2019). Now industries have used this technology as sensing tools for increasing productivity and quality control of products. Due to the increase of drone technology rapidly in several areas of a developed country, the Ministry of Civil Aviation (Rajagopalan and Krishna, 2018), the Government of India introduces drone regulations from 31st December 2018 to create a drone ecosystem in India. Greene and Roberts (2018) mentioned the history of GIS along with drone support services in the academic library and evaluations of its services, success, and challenges. There were some comparisons between the military drone and civil drone in terms of size, battery capacity, internal combustion engine, drive, etc., (Kardasz et al., 2016) also mentioned the risks associated with a drone for the civil purpose such as bad weather conditions, collapsed with an obstacle (tree, high building, electric pole), fall in the ground from a great height due to discharge of the battery, etc. Previously scholars were discussed that drones can be used anywhere in our society, this statement is fulfilled by (Lee and Choi, 2016) they also mentioned the trends of drone technology in the mining industry and its applications. Drone technology is one of the emerging library technologies which is already used in the library of a developed country, and in the future, it will be increased their use, and now in this COVID-19 pandemic, it can be the most helpful library technology to operate the library from the remote. The study (Saloi, 2021) has carried out a study with some steps regarding the implementation of drones in the library for future services. The study has also given an overall status of library drone services worldwide.

3. Overview of the Drone system

Before the implementation of a drone in the library, it is important to understand some physical and technical features associated with drone service.

3.1. Model, Payload, Range, Time, and Pricing of Drone

Let's a start-up with the price of a drone. The price of a drone depends on its carrying capacity, range, and working duration etc. (Table-1)

Table-I: Topmost usable drone in the market for library purpose

SL. No.	Model name	Max payload (kg)	Range (km)	Time (Minutes)	Price (Rupees)
1	Yuneec Tornado H920	1.6	5	24	478793
2	DJI MATRICE 100	3.6	5	40	185640
3	DJI MATRICE 600	06	5	16	407065
4	DJI S900	4.9	3	18	214010
5	DJI S1000	6.8	2	15	407065
6	FREEFLY ALTA 8	09	2	16	711989
7	DJI Agras MG-1	10	1	24	822251

(Source1: Tavares, Thiago. Comparing the cost-effectiveness of drones v ground vehicles for medical, food, and parcel deliveries, Available at: <https://www.unmannedairspace.info/commentary/comparing-the-cost-effectiveness-of-drones-v-ground-vehicles-for-medical-food-and-parcel-deliveries/>, Accessed on: 07-06-2021.

Source2: Chingath, Vysakh & Babu H, Rajendra. Flying Books: Applications of Drones in Libraries, Available at: https://www.researchgate.net/publication/341725647_Flying_Books_Applications_of_Drones_in_Libraries, Accessed on: 07-06-2021)

3.2. Elements of Drone System

Three basic elements of drones are Unmanned Aerial Vehicles (UAV), Communication data links, and Ground Control Station (GCS).

- a) *Unmanned Aerial Vehicles (UAV)*: It is an aircraft without aircrew, but the computer system and radio-link control it. This vehicle is used as a delivery boy to the doorstep of the user's hand. Now a day there are two types of UAVs available in the market, the most usable UAVs are Remotely Piloted aircraft and the most expensive one is Autonomous aircraft which is controlled by itself.
- b) *Communication data link*: The communication data link works as a connector between UAV and Ground Control Station (GCS). The task of the link is to upload connecting information as GCS instructed to the UAV like delivery address or location, destination, traffic, changing altitude, changing flight path, and download. Communication information helps to download the present condition of the UAV, battery condition, or any trouble or instruction from the UAV to GCS by radiofrequency.
- c) *Ground Control Station (GCS)*: The ground control station is the control section from where drones are controlled. All types of instruction have been given from this section. This control station could be controlled by single-handed or multiple workstations.

4. Some Open-Source Drone Projects

Drone devices and their related instruments are very costly along with software. Most of the drone service providers use proprietary software. But it's not necessary to use proprietary software, there are some different routes, a drone building community is created, there are many hardware and software under open-source license. These types of open-source projects will help us to build our drone, customized, repair, and experiment, and supplement (Baker, 2018). Some of the projects are introduced below;

Paparazzi UAV

It's a drone project under GPLv2 (GNU General Public License v2.0) licensed with combines of software-hardware which is built on an open-source UVA and flown under open licenses. The primary focus of this project is to design an autonomous flight that is portable for easy taking their devices in the field by operators and program their flights. The source code of the software components, as well as releases, can be available on GitHub and tutorials can be accessed on the project's wiki.

ArduPilot

It is one of the open-source autopilot software projects that is the most reliable, advanced, and full-featured. It is installed over 1 million drones and different UVAs such as boats, submarines, helicopters, airplanes, etc. and the project has a large number of working contributors. This project is supported by third-party sensors, companion computers, and a communication system including the features of advanced data logging, simulation tools, and analysis. This open-source project is built under the license of GPLv3 (GNU General Public License v3.0) and the source code of this project is available on GitHub. The co-founder of this project is Craig Eldersays.

Dronecode

It's a Linux-based open-source project for a common platform for UVA development. Now it's become an authorized structure for the related components of the drone, in the previous last five years, it was not so a lot of changes happened with this project. Interrelated components of this project are the autopilot flight control system (PX4), robotic communication toolkit (MAVLink), the user interfaces for flight control (QGroundControl), planning for mission, and configuration. All components are available on individual GitHub.

LibrePilot

The software, LibrePilot, is mainly designed to control the radio-controlled drone and multi-copters control. The project is based on the open software project of pilotless UVA, and its major goals are the development of software and hardware for stabilization and control of the device, robotic technology application, and pilotless automatic vehicles. The main aim of this project is to create a collaborative environment on open source with working on other projects in this field. The main project of 'LibrePilot' is organized on BitBucket under the GPLv3 license.

Flone

Flone is one of the most important open-source project at this time because it's based on smartphone software. It's a combination of digitally fabricated airframes and software that is suitable for the android smartphone to control the device from the ground with the help of an airframe via Bluetooth. This project comes under the GPLv3 license and its source code is also available on GitHub. This is a Spain-based project, that's why all related documents and materials are found in Spanish.

OpenDroneMap

It's compatible with the Linux environment and runs with Docker to keep away from the exact configuration environment under GPLv3 license, and the source code is also available on GitHub. Now the drone is used for capturing overhead imagery for various purposes like security, for making video, etc.

OpenDroneMap mainly helps to take this aerial imagery with the process into point clouds, digital surface, elevation models and orthorectified the imaginary like coordinate system, line up the imagery, etc. for further study.

DronePan

It's an iOS app (a going android app), which helps to capture automatic panoramic photography by DJI drones. Because of Preston Ward, DronePan works as the controller of the drone's heading and angle of the camera. It takes 15 to 25 photos automatically with the requirement of an aerial spherical panorama. It is also manually controlled from the ground station to fly and shoot more photos from one location to other locations after the complete panorama. It is built under GPLv3 licence, and GitHub is the distributor of the source code.

Drone Journalism Lab

Recently, drones are used for many purposes, one of the interesting fields is journalism. Here the drone is implicating amateur investigative journalism, capturing from high with a bird's view to know what is going on in the society around us. The Drone Journalism Lab is situated at the University of Nebraska-Lincoln for educating the journalists about how drones can be used ethically and legally in journalism. It is created under the Creative Commons license, its open-source code, and operations manual is also available on GitHub.

5. Application of Drone in Library

Use of drone continues to soar in both public and private sectors maintaining country-wise ethical and legal policies, such as the Obama administration drones policy (Boyle, 2015) of the USA. From the entertainment industry – Harry Potter, Captain America: civil war, fast and furious, to Agriculture, Law, food delivery service, drone service has been covered like an umbrella to reduce time and cost.

“Library is a heart of Institutions”- said Dr. Sarvepalli Radhakrishnan. Not only for institutions, everywhere in our society, but there should also be a public library or a national library or a district library or an academic library for better accessibility, a library placed in the center of the area. We have identified some areas in library service and functions where drone service may be used.

- *24X7 delivery services:* In the context of the public library, there are different kinds of users like a youngster, school students, old people, physically disabled people, and job-holding people. In many cases, lots of users did not use the library only for time, busyness, and for physical disabilities or weakness, such as in these cases the library can go to their doorstep by delivering books or documents by drone where jam traffic, overpopulation problems can overcome.
- *Referral Services:* Drones can be used to deliver the documents from one to another library at working time. It is most useful for the group of an institution where lots of affiliated colleges or institutions are there and covered the same or related courses where resource sharing is the only way to satisfy users and reduce the cost of libraries.
- *Interlibrary referral service:* Through drones from the central library to the departmental library or any faculty, documents can be transferred without coming into the library. This service is mainly used for special requests in an organization.
- *Library Binding and Preservation section:* Drone can help library workers in the binding section. Every year a huge number of periodicals, magazines, and newspapers are transferred for binding. Old and rare books and pamphlets are to be used very carefully, after a certain time they need to

be bound for preservation. A drone can easily transfer very carefully without any human involvement to the binding section.

- *Document delivery service in remote areas:* India is a country of varied geographic regions like desert, hill, plateau, dense forest, and delta. Many people in these remote areas are facing so much trouble in accessing library services. The drone can be used for document delivery services in this context.
- *Reprography service:* In a big library, a drone can also be used for the delivery of reprographic documents to users in terms of library referral service.
- *Remote viewing security:* Remote viewing drones can easily patrol inside and outside of a library. For a large open-access library it is impossible to notice every stack row, but a drone can view every corner of the library.
- *Cleaning and dusting:* Robotic arm drone can be used for the purpose of library stack cleaning and dusting.
- *Drone service during a pandemic:* Recent COVID-19 pandemic has taught us how to stay at home in a lockdown situation. In this context, only drone services can provide document delivery services to the users.
- *Miscellaneous tasks:* In different institutions, drones are also used for content creators, data collectors, and security purposes.

6. The workflow in the library

A workflow is an arrangement of tasks that progress in a proper order to set a goal of an organization, a library of such an organization that is also based on workflow. Before discussing the workflow in detail, we can divide the whole workflow into two parts.

6.1 Tasks related to the user

This part discusses mainly user-related work that means, how to issue a book or library document from home. One of the main tasks of this part is an online borrow of a library document using a valid user ID and password.

6.2 Online borrow

To provide online borrowing of library documents to users, the library should have to implement a library app service by which users can borrow books and other hard copy of library documents using a library app. It is like the present online popular product delivery service by Amazon, Flipkart, Zomato, and others. Before online borrowing, users should have to maintain some instructions given by the library.

- If the price of a book is so less and the user is not comfortable with the delivery charge according to library rules, the library may suggest that the user buy that book.
- In the case of reprographic service, the library will maintain copyright statements. So, the user should also obey the rule.
- According to library rule, there should not be a maximum in the time of document service (borrow).
- Users have to provide the exact mailing address with contact number along with a landmark to the library.

6.3 Tasks related to the library

This part discusses library-related work, and these tasks started when a user borrows a book or any hard copy of a library document using an online borrow facility from home. The whole task of this part may be divided into some sections; those are-

- *Circulation Section:* The primary job of this section is to locate and find the requested book or any other library document for delivery. After collecting the document, it should be issued to the respected user account and create a label regarding checkout, due date, delivery address, and other related information.
- *Packing & labeling section:* After completing the circulation-related work, the document is handed over to the packing & labeling section for packing the checked-out document with the right information about the delivery address and others.
- *Ground control section:* This section is dealing with the remote-control system of the delivery drone after packing the document stored in this section. GCS selects the drone according to availability and capability. Then tracking is done for the faster and smooth delivery way.
- *Delivery section:* After getting all delivery-related information in GCS, the drone will prepare for delivery with the respective items. After the delivery to the respected user address with the delivery photograph, the drone comes back to the library ground station.

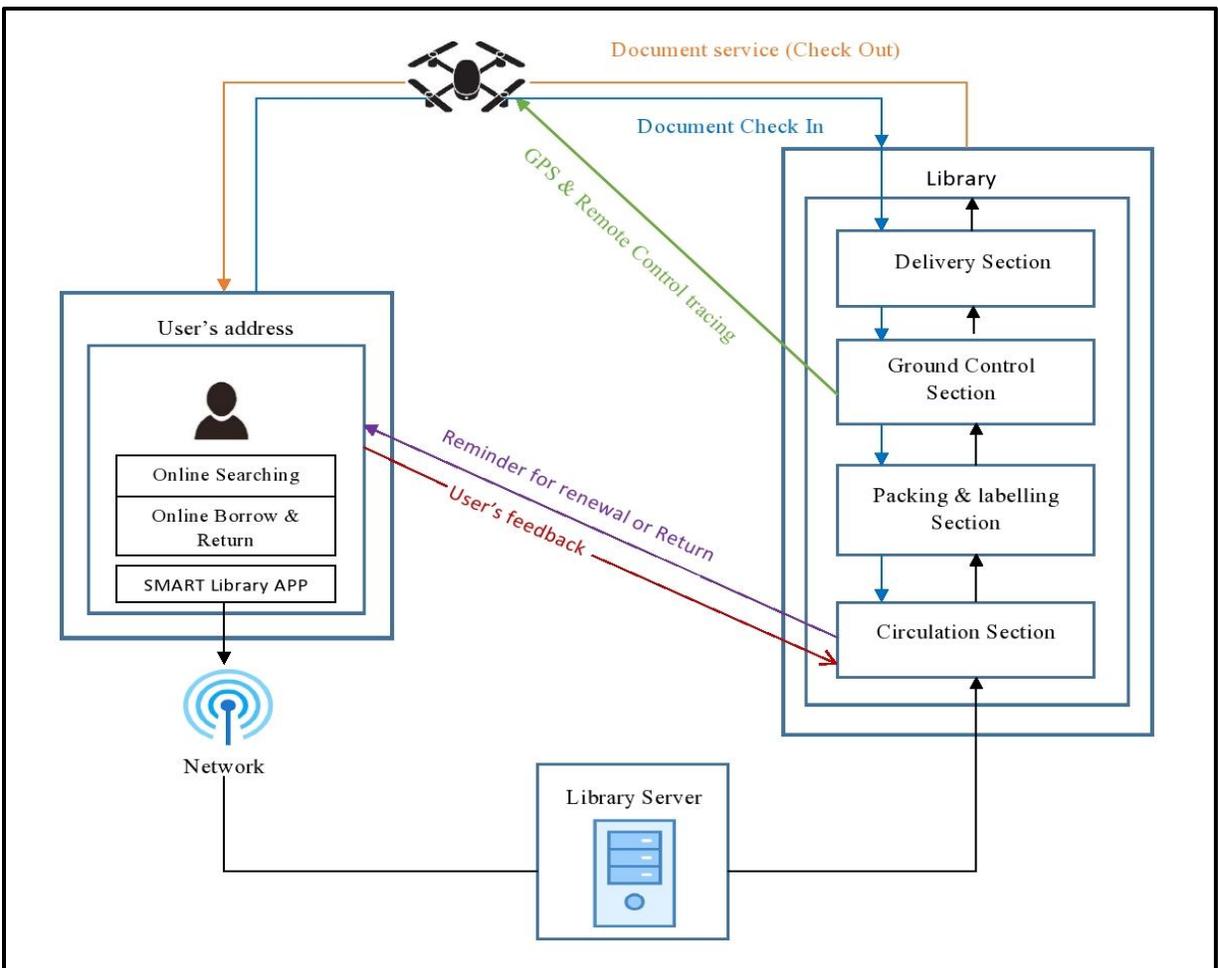


Figure-2: Block diagram of the drone library system.

6.4 Return Policy

After borrowing the books and other documents from the library through a drone, the return process is also maintained remotely with UVA technology. To perform this service, the library has to adopt some procedures and users should also cooperate to successfully run this system.

- System generated due (minimum 5 days before) reminder mail will be sent to the user for document renewal or return.
- After receiving the feedback mail from the user, the further process should be started from the circulation section. In case of renewal, the library will update the user request remotely through the library automation system.
- Regarding the return case, the library will provide further information to a particular user mentioning the return document receiving time from the doorstep of the user and other required information.
- After completing the necessary steps, the ground control station will send the drone to the user door for receiving the document.
- Finally, the document will return through the proper channel from the user's doorstep to the Circulation Section (Fig.1), and then it will be shelved in the proper place.

7. Used globally

Some renewed libraries around the world are tabulated in the below table, these libraries are using drone technology to provide services to the users. Most of the drone-implicated libraries are found in the USA.

Table-II: Use of Drone in the library around the world.

Sl.No	Name of Library	Address
1.	Dubai Public library, UAE	https://dubaiculture.gov.ae
2.	Rose Memorial Library, New York	https://www.rosememoriallibrary.org
3.	NY Public Library, New York	https://www.nypl.org/
4.	University of South Florida Electronic Library, USA	https://lib.usf.edu/
5.	Georgia Highlands College, Georgia	https://getlibraryhelp.highlands.edu
6.	Christiansburg Middle school, Virginia, USA	https://cms.mcps.org/
7.	Colgate University Library	https://cul.colgate.edu/

(Source1: Saloi, Ankita. Drone in Libraries for Document Delivery: “Flying Documents”, Available at: <https://digitalcommons.unl.edu/libphilprac/4599/>, Accessed on: 06-06-2021.

Source2: Brar, Simran et al. Drones for deliveries. Sutardja Center for Entrepreneurship & Technology, Available at: <https://scet.berkeley.edu/wp-content/uploads/Drones-For-Deliveries-Edited.pdf>, Accessed on: 06-06-2021)

8. Regulations of the use of the drone in India

In India, the Ministry of Civil Aviation announced regulations for the drone from 1st December 2018. According to the Indian national aviation authority, the operation of drones in India is legal, but every drone user should be aware of drone regulations. According to the payload, there are five types of drones used in India, namely Nano (less than 250 grams), Micro (250 grams to 2kg), Small (2kg to 25kg), Medium (25kg to 150kg) and Large (getter than 150kg). Primary regulations regarding the use of drones in India are followed.

- All users, pilots & owners are required to do a one-time registration of their drones except for the nano category and assigned a Unique Identification Number (UNI).
- For commercial use, a permit is required to expect for the Nano category those flown below 50feet and for the micro category those flown below 200feet.
- Drones can be flown at a maximum of 400-foot altitude.
- Drone pilots must be maintained by visual line-of-sight. As per air space, there are three portioned visual zone, namely Red Zone (no permission to fly), Yellow Zone (controlled airspace), and Green Zone (permission free).
- No permission to fly "No Fly Zones", areas include international borders, near airports, and military installations.

9. Pros of the Drone service

A drone is an innovative idea for library service in the digital era. The pros of the drone are-

- Doorstep delivery: In the network era, the traditional issue-return system has been obsoleted. Now busyness, weakness, physical disability is not a problem for book lovers, and a drone can provide books or documents at the doorstep of the patron.
- Faster Delivery: Time is a vital element for library service, that is why OCLC in 2014 reordered S. R. Ranganathan's 5 laws of library science and replaced the 1st law (Books are for use) with the 4th law (Save the time of users), and now the 1st law is 'save the time of users'. The fastest delivery of a document by a drone can satisfy this law perfectly.
- Smart library application: the Internet and the smartphone are now common for most people. Especially the young generation can use a smartphone to access the library and order a document from anywhere at any time.
- Conserve energy with high efficiency: A drone is more responsible for traditional delivery. Sometimes the bad condition of the road, traffic, designated delivery location, or dishonest personnel failed to deliver items, but GPS helps the drone to designate the exact location and deliver without any damaged item.
- The drone is common for live streaming events. Live streaming: identify the drone route, any obstructions on the drone path, and after delivering the document, the drone can take a photograph of the user with the item, and that will be proof for the future.

10. Cons of the drone service

- Expensive service: Drone services require a significant investment in the infrastructure of the organization, otherwise, 7-kg weight carrying a capable drone cost is \$5705 (₹355992) and \$ 2.1 (₹149.90) per shipping, it will be very much expensive for both the academic and public library too.
- Low Battery and technical fault during operation: A civil drone provides a maximum of 15 minutes of battery service of flight (Kardasz et al., 2016), but this time is not enough for delivery and returns to the library. If any technical fault happens, an airplane can break down on the runway unpredictably, and it can cause fire to civilians, causing a significant number of fatalities, injuries, and damage to properties affecting a certain area.
- Privacy risk: Delivery drones provide streaming video to the company's headquarters to supervise whether the delivery was completed or not. The problem is drone pick-up video of people and properties that are not associated with the transaction. There would be no consent given by the

patron on this streaming. Any hacker can get much private information, video clips, and delivery item details of the patron.

- Vulnerable to Wild Animal Attacks, bad weather, and night-time delivery: Heavy rainfall, a strong storm, and bad condition of weather is an issue for delay of delivery. Larger flying animals, wild birds such as eagles, kites are usually attacked or captured by drones. At night the drone cannot find routes, observe altitude, and from GCS, it is very tough to control the aircraft, and it cannot deliver that is the major drawback of drone service.

11. Conclusion

After discussing the drone library model, application of drones in library delivery service, and drone regulations in the Indian context, researchers conclude that there are many advantages in the use of drones in the library. This technology fully satisfied the fourth law of library science "Save the time of the reader", which is one of the main aims of library service in the digital era. There have some disadvantages; primarily, libraries have to invest a big amount of money for the purchase of drones and other related instruments and also have their maintenance cost, but these advantages should be overcome in a collaborative partnership way. Now in this pandemic situation where we all are suffering from Covid-19 and suffering to use the library, this is the only way to defeat. Jeff Siddons said "Drones will be used everywhere in ten years" in *Library Journal* April 1, 2017. Kelly Parsek, June 2020, a librarian in a district public school of Virginia has already used this technology to deliver books to re-connect her students from their home. Partnership wise use of drones in libraries, local government, and other delivery service companies will save the library budget as well as overcome the disadvantage of one-time huge investment. So, libraries may use drone technology 24x7 with trained staff to provide faster and better doorstep document service with a medium budget, and after surviving these pandemic situations, libraries can continue their services through drones.

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