

November 2018

Flying high

Drones to drive jobs in
the construction sector

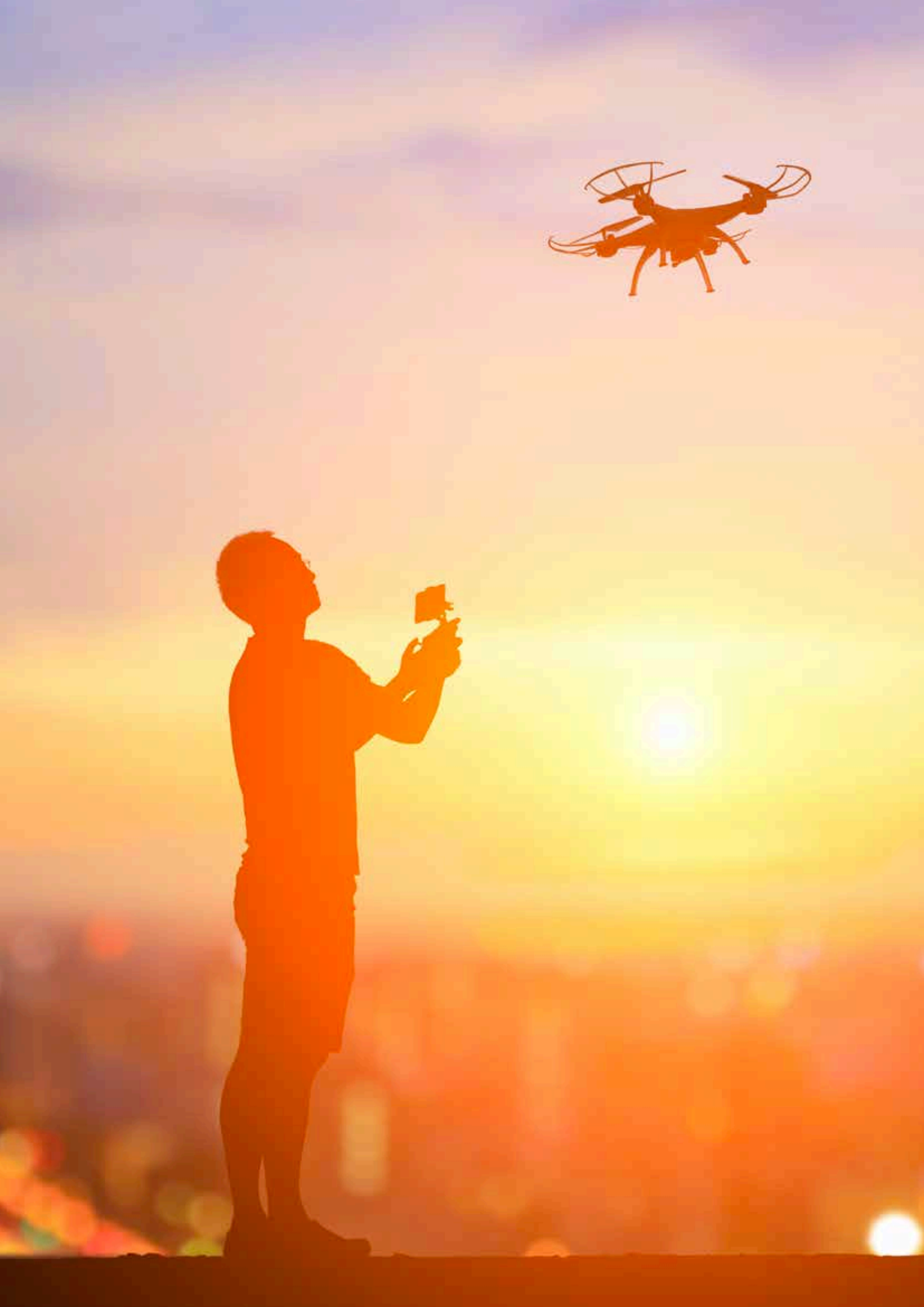


Table of contents

Foreword.....	4
Preface.....	5
Executive summary	6
1. Introduction	7
Global drone industry	7
Application of drones in various sectors	8
2. Indian drone industry	10
Policy and regulations	9
Impact of policy on ecosystem	12
3. Construction industry	15
Global construction industry	15
Indian construction industry	16
Construction lifecycle	17
4. Application of drones in the construction industry	18
Pre-construction	19
Construction.....	20
Post-construction.....	21
Contribution of drones in the construction industry.....	22
5. Employment opportunities	23
6. Way ahead	25

Foreword



Dr P R Swarup
Director General, Construction
Industry Development Council, and
Member Secretary, Engineering
Council of India

I am glad to share the ECI-PwC report 'Flying high: Drones to drive jobs in the construction sector' to be released at the 16th National Conference of the Engineering Council of India (ECI). The theme for this year's conference, which is being organised with the support of the All India Council for Technical Education (AICTE), is 'Use of emerging technologies by engineers for economic development'.

Technology is perhaps the greatest agent of change in the modern world. While never without risk, technological breakthroughs promise innovative solutions to the most pressing challenges of our time. Technology is changing at an ever-accelerating pace and there is a need to not only keep abreast with the latest technologies, but also develop innovative technologies which may reduce costs, save natural resources, enhance the value of the products and processes, protect the environment, and help improve quality of life.

India's track record as a technology market has been phenomenal. The opening up of the market to new and emerging technologies such as drones and unmanned aerial vehicles (UAVs) will set a new precedent and help significantly in expanding the innovation culture in the country. Drones and UAVs are among the fastest-growing segments in India, particularly in the commercial arena, where the demand for these is growing exponentially.

This report provides an understanding of drone technology and discusses its potential to become a disruptive force in the construction industry by transforming monitoring and inspection services, aerial survey work, and delivery and fulfilment. Also, drones can significantly enhance efficiency, productivity, quality and environment while ensuring accuracy of engineering and minimisation of personnel risk.

The growing use of drones will exponentially boost the demand for qualified professionals who can build, manage, service and operate them. This segment will be a booster shot for the job market, as the construction sector alone is expected to create around 2.5 lakh jobs. To meet the demand for professionals and experts in this area, it is imperative for the country to start investing in training and education. Moreover, further advancements and innovation in drone technologies will require large investments and focused efforts towards building the required infrastructure for skill upgrade and capacity building.

Happy reading!

Preface

डॉ. सत्य पाल सिंह
Dr. Satya Pal Singh



मानव संसाधन विकास, और
जल संसाधन, नदी
विकास एवं गंगा संरक्षण राज्य मंत्री
भारत सरकार
MINISTER OF STATE FOR
HUMAN RESOURCE DEVELOPMENT,
AND WATER RESOURCES,
RIVER DEVELOPMENT AND
GANGA REJUVENATION
GOVERNMENT OF INDIA
No.73/2018-19/4719
November 11, 2018

MESSAGE

India's track record as a technology hub and market has been phenomenal. Opening up of the market for new and emerging technologies such as drones and Unmanned Aerial Vehicles (UAVs) will set a new precedent and help significantly in expanding the innovation culture in the country. Emerging technologies, such as drones or UAVs, are rapidly transforming our world. They have the potential to become a disruptive force in the areas of monitoring and inspection services, aerial survey work, delivery and fulfillment. Drone technology promises huge opportunities for job-seekers across all segments of different industries including sales, design, operations, maintenance and education. Their rising use necessitates a large number of skilled operators and maintenance resources.

The Government is encouraging use of this technology. The recent policy on drones, 'Unmanned Aerial Vehicle/Drone Pilot', launched by the Ministry of Skill Development is a step in the right direction. The policy aims to create a pool of trained personnel's who can fly and control drones in line with the guidelines on Drone Policy of the Ministry of Civil Aviation's.

We are conscious of the fact that active measures need to be taken by the Ministry of HRD to create a large skill pool for this sector. And, in view of the huge potential for job creation, there is a need to initiate enhanced interaction amongst stakeholders so that the true benefits of this technology can be harnessed.

I'm pleased to know that the Engineering Council of India, the Construction Industry Development Council and PwC are building this report which highlights the needs and requirements of and the challenges faced in wide adoption of drone technology. I am confident this report will add significantly to the knowledge bank in this domain.


11/11/2018
(Dr Satya Pal Singh)

Office : Room No. 104-A, 'C' Wing, Shastri Bhawan, New Delhi-110 001
Tel.: (O) +91-11-23070036, 23381302, Fax : +91-11-23782052, (R)+91-11-23015800, 23012800 Telefax : +91-11-23794029
E-mail : dr.satypalsingh@gov.in

Executive summary



Neel Ratan
Partner and Government Sector
Leader

India is expected to be one of the fastest growing markets for drones and UAVs because of their ability to transform all key sectors. According to the global market intelligence and advisory firm, BIS Research,¹ India's UAV market is expected to reach USD 885.7 million by 2021. It is predicted that this growth will be coupled with new employment opportunities – particularly in manufacturing, operating and supporting drones. The growth in drone-related jobs will cut across sectors and industries.

Keeping in mind the huge possibilities that drones are expected to create, this paper aims to explore their impact on the construction sector, which employs India's second-largest workforce after agriculture and is a powerful contributor to its Gross Domestic Product (GDP). Drones, as we know and understand them, are set to unleash endless opportunities by enabling this sector to meet the growing demand. Today, this sector is uniquely positioned and is at the heart of all other sectors.

Drones have tremendous utility in construction-related activity. Right from collecting survey data and real-time monitoring of sites to keeping a close eye on logistics and asset management, drones have the power to revamp each stage and bring about transformational changes in the construction ecosystem. The use of drones is expected to maximise productivity, and to keep up with the burgeoning demand, it is critical that drones and UAVs are put to work widely. Their use will not only improve efficiency, but also quality. Consequently, the discernible benefits of using drones have begun to attract several construction players. Therefore, their efficiency and speed should ultimately translate to cost reduction. Furthermore, as consumption of drones grows in the sector, the demand for qualified and trained professionals who can handle these will increase.

In this report, we seek to explore the possibility of extensive use of drones in the construction sector, and their effect on generating employment. We also cover emerging global trends, growth drivers, use cases, government initiatives, policies and regulations. Most importantly, the single factor that resonates throughout this report is our search for 'bright spots' that have the potential to enhance job creation in the construction sector.

1. Economics Time article "India fastest growing market for unmanned aerial vehicles"

Introduction

An unmanned aerial vehicle (UAV) is defined as “an aircraft and its associated elements, which is operated with no pilot on board”. UAVs or drones have been widely used in several areas including agriculture and forestry, electrical power supply, geographical mapping, environmental monitoring and film shooting.²

Global drone industry

The global market has become a hotbed of activity for drones. Overall investment in research and development activities, and a focus on technological advancement are healthy signs in emerging economies and enable them to enhance their growth. The global commercial drone market will grow at a CAGR of between 16% and 17%

from 2017 to 2023.³

The global UAV market will reach US\$ 21.47 billion, with the Indian market touching the US\$ 885.7 million mark, by 2021.¹ This uptake is prompting governments to frame policies and regulations on use of drones.

Application of commercial drones cuts across various sectors construction, education, law enforcement, media and entertainment, precision agriculture, surveying and mapping, and inspection and monitoring. The market value of drone-powered solutions in addressable industries is depicted below:

Value of drone powered solutions addressable industries (\$bn)⁴



Infrastructure

Market value
\$45.2 bn



Agriculture

Market value
\$32.4 bn



Transport

Market value
\$13.0 bn



Security

Market value
\$10.5 bn



Media and Entertainment

Market value
\$8.8 bn



Insurance

Market value
\$6.8 bn



Telecommunication

Market value
\$6.3 bn



Mining

Market value
\$4.3 bn

2. Office of Director General of Civil Aviation, Government of India. “Requirements for Operation of Civil Remotely Piloted Aircraft System (RPAS).”, F. No. 05-13/2014-AED Vol. IV. (August 27, 2018)

3. Infinium Global Research. “Commercial Drones Market: Global Industry Analysis, Trends, Market Size & Forecasts to 2023.”

4. PwC Poland report on “PwC global report on the commercial applications of drone technology”



Application of drones in various sectors

Commercial use of UAVs was first recorded in the early 1980s in Japan, where they were used to spray pesticides on rice fields. Since then, drone technology had advanced significantly and provided new applications for all major industries. Drones have effectively disrupted business and operating models in key sectors including agriculture,

urban development, traffic management, disaster management, forest and wildlife, healthcare, security and mining. They have empowered organisations and enabled them to capture real-time, highly accurate data, and that too in the most cost-effective manner.



Application of drones in each sector⁵

 <h4>Agriculture</h4> <ul style="list-style-type: none"> • Crop health monitoring • Soil health assessment • Improved resource utilisation 	 <h4>Traffic management</h4> <ul style="list-style-type: none"> • Road surface condition monitoring • Improve traffic management • Traffic feedback
 <h4>Forest and wildlife</h4> <ul style="list-style-type: none"> • Wildlife conservation • Managing human wildlife conflict • Forest protection 	 <h4>Homeland security</h4> <ul style="list-style-type: none"> • Real time surveillance • Security planning • Drugs/Narcotics detection
 <h4>Urban development</h4> <ul style="list-style-type: none"> • City survey • Improved urban planning • Project monitoring • Project quality assessment 	 <h4>Disaster management</h4> <ul style="list-style-type: none"> • Real time surveillance • Search and rescue • Delivery of essential goods
 <h4>Healthcare</h4> <ul style="list-style-type: none"> • Epidemic control • Cleanliness & hygiene • Healthcare delivery 	 <h4>Mining</h4> <ul style="list-style-type: none"> • Mineral scouting • Managing encroachment • Contract monitoring

5. PwC Poland report on "PwC global report on the commercial applications of drone technology"

The figure on the previous page provides a succinct and clear view of application of drones across sectors. A brief on the use of drones in these sectors is given below:

	Agriculture <p>Drones have the potential to increase food production through prevention of environmental damage. Effective monitoring of the crop health of a variety of crops is possible through drones. Drones allow agriculturists to get insights on the health of soil and the nutrients in it before sowing. This data can be used to plan irrigation. Moreover, precise field maps enhance utilisation of resources such as water, compost and others.</p>		Urban development and construction <p>City Survey is the fundamental platform on which urban planning-related decisions are proposed. Aerial surveys by drones not only help with high quality accurate site images, but also capture data efficiently. Project monitoring at construction sites through quick volumetric calculations and mapping progress against schedules provides real-time progress reports. This was not possible earlier without the use of drones, which have significantly improved the safety of sites, asset monitoring and maintenance.</p>
	Traffic management <p>Traffic management has become a major challenge due to rapid urbanisation. And maintenance of roads in all weather conditions is a cumbersome task. Information collected with the help of drones eases identification of defects, patches on roads, the traffic situation at different times of the day, obstructions, etc. Drones can enable provision of cheap, safe and fast information to the concerned stakeholders. Their use also facilitates raising of alerts, detection of violations, etc.</p>		Disaster management <p>Climate changes, which are triggering disasters, require governments and agencies to improve their disaster management systems by using advanced technologies. Drones can play an important role in emergency response systems and are capable of facilitating rescue operations. Their role goes beyond real-time surveillance, search and rescue operations. Drones can also help to ensure delivery of essential medical first-aid and food items to affected areas.</p>
	Forest and wildlife <p>Forest and wildlife management is arduous, in view of the length, breadth and complexity of the landscape. Poaching and wildlife fires are key challenges and handling these requires the use of advanced technology. Drones are a remarkable solution to the problems encountered in wildlife management. Monitoring poaching, tracking wildlife and counting of critical species become easier with drones. Moreover, aerial surveys of wildlife provide instant visual data that are a significant help in management and protection of forests.</p>		Healthcare <p>The healthcare sector is limited to accessible areas and personal interactions between medical practitioners and patients. Drones play a significant role in controlling epidemics by transporting critical medicines and delivering healthcare items to rural areas. In addition, they have eased the functions of telemedicine and transfer units in the healthcare industry.</p>
	Security <p>Equipped with enhanced tools such as cameras and facial recognition systems, drones can play an important role in checking theft and tracking thieves. There are also a number of security applications which drones can support and real-time surveillance with a dynamic view can provide additional security insights. In critical situations such as fires, drones can intervene and inspect the surroundings for associated danger. Moreover, sensor-based drones can detect illegal transportation of drugs in border areas.</p>		Mining <p>Mining sites are unsafe and environmentally unfit for human activities. Drones can replace humans to do perilous tasks and increase effectiveness at mining sites. They are also currently used to acquire geo-technical and hydrological data for open-pit mines. Moreover, they help in remote soil sampling and tool delivery in exploration sites as well as to track changes in vegetation due to mining activity, and report this by using digital models.</p>

Along with the sectors mentioned above, many others such as energy and utilities, telecom and insurance are exploring the use of drones and other emerging

technologies to solve problems, help in real-time monitoring, and enhance safety and cost-effectiveness of their businesses.

Indian drone industry

India is a developing economy and requires harmony between its economic, social and environmental needs in order to achieve sustainable development. A key enabler for building a sustainable economy is through technological intervention in market development. Currently, India is transitioning into a tech-enabled economy. And while it has emerged as one of the top importers of UAVs for military services, there is a consistent demand for commercial activities including construction, agriculture, mining, surveillance, infrastructure management and monitoring, amongst others.

The Indian UAV market is expected to reach US\$ 885.7 million (nearly 4 percent of the global market at US\$ 21.47 billion) during 2017-23 at a CAGR of 18%. With 22.5% of the world's UAV imports, India tops the list of drone-importing countries.⁶ The country's major imports in drones currently include products required for military purposes. Commercial drones are expected to display a steady climb as well. However, according to BIS research, the commercial drone market is projected to supersede the military market by 2021.

The Government of India released a draft version of its drone-related policy in August 2018.⁷ The policy will open up use of drones for commercial activities in the country.

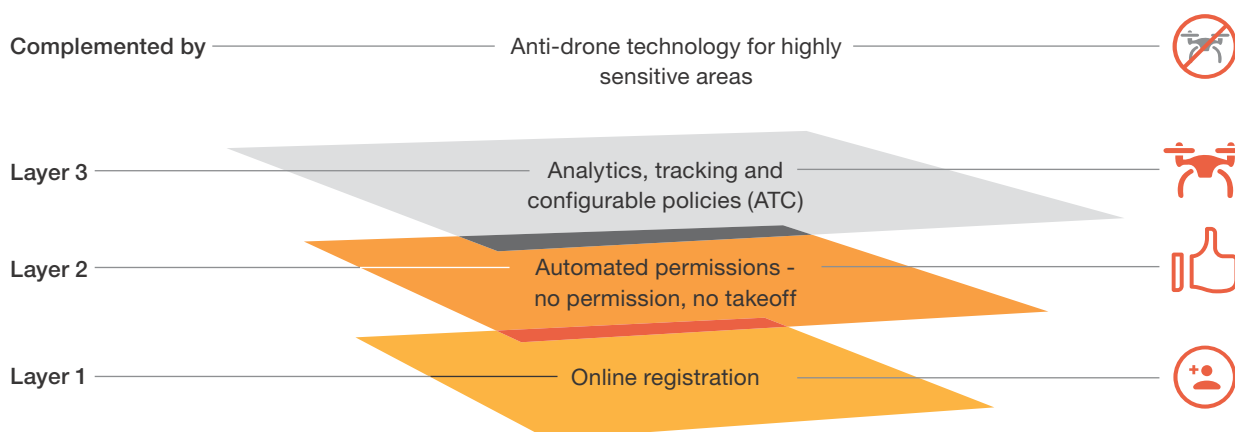
Policy and regulations

On 27 August 2018, India achieved a major milestone in the techno-legal sphere by releasing 'Requirements for Operation of Civil Remotely Piloted Aircraft', also known as India's Drone Policy 1.0.⁸ The policy, which will go into effect on 1 December 2018, lifts the blanket ban on UAV-related activity and authorises the use of drones for commercial purposes. Once this policy comes into effect, drones will be widely used in the country.

Digital Sky platform

The Digital Sky platform, planned to go live in December 2018, will form the foundation of India's drone policy. It is a national Unmanned Traffic Management (UTM) platform, designed to automate the entire chain of approvals required to own and operate a drone. The platform facilitates registration, operation and management of drones through a single-window mechanism, while eliminating any paperwork.

The Digital Sky Stack⁸



6. PwC India report on "Data on wings – A close look at drones in India"

7. Office of Director General of Civil Aviation, Government of India. "Requirements for Operation of Civil Remotely Piloted Aircraft System (RPAS).", F. No. 05-13/2014-AED Vol. IV. (August 27, 2018)

8. Article on "After drone regulations, India's Digital Sky system takes shape"

The platform will enable one-time registration of drones, operators, pilots and manufacturers. It will also allow users to record a drone's specific flight plan, as well as report any untoward incidents that may occur during the flight.

In order to prevent unauthorised flights, the UTM intends to include a 'no permission, no takeoff' (NPNT) module, which will require UAV operators to obtain permission before each flight. Operators will be able to file their permission-related requests through the Digital Sky mobile app. Once a request is filed, the system will automatically validate an operator's registration details, pilot license and security clearance. It will also cross-check the flight path against geo-fences set up for designated No-Drone Zones, and then approve or deny the request accordingly.

Digital Sky comprises the following three key categories of activities:

1. **Pre-flight:** Related to permits (for organisations and manufacturers), issuance of licenses (for pilots), registration (of drones), categorisation of Airspace on Digital Maps (no-fly, free, semi restricted zones, etc.)
2. **Take off:** Related to flight permits; includes considerations relating to availability, digital approval certificates (to be uploaded into drones for take-off, geo-fencing, etc.)
3. **Post-flight:** Actual flight path data analysis, data analytics on potential threats or safety issues, non-compliance checks, enforcements, AI-based data authenticity validation, etc.

How digital sky will work⁹



Other countries such as the US, the UAE, China, Australia and India also have similar online portals for registration and licensing, but most of their flight approvals,

clearances, etc. continue to be processed and issued manually. In comparison, India's proposed Digital Sky would be ambitious, complex and impactful.

9. Article on "After drone regulations, India's Digital Sky system takes shape"

Classification of drones

India's drone-related policy classifies drones on the basis of a maximum all-up weight into five categories: Nano, micro, small, medium and large. The all-up weight is the total weight of the drone and any material it may be carrying (e.g., fuel and equipment.). Nano and micro drones are exempted from a number of regulatory requirements. Details of the classification matrix are provided in the table below.

Manufacturing and import

India's drone policy permits the use of both locally manufactured and imported drones. As a precursor to the registration process, both local drones and imported drones are required to obtain an Equipment Type Approval (ETA) from the Wireless Planning Coordination (WPC) wing of the Department of Telecommunications (DoT) to operate in delicensed frequency bands. In order to import drones, owners and operators will also be required to obtain an import clearance from the Directorate General of Civil Aviation as well as a license to import drones from the Directorate General of Foreign Trade. On the other hand, local drone manufacturers will be required to procure an industrial license from the Department of Policy and Promotion (DIPP). This is because drones come under the dual-use category, i.e., defence and civil.

Unique Identity Number (UIN)

All civil drones will require a UIN issued by the DGCA to operate in India. An UIN will only be issued to drones owned by citizens of India, Central or state government entities, companies registered in India, and companies or corporations registered outside India, provided they have leased the RPAS to any organisations registered in India.

Unmanned Aircraft Operator Permit (UAOP)

All civil drone operators will require an UAOP from the DGCA. An UAOP is issued within seven days, provided all documentation is complete and accurate, and is valid for five years. Operators are also required to submit details pertaining to their drones, such as technical and design-related specifications, Standard Operating Procedures (SOPs), permission from property-owners for take-off and landing locations. Additionally, operating manuals, manufacturers' maintenance guidelines, a certificate of compliance for NPMT from the manufacturer will also need to be submitted. Details about remote pilots, along with their MHA security clearance or self-attested copies of ID proof, training records, insurance and security programme-related details will also need to be submitted. RPAs employed for the purpose of discharging or dropping substances will require special clearances.

Training requirements

Pilots of civil drones are required to be at least of 18 years old with a 10th standard qualification in English. They need to undergo training at approved Flight Training Organisations (FTOs). The training programme should include live or simulated components to replicate operating conditions, along with a theoretical curriculum that is similar to the one undertaken by the aircrew of a manned aircraft or a holder of a private plane license.

Standardisation of equipment

The design and construction of civil drones will need to incorporate standardised equipment and serviceable components and integrate NPNT. Compliance-related criteria will vary based on the height of drones, and intended airspace (controlled or uncontrolled). All drones must be capable of establishing two-way communication between remote pilots and concerned air traffic services, and include self-powered and tamper-proof tracking systems.

Operating restrictions

Operations of all civil drones will be restricted to the following conditions:

1. During day light (except those flying in enclosed spaces)
2. Within visual line-of-sight (VLOS)
3. A maximum height of 400 ft. Above Ground Limit (AGL)
4. No drones to fly over designated No Drone Zones



	Nano	Micro	Small	Medium	Large
Classification criteria	<=250 g	>250 g<=2kg	>2 kg <=25kg	>25 kg <=150 kg	>150 kg
UIN	✗	✓	✓	✓	✓
UAOP	✗	✗	✓	✓	✓
NPNT	✗	✓	✓	✓	✓
Approval time for UIN UAOP	✗	2 days	2 days/7 days	2 days/7 days	2 days/7 days
Equipment standardisation	✗	✗	✓	✓	✓
Max. height allowed (AGL)	50 ft. (Above 50 ft. not exempt from requirements)	200 ft. (above 200 ft. not exempt from requirements)	400 ft.	400 ft.	400 ft.
VLOS	✓	✓	✓	✓	✓
Day operations	✓	✓	✓	✓	✓
Flight plan	✗	✗	✓	✓	✓
ADC/ FIC	✗	✗	✓	✓	✓
Local police	✗	✓	✓	✓	✓
Area of operation	Uncontrolled airspace and indoor	Uncontrolled airspace	Controlled and uncontrolled airspace	Controlled and uncontrolled airspace	Controlled and uncontrolled airspace
Security clearance	✗	✓	✓	✓	✓
Import clearance	✗	✓	✓	✓	✓
Training for pilots	✗	✗	✓	✓	✓
All responsibility with operator	✓	✓	✓	✓	✓

10. Office of Director General of Civil Aviation, Government of India. "Requirements for Operation of Civil Remotely Piloted Aircraft System (RPAS).", F. No. 05-13/2014-AED Vol. IV. (August 27, 2018)

Impact of policy on ecosystem

The release of regulations governing civil use of drones is seen as a strong step taken by the Government to build a safe, world-class and drone-friendly regulatory environment in India. The regulations reflect its tenable approach to seizing the potential of an emerging technology, which is still at its nascent stage. The guidelines will enable the use of drones to survey and collect aerial footage in various sectors.

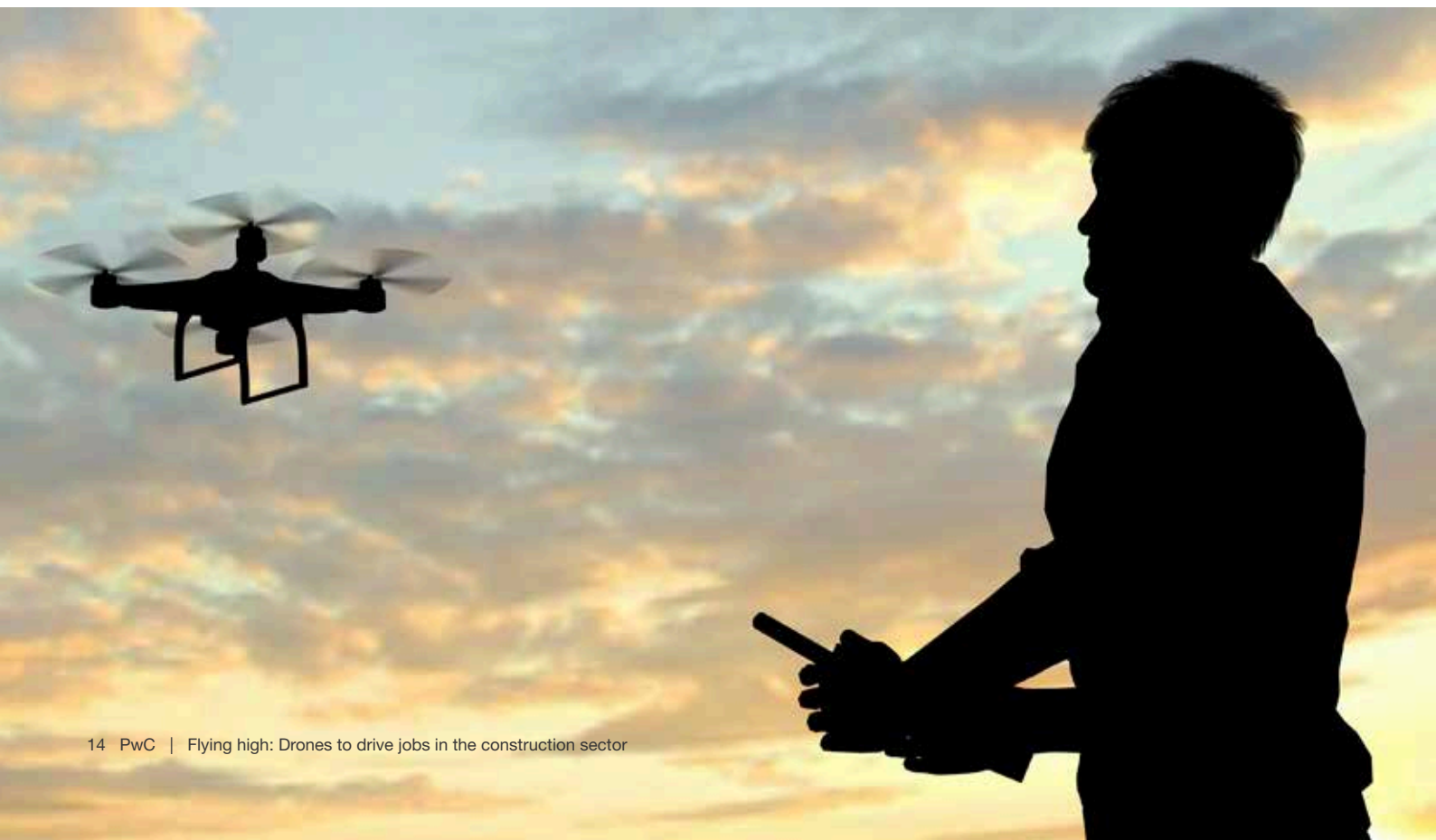
A conducive regulatory environment attracts significant capital investment. This has been seen in countries such as the US and China, which have become market leaders, and are driving innovation. Something similar can be expected in India in coming years.

Commercialisation of UAV technology has come as a breath of fresh air to several industries that have been eagerly waiting to leverage UAV technology since 2014. It has opened up the opportunity for them to tap a huge untapped market. Most importantly, it has given new life to a number of drone start-ups that had been struggling to survive through the blanket ban on drones. The policy has also created a huge opportunity for the largely untapped Business-to-Business (B2B) market in the country and given start-ups the opportunity to innovate.

The policy will also pave way for manufacturing of drones in India, especially under the Government's 'Make in India' scheme. Domestic manufacturing will help in moderating the market prices of drones and related appliances. Moreover, employment opportunities for skilled and trained professionals are expected to rise exponentially with the increase in adoption of drones in industry. An important part of the Internet of Things (IoT) ecosystem, drones have begun to boost the demand not only for the manufacturing and support they provide, but also for their associated functions such as software integration and data analytics.

Currently, the market for UAVs in India is largely dominated by non-commercial end users because of the high prices of UAVs in military applications. However, after December 2018, aggressive and fast-paced development of commercial end users should propel the industry to create more cost-effective and feature-packed UAVs. This should push open the flood gates in the drone market.

Another sector that is expected to benefit from the regulations are educational institutes providing training for flying drones. Start-ups and institutes are both expected to attract an influx of interested students and provide a lot of job opportunities. Moreover, the policy is forecast to make space for 'drone micro-entrepreneurs' who do not need to be experts in any specific sector such as construction or telecom, but know how to fly a drone expertly.



Construction industry

Construction is one of the most dynamic, responsive and unique sectors in the Indian economy. It contributes significantly to the country's economic development by generating output, creating jobs and facilitating income

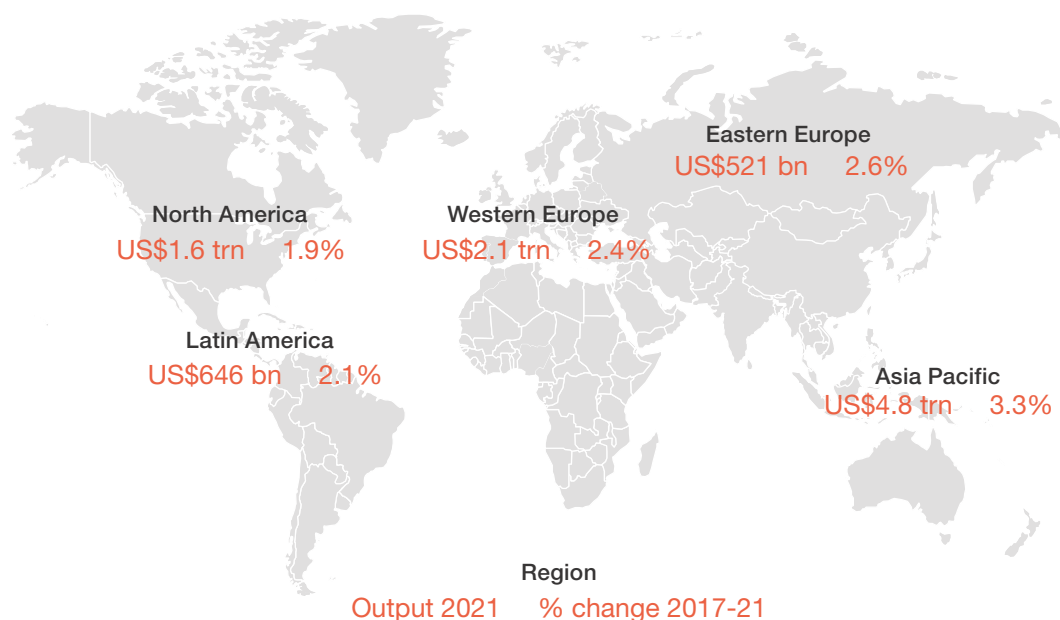
generation as well as redistribution. In addition, the sector has created a platform for other sectors for production and distribution of goods and services.

Global construction industry

According to the PwC report 'Global Construction 2030', the volume of output from construction is likely to grow by 85% and reach US\$15.5 trillion around the world by 2030, with China, the US and India accounting for 57% of this growth.¹¹

As of 2016, the growth in the construction sector has been 2.4% but it is expected to grow around 2.8% during the next five years.¹² Intensive and extensive activity in this sector should automatically propel the economic engine.

Global Construction Output, 2010¹²



"Construction is likely to be one of the most dynamic industrial sectors in the next fifteen years and is utterly crucial to the evolution of prosperous societies around the world. The numbers within this report are huge and that

translates to the creation of vast numbers of new jobs and significant wealth in certain countries across the globe," said Fernando A. González, Chief Executive of the global building material-manufacturing company CEMEX.¹³

11. PricewaterhouseCoopers. "Global Construction 2030: A Global Forecast for the Construction Industry to 2030." PwC.

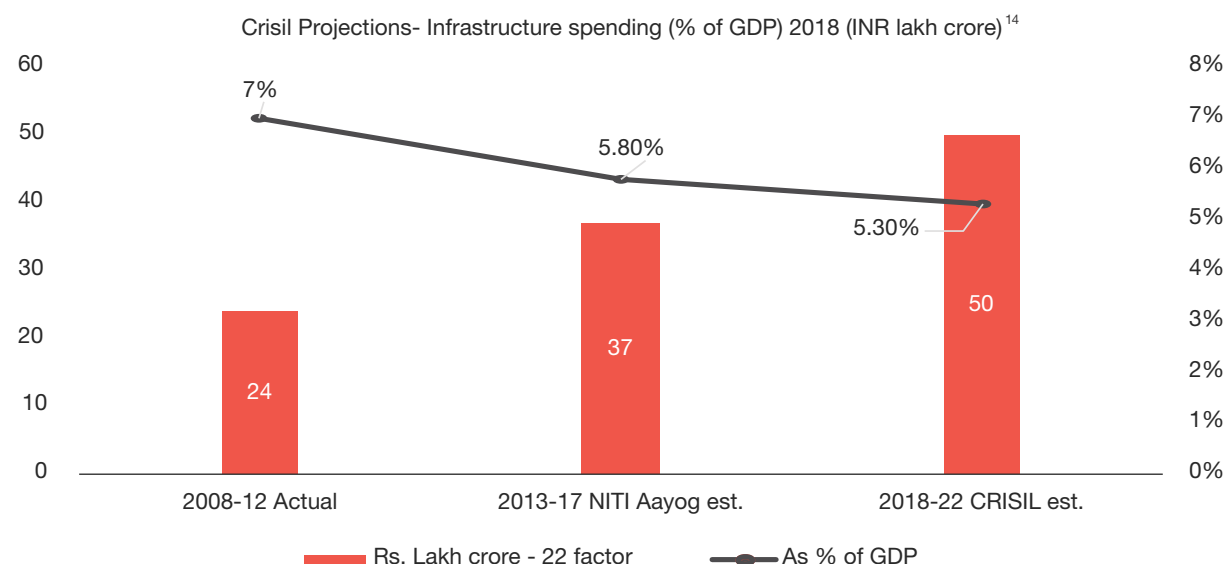
12. Trimetric. "Key Highlights From Global Construction Outlook 2021."

13. General Construction Perspectives. Oxford Economics.

Indian construction industry

Construction, while being a significant employer and contributor to India's GDP, is also one of the most hazardous sectors in the country. According to the International Labor Organization, construction contributes around a quarter of all occupational fatalities in India. A large number of people working in this sector come under the informal economy. There is no health and safety legal net to protect them.

India is among the top global destinations for foreign investment. The key growth drivers include local market opportunities and a skilled workforce. In coming years, infrastructure, technology, consumer products, media and telecom are expected to be a hotbed of activity. Investors are seriously considering India for their services and manufacturing supply chains. In this scenario, with the services sector forming the backbone of India's economy, the Government is placing additional weight on strengthening the country's manufacturing ecosystem.



	FY08-12 actual	FY13-17 RE NITI Aayog	FY18-22 E CRISIL
Power	7.8	12.7	14.7
Railways	2.0	3.8	8.0
Airports and ports	0.8	0.9	8.0
Highways	4.6	7.6	10.0
Urban	0.8	0.9	5.5
Others	7.4	10.2	11.0
Total	23.8	37.2	50.2

Growth pillars of the Indian construction industry -

- Robust demand:** India requires huge investment in the infrastructure sector to enable it to focus on building roads and highways, and renewable energy resources.
- Attractive opportunity:** The favourable external environment adds to the attraction of the infrastructure sector in India. Currently, only 24% of its national highway network is four-lane. Consequently, there is a burgeoning demand for wide highways, which indicates significant scope for improvement in the sector.¹⁵
- Increasing investment:** There is a considerable increase in investment in the construction and infrastructure sector. Foreign Direct Investment (FDI) inflows account for US\$ 24.67 billion and US\$ 12.36 billion, respectively, between April 2000 and December 2017¹⁶.
- Government initiatives:** The Government is focusing on reducing or removing bottlenecks and expediting growth in infrastructure by framing policies such as 'Housing for all' and 'Smart Cities Mission'.

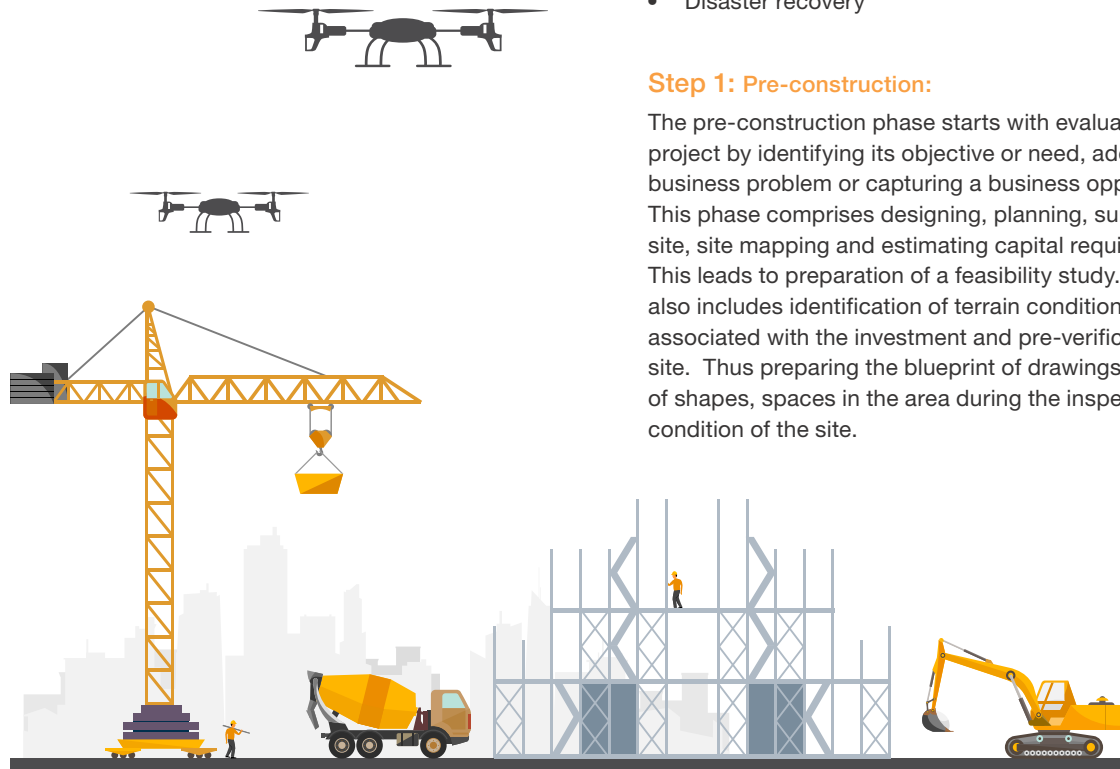
14. Crisil Infrastructure Yearbook 2017

15. PricewaterhouseCoopers. "The Road Ahead - Highways PPP in India." 2012.

16. India Brand Equity Foundation. "Indian Infrastructure- Industry Analysis." 2018.

Construction lifecycle

Construction projects go through different steps in their lifecycle. These steps include wide site surveys, creation of 2D/3D maps, architectural designing, procurement, resource management, precision and quality management, environmental monitoring, monitoring of execution, etc. While technological interventions speed up the pace of construction, the processes (encompassing monitoring, quality control, identification of discrepancies and deviation, etc.) continue to be time-consuming. They require a large physical commitment in terms of time, especially in the case of project managers. This is where drones come in. Equipped with cameras and remote sensors, they have significant utility in the construction sector. From aerial photography to 3D modelling, drones can transform almost every step of the construction workflow. Their use not only saves money and resources, but also enables teams to access granular data for streamlined communication and decision-making.



Step 2: Construction:

The next phase, the construction phase, is when the project is analysed in detail. This starts with a comprehensive analysis and real-time monitoring of the site, 3D modelling, management of supply chain of raw material and putting in place of effective safety measures so that the objective of the project can be achieved as planned. This is followed by the creation and implementation of a project execution plan to identify tasks, activities, dependencies, timeframes and resource requirements. The project plan is then put into action and the progress is continuously monitored. Progress-related updates are reported regularly through site inspections, analysis and meetings with various departments, such as field, supply chain and inventory management teams.

To understand the role of drones, we have divided the construction lifecycle into three stages:

Pre-construction

- Design and planning
- Site survey
- Site mapping
- Estimation of capital



Construction

- Site monitoring
- Project execution
- 3D modelling
- Inventory management
- Warehouse management



Post-construction

- Operation and maintenance
- Detection of defects
- Disaster recovery



Step 1: Pre-construction:

The pre-construction phase starts with evaluation of the project by identifying its objective or need, addressing a business problem or capturing a business opportunity. This phase comprises designing, planning, surveying the site, site mapping and estimating capital requirement. This leads to preparation of a feasibility study. This step also includes identification of terrain conditions, risks associated with the investment and pre-verification of site. Thus preparing the blueprint of drawings/sketching of shapes, spaces in the area during the inspection of the condition of the site.

Step 3: Post-construction:

The third phase after construction constitutes operation and maintenance of the infrastructure created at the previous step. This starts with regular maintenance of the asset, detection of defects and disaster management. Regular check-ups are carried out to identify potential problems early in the context of the planned maintenance system, so that corrective action can be planned and completed in time.

Application of drones in the construction industry

As India moves into its second phase of economic growth, the first one having been propelled by the tertiary sector, the need to improve manufacturing and create production-enhancing resources has become ever more important. The construction industry is the backbone of this process.

The construction industry is of great importance in the growth of India's net output, not only because of its total share but also because of its multiplicative factor and the forward and backward linkages it has with other industries. The multiplier effect of construction is estimated to be in the range of 1.8 to 2, which makes it one of the highest multipliers in the economy.¹⁷ This is due to the high labour intensity in the sector, its relatively few imports and its reliance on its extended and varied supply chain.

Therefore, it is imperative to ensure increased productivity and competitiveness in the industry. However, although productivity in the construction segment is 58% higher than agricultural productivity, it lags behind other sectors, and is the only major employment-generating sector that

has seen a decline in its productivity over the past few years.¹⁸ Since it is a labour- and input-intensive industry, the only way in which it can increase its productivity is by cutting costs and making the requisite processes efficient.

One of the most important procedures for ensuring successful prevention of accidents is periodical inspection of construction sites. On a typical construction project, new hazards are a recurrent feature, equipment, with people and materials moving around the site. Instead of safety managers physically conducting site 'walk-throughs' to identify potential hazards, UAVs and drones can be deployed to conduct safer, faster and more accurate inspections.

17. Planning Commission, Government of India. "Recommendations of Working Groups - Eleventh Five Year Plan." 2006

18. Bhattacharya, Pramit. "Which Are the Top Sectors That Generate Employment in India?"



Pre-construction

Design and planning have always constituted a crucial step in the lifecycle of construction. Data from surveys aid in designing of complex infrastructure. As a rule, engineering and construction companies spend significant effort, manpower and money to collect survey-related data. This is a difficult task if a site is located on tough terrain. Moreover, the accuracy of data collected by using manual hand-held devices is questionable. In this scenario, drones are definitely a better alternate.

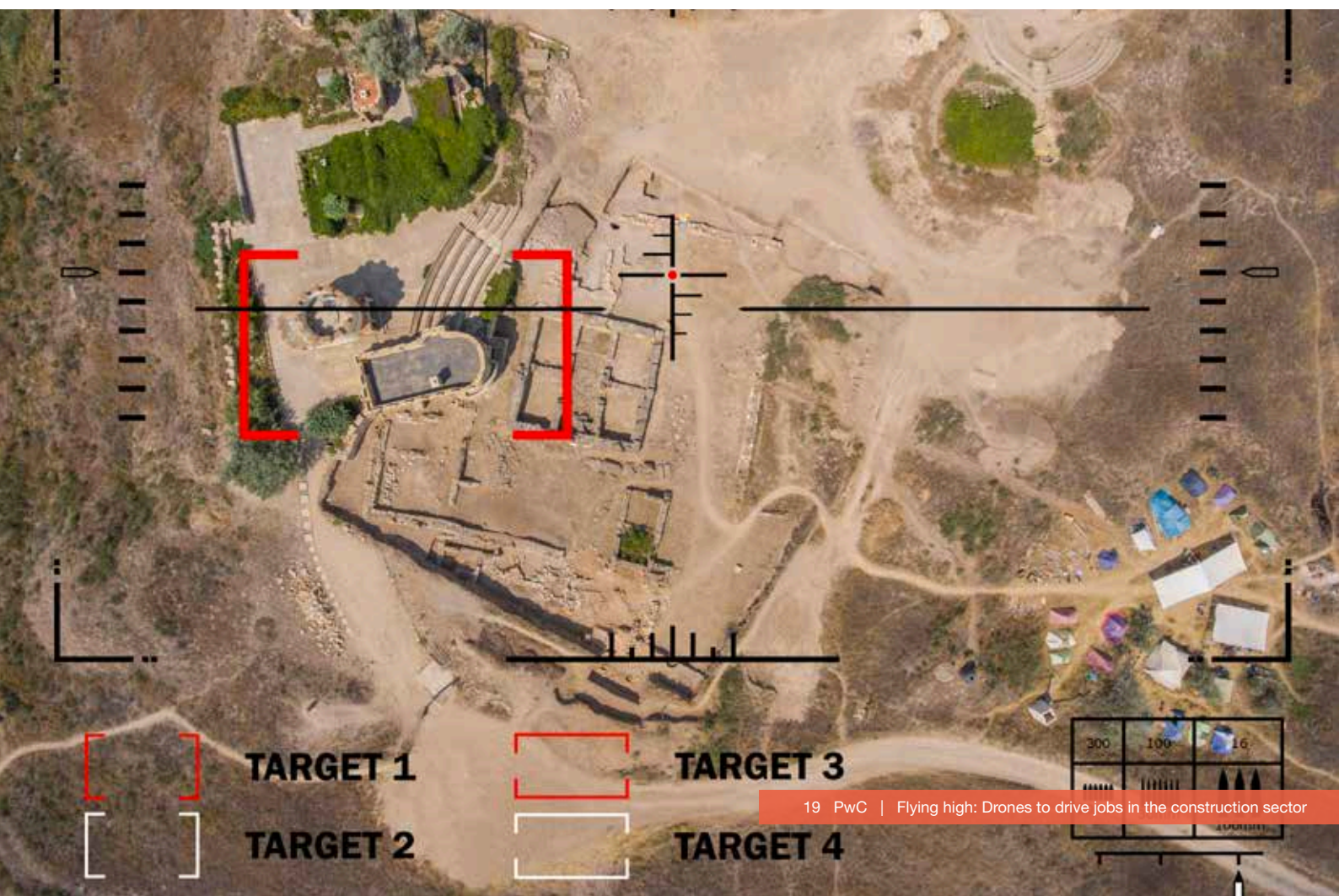
Drones are of great importance in the survey process in the construction industry. Their ability to hover over sites in all weather conditions, and store and transmit accurate data gives them an edge over manual processes.

Drones are already being used for commercial purposes in surveys. The following are applications commonly used by drones or UAVs:

- Automated mapping can be conducted by drones using Ground Control Points (GCP). They can plan a flight path and capture geo-coordinates to create accurate field maps. This eliminates the time-consuming task of geo-referencing a satellite image and digitising it. Moreover, acquiring of Ground Control Point is a constraint in using the manual process, since poor site conditions and distorted site maps hamper accurate capturing of data. The use of drones helps to overcome these challenges.
- Cadastral surveying of established land or plot boundaries can be easily conducted by using drones. UAVs can capture aerial site imagery, which is low-cost and time-efficient. In the manual process, this is often an arduous task.
- In LiDAR mapping of 3-D digital representation of buildings, objects and terrain, the conventional method involves mounting LiDAR devices on manned vehicles on a planned route. This process can be significantly facilitated and expedited by the use of UAVs or drones, which can perform this task much more efficiently at a substantially lower cost.
- Volumetric calculation of stockpiles at construction sites or of 'cut and fill' requirements are generally erroneous. UAVs are very useful for capturing data and achieving accuracy in volumetric estimations. Such estimations have significantly cost-related implications for supply of construction materials.

Drones have emerged as a solution for conducting surveys that involve planning, designing and construction. According to PwC's Drone Powered solution team's report in January 2017, construction sites surveyed by drones were able to complete their task 20 times faster. Moreover, such tasks became 91% safer than those conducted by ground teams.¹⁹

19. PricewaterhouseCoopers. "Clarity From Above." 2016.





Construction

Monitoring of projects is one of the most challenging tasks in construction, especially of road and rail infrastructure. Furthermore, project monitoring of road and rail infrastructure is exacerbated by linear distances and holistic information about site activities, safety compliance, and progress reporting is required. Bad monitoring will result in poor project management. And poor project management results in time and cost overruns. Collection of data for the current progress of workflow is never in real time and provides an inexact progress report. The performance of construction activity is also linked to a contractor's payment, trust and reputation. Drones are at the cusp of transforming project monitoring and handling of construction sites in real time. Some applications that drones or UAVs can conduct during the lifecycle of a construction:

- Monitoring of the progress and quality of work against a project design and schedule, and reporting deviations from the actual design to avoid cost or time overruns is easier with drones. It is practically impossible for project managers to keep a tab on real-time progress in every corner of a site. This is now possible with drones, which can map and report progress with quick visual records, for instance, aerial maps.
- Detection and barring of trespassers or unauthorised persons at construction sites has improved with the introduction of drones. It is now possible to take action on security breaches and also monitor laxity in safety at sites.
- Trenching is a hazardous activity that can cause cave-ins and falls at a site and can result in fatalities. Drones are being used to enhance protection of trenches and thereby improve safety at sites. Moreover, alerts sent by drones to site managers about the unplanned proximity of site workers near trenches can avert accidents.
- Capturing of real-time data and pictures for the accurate 'as-is' state of a site has now become possible with the use of drones. This helps in reporting of the work progress and managing workflow to significantly improve delivery of

projects. Moreover, streamlining of communication with stakeholders through visual data has made it possible for everyone to be on the same page, since geo-tagged drones are equipped to take basic measurements and estimate stockpiles in order to facilitate on-the-spot decision-making.

- Measurement of ground data enables the creation of real-time 3D models to give a realistic picture of a proposed construction. For improved planning, drone-generated images can be superimposed on utility maps and reveal alignment-related flaws, construction-related challenges to re-plan or redesign conflicting situations with minimal alteration of design and cost. Moreover, 3D models can be exported to industry software such as CAD, BIM or GIS for advanced sighting and to take informed decisions.
- Usage of drones to obtain real-time data about ongoing warehouse operations is possible with cloud connectivity. Furthermore, drones can be used to carve a path in GPS-denied indoor environments. Thus, management of a fleet of autonomous drones in real-time by using a single web-based dashboard has now become possible.
- Stocktaking of assets is time-consuming and labour-intensive. Using drones, along with new technologies such as optical barcodes and radio frequency tags (RFID), makes the inventory management process more efficient, safe and reliable. Moreover, drones can play a vital role in monitoring of the asset inventory of a project. Real-time data generated can be further analysed to manage a project schedule and obtain regular updates on projects by 'live tracking and management of documents and images.'

PwC Belgium's report, 'A Drone's Eye View', discussed the case of Hoogmarten, a Belgium-based construction company, which used drones to measure onsite progress and assess the condition of infrastructure. These measurements can calculate the amount of asphalt required for repair. The use of drones enabled the professionals to increase their efficiency with more accurate reporting and cost estimations.²⁰

20. PricewaterhouseCoopers. "A Drone's Eye View." 2018.



Post-construction

The post-construction phase requires operational maintenance of assets created. This is a time-consuming activity, which starts with the development of an inspection schedule. An inspector visits a site, collects images, prepares a progress report manually, and thereafter uses the collected images and data from the site to detect violations. If there is a violation, the inspector issues a warning.

Drones are widely used to manage inventory and assets across the infrastructure industry. Usage of drones in inventory assessments is expected to support organisations in reducing their operational expenditure as well as time and cost. They will also increase safety at the workplace, since they can cover areas that are difficult to reach manually.

According to a study published by the Journal of Information Technology in Construction, using a combination of a drone and an iPad to detect safety hazards is more accurate than using drones on their own, and can generate up to 100 times more observations than a safety manager walking around a site. In addition, this combination enables more accurate inspections more accurately, and can therefore spot more issues in less time and get them rectified.

- **Maintenance:** Drones have made greatly enhanced and eased the process of data collection from inaccessible and difficult-to-reach areas such as roofs, building enclosures, on and under bridges, along busy highways and other elevated structures, without additional safety risks to personnel. For example, in the case of highway work zones, drones can inspect an entire expanse of road or an adjacent structure, even when fast-moving traffic constitutes a serious hazard for workers. They are also useful in applications where workers' access to a site is difficult.

- **Disaster recovery:** UAVs are also critical for post-disaster recovery at construction sites. After disasters, conditions on a site may be unsafe and unstable. Decisions need to be taken quickly to minimise danger and begin the rebuilding process. Drones are proving to be a great help at disaster-hit sites. In addition, they help in fast rebuilding and re-development of sites.
- **Detection of defects:** Drones are capable of detecting defects quickly and accurately. Data captured can be used to create a progress report and process images to achieve enhanced accuracy. This can not only help to anticipate the risks and challenges associated with a project, but also address these well in time.
- **Legal compliance and documentation:** Drones can support creation and updating of documentation of assets' technical condition and the timing of regular maintenance inspections. Moreover, data captured can be stored on adequately secured servers to comply with industry security standards and national legal regulations.
- **Safety:** Application of aerial technologies to collect information on the technical condition of assets can immediately decrease the number of accidents and minimise network downtime. Recording and storing images and video data from inspections also enables teams to control the quality of inspection work and the level of employees' and subcontractors' engagement.

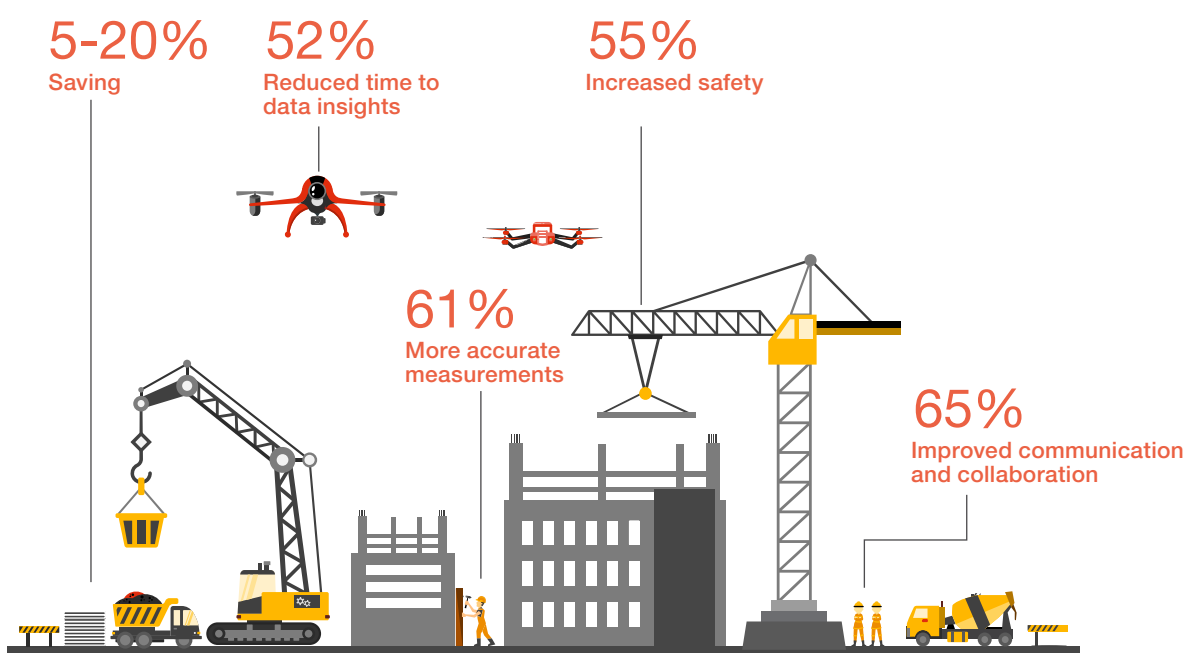
Contribution of drones in the construction industry

Drones are being looked at as the next big disruptor in the construction industry. Construction directly benefits from increased savings and safety, enhanced communication, and accurate measurements and insights enabled by the adoption of UAVs. The benefits and direct positive effects of using drones can be noticed by the 239% growth²¹ in adoption of drones in the construction industry. (This is their highest usage in any sector that uses commercial drones.) Therefore, the commercial drone industry and the construction sector both stand to benefit from each other, with construction being the largest market for drones and boosting the growth of the industry.

The use of UAVs has the potential to dramatically and positively affect the construction sector. According to a McKinsey report in 2016, UAVs will dramatically improve the accuracy, speed and safety of construction projects in the future. Moreover, their commercialisation in India has laid the foundation for enhanced employment generation and GDP growth.

Use of UAVs results in the following advantages:

- **Quick inspection response:** Drones facilitate methodical inspections of job sites and equipment without the delays caused by human intervention. Drone software and controls enable rapid collection of data and imagery. No one is put at risk. Professionals using advanced construction safety analysis tools confirm the details.
- **Reduction in or elimination of equipment downtime:** In order to ensure personal safety, certain equipment inspections require shutting down of normal operations. Sending drones generally facilitates inspection and analysis of moving parts without the need for costly equipment shutdowns.
- **Precision and accuracy:** Data collected by drones can be used to perform precise work such as positioning of steel slabs in concrete or in measurement of the depth of pipelines, preventing costly and dangerous construction errors.
- **Increase in safety:** Safety-related problems are quickly identified. This reduces the risk of injury to employees. Drones eliminate many safety inspection precautions. They do not need scaffolding, aerial lifts or costly preparation steps. Manual surveys often expose surveyors and employees to greater risk and dangers in unknown and remote areas. The use of drones eliminates these risks entirely. Moreover, they can operate in extreme conditions and provide instant data on floods, earthquakes, etc.
- **Time reduction in data collection:** Data collection is heavily dependent on surveys. This is a highly time-consuming task. Drones are able to drastically reduce the time spent in collection and processing of survey data.
- **Real-time imagery:** Procurement of high-resolution satellite imagery for analysis is tedious. Drones have made it possible to capture imagery data and process it for topographical models and heat maps instantly.
- **Detailed site analysis:** Drones enable managers to take advantage of extensive risk calculation and plans in a new environment before a single worker sets foot on a site.
- **Reduction in regulatory demands for health and safety check-ups:** Specific safety requirements burden every high-risk safety check performed by a human worker. In many cases, sending in a drone can completely eliminate such safety requirements.
- **Photo documentation of before and after inspection:** Drones enable effective, reliable and automated comparisons with GPS precision and integrated photo documentation features.



*

21. DroneDeploy. "2018 Commercial Drone Industry Trends." May 2018.

Employment opportunities

As discussed, the construction industry is an indispensable part of India's growth story. As a result of its notable multiplier effect, and forward and backward linkages with other industries, construction significantly affects employment and job creation. Along with agriculture and manufacturing, it is one of the largest employers in India. Jobs in almost all industries except construction have decelerated since the 2000s.²² Construction has been the fastest growing sector in terms of employment creation since economic liberalisation took place in 1991.



Sectors	Employment (in millions) 1999-2000	Employment (in millions) 2004-05	Employment (in millions) 2009-10
Agriculture	237.67	258.93	244.85
Manufacturing	44.05	55.77	50.74
Mining	2.17	2.64	2.95
Electricity, gas and water supply	1.13	1.30	1.25
Construction	17.54	26.02	44.04
Services	94.20	112.81	116.34
Total	396.76	457.46	460.22

Source: Employment by Sector, Planning Commission²³

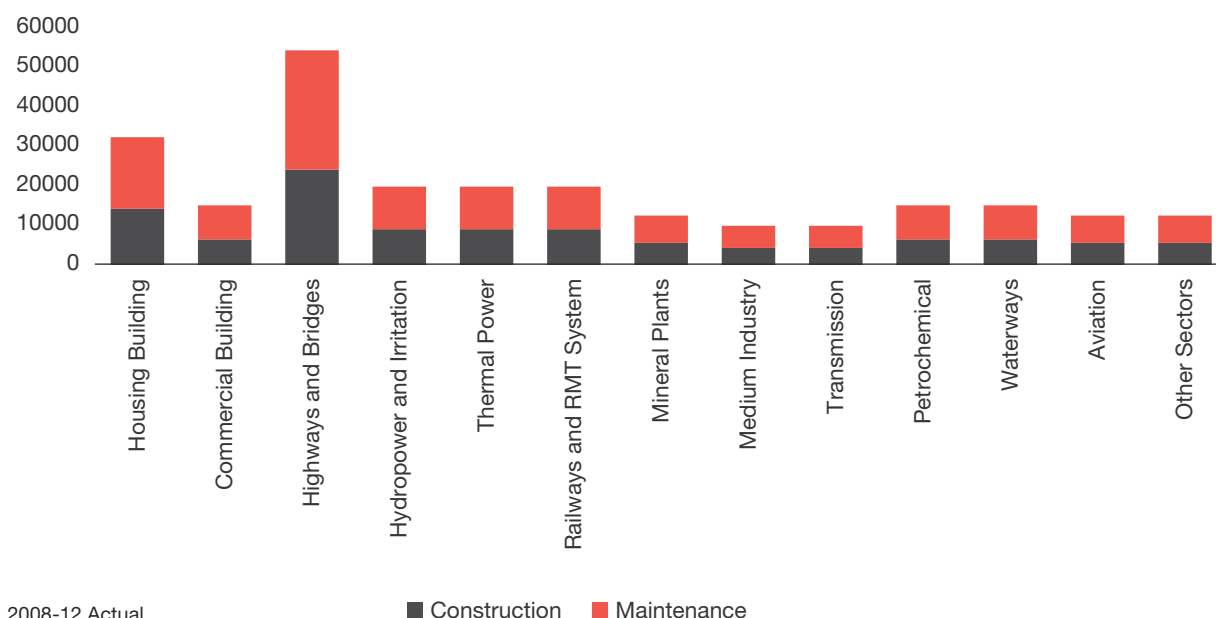
According to the Economic Survey 2017-18, construction employed a workforce of 40 million in 2013, and is projected to employ 67 million by 2022.²⁴ However, over 80% of those employed in the sector are either unskilled or minimally skilled. The advent of drones has the power to bring in a shift in this paradigm. The demand for drones on construction sites is expected to trigger an exponential increase in the demand for skilled manpower in drone operations. This will include professionals for data collection (drone pilots) and data processing (with data scientists who use information collected by drones in various ways).

The Construction Industry Development Council (CIDC) has conducted a study to assess the impact of drones on employment generation across 13 sub-sectors in the construction and maintenance industry. The study estimates the manpower requirement for people with UAV operating skills to be approximately 2.5 lakhs in the coming years, with highways, roads, bridges and housing taking the lead. According to the CIDC, future deployment of UAV technology and its greater acceptance in a number of different applications across a diverse stakeholder base has the potential to boost the demand for professionals who are skilled in using this technology.

22. Thomas, Jayan Jose. "India's Labour Market during the 2000s Surveying the Changes." *Economic & Political Weekly*, 51st ser., XLVIL (2012).

23. Planning Commission, Government of India. *Employment by Sector - Industries*. 2015. Raw data.

24. "Realty, Construction to Generate 15 Million Jobs by 2022: Economic Survey." *The Economic Times*. January 29, 2018.



Source: Projected manpower requirements for UAV related skills in Construction & Maintenance; Construction Industry Development Council (CIDC Survey) Permissible Variant $\pm 5\%$

Note:

1. The estimates do not cover other allied fields, such as agriculture, forestry, defense, etc., and only pertains to core construction sub sectors.
2. The figures would need an upward revision, based on the enhanced investment in the infrastructure sector.
3. The figures only relate to skilled, trained, tested and certified Remote Pilot License holders. The analysts' estimate has not been included (in Level I only).

In addition to operations, there will also be a significant demand for qualified professionals, in drone manufacturing and maintenance. This category of professionals will include engineers, technicians, assemblers, machinists, etc. The influx of such professionals may also be successful in reversing the attrition of engineers and other qualified individuals in the construction industry.

In order to fulfil this huge demand for skilled professionals, putting in place of a robust skill development framework is imperative. The foundation for this, which was laid by the Director General of Civil Aviation guidelines, outlines the training curriculum to be completed by UAV pilots.² Such training is currently offered at a number of DGCA-approved FTOs. However the current educational infrastructure is likely to be insufficient for meeting the impending demand. There is now a need for the Government and private sector entities to enter this niche market and fill the gap between demand and supply.

CASE STUDY

ANDHRA PRADESH REAL ESTATE REGULATORY AUTHORITY (APRERA)

CIDC and APRERA recently signed an MOU for real time monitoring of 2,950 construction projects across Andhra Pradesh. For effective deployment of UAV related technology, an average of three persons are deployed on each of these projects, resulting in the employment of 8,850 drone operators in the state.

Extrapolating these numbers for Pan-India, translates into a demand for 1,68,000 drone operators for monitoring alone.

Source: Construction Industry Development Council (CIDC) and Andhra Pradesh Real Estate Regulatory Authority (APRERA)



Way ahead

As regulations evolve in India, drones will set new benchmarks in adding value to the economy. The safety, efficiency and cost benefits of drones, which the military has utilised so far, also attract a wide range of businesses. Construction is one of these. The Indian drone market is estimated to reach US\$ 885.7 million over the next five years.¹ And this is just the tip of the iceberg. The full economic potential of drones is likely to be manifold.

Drones, as mentioned earlier, can eliminate redundancies and bring in efficiency. At every step of the construction lifecycle, they have a role to play. The reason for the growth of the construction sector is that it is the fastest-growing adopter of commercial drones. Adoption of drones is surging at 239% in this sector.²¹ Builders deploy drones on job sites around the world to enhance safety, document and understand the progress at sites, enable precise planning, generate 3D maps and identify potential issues before they begin costing dearly.

NHAI has been leveraging drone technologies to build 14,799 km of roads. Drone have been used for highway inspection, monitoring, aerial mapping and other project progress aspects.²⁵



Namami Gange Program: Drones can be utilised for site surveys, monitoring, and mapping. Sample water can be taken from distant locations for random quick checks.²⁶



25. "NHAI to Use Space Technology, UAVs for Highway Projects." The Economic Times. January 13, 2016.

26. NMCG brainstorms on G-governance of Namami Gange programme through Geospatial technology





The following segments should lead us to achieve new heights in the domain:



Regulations:

The next version of the policy will be released on 1 December 2018 and is expected to more progressive and allow for greater flexibility and freedom in utilisation of drones for many more applications. These include revision of restrictions for visual line of sight, flying in daylight and carrying of payloads.



Research and development (R&D):

The Government needs to make a concerted effort to obtain and implement state-of-the art global technology and forge strategic associations between the industry, government and international bodies. Increased investment should be made in R&D to encourage sustained innovation and find new applications for drones across sectors.



Investment:

The Government and private sector will need to take an active role in attracting Foreign Direct Investment to supplement domestic capital in order to accelerate the growth of the industry.

Skill development: More institutes need to be empanelled by the DGCA to provide drone pilot certifications and training to meet the impending demand. Large institutions in the construction sector need a specialised curriculum that is focused on the use of drones in the construction industry for data collection and mining.



Governance:

Public Private Partnership (PPP) models for employing drones need to be set up. The Directorate General of Civil Aviation, along with industry-specific organisations such as the Construction Industry Development Council, should develop safety guidelines, best practices and quality standards for the use of drones.

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Contact us

Neel Ratan

Partner and Government Sector Leader
neel.ratan@in.pwc.com

NSN Murty

Partner, Smart Cities
nsn.murty@pwc.com

Sreeram Ananthasayanam

Partner, Government and Public Sector
sreeram.ananthasayanam@pwc.com

Amit Singh

Director, Smart Cities
amit.v.singh@pwc.com

Rajinder Banyal

rajinder.banyal@pwc.com

Abha Dhaka

abha.dhaka@pwc.com

Mandeep Singh

mandeep.x.singh@pwc.com

Mehaque Kohli

mehaque.kohli@pwc.com



pwc.in

Data Classification: DC0

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