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Growing seed

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Article Id  
AL04147

## UNFRUITFULNESS IN TROPICAL AND SUB-TROPICAL FRUIT CROPS: CAUSES AND REMEDIES

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**F**ruit growing is one of the most important and profitable venture in horticulture. The art and science has now developed into one of the most devided, skillful and intensive forms of land utilization. Today the standard of living of different people of countries is judged by the production and per capita consumption of fruits.

### What is unfruitfulness?

Fruitfulness' refers to the state where a plant is not only capable of flowering and bearing fruit, but also takes these fruits to maturity. The inability to do so is known as 'unfruitfulness' or 'barrenness'. Unfruitfulness is one of the leading problems in many fruit crops which results in huge loss to growers thus make fruit cultivation less profitable. Although tree produce adequate flowering, low initial fruit set and subsequently higher fruit-let abscission leads to unfruitfulness.

The causes of unfruitfulness in fruit plants have been broadly classified into two categories

1. Internal factors
2. External factors.

### Causes of Unfruitfulness

**External Factors:** comprises of Environmental factor *viz.* Temperature, Rainfall, Wind, Frost, Hailstorm, Cloudy weather, Light intensity.

- And there are many other factors which affect the unfruitfulness such as Disturbed water relations, Nutrient supply, Rootstocks, Seasonal influence, Spraying fruit plants during flowering, Insect-pest and diseases, Miscellaneous factors.

**Internal Factors:** Impotence, Incompatibility, Abortion

### Classification and Explanation of Unfruitfulness

#### 1. External factors :- Environmental factors

**Temperature:** - It affects the flowering, pollination, fruit set, growth and development of the plants. Every species requires certain optimum range of temperature for growth, flowering and fruit set. Extreme temperature fluctuations and continuous high temperature etc., are injurious to fertilization process.

**Example:-** The pollen of most of the fruit crops grown in temperate climate, like apple, pear, cherry, plum, walnut, pecan nut etc., germinate freely at a temperature of 50<sup>0</sup>F or above, but the fertilization process is practically inhibited if the temperature falls below 40<sup>0</sup>F. Of the different climatic factors, temperature appears to have some relation with the variability in the incidence of mango malformation. Higher temperature and dry atmosphere appear to be associated with the increased production of pollen per anther in mango crop. It have indirect influence on fruit set through its effect on the activity of pollen carrying insects. Influence of temperature on fruit set has also been reported in papaya such as sex reversing male plants.

**Wind:-** It is an important pollination agency in many fruit plants like walnut, pecan nut, oak, hickory, hazelnut, coconut etc. (Anemophilous or Wind pollinated) In insect pollinated fruit plants, wind hinders rather than help in pollination, because pollen carrying insects work more effectively in a still atmosphere. It may also cause the stigmatic fluid to dry prematurely thus affecting the pollen germination.

**Frost:-** These factors responsible for causing even a regular bear cultivar or a plant in an orchard to become an irregular bearer. Spring frosts are harmful to the plants in temperate climate. It may either kill the sexual organs of a flower or completely destroys the blossoms, thereby influencing the fruit set and ultimately the fruitfulness (mango, banana, guava, litchi, etc.)

**Cloudy weather:-** It also make unfruitfulness in many fruits plants by making conditions favourable for development and spread of diseases. For example, powdery mildew, a most serious disease of many fruit crops, usually appears immediately following cloudy weather which consequently dry up and drop. It is most destructive during March-April, especially during cloudy weather.

**Nutrient supply:-** Balanced supply of nutrients is always desirable for realizing optimum fruit production. However, it is often impossible to distinguish clearly between the influence of nutritive conditions within the plant and the conditions without nutrient supply on fruit set, fruitfulness and fertility. Excess supply of manures and fertilizers, though, may result in vigorous growth of the plants, but it affects flowering and fruiting adversely. It is assumed that overfed plants have low C: N ratio, which is not desirable for proper set in fruit plants.

**Example:** Jonathan apple self sterile on rich land in Victoria (Australia), becomes self-fruitful when grown on land of low productivity. The Hope grape (perfect flower variety) and Muscadine group, produce hermaphrodite flowers only when proper nutrient supply is given. Under inadequate management practices, most of the flowers produced by these varieties are staminate. Some cultivars of strawberry produce perfect flowers and are productive when grown under ordinary management cultural practices, but produce only little pollen for satisfactory crop when grown on rich soils.

**Rootstocks:-** Rootstocks are known as the backbone of fruit industry, thus many rootstocks are used for inducing various desirable benefits on the scion cultivar. In some instances, stocks exerts considerable influence on flowering and fruit set of the scion cultivar.

**Example:** Troyer Citrange (Citrus), Dogridge (Grapes), Pusa Srijan (Guava), Khirni (Sapota), etc. Seedlings plants are relatively slow to come into bearing, but it can be hastened by grafting on trees of some kind that are bearing. Thus, rootstocks, directly or indirectly influence the fruitfulness of the plant.

**Age and vigour of the plant:-** The effects of age and vigour on bearing behavior of fruit plants are well known. The age of the plant has been the factor, apparently associated with the degree or percentage of fruit setting.

**Example:** Young and vigorous plum trees are known to produce higher proportion of defective pistils than older trees of the same variety. Young vigorous apple trees often fail to set fruits under controlled cross-pollination, whereas old and less vigorous trees of the same variety set freely. The problem of *coulure* is very serious disease in the initial years of bearing in Muscat of Alexandria grape, but later it is less serious.

## 2. Internal factors

It is a common observation that some fruit plants even produce abundant flowers, but usually fail to set adequate number of fruits and sometimes they do not produce fruits at all. This failure of fruit set may be due to various reasons, like failure of pollination, sterility or even nutritional deficiency. Stout and his co-workers in 1916 recognized that such type of unfruitfulness is mainly due to the following three internal factors:-

- Sterility from impotence
- Sterility from incompatibility
- Sterility from embryo abortion

**Sterility from impotence:** - Sterility from impotence arises when one or both the sex organs fail to develop the fruit properly. The impotence may be complete, in which either no flower or no sex organs are formed, or it may be partial, in which either stamens or pistils are abortive.

**Sterility from incompatibility :** - Sterility from incompatibility arises, when, although the sex organs are completely formed, they fail to function properly. The pollen grains are unable to germinate freely on stigma or stigma is not compatible with the pollen. Thus in incompatibility, the properly developed gametes fail to unite together, although the sex organs are completely formed or functional.

**Abortion:-** In sterility due to abortion, even after the proper pollination and fertilization, the abortion of the embryo takes place before reaching the maturity. However, sterility associated with the internal factors are based upon the following fundamental processes:

**a) Due to evolutionary tendencies:-** Due to evolutionary tendencies, cross fertilization must be done in order to maintain the vigor of the species. In these species, self fertilization is difficult.

**b) Due to genetic influences:- Unfruitfulness due to incompatibility:** Incompatibility between pollen and ovule.

**Self incompatibility:** Inability of a plant with functional pollen to set fruits or seeds when self pollinated. In mango, self-incompatibility is reported in cvs. Dashehari, Chausa and Langra.

**Unfruitfulness due to hybridity:** Generally, the wider the cross, greater is the degree of sterility encountered. For example, hybrid between ‘Troth Early’ peach and ‘Wild Goose’ plum, which has been named as ‘Mule’ bears flowers abundantly, but the flowers neither have petals nor pistils. A number of hybrids between *Vitis rotundifolia* and *Euvtis* group are almost sterile due to hybrid condition.

**Inter-fruitfulness and inter-fertility:** The ability of two plants or two varieties to set fruits and develop seeds with each other’s pollen is called as inter-fruitfulness or inter-fertility.

**Example:** Smyrna fig, Datepalm, some varieties of Grapes.

**Reciprocal Crossings:-** In certain fruit species, it has been observed that, if a certain crossing proved sterile, its reciprocal crosses were also sterile and if one variety proved to be incompatible with the other, those two were likewise incompatible with each other. However, in other, a certain set of crossing has been fruitful, but the reciprocal crossing being sterile.

**Example:-** Tragedy plum (European type) good pollinizer for several varieties of Japanese type, but fail to set fruits when Japanese varieties is used for the Tragedy plum. *Vitis Vinifera*, *V. labrusca* and *V. cordifolia* species of grape set fruits freely either with *V. rotundifolia* and *V. munsoniana*, but when *V. rotundifolia* and *V. munsoniana* are used as pollen parents either for *V. Vinifera*, *V. labrusca* and *V. cordifolia*, they never set fruits freely.

**c) Due to physiological factors:-**

- Slow growth of the pollen tube (Clementine mandarin)

- Poor pollen germination
- Premature or delayed pollination (Kagzi Kalan)

### Remedial measures:-

- ✓ Use of suitable rootstocks
- ✓ Control of frost damage
- ✓ **Proper nutrition:-** Nitrogen application after terminal bud formation led to the development of flower with enhanced embryo sac longevity.
- ✓ Control of pollination
- ✓ Proper used of pollinizers
- ✓ Application of plant growth regulators

**Eg.** Litchi application of TIBA (2,3,5 Triiodobenzoc acid ) and  $KNO_3$  Increase pollen fertility.

### Conclusion

It can be concluded that fruiting of a tree is influenced by many factors. So, it is necessary to adopt corrective measures which should begin from planning level and extends to established orchard. Compatible, disease resistant, high yielding rootstocks should be selected. To maintain healthy condition of the tree as well as to get profitable yield it should be supplemented with ample quantity of nutrition. Different varieties should be cultivated and the introduction of effective pollinizer varieties as well as pollinators was essential. Thinning and crop regulation should be practiced to maintain balance between vegetative and reproductive phase. So proper planning in initial establishment of orchard must be done for effective encounter of arising problems that may leads to unfruitfulness.

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## CORAL BLEACHING

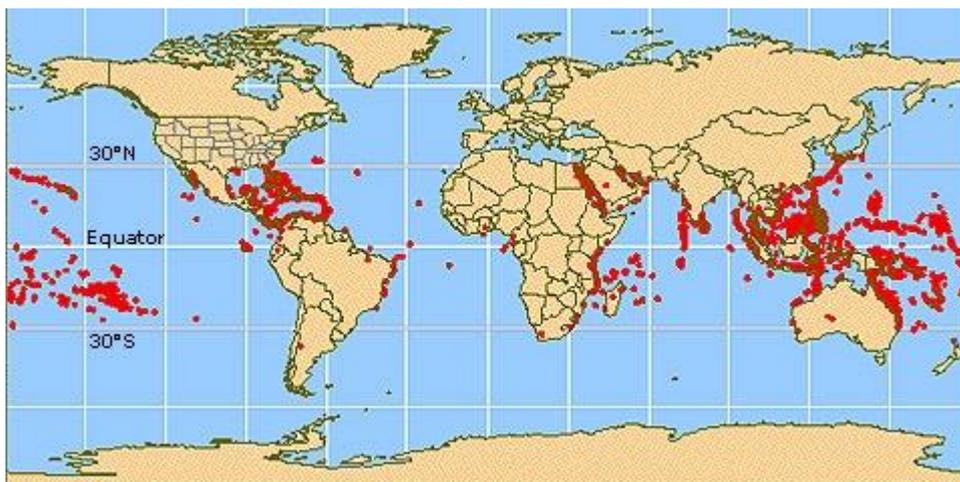
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**T**he coral reefs are distributed in the tropical regions and cover less than one percent of the earth's surface, but provide habitat for many species in the marine realm. The majority of reef building corals is found in tropical and subtropical waters and typically occurs between 30° N and 30° S latitudes. Coral reefs are greatly valued due for their beauty, biodiversity it encompasses and the products and services they provide to human society (Saravanan *et al.*, 2017). The coral reefs are made of calcium carbonate secreted as skeletal material by the coral polyp. Coral polyps live in association with intracellular algae (zooxanthellae), which provide additional nutrition to the coral in its life processes. The association of coral polyp with zooxanthellae, restrict its distribution in waters up to the depth of 100 meters where sunlight would be available for the photosynthetic zooxanthellae (Hoegh- Guldberg, 1999).



## Coral Bleaching

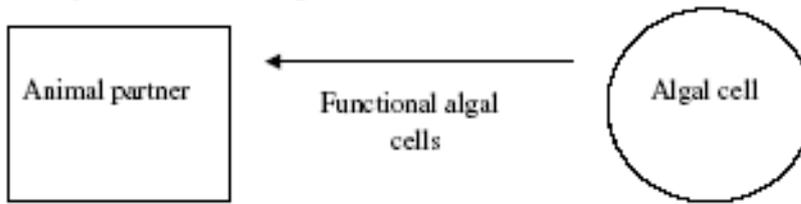
Coral Bleaching is a stress condition in coral reefs that involves the breakdown of zooxanthellae. Bleaching is a stress response that results when the coral algae relationship breaks down. The term 'bleaching' describes the loss of colour that results when zooxanthellae are expelled from the coral hosts or when pigments within the algae are degraded. Because the photosynthetic pigments found in zooxanthellae give corals most of their colouration, the loss of zooxanthellae renders the tissue largely transparent (Hughes *et al.*, 2003).



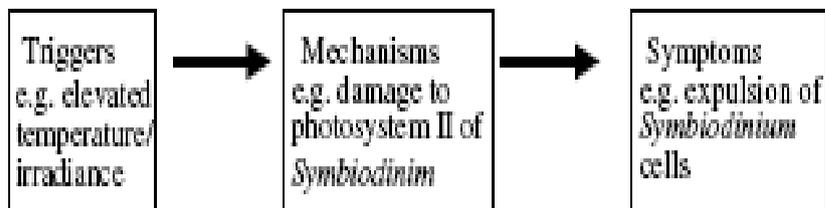
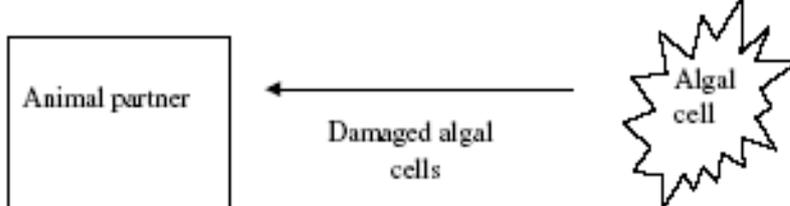
## The Causes of Coral Bleaching

The role of temperature and light increased temperatures cause bleaching by reducing the ability of the photosynthetic system in the zooxanthellae to process light. When temperatures exceed certain thresholds, incoming light overwhelms the photosynthetic apparatus, resulting in the production of reactive oxygen species that damage cellular structures. Corals cannot tolerate high levels of these toxic molecules, and they must expel the zooxanthellae to avoid tissue damage. Because of the low tolerance of the photosynthetic process to high temperatures, even normal levels of sunlight are enough to damage the photosynthetic system of the zooxanthellae when temperatures exceed certain levels (Parry *et al.*, 2007).

(a) Repression of bleaching

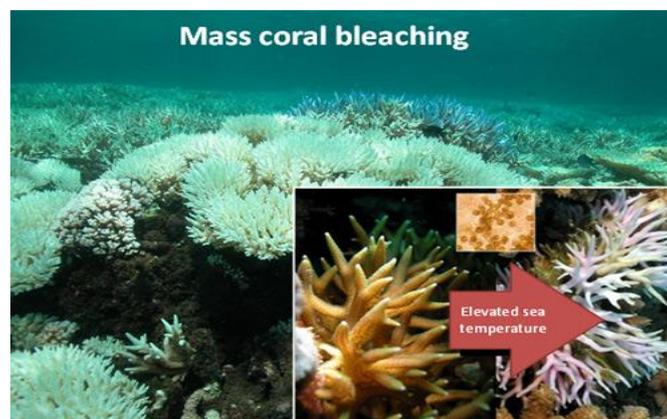


(b) Induction of bleaching



### Consequences of Coral Bleaching

- ❖ **Sea surface temperature** key factor for organisms associated with symbiotic dinoflagellates (zooxanthellae) or that have a narrow temperature tolerance range. Coral reefs grow in shallow areas with good light penetration where water temperature rarely declines below 18°C (Lesser, 2011).



- ❖ **Salinity:** Zooxanthellae are sensitive to low salinity due to precipitation and runoff. Therefore, they tend to live near shallow, clear waters (no deeper than 100m) with plenty of sunlight.



- ❖ **UV radiation:** High levels of photosynthesis lead to high amounts of nitric oxide production by zooxanthellae (Gleason and Wellington, 1993).



❖ **Global Warming**

- If temperatures continue to increase to 1-2 C, for the next 20 years there will be mass coral bleaching worldwide.
- The high seawater temperature elevation will affect over 95% of the species living within the coral and lead species to become extirpated or extinct.

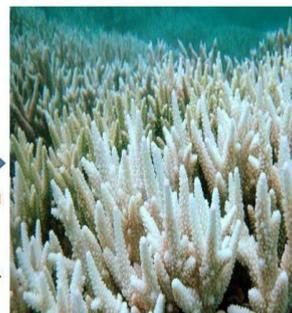
**EFFECTS OF GLOBAL WARMING ON CORAL**



**Healthy Coral** provides food, shelter, protection for 4,000 types of fish

**Acid** →

Oceans absorb acid CO<sub>2</sub> from burning coal, oil, natural gas, Sunscreen\*



**Bleached Coral** - Acid and sunscreen kill coral. 1/4 already dead; 2/3 will die in 30 years

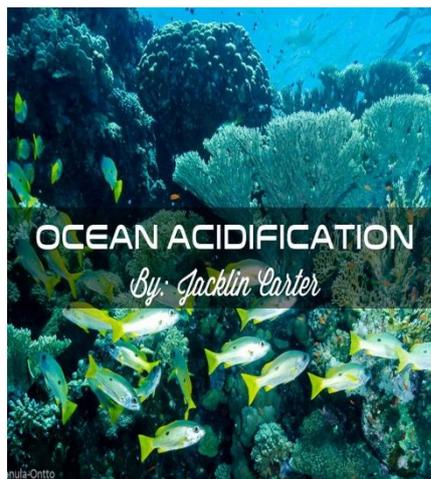
\*5,000 tons of sunscreen enters coral reef areas; toxicity occurs at a concentration of

## ❖ Irradiance

Irradiance (both visible light and ultraviolet (UV) light) is a key environmental factor for coral reefs. Coral reefs need sufficient irradiance for photosynthesis, and are therefore restricted to the upper 50 metres depth in clear oceanic waters, and four metres in turbid inshore waters<sup>128</sup>. However, too high levels of irradiance during hot periods can cause permanent physiological and structural damage to photosynthetic symbiotic organisms through photoinhibition and other stress processes.

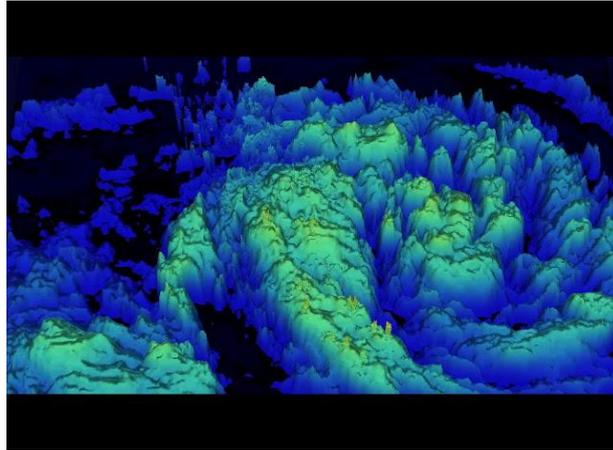
## Ocean Acidification

Evidence is strong that a reduction in pH following rising CO<sub>2</sub> will cause profound changes in the physiology of marine calcifying organisms and in reef processes. Direct effects will be greatest for calcifying algae such as crustose coralline algae and *Halimeda*. The sensitivities of calcifying and non-calcifying organisms to ocean acidification (Downs *et al.*, 2002).



## ❖ Tropical storms

Susceptibility to tropical cyclone damage varies widely between species and growth forms, and also changes across the continental shelf and with depth. In general, species with slim bases and slender branches, such as branching *Acropora* or large upright seaweeds (eg *Sargassum*), and organisms residing in shallow water are highly sensitive to cyclone damage.



### ❖ Coral disease

Just as in humans, corals are regularly exposed to diseases. Bacteria, viruses, protozoa, or fungi can cause coral diseases, but generally disease is isolated, patchy or not deadly in healthy coral reef systems. However, under certain conditions disease can spread through entire populations or reef communities, causing widespread damage of coral.



### Consequences of Increased Bleaching

#### ❖ Increased coral mortality

One of the most direct impacts that coral bleaching has on corals and coral reefs is that affected organisms tend to die at greater rates. Mortality estimates following mass bleaching range from close to zero in cases of mild bleaching to close to 100% as seen in some shallow water reefs. Island at the southern end of the Great Barrier Reef. Corals of some genera (e.g. *Pocillopora*). Mortality was family specific with staghorn corals (Acroporidae) being the worst affected. Bleaching affected all colonies of *Acropora hyacinthus* and *A. gemmifera* and

70–80 % were dead 5 weeks after the initial bleaching began (Schuttenberg and Marshall, 2005).

#### ❖ **Decreased coral reproduction**

In addition to killing corals, increased temperature has recently been found to effect coral populations by reducing the reproductive capacity. The effect of bleaching stress on corals was dramatic. Bleaching reduced reproductive activity in most reef flat corals examined. Bleached colonies of many important reef flat species contained no eggs at all despite the fact that they were supposed to be reproducing month's later (*Symphyllia* sp, *Montipora* sp, *Acropora humilis*, *Favia* sp, *Goniastrea* sp, *Platygyra daedalea*. Observations during the spawning period in November revealed that these bleached corals, even though recovered, did not spawn (Douglas, 2003).

#### ❖ **Reduced reef productivity and growth**

Although mortality might not always eventuate, reef-building corals that undergo bleaching have reduced growth, calcification and repair capabilities following bleaching. The primary effect of increasing the temperature is to induce the loss of zooxanthellae from reefbuilding corals and other symbiotic invertebrates. As zooxanthellae are the principal engine of primary production in these organisms, the rate of photosynthetic productivity of reef-building corals and other symbiotic organisms falls off dramatically. Reef-building corals contribute a substantial proportion of the total productivity of coral reef ecosystems (Baird *et al.*, 2009).

### **Mitigation Measures**

#### ❖ **Management of local stressors**

Local stressors includes physical damage due to diving, snorkeling and anchoring, water quality and fishing activity. In the present case, the Lighthouse Reef suffers from physical damage due to anchoring as well as effluent discharge from the adjacent shrimp farms. The local, regional and global stressors for the reef system should be analyzed as indicated in. Monitoring light, temperature and water currents is important as Palk Bay is prone to quick and longer spells of seawater warming (Brown, 1997).

### ❖ **Identifying resilient coral reef areas**

Identifying the healthy reef areas, which tolerate bleaching and protecting them for the reef recovery, is required. A resilient coral community might suffer significant coral mortality from a bleaching event, but reorganize so that the community composition shifts toward different coral species that require similar habitat and are more tolerant to coral bleaching. Building long term reef resilience can be achieved by identifying the resilient coral community and incorporating the area into a management plan (Loya *et al.*, 2001).



### ❖ **Fishermen involvement in reporting and monitoring coral bleaching events**

Identifying the fishermen for reporting the bleaching events to the state and central government agencies and monitoring the bleached coral reef sites as community management is required (Hoegh-Guldberg, 1999).

### ❖ **Marine Protected Areas**

Marine Protected Areas (MPAs) are considered as the best strategy to conserve coral reef habitat and biodiversity. The Great Barrier Reef Marine Park that was established in 1975 is a good example. In 2004, the park was re-zoned to increase the no-take area, which means that no fishing or disturbances such as anchoring or removal of material is allowed. Especially no-take marine reserves have resulted in positive ecological effects (Buddemeier and Fautin, 1993).

### ❖ **Developing a forecast model for coral bleaching**

The US National Oceanic and Atmospheric Administration (NOAA) developed a forecast system on global level for coral bleaching due to thermal stress. Operating on similar lines, the Coral Bleaching Alert System (CBAS) is a service initiated by Earth System Science Organization – Indian National Centre for Ocean Information Services (ESSO-INCOIS) since February 2011 in India. This employs a model that assesses the thermal stress

accumulated in the coral environs with the help of satellite derived SST (West and Salm, 2003).

### Conclusion

Climate change is emerging as the single greatest threat to coral reefs. Rising CO<sub>2</sub> emissions into the atmosphere is taken up by the oceans and alters ocean chemistry, leading to acidification. This in turn affects coral calcification, an important determinant of the health of coral reef ecosystems. The ability of corals to deposit calcium carbonate has declined and is likely to have several consequences such as weakening of coral skeletons and reef structures. 19% of the world's coral reefs are estimated as already lost and model outputs show that bleaching and acidification will be a severe threat to continued coral survival. The current rate of increasing CO<sub>2</sub> is worrying, because modern coral reef may not have the ability to adapt to these changes and together with direct human pressures, this may drive coral ecosystems toward domination by non-coral communities. Actions to conserve reefs are urgent and must include policies to reduce CO<sub>2</sub> emissions. Further research is needed to fully understand this highly complex subject. Investments and collaboration in order to include more coral reef areas in MPA networks and to also improve other management strategies would help to protect coral reef ecosystems and increase their ability to survive.

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## USE OF MOBILE APPS IN AQUACULTURE SECTOR: ITS ADVANTAGES

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The primary vital purpose of smartphone victimization is for its applications, which can be downloaded from the Play store. These mobile applications help both aquaculture and fisheries. Fishermen will be ready to build a more pleasant fishing duty by using a mobile application, and a lot of profit may be taken from cultivation by diagnosing fish health diseases in time. The victimisation of trendy technologies in fisheries and agriculture would be beneficial in supporting higher cognitive processes for developing and managing land use and alternative natural resources. There were 124 mobile apps in the fields of Angling, Aquaculture, Aquarium Management, Marine Fisheries and Fisheries Governance, Marketing, and Biology, out of which 22.58 percent of the apps were of Indian origin. The software market for precision agricultural tools is expected to grow, and there is a need for fisheries organizations to collaborate with information technology providers to come out with solutions that are visionary for both sustainability and profitability.

Fisheries and aquaculture are one of agriculture's fastest-growing subsectors. It plays an important role in meeting out the food and nutritional security of the growing population. The sector plays a major role to contribution in global food production and prosperity (Dhenuvakonda and Sharma, 2020). Nowadays, mobile phones are a necessity for everyone in their day today life. The usage of mobile applications has become essential in several fields. Smartphone apps were initially designed for productivity assistance such as email, calendar, and phone databases; however, the general public demand for apps caused speedy enlargement into alternative areas such as mobile games, works automation, GPS and location-based services, order-tracking, and price ticket purchases. The public's demand leads to the invention of numerous apps in various fields. Applications are usually downloaded from application conveyance stages that are worked by the proprietor of the mobile OS, for example, the App Store (iOS) or Google Play Store (Zhang and Adipat, 2005; Sarwar and

Soomro, 2013). This article discusses the use and importance of smartphone mobile applications in fisheries and aquaculture. Mobile phones have significantly reduced the cost of communication and information. More than just hardware, the smartphone has inaugurated in a new era for software developers all over the world (US. App Economy,2017).Fisheries sector has not been left untouched by this digital revolution. Aquaculture is one of the leading revenues generating industry. Current fisheries production of India (2020-22) is 14.14 million metric tonnes (HoFs, 2020). Now the government is launched a scheme PMMSY (Pradhan Mantri Matsya Sampada Yojana) for improving the fisheries and aquaculture sector for future. For this scheme, government has allotted Rs. 20,050crores. For achieving this, better awareness is needed among the farmers and fishermen's. This digital platform will help in achieving the production of sustainable and profitable aquaculture and fisheries. As per Amrita and Karthic (2016) usage of mobile applications is becoming popular in the fisheries sector in developing countries.

### Use of Mobile Apps in Aquaculture and Fisheries Sector

The fishing community is one of the most vulnerable groups, facing a number of challenges that threaten their lives and livelihoods, such as unpredictable weather and ocean states, danger zones at sea, a lack of GPS information on the fish shoal, quality fish processing, value addition and storage, market trends, and government schemes. Mobile phones reached great heights in markets because it provides information in real time. By using Mobile Application, ocean Fishermen can do their work easily and safely as they get timely updates (Abbibrinda *et al.*, 2020). The mobile apps which were providing information to fishers/users on topics related to fisheries/aquaculture were studied. A total of 124 mobile apps could be found in the fisheries sector. Out of these highest percentage i.e., 49.19% were from marine fisheries followed by aquaculture and angling. Aquarium management had 8.06% of apps (Sharma and Dhenuvakonda, 2019)**Table 1.**

Sl. No.	Field	Number of mobile apps	Percentage (%)
1.	Aquaculture	20	16.12
2.	Aquarium Management	10	08.06
3.	Angling	18	14.51
4.	Marine Fisheries	61	49.19
5.	Fisheries Governance, Marketing and Biology	15	12.09
	<b>Total</b>	<b>124</b>	

**Table 1:** Mobile apps in fisheries sector

## Mobile Apps for Aquaculture

In the field of aquaculture, mobile apps provide information about inputs, new advancements, market prices etc. The table 2 show that there are 20 apps in the field of aquaculture. Out of these there are 10 apps which are of Indian origin. These are Aqua app, Aquadeals, AquaBrahma, m-KRISHI Aqua Service, Pescare, Vanamei Shrimp app, Aquall app, Fish Disease Advisory, Fish Names and IndAqua.

Sl. No.	Mobile app Name	Features
1.	Aqua app	<ul style="list-style-type: none"> <li>✧ Locate manufacturers of feed</li> <li>✧ Statistics about weather</li> <li>✧ New advancements in aqua culture</li> <li>✧ Up-to-date market prices</li> </ul>
2.	Aquabrahma	<ul style="list-style-type: none"> <li>✧ Connect farmers and suppliers</li> <li>✧ Information on suppliers, hatcheries</li> </ul>
3.	Aqua deals	<ul style="list-style-type: none"> <li>✧ Information on feed, health care, machine and equipment like aeration tubes, aerators, blower, paddle wheels, pipes, pumps, testing kits, hatchery machinery, and fish cages</li> <li>✧ Deals for seed, feed, health care, machinery and farm equipment</li> </ul>
4.	Aquaimate	<ul style="list-style-type: none"> <li>✧ Has a collection of freshwater and saltwater fish, corals, invertebrates and plant species Record parameters test results.</li> <li>✧ Customize parameters and calculate the required dosing</li> <li>✧ Create husbandry tasks and set up reminders for them with an advanced scheduling system</li> <li>✧ Monitor activities integrated with tasks and reminders</li> </ul>
5.	Aqua Plant	<ul style="list-style-type: none"> <li>✧ Identification and management of pond vegetation</li> <li>✧ Treatment options which includes biological, mechanical and herbicide controls</li> </ul>
6.	Aqua Reef	<ul style="list-style-type: none"> <li>✧ Includes pond filling time</li> <li>✧ Pumping rate equivalents</li> <li>✧ Discharge rates from standpipes</li> <li>✧ Net mesh sizes for grading fish</li> <li>✧ Length/weight relationships for fish</li> </ul>
7.	Aquatic Log	<ul style="list-style-type: none"> <li>✧ Ability to log water parameters</li> <li>✧ Record dosing additives and supplements</li> </ul>
8.	Fish Advice	<ul style="list-style-type: none"> <li>✧ Education app contains various picture of fish disease, symptoms, preventive measures, fish culture methods</li> <li>✧ Information on fish feed sellers, fish medicine sellers, fish farm owners, local extension agents</li> </ul>
9.	m Fish	<ul style="list-style-type: none"> <li>✧ Set of mobile applications for fishing and aquaculture that educates and connects fishers to market prices</li> <li>✧ Gathers information directly from the fishermen</li> <li>✧ Access to information such as weather data, fish prices at port, fish handling and best practices for safety</li> </ul>

10.	m-KRISHI Aqua Service	<ul style="list-style-type: none"> <li>✧ Alert remote farmers to cloud formation, rainfall and temperature</li> <li>✧ Scientific information on water parameters in tanks, feed supply, growth of shrimp and atmospheric condition</li> <li>✧ Tool for book-keeping, advisory and weather information services</li> </ul>
11.	Pescare	<ul style="list-style-type: none"> <li>✧ Insight into diseases that commonly occur in fish and shrimp aquaculture</li> <li>✧ Brief description of their symptoms, aetiological agent, diagnosis, and treatment</li> <li>✧ Tool to diagnose and prevent the occurrence of diseases in cultured fishes and shrimps</li> </ul>
12.	Pondcalc	<ul style="list-style-type: none"> <li>✧ Determine accurate area and volume of the pond for application of chemical treatments and herbicides</li> </ul>
13.	Source ESE™ solution Trace Aqua	<ul style="list-style-type: none"> <li>✧ Aquaculture operations and supply chain</li> <li>✧ Real-time business intelligence</li> <li>✧ Better resource management and pond health monitoring systems</li> <li>✧ Geo-referenced farm data</li> </ul>
14.	Texas Farm Pond Management Calendar	<ul style="list-style-type: none"> <li>✧ Digital pocket calendar to keep private pond managers up-to-date with the activities required to manage their pond for the best possible fishing</li> </ul>
15.	Vanamei shrimppapp	<ul style="list-style-type: none"> <li>✧ Information on the Better Management Practices of shrimp farming in the form of Frequently Asked Questions</li> </ul>
16.	Aquall App	<ul style="list-style-type: none"> <li>✧ Aquall is a one-stop place for seeds, feeds, chemicals, aerators as well as hardware products.</li> </ul>
17.	Fish Disease advisory	<ul style="list-style-type: none"> <li>✧ The app gives information about diseases, causative agents and remedial measures</li> </ul>
18.	Fish Names	<ul style="list-style-type: none"> <li>✧ Gives information about fish varieties and names in different Indian Languages</li> </ul>
19.	Ind Aqua	<ul style="list-style-type: none"> <li>✧ The app has technology modules for different fishes, the database of stakeholders, FAQs, updates, discussion forum.</li> </ul>
20.	Aquatic Disease Field Guide app	<ul style="list-style-type: none"> <li>✧ Helps to know about diseases that affect finfish, crustaceans, molluscs, and amphibians in Australia</li> </ul>

**Table 2:** Mobile apps related to aquaculture

**Provide the information about the mobile apps related to aquarium management.**

With wholesale value of the global ornamental fish trade estimated to be in billion dollars there is a huge potential of mobile apps in this field. The table 3 show that there are 10 mobile apps which provide information on aquarium management. The Indian ornamental fish sector is a small but vibrant segment, but there are no apps developed which are of Indian origin.

Sl. No.	Mobile app Name	Features
1.	Ammonia Calc	<ul style="list-style-type: none"> <li>✧ Calculate ammonia concentration</li> <li>✧ Un-ionized ammonia calculator</li> <li>✧ Resource for on-the-go aquaculture producers and</li> </ul>

		<p>managers as well as home aquarium hobbyists.</p> <ul style="list-style-type: none"> <li>✦ Allows users to instantly calculate the un ionized ammonia concentration by providing water chemistry measurements such as pH and temperature</li> </ul>
2.	Apex Fusion	<ul style="list-style-type: none"> <li>✦ Monitor the health of aquarium based on current and past water parameters</li> <li>✦ Control aquarium equipment (e.g., turn on or turn off light and pumps, adjust lightning spectrum, and change pump modes)</li> <li>✦ See how fish and plants are doing via IP web cams</li> <li>✦ Can remotely feed, enter crucial water testing parameters</li> </ul>
3.	aquaPlanner	<ul style="list-style-type: none"> <li>✦ Maintenance and scheduling with notifications, water test logging, calculators and equipment log</li> <li>✦ Allows to adjust parameters and time for aquarium</li> <li>✦ Let know when it is time to change the water, filter, carbon, fluorescent bulbs, add medication, and other.</li> </ul>
4.	Aqua Planner Pro	<ul style="list-style-type: none"> <li>✦ Task alert system</li> <li>✦ Attend to all fish tank maintenance duties such as changing the water, checking water chemistry, adding medication and various supplements on time.</li> <li>✦ Can log key water parameters, and monitor parameter changes on graphs</li> </ul>
5.	Aquaria Pro	<ul style="list-style-type: none"> <li>✦ Aquarium management</li> <li>✦ Manage multiple aquariums,</li> <li>✦ create to-do lists for various tasks and testing</li> <li>✦ Monitor water parameters</li> </ul>
6.	Aquarimate	<ul style="list-style-type: none"> <li>✦ Manages both saltwater and freshwater aquariums</li> <li>✦ Library contains information on saltwater fish and freshwater, invertebrate, plant and coral species</li> <li>✦ Variety of tools such as tank parameters tracking and livestock tracking</li> <li>✦ Task reminders, tank parameters and activity analyze.</li> <li>✦ Advanced unit converters and dosing calculators.</li> </ul>
7.	Coral Tank Pro	<ul style="list-style-type: none"> <li>✦ Saltwater fish tank management</li> <li>✦ Track 7 chemical levels with graphs</li> <li>✦ Notifications and a countdown timer displayed on the home screen</li> <li>✦ Store records of fish and coral</li> </ul>
8.	Reef Tank	<ul style="list-style-type: none"> <li>✦ Built-in tests: Calcium, Ammonia, Carbonate Hardness, Phosphate, Magnesium, Nitrate, Nitrite, Total Dissolved Solids Specific Gravity (Salinity), Temperature, and pH</li> <li>✦ Chronological view of the data, track water parameters</li> </ul>
9.	The Fish Room	<ul style="list-style-type: none"> <li>✦ Information about reef tank</li> <li>✦ Set and log custom chemistry goals for PH, Calcium, dKH, Nitrites, Nitrates, and more</li> <li>✦ Keep track of fish and when to change lights and water</li> </ul>
10.	Aquarium Note	<ul style="list-style-type: none"> <li>✦ Record information of aquarium and count days from setup date, calculate expenses, log 24 water parameters and view trend with graphs.</li> </ul>

**Table 3:** Mobile apps related to aquarium management

### Provide the information about the mobile apps related to fisheries governance, biology and marketing

The mobile apps which provide information on fisheries governance, biology and marketing. A total of 15 mobile apps were found which provided information on governance, information and resource networks from fishery monitoring and maritime safety, resilience building, biodiversity information, listing of seafood exporters, track seafood volumes, prices and online marketing. 9 are of Indian origin and are Aqua Pulse, Daily Fish India, Healthy Fish, Marine fish sales, Matha Fresh Fish, Nallameen, Smart fish, Fresh Fish Cart and Fish Stop (Table 4).

Sl. No.	Mobile app Name	Features
1.	Abalobi	<ul style="list-style-type: none"> <li>✧ Working towards good governance and adopting a fisheries approach based on human rights</li> <li>✧ Enabling small-scale fishing communities to be integrated into information and resource networks from fisheries monitoring and maritime safety, local development and market opportunities</li> <li>✧ Enabling social justice and poverty alleviation in the small-scale fisheries chain Resilience building in the face of climate change</li> </ul>
2.	Fish Base	<ul style="list-style-type: none"> <li>✧ Information on biodiversity for all world fish covering more than 34,000 species</li> <li>✧ Includes biology, ecology, taxonomy, life history, trophic features and population dynamics</li> </ul>
3.	Xiaoliu Online Fish Market	<ul style="list-style-type: none"> <li>✧ Foreign seafood exporters can list their products on app</li> <li>✧ Allows buyers to track seafood volumes and prices for product nationally, while also bidding for lots</li> </ul>
4.	Aqua Pulse	<ul style="list-style-type: none"> <li>✧ Shrimp purchase mobile app and acts as a bridge between companies and sellers</li> </ul>
5.	Daily fish India	<ul style="list-style-type: none"> <li>✧ It is an online seafood store, available in Ernakulam and Trivandrum.</li> </ul>
6.	Healthy Fish	<ul style="list-style-type: none"> <li>✧ Online marine fish, farm freshwater fish, Dry fish, Crabs, Shrimps, Lobsters delivery app</li> </ul>
7.	Marine fish sales	<ul style="list-style-type: none"> <li>✧ The app facilitates direct sales between fisherfolk and customers.</li> </ul>
8.	Matha Fresh Fish	<ul style="list-style-type: none"> <li>✧ Online seafood store</li> </ul>
9.	Nallameen	<ul style="list-style-type: none"> <li>✧ The app delivers fresh fish from the daily catch in and around Kochi</li> </ul>
10.	Smart fish	<ul style="list-style-type: none"> <li>✧ Online fish delivery app</li> </ul>
11.	Fish.qa	<ul style="list-style-type: none"> <li>✧ Qatar online fish purchase app</li> </ul>
12.	Sydney Fish Market Supplier	<ul style="list-style-type: none"> <li>✧ This app allows the registered suppliers access to daily auction prices</li> </ul>
13.	Fish.me	<ul style="list-style-type: none"> <li>✧ The app allows to shop directly from fishermen.</li> </ul>
14.	Fresh Fish Cart	<ul style="list-style-type: none"> <li>✧ Delivers all type of fish and sea foods with freshness</li> </ul>
15.	Fish Stop	<ul style="list-style-type: none"> <li>✧ Online fish market</li> </ul>

**Table 4:** Mobile apps in fisheries governance, biology and marketing

## Advantages of Mobile App in Aquaculture

The advent of mobile application development has allowed the farmers to work in a more efficient manner. Also, they play a major role in lowering down the costs involved. For achieving the Blue Revolution (Neel Kranti Mission) and making fisheries a modern world-class industry, the need is to embrace new technologies like blockchain, AI and IoT and mobile apps. These technologies can play an important role in ushering the blue revolution. The number of mobile apps in the market is increasing and is a big source of revenue generation. Mobile apps can help in the dissemination of the required information in the right form and at the right time. One of the benefits that modern technologies provide is that it promotes efficient resource utilization, minimizes human efforts in many life aspects.

## Conclusion

In conclusion this modern world, usage of mobile application becomes mandatory in everyone's life. In developing countries, smart phone usage has become very popular. For prevention and precaution, the mobile applications are highly useful for the fisherman. Mobile application helps the fishermen to know the seller and buyer. More research is needed to know how many apps are successful by way of their downloads as well as user engagement and feedback. The software market for precision farming tools is expected to grow by 14% in the United States alone by 2022 in agriculture. In this background, it has to be realized by the policy makers that big data is moving into every field and fisheries cannot be left behind. In Indian scenario, there are more mobile applications have been developed but they have not reached the stakeholders, fishing community and fish farmers, due to language issues. However, there are some apps provide multilingual choice which is very useful to them. Thus, in future, the smartphone apps with user-friendly mode and provide much information in their local languages need to be developed for the welfare of fisherman and aqua culturist.

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## A COMPREHENSIVE SUMMARY OF DIGITAL REVOLUTION IN INDIA

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**D**igital India is a visionary initiative of the prime minister to transform India by leveraging the power of information technology. It is aimed to empower the poor and the underprivileged by using technology that is affordable, developmental and inclusive growth and empowerment of ordinary Indians is at the core of Digital India. Today India is recognized in the world for its thriving IT industry that is present in more than 200 cities of 80 countries. Growth of IT industry in India can be divided into three phases. In the first phase the Indian IT professional and IT companies travelled to different parts of the world and established their presence, while in the second phase the global IT giants started investing in India and tapped its vast domestic market. It is a matter of great assurance that India has the biggest user base for many of the IT and internet companies today. Whereas in the current phase where India is witnessing great growth in innovation and entrepreneurship led by startups which are mostly founded by young Indians. The efforts of our government to encourage startups have paid rich dividends and today India has emerged as the third largest Startup ecosystem in the world. India's vibrant IT industry has been growing very fast. In the year 2017-18 the total revenue of India's IT industry was 167 billion and the exports made were to the tune of 125 billion. Under Digital India programme various initiatives have been undertaken towards providing digital identities, creating digital delivery of services and promoting employment and entrepreneurial opportunities that has transformed India into a digitally empowered society while bringing significant change in the lives of citizens.

### Digital Identity

Digital Identity is the key to unlocking access and potential of the digital India programme. To provide a unique digital identity, Aadhar has covered around 122 crore residents of the country. It is a form of digital identity of individuals for efficient delivery of various governmental programmes and schemes with flexible portability. It has controlled

leakages and corrupt malpractices from the public welfare distribution mechanism. Today financial entitlements under 434 Government services based Direct Benefit Transfer, which has been discussed in detail in the subsequent paragraphs. The supreme Court, in its historic judgment on Aadhar, has not only upheld the constitutional validity of Aadhar but also described it as a tool for empowerment of poor people. Digital Infrastructure: Building robust digital infrastructure is essential for the success of digital India. Bharat Net aims to provide high speed internet in rural areas of India by building optical fibre network connecting all the 2.50 lakh Gram panchayats of India. About 2,99,765 km of optical fiber length has been laid connecting 1,25,100 Village panchayats till 2021. National Knowledge Network (NKN) is latest information technology tools comprising of Virtual Class Rooms, Smart classes, Collaborative research groups, Hybrid mode meetings being utilized by closed user groups like NDL, NPTEL, various grids (like cancer Grid, Brain Grid Climate. To provide flawless e-services in the country and optimize ICT spending of the Government NKN has ensured development of appropriate infrastructure along with speeding up the development and deployment of dedicated eGOV applications. More than 950 applications are have been developed and are running on 15750 virtual servers for example eSign an electronic signature service is an innovative initiative for allowing easy efficient, and secure signing of governmental electronic documents by authenticating signer using eKYC for use in Digital locker, income tax eFiling, account opening in banks and post offices, driving license renewal, vehicle registration, certificates for birth, caste, marriage income certificate etc. 5 eSign providers have been on board and more than 5.89 crore eSigns have been issued. Digital India for Better Governance: (Jan Dhan Aadhaar Mobile) trinity for direct benefit transfers (DBT), the combination of 32.94 crore Jandhan bank Accounts, 121 crore mobile phones and digital identification through 122 crore Aadhaar is helping the poor receive the benefits directly into their bank accounts. Financial entitlements under 434 government schemes are being delivered through Direct Benefit Transfers. In last five years a total of Rs. 5.09 lakh crore have been transferred directly into the bank accounts of beneficiaries leading to a saving of Rs. 90,000 crores (Yojana, 2018). This has not only enhanced efficiency of service delivery mechanism but also eliminated leakages and curbed corruption. Growing digital payments ecosystem is set to transform the economy. Over the past four years digital payment transactions have grown multifold from 316 crore transactions in 2014-15 to 2081 crore transactions 2020-21. Today, BHIM UPI (Unified Payment Interface) platform and Rupay debit cards have become very popular digital payment instruments for sending and collecting the money and for payments at merchant outlets. UMANG has put the power of

governance in the hands of common man. It is a single mobile platform that provides more than 325 governmental services in coming time it will serve more than 1350 digital services through the app. More than 8.6 million users have downloaded and used this app since its launch in November 2020. Now, instead of surfing in various websites citizens can simply use just one mobile app and that too in 13 different languages easily available to common people. National scholarship portal has become a one stop spot for all the scholarship related needs of Indian students. Over 1.08 crore students have already benefitted with scholarship worth Rs. 5295 crore in the last 3 years. Jeevanpramaan is available for verification of pensioners using Aadhaar digital identity over 1.73 crore Digital Life Certificates have been submitted since 2014. eHospital and Online registration services have ensured that patients get easy access to doctors.

### **Digital Service Delivery near Doorstep (Common Services Centers)**

A vast network of more than 3.06 lakh of digital services delivery centers spread across 2.10 lakh Gram panchayats of the country has been created to provide easy access to digital services especially in rural areas at a nominal cost. These centers have also led to empowerment of marginalized sections of the society by creating jobs for 12 lakh people and by promoting rural entrepreneurs, out of which 61,055 are women. CSSs have also undertake the 'streeswabhimani' initiative to create awareness about menstrual health and hygiene among rural women. Under this initiative, more than 300 micro sanitary pad manufacturing units have been opened in rural areas. These units have provided livelihood opportunity to rural women but and also made low cost sanitary pads locally available.

### **Digital Literacy for the Masses**

In line with the objective to make atleast one-person e-literate in every household in the country, two schemes were launched viz. NDLM and DISHA wherein a total of 53.7 lakhs person were trained. Government has also initiated a new scheme 'Pradhan Mantri Gramin Digital Sakshrata Abhiyan' (PMGDISHA) to usher in digital literacy in rural India to cover 6 crore rural households. So far a total of 1.47 crore candidates have been enrolled under the PMGDISHA Scheme, out of which 1.43 crore candidates have been trained and 74.5 lakh candidates have been certified. This is the largest digital literacy mission in any nation. BPO promotion in small towns for 'Technology and IT Enabled services (IT/ITES) sector in each state, India BPO promotion scheme and North East BPO Promotion Scheme have been launched under Digital India programme. Today more than 230

BPO units have come up in about 100 small towns of India across 20 States and 2 Union territories

### **Digital India for Make in India**

Government of India has undertaken various initiative to promote electronics manufacturing in India, with the target to reduce imports. Phased Manufacturing programme for mobile phones was launched with the goal of widening and strengthening the mobile handsets and components manufacturing ecosystem in India which has now grown from 2 units in 2014 to 127 units manufacturing mobile handsets and components. The duty on import of mobile components fell from over 29 percent to 12.5 percent in 2016-17 and domestic mobile handset manufacturing output increased from 60 million units in 2014-15 to 225 million in 2017-18.

Centers of excellence (COE) are being set up in the areas of Internet of Things (IOT), Internal security, Large area flexible Electronics, intellectual property Rights (IPR), tactile Graphics for visually Impaired, agriculture and environments, ESDM, Fin tech language technology automotive electronics virtual Augmented Reality, medical tech and health informatics, block chain, gaming and animation and biometrics.

### **Cyber Security**

To create an inclusive, safe and secure cyber space for sustainable development, the Cyber Swachhta Kendra (Botnet clearing and malware analysis center) has been set up to provide alerts to users for preventing losses of financial and other data. The center is providing facility to clean botnets in real time. National cyber coordination Centre has been in operation since 2017.

### **Way Forward**

In the 21st Century, digital economy has emerged as a key driver for global economic growth and will also effectively address common global challenges including energy, environment and inequality. Digital technologies offer new opportunities for business, workers and citizens to engage in economic activity and to enhance efficiency. India is today among the top three global economies of digital consumers. Concerted efforts to facilitate and promote process of digitalization including upgrading digital infrastructure, augmenting capacity to develop standards and testing for conformity assessment promoting electronics

manufacturing with appropriate incentives, developing capacity to harness emerging technologies and strengthening cyber security as more services, including digital payments, permeate the economy and has the potential to make India into a trillion-dollar digital economy by 2025. India's digital story is one of digital empowerment and digital inclusion for digital transformation based on technology that is affordable inclusive and equitable.

### **Towards a Digital Future**

India's move towards its digital future began several decades ago. However, unprecedented acceleration in recent times has brought sharply into view both the enormity of the benefits that have already accrued and the immense opportunities that lie ahead. It is equally clear that the challenges that must be overcome while traversing this path are not trivial either. Today we stand at a confluence of several synergistic progressions both in India and globally, that have collectively created an incredible springboard for highly accelerated economic development as well as far more equitable growth. This endeavor is and will remain, a key determinant of India's future growth path. Early efforts at digitization in government were largely administration focused: how to improve efficiency, record keeping and data storage and processing especially in number crunching departments like finance (treasuries) taxation (commercial taxes, Income tax, Excise), statistics, etc. substantial efforts and progress were seen in departments that dealt with large number of beneficiaries like rural development, PDS, etc. These efforts were largely spread over a couple of decades during 1976-96 and almost entirely based on NIC support, barring a couple of states like AP where NIC efforts were augmented by state technology organizations like APTS. It was in 1997 that the first steps towards a citizen focused e-governance program was taken initially in the state of Andhra Pradesh. Later, thanks to a strong push by the central Government and the birth of the National annual eGovernance conference series, the movement rapidly spread to several other states. The next decade saw the emergence of several e-governance initiatives in diverse areas like land records, transportation, land registration, urban local bodies, PDS, etc. at the state level and Income tax, Excise and MCA at the national level. Towards the end of this period, State Wide Area Networks were created under a scheme funded by the Central Government. Some of these projects were implemented in a PPP mode, thereby drawing the country's technology industry into the nationwide effort and opening new approaches to rapid deployment of comprehensive e-governance solutions. These sporadic, but highly visible initiatives were widely appreciated and hailed as truly path breaking changes in systems of governance in the country. The foundation for a comprehensive National eGovernance plan

had been laid through these efforts. Approval of the SWAN project and early discussions at the highest levels of Government on the contours of a National eGovernance plan took place in 2003. These efforts culminated in the approval of the National eGovernance plan and the game changing Common Services Centers project in 2006 by the Union cabinet. Thereafter steady progress was made across the country: faster in some states and much more slowly in others. During this period (2004-2013), some of the more ambitious projects like UID (later renamed as Aadhaar), passport seva, MCA21 etc. were initiated. Parallel developments in the telecom sector unfolded at a staggering, globally unprecedented pace. The country went from 100 to 1,000 million telecom subscribers in a little over a decade, broadband coverage was expanding and the National optical fiber Network (NOFN later renamed as Bharat Broadband) was launched. Smart phone coverage grew rapidly as did social media usage, especially by the young population.

### **Potential of Digital Economy**

The advent of the present Government in 2014 was marked by a clear recognition of the huge potential of the digital economy. The Government took the digital push in the country to unprecedented levels with many spectacular initiatives that attracted global attention and drew praise. The Aadhaar project was taken to its logical conclusion by a vigorous drive, the JAM program (jandhan, Aadhaar and mobile) program saw over 200 million people benefitting from financial inclusion through bank accounts and direct benefits transfer (DBT). Linkage of mobile telephones and bank accounts with Aadhaar (recently barred by the supreme Court gave Government and businesses the ability to deal with a vast population individually and without leakage caused by nonvalue adding intermediaries the CSC program has expanded to 2,50,000 panchayats and now provides employment to nearly a million people in the rural heartland. Technology can indeed be used to distribute economic opportunity and job creation more equitably. Meanwhile, global developments in technology led to the emergence and use at scale of enormously powerful, highly affordable, almost infinitely scalable disruptive technologies like Social Media, Mobile, (Data) Analytics, Cloud Artificial intelligence, 3D printing etc. The Indian IT industry had also grown immensely and had become a 150-billion-dollar behemoth that was globally respected and often envied. The last 5 years have seen one other major development, namely the rapid growth of the third largest start up ecosystem in the world with around 7,500 tech startups. After initially coming up with clones of western products in ecommerce, transportation, entertainment and hyper local logistics and deliveries, the startup eco system is increasingly creating innovative

products and services focused on solving Indian. Problems in healthcare, agriculture, cyber security, energy to name a few. Of course, many of these have a global potential even though they started off with an India focus. India is well on its way to becoming a fountainhead of frugal innovation for the globe by creating services in various areas, but more importantly in the social sector, by leveraging new disruptive technologies.

### **Digital Services Delivery**

E-commerce, transportation, payment wallets, hotel/ accommodation/ cinema booking, local food and provision delivery services enabled by mobile apps are now familiar to most urban citizens and increasingly smaller towns as well. Global products like IBM Watson already provide a range of medical services across countries including treatment recommendations based on patients' records. But within India, well known products in healthcare such as practo, portea, lybrate, etc. are connecting doctors and medical professionals to patients in ways that make it easy to reach the right person from the comfort of your home. Apps like Byjus are making high quality educational content and services easily accessible at highly affordable costs. Similar established products albeit in smaller numbers exist in the agriculture sector too. But there are more new exciting efforts in the pipeline in social sectors like healthcare, agriculture, fintech/ financial inclusion that hold the promise of scripting India's future riding on the back of and reinforcing the Digital India program. Some examples would suffice to convey a sense of the range of innovation and extent of changes being ushered in by these young innovators and change leaders. Medicea technology solutions is building a tech driven pharmaceutical distribution business with next generation anti counterfeit technology using private block chain. Artoo has built an intelligent lending system specifically designed for micro enterprise lending. Dheeyantra has built a product that enables vernacular interactions and engagement with end customers using AI and NLP inform DS Technologies has built Doxper, an AI powered product that enables doctors to instantly digitize prescriptions and clinical notes using a digital pen and encoded paper. Krishi Hub is a free AI powered mobile app that enable farmers to make datadriven decisions and supports 8 local languages and is currently being used across 17 states. Deep Mind mines through medical records and analyses digital scans of the eye to diagnose eye disease. AI and Internet of medical things (IoMT) are transforming healthcare. Similar transformation in the agriculture sector through technology interventions that enable precisions farming, early warning of pest attack in cotton farming for example, are available through AI powered system to lower risks and costs while increasing productivity. It is

interventions like these and hundreds of other such innovations that are going to help deliver desired outcomes like doubling farmers' incomes and health coverage for the poor.

### **Regulating the Digital Revolution**

The Digital revolution is often called as the fourth Industrial revolution, the first three being the steam Engine, followed by the age of science and mass production and computers. World over the Digital revolution is driving the socioeconomic and technology growth of the human race. The revolution is driven by various factors like the availability of high speed Internet, innovative products and services the need for efficient management and distribution of resources both by the government as well as private entities, the users' ubiquitous requirement of remaining connected at all times etc. As stated in the TRAI's recommendation on privacy security and ownership of the data in the telecom sector. The ecosystem used for delivery of digital services consists of multiple entities like telecom service providers (TSPs) personal devices (Mobile handsets, tables personal computers etc.) M2M (Machine devices, communication networks (consisting of base trans receiver stations, routers, switches etc., browsers operating system over the top (OTT) service providers etc. It is estimated that the global volume of digital data created annual was 4.4 zettabytes in 2013 and this would reach 44 zettabytes by 2022 further it is expected that the number of devices connected to the IP Network would be approximately three times the global population by 2021. It would be pertinent to note that the mode of communication has transformed from purely analog to digital now and mobile communication has become an inseparable part of our lives. The entire gamut of digital transformation is to provide innovative products and services to improve productivity and efficiency. The connectivity to the digital devices would be predominantly provided by the telecom networks hence the telecom sector would be the key growth engine driving the Digital Revolution of India.

### **Technological Challenges**

These are far too many and are dynamic in nature *i.e* issues related to data, digital privacy and security, data ownership, AI based challenges etc. One of the major challenges in the telecom sector today is to simultaneously regulate the legacy as well as the new digital networks. This requires framing of new set of regulations and frameworks that facilitate seamless coexistence as well as smooth migration. India is the second largest market in the world. Though a large number of initiatives have been undertaken both by the Government as well as the private sector but still a large population remains devoid of connectivity to the

internet. Spreading awareness as well as connecting every individual are keys to the socio economic metamorphosis of our country. As new business models and services emerge, government agencies are expected to create or modify regulations, enforce them and communicate the same to the environment at faster pace. The regulator is not only entrusted with the responsibility to ensure the compatibility of the new technology with the legacy frameworks but also foster innovation on the other. Regulation of IT is also necessary to provide a safe and clean environment for development.

### **Conclusion**

India is witnessing the biggest transformation in the past decades with new technologies and services based on Digital connectivity and social media. Data analytics, cloud computing, IoT, applications are being increasingly designed and used in all sphere of life today. This development of technologies and services have removed all geographical boundaries, created exciting business models, created job opportunities, empowered the citizens and attracted world telecom leaders to India which has a very important role today in the global Digital revolution in telecom and IT sector but we must also be aware that emerging technologies are carefully regulated to avoid critical errors and misuse.

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Article Id  
AL04151**THE RETURN OF PINK BOLLWORM IN INDIA'S BT  
COTTON FIELDS AND ITS POSSIBLE WAYS TO DEAL  
WITH IT**

Email

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**B***acillus thuringiensis* (Bt) cotton technology has been the subject of heated discussion among academics and non-academics alike ever since it was introduced in India. Cotton farmers in several Indian states are worried about widespread resistance to endotoxins produced by Indian Bt cotton plants among Lepidopteran pests and the consequent loss of their livelihoods as a result of the return of pink Bollworm (*Pectophora gossypiella*) in those states recently rediscovered. There has been a recent spate of bollworm outbreaks in India, and this research is the first to examine the socio-economic impact that these assaults have had on the local economy. According different study, it explains why smallholders are now more vulnerable than ever before, and why some can only handle the repercussions of this technical failure to such a limited level. Pink Bollworm, the primary pest of Bt Cotton, has returned to a number of Indian cotton-producing states in recent months, and this is a major turning point. From last 5-6 years, the infection has extended across the central and southern zone of cotton production, resulting in yield losses of up to 30 percent in fields in Gujarat, Maharashtra, Karnataka, and Andhra Pradesh. Since this occurrence, there has been a renewed discussion over the long-term viability of Bt cotton technology among cotton farmers and other stakeholders in the business. While the Bt cotton technology offered built-in protection against pink Bollworm and other Lepidopteran pests, it is now reported to have 'lost the war'. Many possible factors for the pest's recurrence are contested in this context, of which we only address those that are directly connected to farmers' livelihoods systems, such as the trafficking of illegal and bogus seeds, and the need of planting refuge crops surrounding Bt plants

## Pink Bollworm

- ❖ Insects like the pink Bollworm, also known as the *pectinophora gossypiella*, are well-known cotton-farming pests.
- ❖ Originally from Asia, the pink Bollworm has spread across the world's cotton-growing areas.
- ❖ The pink Bollworm has developed resistance to first-generation transgenic Bt cotton (Bollgard cotton), which expresses a single Bt gene, in certain regions of India (Cry1Ac).



**Fig. 1:** Pink Bollworm and its effect on cotton

## Possible Reason for the Reappearance of the Pink Bollworm

Because of the frequency of unregulated seed trades, it's possible that the pest may return. Bt cotton seeds are more expensive than conventional cotton seeds and have a "stronger official intellectual property (IP) status," which encourages the development of informal marketplaces for Bt cotton. In the battle against Bollworm, the illegally sold seeds have a negative impact because of the poor quality of the seeds. This is owing to the fact that transgenic cotton plants express different amounts of Bt toxin. Toxin proteins cannot be produced in sufficient numbers in stealth and counterfeit seeds in order for the technology to work throughout the season. As a result, farmers are unable to make an informed decision based on credible information because of the illegal seed problem. For the sake of using the most popular brand and variety of seed each season, farmers "essentially ignore what they know about the previous years' seeds." Thus, farmers seldom replant seeds, limiting their ability to learn about the environment in a seed market that is becoming more opaque.

Farmers' non-compliance with refuge rules may also be a factor in the pest's recurrence. To minimise the evolutionary pressure of the pest to adapt to the endotoxins

generated by the Bt plants, refugia consisting of non-GE cotton crops must surround each field prior to sowing GE cotton. It blames the 'erosion of resistance to pink bollworm' on poor management of the technology and claims that farmers could have extended the technology's effectiveness if they had followed instructions. Others, on the other hand, point the finger at the technology itself: Technology must be judged in context, says Glover (2010), since it is not only "in the seed," but must "function in certain socio-technical and institutional situations. In light of the current issues regarding the resurgence of pink Bollworm in India's Bt cotton fields, we ask the following two questions: In Karimnagar district, how has the recent adoption of Bt technology affected agricultural families in general? As pink bollworm pests return to Karimnagar district farms due to the breakdown of host resistance, what immediate livelihood vulnerabilities have they produced and how are they coping with this new situation?

### **Socio-Economic Effects of Bt Cotton**

**Farmer's Subsistence Cultivation** According to the socioeconomic impacts of Bt cotton growing on the livelihoods of peasant farmers, the technology has a disputed impact on the amount of cotton that can be produced. Scholars with economics degrees have claimed that Bt technology improves yields. Almost all of these studies credit Bt cotton for the early 2000s' success in yield improvements. So it is said, that Bt cotton has performed far better than traditional cotton, resulting in a 40 percent yield advantage. Others take into account numerous major developments in Indian cotton production for total yield gains and find lower contributions from the GE technology. For instance, just 18 percent of the proposed yield gain is attributed to the technology itself. Recent long-term research claims that "yield increases are explained much better by other technological changes" and thus credits yield increases in the early 2000s to a variety of agricultural factors, such as cotton seed hybridization, improved access to irrigation facilities throughout Indian cotton-producing states, and most notably the increasing use of fertiliser. According to some experts, 'the yield advantage of Bt over non-Bt is insignificant' and that it is due to cultivars and agronomic approaches, not the technology itself. Larger effective yields have resulted to higher profits, according to some experts, who claim a 50 percent rise in cotton profit among smallholders, which boosted family living standards by 18 percent and increased household spending. Because most peasant families adopting Bt cotton are rather poor, the authors conclude that 'Bt cotton leads to good economic and social growth.' Furthermore, according to another study, both the greater yields and the increased earnings were long-term advantages.

In addition to this, however, there is a counterargument: Several academics have described the technique as raising farmers' risks since it is not characteristically yield-enhancing, but rather its success is strongly dependent on local appropriateness, irrigation, and rainfall circumstances. Because of this, 'any effects beyond particular bollworm infection' are not assured. Furthermore, Gaurav and Mishra (2012) claim that Bt cotton's yield swings are much greater than the irregularity of conventional cotton in terms of risk. Since net returns have risen at a slower rate than input costs over the years.

### **Effects of the Pink Bollworm Pest Infestation on farmers Health and Welfare**

Recent studies estimate yield losses of up to 30 percent, making smallholders and other people involved in the cotton sector more anxious, a critical re-examination of the technology is necessary in light of the immediate livelihood hazards and associated coping techniques that may arise. An August and September 2018 study shows that the pest has returned to cotton-producing regions in central and southern India since the *Kharif* season of 2015, and that this infestation from 2017/2018 has had lasting effects. Despite the lack of data for later seasons, a researcher might deduce that this issue had a negative impact on cotton production in the upcoming years. An interviewer viewed the infestation as unexpected and stressed the idea of surprise in its occurrence "I opened approximately 50 cotton bales to make sure they weren't contaminated, but sadly the whole field was infested with pink bollworm." Farmers in different areas/ regions have acknowledged these assaults and claim to have lost a significant amount of money as a result of these incidents. After the pink bollworm pest reappeared, another group of farmers explained how they began constructing their homes with the excess they had collected during the early years of adopting the technique but were unable to make enough money to complete the construction due to lower production and productivity of cotton.

### **Plan to Tackle Pest**

- ❖ For example, the "Central Institute for Cotton Research" plans to put up pheromone traps to attract male moths and teach farmers and oil extraction facilities to take precautions against cotton seed brought in from outside being a cause for the infestation to grow.
- ❖ Unusual RIB (Refugia in Bag) idea has been advocated by the federal government as an alternative solution to this issue. In this case, 25 grams non-Bt Cotton seed is combined with an equal amount of Bt Cotton seeds.

- ❖ The goal of planting 'refuge' plants near GM crops is to prevent Bt-resistant insects from developing. This allows for the cultivation of non-BT cotton, which may host pink bollworm wild insects, and prevents the pink Bollworm from developing resistance to pink Bollworm.
- ❖ Agriculturalists fear that the infection may lead to a 10 percent reduction in the area planted to cotton, resulting in lower yields and lower pricing.
- ❖ The National Seeds Association of India (NSAI) has also endorsed the RIB idea, which it claims would reduce the spread of pink Bollworm on Bt Cotton.

### Why the Case is Unique for India?

**Toxin-resistant pink bollworms have been found in India because of this.**

- ✓ Since the advent of Bt cotton in 2002, India has confined itself to farming long-duration hybrids.
- ✓ There are no other Bt cotton-producing nations that cultivate open-pollinated cotton types like China or the United States.

### What's Next?

Agricultural rotation with other crops, biological control of insects with the assistance of insects and parasites that consume pink Bollworm, and destruction of crop waste and garbage in the field are all part of the NSAI's IPM programme. There has also been a recommendation from NSAI for the government to return to Bollgard. Short-duration crop varieties should be adopted as soon as possible by growers. As Monsanto did not patent BG-2 in India, seed firms cannot create open-pollinated cultivars using BG.

### Solutions

- to 3 pesticide applications on average since the seeds at the time were resistant to pests.
- There are three primary ways to manage and eradicate pink bollworms as outlined by scientists and field researchers.
- There are two methods of reducing the population of the pink Bollworm, the first of which is known as the mating disruption technique.

- To prevent the spread of the disease, sterile male moths are dispersed across fields to inhibit procreation. Third, cotton seed types that are resistant to pink Bollworm may be widely used.
- BG-3 seeds and mating disruption have been offered as a permanent solution to this problem by researchers. According to them, the only other option is to drastically increase the quantity of pesticides used.
- To limit the spread of the pink Bollworm, the crop will need to be sprayed with pesticide every 7-8 days, therefore after 50 days in the field, the crop will need a dose of pesticide every 10 days.
- Cotton crops were pest-resistant prior to the arrival of the pink Bollworm, which needed just two to three pesticide treatments per acre.

### Conclusion

This article demonstrates how the livelihood effects of the Bt cotton technology on Indian farmers are varied and have changed over time. The early years of Bt cotton adoption were marked by detectable yield of cotton, noticeable decreases in pesticide use, and increased economic prosperity. The farmers who were interviewed said that in the last 4–5 years, they had significant output losses as a result of pink bollworm infestation—a Lepidopteran pest that Bt technology is said to guard against. This insect infestation severely harmed farmers' livelihoods, and the resulting additional vulnerabilities disproportionately impacted households with few assets. Therefore, those farmers with marginal assets have been put at the greatest risk as a result of the Bt technology's failure. Given the re-emergence of pink Bollworm in Indian cotton fields, we have reason to worry that the second generation Bt cotton technology's (Bollgard-II) built-in pest management is no longer effective. The livelihoods of cotton farmers in India are at danger because of this.

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## CORAL REEFS IN INDIA: THREATS, STATUS AND CONSERVATION

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Coral reefs are primitive and most diverse eco-systems on earth. Despite they occupy less than 1% of the sea floor; they are shelter to more than 25% of all recorded marine species. There are about 4000 varieties of fish, 700 species of coral, and thousands of other fauna and flora in the reef ecosystem, all of which contribute an unique and crucial function. Coral reefs are known as the "Tropical Rainforests of the Sea" because of their incredible diversity of life and unique individuality. Reefs also benefit millions of people all over the world by providing a variety of economic and environmental benefits. Coral reefs are now being devastated at a rising rate underwater as a result of both natural and manmade processes, despite their tremendous value. According to a 2011 report by the World Resources Institute, 75% of the world coral reef are threatened, with a 25% of them already destroyed below recovery. If current destruction rates are forced to continue, 90 percent of reefs would be threatened by 2030, and virtually all will be threatened by 2050. Experts predict hunger, poverty, and political uncertainty throughout the worldwide when coral reefs totally vanish, as millions of people's livelihoods would be lost.

The current states of coral reefs, as well as the rising threats to them, are important concerns. Ngoile, (1998) reported that coral reefs cover a worldwide area of 6,00,000 km<sup>2</sup> (about the same as France), from which 60,000 km<sup>2</sup> have been destroyed and 1,80,000 km<sup>2</sup> are endangered. Mangrove forests shelter coral reefs from intense storms, while corals prevent silting, provides nursery grounds for fish that mature stage is in the reef region, and obtain nutrients from the terrestrial environment, softening the impact on reefs that require less nutrients. According to Venkataraman, (2011) the Indian Ocean is home to a large share of the universe coral reefs, there are 199 species on Indian reefs, classified into 37 genera. There are 18 families recorded from throughout the world, including 15 from India. The aim

is to shed light on the growing exploitation of corals, to comprehend their significance and to examine government policies aimed at their protection and management. Presents an overview of the worldwide policy framework on coral reefs, as well as a comparison of these policies with those in India.

### **Coral Reef in India**

India has roughly 8129 sq. km of coastline. The reef formation, on the other hand, is limited to four main areas :- Gulf of Kutch, Gulf of Mannar, Lakshadweep Islands and Andaman and Nicobar Islands. According to (DOD and SAC 1997) in India, the total area of coral reefs is estimated to be 2,375 square kilometres. The coral reefs in each of these areas are not the same. The structure and kind of reef varies by location. Reefs come in several forms. (i) Fringing reefs: The Gulf of Mannar and Palk Bay both have fringing reefs. Along the Gulf of Kachchh, platform reefs can be found. Patch reefs may be found near the coastlines of Ratnagiri, Malvan, and Kerala. The Andaman and Nicobar Islands have both fringing and barrier reefs. (ii) Barrier reefs: are found in the Andaman and Nicobar Islands and are separated from the mainland or island coast by lagoon. (iii) Atoll reefs in India are found only in Lakshadweep.

### **Benefits of Coral Reef Ecosystems**

**Food and Fisheries:** They serve as nurseries for around a quarter of the ocean's fish, providing a key supply of nutrition. They also generate earnings for communities, national and international fishing grounds, Around 15 tonnes of fish and other seafood may be harvested from reefs.

**Medicinal Advances:** Coral reefs may play a pivotal role to curing life-threatening disorders like heart disease, ulcers, leukaemia, lymphoma, and skin cancer. Furthermore, the specific skeletal composition of coral has been exploited to develop the most modern bone-grafting technologies.

**Rich Minerals:** Limestone is abundant on coral reefs, and it is frequently utilized as a cement alternative in the building sector.

**Protection of Coastline:** Reefs operate as natural barriers, shielding coastal cities, villages, harbours, and beaches from pounding ocean waves, prevent soil erosion, damage to property,

and loss of human life. Barrier reefs also promote in the stabilisation of mangroves and seagrass beds, which may be uprooted quickly by strong waves and currents.

**Filtration of water:** The majority of corals and sponges is filter feeders, means they eat suspended fine particles in the water column. The near-shore waterways will benefit from improved quality and clarity as a function of that one.

**Air Quality Maintenance:** Corals produce new reefs by using dissolved carbon dioxide in the sea water. The carbon dioxide levels in the water are controlled by this gas conversion to limestone shell.

**Recreation and Tourism Services:** Scuba trips, fishing expeditions, resorts, hotels, and other businesses located near coral reefs provide millions of jobs and billions of dollars across the world. Through widespread tourism, coral reefs are frequently a backbone for coastal economies.

### Threats to Coral Reefs

Coral reefs are vulnerable to a variety of natural and anthropogenic challenges because of their sensitivity.

#### Natural Threats Include

**Predation through the Crown:** Snails couldn't eat the starfish because there are not enough of them. This resulted in an increase in starfish populations, which fed coral reefs. In India's Gulf of Mannar and Lakshadweep islands, the situation is particularly significant.

**Natural Breakdown:** Many fish feed dead or alive corals, altering their shape and making them more vulnerable to other physical and chemical hazards.

**Pounding by Waves:** Violent waves and storms have the greatest impact on corals living in shallow seas. Corals can be killed, especially during hurricanes.

#### Anthropogenic Threats Include

**Coral Mining:** Corals are frequently collected and used to construct buildings and generate lime. In the 1980s, a cement business leased the mining of coral sands in the Gulf of Kutch. A million tonnes of coralline debris, including living corals, were taken away every year,

destroying a substantial percentage of the reefs. According to Rajasuriya *et. al.* (2000) significant impact in the Gulf of Mannar, where 250 m<sup>3</sup> of corals are mined every day.

**Destructive Fishing Methods:** Fishermen commonly use dynamite under water, which causes fish to be narcotized and shocked, causing them to come to the top to be collected. This activity has an effect on the variety of coral species in the Lakshadweep Islands, where tuna fishing is a key stream of income.

**Boat Anchors:** The chain is dragged across the corals when the anchor falls on them, or when the boat drifts. This has the capability to uproot corals by breaking their branches. When reef fishing, many fishermen anchor small vessels in shallow water.

**Coral Collection:** Beautiful black and white corals are picked for jewellery, while branching corals are commonly collected as mementos. Coral collection has severely harmed the Gulf of Kutch and the Andaman and Nicobar Islands.

**Mangrove Destruction:** When mangroves are destroyed on a wide scale, it has an indirect impact on the corals that live in their shadow. The ability of mangroves to bind mud helps them filter the quantity of silt that reaches the ocean floor and settles on corals.

**Pollution:** Oil and metal pollutants are extremely harmful to corals. Reefs in the Gulf of Kutch that are close to harbours are doomed from the beginning. Corals beneath water are suffocated by the muck and silt sinking. Thermal pollution has a negative impact on reefs as well.

### Climate Change

**Coral Bleaching:** Coral bleaching may occur when sea temperatures rise. Corals can eject the algae (zooxanthellae) that live in inside tissues if the water is warm, causing the coral to bleach entirely white. According to Goldberg and Wilkinson (2004), 16% of the world's coral reefs have been lost.

**Rising Sea Level:** Glaciers melt as the world warms, causing sea levels to increase. Corals are expected to sink deeper down, absorb less sunlight, and develop more slowly as a result.

**Stronger Storms:** Stronger and more forceful waves are produced by these storms, which can damage coral branches and topple coral colony.

**Ocean Acidification:** The chemistry of the seas alters when CO<sub>2</sub> is absorbed, making it more acidic. Corals and other marine animals find it difficult to produce skeletons and shells. Corals as well as other reef animals' calcification processes already have begun to decline.

**Ozone Layer Depletion:** Coral reefs have such a naturally sunlight to defend themselves from UV light, at increased levels which can harm corals in shallow seas at high rates.

### **National Initiative for Coral Reef Conservation**

The Department of Forests and Wildlife is in control and it is their obligation to monitor, manage, and maintain these coral reefs eco-systems. The Ministry of Environment and Forests has the authority to design a positive action plan for managing reef resources and provide recommendations for coral reef sustainability. In India's National Conservation Strategy and Environment Action Plan (UNDP, 1997), the management of coral reef ecosystems is also supported. There are some legislation in the nation that can be activated for the protection of coral reefs areas such as in the 'Environmental Protection Act (1986) and the 'National Protection Strategy and Policy Statement on Environmental Development (1992) both include coral reef conservation and Protected areas and some marine species are covered under the 'Wildlife Protection Act (1972). Corals are still being brought under the legislation, and more strict enforcement of protective measures is being supported. Some other policies which would have a direct effect on coral reef areas are indeed the Indian Forest Act (1927), the Forest Conservation Act (1980) and the Indian Fisheries Act (1896) that is of vintage origin. The 'Environmental Protection Act 1986' and the 'National Protection Strategy and Policy Statement on Environmental Development 1992' both include coral reef conservation. The 'Action Plan of the Ministry of Environment and Forests' designates this ministry as the focal point for the Indian Coral Reef Monitoring Network and the International Coral Reef Initiative, as well as the conservation and management of coral reef resources. The Coastal Regulation Zone (CRZ) Notification (1991) provides the only legal rights for all coral reefs in India, and the CRZ1 category includes all coral reef habitats. The Coastal Regulation Zone Notification (1991), issued by the federal government, controls onshore development activities that have an influence on coastal habitats and strictly restricts the collecting and trafficking of corals.

These protected areas are poorly managed, mainly those near the subcontinent, because human influences from resource usage, urbanization, and rapid industrialization are significant. Corals reef in the Gulf of Kutch Marine Park have been neglected, with

monitoring restricted to irregular EIA assessments related with development initiatives, and there are rising fears that portions of the park would be repealed for industrial development. Protected areas on the Andaman and Nicobar Islands, as well as those in Lakshadweep, are in better physical condition, but only because human effects are reduced. These MPAs are indeed vulnerable to crown-of-thorns starfish and bleaching, both of which are essentially uncontrollable at the regional management. In the Lakshadweep, Andaman, and Nicobar Islands, surveys are limited to a few easily accessible places. Fish surveys have not been included in monitoring programmes, and sampling in deeper locations is impossible due to a lack of skilled divers and scuba gear. Long-term monitoring requires a small number of trained and skilled workers, and there is little NGO or community support in reef management.

The ICRMN has launched Coral Reef Monitoring Action Plans (CRMAs) for all reef regions except the Gulf of Kutch, which were developed during the first phase of the GCRMN (1997-98). Government assistance has been provided to establish CRMAs and educate individuals to observe the reefs; nevertheless, operations are still in their early stages, and management and monitoring capability is still lacking.

Other important international coral reef programs in India include: India-Australia Training and Capacity Building (IATCB) programme; UNDP-GEF Projects on the Gulf of Mannar and Andaman and Nicobar Islands; The UK Department for International Development (DFID) supported the Integrated Coastal Zone Management Training Project (ICZOMAT) (DFID) and the Coral Reef Degradation in the Indian Ocean project (CORDIO) (Rajasuriya *et al.*, 2002).

## Conclusions

Human factors involved with expanding populations and coastal erosion, particularly unregulated exploitation of resources, coral mining, and the consequences of sediment and pollutants, continue to harm coral reefs. Natural factors such as the crown-of-thorns starfish and climate change-related effects such as coral bleaching and storms have a role in coral reef deterioration. The GCRMN Network for India, the Maldives, and Sri Lanka has strengthened the ability to monitor reef resources through training initiatives. India has made significant progress in biophysical monitoring, especially to continuing training funded by the ICRMN. However, there is currently a shortage of capability for periodic socioeconomic monitoring of reef resources, and monitoring data is only used infrequently in management. Strengthen the

ICRMN's function and authority to operate as the key coordination organization for coral reef policies and programmes, to improve cooperation between government agencies, institutions, and local organizations, and to assist in the execution of Management Action Plans; Enhance monitoring operations and improve ability to monitor reefs. To better understand the ideas of development and preservation use of coral reef resources, promote awareness and training development at all levels. The GCRMN Node and the CORDIO initiative are providing support for additional training in socioeconomic monitoring as well as demonstrative monitoring projects. The GCRMN Node is also developing national coral reef databases to make it easier to apply socioeconomic and biophysical data to management.

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